PDHonline Course C615 (8 PDH)

Sydney Opera House: Splendid Geometry

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Sydney Opera House

Splendid Geometry

Table of Contents

Part 1

The Spirit of Tubowgule

First Fleet

On January 25th 1788, *Captain Arthur Phillip* (left) of *His Majesty's Ship* (HMS) *Supply* entered a vast, undiscovered and secure harbor extending inland for many miles. The next day - with the indigenous (Aboriginal) *Gadigal* people watching intently (from a distance), Captain Phillip went ashore and planted the *Union Jack* on the new found land claiming it for God, King (*George III*) and country. Over the next few days, the rest of the *First Fleet* arrived with its cargo of 730 prisoners, most convicted of petty crimes or as debtors. Under armed guard, the prisoners commenced unloading provisions, clearing land and building shelters. Though prisoners in a strange, distant land of the southern oceans, the prisoners were relieved that their long sea voyage from England was at its end. A pre-fabricated canvas "Government House" was established and the convicts were housed in an area along the harbor's shore which came to be known as "The Rocks." By 1789, the settlement of *Sydney Cove* was established.

A period oil painting of Captain Phillip's First Fleet arriving in Sydney Cove (a.k.a. "Port Jackson")

To Conciliate Their Affections

With the Sydney Cove settlement firmly established; protected by naval guns and a detachment of British Marines, Captain Phillip set out (by royal decree) "To open an intercourse with the natives, and to conciliate their affections." Unable to achieve this high-minded objective by conventional means, he resorted to kidnapping. Two men; one a Gadigal (*Colebee*) and the other from the *Wangal* clan were captured while fishing, but Colebee soon escaped. For *Woollarawarre Bennelong*, his captivity would prove to be the breakthrough Captain Phillip was looking for. Highly intelligent and opportunistic, Bennelong learned the English language and adapted himself to his captors ways, even going so far as dressing like an Englishman. Phillip too learned much from Bennelong about the Aboriginal culture and the men became friends. Bennelong acted as middle-man in trade deals between his people and the English colonizers thus elevating his standing in the tribe and helping his people, though many considered him a traitor. In the Autumn of 1790, Bennelong escaped from his Government House domicile back to his village at *Manly Bay*. Seeking to re-establish his friendship with Bennelong, Captain Phillip went to Manly Bay where he was speared by a friend of Bennelong. Bennelong's pleadings that the incident was the result of a misunderstanding and his deep-rooted friendship with Captain Phillip narrowly averted open warfare. In the wake of the incident, a truce was signed whereby kidnapping of the local Aboriginal people was outlawed and Bennelong's clan were given open-access to the Sydney Cove settlement. In 1792, Bennelong accepted Captain Phillip's invitation to return to England with him. There, the adventuresome Bennelong met King George III, visited Parliament, learned to skate, box and consume excessive amounts of alcohol.

The Gathering Place

The Gadigal were one of twenty-nine Aboriginal clans who occupied the *Sydney Basin*. For the Gadigal, *Tubowgule* was a favorite place for fishing and harvesting food. At the tip of this peninsula was a rocky tidal isle (*Bruang*) with a small beach at its western end and a white clay quarry from which ceremonial body *Ochre* was obtained. In 1790, Philip built a brick hut for Bennelong at Tubowgule. This was the first dwelling and one of the few ever erected there. The rocky sloping land wasn't attractive to the European settlers and from then on, the point became known as *Bennelong's Point.* Bennelong returned from England in 1795 a changed man. An alcoholic, he was welcome neither among his own people nor the colonizers. He died a broken man in 1813.

Bennelong Point from Dawes Point **(ca. 1804)**

Corroborees

Tubowgule was popular with the Gadigal as a gathering place providing an opportunity for adults to pass on the oral history of their culture to their children. As such, Tubowgule was important to the Gadigal people serving as a central place for recreation and cultural activities. Other Sydney Harbor clans often visited Tubowgule. At nightfall, *Corroborees* were often held at the point. These “Bush Operas” (as they became known) were large gatherings of the clans. A Corroboree could go well into the night with singing and dancing. In March 1792, a Corroboree was presented by Bennelong for the benefit of the colonists.

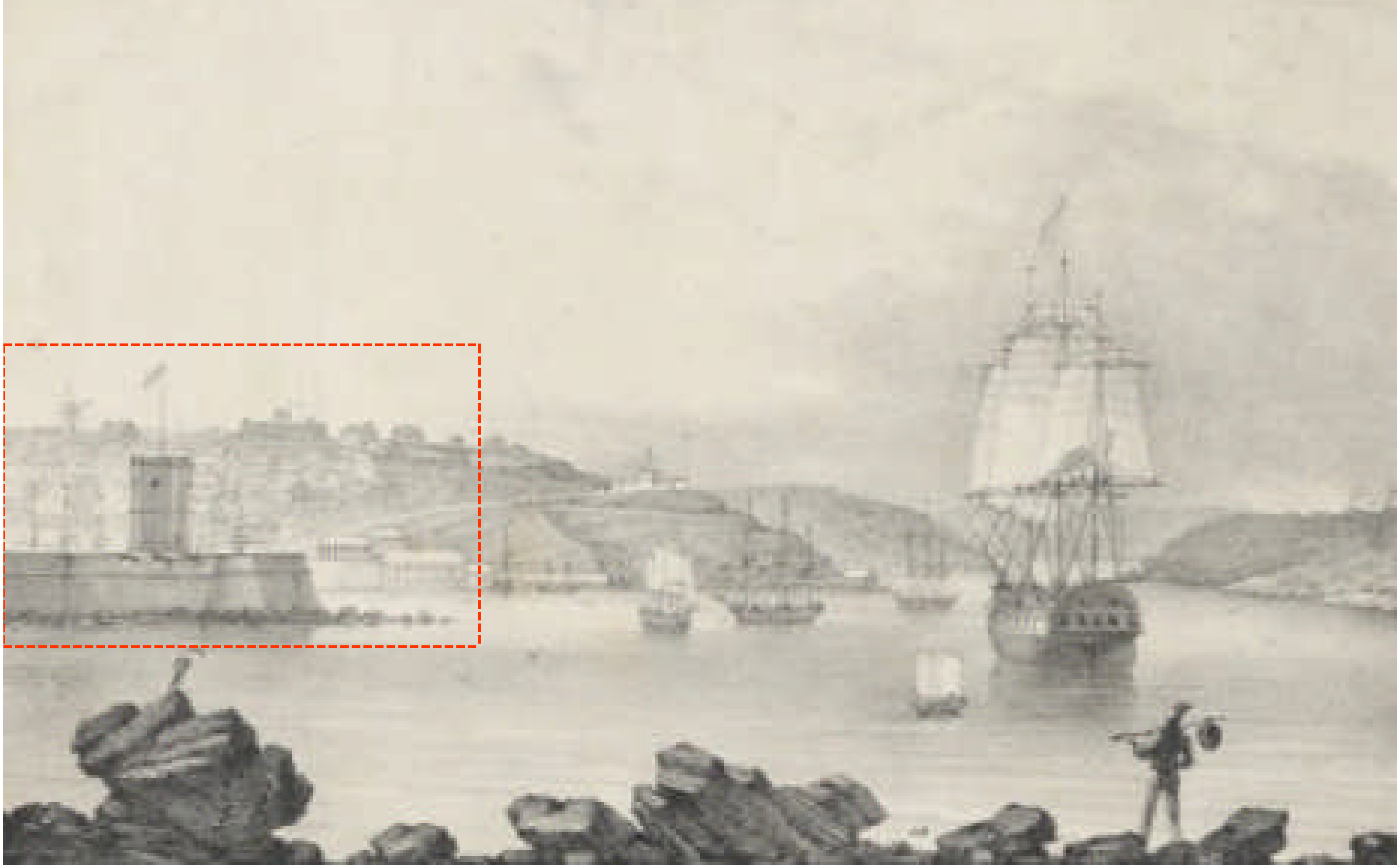
Left: County of Cumberland, Parish of St. James (Parish Map ca. 1835) showing Sydney Cove and Bennelong Point.

From 1818 to 1821, the tidal area between Bruang (tidal island) and the peninsula (mainland) was filled with rocks excavated from Bennelong Point. The area was leveled and a large portion of the rocky escarpment was cut away to allow a circumferential road to be built around the point. The existence of the original tidal island was long forgotten until both were rediscovered during the excavation work for the *Sydney Opera House* (SOH) begun in the late 1950s. Ever since, *Kooris* (Aborigines) have returned to Bennelong Point recognizing its importance as an Aboriginal cultural site. When *Queen Elizabeth II* opened the Sydney Opera House in October 1973, *Ben Blakeney -* a direct descendant of *Woollarawarre Bennelong*, appeared silhouetted in the apex of one of the high roof shells of the building representing his ancestor and blessing the Opera House and its generations of patrons to come. In 1974 (as part of the Opera House's opening season) Aboriginal actor *Jack Charles* played Bennelong in the stage production of *Cradle of Hercules*. Kooris have returned to the old traditional gathering place and many indigenous artists perform on the stage/s of the Opera House, reminiscent of the "Bush Operas" performed at the Corroboree/s so long ago.

North View of Sydney, New South Wales **by** ***Joseph Lycett*** **(1825)**
Bennelong Point at left (Lycett was a convict/artist)

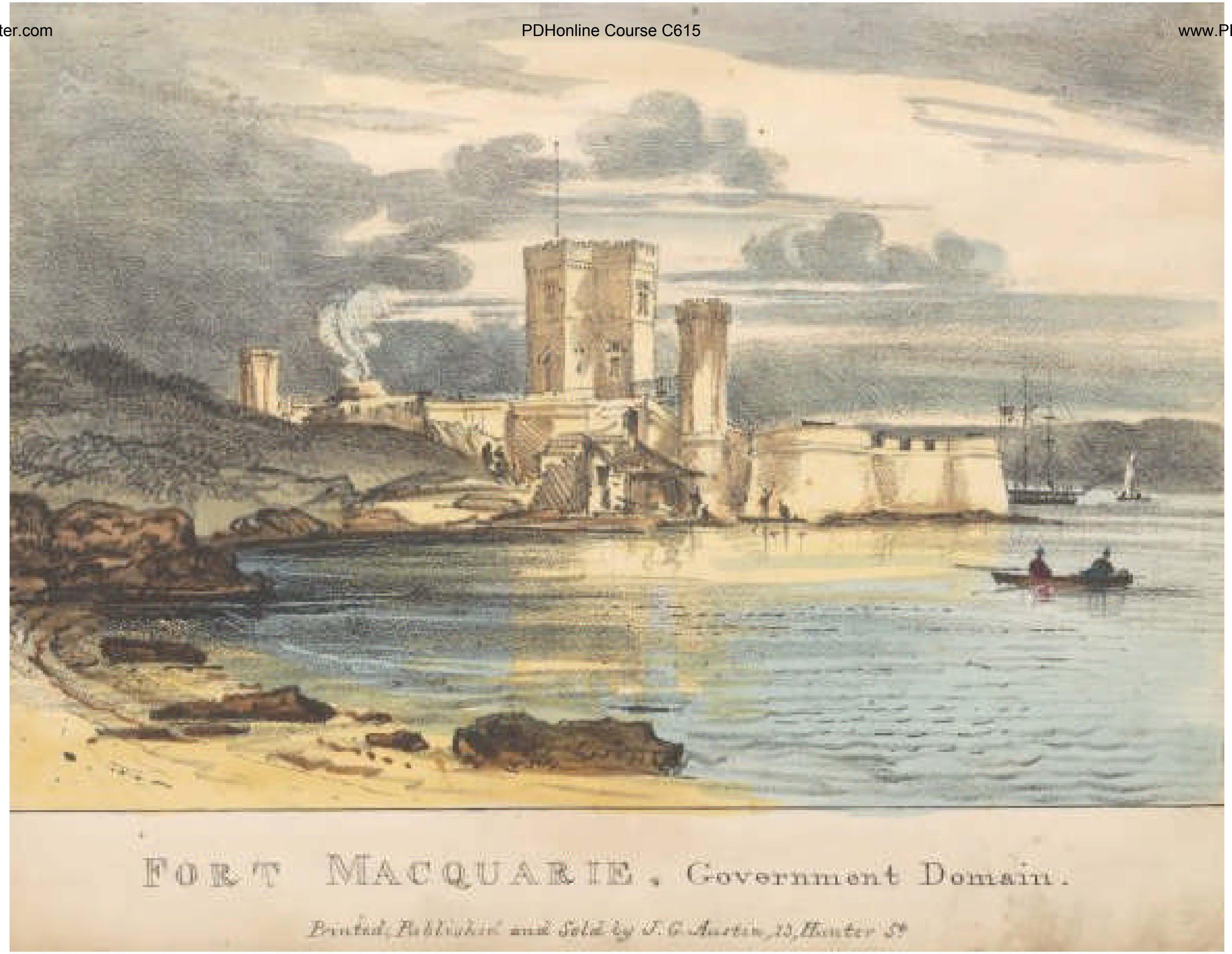
Performance (on the forecourt) of the SOH. Part of Tubowgule (*The Meeting of the Waters*), *Sydney 2000 Olympic Arts Festival* welcoming ceremonies (August 18th 2000).

The first fortification for the new colony was a small redoubt on Bennelong Point built in 1789. It held eight cannon from *HMS Sirius.* It was demolished in 1791 and was replaced by an 80 by 20-foot storehouse. In 1798, the storehouse too was demolished and replaced by a "Crescent Battery." In 1817, convicted forger and architect *Francis Greenway* was given the assignment of building a stone fort on Bruang by the colony's fifth governor; *Lieutenant Colonel Lachlan Macquarie* (the drawbridge that had connected the small island to the tip of the peninsula was replaced by rock fill). Completed in 1821 and known as *Fort Macquarie*, it never fired a shot in anger and itself was demolished in 1901 to make room for a tram depot.

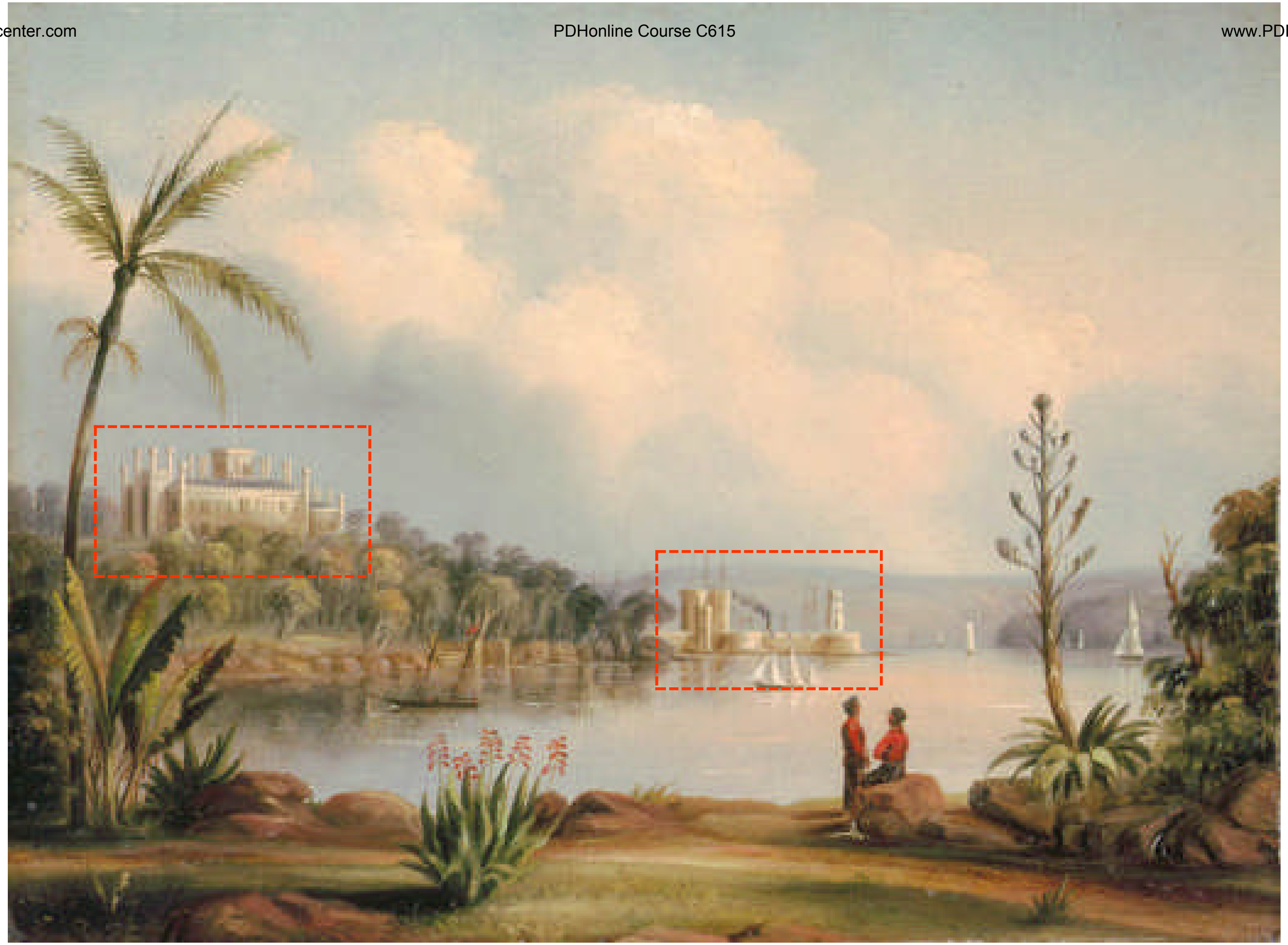


Coming to an anchor off Sydney Cove
by *Augustus Earle* (1830)

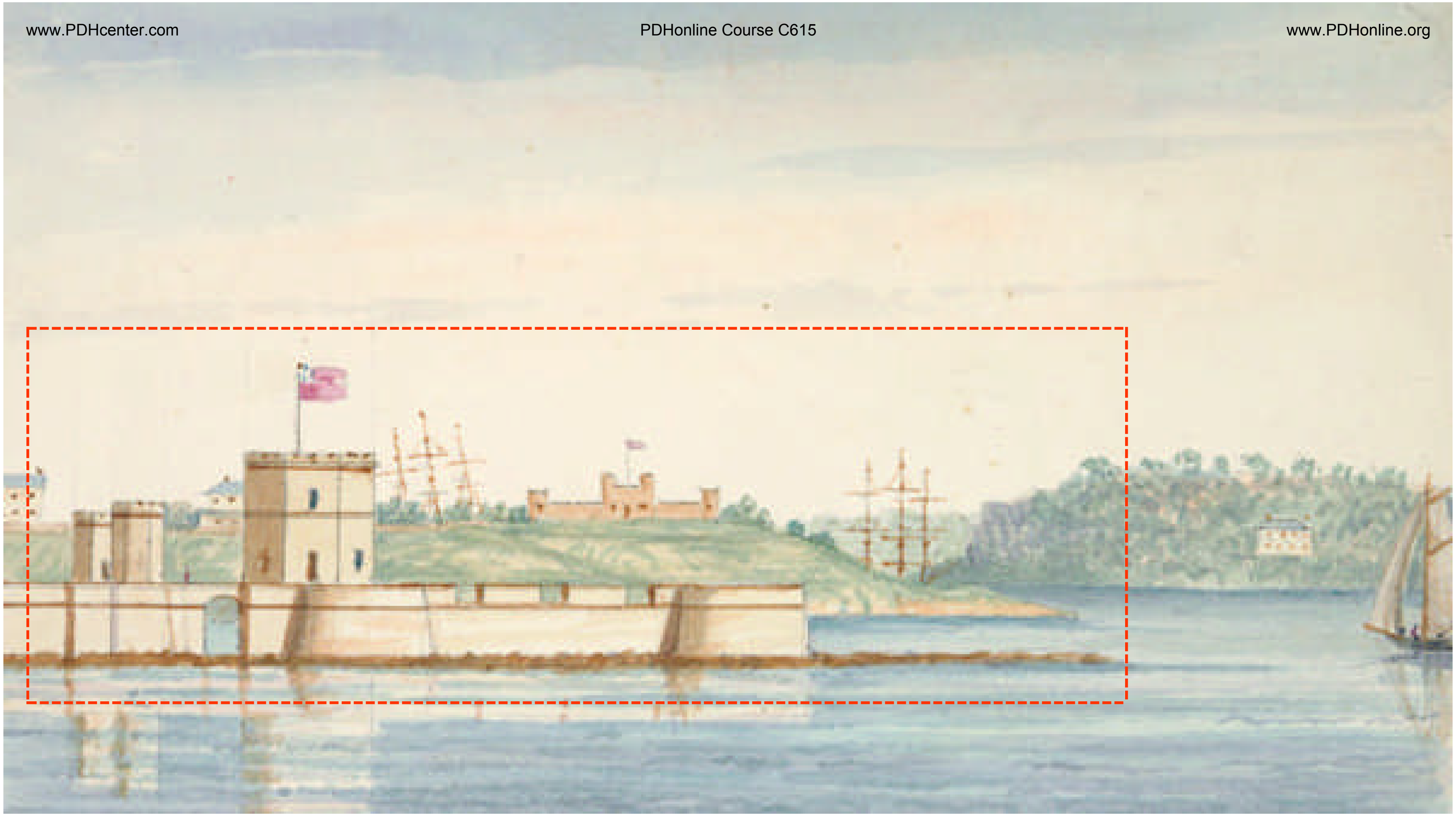
Plan of the streets of the town of Sydney (1832)



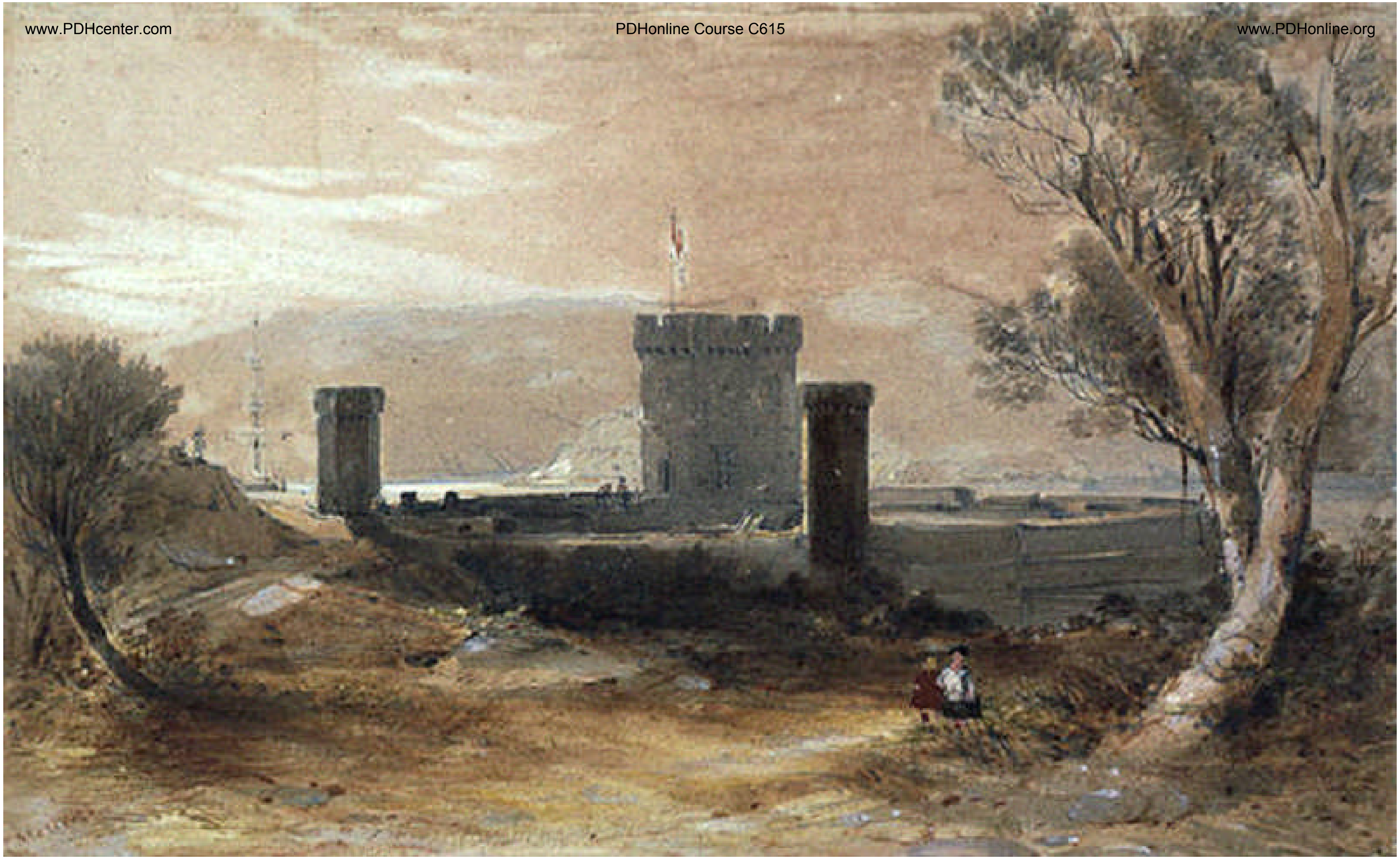
***Fort Macquarie, Government Domain* (1836)**



***Government House and Fort Macquarie from the Botanical Gardens* (1846)**



Dawes Battery and Fort Macquarie **(ca. 1850)**

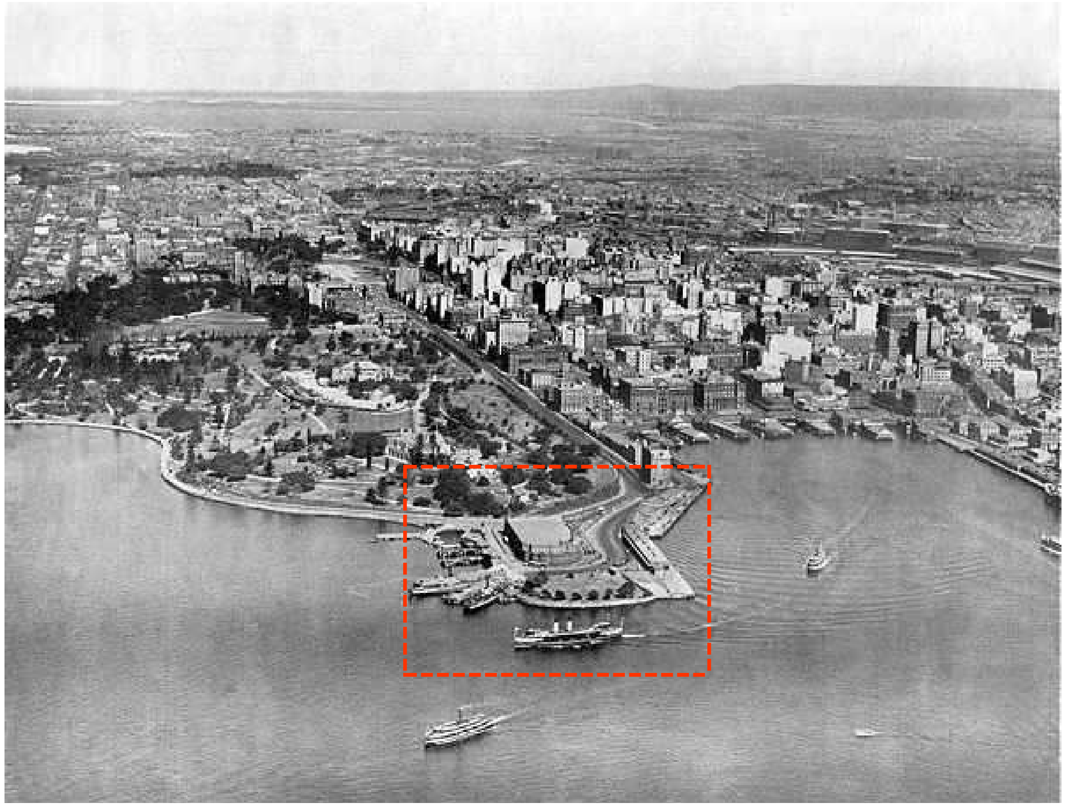


***Fort Macquarie, Port Jackson* by *Conrad Martens* (ca. 1852)**

Bennelong Point, Sydney, from the North Shore
by *Conrad Martens* (ca. 1860)

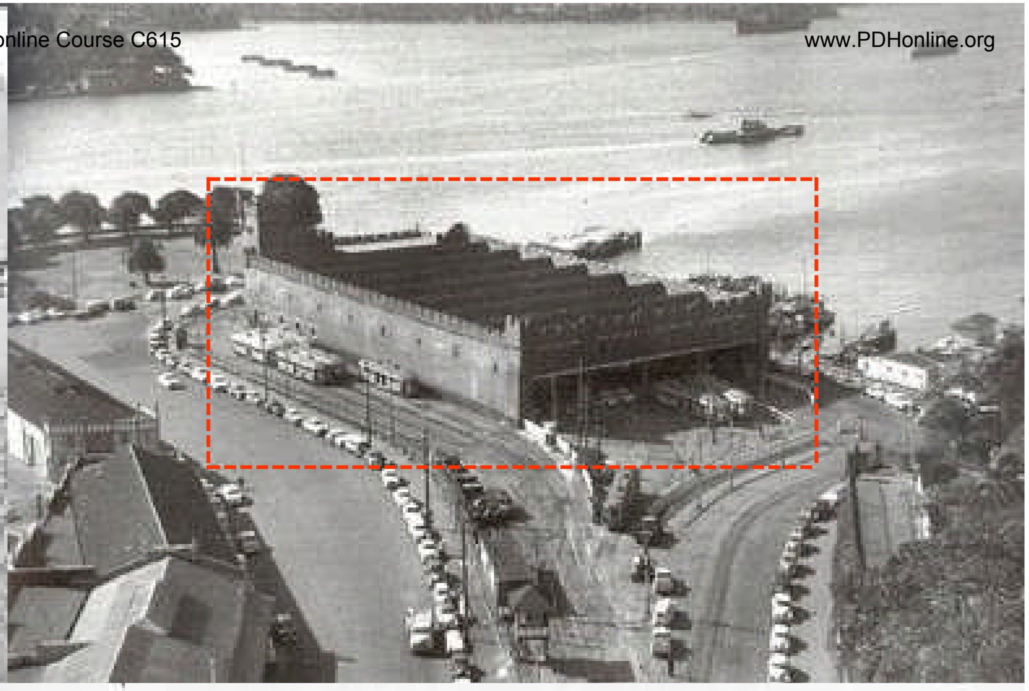
<u>Top Left</u>: Fort Macquarie, Sydney (ca. 1870)
<u>Top Right</u>: Fort Macquarie, Sydney (1900)
<u>Left</u>: model of Fort Macquarie

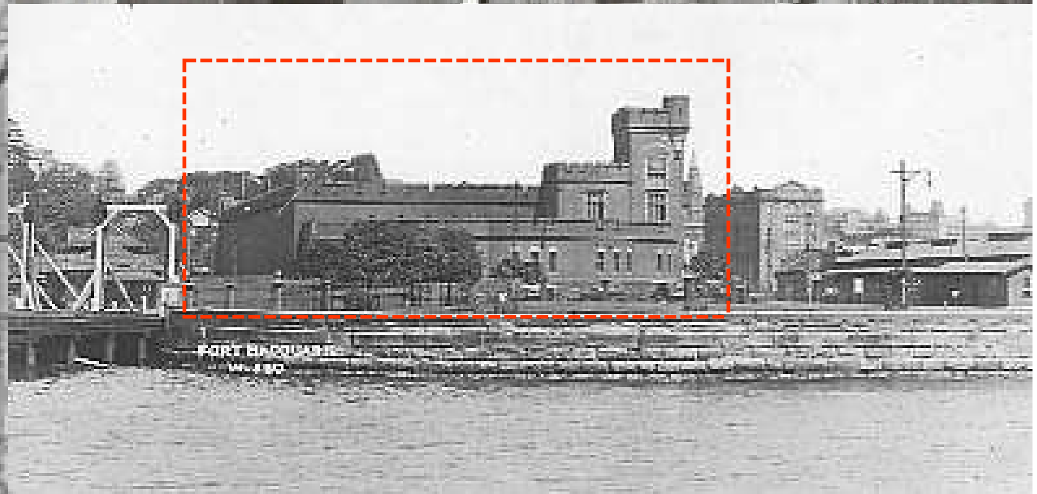
Fort Macquarie Tram Depot **featured red brick and sandstone crenellated towers, parapets and convex bay walls as disguise for its sawtooth roof which was a stone's throw from *Government House*. The phase-out of Sydney's tram service in the post-war years led to the closure of the depot in October 1955. Three years later, it too would be demolished to make room for the SOH.**



<u>Left</u>: *Circular Quay* (a.k.a. *Farm Cove* at left), Bennelong Point/Fort Macquarie Tram Depot and Sydney Cove (right) (1929)

<u>Above</u>: (left to right) Circular Quay, Bennelong Point/Fort Macquarie Tram Depot and Sydney Cove (ca. 1939)





Left: City of Sydney Tram Map (ca. 1925)
Above: Fort Macquarie Tram Depot (aerial view at top, view from harbor below) 28

Flash of Genius

“First you will see the Opera House, then you will see the Bridge!
Eugene Goossens

One day, while strolling along the shoreline of *Farm Cove*, Resident Conductor of the *Sydney Symphony Orchestra* (SSO) and Director of the *New South Wales Conservatorium of Music, Eugene Goossens* (1893-1962) had a "Flash of Genius." He was looking towards the Harbor Bridge and the tram depot when the thought came to his mind what a splendid site Bennelong Point would make for a world-class Opera House. He envisioned a gleaming structure with a vast interior space occupying the whole of the peninsula. In 1955, Goossens (left) was appointed to a committee of five to advise the NSW government on the feasibility and location of an Opera House for Sydney.

"It would be hubristic for any architect to expect a more spectacular site. Bennelong Point in Australia's Sydney Harbor is almost encircled by water. There is a green parkland behind it, and to the west new skyscrapers and the arching, spidery profile of Harbor Bridge. Any structure built on the point would be thrust forward in a vast parenthesis of sea and air, displayed like sculpture on a plinth, and visible from almost every angle of the harbor. It would not be part of a street – not, therefore, 'façade' architecture…"

***Time* magazine, October 8th 1973**

"Imagine visitors on a liner coming up Sydney Harbour, seeing this magnificent building and being told 'That is Sydney's opera house'…There is no other place to equal this. The Opera House must be built on Bennelong Point!"

Eugene Goossens

<u>Left</u>: satellite view of Sydney Harbor (Darling Harbor at center)
<u>Top</u>: view of the "Gulf of Sydney" (SOH at center)

"It's absolutely breathtaking. There's no opera site in the world to compare with it…"
Jorn Utzon, Architect

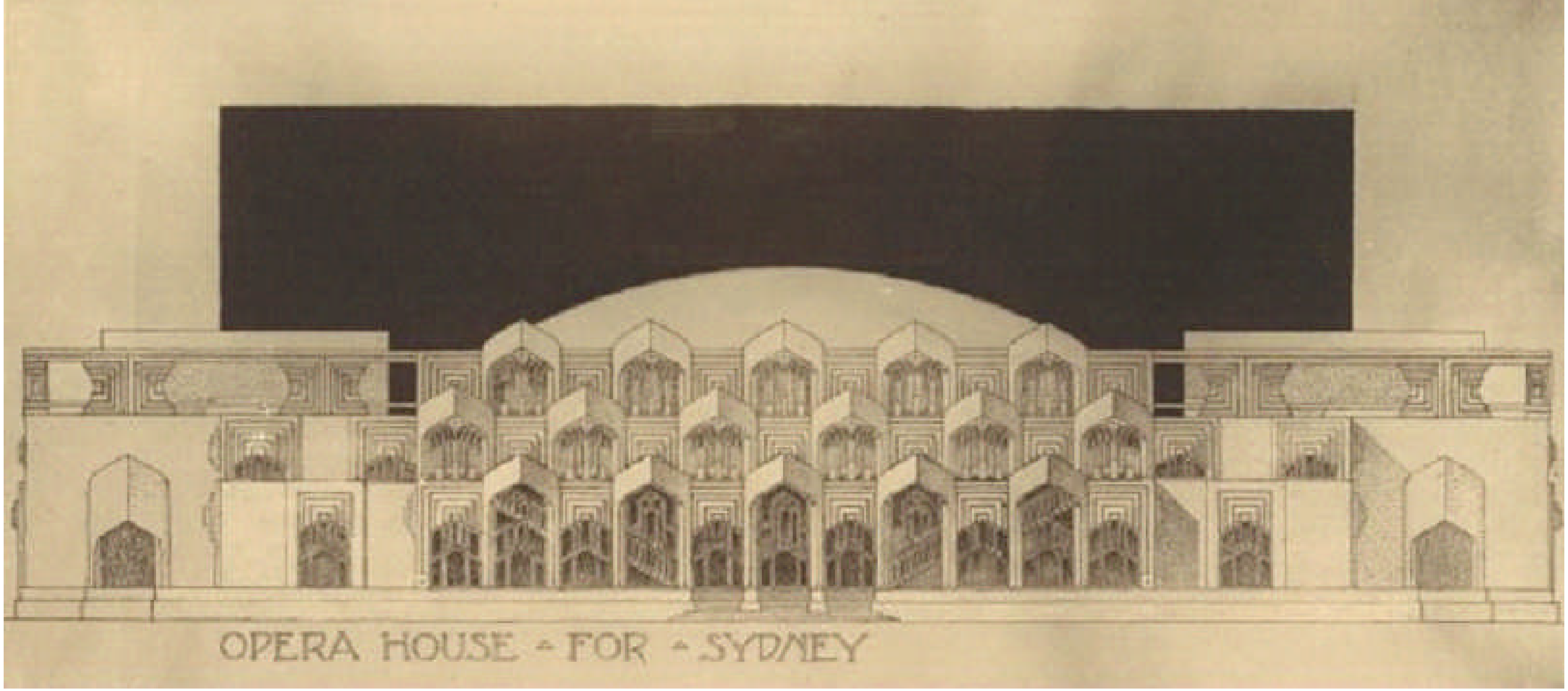
Part 2

The Competition

There, That'll Show You

"The fact that Australia is not a great world center of culture is – while geographically understandable – a source of acute embarrassment to an Australian society that is increasingly dynamic and on the make. Australians have thought to <u>do</u> something about it and so, a dozen years ago, the people of Sydney decided that they wanted to build a proper opera house that would serve as a center for music and the performing arts. What they had in mind then was something fairly modest – a structure that would be both handsome and tasteful, cost a few million dollars, and allow Australians to hold their heads up high among such look-down-the-nose nations as England – especially England. 'There, that'll show you,' they would be able to say. 'There's more to us than just kangaroos and billabongs…'"

Life **Magazine, January 6th 1967**



Front Elevation of a proposed Opera House for Sydney (ca. 1935) by *Walter Burley Griffin* (1876–1937)

***Charles Moses*, General Manager of the *Australian Broadcasting Commission* (ABC) introduced Eugene Goossens, to *Joseph Cahill*, Premier of *New South Wales* (NSW) in 1954. The meeting was decisive and affirmed the belief that Australia's economic center; Sydney, needed a proper Opera House in order to give the people of Sydney/NSW an opportunity to enjoy the performing arts in a way not previously available "Down Under." Sydney's large population of European immigrants would no doubt appreciate the gesture. Charles Moses and the symphony orchestra's first conductor; *Bernard Heinze,* were also enthusiastic about the conceptual idea of a National Opera House. Established by the ABC in 1946, both Moses and Heinze believed that the SSO needed a larger space in which to perform. To further the idea along, in 1954 the Architecture faculty at the *University of New South Wales* commissioned graduate students to design an Opera House for their native Sydney. Having previously formed a Committee and with Bennelong Point selected as a site (from a range of twenty-one locations), on December 7th 1955, Premier Cahill announced an international design competition for a National Opera House.**

<u>Above</u>: Sir Charles Moses, ABC General Manager
<u>Left</u>: The Honorable Joseph J. Cahill, New South Wales Premier and Treasurer (1952-1959)

"Goossens and Cahill saw eye to eye with the ideas that music should not be an elitist form of entertainment and should be accessible to everyone"
Philip Drew, Architectural Historian

"…It began innocently enough back in 1954 when the late Sir Eugene Goossens, then conductor of the Sydney symphony, felt that the orchestra should have a permanent home. He found receptive ears within a Labor government which was anxious not only to improve Australia's image internationally but also to demonstrate to the folks at home that the party of the common man was not bereft of cultural sensibilities. A site was selected on Bennelong Point, a narrow spit of land jutting into the harbor, an opera house committee was established and in 1956 a prize of more than $10,000 was offered for the best design in international competition…"

***Life* Magazine, January 6th 1967**

RE: knighted in 1955, *Sir Eugene Goossens* arrived in Sydney (after completing a tour of European concert halls) on March 9th 1956 and was promptly arrested for possession of 1,100 "indecent items" (pornographic materials). Humiliated, he was forced to resign his post/s and left the country for good two weeks later. Goossens was the SOH's great champion and loss of his extensive knowledge of Concert/Opera House design and the competition brief requirements would be a step backwards not easily reconciled. Goossens died in 1962.

Prior to the Opera House, the SSO venue was *Sydney Town Hall* (1883). Though it was acoustically adequate, it was in all other ways inadequate for the nation's premier orchestra. Concert-goers were forced to wear their hats and gloves in winter since the building was essentially unheatable. Refreshments were not served forcing the audience to venture outside the building at intermission/s. Sydney was competing with *Melbourne* for cultural status (particularly since Melbourne was hosting the 1956 Olympic Games) and Goossens was determined to use the SSO and the new Opera House to reverse Sydney's "backwater" status/reputation.

Charles Moses had lured Eugene Goossens away from the *Cincinnati Symphony Orchestra* with a promise to match the salary he was earning in America. To this end, Moses appointed Goossens director of the NSW Conservatorium of Music which is located in the *Botanical Gardens* overlooking Bennelong Point. Though the *National Theatre Movement of Australia* had preceded Goossens (in the 1940s) on recognizing Bennelong Point as the most desirable location for a performing arts venue, it was Goosens who would be the driving force in making the choice of Bennelong Point a reality by the time of the international competition in 1956. Goosens had arrived in Sydney in July 1947 to assume his new position/s. At that time, he described to *The Sydney Morning Herald* his desire to elevate the SSO to world-class status and his plans to create a concert hall with as near-to-perfect acoustics as was humanly possible with seating capacity for 3,500 persons. He also outlined his supplemental plans for a chamber music hall and a home for an opera company. The 1954 meeting with Cahill proved pivotal resulting in the formation of a four-man committee consisting of Goossens, Moses, *H. Ingham Ashworth* - Professor of Architecture at the *University of Sydney,* and *Stan Havilland* – under-secretary at the *Department of Local Government.* Goossens' model was the *San Francisco Opera House* which provided (in an all-purpose building) venues for orchestra, opera, ballet and choral festivals. Goossens' arrival on the Sydney scene had revitalized interest in concert performances with a more than doubling of the demand for SSO tickets (forcing repeat performances). Goossens reasoned that a larger hall accommodating larger audiences would mitigate the need for repeat performances while freeing the SSO to support an opera program.

"At orchestra and choral concerts 3,500 to 4,000 can listen adequately and comfortably. Grand opera is best presented to audiences of 1,800 to 2,500, though theatres in Milan and elsewhere have larger audiences. In my own former town of Cincinnati, operatic performances are given in buildings accommodating 3,800 patrons. The effective presentation of drama involves much smaller audiences; 1,500 to 1,800…The right approach would be to envisage an auditorium large enough to seat from 3,500 to 4,000 people and to make the auditorium adaptable, by simple mechanism, for opera, for drama and other users, for which a smaller auditorium is desirable"

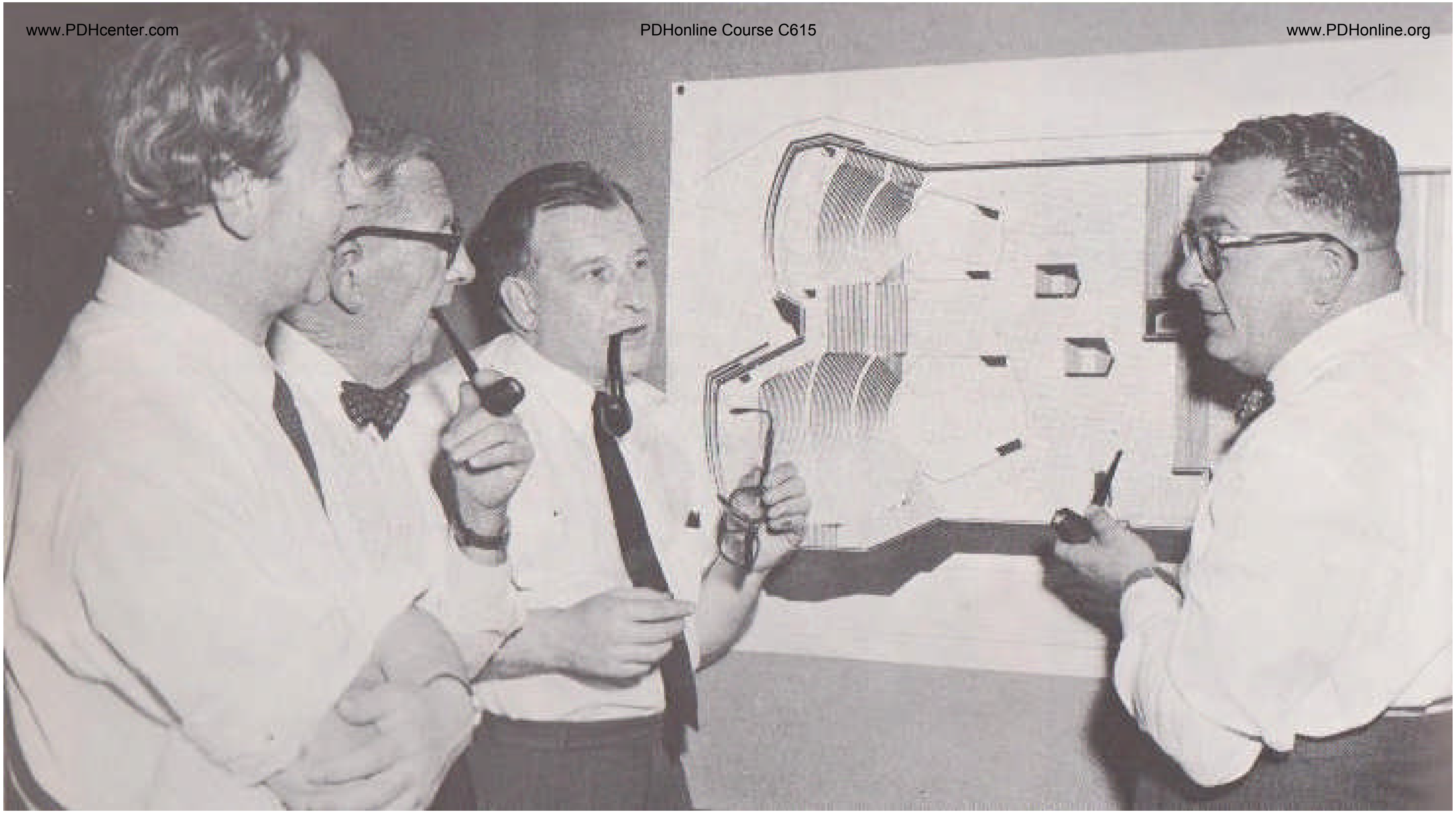
Eugene Goossens

RE: aside from the multi-purpose *San Francisco Opera House*, Goossens much admired the *Malmo Opera House* in Sweden. With a capacity of 1,800, it could be readily converted into a theater with 1,200 seats or a hall for recitals with 800 seats via "traveling" (movable) walls.

The Four Assessors

"…This, in the minds of the competition judges who were deciding back in early 1957 on the design for a new Opera House, must have ruled against the pat solution of an International Style box. But nobody in the Architectural profession, in or out of Australia, could have predicted what the judges selected from the 233 entries that had been submitted from 32 countries…"

Time **magazine, October 8th 1973**



“The Four Assessors” (Competition Judges); *Eero Saarinen,* Prominent Architect (center), *Dr. Cobden Parkes,* NSW Government Architect (far left), *Sir Leslie Martin*, Chief Architect of the *London County Council* (second from left) and *Professor H. Ingham Ashworth* (right) discussing Jorn Utzon’s winning design.

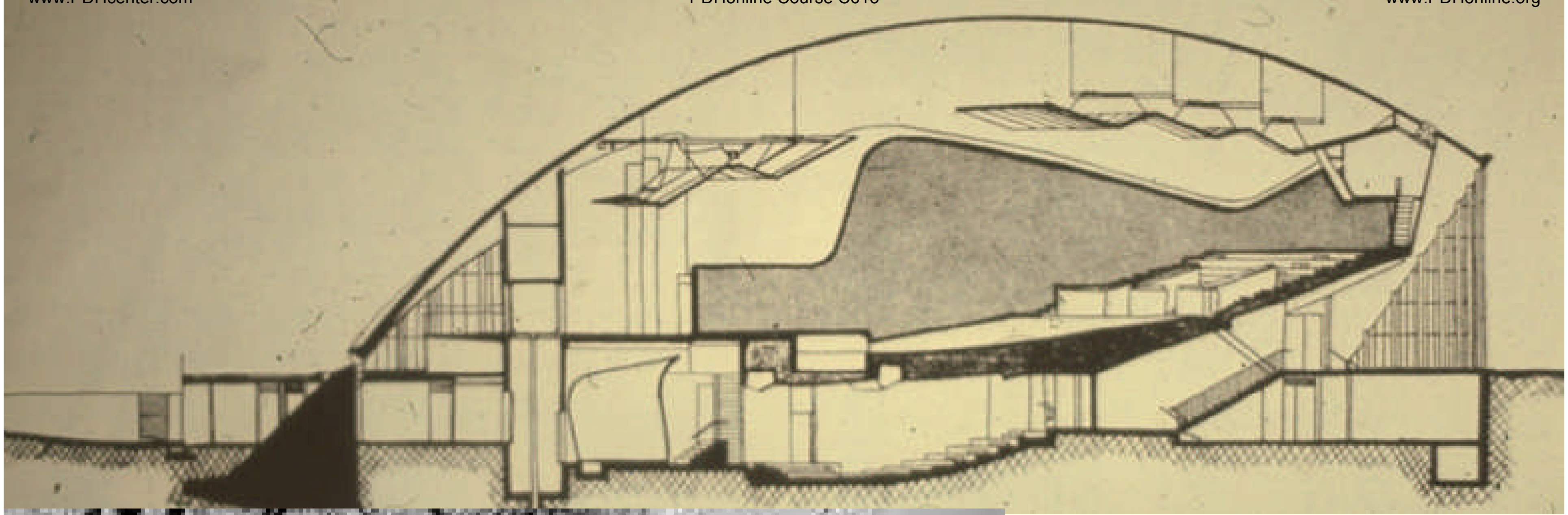
Where the Trouble Began

"…That is really where the trouble began. When the late Eero Saarinen turned up four days behind schedule to help judge the contest, the American architect and designer, whose exuberant innovations in building forms had been widely acclaimed, discovered that the other three judges had already winnowed the 222 entries down to just 10. Saarinen looked them over, yawned inwardly, then went prowling through the discards stacked in a corner. There among the rejects, tossed out because it was too outrageous, Saarinen turned up a startling, free-form design that looked nothing so much as a cluster of great white sails tacking down the harbor. This, Saarinen announced, was it – and Saarinen's prestige and enthusiasm finally won over the rest of the board…"

***Life* Magazine, January 6th 1967**

First Among Equals

From the get-go, the competition was controversial. There was no doubting that an architectural competition should be held, but its scope was a sticking point. The NSW Chapter of the *Royal Australian Institute of Architects* (RAIA) not surprisingly suggested that the competition be open to Australian nationals only. However, the *Sydney Opera House Executive Committee* (SOHEC) overruled the RAIA making the competition international in scope with the hope that "magnificent, lonely ideas" would get a public airing. As well, the identities of the contestants would not be revealed to the judges. Saarinen was clearly "First Among Equals" having attained the status of one of the world's great architects with his designs for *Kresge Auditorium* (MIT) and the *TWA Terminal* at New York's *Idlewild Airport* (now JFK International Airport). Saarinen was partial to thin concrete roof structures such as that of the TWA Terminal (which he was working on at the time of the competition).



<u>Left</u>: Kresge Auditorium (MIT campus) by Eero Saarinen (1955)
<u>Above</u>: cross-sectional view


TWA

Extravagance Cannot Be Entertained

The competition program and guidelines for "A National Opera House at Bennelong Point" was released on February 15th 1956. An entry fee of ten *Australian Pounds* was required to register for the competition whereby the applicant would receive the "Brown Book" (formal competition brief). The winner of the competition would receive $A5K, $A2K and $A1K for the second and third prize winners respectively. The detailed brief outlined a program for the building inclusive of two halls; one to seat 3K to 3,500 people and the other 1,200. The function/s of each hall were described in their order of priority:

Large Hall;

1) Symphony concerts (including organ music and solo recitals)
2) Large scale opera
3) Ballet and dance performances
4) Choral concerts
5) Pageants and mass meetings

Small Hall;

1) Dramatic presentations
2) Intimate opera
3) Chamber music
4) Concerts and recitals
5) Lectures

Furthermore, the brief stated that, although the winning scheme would most likely be built with changes, the judges were primarily looking for "A Sound Basic Scheme by a competent architect." Costs were not discussed save for the statement: "Extravagance cannot be entertained."

"There's nothing to it. The shells might be about three-inches at the top and, say twelve-inches thick at the base"

Eero Saarinen, Competition Assessor

RE: Saarinen's advice to the Quantity Surveyor from the Sydney firm of *Rider Hunt and Partners* concerning how to "cost" the sails (shells) of Utzon's schematic design. Since Saarinen had experience with shell structures and there was nothing similar to compare it to in Australia, the Quantity Surveyor established an initial estimated cost for Utzon's design of 3.6 million Australian Pounds (AP) or $A7 million (Australian Dollars) and noted it was the most economical design of the three contest finalists (the second and third prize initial estimates were $A10.8 and $A15.6 million). The final cost of SOH (in 1973) was $A102 million; more than fourteen-times the original estimate.

"…It was all heady stuff indeed. For icing on the cake, the first rough estimates seem to indicate that, of the three finalists, Utzon's design would be the cheapest to build. For a total outlay of about $7.5 million, these early figures promised, Sydney would have a 'major' hall seating 2,800 for its symphony orchestra and the opera company, a 'minor' hall with 1,200 seats, a still more intimate room for chamber music, as well as rehearsal rooms, a restaurant, an experimental theater and some of the most elaborate stage machinery anywhere…"

***Life* Magazine, January 6th 1967**

Utzon’s Victory

The competition was internationally advertised in December 1955 with the deadline for registration set for March 15th 1956 and submissions required by December 3rd 1956. Jorn Utzon's design was numbered "218" - one of the last of over 220 entries received from 28 countries around the world (722 interested parties had requested the Brown Book). March 1956 saw the departure of Goossens but Cahill's Labor government was re-elected – a good omen for the Opera House project. A few weeks later, architect Jorn Utzon celebrated his 38th birthday in Denmark and set to work on his design for the competition. Utzon had been in partnership with *Eric Andersson* (since 1952) and they initially collaborated on the project. Later, Utzon emerged as primary author of the design and it was submitted in his name exclusively. Competition judging began on Monday, December 7th. Saarinen arrived four days later by which time his colleagues had, between them, narrowed down the field of over two-hundred submissions to just ten. *Cesar Pelli* (at the time a young Saarinen associate working on the TWA building) recalled that he had no doubt that the similar aesthetics between Saarinen's shell design for the TWA Terminal and Utzon's shells for SOH resonated strongly with Saarinen. Sir Leslie Martin (designer of London's *Royal Festival Hall*) was also enthusiastic about Utzon's design while the other two judges deferred to their more distinguished peers' decision.

"I was surprised that I could only find twenty-five or so designs. That leaves around two-hundred entries for which we have no record…While Australian architects submitted sixty-one schemes, the bulk of the remainder came in the form of fifty-one entries from the UK, twenty-four from the USA and twenty-three from Germany. Entries were submitted from as far as French Morocco, Japan and Israel."

Anne Watson, Author


The Sydney Morning Herald.

DANE'S CONTROVERSIAL DESIGN WINS OPERA HOUSE CONTEST

Joern Utzon, 38, of Hellebaek, Denmark, has won the £5,000 first prize in a world-wide contest for a design for a National Opera House to be built at Bennelong Point.

PHONE TALK TO WINNER

"CHEAPEST TO BUILD"

Rocket Range Talks Started

Boy Drowns After 25ft Fall In Pool

QLD. STUDY OF PETROL PRICE ORDERED

LATE NEWS

New Liner On Proving Flight

Fire, Flood Threats

Six Players In Team For Tennis Tour

On Other Pages

On Tuesday, January 29th 1957, Premier Cahill announced the winning design at *The National Art Gallery* as "218" and (at the request of Stan Havilland) reached back into the envelope to read out the name of the winning competitor; *Jorn Utzon*, from *Hellebaek, Denmark*.

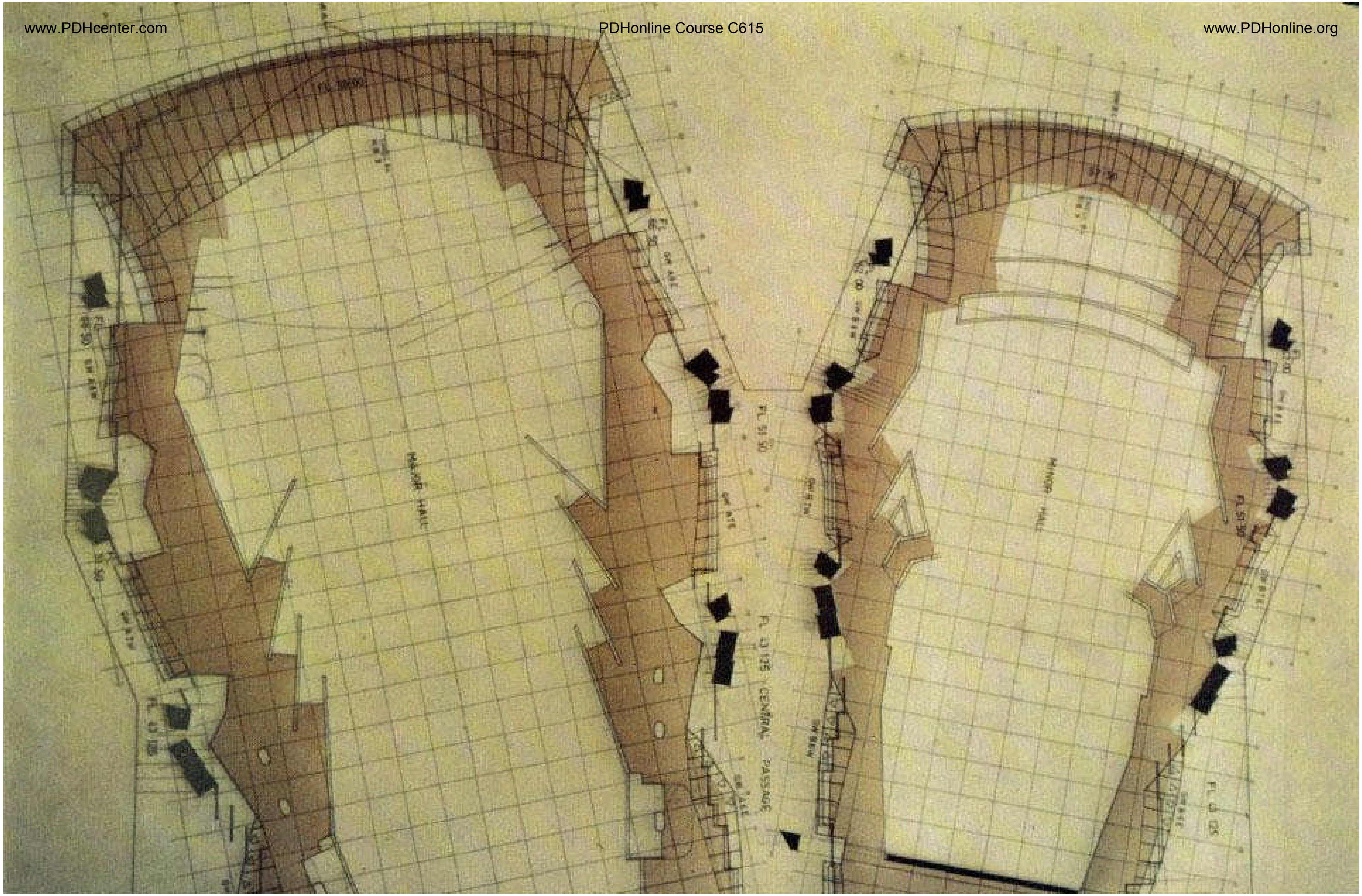
<u>Left</u>: the Wednesday, January 30th 1957 front page of *The Sydney Morning Herald* (note the "Cheapest to Build" byline)

"…It was a rough, schematic set of plans and elevations that showed a flowering of concrete shells, like sails or beaks, rising to a height of more than 200-feet above a horizontal platform. There was only the sketchiest indication of function. The architect, an almost unknown 38 year-old Dane named Jorn Utzon, had worked none of that out; he did not, as he later remarked, expect to win. Utzon's victory, it is believed, was largely due to one of the judges, the late Eero Saarinen, whose own fondness for shell construction had been embodied a year before in his design for the TWA terminal at Kennedy Airport…"

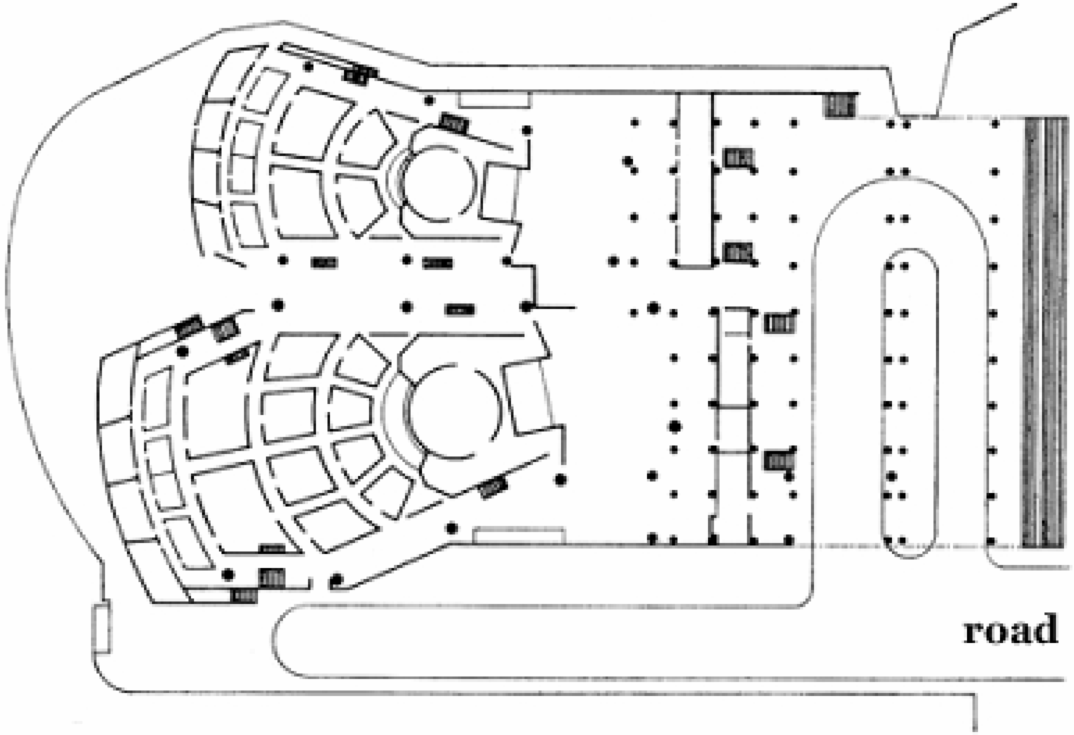
Time **magazine, October 8th 1973**

Nothing More Than a Magnificent Doodle

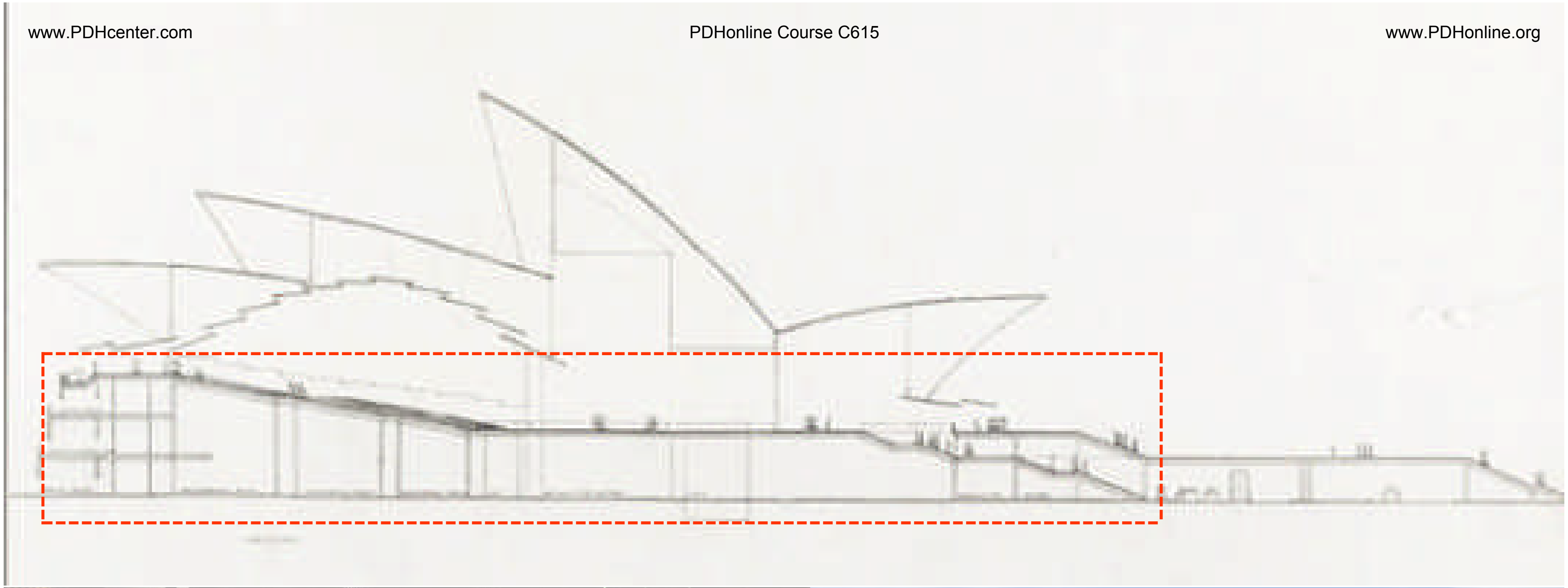
Had the judges adhered to their own set of rules as outlined in the Brown Book, Utzon's design for the Sydney Opera House would have been disqualified as non-compliant. The required drawings were not included. Rather, he submitted enlarged sketches with no perspective drawing. Australian art/architecture critic *Robert Hughes* referred to Utzon's design as: *"nothing more than a magnificent doodle."* The site requirements stated: *"the building may be located anywhere on the site, but should not be placed right on the boundary,"* and an entry would be disqualified if: *"it exceeds the limit of the site as outlined on the site plan."* Utzon's design violated this criteria on the western boundary. Also (per Goossens recommendation), the brief required 3K to 3,500 seats in the large hall. Even when the requirement was later reduced to 2,800 seats, Utzon's design could not meet the requirement. The stretching/ignoring of the competition rules was not well-received by the other competitors.

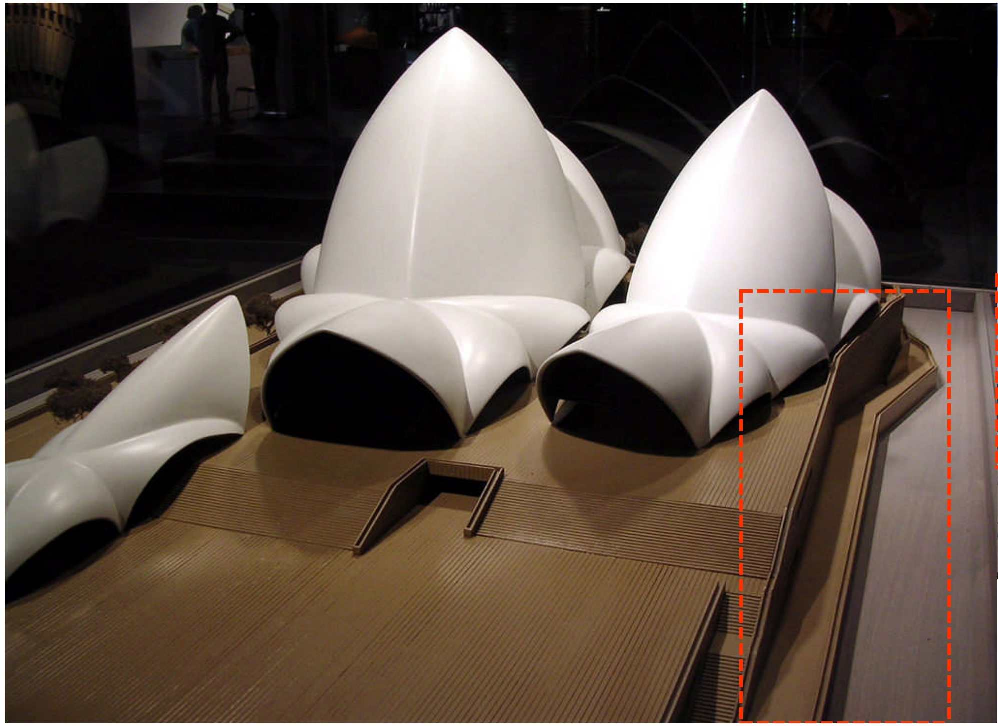


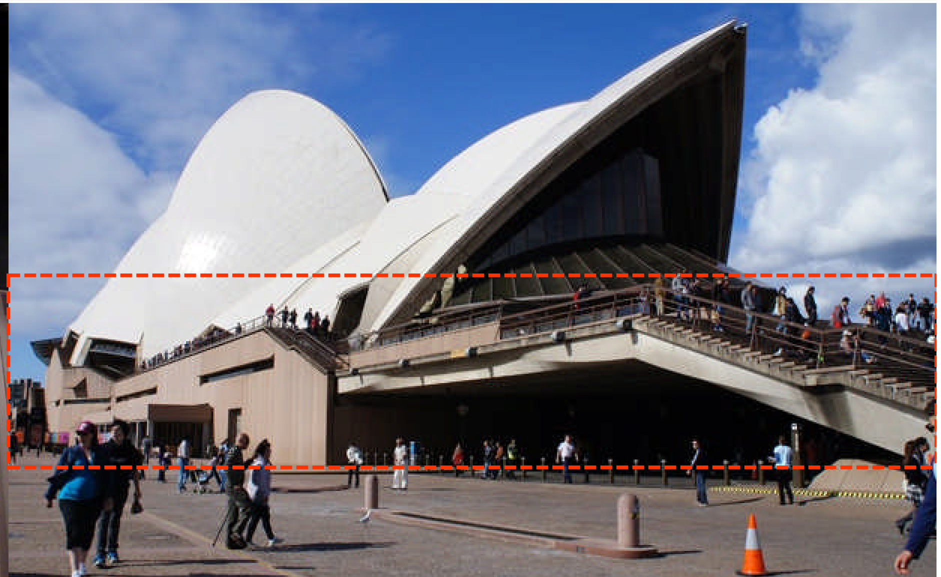
Major Hall Plan (left), Minor Hall Plan (right)



Most competition designs placed the two halls (minor and major) back-to-back so that their *Fly Towers* adjoined. This configuration had the significant disadvantage whereby the two hall auditoria foyers were at opposite ends of Bennelong Point. Utzon's breakthrough idea was to place the halls side-by-side (left) so that the entrances would be at the same end 9north). He placed the hall entrance/s at the far (seaward) end and provided circulatory galleries (right) around the sides. This helped to mitigate what he felt was aesthetically undesirable; to have the bulk of the structure (the Fly Towers) at the terminal end of the peninsula.





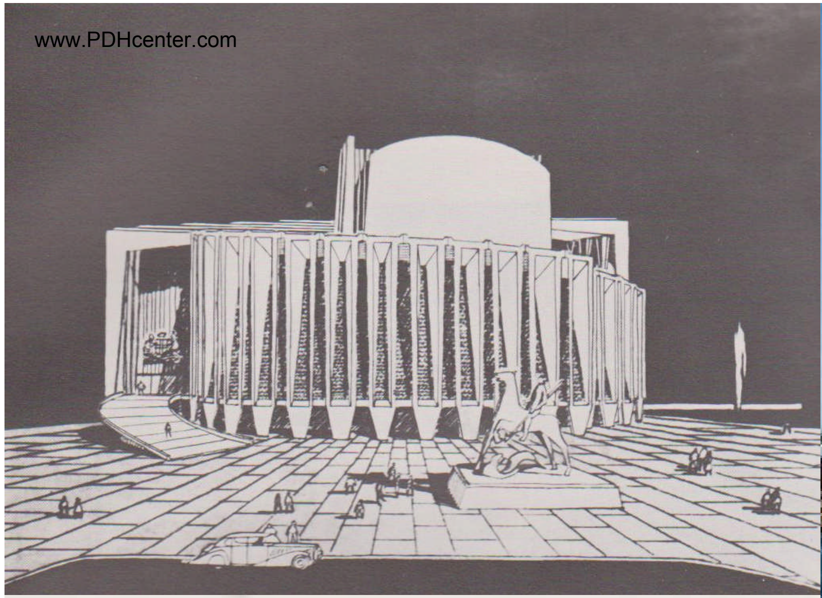


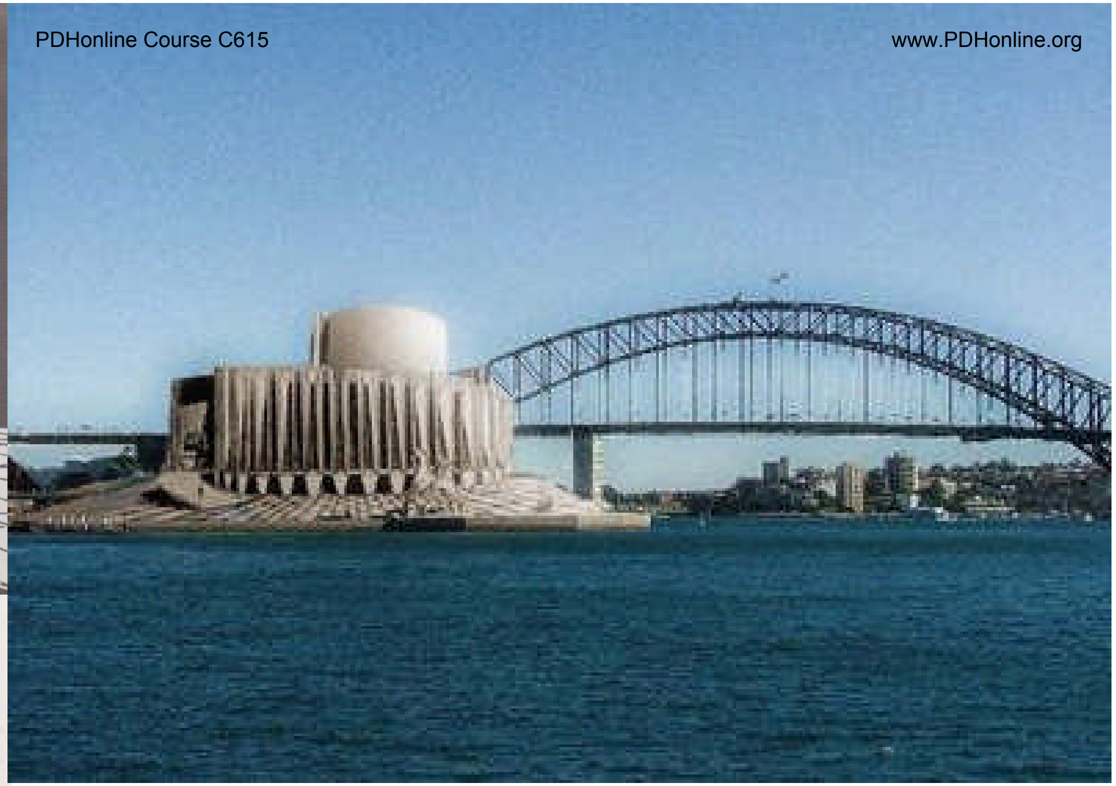
One of the Great Buildings of the World

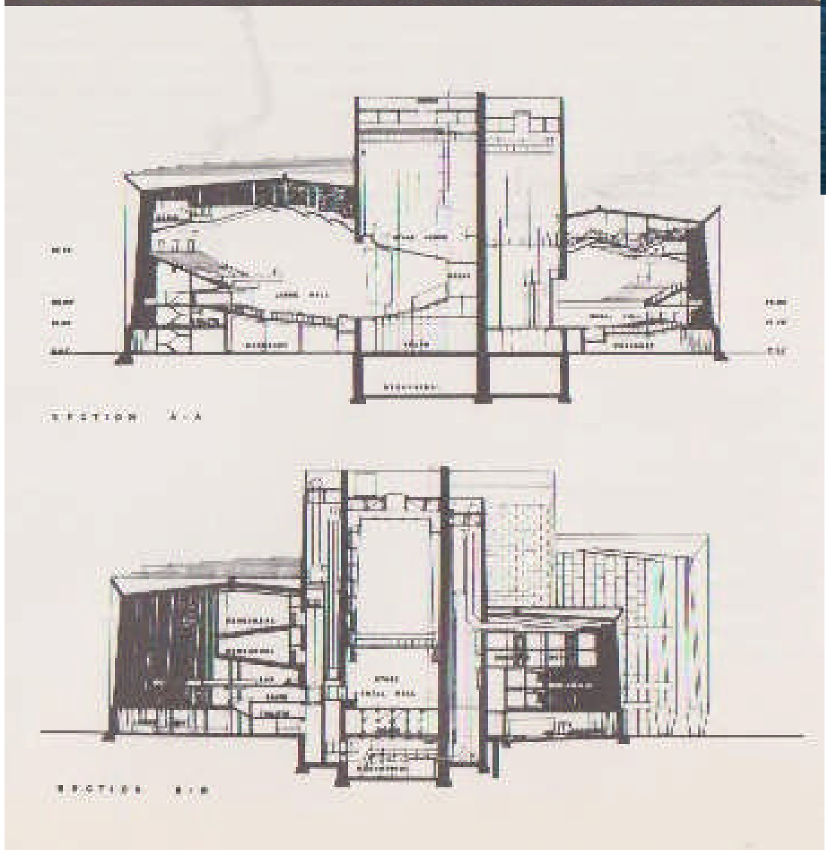
"We consider this scheme to be the most original and creative submission...The white sail-like forms of the shell vaults relate as naturally to the harbour as the sails of its yachts…The drawings submitted for this scheme are simple to the point of being diagrammatic. Nevertheless, as we have returned again and again to the study of these drawings and are convinced that they present a concept of an Opera House which is capable of becoming one of the great buildings of the world…Because of its originality, it is clearly a controversial design. We are however, absolutely convinced of its merits"

Assessor's Report

"I was surprised there were not more schemes of a more advanced character in terms of architectural thinking. I imagined we'd be spoilt for choice with half-a-dozen outstanding designs, instead there was only one."
Professor H. Ingham Ashworth, Competition Assessor



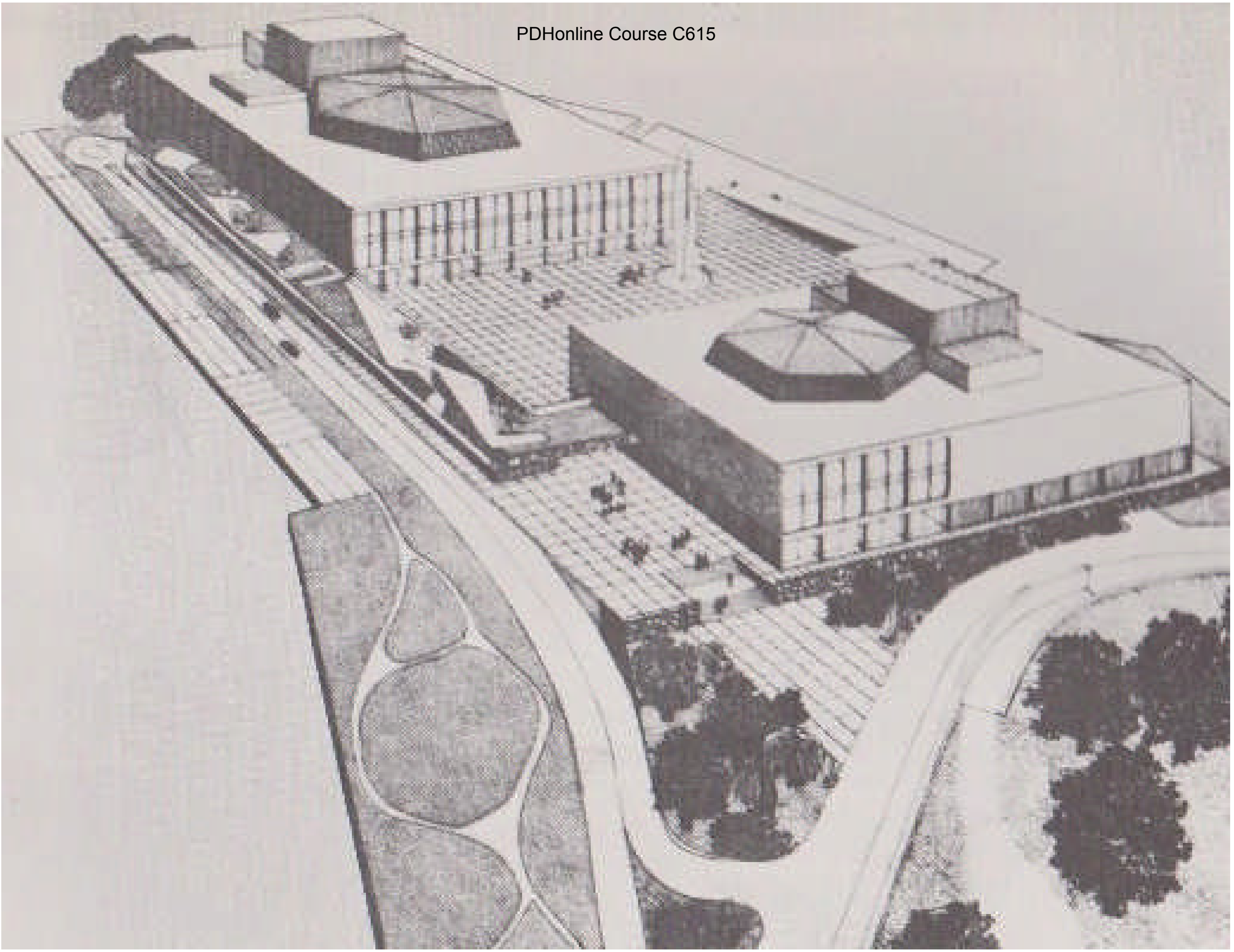




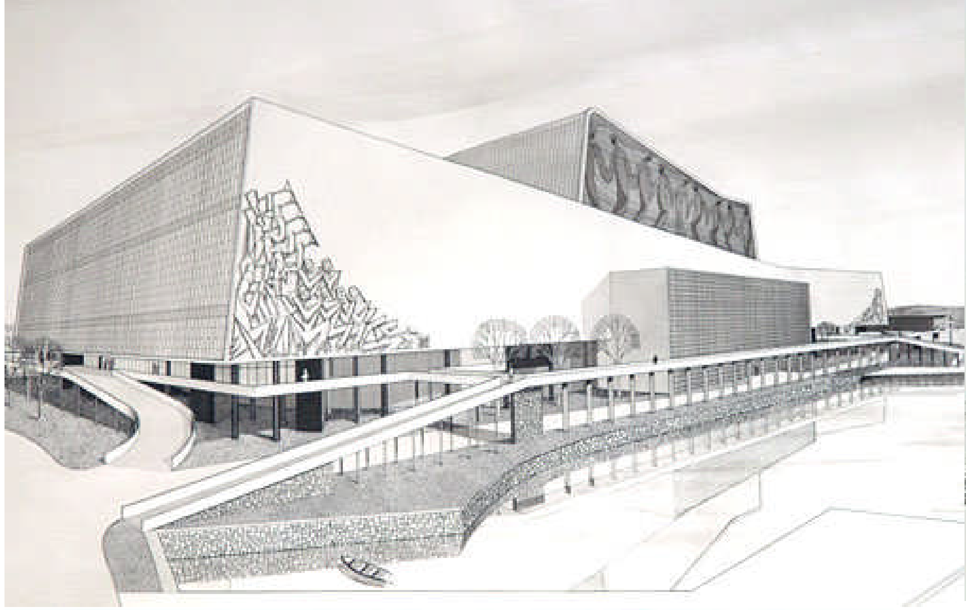
Perspective/s (top left/right) and section/s (left) of a Nautilus shell-inspired spiral design for the SOH design competition which won Second Prize. It was submitted by an American Group from Philadelphia (led by *J. Marzella*). It featured stages in the middle with auditoriums, cafes and galleries wrapped around.

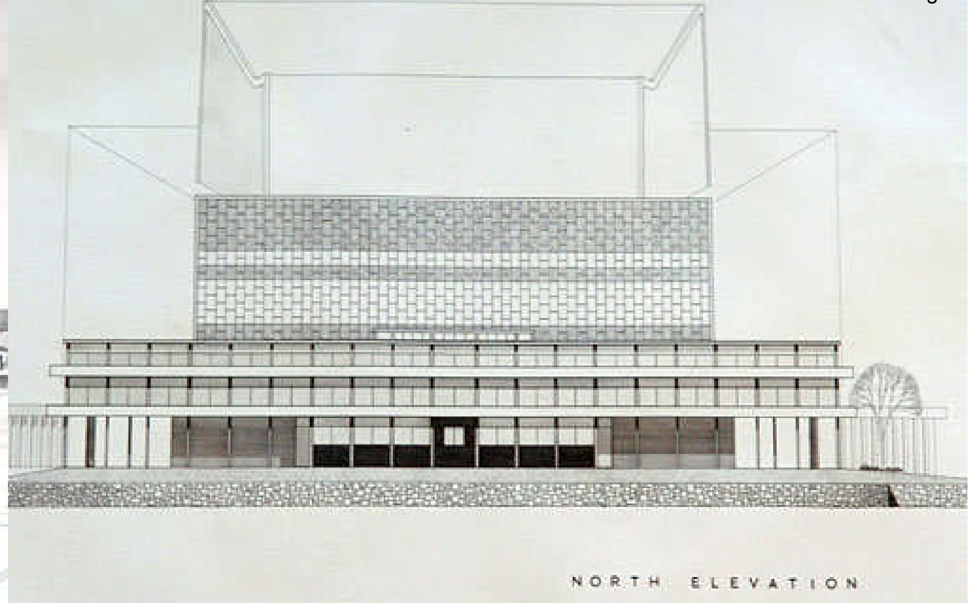
"We almost won. But we didn't. Why? Because Jorn Utzon's design was a masterpiece."

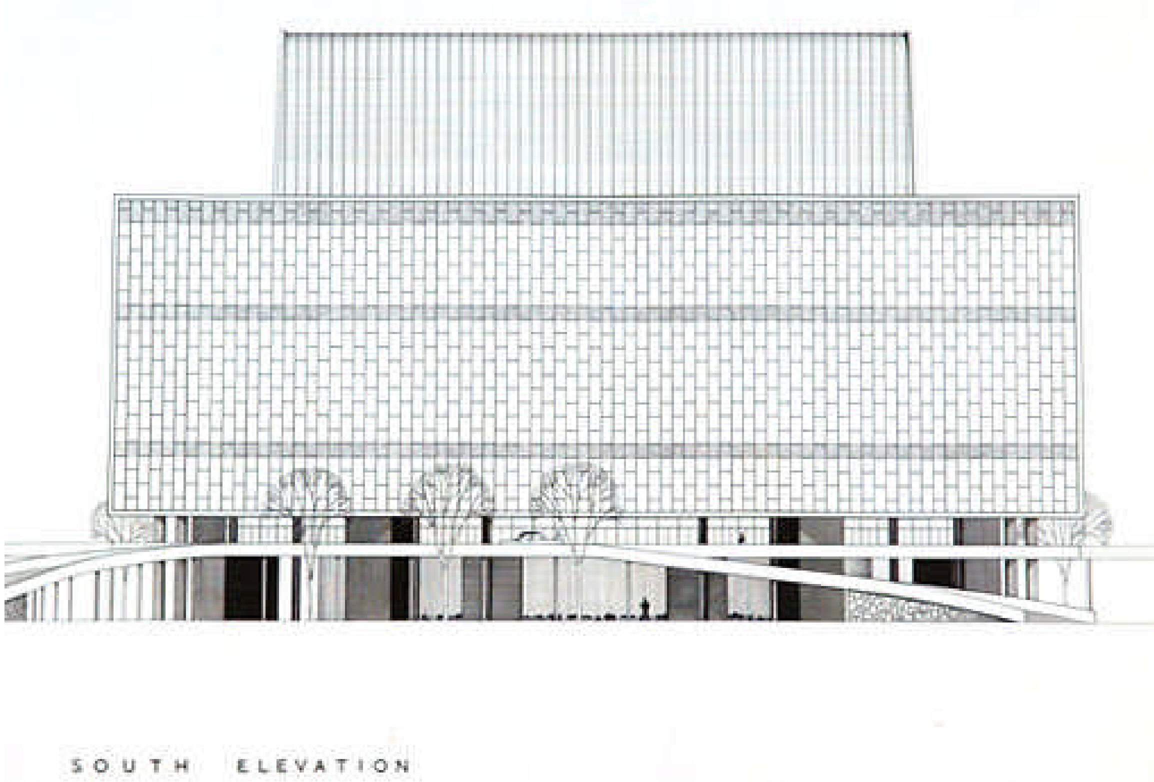
Robert Geddes, member of the Philadelphia group which won second prize in the 1957 SOH design competition



Perspective drawing of a rectangular design for the SOH design competition (submitted by the English firm *Boissevain and Osmond*) which won *Third Prize.* The conventional design featured two buildings (lengthwise to the site) separated by a courtyard.





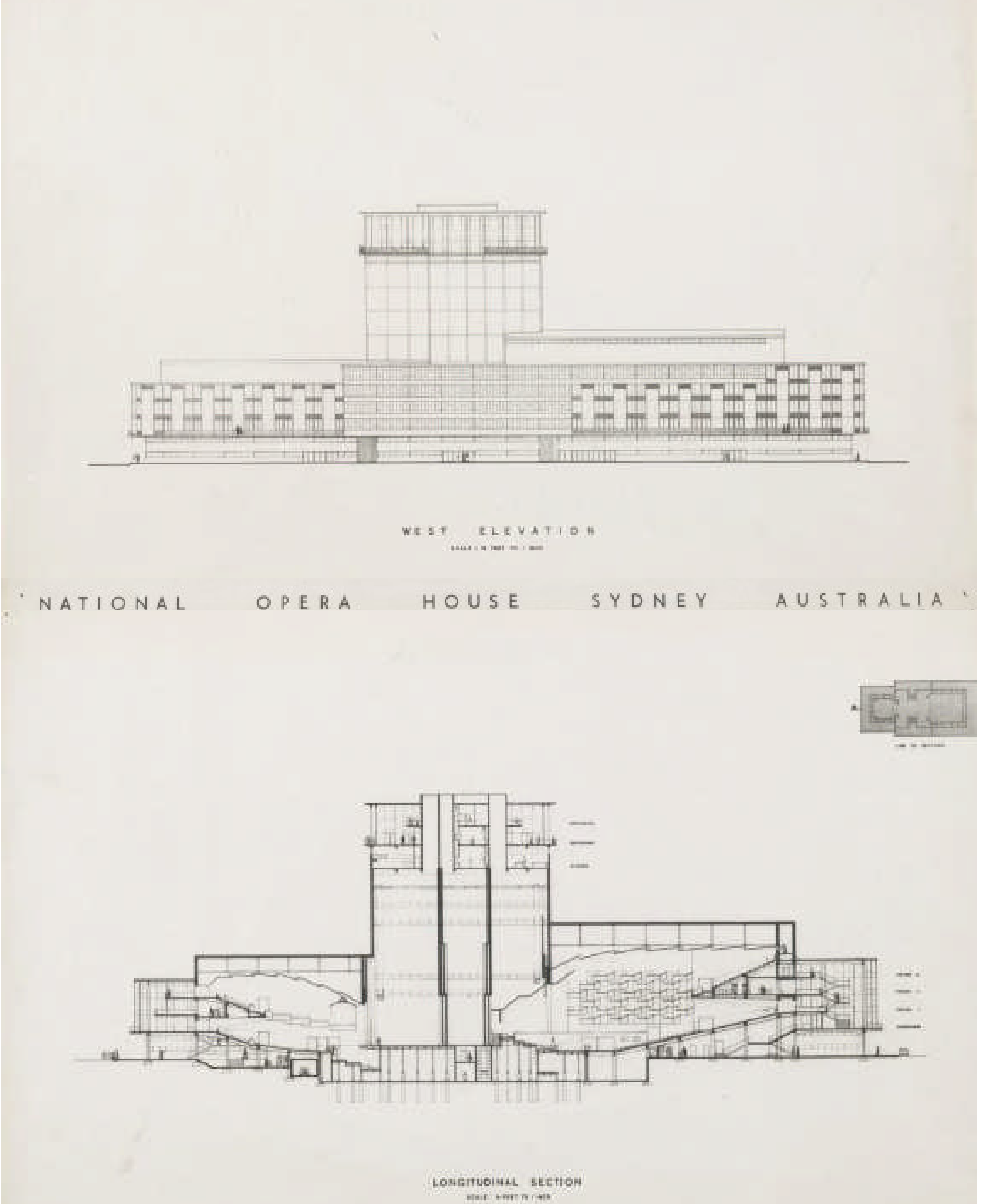


Perspective view (top left), North Elevation (top right) and South Elevation (lower left) of *Anatol Kagan's* design competition entry for the SOH

Theater designer *Bill Constable's* watercolor perspective of an Opera House on Bennelong Point (based on Eugene Goossens' dramatic vision for the building). Though it was not actually submitted during the 1957 competition, the design featured an outdoor "Music Bowl" (not very practical given Sydney's notorious variable winds and the considerable noise generated by harbor traffic/activities).

"Masterpiece! Of course, originally it was an entry for the Opera House competition"

RE: cartoon drawn by *George Molnar* (1910–1998)



George Molnar's entry for the SOH design competition;
<u>Top</u>: West Elevation
<u>Bottom</u>: Longitudinal Section

Fatally Flawed

"It was a brilliant conception, but fatally flawed"

Paul Boissevain, Principal – *Boissevain and Osmond*, Architects

RE: opinion of the Third Prize winner in the international SOH competition. The English firm had experience with concert halls prior to the competition. For six months, Boissevain and his wife/partner *Barbara Osmond* worked with acousticians and theater consultants in order to produce their conservative but highly functional competition design entry. Upon seeing Utzon's plan for the first time prophetically, Boissevain immediately recognized the problem would be fitting all the brief/program required into the beautiful but unorthodox conceptual design.

Architecture is a Language

"Architecture is a language and architect's speak it. Most of them just barely manage to speak – very few ever speak eloquent prose, but it happens rarely indeed that any of them ever create poetry with just a few words…One of the unique characteristics of Utzon's design was that unlike most of the other entries into the Sydney Opera House design competition, is that he arranged both performance halls side by side so both could be entered from the city side of the Bennelong Point site "

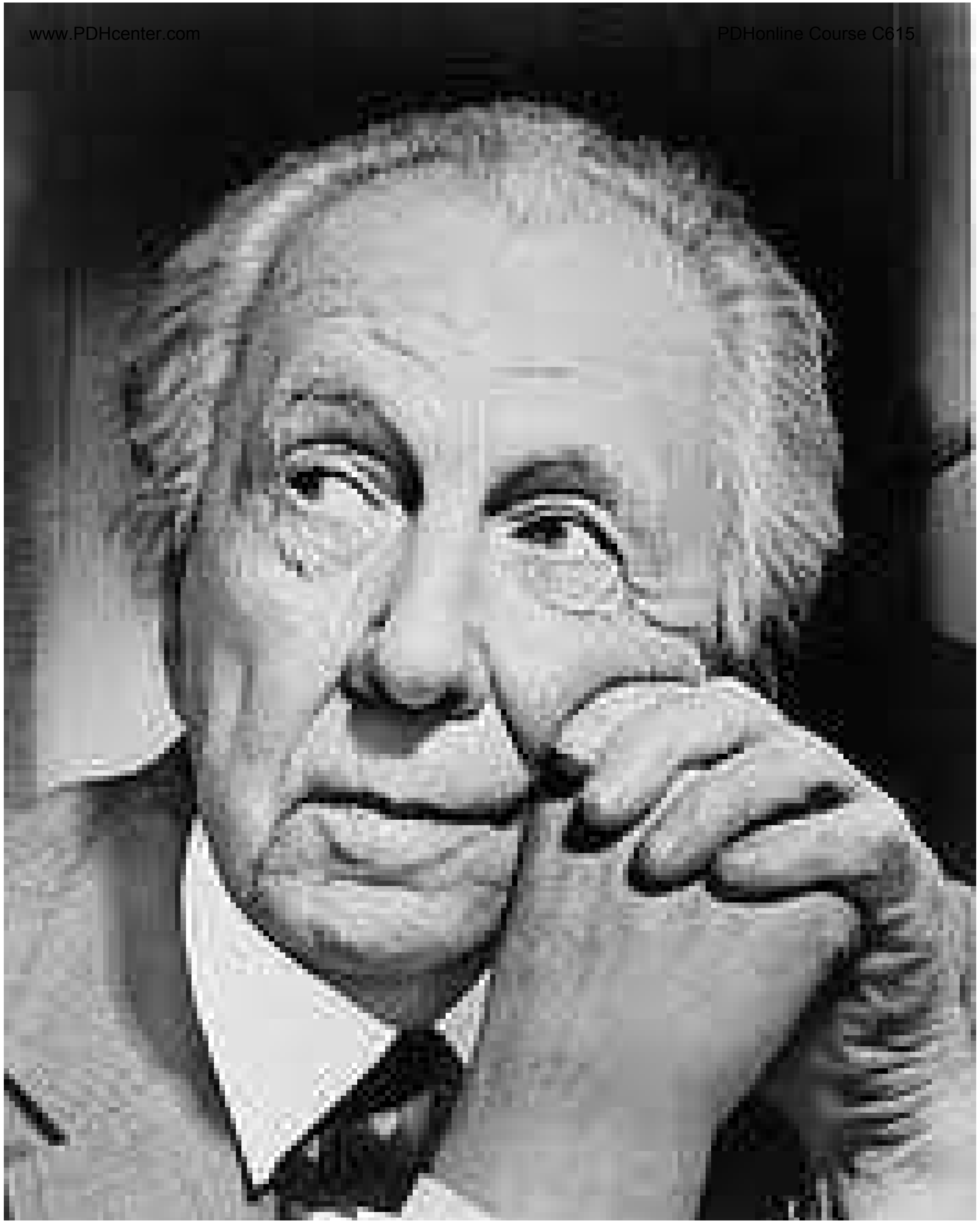
Harry Seidler, Australian Architect

RE: quote appearing in *The Sydney Morning Herald* in 1957. Seidler was a highly regarded local architect who entered the SOH competition himself and admired Utzon's bold, eloquent design.

The Building of the Century

"…The winning design was the conception of Jorn Utzon, a 37 year-old Danish architect. The son of a naval architect and the nephew of a sculptor, he had studied under Frank Lloyd Wright and built a small but sound reputation with his designs for housing projects in Denmark. He had always been entranced by the idea of great free-form shapes floating on the air. The city of Sydney was entranced, too. During those palmy days of 1957, architects round the world acclaimed the building as one of the most daring and exciting structures ever attempted. The London Times called it 'the building of the century,' and later the internationally influential architectural magazine 'Zodiac' devoted a large chunk of an issue to Utzon and the Opera House. Sydney basked in the warm glow of world cultural approval…"

Life **Magazine, January 6th 1967**



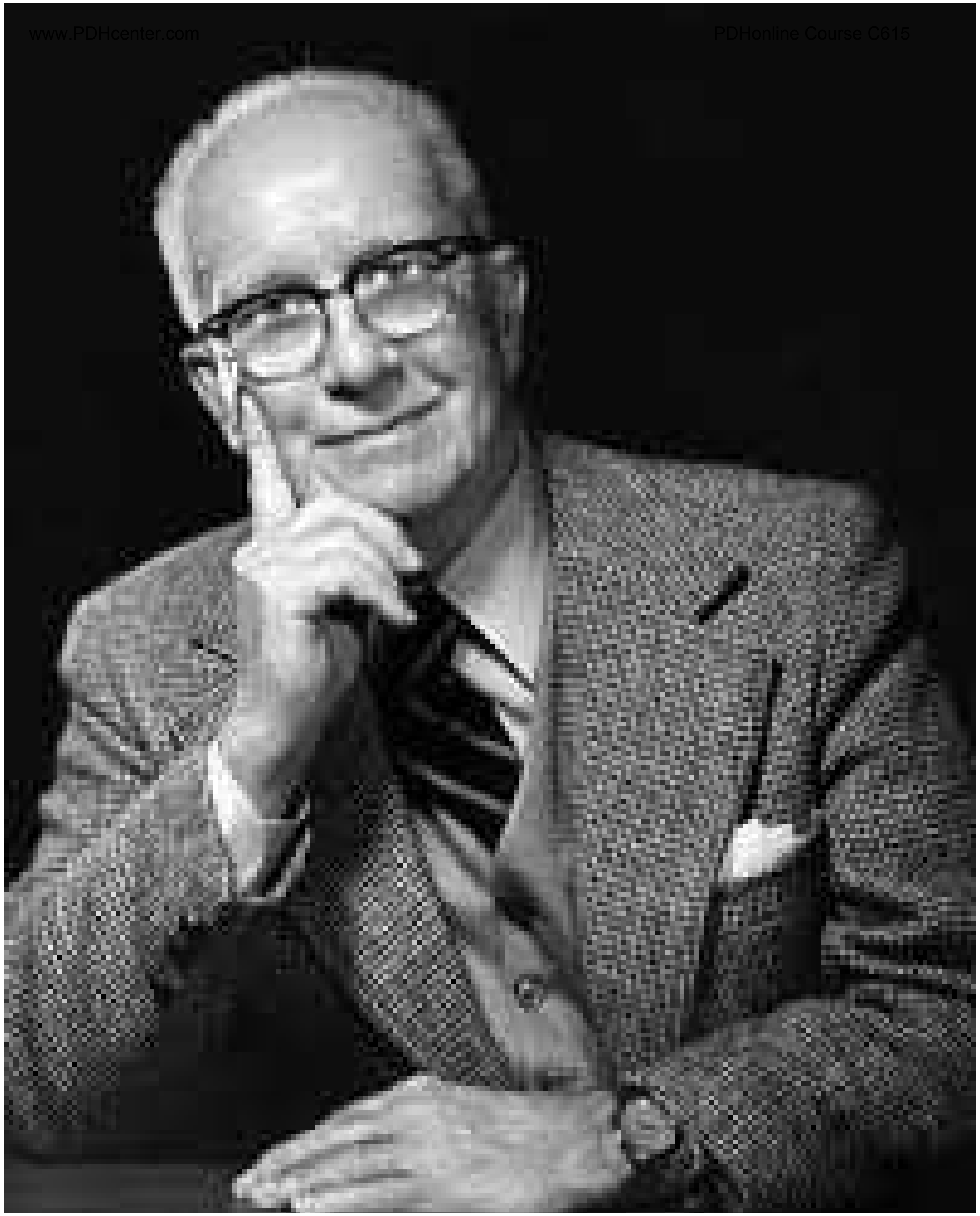
"The circus tent is not architecture"

Frank Lloyd Wright, Architect

RE: his opinion of Jorn Utzon's winning design for the SOH

"At last! A clean refreshing breeze has found its way into the musty corridor of Australian architectural thought"

RE: *The Sydney Morning Herald* (Letters to the Editor), January 31st 1957

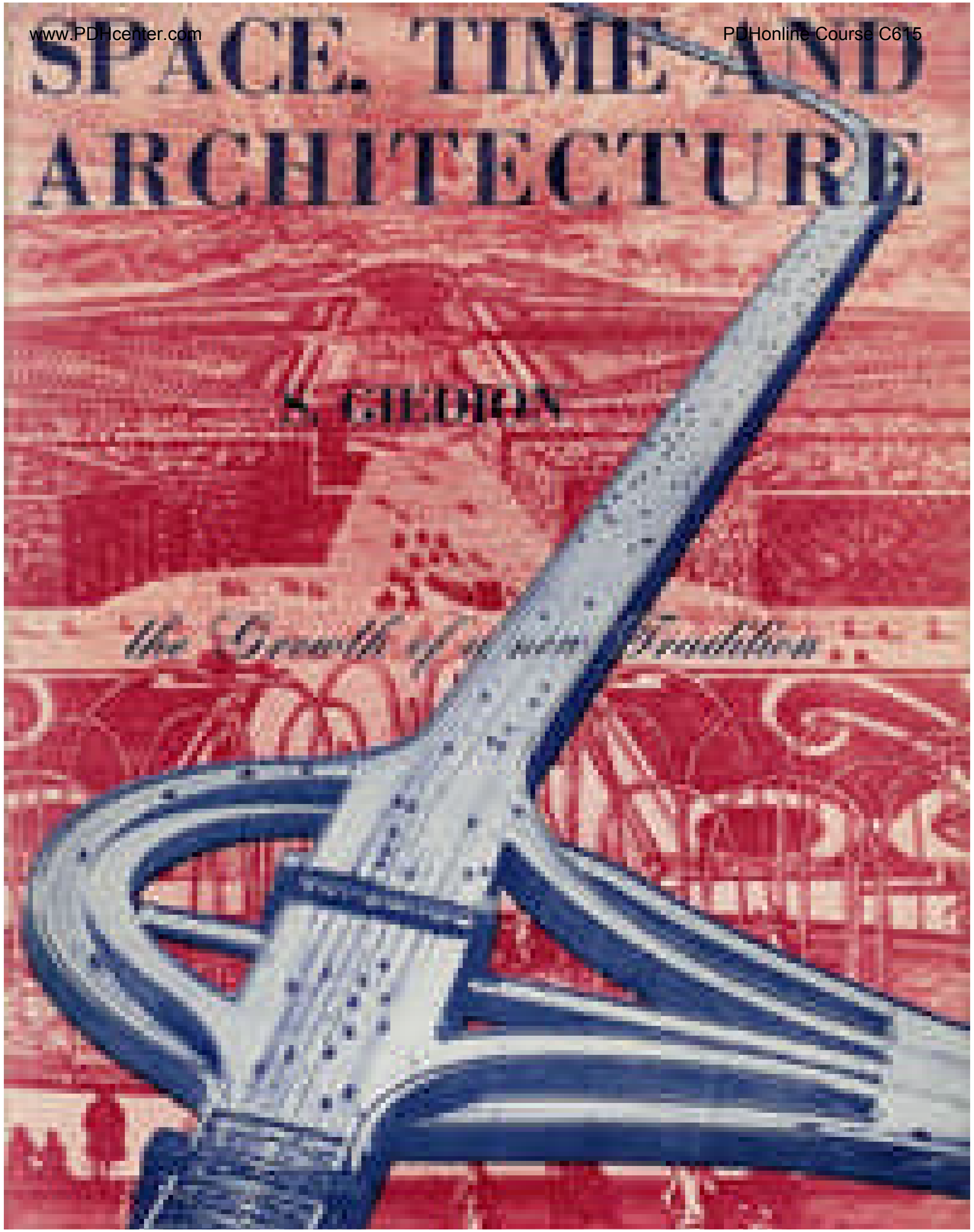


"It will give simple people pleasure"

Richard Buckminster Fuller, Futurist

RE: SOH design

Are We Prepared?



"A remarkable amount of opposition manifested itself against a series of great vaults for the Opera House. It is not usual for a series of 10 vaults to give rise one behind another to sixty metres. The most widespread objection is that the shells were arbitrary and superfluous. If one recognizes only the function in architecture, this objection gives rise to a basic question - a question which our period must again answer and decide: Are we prepared to go beyond the purely functional and tangible as earlier periods did in order to enhance the force of expression?"

Professor Sigfried Giedion, Author

RE: excerpt from his book: *Space, Time and Architecture: The Growth of a New Tradition*

"It is all very well to chatter about the thing causing an artistic furor, but it is well to remember that the people who have to pay for it will also have to live with it, and, if at some suitably remote period, our descendants regain any sense of taste or proportion, they will be forced to foot the bill for removing it and putting up something less repellent"

RE: ***The Sydney Morning Herald*** **(Letters to the Editor), January 31st 1957**

"…Here is the epitome of romantic sculpture on the grand scale…No doubt there will be controversy over the design – controversy over competition results is inevitable nowadays anyway. But the citizens of Sydney should congratulate themselves. The design will always be of interest, however the theorists may argue, and will be worth traveling many a mile to see, admire and wonder at. Sydney need have no doubts that its policy in holding an International Competition was absolutely right."

***The Observer*, London – February 7th 1957**

"The site is quite unsuited for the purpose. It's a marvelous site, it's wonderful, the water is all around it, the Harbour is beautiful and everything's excellent, but to get people there and to use it as a cultural centre is really quiet wrong. So you start off with the wrong site, and then you select a scheme which defies a few fundamental principles, like they don't quite know how the roof is going to work, and they don't quite know how the stage machinery is going to work, and you put these two halls side by side."

Michael Lewis, Engineer, Ove Arup & Partners

RE: comments made in 1973

Alpenglow

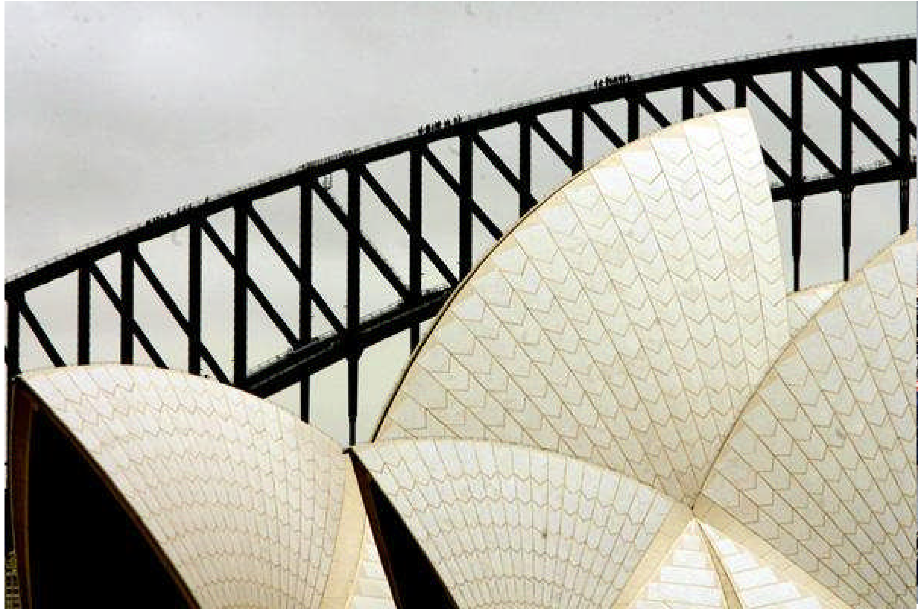
"…The Danish architect who drew his sketches without visiting Australia, was struck by photographs of the dark landscape and tangled foreshore scrub: 'There is no white here to take the sun and make it dazzle the eyes – not like the Mediterranean or South America. So I had white in mind when I designed the Opera House. The final effect will sometimes resemble what we call Alpengluhen (Alpenglow), the color you get on snowcapped mountains when the sun is setting, the beautiful pink and violet reflections from the combination of mat snow and shiny ice.' The bouquet of shells, holding the main hall, two secondary theaters, art-exhibition space, a chamber-music room and a restaurant, would be anchored to float above a massive platform containing the several hundred utility rooms of the Opera House…"

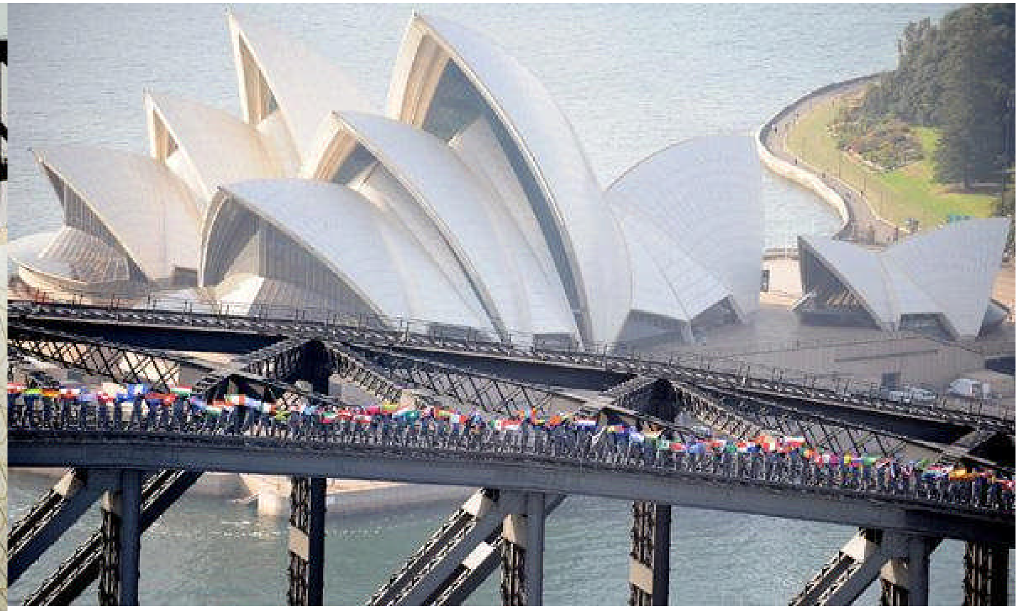
***Time* magazine, October 8th 1973**

Sketch of the proposed SOH prepared by Eero Saarinen. He prepared several sketches in order to assist his fellow assessors in their deliberations concerning Utzon's design submittal. The sketches were placed on display at the *National Art Gallery* (at Cahill's request).

Utzon set himself to task when he entered the competition by supplementing the information contained in the Brown Book. He researched Bennelong Point, Sydney and Australia for weeks even going so far as to visit the Australian embassy in Copenhagen to look through its collection of books and brochures and to view a film about Sydney. An experienced sailor, he obtained maritime charts of Sydney Harbor to measure distances and relationships between Bennelong Point and its surroundings. Utzon often sailed around the peninsula at *Helsinger* which was dominated by *Kronberg Castle*. Just as the castle on the peninsula could be viewed from all sides, Utzon realized so too would the SOH be viewed from all sides as well as from above (Botanical Gardens and Harbor Bridge). With nowhere to hide a utilitarian facade, Utzon solved the problem by adaptation. Though it violated competition rules, the two halls would be placed side-by-side with the roof shells covering the halls and fly towers above the stages. Grand but simple Grecian style stairs to the Theater Lobby/s were placed at the northern end while stages were placed at the southern end. The stage wings (where sets are stored aside the stage/s) would be replaced with mechanical lifts to save horizontal space. A podium – like that of a Mayan temple which lifted the temple above the tree line, would lift the shells (sails) well above the waterline providing a vista from all points of the city and harbor.


Kronborg-Helsingør





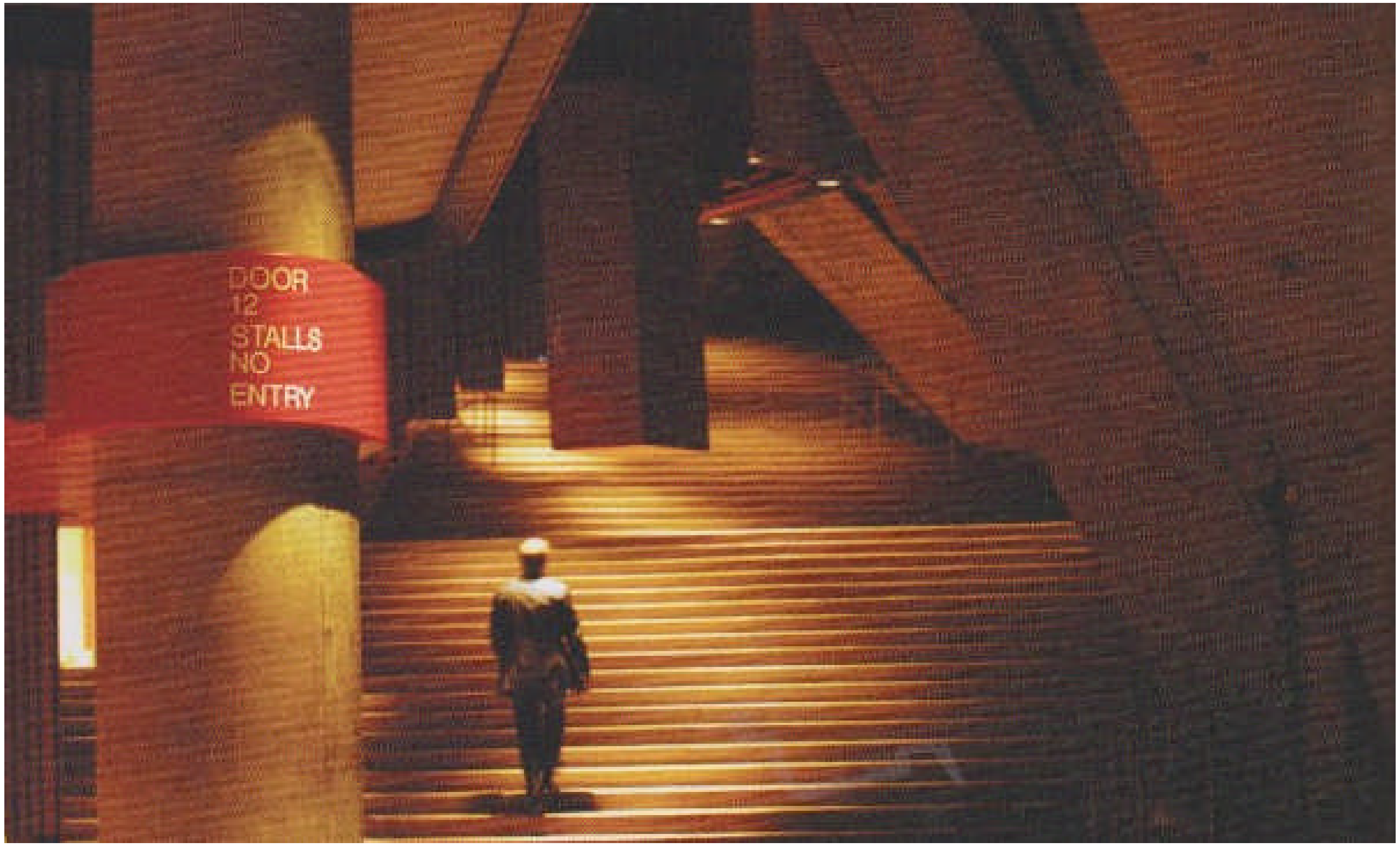
"I stood looking at clouds over a low coastline and I had a look at Kronberg Castle at Helsingor, and at Gothic churches. There you have forms against a horizontal line like the sea or the clouds without a single vertical line, nothing constituting weight, and with forms that are different from all angles… because the site was rather small, I came to the conclusion that I would have to make one architectural unity out of the whole peninsula. Everything had to be planned, nothing left to circumstances. The rim of the cape, the original view and my building had to be a unity."

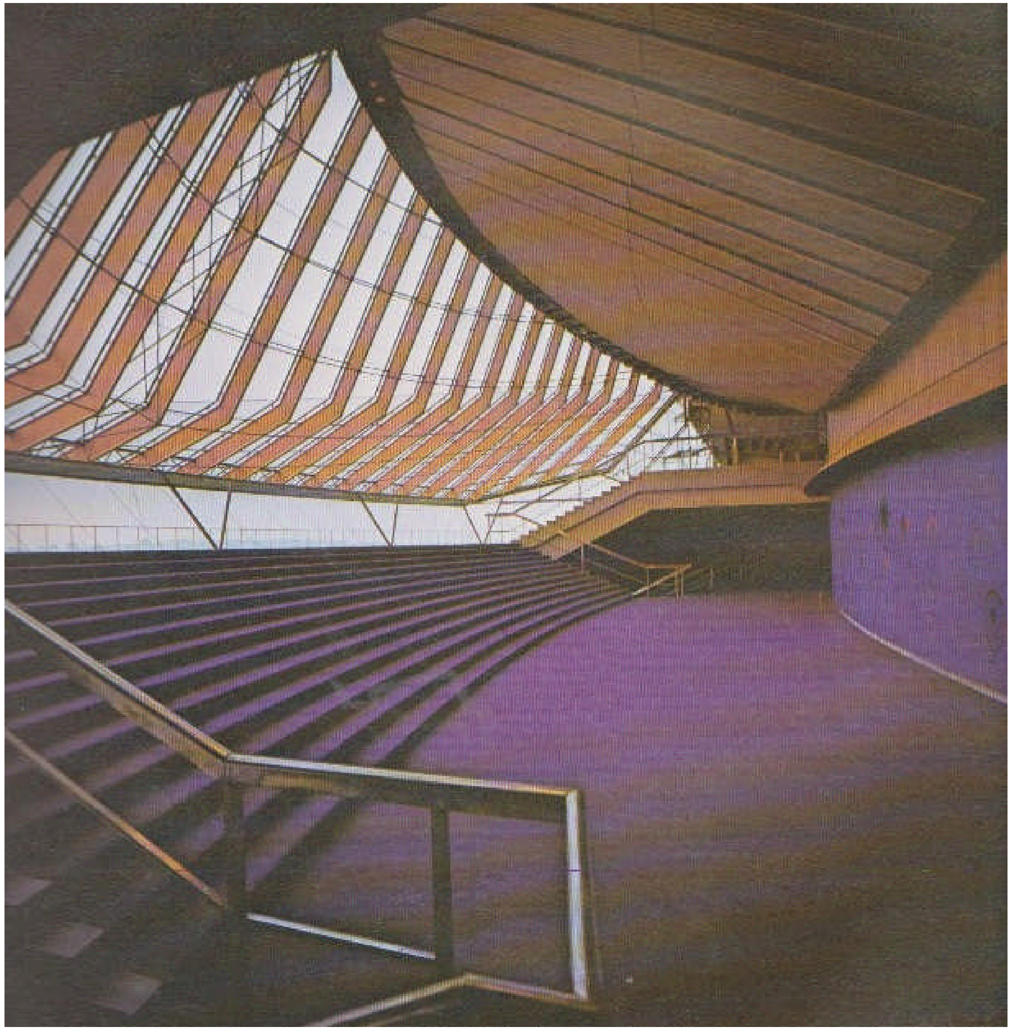
Jorn Utzon, Architect

Like a Gull in Flight

"…Utzon's podium originated with a 1949 visit to Mexico, where he studied the ruins of Mayan architecture; the monumental stairways and levels of buildings like the Temple at Uxmal in Yucatan were to be reflected in the Opera House's huge entrance stair. Finally, vaults and base were to be linked by hung glass walls with plywood ribs, flexing outwards like the primaries of a gull in flight…"

***Time* magazine, October 8th 1973**


DOOR
12
STALLS
NO
ENTRY



"The idea has been to let the platform cut through like a knife, and separate primary and secondary function completely. On top of the platform the spectators receive the completed work of art and beneath the platform every preparation for it takes place."

Jorn Utzon, Architect

Brown Book

"An International Competition for a National Opera House at Bennelong Point, Sydney, New South Wales, Australia: Conditions and Programme"

Commonly known as the "Brown Book", this is the booklet for the conditions and programme for the *International Competition for a National Opera House at Bennelong Point, Sydney, New South Wales, Australia*. The booklet contains the following headings: conditions of competition, black and white photographs of site, a summary of relevant regulations to be observed, description of site, site requirements, building requirements and schedule of dates associated with the competition.

The booklet was printed in Sydney by A.H. Pettifer, Government Printer in 1955.

ORTA RECENS QUAM PURA NITES

An International Competition

for a

NATIONAL OPERA HOUSE AT BENNELONG POINT
SYDNEY, NEW SOUTH WALES, AUSTRALIA

Conditions and Programme

AERIAL VIEW OF BENNELONG POINT AND SURROUNDING HARBOUR FORESHORES LOOKING TOWARDS THE SOUTHWEST

Photo by Courtesy of "Sydney Morning Herald".

AERIAL VIEW LOOKING OVER SYDNEY HARBOUR BRIDGE TOWARDS BENNELONG POINT

Page 2 *Photo by Courtesy of "Sydney Morning Herald".*

Conditions of Competition

This Competition has been approved by the Royal Australian Institute of Architects and the International Union of Architects.

Throughout these Conditions:

"Promoters" shall mean the Government of the State of New South Wales.

The "Secretary" shall mean the Secretary and Executive Officer of the Opera House Committee, c/- Department of Local Government, Bridge & Phillip Streets, Sydney, Australia.

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1. Invitation

The Promoters invite all Architects, who are members of their respective Architectural Institutes in any country in the world, to submit designs in competition for—

A proposed National Opera House, to be erected on Bennelong Point, Sydney, Australia,

in accordance with these Conditions and the Annexed Appendices, which form part of these Conditions.

The winner of the Competition shall become registered in New South Wales as an Architect under the Architects Act, 1921–1946, before he can be appointed.

The qualifications for registration in New South Wales are set forth in Appendix 1.

2. Register

Every intending competitor shall register his name and address in writing with the Secretary, not later than 15th March, 1956.

The register shall be confidential and the names of the competitors shall not be disclosed until the Assessors have made an award.

Competitors may obtain one set of these Conditions by depositing the sum of £10 0s. 0d. (Australian) or its equivalent, with the Secretary. This sum will be refunded to those Architects who submit a bona fide design. Remittances to be made payable to the Government of New South Wales.

Designs will not be accepted from any person other than those whose names appear on the register.

3. Correspondence It is desirable that all correspondence from overseas addressed to the Secretary should be by airmail.

4. Questions Competitors wishing to obtain further information in respect of this Competition, shall forward their questions in English, typewritten and without name and address, to the Secretary, so as to be received in Sydney on or before 15th May, 1956.

A copy of all questions received and the answers thereto will be posted by the Secretary by airmail to all registered Competitors not later than 1st June, 1956. Questions received after the 15th May, 1956, will not be answered.

5. Anonymity A competitor shall not communicate directly or indirectly with any Assessor in respect of any matter associated with this competition, or with any member of the Opera House Committee, in respect of this competition, if he does so, he shall be disqualified.

6. Assessors The Assessors in these Conditions and Annexures thereto, mean:

Professor Henry Ingham Ashworth, M.A. (Arch.), F.R.I.B.A., F.R.A.I.A., M.A.P.I., Sydney.
Cobden Parkes, Esq., F.R.I.B.A., F.R.A.I.A., Sydney.
Dr. John Leslie Martin, M.A., F.R.I.B.A., London.
Eero Saarinen, Esq., A.I.A., Michigan, U.S.A.

or a majority of them.

In the event of any assessor being unable to act, the Promoters may appoint a substitute approved by the Royal Australian Institute of Architects in his place.

The Assessors reserve the right to call upon specialist consultants for advice.

The Assessors shall advise the Promoters on the conduct of the Competition, shall adjudicate on the designs submitted and shall make the award

The Assessors, or any partner or associate, or any employee of any of them, shall not be eligible to compete or assist a competitor, or act as architect, or associate architect, or consulting architect for the work.

7. Award to be Binding The award of the Assessors shall be final and binding on the Promoters and all the competitors.

8. Premiums

The following are the premiums which shall be paid by the Promoters within twelve weeks after the publication of the award. :—

To the author of the design placed first by the Assessors—£5,000 (Australian).

To the author of the design placed second by the Assessors—£2,000 (Australian).

To the author of the design placed third by the Assessors—£1,000 (Australian).

9. Competition Drawing Requirements

No restriction is placed upon either the number of drawings or the size of the sheets, but all sheets submitted by each competitor must be of a uniform size and delivered unmounted and preferably flat.

Drawings shall be in black and white (ink, pencil or photostat reproductions). The Assessors do not require elaborate drawings and would prefer them to be unrendered line drawings finished in black ink or pencil or black and white reproductions of such media.

The title should be placed at the bottom of each sheet, and should read—

"National Opera House, Sydney, Australia."

No other title or identification marks are required except those necessary to identify the various drawings. Area and room names in English should be placed within the area or room, not outside of it. Only important areas require identification.

10. Drawings Required

1. A site plan showing proposal for development of the whole site to a scale of 1/40″ = 1′ 0″, or 1/500 full size metric.

2. All floor plans necessary to ensure an understanding of the scheme, at a scale of 1/16″ = 1′ 0″, or 1/200 full size metric.

3. Diagram, or diagrams, showing principles which would be followed in obtaining satisfactory acoustics in the auditorium.

4. A diagram, or diagrams, demonstrating that the sight lines are satisfactory from all parts of the auditorium for different types of programmes.

10. Drawings Required *—continued*

5. A longitudinal and cross-section through the auditoriums at a scale of 1/16″ = 1′ 0″, or 1/200 full size metric. Principal levels are to be indicated.

6. Four main elevations at a scale of 1/16″ = 1′ 0″, or 1/200 full size metric.

7. Perspective drawing of such elevation as the competitor may select as his main elevation and/or approach to the building. The perspective drawing may be presented in any medium and any form the competitor may desire; the area occupied by the actual drawing shall not exceed 18″ x 15″ and should be mounted on one of the uniform size sheets.

8. A ½″, or 1/25 metric, detail illustrating any portions of both the exterior and interior of the building, and as selected by the competitor, to fill one sheet of the drawings submitted.

9. A schedule of the principal materials proposed for the structure and finishes, to be shown on one of the drawings.

11. Report

Every set of drawings shall be accompanied by a report, which shall be in English and which should be as concise as possible, explaining only matters which cannot be readily explained on the drawings.

The report must not be enclosed in an envelope, but must be securely tied or otherwise fastened to the site plan.

12. Cost

The Assessors feel that the cost of the building cannot be limited to a specific amount. It is stressed that although the contemplated project is one of national standing and character, funds are obviously not unlimited. Thus while extravagance cannot be entertained, competitors are allowed to use their discretion in submitting a design of the character and dignity associated with this type of building. At the same time, they should bear in mind the necessity for sound judgment as to the financial implications.

13. Guarantee of Authorship

Each design shall be accompanied by a declaration, signed by the competitor, or joint competitors, stating that the design is his or her or their own work, and that the drawings have been prepared under his or her or their own supervision.

This declaration shall be inserted in an opaque envelope, endorsed " Identification," wax sealed and containing only the name and address of the competitor and also a tracing of portion of the ground plan for identification purposes.

14. Submission and Closing Date

The Competition shall close on 3rd December, 1956, and competitors must despatch their drawings on or before this date. The drawings must be sent by airmail, unsigned, to the Secretary. Competitors must also inform the Secretary by airmail of the despatch of their drawings and enclose the consignment note. Assessing will commence early in January, ~~1956~~. 1957

Drawings shall bear no distinguishing mark and be delivered under cover to the Secretary ~~on or before 3rd December, 1957~~.

The cover itself shall bear no distinguishing mark other than the name of the Competition. Where delivery addresses are necessary, the package, without distinguishing mark other than the name of the Competition, shall be enclosed in a separate external wrapping for delivery purposes. The envelope referred to under "Guarantee of Authorship" is to be attached to the external face of the inner package, so that it may be detached as soon as the outside wrapping marked with the delivery names and addresses is taken away and before the inner package is passed to the Assessors.

Where drawings are delivered the responsibility for the delivery of the designs not later than 1700 hours on 3rd December, 1956, rests with the competitors. The Secretary will receive the packages and each package will be numbered and the same number will be placed on each drawing, the report, and the envelope containing the identification and guarantee of authorship, which must be included in the package.

The envelope containing the identification and guarantee of authorship, will be kept in safe custody under the personal control of the Secretary and will not be opened until after the Assessors have made their award.

15. Disqualification

A design shall be disqualified if—

(a) It exceeds the limit of the site as outlined on the site plan.

(b) If, in the opinion of the Assessors, the cost of the scheme, as submitted, is excessive.

(c) It does not provide substantially the accommodation prescribed.

(d) It is despatched when forwarded airmail or received where delivered after the 3rd December, 1956: accidents and delays arising from causes beyond the control of the competitor (of which the Assessors shall be the sole judges) excepted.

(e) If it is not drawn and submitted substantially in the manner prescribed in the Conditions and Appendices.

(f) Its author shall disclose his identity or attempt to influence the decision of the Assessors or any of them.

The decision of the Assessors that any design or competitor is disqualified from the Competition shall be absolutely final and binding.

16. Publication of the Award

The award will be published within eight weeks from the date of the closing of the Competition, or as soon thereafter as possible.

A report by the Assessors will be sent to all competitors who have submitted designs as early as possible after the announcement of the award.

17. Exhibition of Drawings

The designs will be exhibited in Sydney for at least two weeks and within eight weeks after the award has been made.

18. Return of Drawings

The designs, except the design placed first, will be posted to competitors free of charge within four weeks after the closing date of the exhibition.

The design placed first and any copyright thereto will become the sole property of the Promoters. The Promoters reserve the right to illustrate or publish any of the designs submitted.

19. Liability

The Promoters will take reasonable care of the drawings and will insure them whilst in their custody, for an amount of £400 os. od. (Australian) per set of drawings, but they undertake no further liability in the event of loss or damage.

20. Appointment of Architect

The author of the design placed first shall be employed as Architect of the work, unless the Assessors shall be satisfied that there is some reasonable objection to such employment, in which case the author of the design placed first shall be required to enter into an agreement with some other Architect selected by him, and approved by the Assessors, for the joint design and supervision of the work.

Such association as may be required shall in no way increase the fee which will be paid for the execution of the work.

Should the author of the work placed first, fail to enter into such agreement within a reasonable time to be determined by the Assessors, he shall forgo all right of employment as Architect for the work, and the Promoters shall be at liberty to make other arrangements for the carrying out of his design, providing always that in making such other arrangements, the Promoters shall give consideration to any recommendation of the Assessors concerning the other competitors in order of merit.

In consideration of the magnitude of the project and of the special technical problems involved, the winning Architect(s) if necessary, and at no expense to the Promoters, will be required to submit to the Assessors proof of the adequacy of his, her, or their qualifications to organise and carry out the commission.

21. Remuneration of the Architect

The Architect employed to proceed with the work shall be engaged and remunerated according to the Conditions of Engagement and the Scale of Minimum Professional Charges of the Royal Australian Institute of Architects. His remuneration shall be exclusive of any premium awarded.

22. Delay in Building

If, before any further drawings are made, and within two years of the publication of the award, the Promoters shall not proceed with the building and such delay be not caused by any act or default of the competitor placed first, the Promoters will pay to the competitor placed first, the sum sufficient to increase the first premium to 1 per cent. on the cost of executing the building as estimated by the Assessors. Should the work subsequently be proceeded with, the amount of such additional payment shall be merged in the total remuneration to be paid in respect of the design and execution of the building.

23. U.I.A.

The Assessors awards are final and binding. In the event of any dispute arising other than in connection with the Assessors awards, then the Promoters will seek the advice and assistance of the Union Internationale des Architectes in the settling of such dispute.

1. VIEW FROM THE NORTHERN END OF MACQUARIE STREET SHOWING APPROACH AND EXISTING BUILDINGS

Page 10

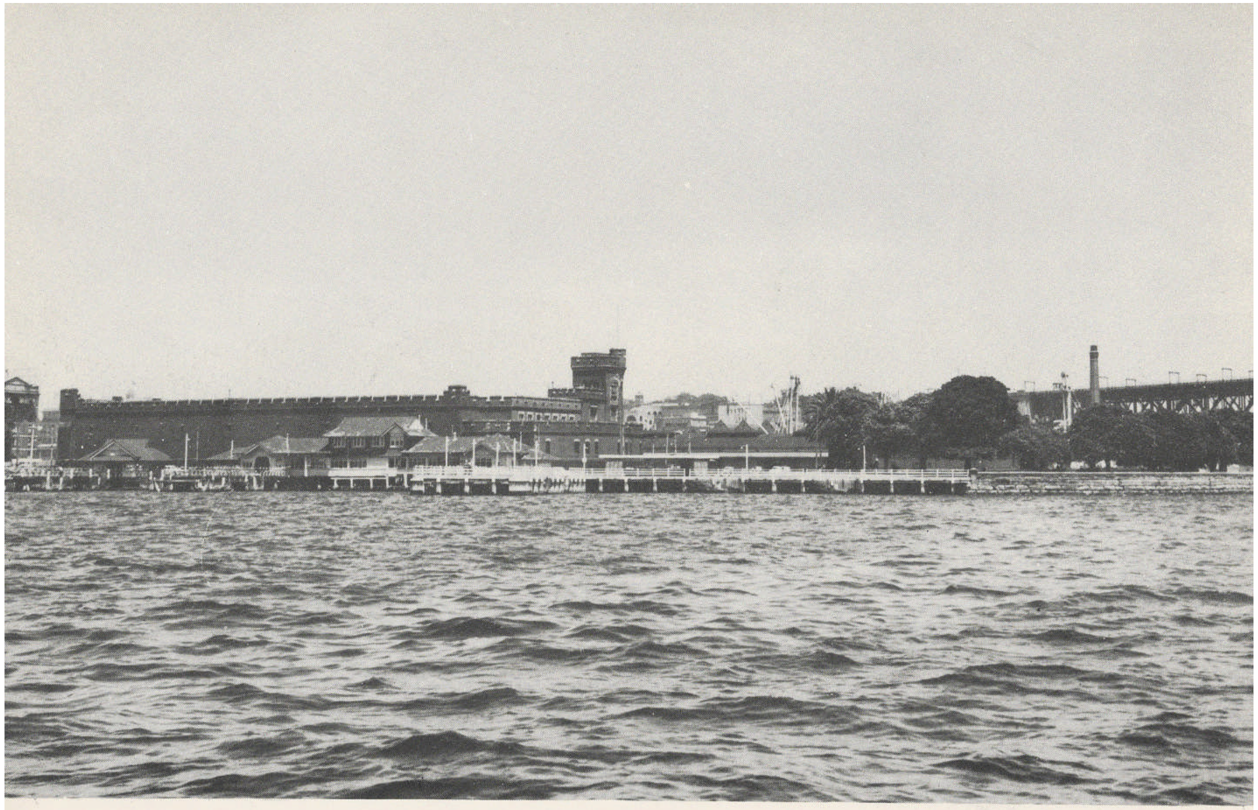
2. VIEW FROM THE EAST

3. A VIEW FROM THE WEST

Page 12

4. VIEW LOOKING ACROSS BENNELONG POINT TOWARDS THE HARBOUR

5. VIEW FROM BENNELONG POINT LOOKING TOWARDS THE REAR OF THE EXISTING TRAMSHED



6. VIEW OF THE SITE FROM THE HARBOUR LOOKING FROM THE EAST

Page 16

7. VIEW OF THE SITE FROM THE HARBOUR LOOKING TOWARDS BENNELONG POINT

8. VIEW OF THE SITE FROM THE HARBOUR LOOKING FROM THE WEST

Page 18

Appendix 1

Extract from the Architects Act, 1921-1946, covering Registration in the State of New South Wales, Australia.

Section 12

No person shall be entitled to be registered as an architect unless he has attained the age of twenty-one years and satisfies the Board that he is of good fame and character.

Section 13

(1) Subject to the provisions of this Act, a person shall be entitled to be registered as an architect who—

(a) has passed the prescribed examination ; or

(b) holds a prescribed degree, diploma, or license of competency from the University of Sydney or the Sydney Technical College ; or

(c) holds a prescribed degree, diploma, or license of competency from some university, institute, college, or school outside New South Wales approved of by the Board, and also either passes the prescribed examination or shows to the satisfaction of the Board that in the country or state where such degree, diploma, or license was issued persons registered as architects under this Act, are entitled to practise architecture by virtue of such registration and without further examination ; or

(ci) holds a degree, diploma, or license of competency, approved of by the Board from some university, college, school, institute or other authority, and also satisfies the Board that he possesses the requisite knowledge and skill for the practice of architecture ; or

(d) holds a degree, diploma, or license of competency from some architectural college, school, or public institution in a British possession, or in some foreign country approved of by the Board, and also satisfies the Board that he possesses the requisite knowledge and skill for the practice of architecture ; or

(e) has, prior to the commencement of the Act, completed a term of not less than five years as an articled pupil or assistant to a practising architect in New South Wales, or, has prior to the first day of November, one thousand nine hundred and twenty-one, practised as an architect in New South Wales as his sole or main source of livelihood ; or

(f) satisfies the Board that he is engaged in the acquirement of professional knowledge in architecture and passes within three years of the commencement of this Act the prescribed examination ; or

(g) satisfies the Board that, during four years preceding the commencement of this Act, he has been a competent teacher of Architecture.

(2) No person shall be entitled to be registered under the provisions of paragraphs (d), (e), (f) or (g) of subsection one of this section unless he applied to the Board to have his name recorded as a person entitled to the benefit of this section within six months from the commencement of the Act.

Provided that the Board, if satisfied that for some sufficient reason such person was unable to make such application within the said six months, may permit such application to be made at a later date.

The Board referred to in the above extract means the Board of Architects of New South Wales, Daking House, Rawson Place, Sydney, New South Wales, constituted by the Architects Act for the purpose of issuing Certificates of Registration and keeping a Register of Architects as called for under the Act.

Appendix 2—A Summary of Relevant Regulations to be Observed

Competitors must comply with the Building Regulations set out below.

1. It will be necessary for the buildings to be of " Framed Fire-proof Construction ".

   This means that the walls and structural members have fire resistance ratings as determined by the Standard Fire Test of not less than four hours for external walls, fire walls, isolated piers and columns; of not less than three hours for beams, floors, roofs, walls and girders other than as hereinbefore specified and of not less than two hours for fire partitions.

   Note.—The above does not preclude the use of materials of a non fire-resisting type being applied to any part of the structure after the necessary fire-proof construction has been attained.

2. Auditoriums, restaurants, kitchens, bars, dressing rooms, toilet rooms, and other spaces used for any purpose other than storage must be adequately ventilated either by natural means or a mechanical system.

3. No portion of the building used for any purpose other than for housing plant or for storage must exceed 150′ in height from ground level.

4. Glazed windows may be used in the external walls of fireproof buildings, provided that the space between the heads and sills of those above is not less than 3′ 0″ and that such space is constructed of fireproof material having a 4-hour rating.

5. Exits shall consist of stairways, passageways or doorways. The dimensions and capacity of exits shall be proportioned to the number of persons which the building is designed to accommodate on any floor served by such exits. It may be assumed that the number of persons which the building is designed to accommodate on a floor shall be that as ascertained by taking the gross floor area devoted to each occupancy and applying thereto the scale hereunder:—

   Auditoriums and other places of assembly—one (1) person to every 8 square feet of floor space.

   Restaurants and rooms not otherwise provided for—one (1) person to every 40 square feet of floor area.

   Offices—one (1) person to every 80 square feet of floor area.

   Number of Exits.—Every room which is designed to be occupied by more than 60 persons shall have at least two (2) doorways as remote from each other as practicable.

   No exit shall be more than 100′ distant from another.

6. *Exit Passageways.*—Where exit stairs discharge into a passageway the width of such passage shall be not less than 4′ 0″ or three-quarters of the aggregate width of the stairs.

7. The minimum toilet facilities to be provided in each section of the building shall be in accordance with the number of persons estimated to occupy such section in accordance with the following schedule:—

Total number of persons of both sexes combined which such section of the building is designed to accommodate	Males		Females
	Water Closets	Urinals	Water Closets
Not exceeding 50 persons	1	1	2
Exceeding 50 but not exceeding 200	2	2	3
Exceeding 200 but not exceeding 400	2	4	4
Exceeding 400 but not exceeding 600	2	6	5
Exceeding 600 but not exceeding 800	2	8	6
Exceeding 800 but not exceeding 1,000	2	10	8
Exceeding 1,000 but not exceeding 1,200	3	12	9
Exceeding 1,200 but not exceeding 1,400	3	14	10
Exceeding 1,400 but not exceeding 1,600	4	16	11
Exceeding 1,600 but not exceeding 1,800	4	18	12
Exceeding 1,800 but not exceeding 2,000	4	20	12

For a greater number of persons than 2,000 the requisite number of conveniences shall be calculated pro-rata with those set out above for 2,000 persons.

Adequate wash basins are also to be provided in each toilet room. It may be assumed that the number of persons of each sex will be equal.

8. *Exits and Staircases.*—Each hall should have independent staircases and exits which must discharge directly on to an open space on at least two sides of the building.

The minimum width of staircases shall be 5′. Staircases from gallery or circle shall be based on the following:—

300 persons—2 staircases of a total width of 11′ with an additional width of 1′ for every 30 persons or fraction thereof in excess of 300.

Exits from stalls or ground floor for 1,000 persons would be 4 or more exits of an aggregate width of 27′.

Persons	*Exits*	*Aggregate Width*
1,100 to 1,200	4 or more	30 feet
1,200 to 1,300	4 ,,	33 ,,
1,300 to 1,400	5 ,,	35 ,,
1,400 to 1,500	5 ,,	38 ,,
1,500 to 1,600	5 ,,	40 ,,
1,600 to 1,700	6 ,,	43 ,,
1,700 to 1,800	6 ,,	45 ,,
1,800 to 1,900	6 ,,	47 ,,
1,900 to 2,000	7 ,,	50 ,,

and for more than 2,000 persons there shall be an increase of 1′ 6″ for each additional 50 persons or fraction thereof.

9. *Ventilation.*—All parts of the building should be properly and efficiently ventilated by means of an approved mechanical plant so as to provide for the complete change of air in the building approximately 8 times in an hour.

10. *Capacity of Respective Halls.*—The approximate capacity of the respective halls would be based on the figure of 5.8 to 6 square feet per person inclusive of aisles and cross overs.

11. *Seating Accommodation.*—

Aisles to be a minimum width of 3′ 6″.
Cross overs to be a minimum width of 4′.
Maximum number of seats between wall and aisle—7.
Maximum number of seats between aisles—14.

This may be varied in the case of seating set out in concentric circles where there may be as many as 18 seats between aisles and 8 between aisles and wall.

12. *Gallery Platform.*—No platform in galleries formed to receive seats shall be less than 30″ in width and no such platform shall be nearer than 8′ from the ceiling or 20′ higher than the top of the proscenium opening.

13. *Proscenium Wall.*—Shall be of fire resistant construction and fitted with an approved rigid-frame fire curtain.

14. *Stage Smoke Escape.*—A smoke escape having an area of at least 1/10th of the total area of the stage shall be constructed over the centre of the roof at the rear of the stage.

15. *Dressing Rooms.*—Dressing rooms, etc., for Artists and Musicians shall not be placed under the stage or under the auditorium. They should be arranged in a section separated from the stage by fire-proof walls and construction.

All dressing rooms shall be connected with independent exits. Escapes from the dressing rooms and the stage are to be provided at both sides.

16. *Ventilation and Generating Plants, etc.*—All heating and generator plants and the like shall be isolated from the auditorium, the stage and the exit areas.

Appendix 3—Description of Site

The Site

The site selected is the promontory projecting into Sydney Harbour and known as Bennelong Point.

It is an outstanding site and should prove a worthy setting for an Opera House possibly unrivalled anywhere in the world.

It fulfills all the requirements of size, spaciousness and beauty of setting, so essential to the type of building to be erected upon it.

The site is well located with regard to public transport. The approach is possible by train, bus and ferry to Circular Quay adjacent to the site. Private cars would approach mainly via Macquarie Street, and less frequently via Circular Quay which discharges into lower Macquarie Street. There is no vehicular approach from Farm Cove.

It is anticipated that the east side of Bennelong Point will be served by a ferry.

Ample parking space can be found within easy walking distance of the site and only a limited amount of parking accommodation is required on the site itself. See paragraph No. 7 under Site Requirements.

To all intents and purposes, the site is a level one. All existing buildings on the site will be removed.

The site is bounded on the west by existing wharves and wharf buildings—competitors are at liberty to offer suggestions as to the possible development of this front, on the assumption that the existing wharves and wharf buildings are demolished.

The boundaries of the site are indicated upon the site plan, together with the results of trial borings and levels.

The Soil

The results of borings shown on the site plan would indicate that it is undesirable to contemplate any excessive excavation. Bearing capacity of the rock may be taken at 15 tons per square foot.

The Weather

1. Average annual rainfall for Sydney—46.93 inches.
2. Wettest months in Sydney are April (5.27"), May (5.05") and June (5.05"). Driest months are September to December.
3. Average daily hours of sunshine vary between 7.6 in November and 5.3 in June. Clearest months are September to January inclusive, when average hours of sunshine equal or exceed 7.3 per day throughout.
4. Snow and frost conditions may be disregarded.
5. Lowest temperature recorded 35.7° F. Highest maximum reading 113.6° F. Greatest diurnal range of temperature 42.2° F.
6. Average wind speed 8.2 m.p.h. Highest gust recorded 95 m.p.h. Wind gusts of 58 m.p.h. or over have been recorded in all months.
7. Prevailing wind direction for the year is west, but varies between east and north-east from November to March.
8. Strongest wind gusts come from directions between W.N.W. and S.S.E.

Appendix 4—Site Requirements

The following requirements form a part of the design considerations and must be related to the design of the Opera House—for this reason, competitors are asked to submit a layout and development of the site which they consider appropriate to their scheme.

The principal design requirements are:

1. The building may be located anywhere upon the site, but should not be placed right on the boundary of the site, either on the east or the west. Location of the building and landscaping of the remaining site are left entirely to the discretion of the competitors.

2. A landscaped forecourt or square with considerable paving and forming an attractive setting and approach to the building from Macquarie Street. The competitor has an opportunity here of suggesting the general "townscape" which he considers would add most to the setting of the Opera House.

3. A corresponding landscaped area on the northern promontory of Bennelong Point, overlooking the Harbour, should the scheme so permit.

4. It should be assumed, insofar as the Competition is concerned, that on the west side a Boulevarde link external to the boundaries of the site will be provided between Circular Quay and the Opera House. Facilities for ferry services approaching the site on the east will also be provided.

5. Service areas for kitchens and stages together with proper unloading and loading facilities.

6. Adequate areas for people arriving and departing by motor transport.

7. Accommodation for approximately 100 cars is required on the site. Primarily, these cars will belong to members of the orchestra, administrative staff and invalid persons attending performances. The major parking areas are available elsewhere within reasonable walking distance of the site.

8. Garage accommodation for the public within the building itself, is not required.

Appendix 5 — Building Requirements

The Competition is intended to select an Architect and a design for the proposed new Opera House. Competitors should appreciate that it is unlikely that the winning scheme would be erected without variation and that in consequence, the Promoters seek a sound basic scheme by a competent Architect.

For this reason, mandatory requirements are limited and are listed below in Items 1 and 2 in order of their importance.

1. There shall be two halls—one large hall and one small hall. The large hall should seat between 3,000–3,500 persons. The small hall should seat approximately 1,200 persons.

   The large hall to be designed for use for the following purposes:—

   (a) Symphony Concerts (including organ music and soloists).
   (b) Large-scale Opera.
   (c) Ballet and Dance.
   (d) Choral.
   (e) Pageants and Mass Meetings.

2. The small hall to be designed for use for the following purposes:—

   (a) Dramatic Presentations.
   (b) Intimate Opera.
   (c) Chamber Music.
   (d) Concerts and Recitals.
   (e) Lectures.

The requirements under 1 and 2 above, have been listed in order of priority with respect to the attention which should be given to their specialised building needs.

It is expected that ideal conditions will be provided as far as possible acoustically, visually and in connection with stage and orchestral facilities. Compromises which will prejudice the entirely satisfactory performance of a function with a higher priority in the above list should not be made.

Competitors must provide adequate accommodation as follows:—

1. A large organ for use in the main hall. The siting of the organ must not, of course, prove detrimental to stage facilities for opera.
2. Separate rehearsal rooms for orchestra, choir and other performances to be provided for each hall.
3. Broadcasting centre—which may be located anywhere in the building and which will be used to control and operate the broadcasts and television. An area of not less than 500 feet is required. Except for wiring, no other facilities are needed.
4. Full stage facilities for both halls and a small projection booth in the small hall.
5. Access to the small hall independent from access to the large hall. The public areas of both halls may be linked at some point, but this is not mandatory.
6. A restaurant to seat approximately 250 people with lounge, cloak-rooms, bar and all the usual accoutrements, easily accessible from the exterior for day-to-day use.

   While these restaurant facilities may well be associated with the patrons attending the Opera House, it is also intended that the restaurant should form a separate revenue producing element and an amenity to the general public.
7. Adequate light refreshment rooms and separate bars for theatre patrons within the building. Competitors should give consideration to the type of programmes to be given in the halls, and that some of these will last for a considerable time with numerous and some-what lengthy intermissions.
8. Two meeting rooms. One to seat approximately 100 people and the other, 200 people. These are to have raised platforms and a level floor. They are intended to be used for formal meetings of groups interested in general cultural subjects as well as for dances, exhibitions and such similar functions. It would be an advantage if they could be adjacent to each other and be separated by movable partitions. If food could be served in these areas, it would increase their value.
9. Necessary foyers and public areas, circulation, public amenities, stage and back-stage facilities, service rooms, ticket offices and administra-tive offices, etc., as needed for the functions which are anticipated to take place in this building.

The proposals made by competitors in connection with the foregoing will contribute substantially to the evaluation of the schemes submitted.

Appendix 6—Schedule of Dates Associated with Competition

15th February, 1956	1.	Competition programme and requirements will be available in Sydney.
15th March, 1956	2.	Latest date for registration as a competitor.
15th May, 1956	3.	Latest date on which questions from competitors will be received in Sydney by the Secretary.
1st June, 1956	4.	Answers to questions will be posted from Sydney by airmail to all registered competitors.
3rd December, 1956	5.	The closing date of the Competition and the latest date on which drawings may be despatched by airmail or delivered in Sydney.
Early January, 1957	6.	Date of commencement of adjudication.

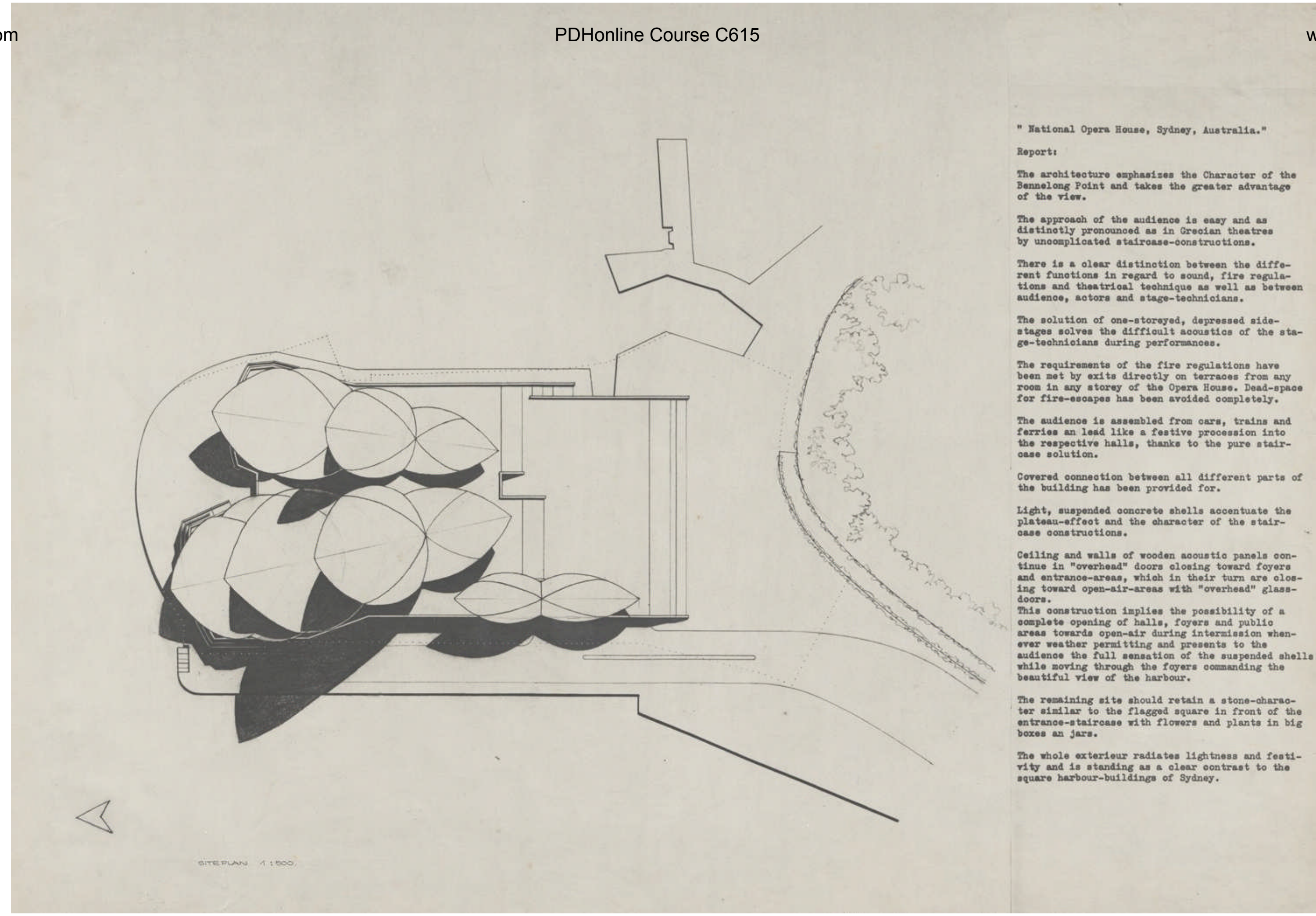
9) restaurant to serve both halls.

Drawings

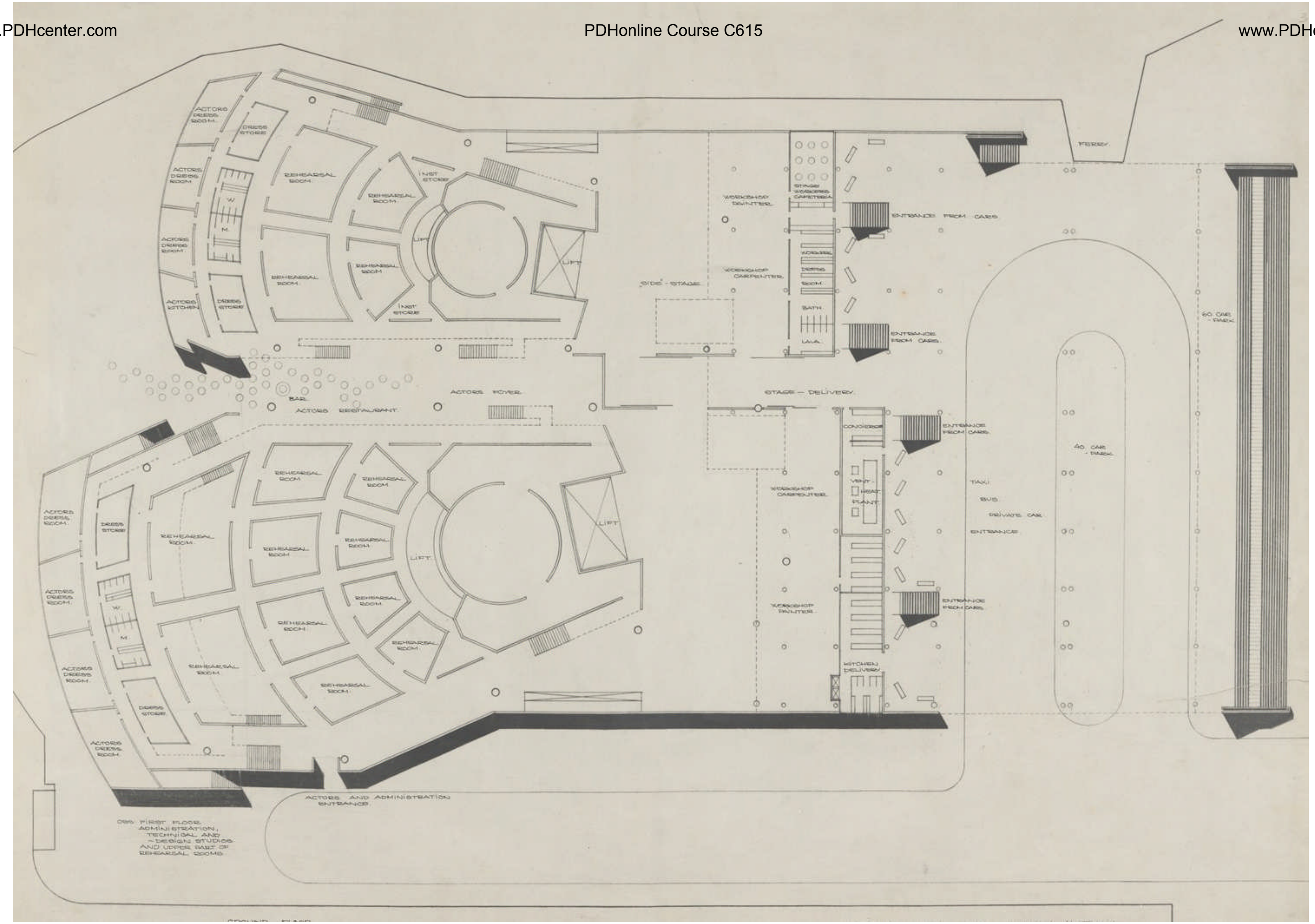
Competition drawings submitted by Jorn Utzon to the Opera House Committee

These are the original competition drawings for which the assessors of the Committee awarded Jorn Utzon first prize of £5,000 on 29 January 1957. As a result Mr. Utzon was commissioned by the Government of New South Wales to do final drawings for the Opera House, and to supervise its construction.

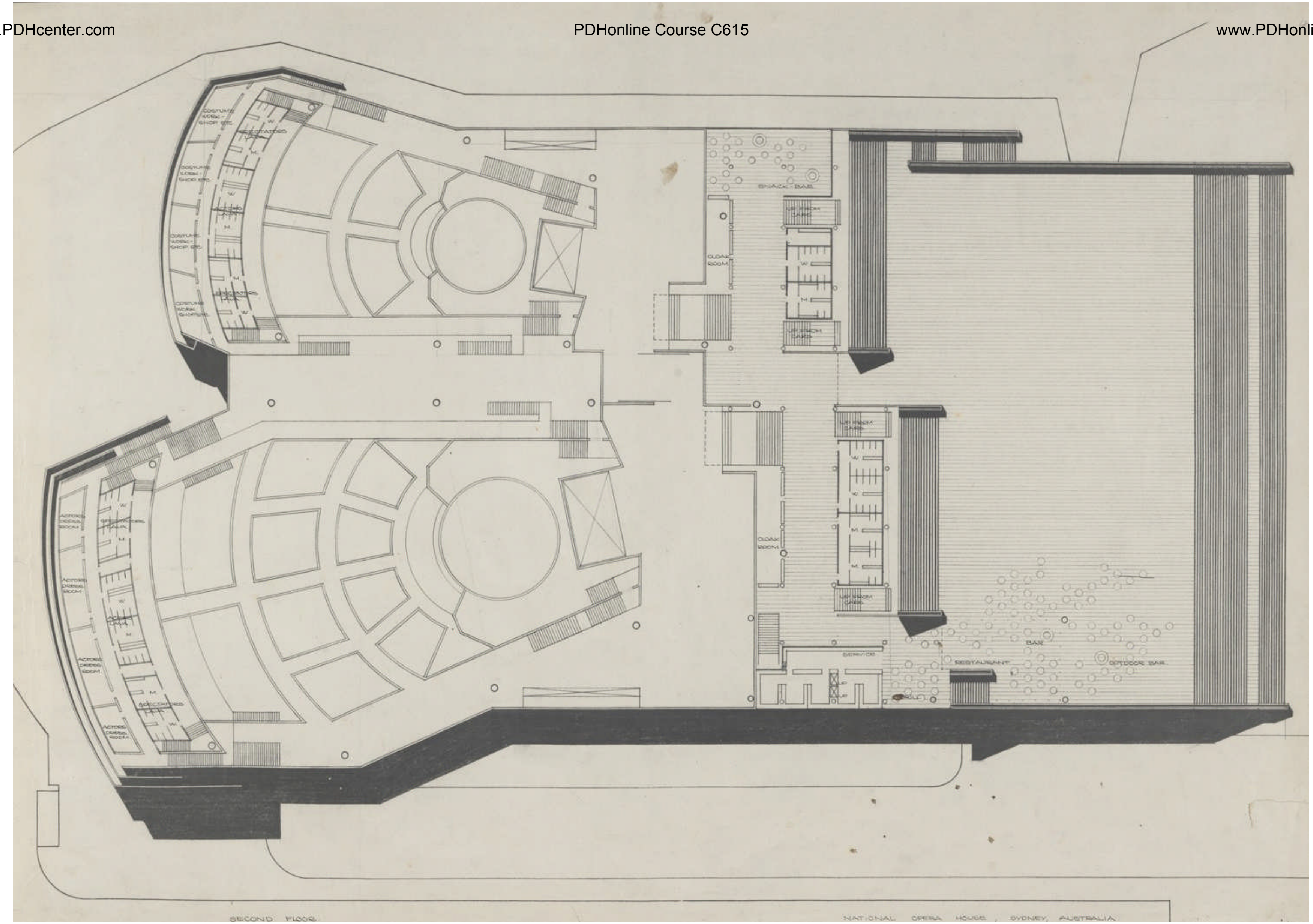
Perspective from staircase between the two halls looking towards the north



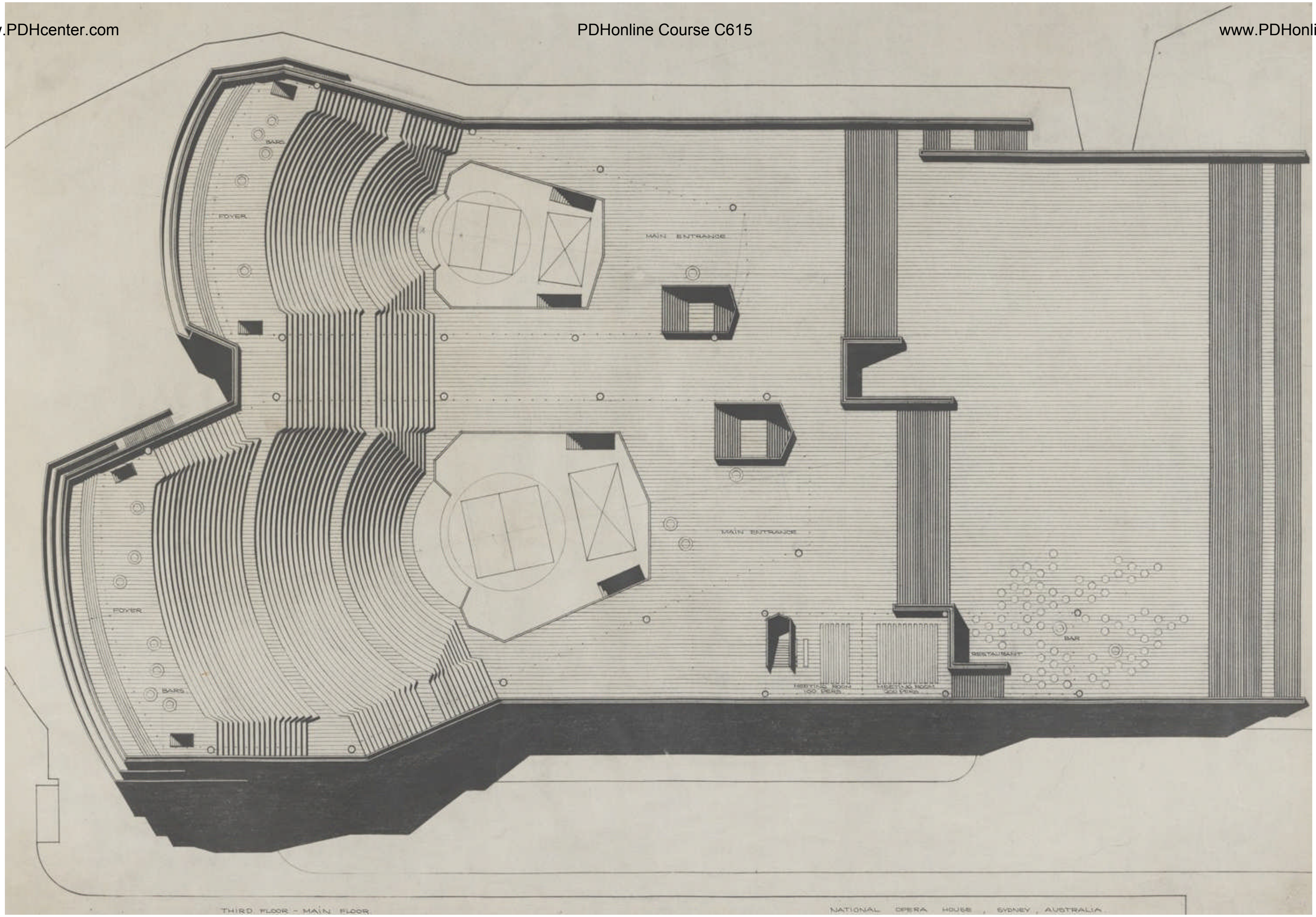
From the Report: ***"The architecture emphasizes the character of Bennelong Point and takes the greater advantage of the views...The audience is assembled from cars, trains and ferries an lead like a festive procession into the respective halls, thanks to the pure staircase solution..."***



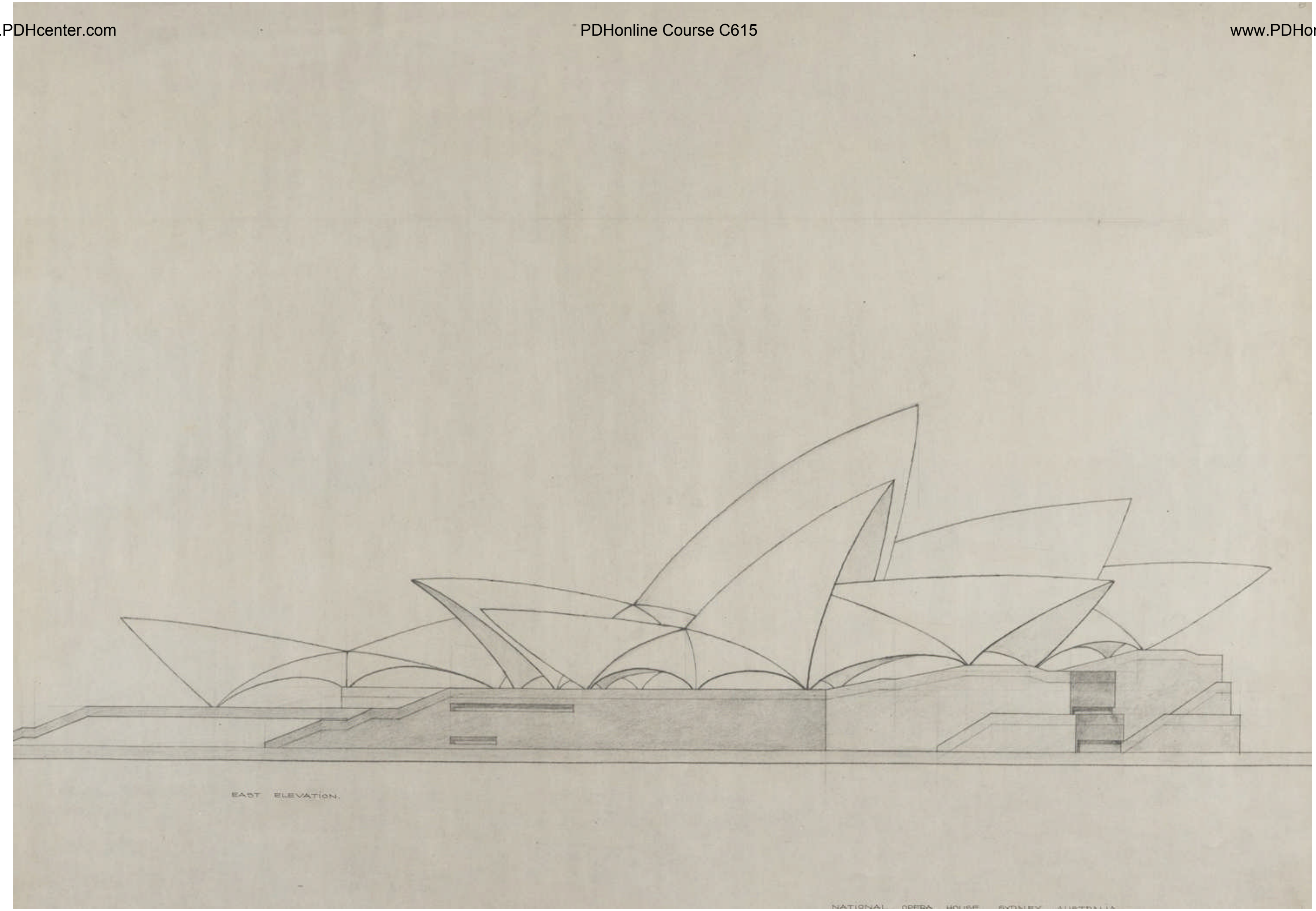
Ground Floor



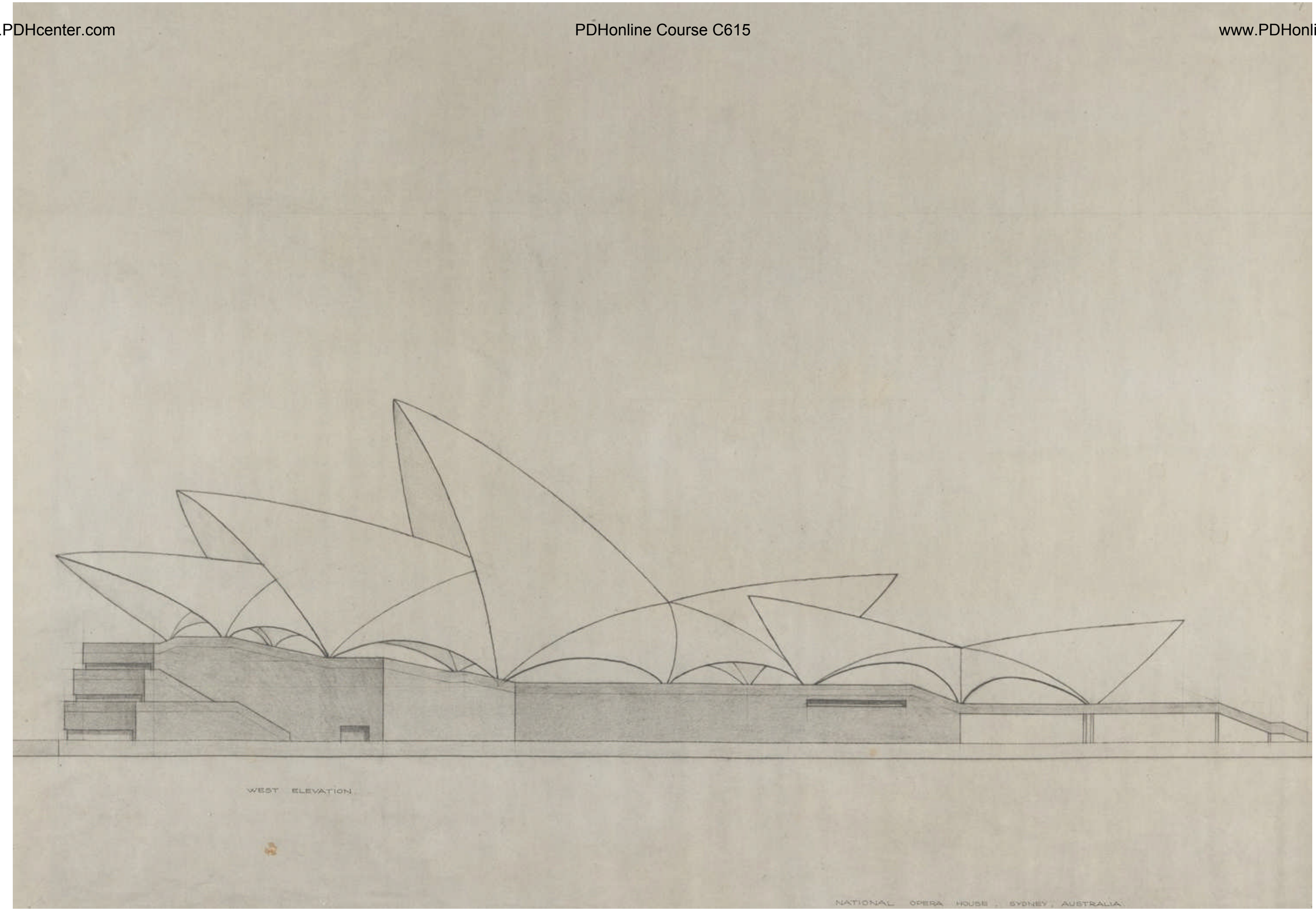
Second Floor



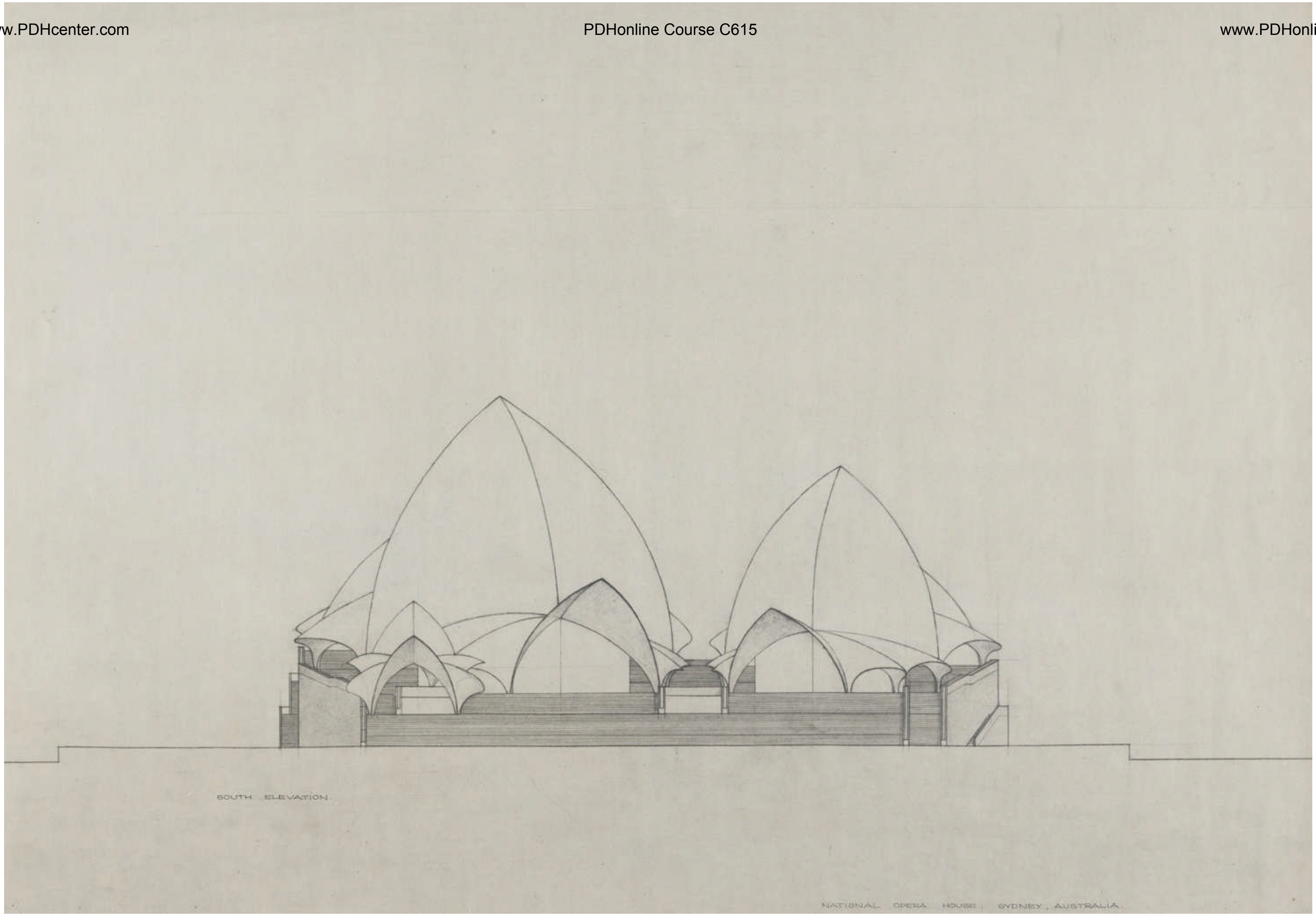
Third Floor (Main Floor)



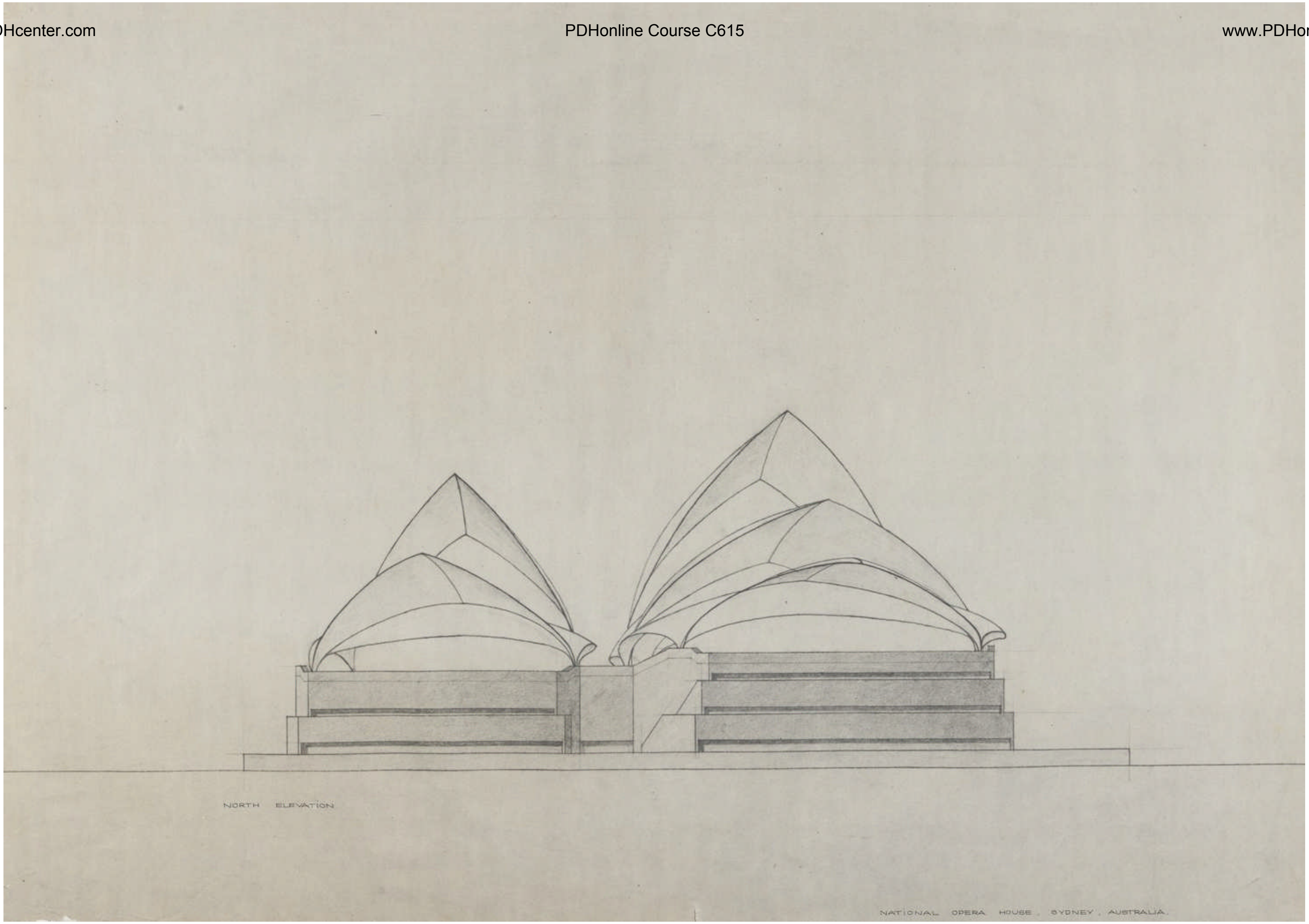
East Elevation



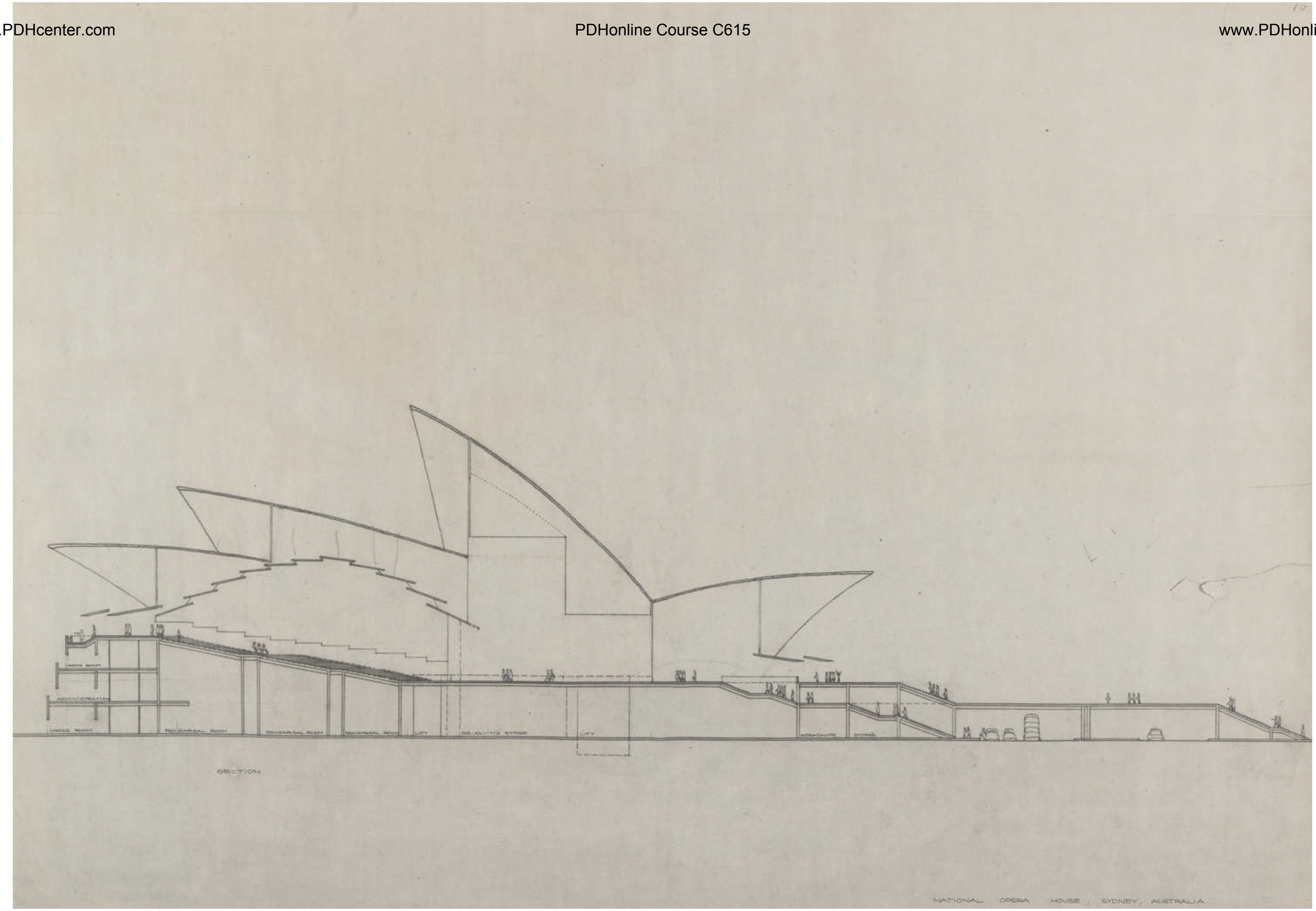
West Elevation



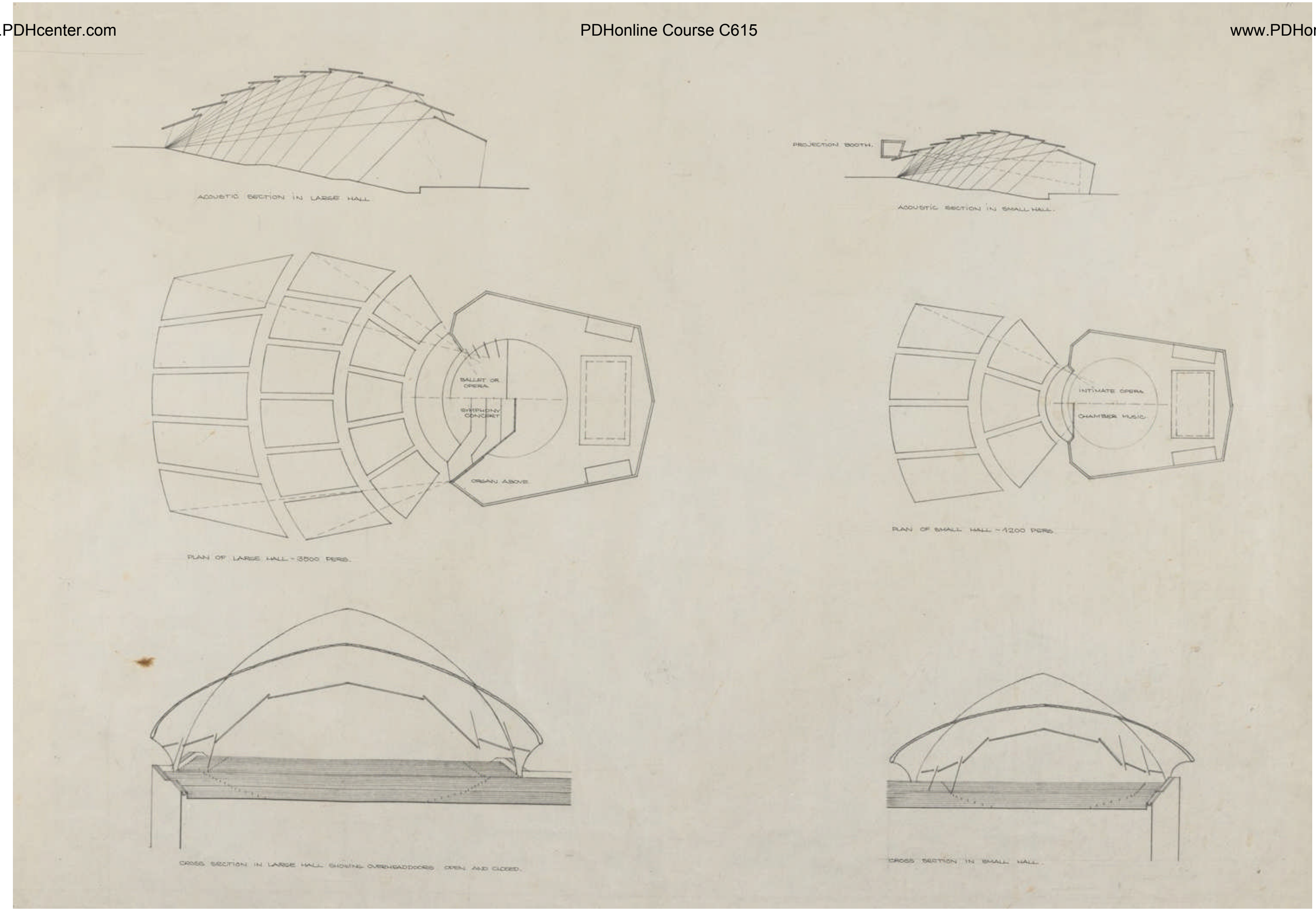
South Elevation



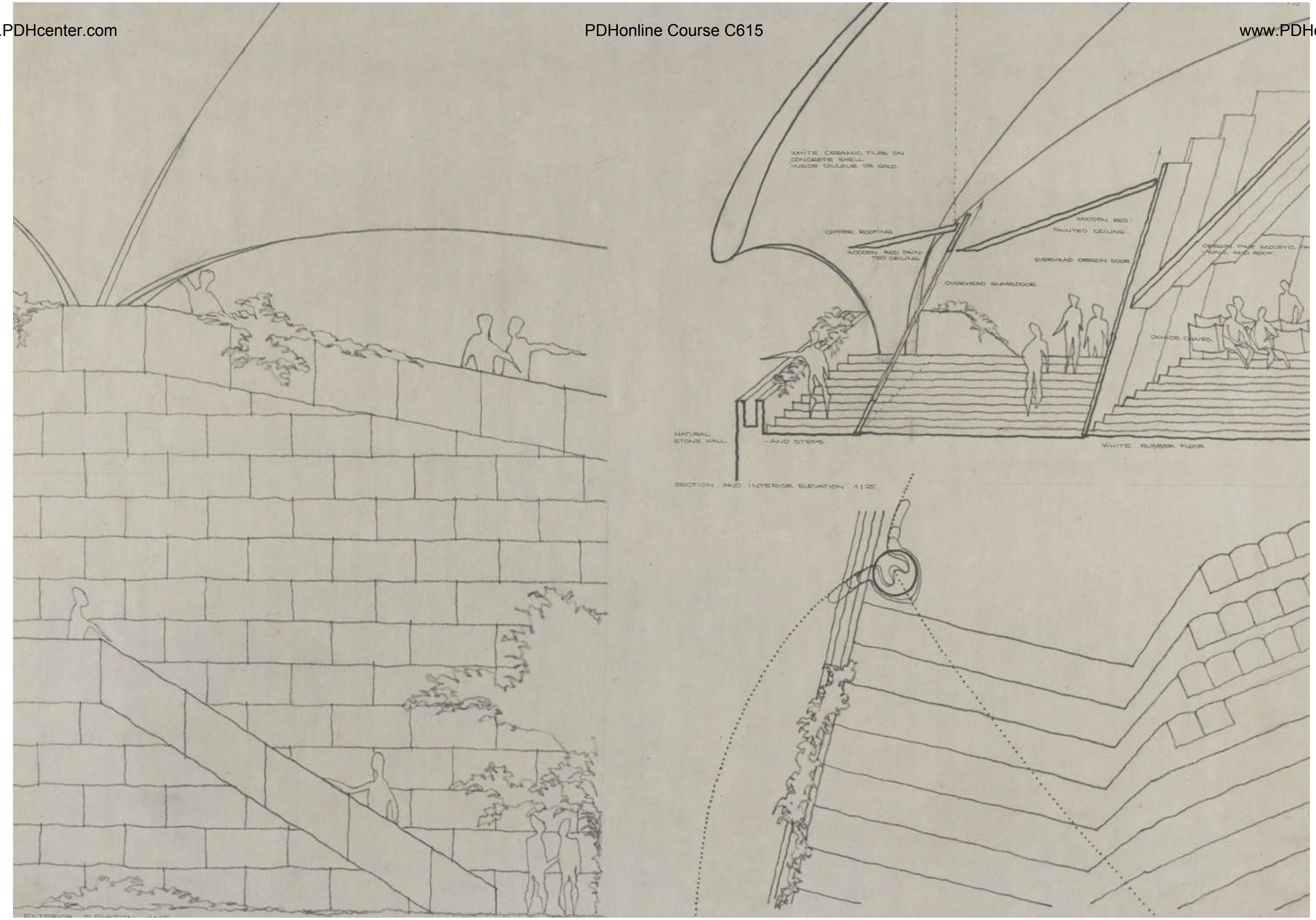
North Elevation


ADMINISTRATION
DRESS ROOM
REHEARSAL ROOM
REHEARSAL ROOM
REHEARSAL ROOM
LIFT
REVOLVING STAGE
LIFT
WORKSHOPS
STORES
SECTION
NATIONAL OPERA HOUSE, SYDNEY, AUSTRALIA

Section



Cross-section in large hall showing overhead doors open and closed



Exterior Elevation

The Talisman

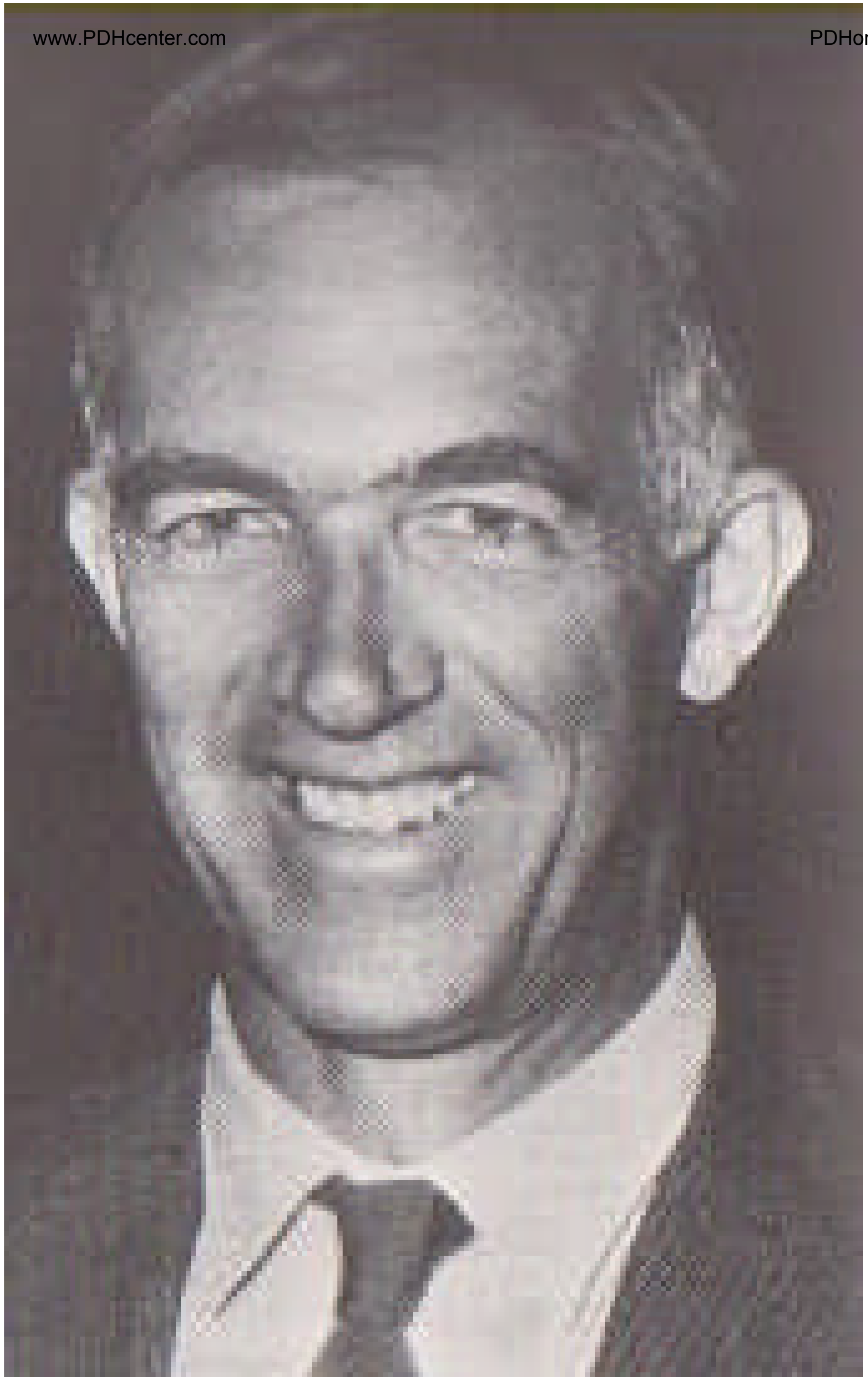
"…The Opera House would be Sydney's Taj Mahal. Thus it became a talisman well before it took form as a structure, and one can hardly think of another building erected since Paxton's Crystal Palace in London (1851) that so mobilized the interest of a major city, becoming a cult object of enthusiasm, dissent, jokes and hobnailed political infighting…"

***Time* magazine, October 8th 1973**

Part 3

The Vikings

He Simply Bowled the Aussies Over



"…And when Utzon himself turned up – tall, handsome, urbane and fired by enthusiasm for his vision – 'he simply bowled the Aussies over,' a colleague recalls. 'He was a film star overnight.' With pride and affection the Australians called him 'The Viking.' He told them the that 'the opera house will be a beautiful white shimmering thing as alive to the eyes as architecture can make anything, set in the blue-green waters of Sydney Harbor.' And he described how its surface of gleaming white tiles would catch the warm evening light and reflect it back with an alpenglow on a mountain peak…"

***Life* Magazine, January 6th 1967**

RE: upon winning the SOH design competition, a women's magazine described Utzon as: *"The Danish Gary Cooper, only better looking."*

Form Follows Function

Born in the waning days of the *First World War* (April 9th 1918), Jorn Utzon grew up in a period of European history that was tumultuous and driven by a desire for change; *cultural, political, artistic, scientific* etc. Utzon's father – *Aage Utzon*, was a prominent and talented naval architect who was director of the *Aalborg Shipyard* and later the *Helsingor Shipyard*. He learned from his father and the world of shipbuilding he was exposed to as a boy how form and function combine for an express purpose; neither wasteful nor dishonest. In 1937, at the age of nineteen, Utzon began his studies in architecture at the *Royal Academy of Arts* in Copenhagen. From the time of his formal education in architecture, Utzon expressed a deep interest in the architecture of ancient civilizations; an interest that would influence his later designs. In 1942, Utzon graduated and left Nazi-occupied Denmark to ply his craft in Sweden. There, he developed an interest in organic theory and forms and was inspired by the landmark work: *On Growth and Form,* by *D'Arcy Wentworth Thompson.* At an exhibition entitled: "America Builds," Utzon was first exposed to the work of "America's Architect" *Frank Lloyd Wright.* Utzon worked briefly with *Alvar Aalto* - the great Scandinavian architect, in 1945. Both Utzon and Aalto combined the traditions of *Nordic Classicism* with modernist principles and were disciples of impressionist/modernist artist/architect *Gunnar Asplund.* In choosing natural surroundings to live and work in, Utzon was following the sage advice of his mentor Alvar Aalto.

"My parents returned home completely carried away by the new ideas and thoughts. They soon commenced in redoing our home...We developed new eating habits...We began to exercise, get fresh air, cultivate light and the direct, so-called natural way of doing things...That's how much architects can bring about, and it came to influence our whole society."

Jorn Utzon, Architect

RE: in 1930, Utzon attended the *Stockholm* (Sweden) *International Exhibition* with his family; all were transformed by the experience. In particular, the architecture of *Gunnar Asplund* left a deep impression on his parents and the then twelve year old Jorn.

"For me it was a great inspiration to talk to Carl Kylberg. He taught me about the introspection in nature that he knew so well. He constantly dealt with this theme in his work: longing and expectation. I repeat it again and again to myself that Kylberg found a great wealth in his inner being, as can anyone who dares to open themselves up. There was a sense of timelessness to him like that of water and life."

Jorn Utzon, Architect

RE: young Utzon developed a passionate interest in graphic design and was very much influenced by the expressionist painter *Carl Kylberg* (1878-1952) and his mystical philosophy. Kylberg (self-portrait at left) introduced Utzon to *Hinduism* and inspired the use of color in his designs.

In the late 1940s, Utzon visited Paris where he met international-style architect *Charles-Edouard Jeanneret*; a.k.a. "Le Corbusier" (The Crow), and the sculptors *Fernand Leger* and *Henri Laurens*. The mud-brick villages of *Morocco* he also visited during this time period inspired his exotic, "craft approach" to architecture and design. In 1949, Utzon won a scholarship that allowed him to visit North and South America. In North America he met architects *Frank Lloyd Wright, Eero Saarinen, Mies van der Rohe* and designer *Charles Eames*. In South America, he was deeply impressed by the *Mesoamerican* ruins. From them, he elaborated in his architecture on ancient ideas of *Procession* and of elevating people up above their daily lives. Inspired by the *Usonian* style of Frank Lloyd Wright, upon his return to Denmark Utzon designed his own house in *Hellebaek* (situated in a Beech-tree forest). This house was his first built-work and was followed by the *Svaneke Water Tower* and *Middleboe House.*

Jorn Utzon's house in Hellebaek, Denmark (1952)

<u>Left</u>: the *Svaneke Water Tower* (1952) in the small town of *Svaneke* on the Danish island of *Bornholm*. It was the first commercial project completed by Utzon.

<u>Above</u>: Middelboe House (1955)

"Almost the only things Utzon had built were sixty-three houses near Elsinore and a smaller housing project near Fredensborg"

Siegfried Gledion, Architectural Historian

RE: between 1944 and 1956, Utzon entered about twenty architectural design competitions, alone or in partnership with other architects. He entered London's (1946) *Crystal Palace* competition (the original, which had been relocated from its 1851 site, burned to the ground in 1936) and even a competition for a *Crematorium*. Though he won seven competitions, none were ever built. In particular, a Swedish competition for affordable "Courtyard Housing" (he won first-prize) was near and dear to his heart. Utzon's design was influenced by Chinese farm houses which were closed to the outside but opened onto a central courtyard. Not to be left at the alter once again, Utzon rolled up his prize-winning plans and confronted the Mayor of *Helsingor* (Sweden) with them. Utzon's gamble paid-off and the Mayor approved what came to be known as the *Kingo Project*. Delivered on-time and on-budget, it led to another housing project (in Denmark): *Fredensborg Houses.* The SOH was the eighth architectural design competition Jorn Utzon had entered and won. This time however, he automatically became the design architect charged with seeing the project through to completion.

"Flowers on the branch of a cherry tree, each turning towards the sun"

Jorn Utzon, Architect

RE: *Kingo Houses* in Helsingor, Denmark (1958). Consisting of sixty-three L-shaped homes (based on the design of traditional Danish farm houses) and featuring central courtyards (left). They were built in rows following the natural contours of the site. Each of the houses was designed to accentuate the best possible conditions for view/s, sunlight and shelter from prevailing winds.

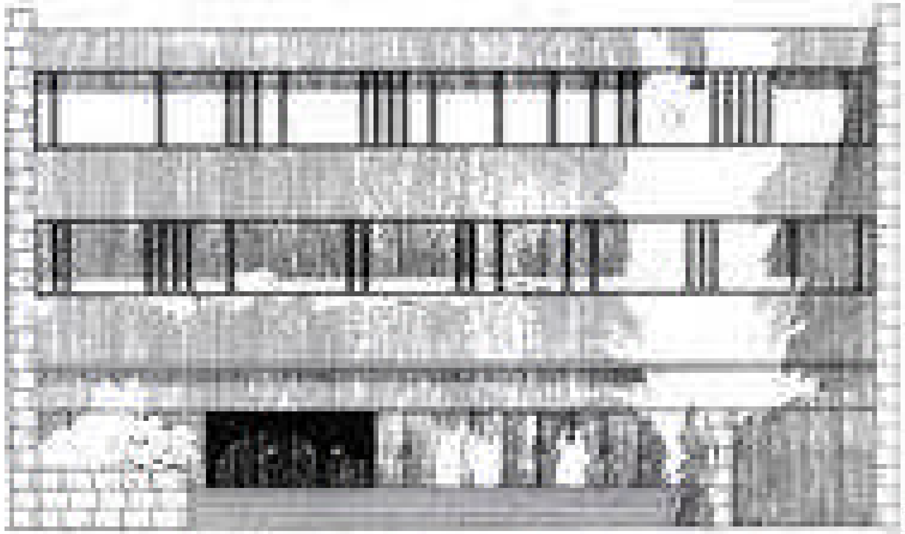
"I have a strange, innate sense for space. I dream a house and then I have it in my head."

Jorn Utzon, Architect

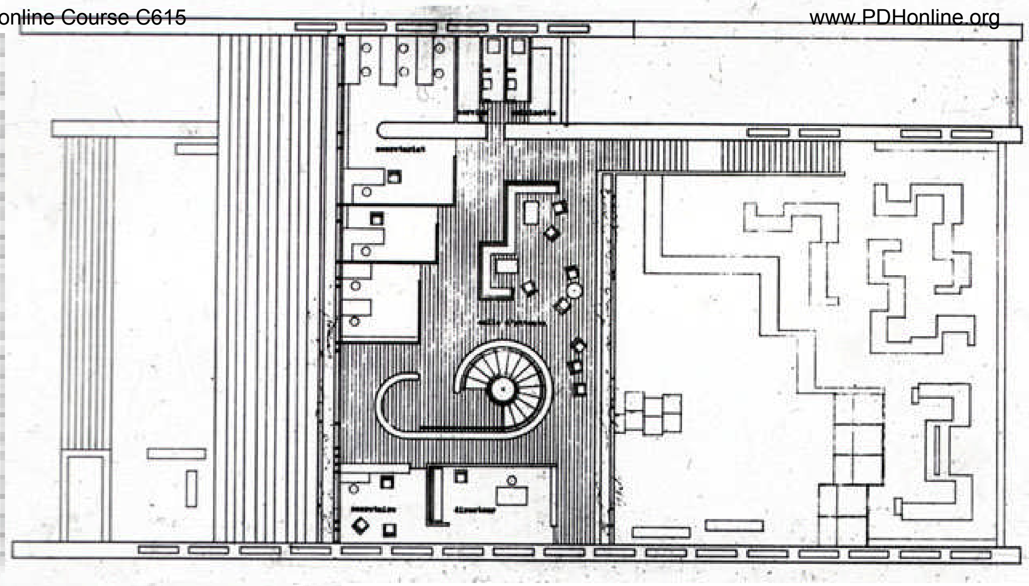
Fredensborg Houses **(1963) was developed for Danish pensioners who had worked abroad for long periods of time. Located in natural surroundings and inspired by housing Utzon observed in Beijing, China's** ***Forbidden City*****, the complex consisted of forty-seven courtyard homes and thirty terraced houses. As well, there was as a central building with a restaurant, meeting rooms and nine guest rooms. The homes were arranged around a square (in groups of three), all with entrances from the square.**

The Edge of the Possible

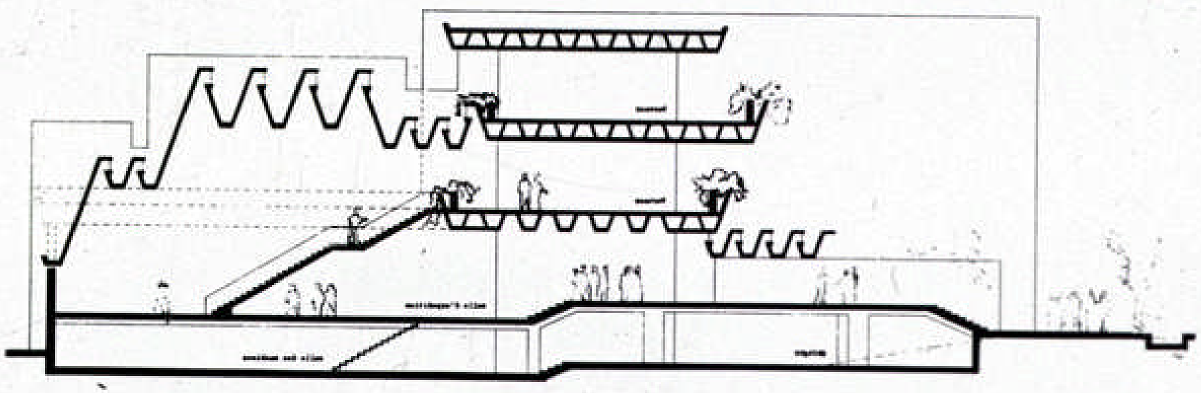
"I like to be absolutely modern and work at the edge of the possible."
Jorn Utzon, Architect



Elevation



Ground Floor Plan



Section

The *Melli Bank* Building (1962) in *Tehran, Iran* has a reinforced concrete frame faced with natural stone. The Ground Floor *Banking Hall* (above) was naturally illuminated by skylight vaults and was connected to the upper floor by a central spiral staircase.

***Hammershoj Care Centre*, Helsingor, Denmark (1966)**

"You can stand on the 14th floor and look at the beautiful sea two kilometers away"

Jorn Utzon, Architect

RE: the *Elineberg Housing Development* (1965) consisting of five mid-rise apartment buildings (located in the residential section of *Elineberg* in *Helsingborg*, southwestern Sweden). The apartments on the higher floors were terraced into slightly different levels, the floor being raised on the entrance side, the lower-level leading through to the balcony. Utzon felt that if the floor was flat, the view would draw attention to the often dull and dreary sky over the *Oresund*.

***Education Center and Prototype House*, Herning, Denmark (1967)**

“A very important influence for a number of architects at that time…without disturbing the serenity and continuity of the whole.”

Richard Johnson, Australian Architect

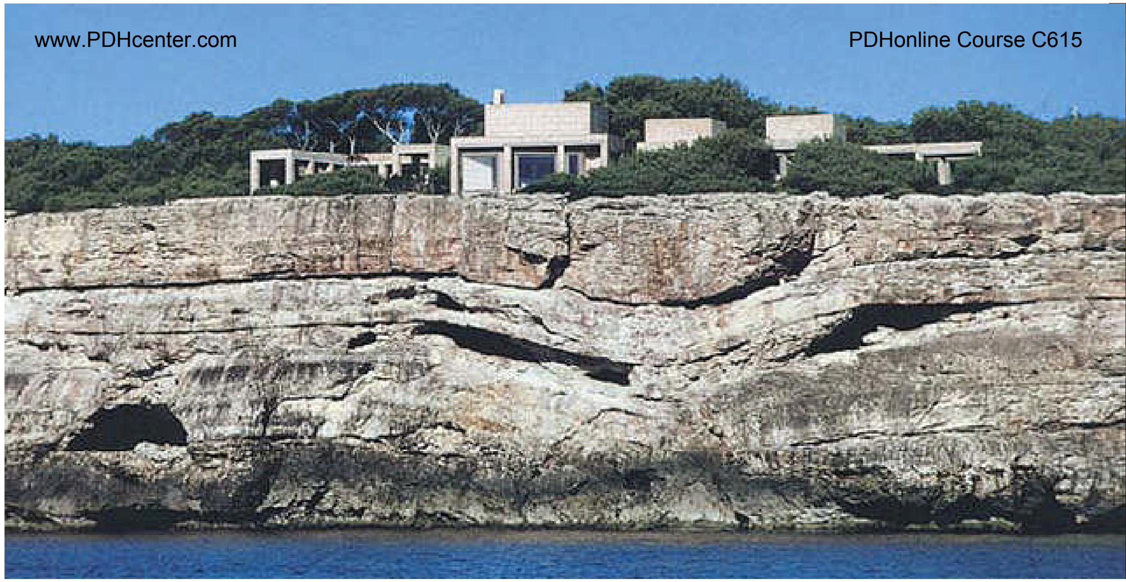
RE: Johnson visited Utzon’s medium-density housing projects in Denmark in the late 1960s. He admired their sense of relationship to the landscape and Utzon’s ability to use standard design elements to provide great variety for each occupant. Johnson would later work with Jorn and Jan Utzon on additions to SOH.

Additive Architecture

"If it grows naturally, the architecture will look after itself"

Jorn Utzon, Architect

RE: Utzon's Nordic sense of design synthesized form, material and function while maintaining a deep respect/concern for nature. Combined with his fascination of the architecture/culture of ancient, exotic civilizations, he termed his architectural style "Additive Architecture," which was akin to the growth patterns found in nature (i.e. trees).



Upon his exile from Australia (in 1966), Utzon stopped on the island of *Majorca*. He decided to build a summer house on top of a cliff near the fishing village of *Portopetro*. Named *Can Lis* (after his wife), the house (above) was based on the home he had intended to build in Australia and was inspired by local materials and climate and set contemporary standards for Mediterranean architecture. The house consists of five linked blocks with a colonnaded outdoor area (above). Utzon and his wife became disturbed by all the tourists who came to see their home while they were in Majorca. They decided to move to a more remote area where they built a second house; *Can Feliz*, also consisting of three blocks for dining, living and sleeping and separated by open courtyards.

"Such a calming, restful, tranquil, inspiring place, sitting in the landscape in a way that seems so inevitable, that it seems to have grown out of the land itself or to have been there for centuries. When I first came there it was by car and it was raining and I thought at first I had arrived at a traditional farmhouse, then I realized when I could see it better that it was, of course, an Utzon house but it had such a gentle, profound relationship with the Majorcan tradition of building, and with the land itself."

Richard Johnson, Australian Architect

RE: Utzon's second home on Majorca (Can Feliz). At left, *Can Lis* (the Utzon's first home on the Spanish island (1973)

Divine Inspiration

"Each commission displays a continuing development of ideas both subtle and bold...that cohere...to push the boundaries of architecture toward the present. This has produced a range of work from the sculptural abstraction of the Sydney Opera House to handsome, humane housing and a church that remains a masterwork today."

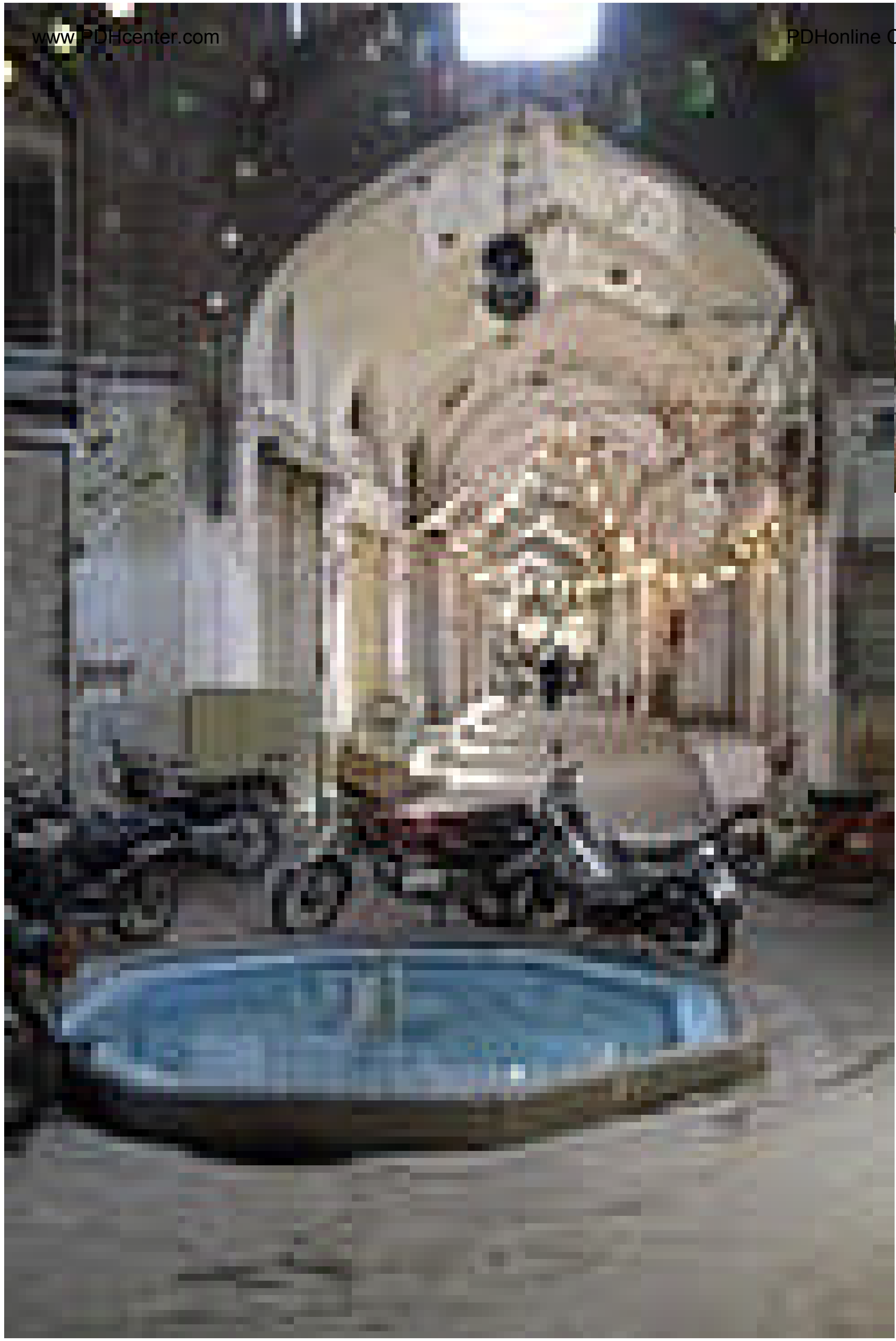
Ada Louise Huxtable, Architectural Critic

RE: *Bagsvaerd Church* (above), Copenhagen, Denmark (1976)

"There I stood, and was offered the finest task an architect can have - a magnificent time when it was the light from above that showed us the way…the inspiration that I derived from the drifting clouds above the sea and the shore forming a wondrous space in which the light fell through the ceiling - the clouds - down on to the floor represented by the shore and the sea."

RE: *Bagsvaerd Church,* Copenhagen, (1968) 180

Haze and White Light and an Untidy Town Behind



"We had the idea of constructing the building around a central hall, a bazaar street, in such a way that all departments met inside roads off the bazaar road, just as we know from the bazaars in the Middle East and North Africa..."

Jorn Utzon, Architect

RE: in 1959, Utzon visited *Isfahan, Iran* where he was impressed by the structure of the town. The Islam-inspired design of the *Kuwait National Assembly* (above, 1982) with its central axis (in the form of a covered main street) are reminiscent of Isfahan's dome-covered *Bazaar* (left)

"Walking in a Danish beech forest is like going through a hall of pillars. This hall of pillars dissolves into branches and into a leafy crown represented by the roof."

Jorn Utzon, Architect

RE: his inspiration for the design of *Paustian House* (1987), a large furniture showroom located on the waterfront in *Copenhagen*. Utzon's son (Kim) designed two adjacent buildings which were completed in the year 2000.

"My father has always found inspiration in nature. When we walked through the forest around my childhood home my father would often point out certain trees and say, 'Jan, go and check the distance between those trees, those would be nice. That seems to be a pleasant distance for columns.' or they had the right size or he said, 'look at how the sun shines through a hole in the forest canopy onto the forest floor.' In nature you find leaves and branches and lots of elements that are all little structures of big structures in their own right and those structures have been a great source of inspiration for my father. At one stage when the lake had frozen over and there was a slight covering of snow, my father took all his architect employees on a tour on the ice creating foot steps in the snow forming lines trying to mark out the Sydney Opera House floor plan in full scale just to see what it would feel like and how big it really was. Something you can not really grasp when you sit working on a piece of paper with a pencil."

Jan Utzon, Architect

Last Hurrah

"From the bottom of my heart, I hope that the Utzon Center will be a place where positive thoughts converge and where students from the School of Architecture gather when they want to get together to discuss their ideas. It is intended to be a power centre for the architects and people of the future"

Jorn Utzon, Architect

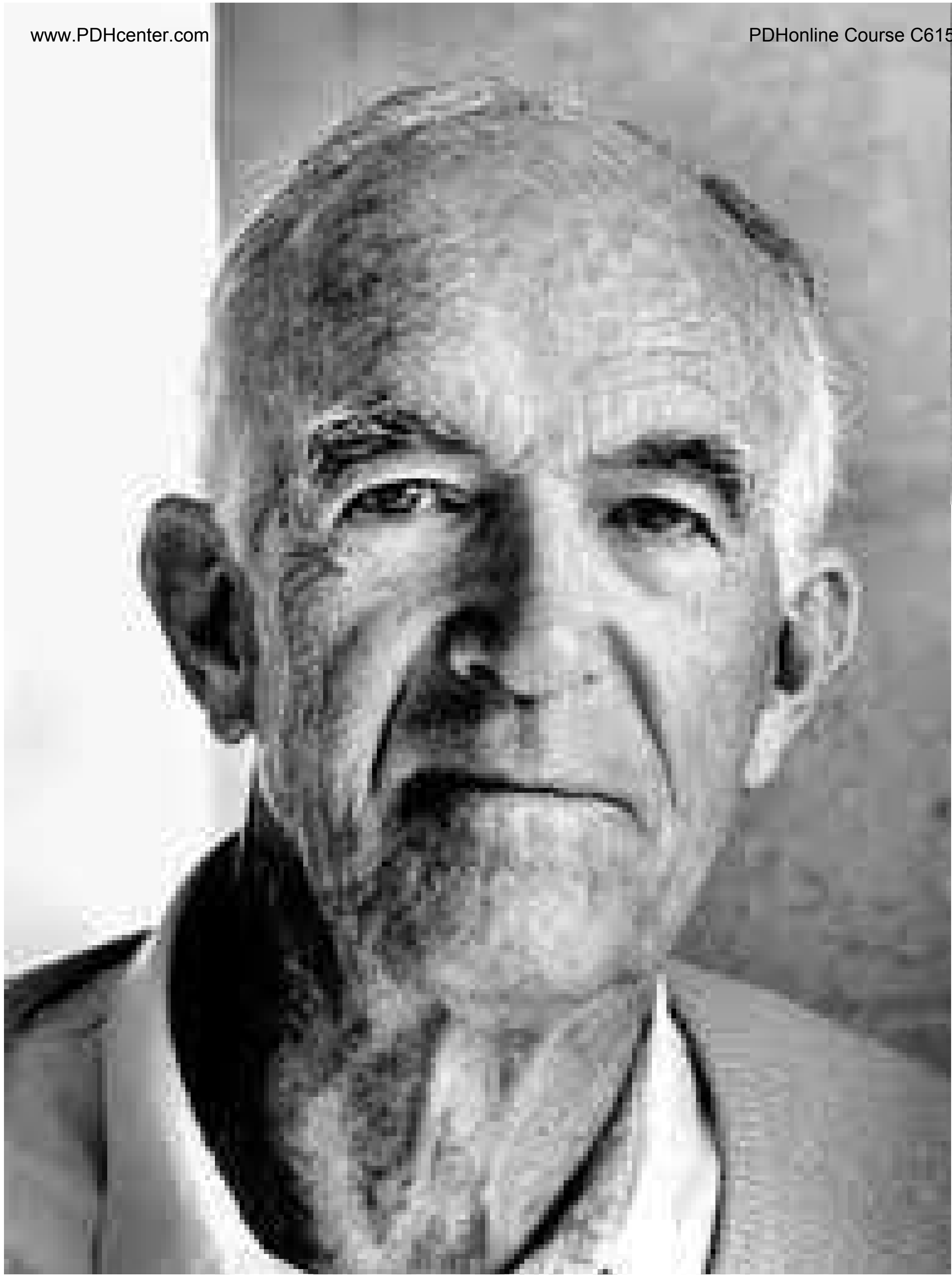
RE: The *Utzon Center* in *Aalborg*, *Denmark*. A joint collaborative effort with his son Kim, it was the architect of the Sydney Opera House's last project prior to his death on November 29th 2008. Utzon never returned to Australia to see the completed SOH; the pinnacle of his life's work. On December 2nd 2008, the Parliament of New South Wales passed a special motion of condolence to honor Jorn Utzon's life and work.

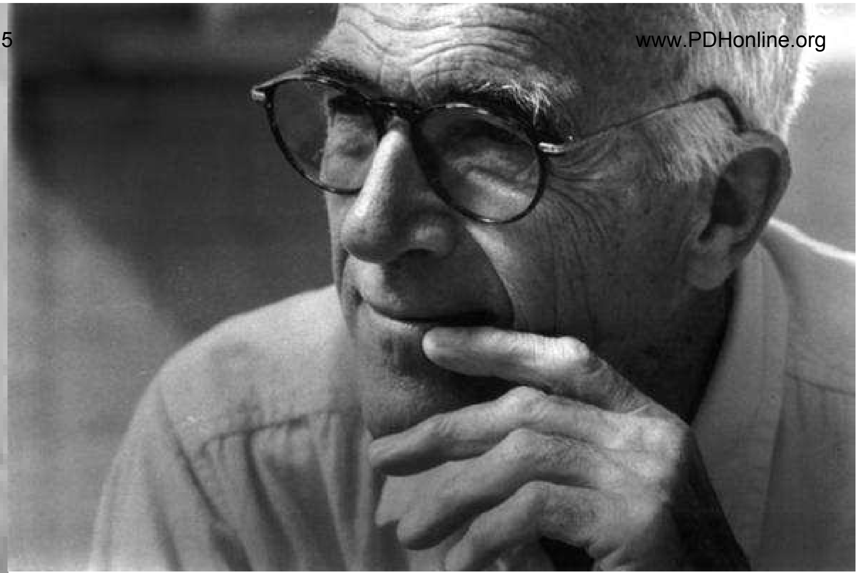
The Utzon Center in Aalborg. Utzon conceived the center as a place where students of architecture could meet and discuss their ideas for the future. Located on the *Limfjord* waterfront in the city where Jorn Utzon spent his childhood. Completed in 2008, his son Kim provided the final construction drawings. Both of his sons (Jan and Kim) are architects and his daughter (Lin) is a designer, muralist and artist.

"Nothing escaped his keen eye. He observed the world around him with extraordinary clearness. From all these sources of inspiration, be it the pyramids of Mexico, the temple compounds of China, the half-timbered farms of Denmark, the branch of a tree, the leaf on a flower, a stone from the beach, the pattern in the snow, the slant of the sunlight, from music, sculpture, paintings and the humanistic thinking by great philosophers, he created a world of his own, a legacy of great and modest buildings that are ours to enjoy, far beyond his lifetime."

Jan Utzon, Architect

RE: remembering his father – *Jorn Oberg Utzon*, upon his death in November 2008





"The architect's gift to society is to bring joy to the people from the surroundings he creates"

Jorn Utzon, Architect
1918-2008

Philosopher Engineer

Within days of NSW Premier Cahill's announcement that a design had been selected from the international competition, news of Utzon's winning design was published around the world. The next day, *Ove Arup* read the announcement in *The Times* of London. Arup wrote Utzon (from his Dublin, Ireland office) to congratulate him and offer the services of his firm; *Ove Arup and Partners, Consulting Engineers*. By 1957, the firm (founded by Arup) was well established and widely respected in the architecture/engineering community worldwide. The fact that the winning design belonged to a fellow Dane had aroused Ove Arup's interest greatly.

Though he was born in Newcastle, England (1895), his father was a Danish veterinary surgeon and his mother was Norwegian. He attended boarding school in Denmark and studied philosophy at *Copenhagen University*. In 1918, he enrolled in an engineering program at the *Technical University of Denmark,* graduating in 1922 with a specialization in reinforced concrete design. He began working for a Danish consulting firm based in *Hamburg, Germany* and in late 1923, he moved to their London office to assume the position of Chief Engineer. He built-up his experience and contacts working as a consultant and chief designer in the following years and in 1938, he founded: *Arup & Arup Limited*, Engineers and Contractors, with his cousin *Arne Arup*. During WWII, Arup designed bomb shelters and contributed significantly to the design of the *Mulberry* temporary harbors used during the D-Day landings.

"If you don't know who the hell I am you may think it very odd that I write to you. You may be right!"

Ove Arup, Engineer

RE: Arup & Arup Ltd. was dissolved in 1946 and in that same year, *Arup and Partners* was founded as a Civil and Structural Engineering consulting firm. By 1957, Ove Arup and Partners had offices in England, Ireland and numerous African countries. In the congratulatory letter Arup sent to Utzon, he pointed out the fact that one of his firm's partners – *Ronald Jenkins*, was a leading authority on shell structures. Utzon soon arrived in London to meet with two of the competition judges (Leslie Martin and Eero Saarinen) who sent word back to the SOHEC that Utzon was: *"admirably equipped to deal with all matters of design."*

Martin recommended Utzon accept personal responsibility for developing the building's program, but be assisted by an engineering firm to develop the complicated vaults and shells. Martin, Saarinen and Ashworth suggested Ove Arup and his firm serve in this role and the two men met for the first time while Utzon was in London. Twenty-four years his senior, Utzon was impressed with Arup; his philosophy and reputation for working closely with architects in order to blend art and engineering into a final design that appreciated the architect's aesthetic vision. A few weeks later, Utzon agreed that Ove Arup and Partners serve as structural engineering consultants for SOH. Until 1962, Ove Arup would be deeply involved in the design, engineering and construction of the SOH. It was Arup who initially divided the program into three stages and designed the distinctive Concourse beams of the Podium (known as *Stage One* in the construction history of SOH).

ARUP

The collaboration and friendship between Utzon and Arup was key to the story of the SOH, particularly for the paternal figure Ove Arup represented to Utzon. *Arup Associates* was formed in 1963 as a new partnership consisting of a body of architects and engineers working on an equal basis as building designers. Ove Arup, architect/s *Francis Pym* and *Philip Dowson*, and the former partners of Arup and Partners made up the firm. Multi-disciplinary, it was a company which provided engineering, architectural and other services for the built environment. Ultimately, all of the various “Arup” names (starting in 1946) resulted in a firm simply called *Arup*. The SOH, though one of the firms most difficult and contentious projects, made Ove Arup and his firm’s reputation as a world-class engineering consultancy which endures to the present day.

Part 4

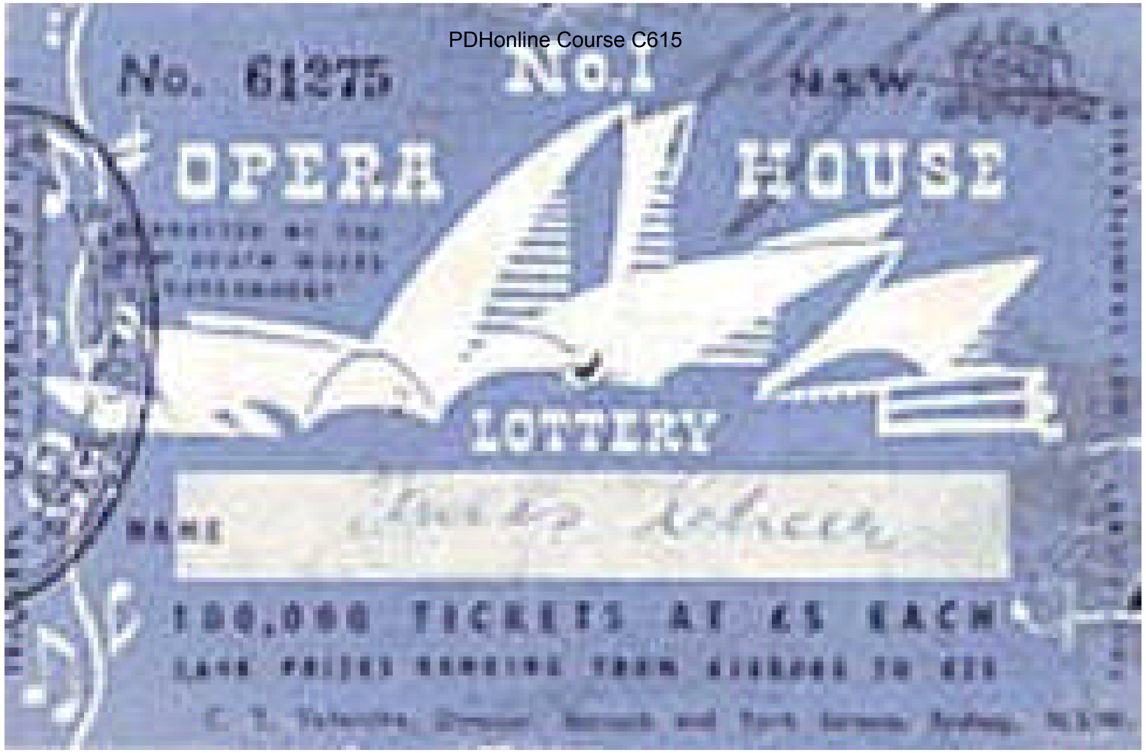
The Red Book

Tax on Suckers

"…Since the structure is being financed by public lottery whose pay-off and overhead absorbs all but a third of its take, the building will ultimately be responsible for almost $200 million dollars' worth of gambling – or approximately $15 a head for every man, woman and child in the nation…"

***Life* Magazine, January 6th 1967**

With the design competition concluded and a world-class design its result, Premier Joseph Cahill had two problems; how to pay for it and preventing a future change in government shelving the project. For the latter, the upcoming election (just two years away) could be problematic. An incoming Conservative government might very well end the SOH project before it ever began or a new Labor government might deem the project elitist and unnecessary. After all, most of the Labor party's constituents were not regular patrons of Grand Opera. Cahill accelerated the start of the project to February 1959 to safeguard the project's viability (prior to the March 1959 elections). For the former problem, Cahill was going to be more creative since "Sydney Opera House" had little appeal to most NSW voters who were more likely to attend a football (soccer) match, horse race or game of Cricket. He wished a less elitist sounding name had been chosen by the SOHEC such as "Sydney Concert Hall" or "Sydney Entertainment Center." As it was, he had to work with the chosen name and convince the taxpayer's to foot the bill for the "Opera House" without alienating his constituency. A small part of the cost would be obtained from donations from the well-heeled *Sydneysiders* who would be patrons of the SOH and some tax revenues could be diverted towards it as well, but the lion's share had to come from another source. Cahill was an astute politician who understood the average voter, he reasoned the order of the day was *quid pro quo*. In May 1957, Cahill announced that the SOH would be funded by a special lottery drawn four-times a year until the SOH was in the black. On July 3rd 1957, the *State Parliamentary Caucus* voted overwhelmingly in favor of building the winning design. An estimated $900K in lottery revenue would be realized before work began supplemented by $200K of public funds.



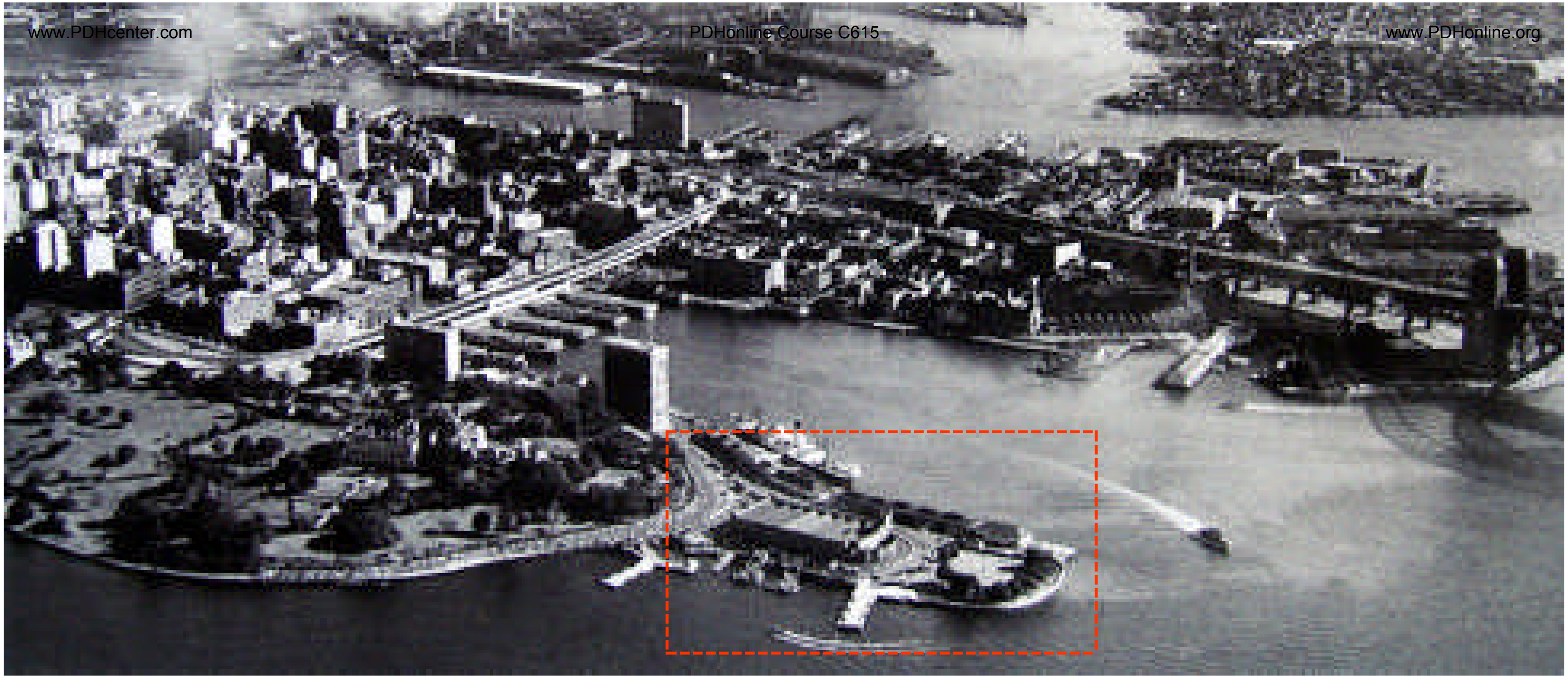
"…In fact, the cost never became a drain on public money; it was mostly defrayed – appropriately, since Australia is a land of gamblers – by a series of state lotteries with a first prize of $280,000. These raised $116.2 million over the years…"

***Time* magazine, October 8th 1973**

RE: the lottery was launched late in 1957 costing $A10 a ticket and offering a first prize of $200K. Paradoxically, the winner of the first drawing of the lottery (Jan. 10th 1958) was one of Sydney's wealthiest citizens.

Hail the Conquering Architect

On the evening of July 29th 1957, Jorn Utzon arrived in Sydney for the first time to meet the members of SOHEC, Premier Cahill and to visit the site. It was unrealistic for most of the international competitors to visit the site since it took three days to fly from London to Sydney in 1957 and cost over 430 (English) pounds. The trip required refueling stops in *Zurich, Istanbul, Karachi, Calcutta, Singapore, Jakarta* and *Darwin*. At his meeting with SOHEC, Utzon was given recommendations for priorities of use and sizes of the two halls which attempted to merge the Brown Book guidelines with Utzon's design which was, in effect, a conceptual work of sculpture that did not meet all the guidelines nor had it yet been assessed by an engineer.



"…This site is even more beautiful than in the photographs from which I worked"

Jorn Utzon, Architect

RE: his reaction to seeing Bennelong Point for the first time during his first visit to Sydney in the summer of 1957. Cahill told Utzon to come to him directly if he needed any problems resolved. When Utzon pointed out that there was a passenger wharf running along the northern wall of Bennelong Point, with one phone call Cahill had it removed.

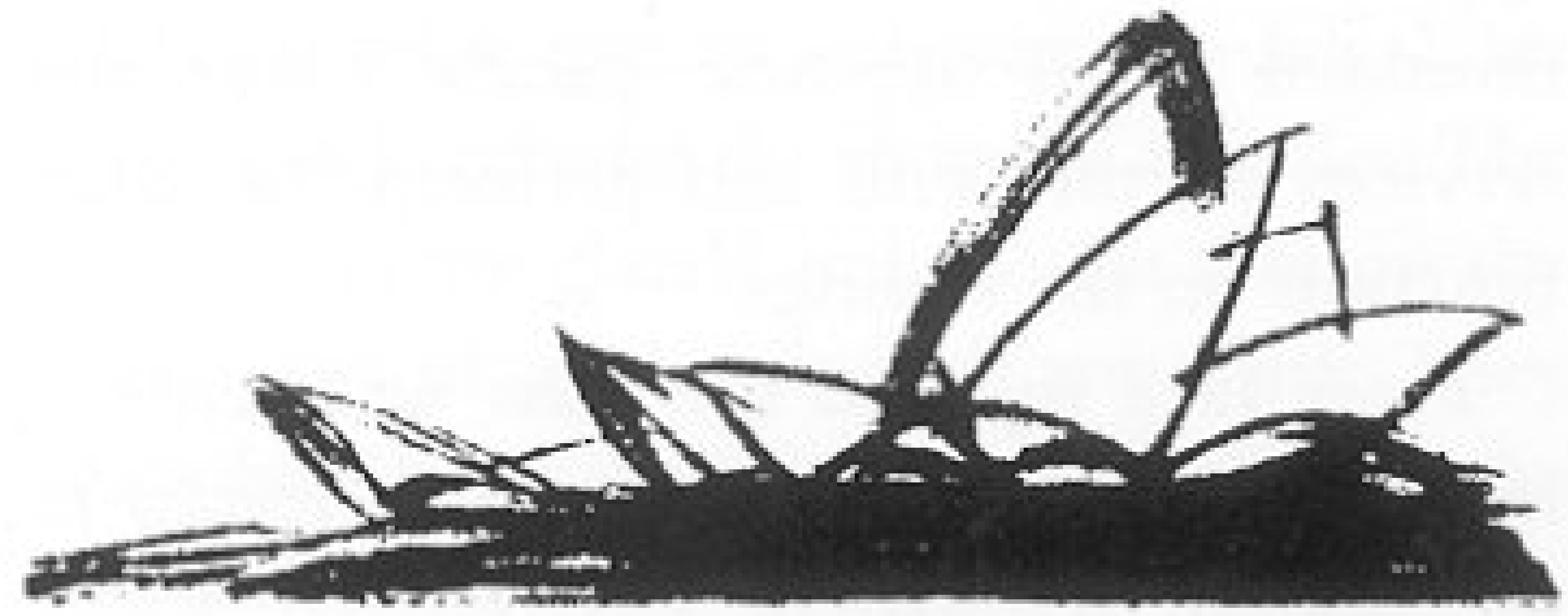
Utzon and SOH design contest collaborator *Professor N.J. Andersson* brought the first model of the SOH with them when they arrived in Sydney on July 29th 1957. On their third day in Sydney, they unpacked the model and prepared it for exhibition in the vestibule of *Sydney Town Hall*.

SOHEC (headed by *Stan Havilland*) now had two advisory panels established to help in decision making. The panels were organized by two of the SOH's original supporters. *Harry Ashworth* led the *Technical Advisory* panel and *Bernard Heinze* convened the *Music and Drama* panel. After meeting with Utzon for the first time, Premier Cahill announced that the *Foundation Stone* for the SOH would be placed in early 1959 and Ove Arup and Partners was on-board as consulting engineer. On August 7th 1957, fundraising efforts began with an event held at Sydney Town Hall. On August 22nd 1957 - after three weeks in Sydney, Utzon departed for Tokyo promising to return in March (1958) with drawings reflecting the advisory panel's requirements. This would become the *Red Book*.

"…But other technical and functional problems were proliferating. There was no provision for parking. There were conflict and confusion over seating requirements. Worst of all, the feasibility of producing an opera in the main hall came into doubt. Utzon had provided only the smallest space for wings and for a while planned to raise the scenery from storage chambers down below in huge, costly elevators…"

Time **magazine, October 8th 1973**

Utzon traveled to Japan and America after leaving Sydney in August 1957. He visited theaters, concert halls and met with noted architects (i.e. *Mies van der Rohe*), and experts in shell/vault design/construction. SOHEC required him to produce new plans within six months of the announcement of his SOH competition victory. These plans (a.k.a. "The Red Book") were presented to SOHEC in March 1958. Prior to submission of the Red Book, several deliberations took place. In November 1957, SOHEC reduced the number of seats required in the main hall (from 3K-to-3,500) to 2,800 for concerts and between 1,700 and 2K for operas. The main hall had been conceived from the very beginning as "dual purpose." In the post-WWII era, such an arrangement was perceived as an inferior approach for performing-arts hall design and are rarely built nowadays. Seating capacity for the halls was problematic throughout the project. From the competition forward, the shape of the roof would not have permitted the required capacities to be accommodated. When Arup requested that Utzon define the curves of the roof, he took a plastic ruler and, holding it perpendicular to a table, made it bend. Utzon traced the curves of the bent ruler and sent them to Ove Arup in London stating these were the shapes he wanted. The first exchanges between Utzon and Arup produced an initial sketch of the roof in which every curve was different, a structurally unsound form with difficult bending moments near its footings. Higher shell profiles would allow far more volume for the stage towers, auditoriums and superior acoustics; all of which had been seriously underestimated in the competition submittals. Utzon re-drew all of the elevations to the new forms and these are indicated in the Red Book. Ridge profiles were much higher and pointed and the end-shell form no longer cantilevered.



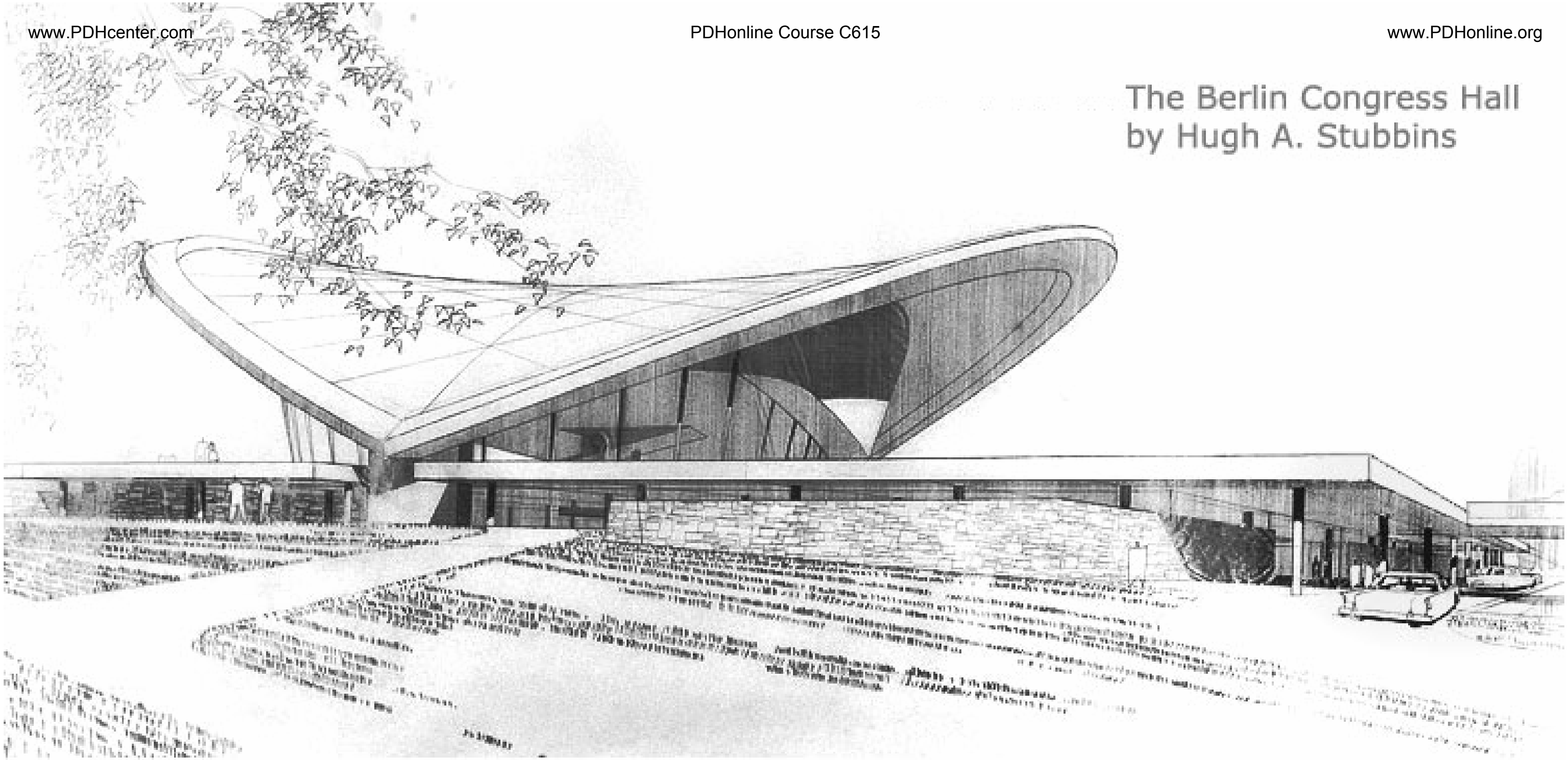
Utzon's original sketch of the SOH roof shells in which every curve is different and each shell unique unto itself

"…The structural design of the latter **(shells)** ***is obviously quite a problem and has only been touched upon. The first task was to define the shape of the shells geometrically. This has been done, at least as far as the main shells are concerned…"***

Ove Arup, Engineer

RE: excerpt from his report in the *Red Book*

Utzon describing an early model of SOH (note the low slung parabolic geometry of the roof shells)



"In Berlin recently, I saw a Congress Hall with such a roof spanning about two hundred and forty feet, and was only three inches thick"
Jorn Utzon, Architect

When Utzon returned to Denmark, he engaged several consultants to aid him in preparation of the Red Book. These consultants broke down as follows;

- **Electrical Installations – *Mogens Balslev***
- **Acoustics – *Vilhem Jordan***
- **Theater Techniques - *Sandro Malmquist***
- **HVAC – *Jorgen Varming***

In the Red Book, Varming compared the shells to parasols having the effect of insulating the halls from solar radiation thus making cooling the interior hall spaces easier than in a conventional theater. Equipment such as fans, vents, A/C and boiler units etc. would be so placed as to minimize noise within the halls and fresh-air would be provided at a rate of 57cubic-meters per person per hour. Malmquist considered the small wing spaces an opportunity stating: *"We have broken out of the snail-shell of the baroque theater and have discovered so many more ways in which to play theatre."* Hydraulic lifts could/would produce a rich, dynamic space on the stage/s while meeting the demands of modern performances whereby scene shifting took place during the performance itself. He noted too that with stage basement space being considerably larger than wing space in SOH, more room for sets could be provided in the building. Varying platform/stage/seating levels were possibilities he found exciting.

"…By means of placing the stage platforms on individually different levels the feeling of the stage floor as a stationary level is eliminated. In the same way in which the modern theatre has worked to treat the theatre stage as a <u>room</u> with horizontal depth effect – with the third dimension – the platform system permits us work also with the possibility of the stage for <u>vertical</u> depth effect…In point of fact this latter form of play-stage is greatly developing as a new form of theatre, and everywhere such experiments have proved artistically to be a very popular feature…"

Sandro Malmquist, Theater Techniques Consultant

RE: excerpt/s from his *Red Book* report

From the Depths of the Night

"…The disposition of the building near the water's edge, will give a striking enhancement to the exterior lighting which will spread out into the darkness in ever changing reflections from the water, as from a bright-lit liner gliding softly into port from the depths of the night."

Mogens Balslev, Electric Installations Consultant

RE: excerpt from his *Red Book* report (conclusion)

Hearing is Believing

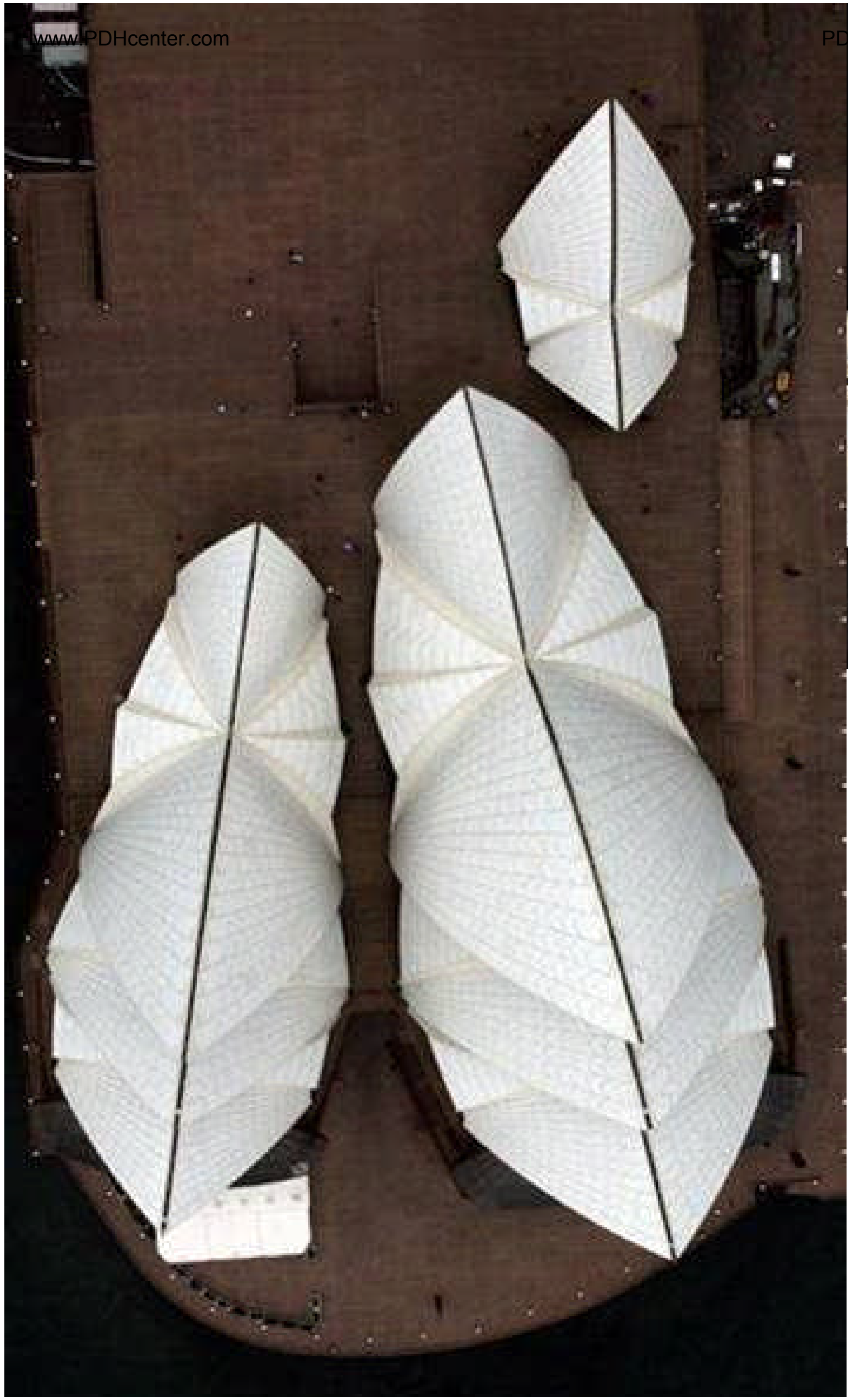
Vilhem Jordan's report outlined the acoustical problems associated with a dual-purpose hall and methods by which they could be overcome. The large (major) hall needed to accommodate the differing reverberation time/s required by symphony concerts and grand opera (reverberation time is the time from the emission of a sound until its absorption by the air, surfaces, people etc.). He described a "hall" as a coupled enclosure featuring stage and seating area/s. If too much sound energy is trapped on stage, there is a resultant deficiency in the seating area and vice-versa. A sound energy deficiency on the stage area is particularly troublesome since the conductor and musicians must hear clearly the sounds they are producing. Based on a major hall volume of 11 cubic-meters per seat, Jordan estimated reverberation time to be 1.8 to 2.0 seconds for symphony concerts and 1.6 to 1.8 seconds for Grand Opera (with part of the hall screened-off). He compared these calculations to other, prominent concert halls such as *Aalborghallen* (in Denmark) with a hall volume of 14 cubic-meters per seat and a reverberation time of 3.0 seconds empty, 1.9 seconds with an audience present. He recommended acoustic panels which could be adjusted/changed (to fine-tune reverberation time) be installed on the upper side and back walls. For the minor (small) hall, he recommended reverberation times of between 1.3 and 1.6 seconds. He also went on to describe how a 1:10 scale model could be used effectively to test acoustics. Recorded music played at 10x normal speed and recorded in the model's seating area and played back at normal speed would provide a reliable indication of the hall/s acoustic properties. He addressed acoustic details for other building areas/components and outlined two separate foundations and two structural layers to minimize inter-hall and/or exterior noise transmission.

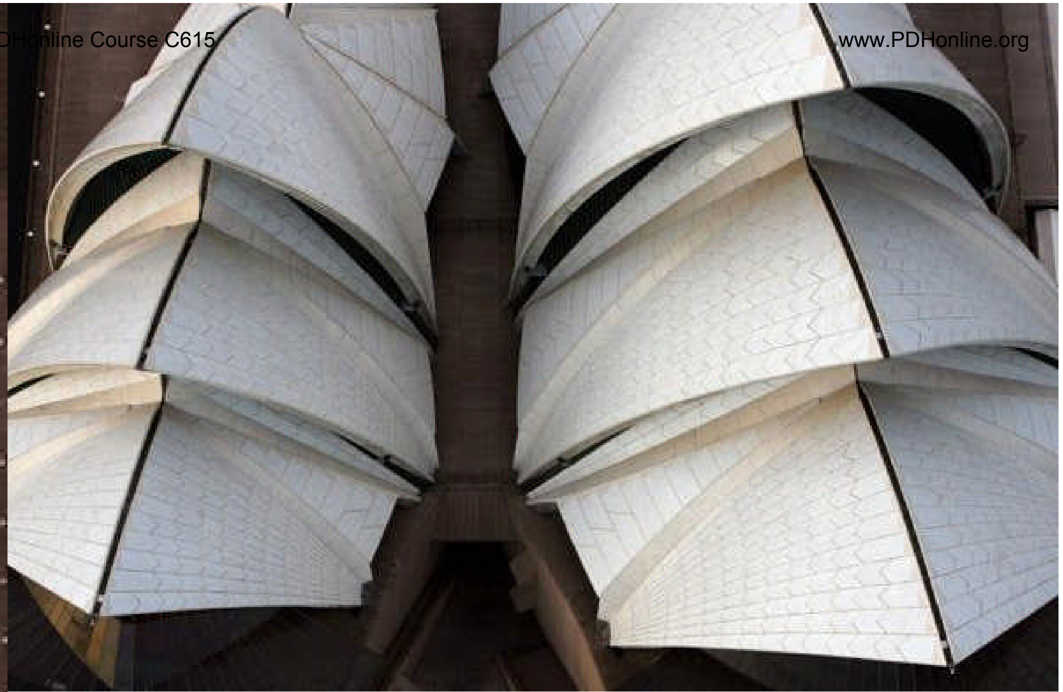
"…A noise survey of the site should be undertaken with as little delay as possible, because noise figures have influence upon the calculation of the sound insulation of outer walls, shells, glass partitions etc. It is emphasized that a model research of major and minor hall is particularly valuable for investigating sound distribution, reverberation process (first slope) and the 'building-up-process' of sound pulses. Complete structural independence of the buildings of major and minor hall and of all the interconnecting piping, wiring, ducts etc. is a condition, which should be fulfilled to ensure proper sound insulation between the two halls. Also the little theater should have separate foundations, walls and roof. Noise from all technical services should not exceed a background noise level of more than 20-25 db in any of the halls. A sound amplification system for the entire building is indispensable and a thorough planning of this system should be part of this whole project."

Vilhem Jordan, Acoustics Consultant

RE: excerpt from his *Red Book* report (conclusion)

The Parabola Problem





Ove Arup and his firm served Utzon as consultant on all structural matters, particularly the roof shells. Arup described the shells as a series of symmetrical co-axial parabolas joined at a ridge line along the top. He used the analogy of a stone thrown horizontally from a cliff to describe the curve of the shells; flat at the top, steep at the bottom. He recommended extensive model testing be performed due to concerns of extreme bending moments based on preliminary calculations.

"…Each of the main shells consists of two symmetrical halves meeting in a ridge in the vertical plane going through the longitudinal axis of the Hall. This ridge is part of a parabola. The two symmetrical surfaces meeting in this ridge are roughly triangular in shape and descend on each side to a point which forms a support for the shells. These surfaces are formed by a series of coaxial parabolas with a common axis in the line between the two supporting points at ground level. All these parabolas therefore meet at the point of support and at this point are perpendicular to the horizontal axis…From a preliminary calculation it is obvious that the bending moments in the shells will be considerable owing to the heavy wind loads and it has been decided to provide the main shells on the inside with a series of ribs fanning out from the two supporting points and meeting at the ridge at the top…"

Ove Arup, Engineer

RE: excerpt from his report in *The Red Book*

Utzon's last model (1966) of the dual-purpose major hall (showing shell rib structure). The model was formally donated by Jorn Utzon's daughter; *Lin Utzon* (top right), at a ceremony held inside SOH.

When Utzon returned to Sydney in March of 1958 to deliver (along with Ove Arup) the Red Book to Premier Cahill and the SOHEC, he also met with Charles Moses (of ABC) and *Hugh Hunt*, Executive Director of the *Elizabethan Theater Trust* (now *Opera Australia*). ABC was the sponsor of the SSO thus it would be the primary client of the major hall. With 10K subscribers to satisfy, more seats meant more revenue per each SSO performance. The Red Book provided two seating options for the major hall;

- **2,700 seats (w/o a balcony)**
- **3K seats (w/balcony)**

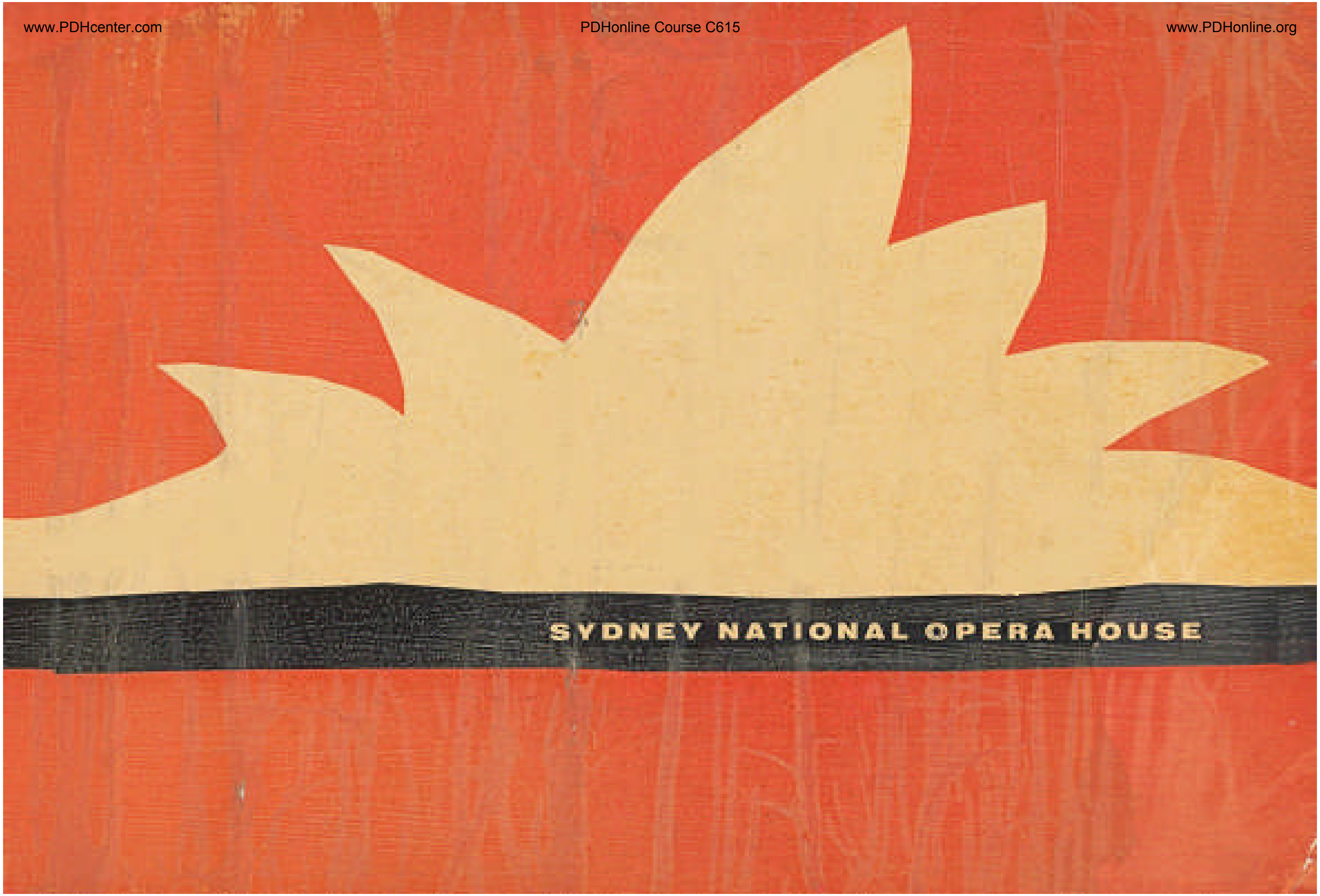
For acoustical reasons, Utzon recommended against the inclusion of a balcony which Moses accepted on condition that the capacity be upgraded to 2,850. Town Hall could seat 2,350 thus, this represented an additional 500 seats in the new SOH venue. Even so, it was well below the 3K-3,500 seating capacity Goossens recommended and the *Brown Book* required. To accommodate Grand Opera performances (which require a larger stage), rows of seats in the front of the hall would be removed and floor sections hydraulically raised (to stage level) thus providing a seating capacity of 1,826. In later meetings, the major/minor hall seating capacity was changed to 2,800/1,200 for concerts and 1,700/1,100 for Grand Operas respectively (with a row spacing of 90cm).

Red Book

This 1958 report (known also as the Red Book) was presented by Jorn Utzon to the Premier and the Opera House Committee in order to:

“give…a project which realizes in practical form the vision of the competition”

The report comprises: plans, sections, elevations, photographs of models of the Opera House; reports by other consultants on acoustics (V.L. Jordan), mechanical services (J. Varming), electrical installations (M. Balslev) and theatre technique (S. Malmquist).



Front Cover

SYDNEY NATIONAL OPERA HOUSE

ARCHITECT JØRN UTZON

CONSULTANTS

STRUCTURES	OVE ARUP
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ELECTRICAL INSTALLATIONS	M. BALSLEV
THEATRE TECHNIQUE	S. MALMQUIST

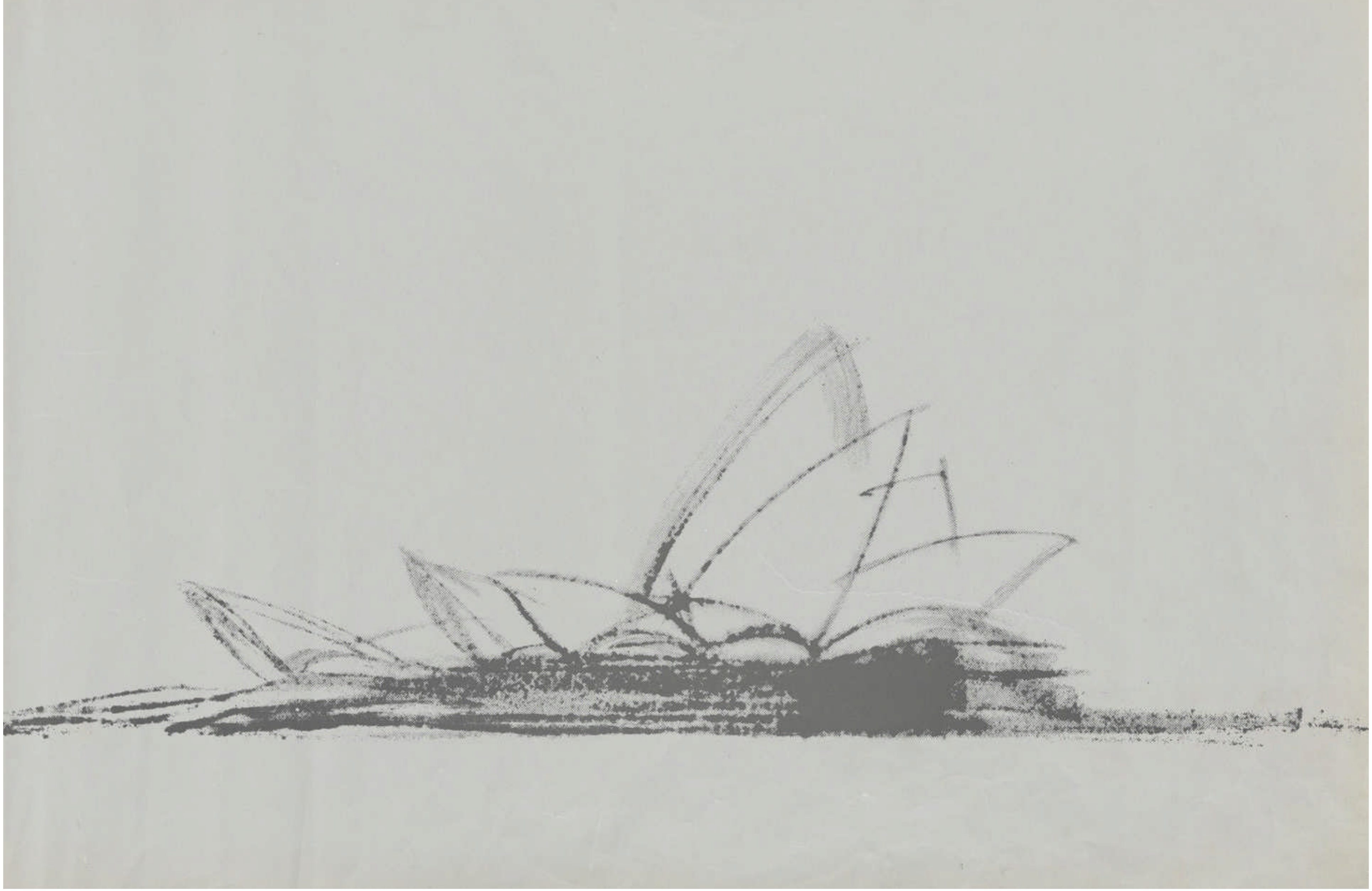
Inside Cover

I am happy that with this book I am able to give the Premier, the Right Honourable J.J.Cahill and the Opera House Committee a project which realises in a practical form the vision of the competition.

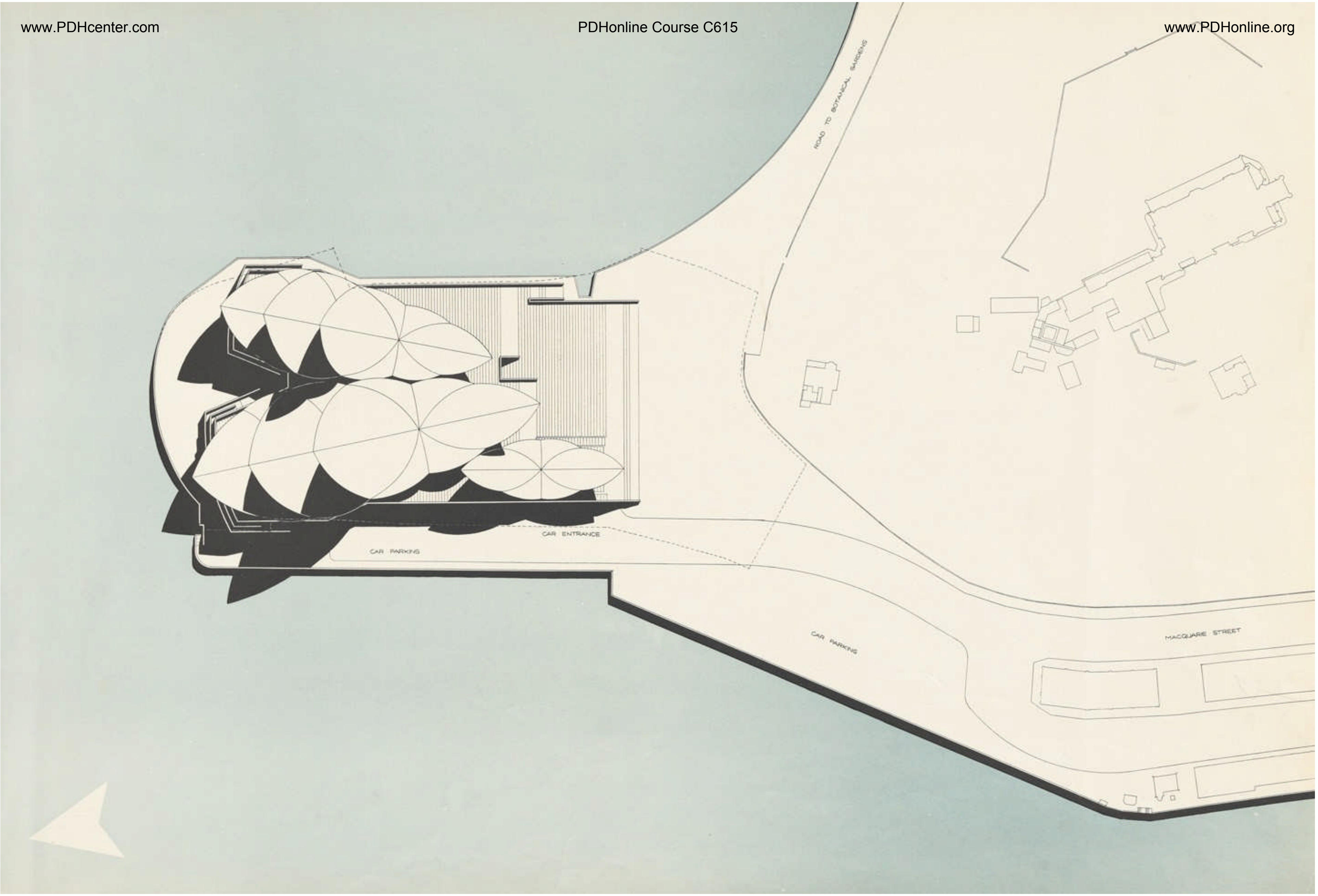
After interesting and intense work with the various specialists, we are convinced that the far seeing aspirations and efforts of the Committee, sponsors and other supporters of the scheme can be crystallised in a building which, in a functional, festive and inspiring manner will shelter the activities and the life lived within it, and in doing so enhance the face of Sydney.

Jørn Utzon
march 1958

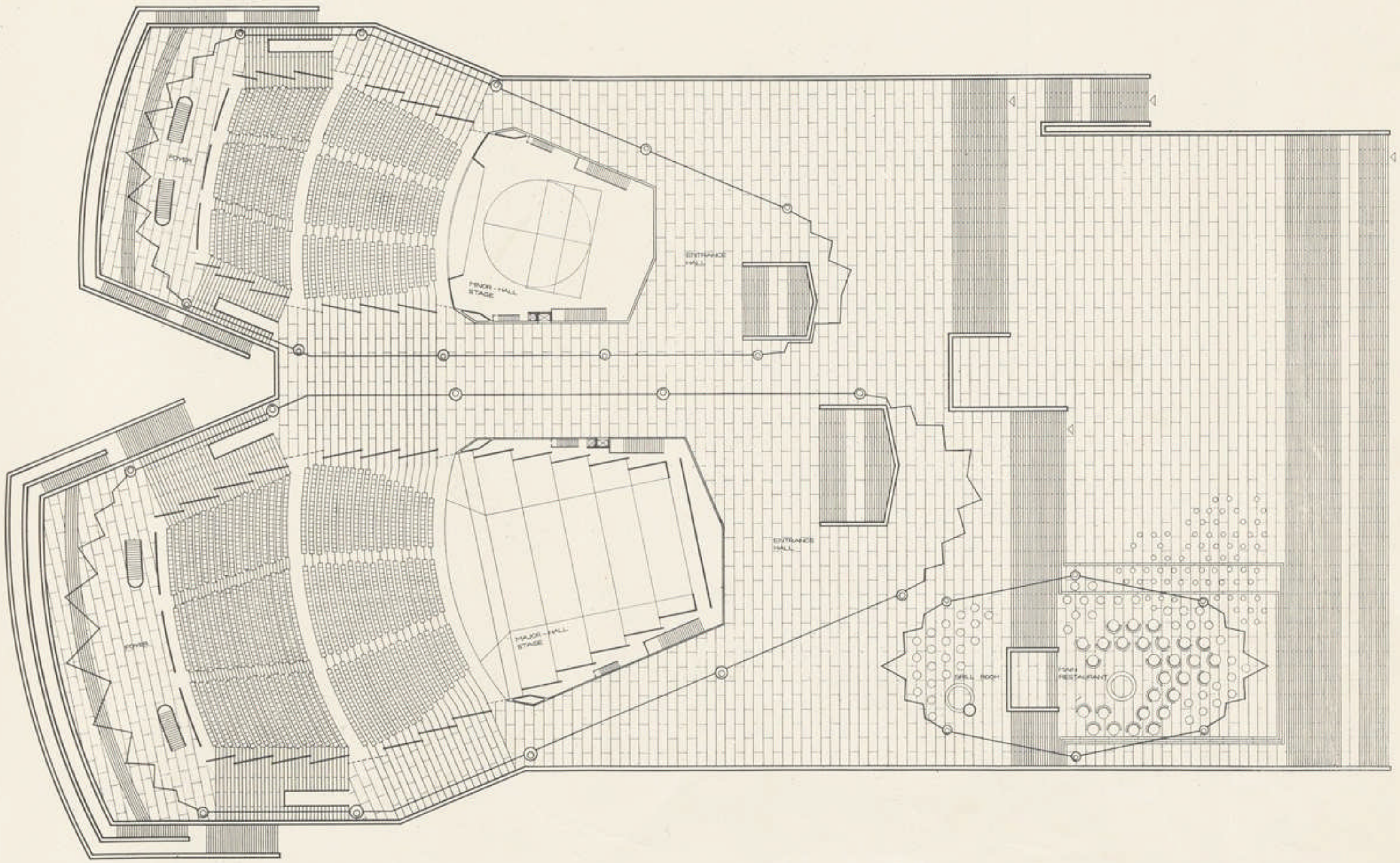
Message by Jorn Utzon. *"I am happy that with this book I am able to give the Premier...and the Opera House Committee a project which realizes in a practical form the vision of the competition...a building which, in a functional, festive and inspiring manner will shelter the activities and the life lived within it, and in doing so enhance the face of Sydney."*



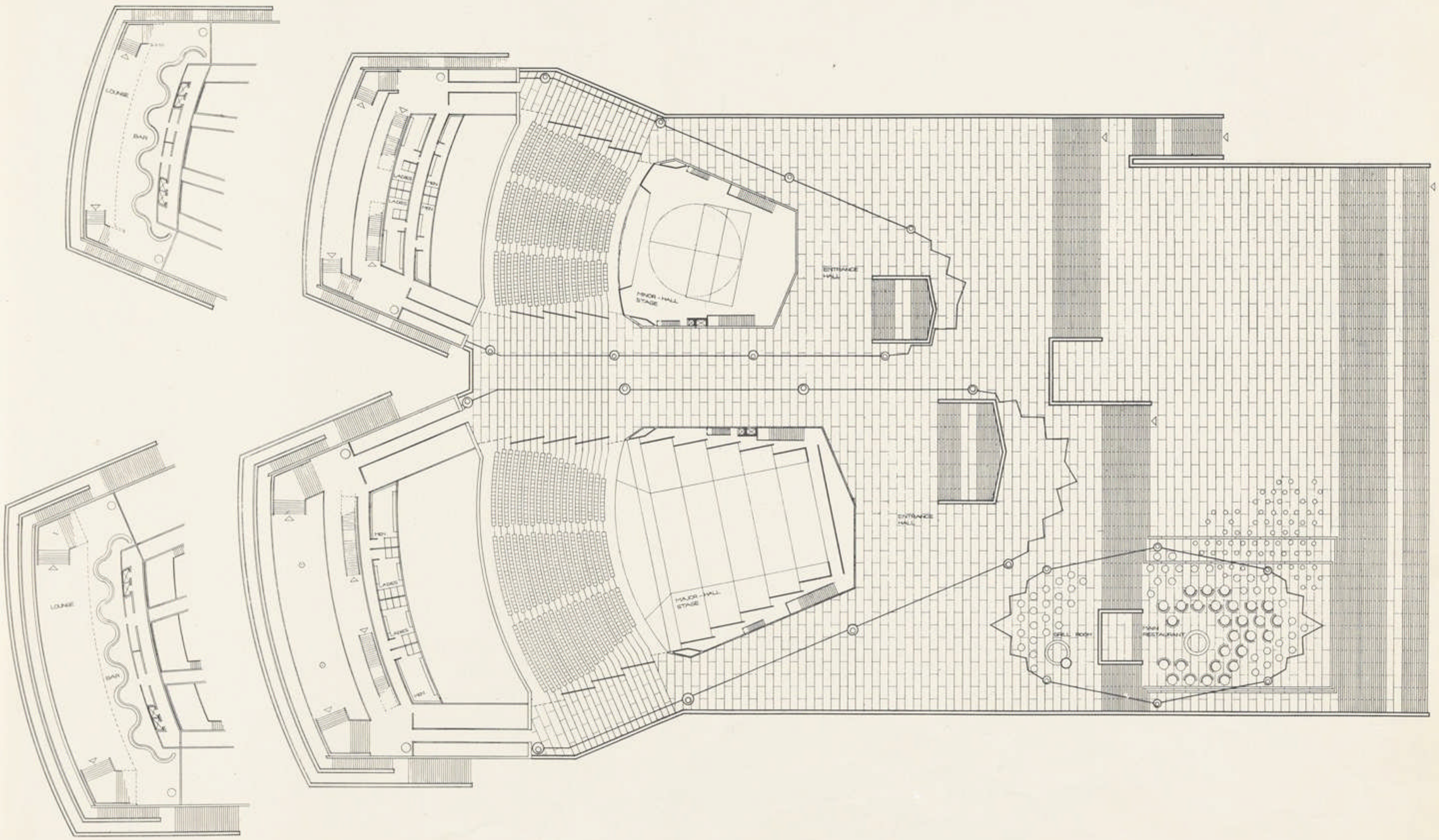
Sketch


ROAD TO BOTANICAL GARDENS
CAR PARKING
CAR ENTRANCE
CAR PARKING
MACQUARIE STREET

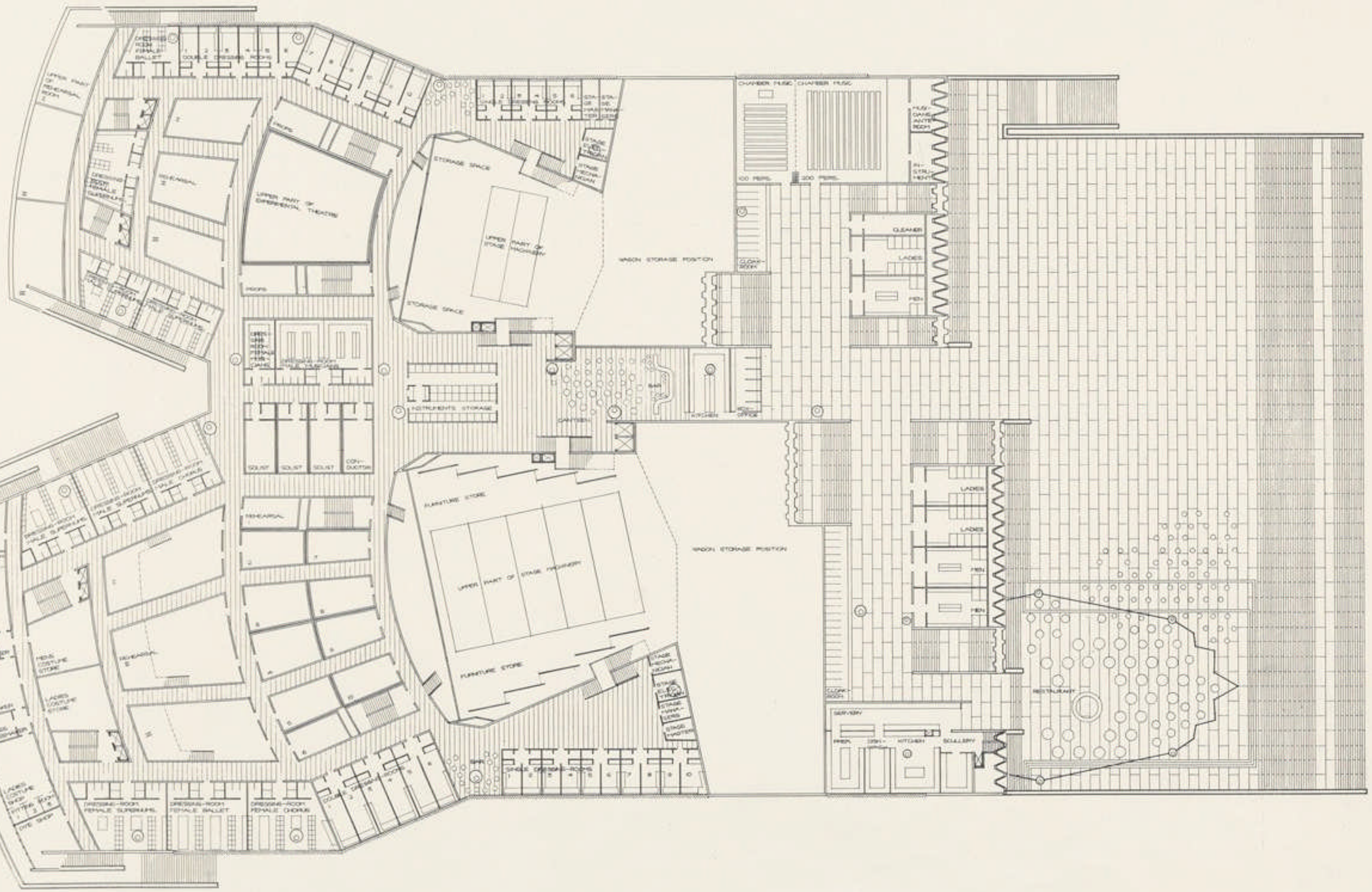
Site Plan



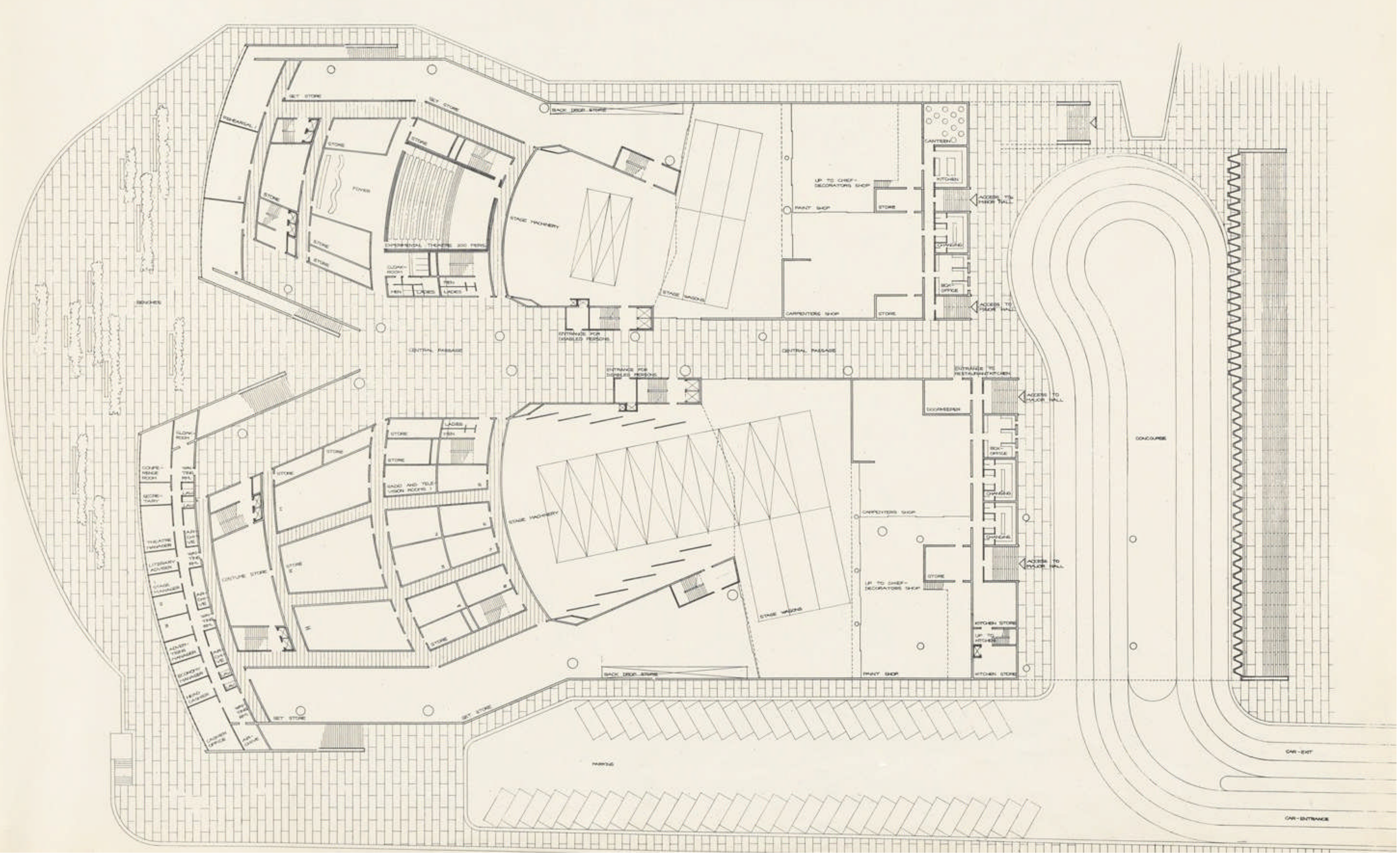
Plan of Halls


LOUNGE
BAR
ENTRANCE HALL
MINOR - HALL STAGE
ENTRANCE HALL
LOUNGE
BAR
MAJOR - HALL STAGE

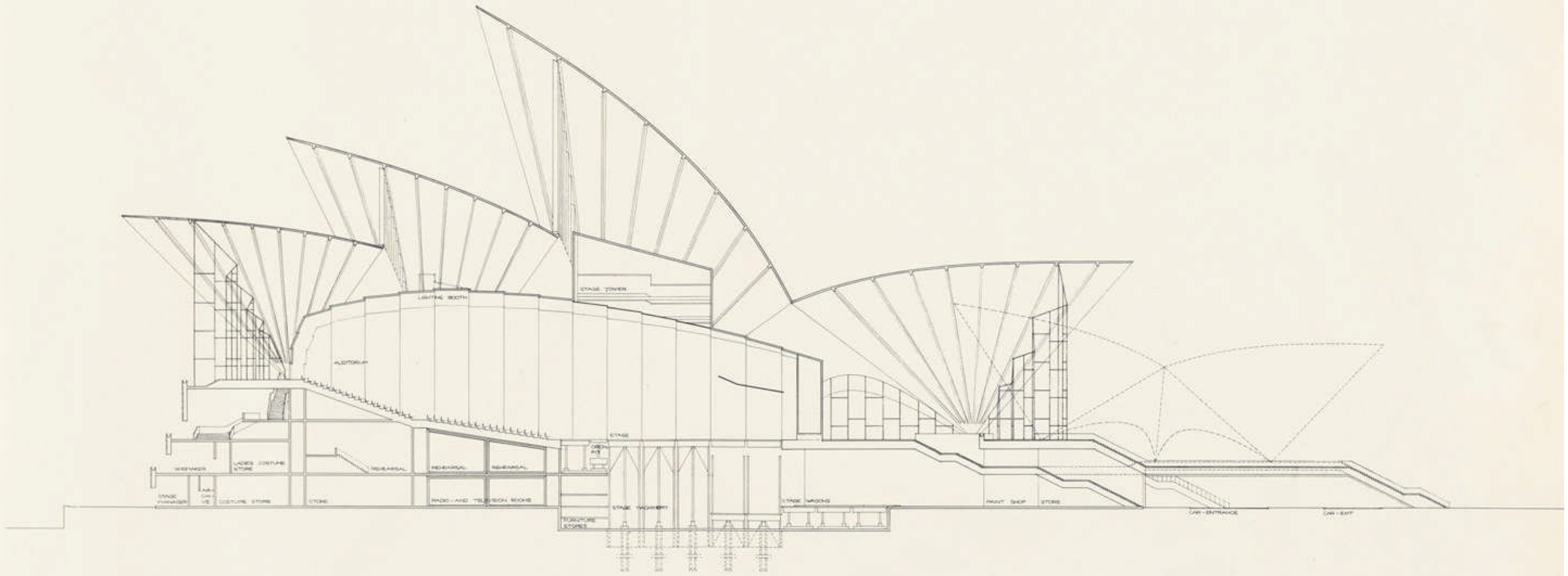
Plan of Bars



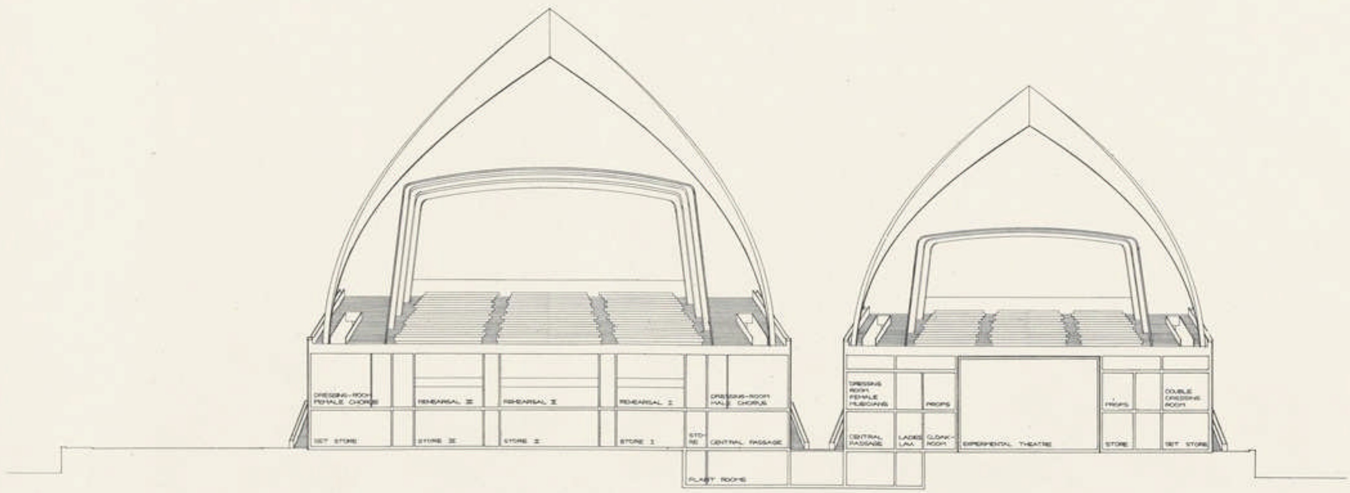
First Floor



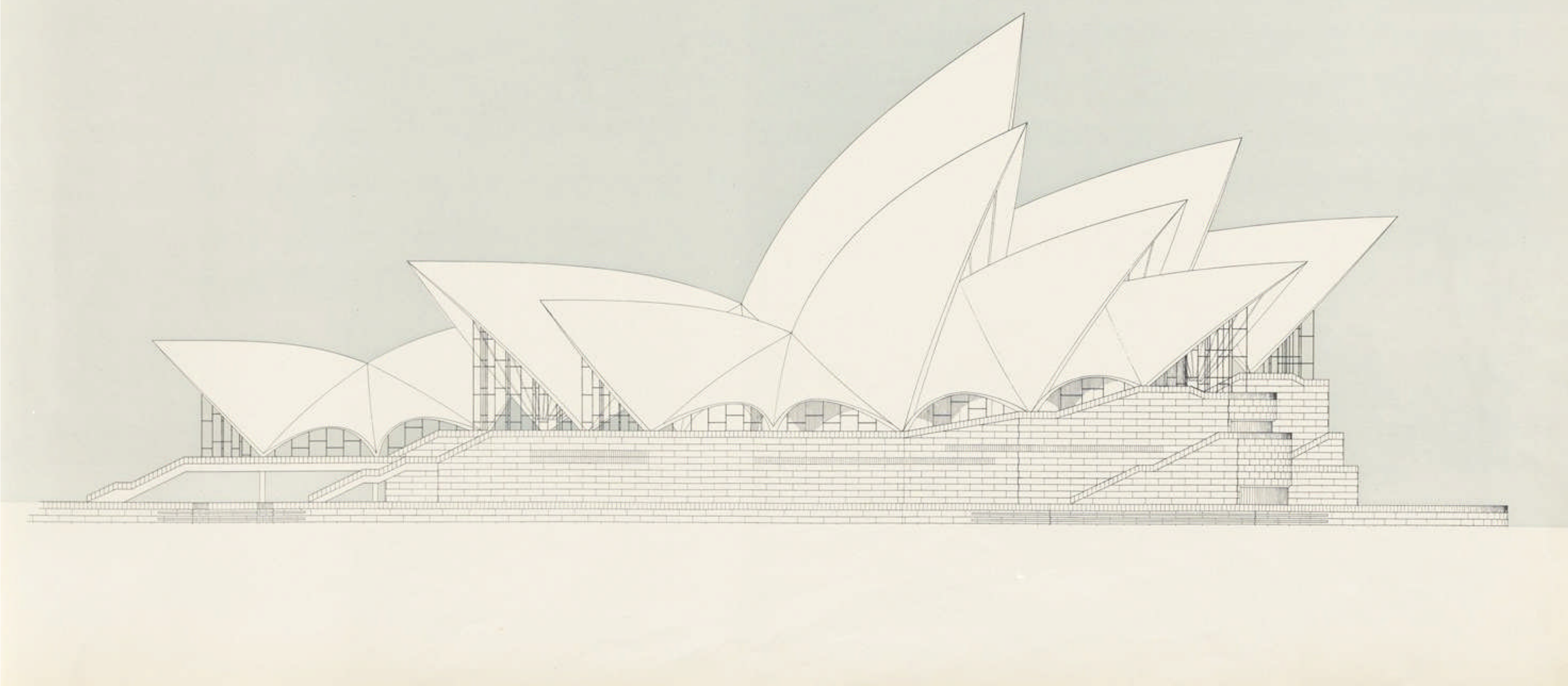
Ground Floor



Longitudinal Section Through Major Hall



Section Through the Halls

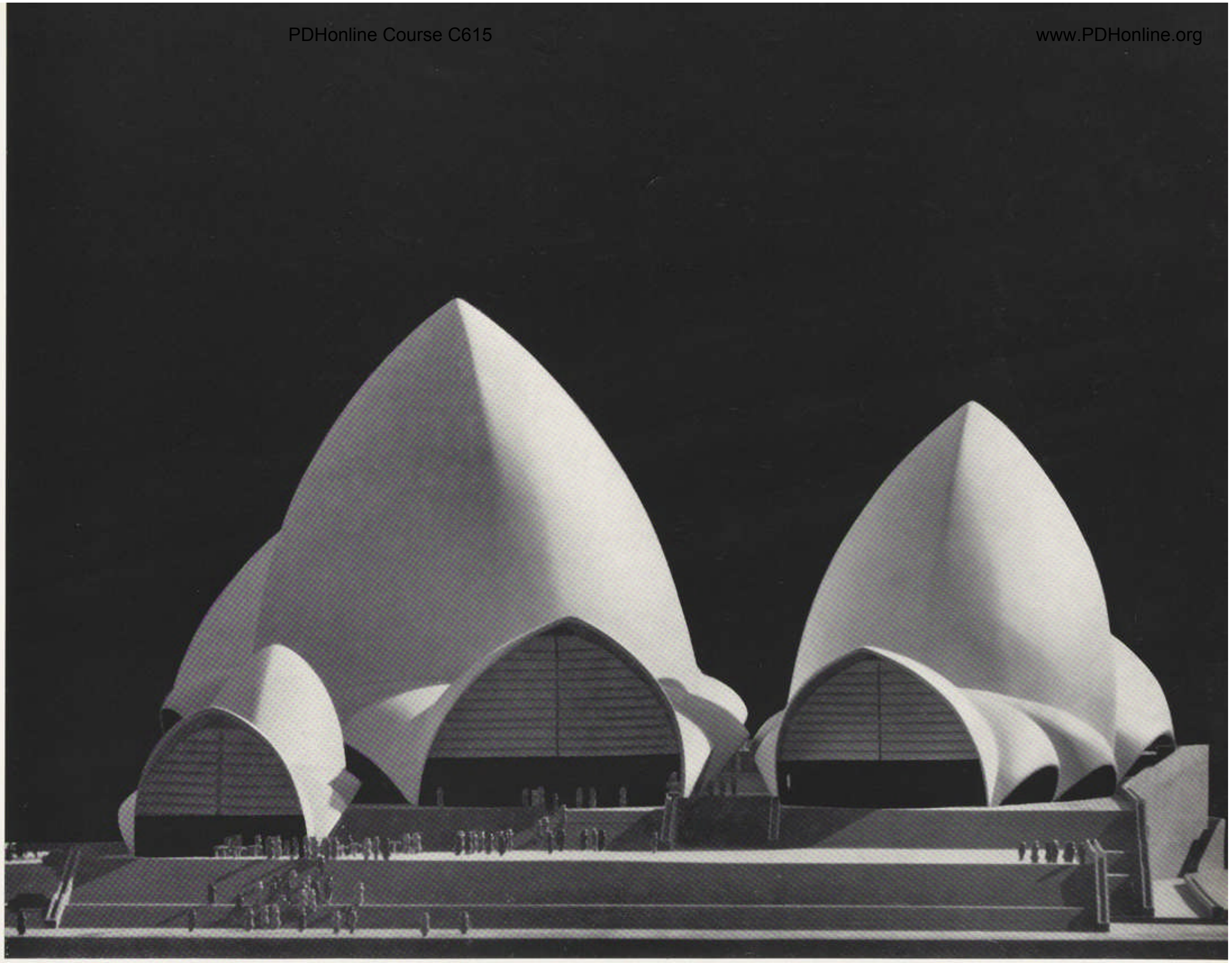


East Elevation

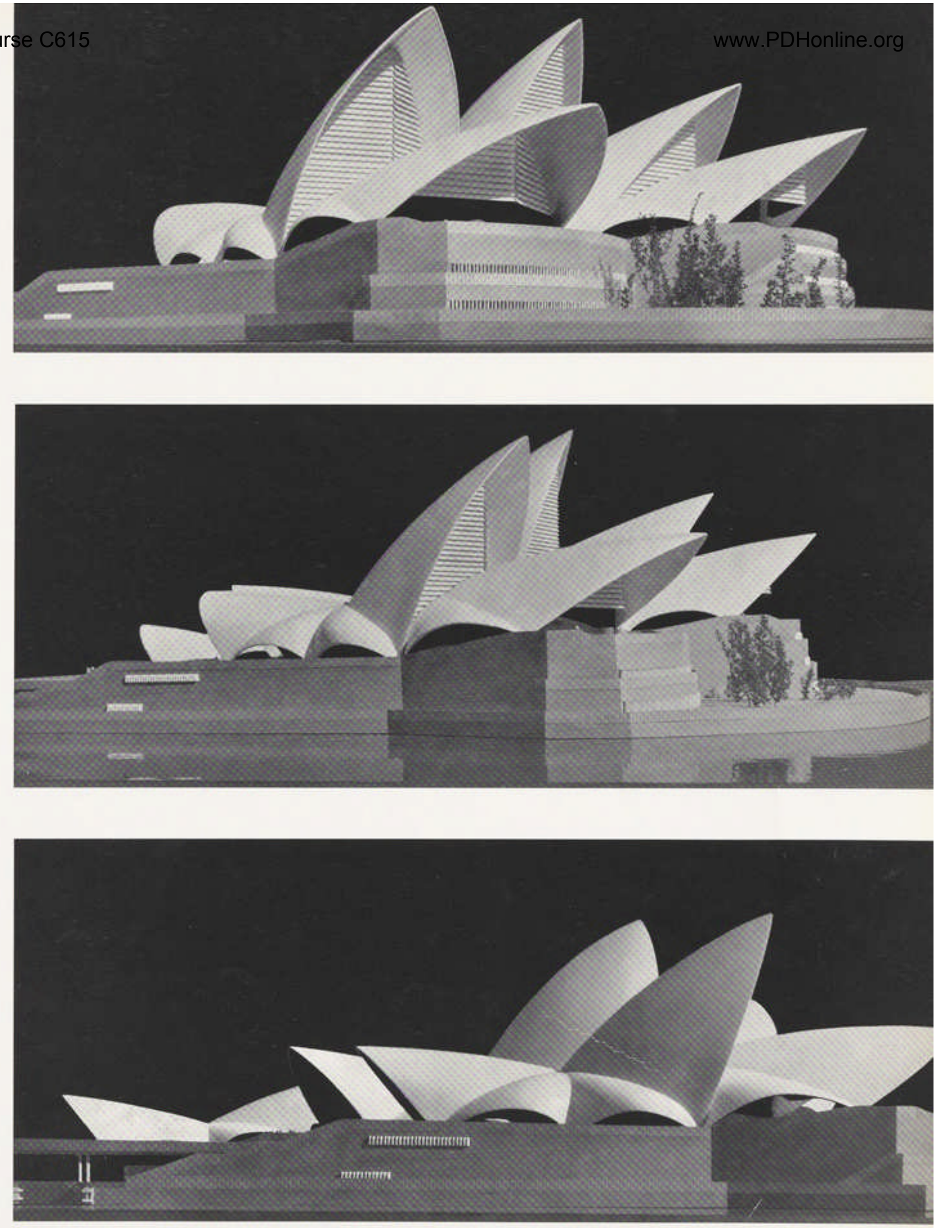
North Elevation

West Elevation

South Elevation



Model



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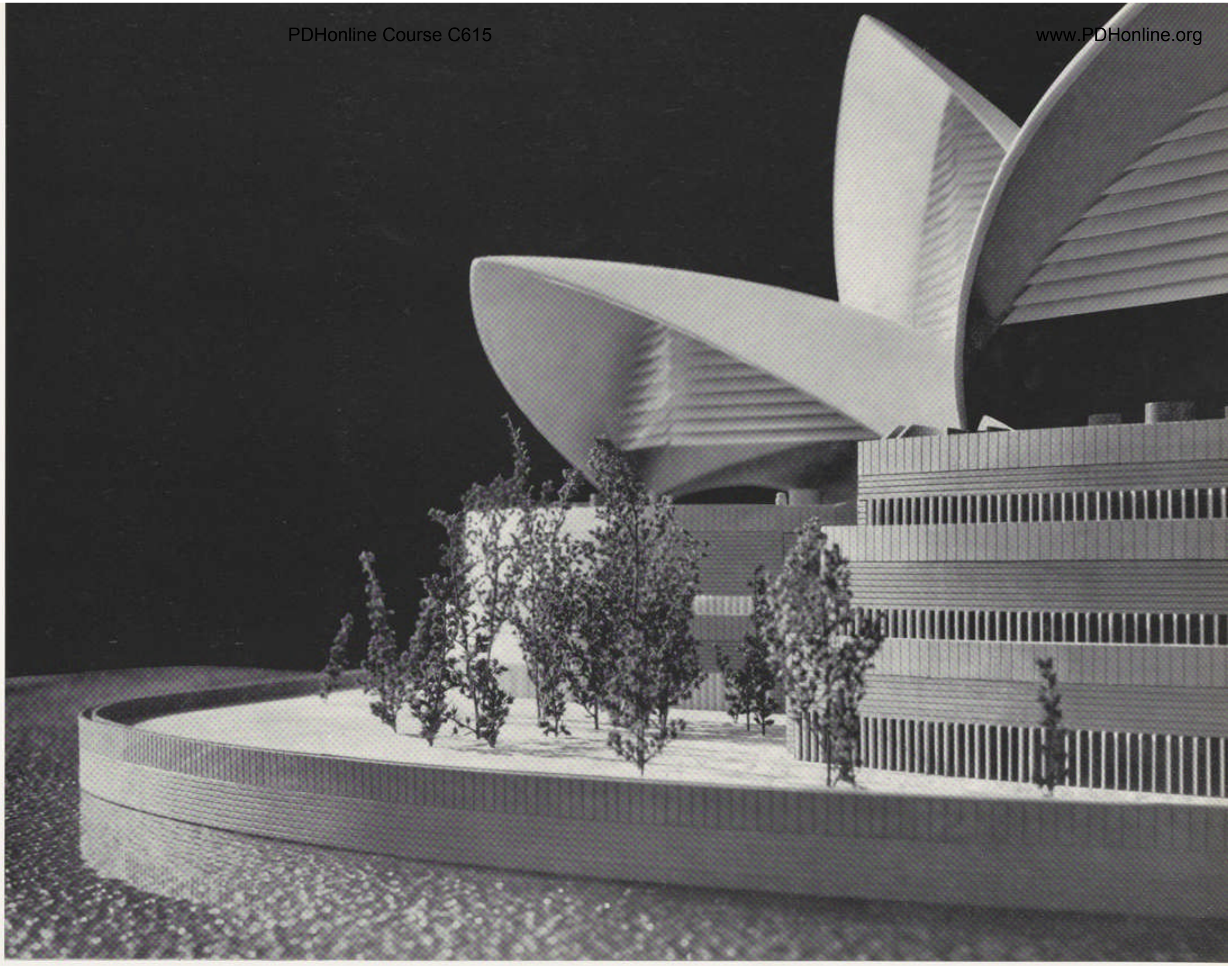
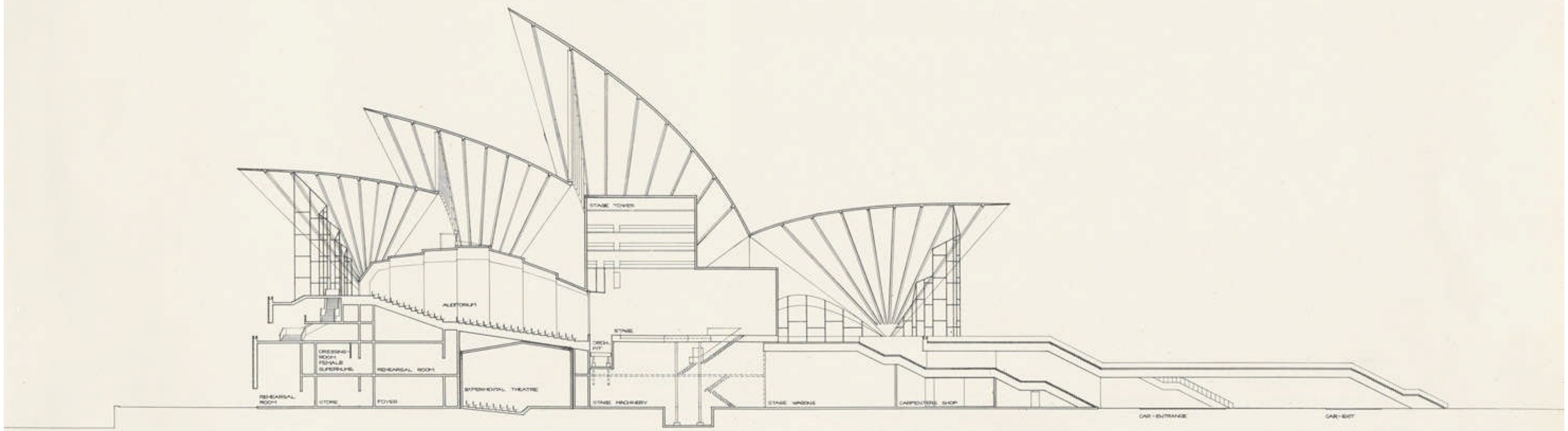
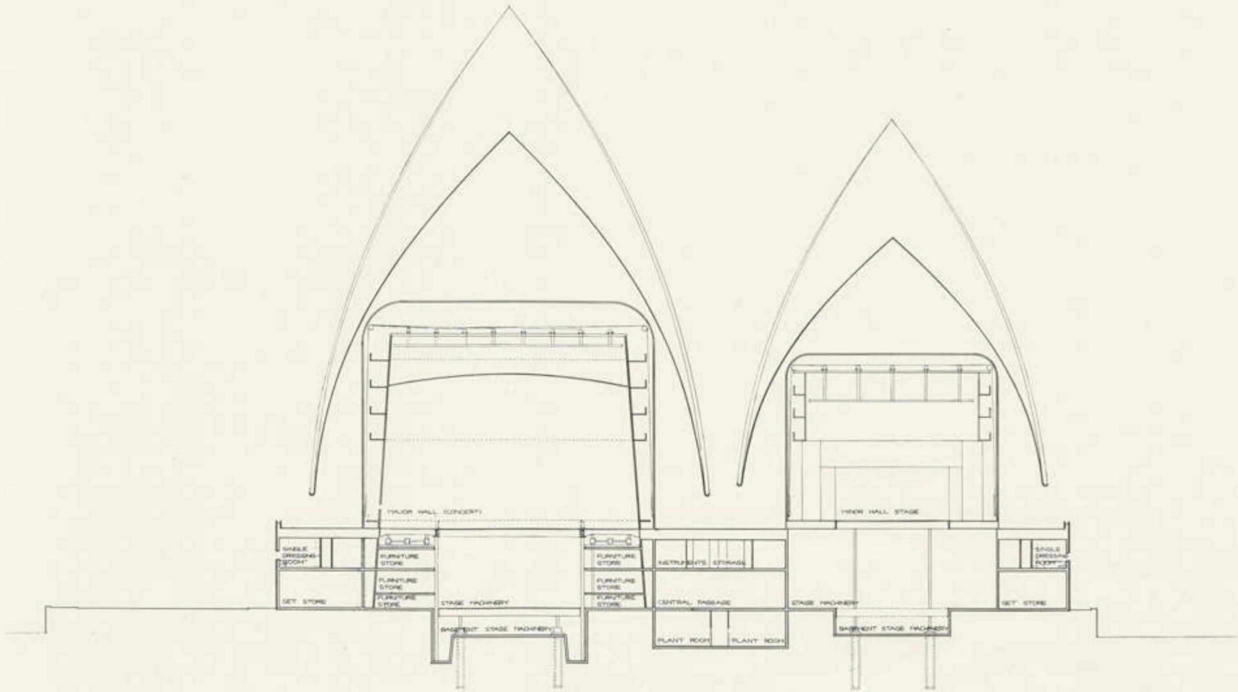


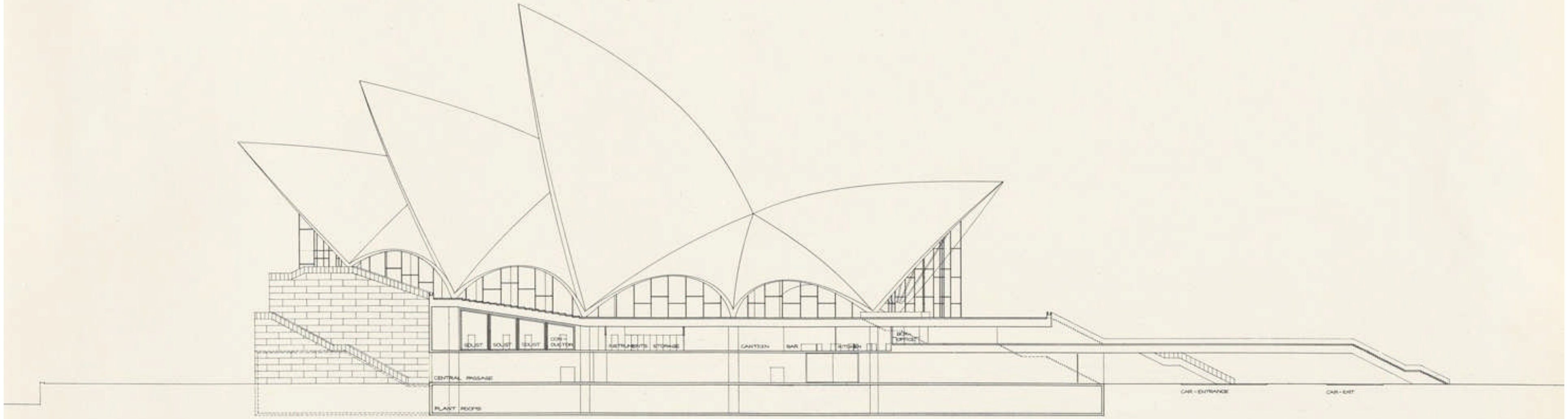
Model



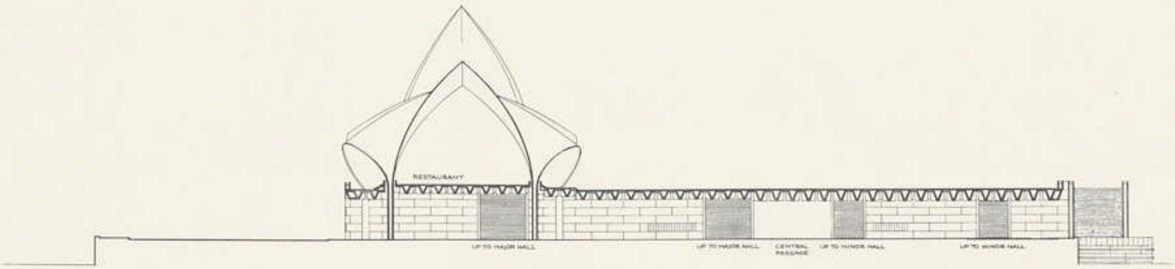
Longitudinal Section Through Minor Hall



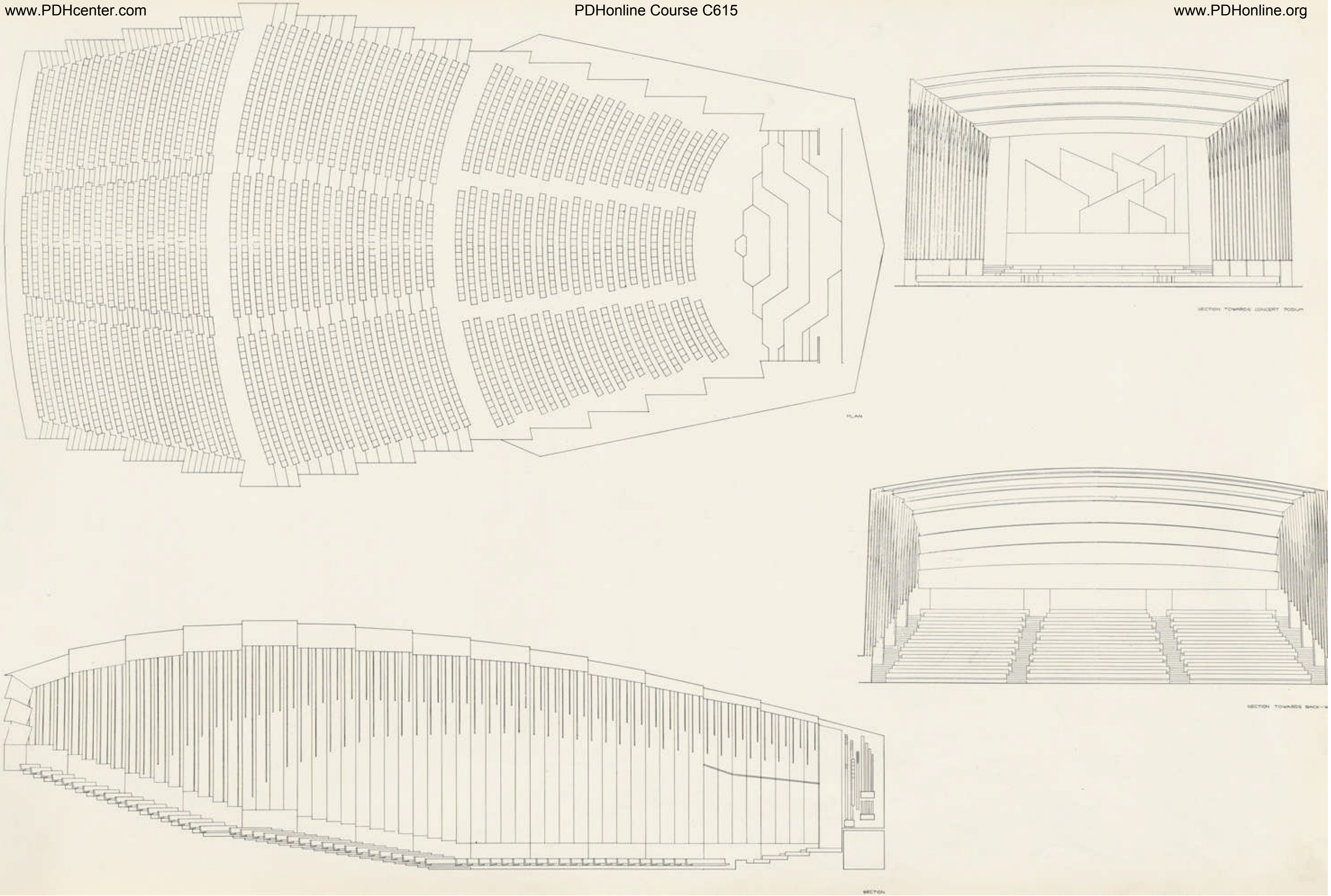
Section Through Stage Towers



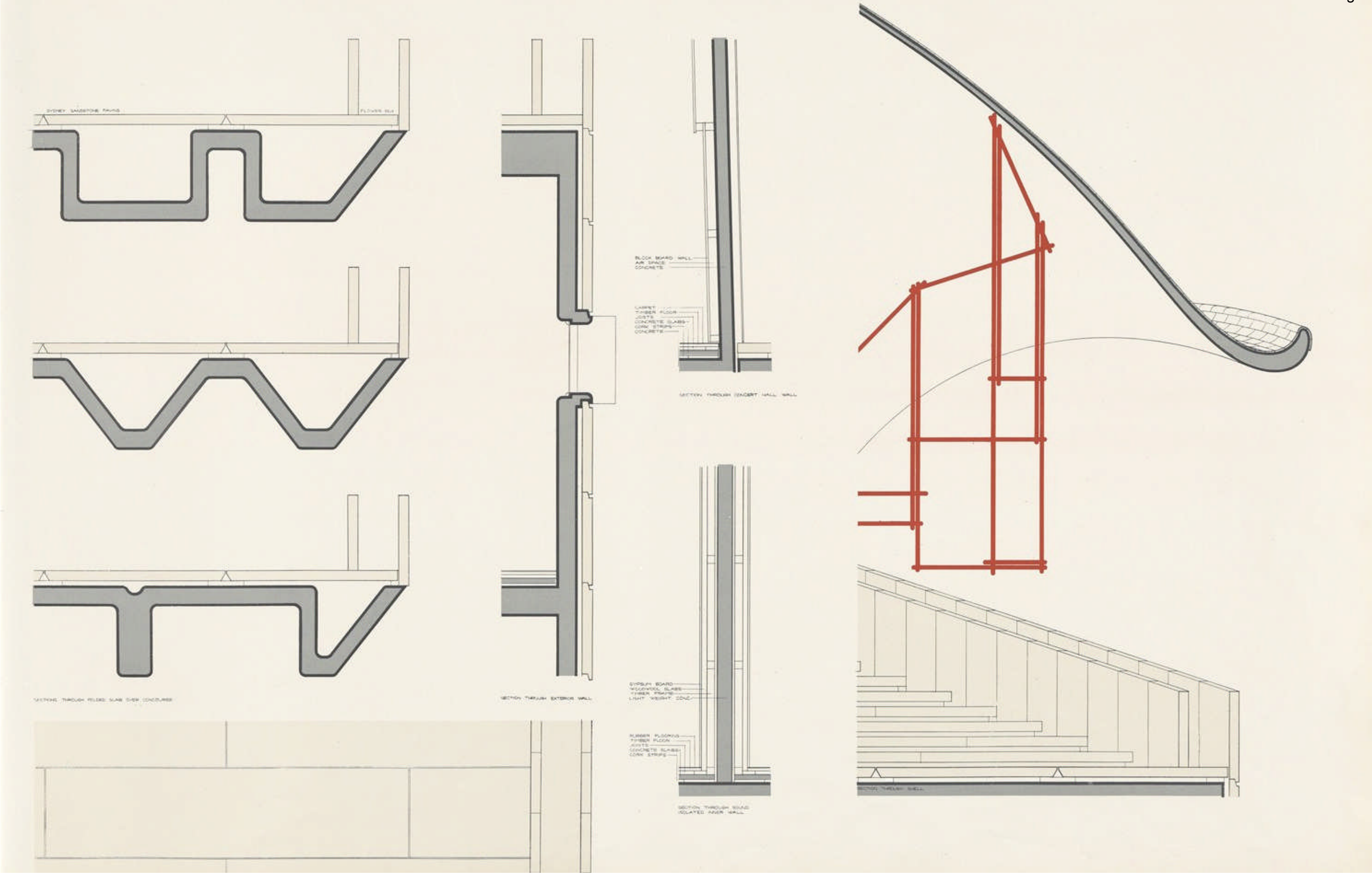
Longitudinal Section Through Central Passage



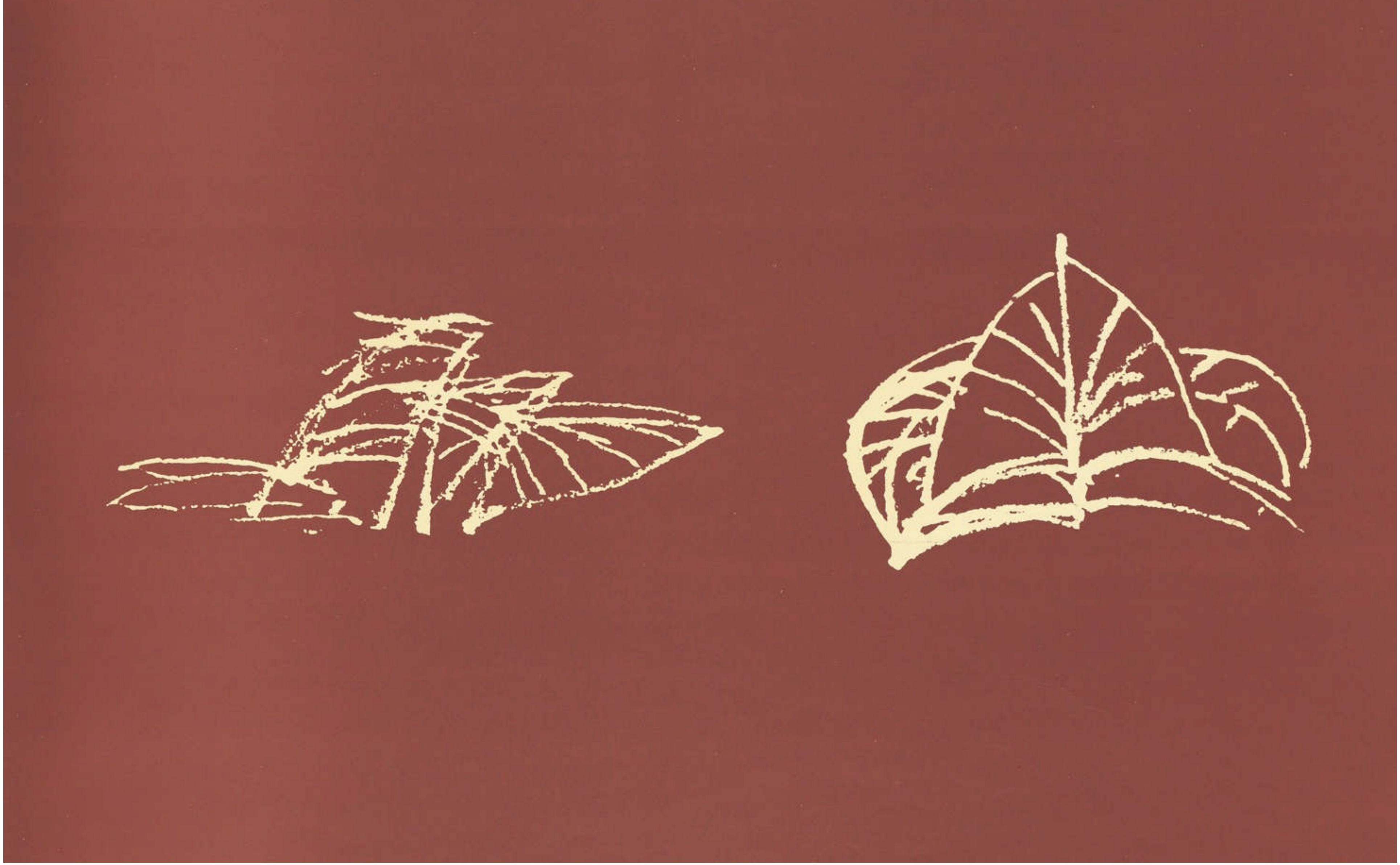
Section Through Concourse



Interior of Major Hall (Concert Hall)



Detailed Sections



Sketch

S T R U C T U R E S

The whole of the sub-structure consists mainly of large horizontal slabs resting on concrete walls. The walls are those which are required for actual architectural reasons and very few extra columns have been provided. This has resulted in very large spans for the slabs. For architectural and structural reasons these very large floor spans have been designed as folded slabs, the folds being arranged in such a way that at mid-span where moments are positive (i.e. compression on top, tension at the bottom) most of the horizontal portion of the slab is situated at the top, whereas over the supports where the moments are negative (in case of continuity), most of the horizontal portion of the slab is at the bottom to take the compression. The transition from the one cross-section to the other is gradual, and in between the two extreme positions the slab is of through section.

This results in a comparatively light structure since the material is placed in a way which is most advantageous structurally. It also provides an interesting architectural effect seen from below.

The slabs are pre-stressed by cables of high tension wires. The folds of the slab form channels through which the rain-water which seeps in between the joints of the stone paving slabs can be led away. In different parts of the structure these large span slabs are supported in different ways because of intervening stair openings, and differences in the supporting walls etc. and these differences are directly reflected in the corrugations of the ceiling so that it is possible to see exactly where the positive or negative moments occur in each portion of the corrugated slab.

The super-structure consists partly of walls and ceilings to the Concert Halls, the shape of which is determined by acoustical considerations, and secondly by a series of large shells covering the whole of the buildings.

The structural design of the latter is obviously quite a problem and has only just been touched upon. The first task was to define the shape of the shells geometrically. This has been done, at least as far as the main shells are concerned.

Each of the main shells consists of two symmetrical halves meeting in a ridge in the vertical plane going through the longitudinal axis of the Hall. This ridge is part of a parabola. The two symmetrical surfaces meeting in this ridge are roughly triangular in shape and descend on each side to a point which forms a support for the shells. These surfaces are formed by a series of coaxial parabolas with a common axis in the line between the two supporting points at ground level. All these parabolas therefore meet at the point of support and at this point are perpendicular to the horizontal axis.

By thus defining the surfaces of the shells geometrically each point of the surfaces can be given spatial coordinates and a basis has been created for the calculation of the forces acting on the shells and the stresses created in the shells.

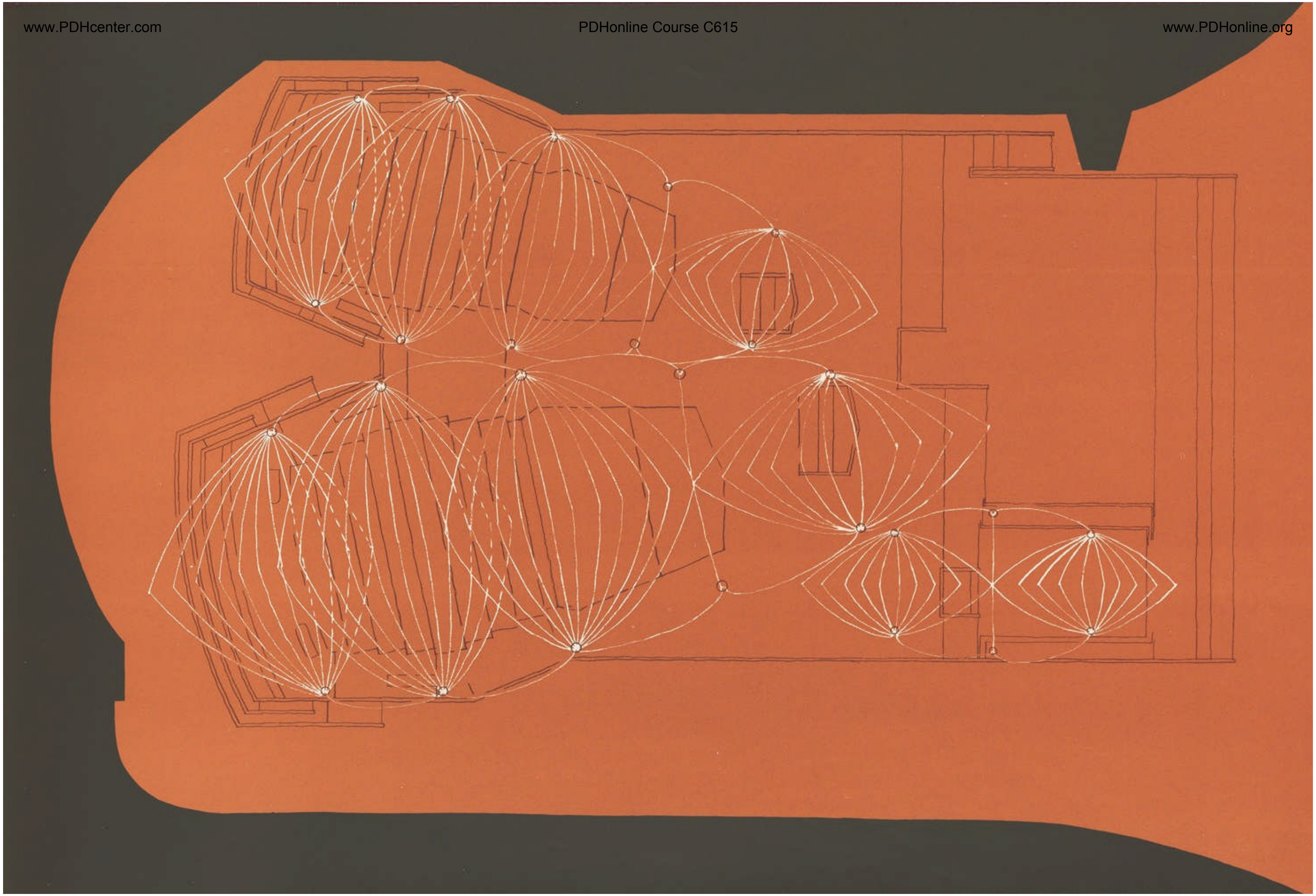
From a preliminary calculation it is obvious that the bending moments in the shells will be considerable owing to the heavy wind loads and it has been decided to provide the main shells on the inside with a series of ribs fanning out from the two supporting points and meeting in the ridge at the top.

It has also been decided to make use of the louvre plane, i.e. the surface closing the opening of the shell, as a stiff membrane supporting the shell. It may even be necessary to connect the shells in some way to the internal structure of the Halls, but no decision has been reached yet. Extensive model tests will be required to arrive at a true distribution of stresses under varying loads.

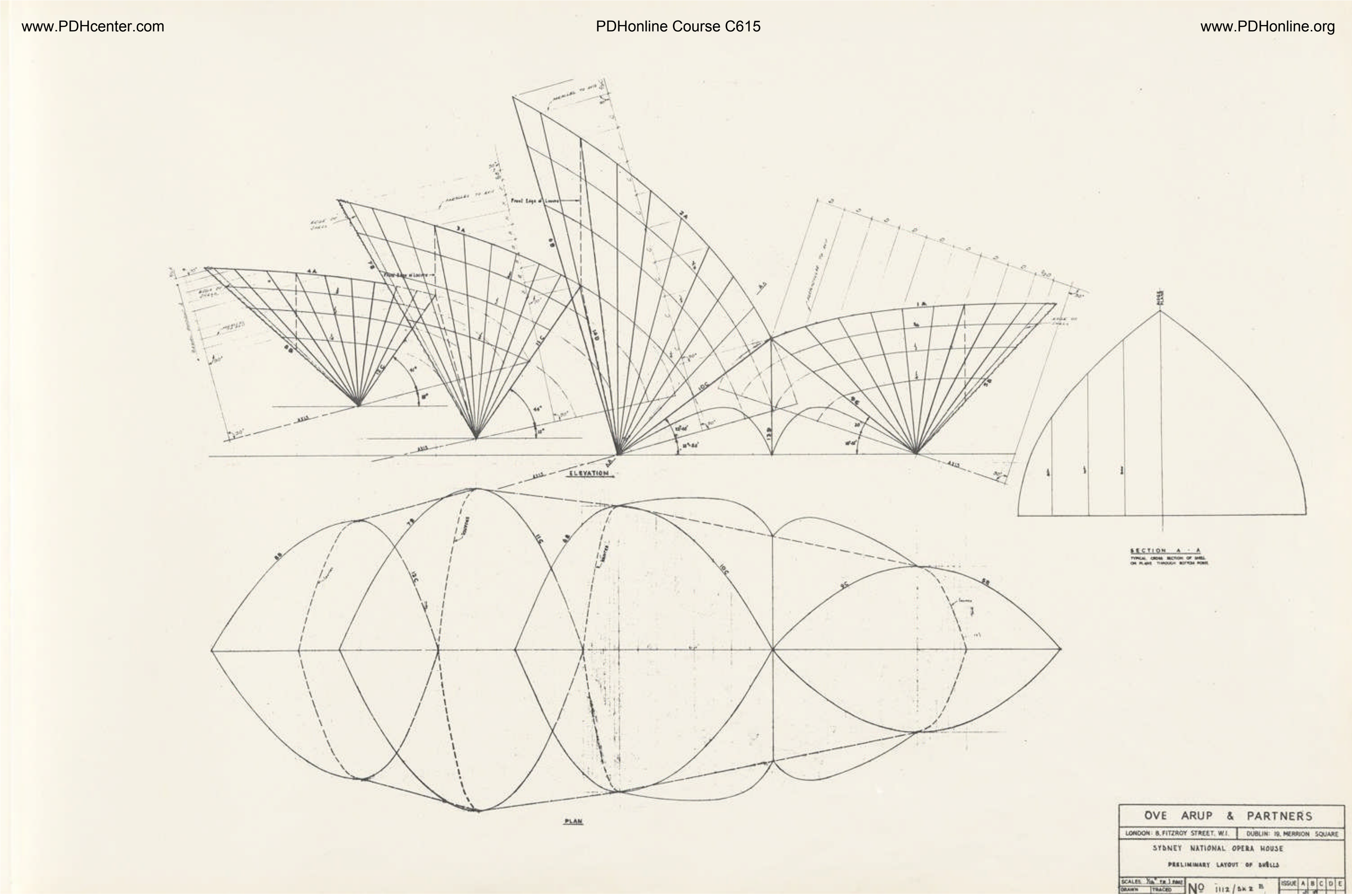
Ove Arup

Ove Arup

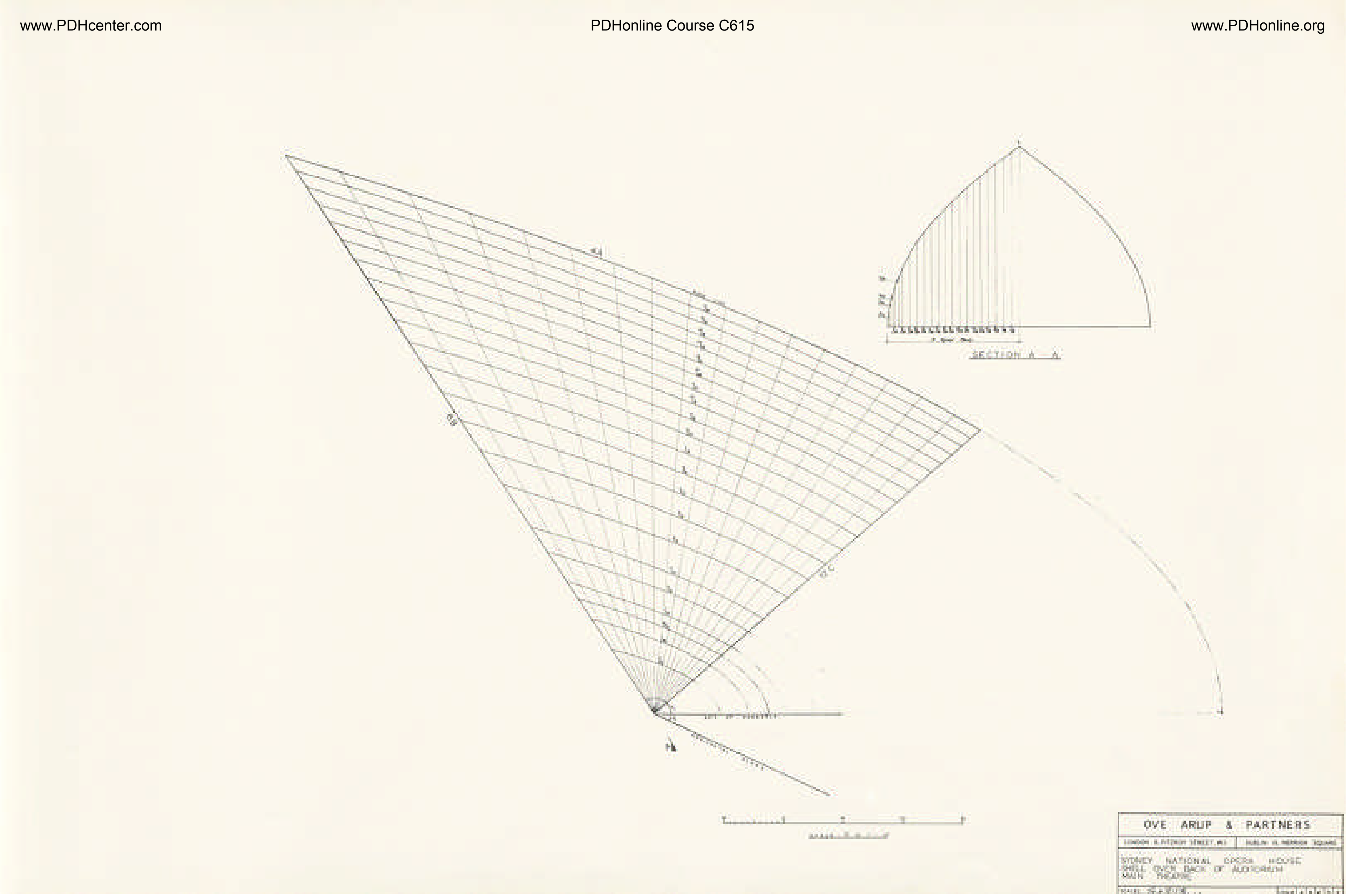
About the Structures by Ove Arup, Engineer. ***"The whole of the sub-structure consists mainly of large horizontal slabs resting on concrete walls"***



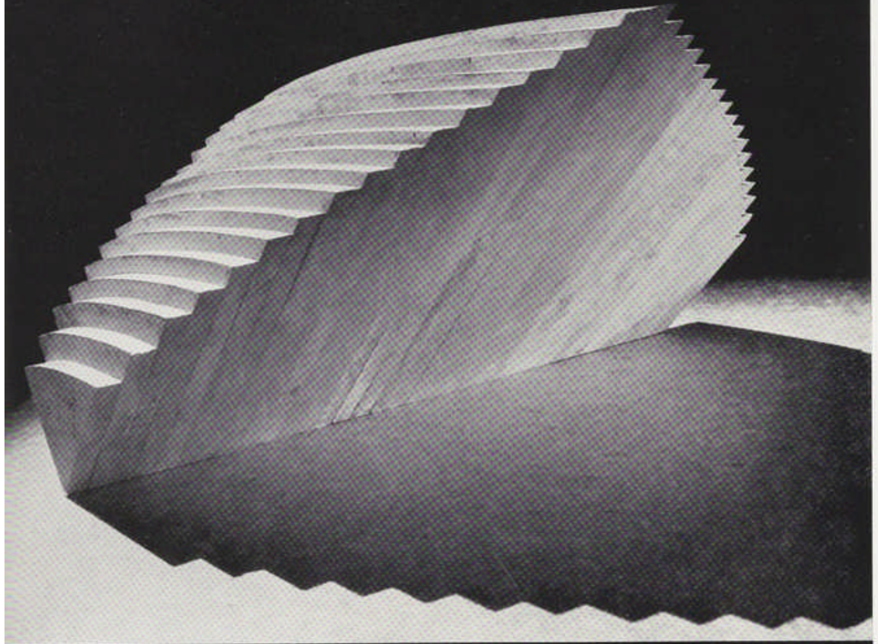
Plan of Principal Construction Features

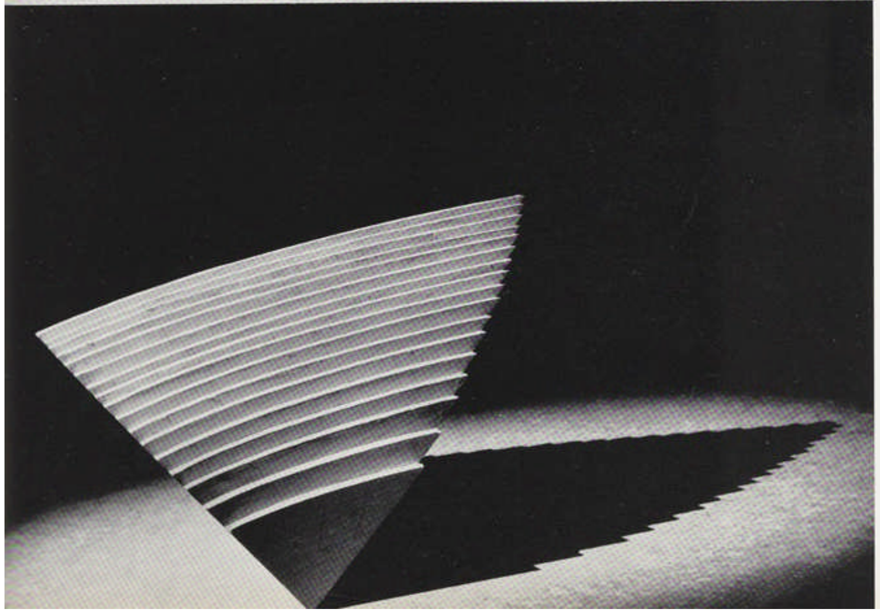


Preliminary Layout (Ove Arup & Partners)



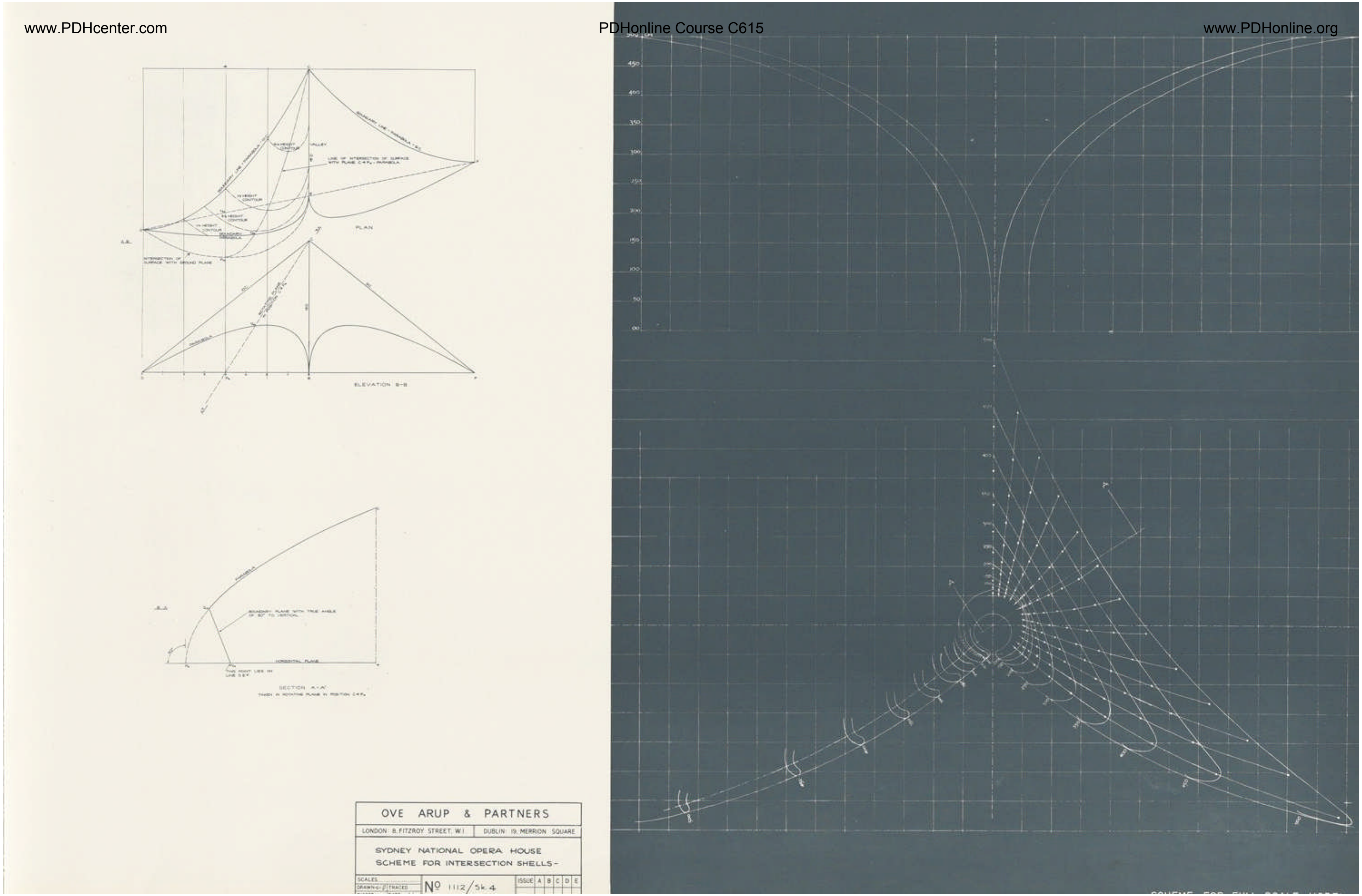
Shell Over Back of Auditorium Main Theatre (Ove Arup & Partners)



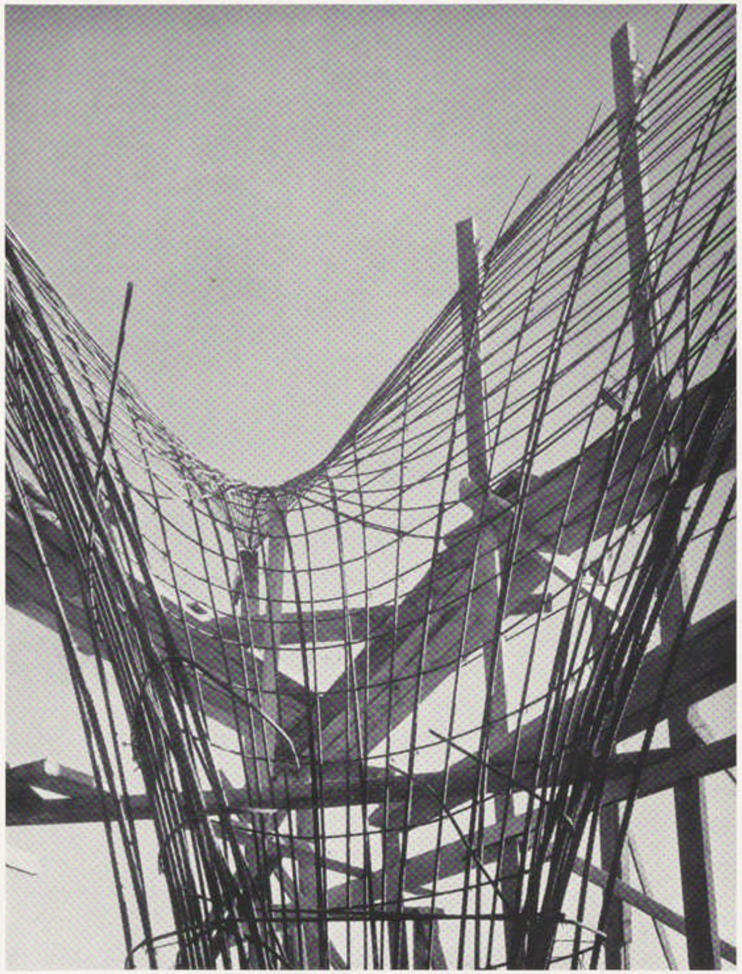


MODELS OF SHELLS

Models of Shells

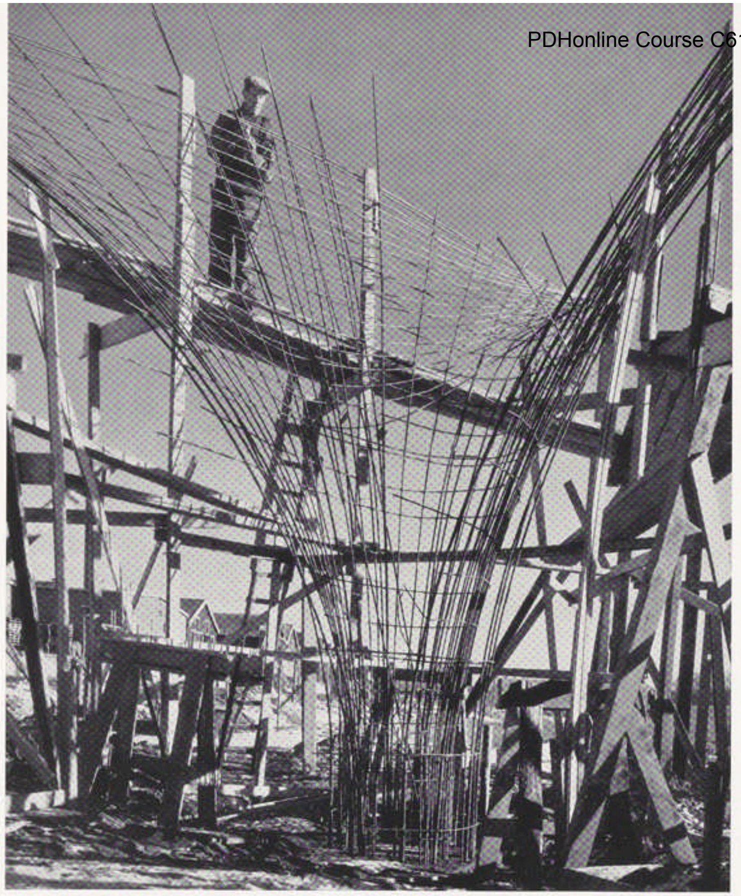


Scheme for Full Scale Model (Ove Arup & Partners)

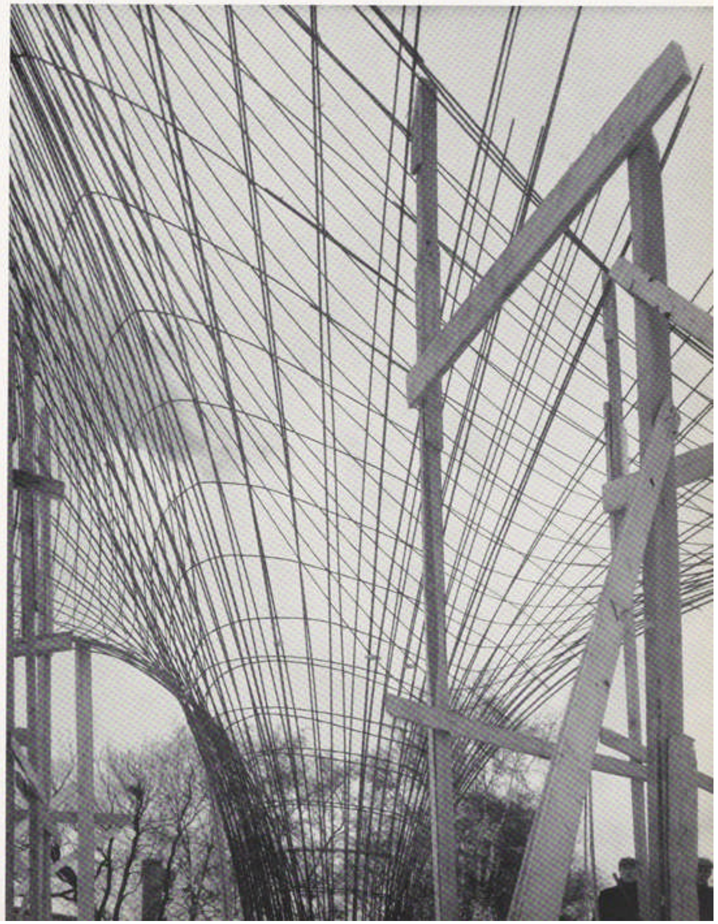


FIRST STAGE OF FULL-SCALE MODEL AT HÖGANÄS CLAYWORKS   ALL PHOTOS: CARL E. ROSENBERG ARPS

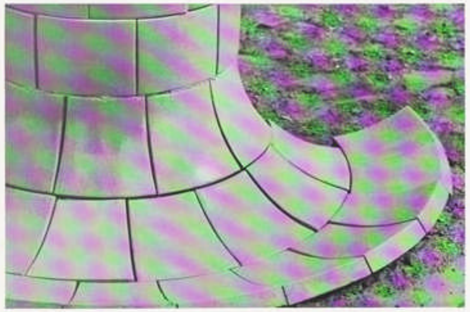
First Stage of Full-Scale Model at Hoganas Clayworks

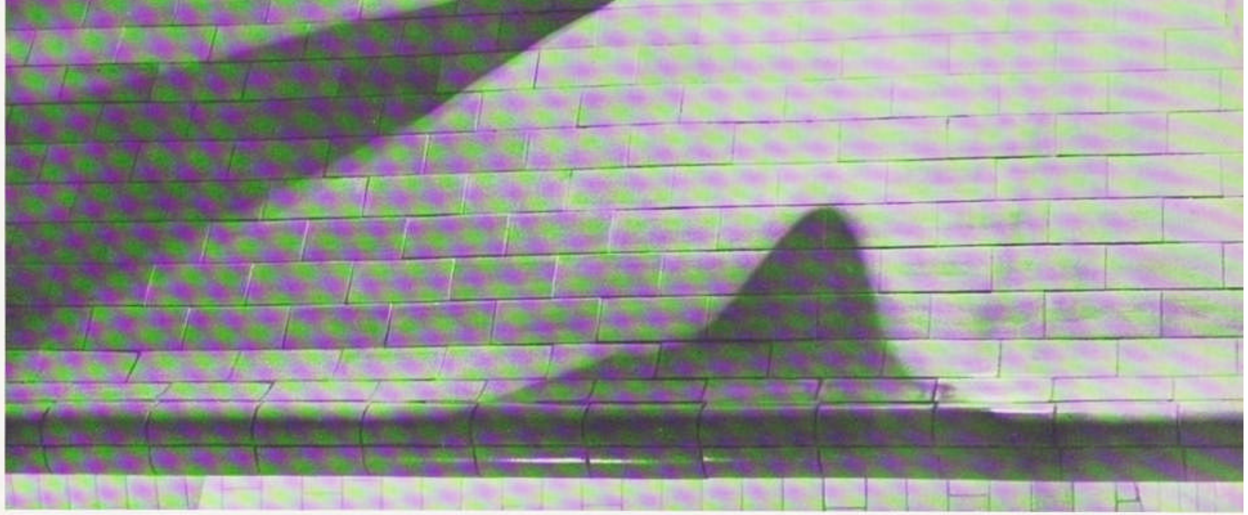


FIRST STAGE OF FULL-SCALE MODEL AT HÖGANÄS CLAYWORKS

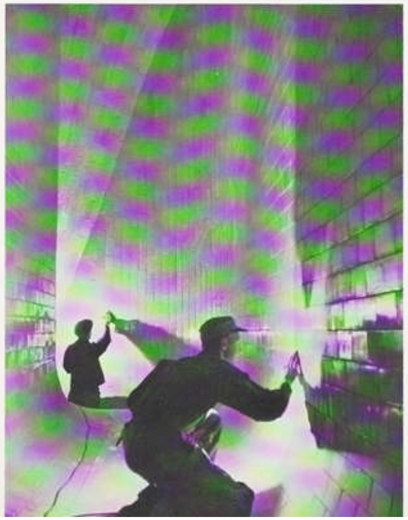


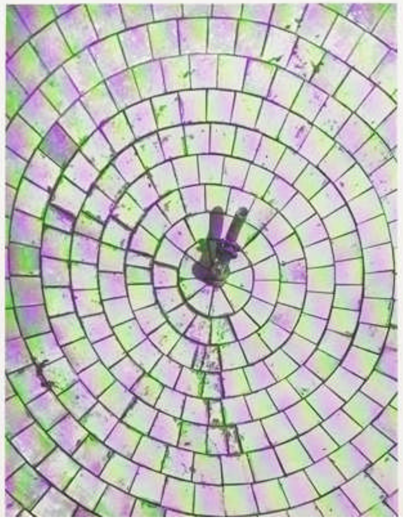
First Stage of Full-Scale Model at Hoganas Clayworks

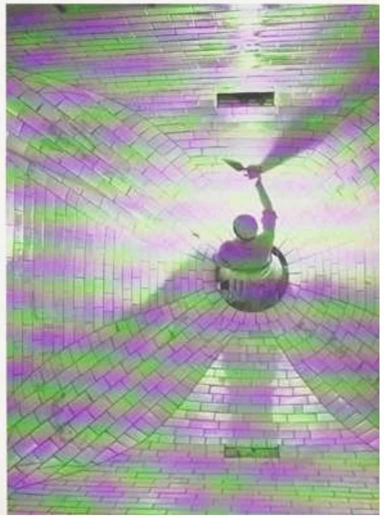




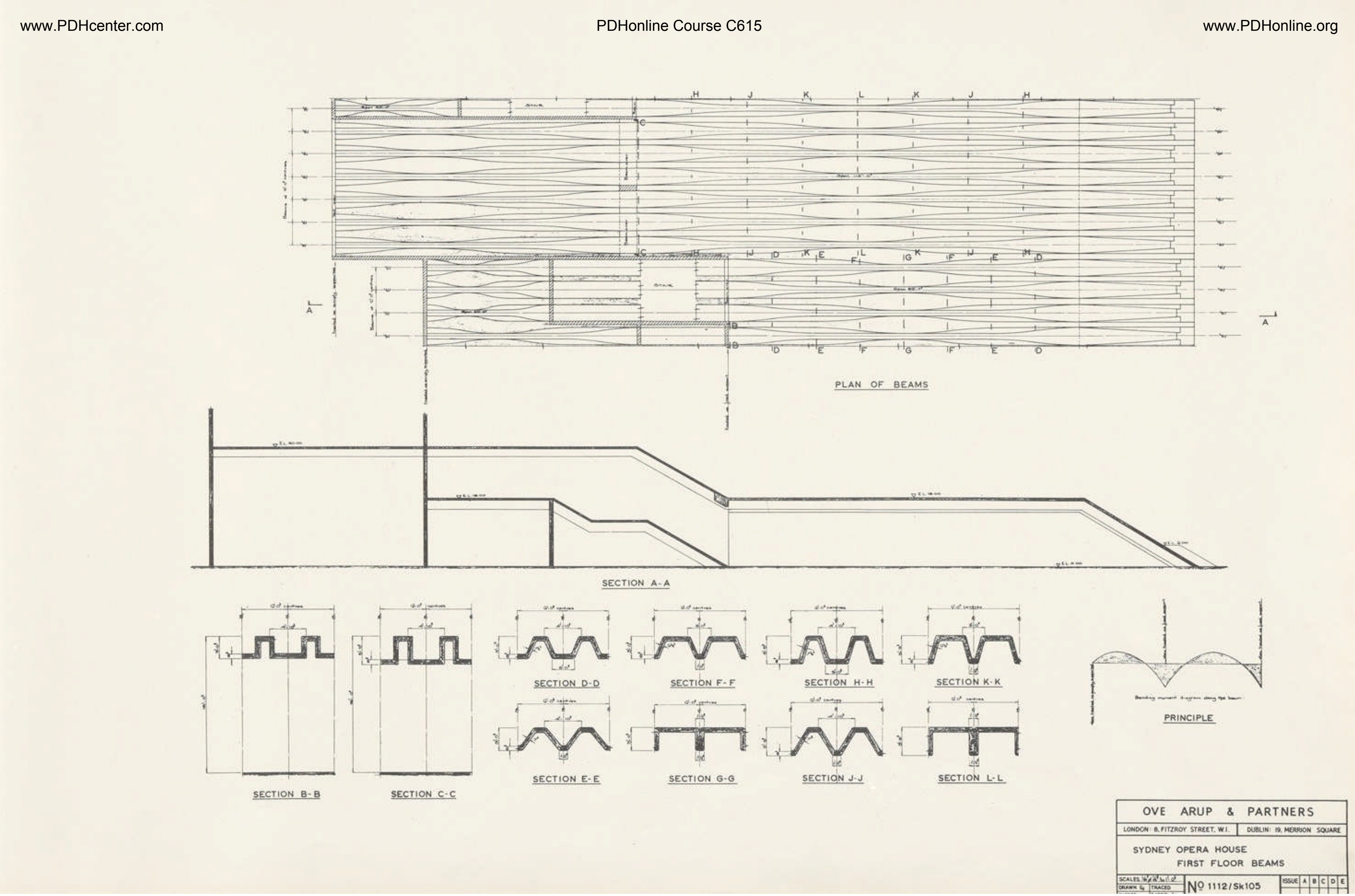
CERAMIC TILES USED ON CURVED SURFACES. HÖGANÄS CLAYWORKS



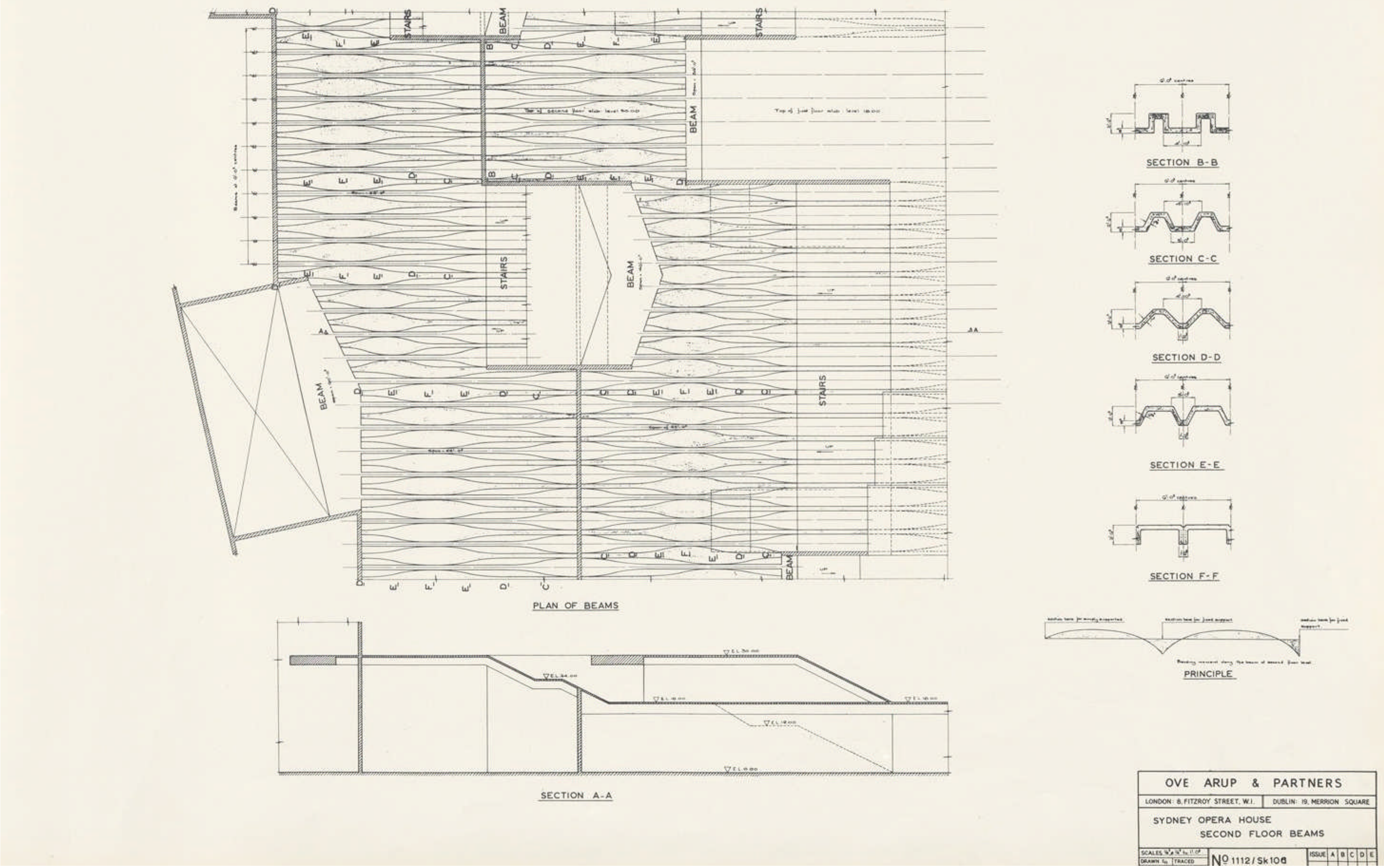




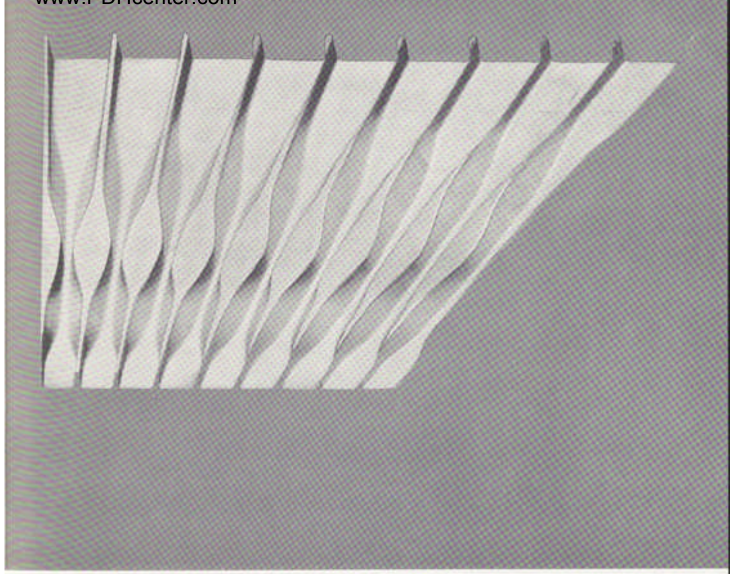
Ceramic Tiles Used on Curved Surfaces. Hoganas Clayworks.

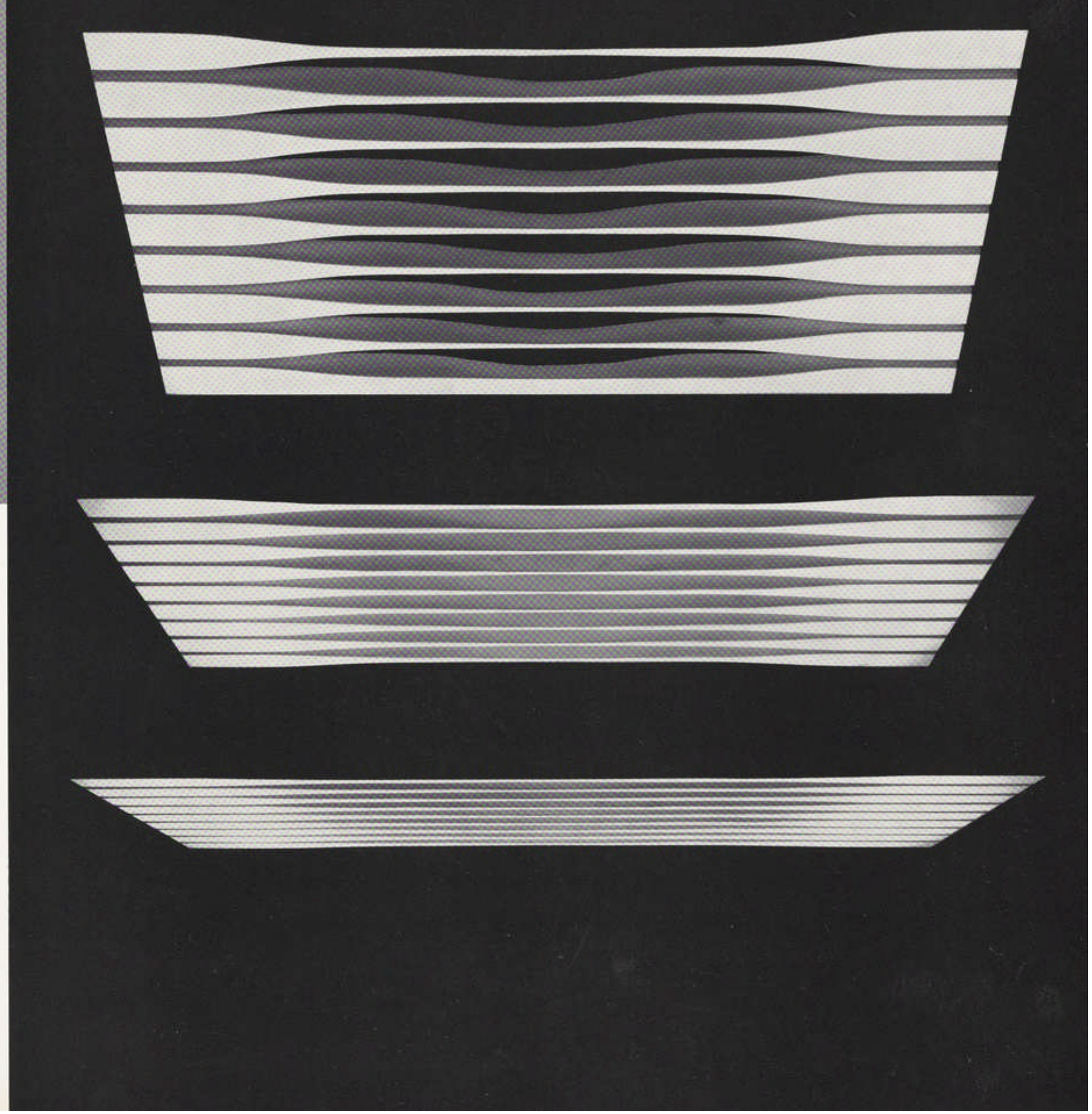


First Floor Beams (Ove Arup & Partners)



Second Floor Beams (Ove Arup & Partners)



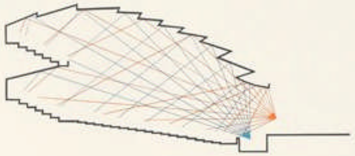


MODEL OF CONSTRUCTION OVER CONCOURSE

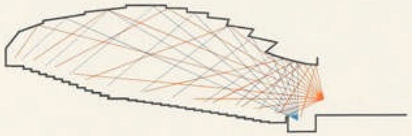
Model of Construction of Concourse

A C O U S T I C S

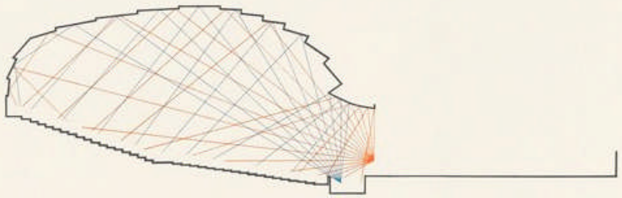
Content:



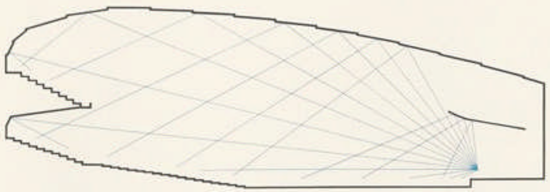
ALTERNATIVE THEATRE WITH BALCONY - MINOR HALL



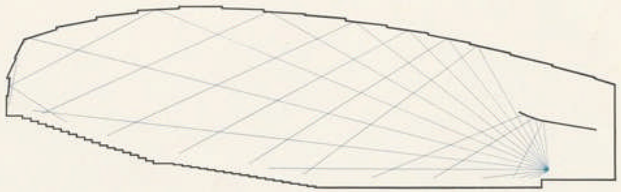
THEATRE MINOR HALL



CONCERT - MAJOR HALL



ALTERNATIVE CONCERT HALL WITH BALCONY - MAJOR HALL



CONCERT HALL - MAJOR HALL

Sound Reflections in Halls

§ 1. The Site and the outdoor Noise.

To the opinion of the author the site should be very favourable with regard to outdoor noise. Due to the considerable distance to traffic lanes there will only be little interference from city traffic noise. The main sources of open air noise will presumably be noise from the harbour traffic (engines, whistles, bells) and more important noise from airplanes. It is very urgent that a preliminary noise survey of the site should take place with as little delay as possible since the noise figures actually measured (or anticipated from measurements) have a direct bearing on the calculation of the sound insulation values which must be obtained from outer walls, shells, etc.. Especially wherever glass surfaces are part of the exterior boundaries it is quite obvious that the knowledge of expected maximum noise levels is indispensable.

§ 2. On the Principles of Large Hall Acoustics.

Although the acoustics of large halls are by no means a new branch of science and even though a solid foundation of quantitative calculation methods exists, there are still problems in this connection which must be solved in the individual cases more in accordance with general experience than by the use of mathematical formulae. We shall first consider the main criterium, i.e. the reverberation time (R.T.) and then proceed to the other principal features of large hall acoustics.

Reverberation Time. It is generally agreed upon that a definite range exists within which the R.T. of the completed hall should lay. Depending upon size and no. of seats a value within this range may beforehand be agreed upon and by appropriate calculations of the absorption of the seats, of the surfaces and of the air, this value may ultimately be obtained in the hall. The uncertainty of the calculation should be compensated by allowing a certain area of the walls (upperpart of side walls and back wall) to be fitted with easily interchangeable or alterable panels, thus securing the possibility of a final adjustment of the R.T.

It is, however, not only a question of obtaining a definite value of the R.T. at a single frequency, it is most important that the R.T. of the hall should be calculated and fixed for a large frequency range corresponding to the musical range of orchestral and organ music. It is commonly agreed that no very great variation of R.T. should be allowed within this range. A slight increase towards the low frequencies is permissible and a slight decrease towards the highest frequencies is unavoidable due to the increase of the sound absorption of the air at these frequencies. It is, in the opinion of the author, very important to keep this decrease of the R.T. towards the high frequencies within narrow limits and deliberately to counteract the influence of the sound absorption of the air by giving to most interior surfaces of the hall a finish, which will make them reflect as much of the sound energy of the high frequencies as possible.

The Sound Distribution in a large hall does not lend itself readily to exact calculation, but preliminary conclusions may be obtained from detailed studies of the geometrical aspects of the hall, especially from the main longitudinal section. In a more general way conclusions may be obtained by the use of model research. Actually it is not only the stationary sound distribution which may be studied in this way, but it is the transient behaviour of the hall to sound pulses. The "direct sound" from sound source to observer together with the first reflections, i.e. those which arrive within a time interval of 35 to 50 msec, after the arrival of the direct sound, are related to a certain acoustical quality, sometimes called "the definition", and which is important for the true reproduction of rapid passages in music.

The Sound Diffusion, too, is not a quantitative notion although certain attempts of defining it quantitatively have been tried. We know that a breaking-up of the surfaces in sections of the same order of magnitude as the different wavelengths of sound has an equalizing effect upon the sound field, which is important for the blending of musical sounds. No simple and convincing method of measuring sound diffusion exist so far, and there is also no generally recognized correlation between attempted definitions or measurements and the extent to which the surfaces are broken up, so that this feature, too, must be decided upon according to general experience.

The Overall Dimensions and the proportions between them have no exact relation to the acoustical quality of a hall, but it is agreed that too great deviations from "harmonic" proportions such as f.i. 2:3:5 (height: width: depth), shoud be avoided. Excessive width compared to depth is always dangerous because it makes efficient blending difficult especially in the front of the hall. Too little height compared to width and depth is also suspect, because it tends to reduce the reverbe-

1. Site and the Outdoor Noise. 2. Principles of Large Hall Acoustics.

ration of the hall unduly. Excessive depth should be avoided because too large a proportion of the audience gets too far from the sound source.

The General Shape of a large hall is a much disputed question.
No definite judgement in preference of either rectangular or fan shape ought to be pronounced, since there exist good halls (and bad halls) of both kinds. A too open fan shape, however, should be avoided, because the tendency to direct the sound towards the rear will be too great and thus will deprive the orchestra of too much sound and make it difficult for the musicians to hear each other playing.

On The Volume of a large hall it may be said, that there is a general agreement, that a certain relationship to the total number of seats should be maintained, an ideal being that the volume per seat is around 350 cbft (10 m^3), but deviations amounting to 30 % or more are in some cases permissible, if the effect upon the reverberation is matched by the control of the absorption.

Another Feature which, to the opinion of the author has been more or less neglected in many cases, but which according to his experience is quite important, is the transient behaviour of the stage and the immediate stage surroundings to sound pulses of different length. This behaviour is intimately connected with-how the musicians hear themselves and each other when playing, how the various groups hear each other and how the conductor hears the various groups. There is some indication from experiments, that this quality may have a numerical value, which may be expressed either by the rapidity with which a sound pulse "builts up" at the stage, or, even more exactly probably, by the "first slope" of the reverberation process as measured upon the stage. Actually, it shows, that in various halls the reverberation process from pulses, when registered at, or near the stage, has a tendency to be "double sloping", having an initial steep slope and continuing with a more flat slope which more or less exactly corresponds to the reverberation time as measured ordinarily. Theoretically this may be explained by considering the hall as actually consisting of two coupled enclosures, one being the stage and the immediate stage surroundings, the other being the seating area of the hall. It is obvious, that if too much of the sound energy stays at the stage (as f.i. when the stage is more or less closed off from the audience as in a theatre) there will be a deficiency in the performance of the hall, but it is also a matter of experience, that if too much of the sound energy is distributed towards the audience immediately, there will be a lack of response upon the stage itself, which gives difficulties for the musicians. Between these two extremes (corresponding to a very small coefficient of coupling and a very large one) there apparently must be an optimum, which it must be possible to decide upon quantitatively.

§ 3. Some Examples of Existing Large Halls and their Acoustic Data.

The following halls are mentioned:

a. Gothenburg Concert Hall
b. St. Andrews Hall, Glasgow
c. Usher Hall, Edinburgh
d. Royal Festival Hall, London
e. Concertgebouw, Amsterdam
f. Aalborghallen
g. Tivoli Concert Hall, Copenhagen.

This choice obviously is arbitrary; they are mostly halls of which the author has some personal experience (with the exception of (e)). They are all in the seating range of 1400 to 3400, the smallest being (a) and the largest (d). The table (1) below gives volume, number of seats, volume per seat and R.T.

Table 1.

year of completion	Hall	Volume cbft.	No. of seats	Vol. per seat cbft.	R.T. (mean) empty measured	R.T. (mean) with audience calculated = c measured = m	
1935	Gothenburg	420.000	1.371	308	1.8	1.6	c
1877	St.Andrews	570.000	2.700	211	2.6	1.8	m
1914	Usher Hall	550.000	2.750	200	2.4	1.5	m
1951	Royal Festival Hall	775.000	3.400	228	1.8	1.5	m
1887	Concertgebouw	730.000	2.275	322	2.8	2.2	?
1953	Aalborghallen	880.000	1.800	490	3.0	1.9	m
1955	Tivoli Concert Hall	450.000	1.780	253	2.2	1.3	m

a. Gothenburg Concert Hall.

The R.T. is in the proper range for the size of the hall, and the RT vs. frequency curve is fairly smooth and level till about 3000 cps (with the exception of a pronounced peak at 200 cps, which may cause some colourations to low frequency sounds).

The shape favours the sound reflections directed towards the audience. Measurements of the stationary sound level (due to a sound source with a static noise spectrum for higher frequencies) show that the level is about 5 db higher at the rear of the hall than at the stage for frequencies between 1500 and 7000 cps.

Diffusion is provided by the side walls but not by the ceiling.

b. St. Andrews Hall.

The R.T. is in the proper range for the size of the hall. The R.T. vs. frequency curve is slightly dropping off from 300 cps and upwards (from 2,0 sec. by 300 cps till 1,5 sec. by 4000 cps.).

The shape is rectangular and no projecting surfaces are applied. Measurements of the stationary sound level (from the sound source mentioned above) show, that the level at the rear of the hall, for frequencies around 1000 cps, is the same as at the stage, but at the higher frequencies the level drops off at the rear. (About 5 db by 5000 cps., and about 10 db by 8000 cps.).

Diffusion is provided by columns and by the deep recessing of the ceiling.

The stage and stage surroundings may provide a good "building up process" of the sound.

The volume per seat is 211 cbft., which is somewhat lower than the figures for most of the halls which have been built recently.

c. Usher Hall.

The R.T. is in the normal range, maybe a bit low when the hall has capacity audience.

The R.T. vs. frequency curve is dropping off from 140 cps and upwards (1,95 sec at 140 cps and 1,2 sec at 4000 cps.)

The shape is horseshoe like a theatre but with a large and nearly rectangular stage. Measurements of the stationary sound level (from noise source) show a dropping off from the stage to the rear of the hall of about 5 db and independent of frequency (in the range 1000 - 8000 cps.)

Diffusion is provided from the balconies, columns and from some recessing in the ceiling. The volume per seat is about the same as in St. Andrews.

The stage provides a good building-up process.

d. Royal Festival Hall.

The R.T. is somewhat below the normal range. The R.T. vs. frequency curve is about level in the range from 200 cps to 1000 cps and then drops off slightly (1,5 sec. at 1000 cps., 1,2 sec. at 4000 cps.).

The main shape is rectangular in plan, but the side walls are broken up by the boxes. The large canopy reflects the sound towards the orchestra and towards the rear of the hall. Measurements of the stationary sound level show that the level is dropping from the stage to the rear about 5 - 10 db especially at the highest frequencies (5 db at 1000 cps., 10 db at 8000 cps.). The dropping off of the level is less pronounced on the Grand Tier.

Diffusion is provided from the boxes and from the corrugated ceiling.

The volume per seat is rather low.

e. Concertgebouw.

The R.T. is in the proper range and rather high. Nothing is known about the R.T. vs. frequency curve.

The shape is rectangular and no projecting surfaces are applied.

Diffusion should be ample from cofferings etc. The volume per seat is 322 cbft. which is high for an old hall.

f. Aalborghallen.

The R.T. is in the proper range and rather high. The R.T. vs. frequency curve is level with a slight rise below 100 cps. and above 1000 cps. The curve is dropping off above 4000 cps.

The shape is rectangular with a large canopy over the stage. The ceiling is broken up and the reflections from the ceiling are directed towards the seats.

Diffusion is provided from the ceiling and from the broken-up side walls.

The volume per seat is 490 cbft. which is high.

g. The Tivoli Concert Hall.

The R.T. is rather low for the hall with a capacity audience. The R.T. vs. frequency curve is fairly uniform and level from 100 cps. to 5000 cps. with a slight rise at 3000 cps.

The shape of the hall is slightly diverging in the plan and with horizontal ceiling, which is broken up, so that the sound is reflected towards the audience. The sidewalls are also broken up in such a way that side-to-side reflections are possible for the higher frequencies.

…3. Examples of Existing Large Halls and Their Acoustic Data.

Diffusion is provided from the broken-up ceiling, the broken-up side walls and the balcony.

Measurements of the stationary sound level show a dropping off of the sound level from the stage to the rear of about 3-5 db. The reduction is less at the highest frequencies (5 db at 2000 cps., 1 db at 8000 cps.).

The stage contracts towards the orchestra so that the building-up process of the sound on the stage is very rapid.

§ 4. The Major Hall of the National Opera House.

The main purposes are (1) symphony concerts with an audience of about 2800 and (2) grand opera with an audience of about 1800.

By placing the orchestra and some of the seats upon the floor of the theatre stage some practical and also acoustical advantages are secured. The acoustical advantages are (1) that a large volume and a correspondingly large volume per seat is obtained when the hall is used for symphony concerts, (2) that the seating area close to the orchestra is horizontal, so that the direct sound is propagated freely towards the rear of the hall (3) by screening off the upper part of the hall near the stage, the volume and correspondingly the volume per seat is lowered when the hall is used for grand opera, which requires less reverberation and more articulation than symphony concerts.

The R.T. is envisaged to be 1,8 to 2,0 sec. for symphony concerts and 1,6 to 1,8 sec. for grand opera.

The R.T. vs. frequency curve is calculated to be substantially flat maybe with a slight increase at the low frequencies and also a slight increase at frequencies around 2-3000 cps. (at least it is attempted to keep the R.T. from falling off in this region).

The upper part of the side walls and the back wall should be covered with panels, which can be changed in their absorption characteristic, so that they can be used for the tuning-in of the hall. An area of about 7000 sqft. is appropriate for this purpose.

The main shape of the hall is a "double fan" having the largest width and the largest seating area in the middle. The side walls are broken up in sections which have surfaces parallel to the longitudinal axis of the hall. This make side-to-side reflections possible in the high frequency range. In the medium frequency range the side walls will provide diffusion. The main shape of the ceiling with the two slopes approximate to a large extent a shape which gives a good sound distribution, but furthermore the ceiling is broken up in sections whose surfaces are inclined, so that the sound reflections are spaced equally over the audience. For low frequencies this shape will provide diffusion.

The volume is for symphony concerts app. 1.100.000 cbft. corresponding to a volume per seat of about 390 cbft. For grand opera the volume is reduced to app. 650.000 cbft. corresponding to a volume per seat of about 360 cbft.

The proportions of the concert hall are: (mean) height: (mean) width: length = 2:2,4:4,7, which is rather near to the harmonic proportions.

The curvature of the rows and the back wall is a bit too pronounced, the centre of curvature being at the back wall of the stage house. This must be corrected by appropriate corrugation of the back wall (sections with surfaces perpendicular to the main axis of symmetry) and of the steps between successive rows (same corrugation).

The stage for symphony concerts is approximately an enclosure with one wall missing, thus a rapid "building-up" process is ensured. The canopy may be moved vertically so that the stage volume may be adopted to the musical purpose.

The organ is placed on the back wall of the stage elevated about 10 ft. over the stage level and closed off when not in use.

The finish of the interior panelling (preferably wood) should be hard, smooth and polished, so that a maximum of high frequency reflection is obtained. Between the stage and the seating area a relatively large distance of free floor space (marble or polished wood) should be allowed, so that a good reflection of the sound from here is ensured.

The back wall is vertical but reflecting shields of wood direct the sound down towards the audience.

The side walls are practically vertical, their inward slope being less than 5 o/oo.

The curvature of the ceiling in the cross-section is only slight (curvature radius app. 360 ft.).

The proper shape of the orchestra pit for grand opera is analogous to the shape of the orchestra stage for symphony concerts i.e. a chamber with one boundary missing, in this case the ceiling. Appropriate measures to ensure reflections from the walls of the pit in all horizontal directions therefore are taken.

§ 5. The Minor Hall of the National Opera House.

The main purposes are (1) Dramatic performances and (2) Intimate Opera in both cases with an audience of about 1000 - 1100.

The R.T. in this case should not exceed the range of 1,3 to 1,6 sec because definition and articulation are very important for these purposes.

The R.T. vs. frequency curve should be substantially flat in the whole range of musical frequencies, and care should be taken to ensure only a slight falling off at the highest frequencies.

4. The Major Hall of the National Opera House. 5. The Minor Hall of the National Opera House.

Areas of panels for tuning-in purpose should be provided for on the upper part of the side walls and on the back wall.

What has been said already about the sound distribution and diffusion of the Major Hall equally applies to this hall but with even more stress upon an equal spacing of the first reflections over the audience.

The volume is about 280.000 cbft. corresponding to a volume per seat of about 265 cbft., which is considerably lower than in the major hall. This is due to the smaller ceiling height appropriate for the purposes of this hall.

The proportions of the hall are: 2:6:7 (mean height: mean width: depth), which is appropriate for a typical theatre hall, where the stress is laid more upon definition than upon reverbaration.

The curvatore of the rows and of the back wall also in this case is somewhat more pronounced than would be permissible, but this is compensated by breaking the curved surfaces up in flat sections perpendicular to the main axis of the hall.

The orchestra pit is shaped so that first reflections for the musicians themselves are obtained.

For theatrical performances the orchestra lift may be placed level with the floor thus making it possible to have some extra rows in the hall.

The finish of the interior panelling (also in this hall preferably wood) should be hard, smooth and polished.

§ 6. A Program for the Model Research of both Halls.

The model research has the following definite purposes: (1) Controlling the sound distribution of a stationary sound field, (2) Controlling the reverberation process especially the first slope of the process in positions at or near the stage, (3) studying the "building-up" process of short sound pulses, (4) listening tests.

ad. 1. It is obvious that by measuring the distribution of a stationary sound field, minor corrections in unequal distribution may be corrected by adjusting the reflecting surfaces.

ad. 2. The shape of the stage and the immediate stage surroundings may be evaluated by measurements of the first slope of the reverberation process thereby making it possible to adjust the coupling between stage and audience area.

ad. 3. The minute study of the "building-up" process of short sound pulses make possible a further detailed study of the acoustical conditions at the stage. The influence of the height from stage floor to canopy may thus be investigated with the purpose of ensuring optimal conditions in the actual situation in the hall itself.

ad. 4. A tape recording of music reproduced in the model with a speed which is as much larger in proportion to the normal speed as the model is smaller than the hall and rerecorded from a microphone in the model, makes it possible, when the tape afterwards is played with normal speed on a loudspeaker, to get an impression of how music sounds in the hall.

A study of the similarity demands of the model shows, that it is not advisable to use a smaller scale than 1:10, the limiting factor being the increase in the sound absorption of the air at high frequencies. Special attention must be given to the application of suitable model loudspeakers and model microphones which should be able to reproduce frequencies up till at least 40.000 cps.

§ 7. The Sound Insulation of the Entire. Building against Outdoor Noise.

The sound insulation against outdoor noise must be decided upon according to the results of the noise survey (as mentioned in § 1) together with the permissible noise level in the halls. The criterion for permissible noise in a concert hall is roughly a level of 20 to 30 db. though somewhat higher values could be allowed at low frequencies.

At least two complete structural layers must be envisaged, one being the shells and the glass surfaces behind the shell opening, the other being the concrete walls of the halls. In case it is necessary the insulation figure of these walls may be increased by an appropriate additional layer of some kind of light building boards. Some gain in insulation also may be obtained by reducing the reverberation time of the space between shells and interior ceiling.

§ 8. The Sound Insulation of the Interior.

The two main halls must be very thoroughly insulated against noise from each other. This is accomplished by: (1) complete structural independence, (2) two complete structural layers between the two halls.

ad. 1. Vibrations and structure-borne sound are effectively damped, if the two structures not only are separated on all points above ground but also are founded upon separate foundations, so that the vibrations have to pass through the ground itself and thus vill be reduced in strength.

6. A Program for the Model Research of both Halls. 7. The Sound Insulation of the Entire Building Against Outdoor Noise. 8. Sound Insulation of the Interior.

ad. 2. The sound level in a concert hall may at least momentarily (by fortissimo) reach values of, say, 100 db. This indicates that the sound insulation of airborne sound by order of magnitude should be not less than 70 db.

To obtain such high figures of sound insulation, complete structural independence as mentioned above, but also with regard to all piping, wiring, ducts etc. is essential. The two concrete walls and roofs of the halls then should provide the necessary two layers, whose insulation figures may be increased by additional layers of building board.

The little theatre is a building whose structure also is completely independent of the structure of the minor hall and which has its own roof below the concrete floor of the hall.

Due to the more isolated position of the chamber music studio, it is not necessary to build this studio up as a complete independent unit, but care should be taken that the two sections of the studio, which occasionally shall be divided by a movable partition, shall be thoroughly insulated from each other.

The several rehearsal rooms for conductors, soloists, musicians, etc. must be very well insulated from each other by using concrete floors riding on cork bricks and having walls and ceilings built upon these floors.

Noise from all technical services such as ventilating fans, lifts, water pipes etc. must be carefully damped by suitable insulation measures.

The noise level in the major and minor halls due to ventilation must not exceed a figure of 20 - 25 db.

§ 9. Acoustics of the little Theatre and the Several Smaller Rooms.

The R.T. of the little theatre preferably should be around 1 sec. and the frequency curve should be flat. From an aesthetic point of view a large ceiling height is wanted and therefore a heavy acoustical treatment of ceiling and upper walls must be envisaged.

The chamber music studio also requires an R.T. of about 1 sec. and a flat frequency curve. It ought to have some diffusing elements both upon walls and upon the ceiling.

The rehearsal rooms require values of R.T. in the range between 0.5 to 0.8 sec. according to their respective size and use. This may be obtained by appropriate acoustical treatment of ceilings and walls. Some diffusing elements also ought to be applied.

§ 10. The Sound Damping of Foyers, Stages, etc.

For acoustical convenience a great deal of all the rooms in the Opera House should be treated acoustically. This especially applies to the large foyer, restaurants, corridors etc., but also to restaurant kitchens and other larger service rooms.

A sound damping of the stage towers may be useful especially if they are only occasionally used for theatre decorations.

§ 11. The Facilities for Sound Amplification.

A sound amplification system for the entire building must be regarded as indispensable. A thorough planning of this system should be part of the whole project. Some of the features for such a system will be exposed in the following.

Major Hall.

For symphony concerts no sound amplification should be allowed. Only for pure entertainment concerts with microphone singers is sound amplification needed in the major hall. In a large hall like this, it may be necessary to use the delayed speech system, which in recent years have been introduced in several places, and which, when properly installed, is very successful in giving a natural sounding reinforcement of the human voice. In fact the impression from a correct system is, that only the speaker or singer himself is producing audible sound.

For use in operas it may be necessary to have a sound system upon the stage which sends out sound effects towards the audience.

Minor Hall.

A sound system for microphone talkers and singers should be planned but no delay system should be necessary in a hall of this size.

Another sound system for use during theatrical performances is necessary.

Overall System.

For communicating messages to the public, for emergency calls etc., an overall loudspeaker system in all public areas and also in all service areas should be planned. A central booth where all amplifiers, gramophones, tape-recorders, wireless receivers etc. are installed should preferably be placed close to the major hall. Probably it will prove convenient to have individual booths for all the halls.

9. Acoustics of the Little Theatre and the Several Smaller Rooms. 10. The Sound Damping of Foyers, Stages, etc. 11. The Facilities for Sound Amplification.

§ 12. Conclusions.

A noise survey of the site should be undertaken with as little delay as possible, because noise figures have influence upon the calculation of the sound insulation of outer walls, shells, glass partitions etc..

It is emphasized that a model research of major and minor hall is particularly valuable for investigating sound distribution, reverberation process (first slope) and the "building-up-process" of sound pulses.

Complete structural independence of the buildings of major and minor hall and of all interconnecting piping, wiring, ducts etc. is a condition, which should be fulfilled to ensure proper sound insulation between the two halls. Also the little theatre should have separate foundations, walls and roof.

Noise from all technical services should not exceed a background noise level of more than 20-25 db in any of the halls.

A sound amplification system for the entire building is indispensable and a thorough planning of this system should be part of the whole project.

Vilh.Jordan

Vilh.Jordan

M E C H A N I C A L   S E R V I C E S

It is proposed to provide heating and full air conditioning throughout the building.

In the layout and detailed design of all plant and ducts emphasis will be made on noise abatement from mechanical apparatus and elimination of fire hazards, as well as sound transmission from space to space. Furthermore, the wind conditions particular to the site and their reaction on the internal pressures will receive careful consideration.

A tentative layout of plant rooms is shown diagrammatically on the plan of the basement.

The fresh air intake is placed in a pit as remote from the building as is practically possible. The inlet to the fresh air duct is covered with a vertical wire mesh to eliminate insect pests.

The fresh air (blue) passes through inlet dampers into the mixing chamber, where recirculated air is added. The inlet fans (five are shown) then draw the air through the oilfilter banks, cooling batteries, heating batteries and, if required air washers, into the inlet main ducts (red).

Air extracted from the Halls (grey) is partly recirculated and partly thrown away through the exhaust ducts and grilles (yellow).

All inlet and extract main ducts are structural and placed below ground floor level. They are accessible and lined with acoustic absorbing material to such an extent that noise penetrating from the plant room is adequately reduced.

Axial flow fans will be preferred to centrifugal fans. They do admittedly produce noise of an appreciably higher intensity, but the pitch is much higher too (600 - 1000 Hertz as against 50 - 100 Herts) which is a considerable advantage, as sound of high frequency is more readibly absorbed than that of low frequency.

The plant is divided into 5 main groups serving the following localities:

1. Major Hall and appropriate public space,
2. Minor Hall and ditto ditto,
3. Rehearsal rooms, offices and staff quarters adjacent to Major Hall,
4. Ditto adjacent to Minor Hall,
5. Restaurant.

A closer investigation into the occupation periods of the different parts of the building may indicate that a further subdivision is required.

From the longitudinal section will be seen that the inlet air is blown into the major hall through the ceiling over the permanent seats and through openings at high level in the walls at both sides of the stage. These latter openings are only required when additional seating has been placed on the stage.

The extract takes place through grilles under the permanent seats and at floor level in the wall at the back of the stage.
The fans have two-speed motors.

The amount of air handled at low speed corresponds to that required for an audience of 1825 persons, whereas the fans are to be on full speed when additional seating has been provided on the stage.

The air inlets and extracts to the stage are closed by automatically operated dampers controlled by the switch gear for the inlet and extract fan motors whenever the hall is being used for operas or other purposes which will require a stage.

A special extract system is provided in the upper part of the stage to create an air movement towards the stage away from the audience.

This plant, which has not been shown on the section, will only be started when the curtain has been raised.

We can give the following information about the proposed air conditioning system.

Both Halls can be considered as separate and independent buildings placed inside a system of concrete shells. This is a great advantage from the air conditioning point of view, in particular when cooling is required, as walls and ceilings of the halls are shielded against the direct heat from the sun. The concrete shells act as enormous parasols.

The solar energy transmitted through the shells can be eliminated therefore before it enters the auditorium. This can be done, either by natural or mechanical ventilation of the roof space or by placing cooling units above the auditorium. The most economical way of achieving this heat barrier can be determined only after a close examination of prevailing wind in connection with the solar radiation on the different parts of the structure.

Our preliminary calculations have been based on the following conditions:

External design conditions, summer:	90°F 42% R.H.
Internal conditions required, summer:	79°F 50% R.H.
External design conditions, winter:	50°F 70% R.H.
Internal conditions required, winter:	70°F 50% R.H.

Inlet air 2000 cubic feet of air per person per hour, or a total of 100.000 c.f.m. for Major Hall, corresponding to a rate of air change of five times per hour approximately.

The cooling necessary for the air conditioning is effected by a refrigeration plant consisting of a number of compressors, condensers and evaporators.

Direct-expansion should not be used, but chilled water coils will be suitable. The refrigerant could be Freon, and sea water should be used for removing the heat from the condensers.

We do not consider it feasible to install a boiler plant inside the Opera building, and the possibility of utilizing the refrigeration plant on the heat pump principle to provide heating as well as cooling should be examined in detail. Should this prove uneconomical then we should recommend that a separate boiler house be erected in the vicinity of the existing warehouses.

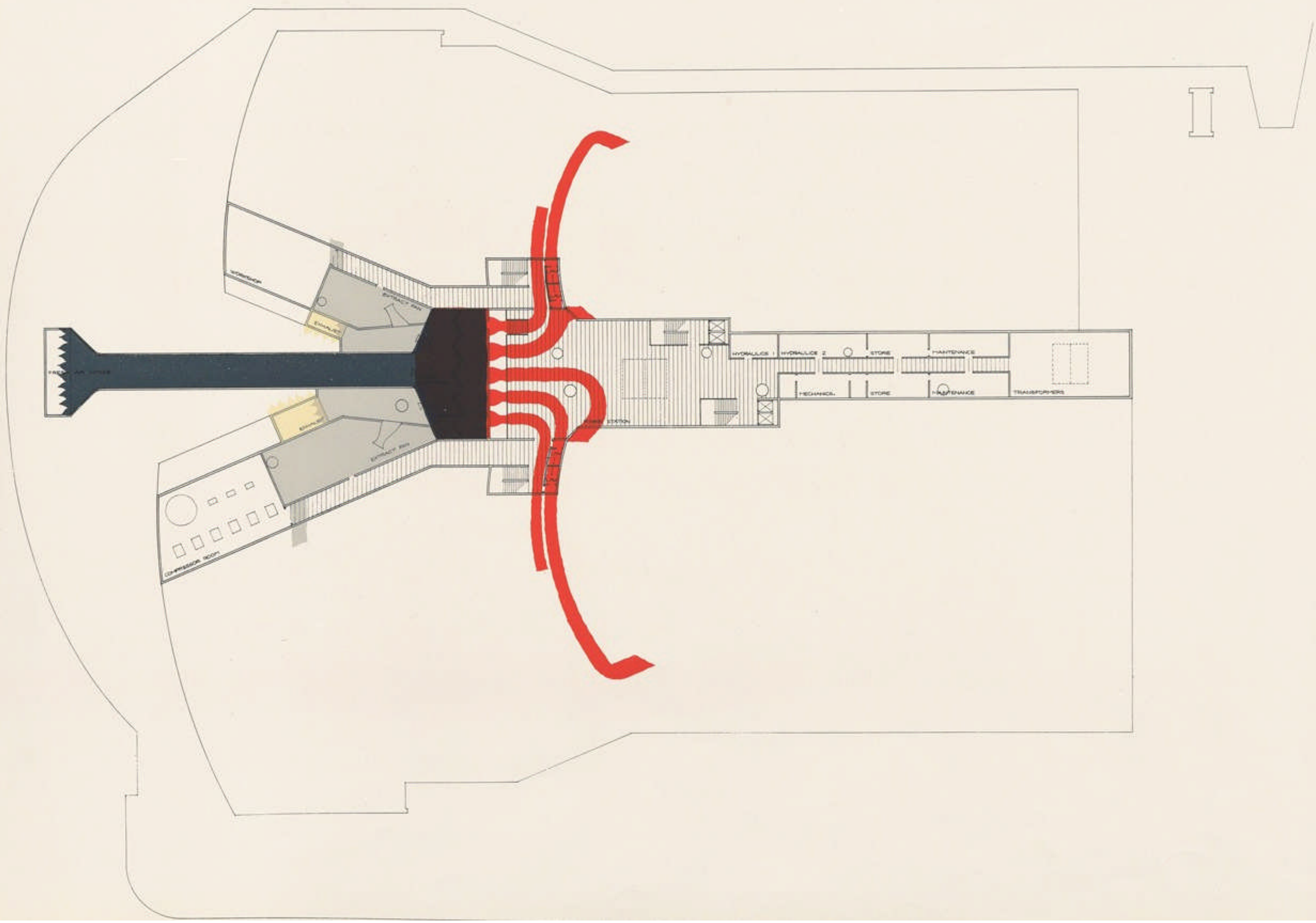
The air conditioning system will be controlled automatically in order that the desired inside conditions can be maintained irrespective of the outside conditions. We shall propose electronic control for this purpose.

The detailed design of the plant will be based on the information given in the publications issued by the Commonwealth Experimental Building Station in Sydney in conjunction with the London County Council regulations concerning Places of Public Entertainment.

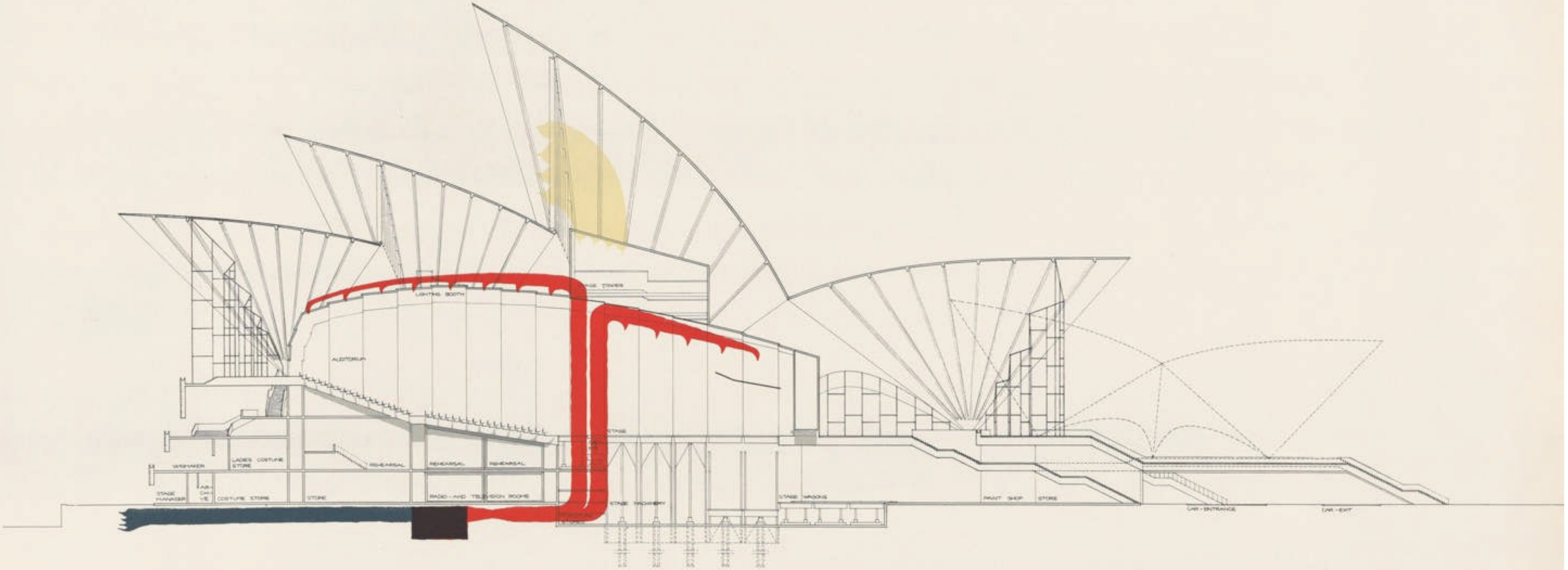
J.Varming

J.Varming .

Mechanical Services (cont'd.)



Basement Floor



Longitudinal Section Through Major Hall

E L E C T R I C A L   I N S T A L L A T I O N S.

The electrical services are closely related to the architectural treatment of the building and the detailed layout of the mechanical equipment. Consequently only brief outlines of the main dispositions can be given at this stage of the design.

Furthermore, a study of a number of electrical installations, such as lifts, clocks, telephones, facilities for radio and television transmissions, call and signal systems, fire detection and other items of vital importance, will have to be postponed until more details are available.

The total maximum load for power, lighting, etc. is estimated to be of the order 2000 kW. The electrical connection to the building should be a high-tension supply from the public electricity system.
Two high-tension cables, each with a capacity of approx. 2500 kW, should be provided. To reduce furthermore the possibility of power failure, these connections should, if at all possible, be taken off two separate sections of the supply grid.

The high-tension cables terminate inside the building in two high-tension circuit-breakers and the necessary metering system. The transformer room should be big enough for four transformers, each with a capacity of approx. 800 kVA, but not more than three transformers would have to be installed initially.

We recommend in accordance with present day practice for buildings of this character, the installation of a standby generator to maintain a reduced power supply in case of a break-down in the public supply system. We estimate that the stand-by generator should be of the order 500 kVA.
The transformers together with the high- and low-tension switch gear as well as the stand-by generator would have to be located in the basement, preferably adjacent to the compressor room.

A security lighting system supplied from a battery will have to be provided in accordance with the Building Regulations. We estimate that a battery of the order 200 Ah at 220 volts will be required.

The supply cables for the different electric motors in the basement should be run in cable trays at high level.

The vertical supply systems for power and lighting should preferably consist of prefabricated buss-bars from which panels for the outgoing feeds can be built up.

The lighting in particular forms an integral part of the architecture and must be studied as such.

It is, however, as a rule recommended to use incandescent lighting for all rooms; indirect lighting may have to be employed in a number of places.

It should be mentioned that the optical communication between the conductor of the orchestra and a chorus or other performers behind the stage will have to be the subject of a special study. This communication ought to be established by a closed circuit television system.

The disposition of the building near the water's edge, will give a striking enhancement to the exterior lighting which will spread out into the darkness in ever changing reflections from the water, as from a bright-lit liner gliding softly into port from the depths of the night.

M.Balslev

M.Balslev

Electrical Installation

T H E A T R E   T E C H N I Q U E

In all theatre countries of importance a feverish experimentation is going on right now with new forms of the theatre and new devices for the purpose and employment of the play stage. The work on this is going hand in hand with the experiments on new dramatics and new expression forms for the actor's art. One result of this work can already now be established. Henceforth, we will have to play theatre in many a greater variety of forms than hitherto.

Until the last few decades, the work-shop of the theatre, the stage, had, in principle, not been subject to any change for 200 years or more - apart from development of the technical auxiliary equipment. The views concerning what sort of architectonic stage house one ought to play theatre in had stagnated. Now it is no longer so. The expression forms of the theatre art have grown richer. We have broken out of the snail-shell of the baroque-theatre and have discovered so many more ways in which to play theatre. That is why it seems the only right and natural thing to the theatre's artistic leaders, to stage managers and producers, that a theatre that is built nowadays must be so constructed that it is not tied down firmly to one playhouse form, but that it is a theatre house that lives and that can change form and architectonic atmosphere according to the changing theatrical forms whose development it makes possible. The forms in which the theatre can manifest itself are infinitely rich and this house must be able to serve these forms and permit them to develop freely. The play stages housed within the Sidney Opera and Theatre House should fill most of the demands that can be made for this purpose. From dramatic and lyric theatre of varying size and style to intimate chamber play- and studio-theatre - from theatre performed on an intimate central arena, with the audience placed in a circle around the play stage, to the show-play of the large arena. For the purpose of educating the new generations to the right understanding of the theatre's art, the studio-stage size might prove to be of particularly great importance.

The stage machinery system as worked out for the Sidney Opera and Theatre House is no doubt the only conceivable one under the given site premises and the composition of the theatre house in general, and one which at the same time provides the greatest number of variation possibilities with regard to the shifting of wings and set pieces and the technical arrangement in connection herewith, and offers the richest possibilities for solving, in a supply way, any technical or artistic problems that might arise.

The play plane, i.e., the stage floor, can, in reality, be said to be alive through its division into platform lifts, planes that can be raised and lowered, and stage conveyor movements in combination with the lifts. Stage scenery, or parts of stage scenery, can be set up in any size wanted and be mutually shifted. At the same time, the stage is large enough to accommodate largesized stationary scenery, thus reducing or eliminating the use of technical machinery. Particularly in the classical dramatics we have many examples of plays with a great deal of scene shifting, but where the producer demands that the scene shifting takes place while the play is on, and without mechanical assistance.

It is possible, for instance, with a considerable artistic advantage, to present a great Shakespeare performance, as, for example, "Hamlet" or "Macbeth", where the text calls for between 20 and 25 shifts of scenery, without any use at all of conveyors or platform lifts - merely through the composition of a sculptural scenery, that is, an irregular plane construction with horizontal and vertical forms that through a many-sided faceting lend themselves to the shifting scenes of the drama. In itself, such a plastic space scenery is what is called a neutral play stage, none of its formations representing anything recognizable or evident - when, however, the actors give life to the stage in the shifting scenes of the plot, these abstract formations change, in the imagination of the audience, into banquet halls, battle fields, entrance halls, cellars, landscapes, ramparts, etc.

The proposed stage machinery may also be used when it is a question of partially changing such a sculpture scenery, set up to remain on stage through the whole performance. Bigger or smaller parts of such set pieces may be lowered on platform lifts and replaced by new components pushed in on stage conveyors.

It is not necessary, of course, that such a disappearing or new-added part of a stage construction is of the same size as the stage lift's total surface area. One is not bound to the maximum capacity of the lifts or the conveyors but can, according to requirements, reduce the extent and volume of the set details that have to be released from the scenery in its entirety.

In principle, there is hardly any limit to the number of settings that, with the system here adapted, it is possible to compose and present successively. Merely by applying the circular motion of the five big stage conveyors over the stage lifts the system functions as a sort of perpetuum mobile. The stage setting is made ready on its conveyor down in the stage basement, is pushed onto the platform lift in the background of the stage, raised to stage floor level, rolled forward on its rails to the stage opening, lowered on the forestage lift to the basement, demounted, and rolled back to the original position for a new set mounting.

The platform lifts function individually or coupled together - two and two, f.inst. On such a couple, operated together, a setting is built up, for example, the banquet hall in "Hamlet". When this is lowered into the basement the ramparts of the castle of Kronborg are raised simultaneously on the platform lift farther back. This simultaneous soft shifting of two settings can, of course, be utilized also for an artistic and dramatic effect, and not only as a supple technical arrangement.

The available stage area has not been large enough to permit, to advantage, the installation of a revolving stage of the size required to make it really effective. A theatre that as technical equipment has only a revolving stage is always faced with the problem that sets built up on the revolving stage are crowding each other and obscuring the free perspective of each other toward the horizon. From this point of view, the system of individually independent settings on conveyors or platforms is highly preferable.

We can imagine how, for example, "Peer Gynt" by Ibsen can be solved essentially by applying the stage technique which the dramatic stage will have at its disposal - that is, if it is not preferred to perform a play of that size on the opera stage. "Peer Gynt" consists of about 26 settings. The 10 scenes of the First Act depict mostly the flight of Peer through the Norwegian mountain world. The landscape is changing all the time as Peer walks along.

First of all, we are working with magic lantern projectors on the cyclorama. The fantastic mountain world looms bluish in the unattainable distance. On the stage lifts, plastic mountain and plateau formations have been built up and combined with the lantern slides of the cyclorama, so that the illusion is created that we are on the highest tops of the mountains. The plastic mountain formations are distributed over the different platforms, so that these, to a certain extent, may be lowered or raised independent of one another. Peer Gynt wanders in the mountains - he walks up a slope on the foremost platform lift - at the same time a platform behind it rises with new mountain formations, namely, the new landscape which he sees when reaching the top of the hill. Also the movements of these lifts may adequately be combined with a simultaneous changing in the nature of the lantern slides of the cyclorama.

By means of placing the stage platforms on individually different levels the feeling of the stage floor as a stationary level is eliminated. In the same way in which the modern theatre has worked to treat the theatre stage as a <u>room</u> with horizontal depth effect - with the third dimension - the platform system permits us to work also with the possibility of the stage for <u>vertical</u> depth effect. The scenery world of the drama continues also <u>below</u> what we called previously "the boards that represent the world".

It is self-evident what extraordinarily gratifying effects may be obtained through opening part of the stage, and from the depth below upward to the stage-area arranging entrance schemes for actors and extras - whether it now be the giant stairs of the Capitol in "Julius Cæsar" or the forest scenery of "A Midsummer-night's Dream". By means of a limited number of cleverly placed extras it is possible to obtain the full illusion of an interminable crowd of people that continue downward to the foot of the Capitol stairs, or below the palace of Oedipus and Agamemnon. And in the Midsummer-night's Dream the field may open and from the underworld below allow an interminable procession of elves, fairies, goblins and wood nymphs to float mistily up into the human world.

The Midsummer-night's Dream has one problem often difficult to solve, i.e., the castle of Theseus that appears only in the beginning and the end of the plot. On a stage like the present one the problem is easily solved, however. The entire big wood, the play's dominating locality, covers constantly the whole stage area. The castle is built up on the foremost platform lift and emerges in front of the wood which is hidden by the castle set. First and foremost the technical construction of the large stage allows for excellent possibilities of acting for the producer. It may be used as an "ordinary" theatrical stage for the traditional opera repertoire and for large musicals and shows, i.e. when the stage is separated from the auditorium by the proscenium wall with its curtain and by using the cyclorama and the stage conveyors.

It may moreover be transformed to a gigant arena when the proscenium with its lighting tower etc. disappear at the sides, thereby eliminating the entire boundary between the stage and the auditorium. On such occasions the stage floor is lowered hydraulically to the horizontal level of the auditorium floor - and not only the part of the stage floor which comprises the stage lifts but also the area between these and the side walls of the stage.

On this arena large shows and revues such as "Round the World in 80 Days" may be shown and with just as great an effect arena stage performances of dramatic and lyrical repertoire may be given.

It is possible to let the stage floor remain sunk at one level, and one may also utilize the lifts and as required "cut the arena stage short" into various levels and heights, all easily changed while the performance is going on. Consequently nothing will prevent suddenly letting a large plastic decorative construction appear from the underworld, or wherever one wishes, onto the open arena stage, thus producing in show-revues a most dazzling effect.

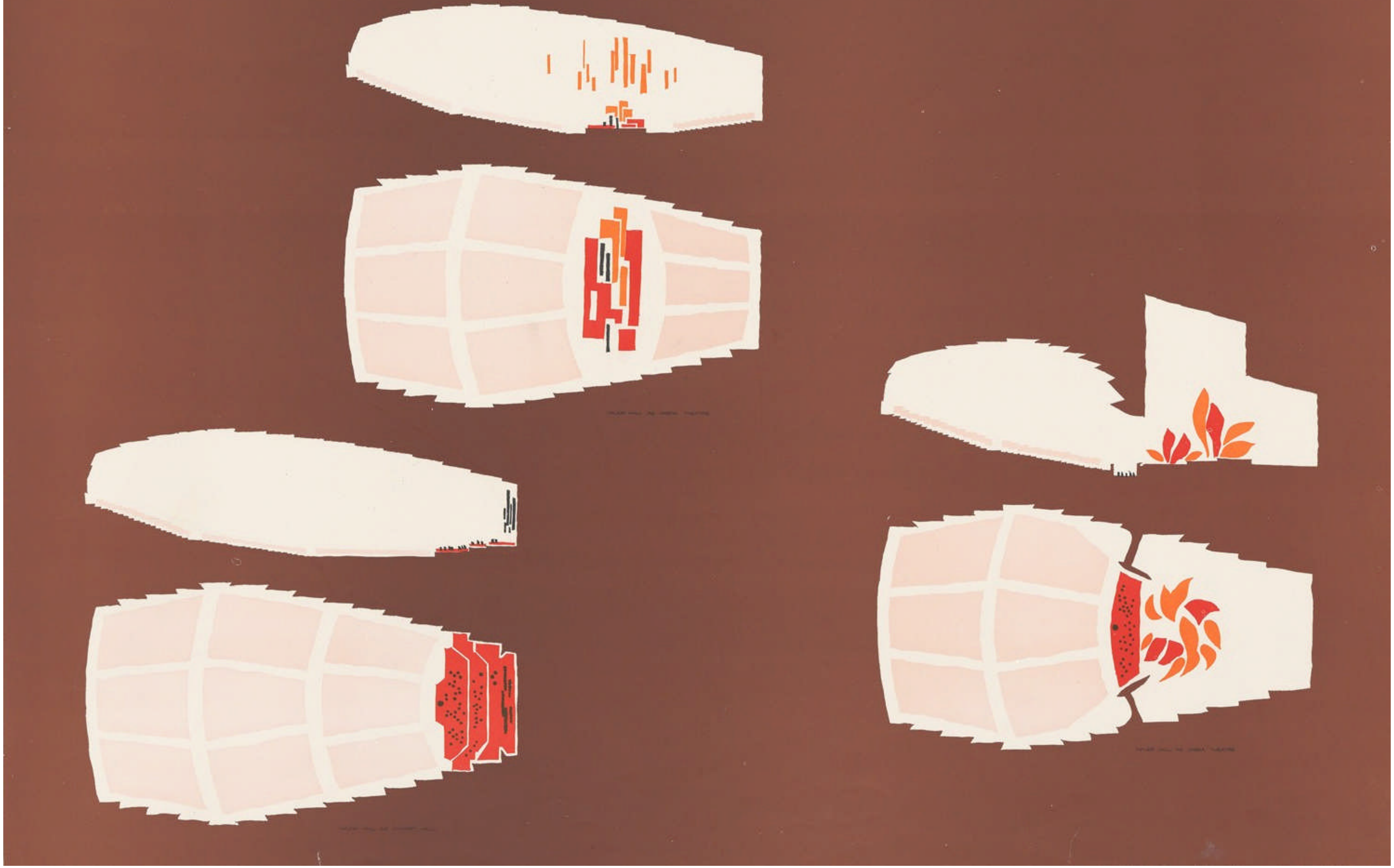
During the above mentioned alternative the public are assumed to remain in the ordinary auditorium - i.e. only on the <u>one</u> side of the arena. It would, however, also be quite easy to utilize <u>half</u> of the former stage area as an arena stage, and to arrange amphi-theatrical pit stalls. In this way a stage space is created in the form of an arena which lies <u>in the middle between</u> two audience pit stalls.

In point of fact this latter form of a play-stage is greatly developing as a new form of theatre, and everywhere such experiments have proved artistically to be a very popular feature.

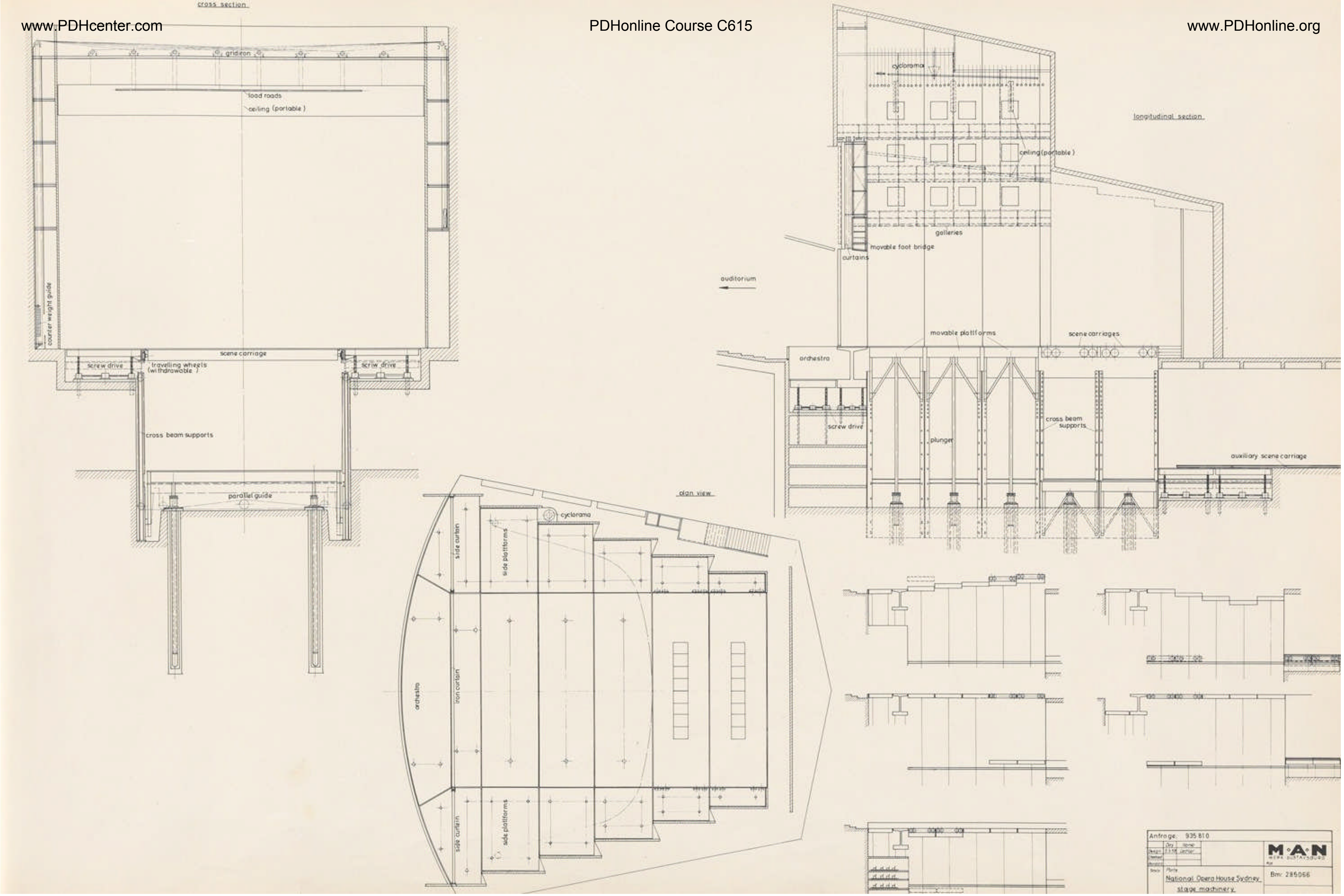
It is obviously not necessary to point out how an arena stage with the above mentioned possibilities of variation, also may be used with great advantage as an arena for various kinds of celebrations, meetings and gatherings outside of the sphere of the professional theatre.

Sandro Malmquist

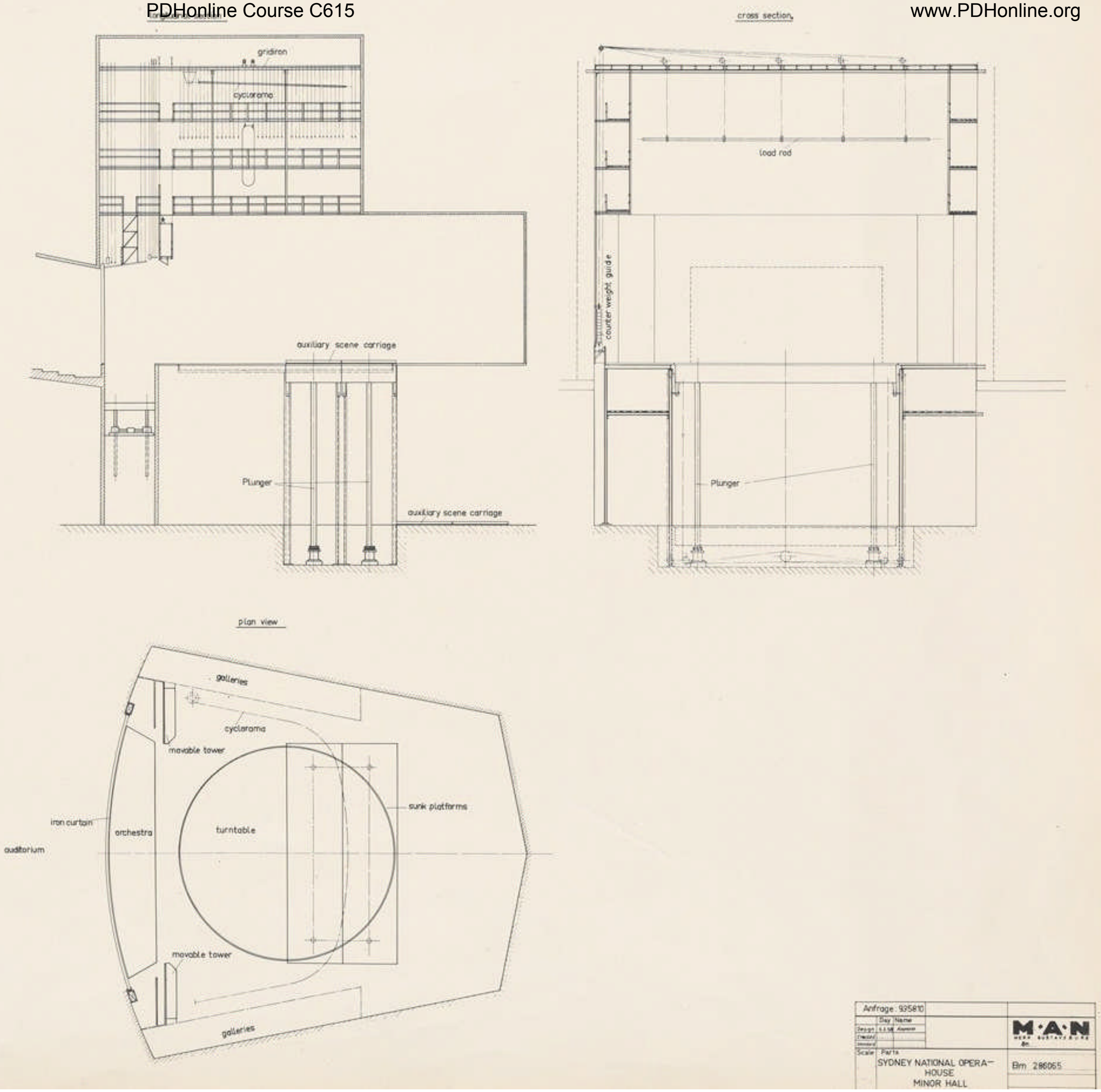
Sandro Malmquist



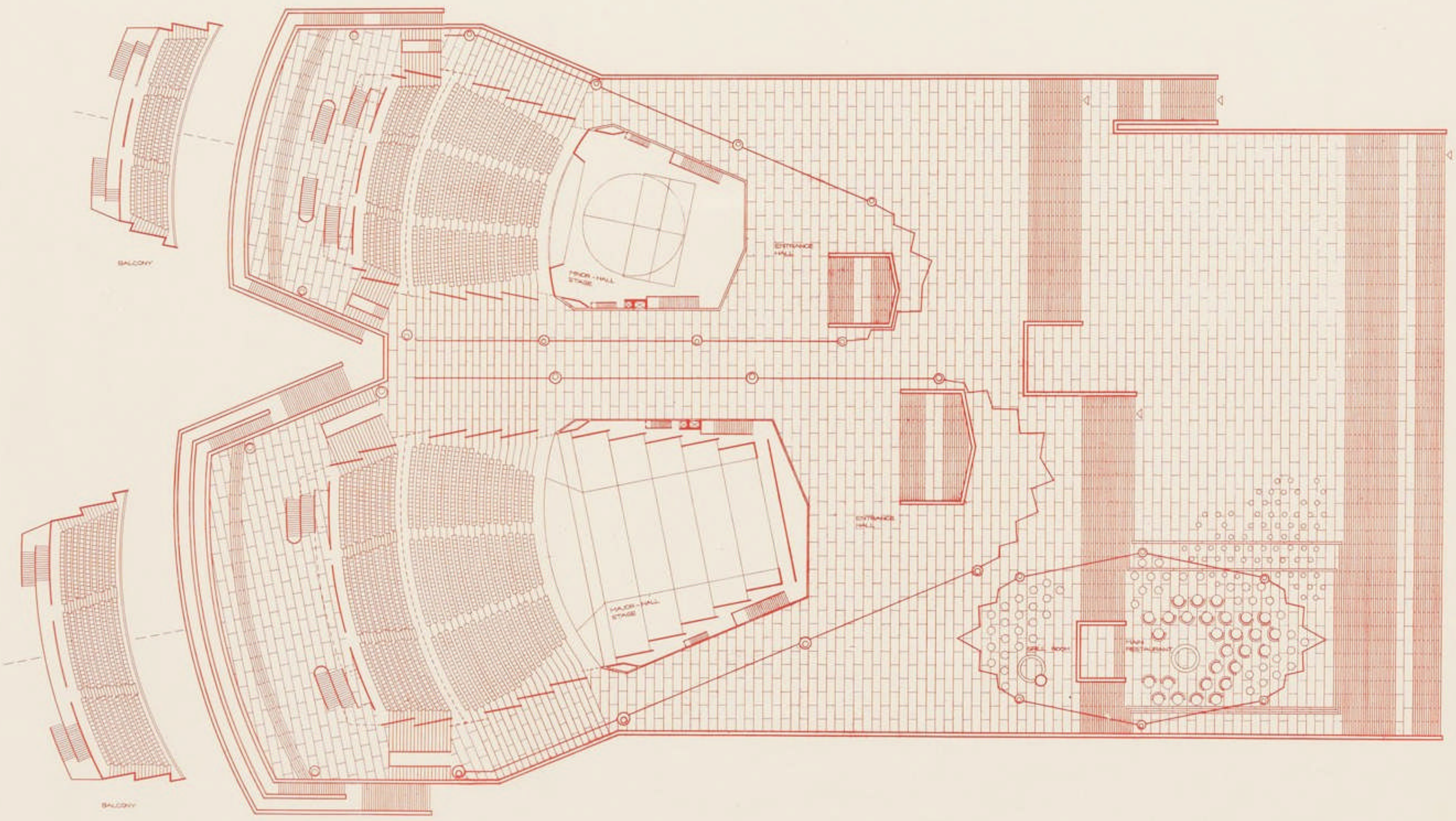
Various Uses of Major Hall



Stage Machinery



Minor Hall Stage Machinery



Alternative Balcony Plan

Back Cover

Part 5

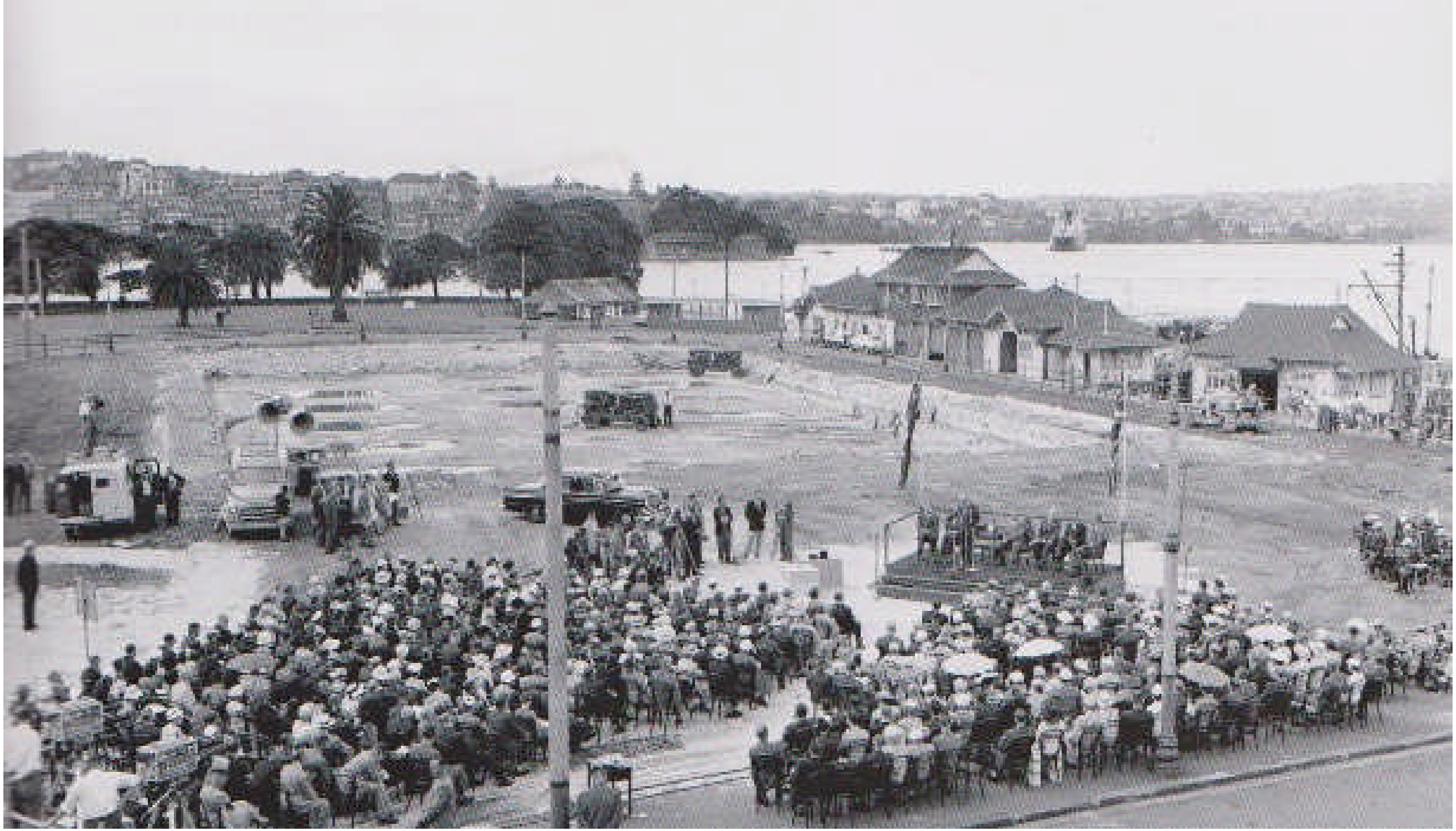
The Gold Book

To Bring A Magnificent Concept Into Being

The Red Book (which Utzon dedicated to Joseph Cahill) clearly demonstrated the quality of the design aesthetics as it developed from the time of the competition. The in-depth, detailed consultants reports assisted greatly in conveying the fact that the sculptural design was feasible from both an architectural and engineering point-of-view. Just a few days after presenting the Red Book, Utzon and Arup met again with Premier Cahill who requested that actual construction commence in February of the following year. Though Cahill had legitimate reasons for wanting to start construction asap, Arup saw it as a premature political decision that could/would damage the smooth flow of the design process leading to problems during actual construction. Arup suggested that the construction process be broken down into three distinct stages. This would allow the project to begin with the demolition of the tram sheds and construction of the *Podium*, a.k.a. "the substructure" (*Stage One*), while resolution of other, more complex issues concerning the roofs and interiors proceeded. *Stage Two* involved the erection of the roof shells and *Stage Three* included all interiors and glass enclosure walls. Arup's simple, elegant "phased" solution allowed for the building process to start immediately and allowed the *Tendering* (bidding) process to evolve in a logical, progressive order. Best of all, Joe Cahill would not have to see the SOH project – so near and dear to his heart for so long, shelved by a new NSW government. Utzon's visit to Sydney in March 1958 would be the second of three he made that year. Known as the *October Scheme* (because it was submitted in October 1958), Utzon was required to produce another set of drawings which provided details about the Podium which were missing from the Red Book (in preparation for the Tendering process for Stage One which would began in November 1958).

Oh Captain, My Captain

While both Utzon and Arup returned to Europe (after their March 1958 visit) to continue work on the SOH project at home, preliminary work had begun on-site. Test bores were taken on Bennelong Point to gauge the depth to bedrock while wind velocities and noise from navigation in the harbor was monitored. On August 18th 1958, fifty-six year old Fort Macquarie Depot began its demolition to make way for the SOH. Utzon returned to Sydney (in November 1958) with further developed plans for the Podium. A Tender for $2.8 million (low-bid) was awarded the contract that month. On March 2nd 1959, the *"Ceremony to Commemorate the Commencement of the Building of Sydney Opera House"* took place on Bennelong Point. Premier Cahill screwed down an inaugural plaque Utzon had brought back with him from Denmark (Cahill's office had requested Utzon design one). Utzon assigned the task to *Yuzo Mikami* who suggested locating the plaque at the intersection of the axes of the two halls. It is from this lone point that both halls can be viewed head-on (Utzon had the plaque made at the Helsingor Shipyard where his father had been director). Cahill proudly announced that the SOH would be open for business on January 26th 1963: *Australia Day.* Sadly, Joe Cahill would not live to see the opening of the SOH; he died on October 22nd 1959. It turned out his political concerns were prophetic based on the results of the March 21st 1959 elections whereby Labor barely retained power.



“Ceremony to Commemorate the Commencement of the Building of Sydney Opera House” (March 2nd 1959)

"The time for controversy is over. It only remains for us to work together in a spirit of goodwill, and raise the necessary finance to bring this magnificent concept into being."

Robin Askin, leader of the opposition party (in the NSW State Parliament)

RE: pledge made at the SOH commencement ceremony. Above, NSW Premier Cahill signs the construction contract for the SOH.

"Stand not merely as an outstanding example of modern architecture, or even as a world famous opera house, but as a shrine in which the great artists may display the flowering of Australian culture"

Joseph Cahill, NSW Premier

RE: from his deathbed, Cahill asked Minister for Public Works *Norman Ryan* to promise him that he would not to let the SOH project fail. Ryan kept his promise to Cahill but struggled to properly manage the incredibly complex project in the years ahead. A printed program for the commencement ceremony became known as the *Gold Book*. It includes comments by many of those who had, up to that point in time, participated in making the SOH a reality.

The first sod Is turned on the Construction Site of the SOH (March 2nd 1959)

Excavation work commenced on Bennelong Point (Spring 1959)

The Mistress Art

"Architecture is the mistress art. We now have the opportunity to produce a building which could rank among the great buildings of the world. We have a fine site, an imaginative design and a practical solution to the problem…"

H. Ingham Ashworth, Professor of Architecture-University of Sydney
RE: excerpt from his *Gold Book* comments

"…This imaginative structure in a beautiful setting will attract and inspire the great artists of the world and stimulate the rapid growth of our native culture…"
Davis Hughes, Leader – NSW Country Party
RE: excerpt from his *Gold Book* comments

"…The premiated design of the Opera House, so universally acclaimed as a bold and ultra-modern concept, has already aroused world-wide interest, which reflects itself in added prestige and publicity for the City and the State…"

H.F. Jensen, Lord Mayor of Sydney

RE: excerpt from his *Gold Book* comments

Vision Splendid

"…It is ten years since I first discussed the building of an opera house for Sydney with Sir Eugene Goossens. A Sydney Opera House such as we are going to build at Bennelong Point was Sir Eugene's 'vision splendid.' Above all else he saw it as a home for his beloved Sydney Symphony Orchestra…"

Charles Moses, General Manager – Australian Broadcasting Commission
RE: excerpt from his *Gold Book* comments

The Soul of Sydney

"Even one building can make a difference in a city. In 1920 the City of Stockholm commissioned an architect to design a new City Hall. Form the day that building was finished the city began to change. For the architect had seen the soul of Stockholm and turned the people's minds to the beauty of the waterfront and the possibility for improvement…The architect must be inspired. I am sure the people of Sydney will understand when I say how deeply I feel my responsibility and how much I am inspired by it."

Jorn Utzon, Architect

RE: excerpt from his *Gold Book* comments

A Great Nation

"…We Australians have already made our mark in many fields of human endeavor and we are rapidly growing into a great nation. The nations of the past have each contributed something to the accumulation of those arts which spring from the soul and mind, and form such an essential part of any great civilization. We have something to contribute also, and my Government is convinced Australia is worthy of a building in which our contribution to the music of the world can be fittingly demonstrated…"

Joseph J. Cahill, NSW Premier

RE: excerpt from his *Gold Book* comments

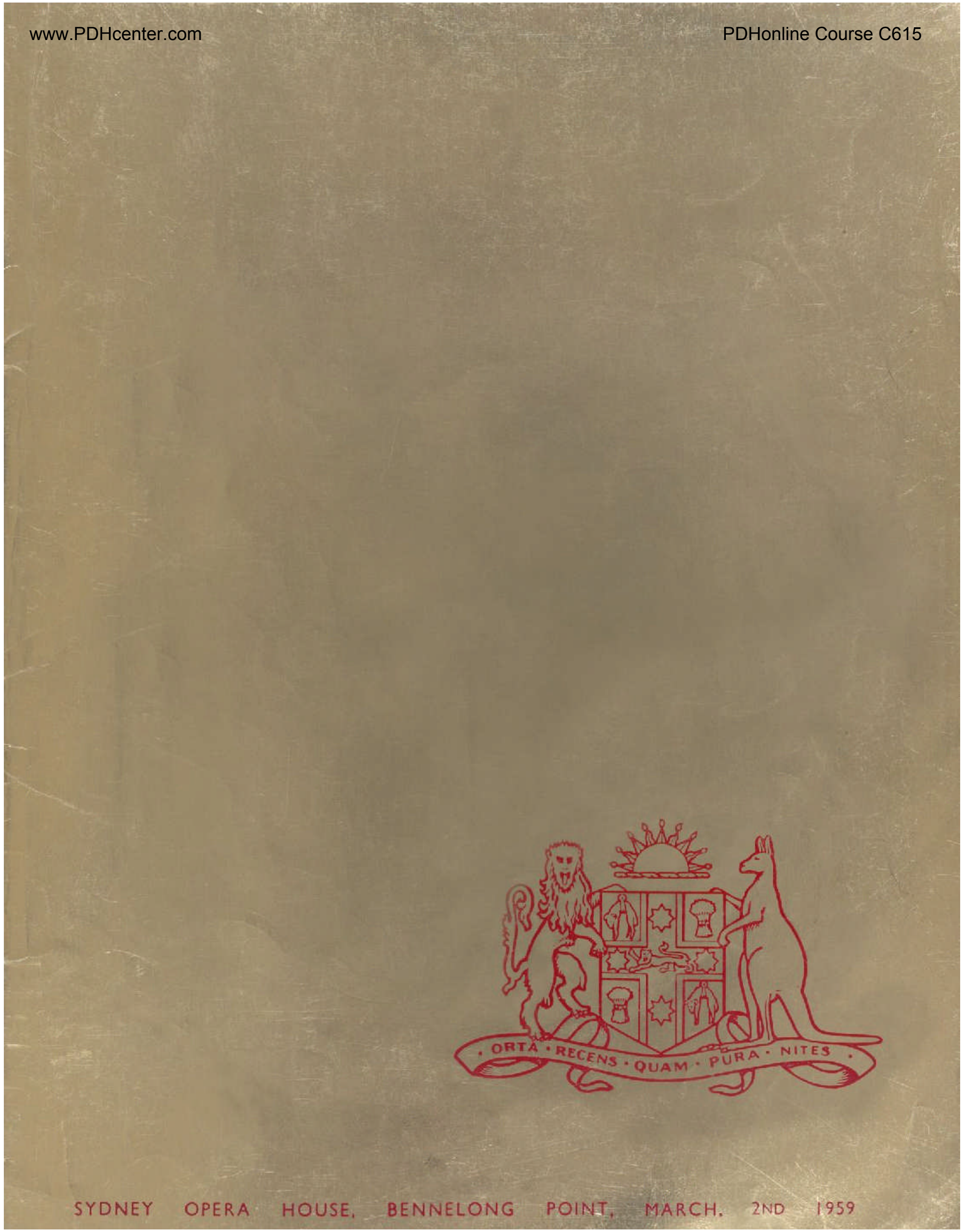
Gold Book

The printed booklet, commonly known as the "Gold Book," was:

"issued to accompany the 'Ceremony to Commemorate the Commencement of the Sydney Opera House' on 2 March 1959"

At this ceremony the Premier, the Hon. J.J. Cahill M.L.A., positioned a plaque indicating the point from which all measurements of the Sydney Opera House would be taken. The booklet comprises a foreword by the Premier, comments on the Opera House, notes on the competition, the site, the design, and plans.

The booklet was printed in Sydney by V.C.N Blight, Government Printer in 1959.


ORTA · RECENS · QUAM · PURA · NITES
SYDNEY OPERA HOUSE, BENNELONG POINT, MARCH. 2ND 1959

Front Cover

SYDNEY OPERA HOUSE

BENNELONG POINT SYDNEY 2ND MARCH 1959

Overleaf

CEREMONY TO COMMEMORATE THE COMMENCEMENT OF THE BUILDING OF THE SYDNEY OPERA HOUSE

On 2nd March, 1959, at 2.30 p.m. on the site at Bennelong Point the following ceremony is to take place.

The Hon. J. J. Cahill, M.L.A., Premier of the State of New South Wales, will fix in position an Inscribed Commemorative Plaque indicating the point from which all measurements of the Sydney Opera House will be taken.

PROGRAMME

Arrival of Official Party.

Opening of proceedings by the Chairman of the Sydney Opera House Executive Committee, Mr. S. Haviland, C.B.E.

The Right Honourable the Lord Mayor of Sydney, Alderman H. F. Jensen, will welcome the guests.

Messages of goodwill conveyed by—

A representative of the Prime Minister of Australia, the Right Honourable R. G. Menzies, C.H., Q.C., M.H.R.

Mr. R. W. Askin, M.L.A., representing the Leader of the New South Wales Opposition, Mr. P. H. Morton, M.L.A.

Mr. Davis Hughes, M.L.A., Leader of the New South Wales Country Party.

A commemorative address will be given by the Honourable J. J. Cahill, M.L.A., Premier of New South Wales.

Mr. Joern Utzon, Architect, will hand to the Premier the trowel to be used in the ceremony of fixing the Commemorative Plaque.

Immediately upon the fixing of the Plaque, a signal will be given for work on the site to commence.

(By courtesy of the Commissioner of Police, Mr. C. J. Delaney, C.V.O., the New South Wales Police Band will entertain guests prior to the ceremony and during refreshments).

Programme for Ceremony

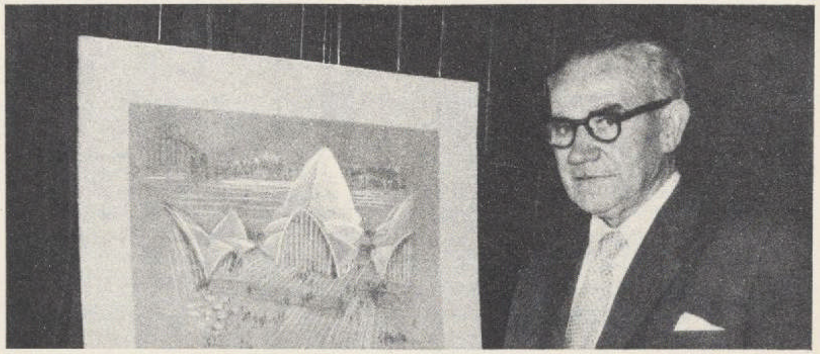


Photo by courtesy Government Printer, Sydney

THE proposal to build the Sydney Opera House and the proof we have given of our determination to see the project through to finality, have focussed the eyes of the world upon us.

We Australians have already made our mark in many fields of human endeavour and we are rapidly growing into a great nation.

The nations of the past have each contributed something to the accumulation of those arts which spring from the soul and mind, and form such an essential part of any great civilisation.

We have something to contribute also, and my Government is convinced that Australia is worthy of a building in which our contribution to the music of the world can be fittingly demonstrated.

Such a building will be the Sydney Opera House and it will stand not merely as an outstanding example of modern architecture or even as a world famous opera house, but as a shrine in which the great artists of the world may be seen and heard and our own artists may display the flowering of Australian culture.

Over the four years during which this project has so far developed there has been much praise and comparatively little criticism.

Any criticism has been along two main lines, one, that we should erect homes rather than this building and two, that only the wealthy will be able to afford patronage of the Opera House.

My answer to the first criticism is that not one home less will be built.

In answering the second criticism, I repeat what I said in August, 1957, namely, that the building when erected will be available for the use of every citizen, that the average working family will be able to afford to go there just as well as people in more favourable economic circumstances, that there will be nothing savouring even remotely of a class conscious barrier and that the Opera House will, in fact, be a monument to democratic nationhood in its fullest sense.

In conclusion, I express my grateful appreciation of the honorary services rendered by the members of the Executive Committee, the Appeal Fund and the Advisory Panels as well as the many other individuals who have voluntarily assisted in developing this project. As true Australians the reward they seek is that in a day which is not far off the dream shall become reality and this beautiful building stand for all the world to see and admire.

J. J. CAHILL
Premier of New South Wales

Message by J.J. Cahill, Premier of New South Wales

THE NEED FOR THE OPERA HOUSE

NEW South Wales needs an opera house such as that now planned for Bennelong Point because the State's artistic development has outgrown the facilities available for presenting to the people music in all its forms, ballet and theatre.

There is, for instance, an enthusiastic audience in Sydney for chamber music but no suitable auditorium for this form of music, nor, for that matter, for musical recitals.

The Sydney Symphony Orchestra, we are repeatedly told by overseas authorities, is rapidly approaching world class but has no appropriate home.

Professional and amateur drama has progressed remarkably since the war but is hampered by the lack of adequately equipped, comfortable, well-situated theatres.

In addition, we need an opera house for opera: a great theatre for the production of a complete operatic repertoire under conditions which will facilitate superb performances by artists and full enjoyment by audiences.

The Sydney Opera House with its four separate auditoria will give us all these things.

The large auditorium, with its maximum seating capacity of 2,800, will be used for the annual opera season of from six to eight weeks but its principal use will be for concerts by the Sydney Symphony Orchestra which gave over 120 concerts of various kinds in Sydney over the last year.

Here the orchestra will give its subscription concerts. The greater seating accommodation of the new auditorium will enable a reduction in the number of subscription concerts from 50 to 40. This in itself is of the utmost importance.

All patrons will enjoy perfect sound and sight of the concerts, and the foyers, cafes and bars of the Opera House will give them facilities not now available anywhere in Australia.

Additionally, the new auditorium not only will reduce the present burden of the subscription concerts on the orchestra but its seating capacity will enable the enrolment of another 1,200 subscribers.

It will also allow at least 2,000 more young people to enrol for the orchestra's Youth Series without adding to the work of the orchestra.

Naturally, it would be the place for recitals by artists like David Oistrakh or Claudio Arrau but its construction will enable it to be "adjusted" to seat 1,700 for opera, and this is an ideal size for recitals by artists not quite in the Oistrakh-Arrau bracket.

The second hall or theatre will seat 1,100 and be used primarily for drama. The theatre will have a revolving stage and every piece of equipment a producer might conceivably need as well as adequate foyers and refreshment facilities.

Of the two small halls one will seat 410 and the other 310. The larger will be completely equipped for modern theatre production or concerts and both will give Sydney superb accommodation for conventions and other public gatherings.

Both of these halls would be used for chamber music and recitals, while the larger will be perfect for the kind of theatrical performances now being staged under comparatively make-shift conditions; this little theatre also will have an excellent foyer and refreshment facilities.

Sydney is one of the world's big cities. If its citizens wish it to be great as well as big they must give it those things which endow a city with greatness. These, very definitely, include a focal point for the arts of music, drama and ballet.

The Need for the Opera House

COMMENTS

THE commencement of building operations on the Sydney Opera House site marks another milestone in the development of Sydney.

I am sure that all citizens will be proud, as I am, that in prospect a magnificent structure will soon appear to add dignity and attractiveness to the skyline, and provide another dominant feature to the Harbour Gateway of Sydney.

The premiated design of the Opera House, so universally acclaimed as a bold and ultra-modern concept, has already aroused world-wide interest, which reflects itself in added prestige and publicity for the City and the State.

The functional character of the structure, with its cultural and utilitarian purpose, adds to the stature of the Mother City of the Commonwealth, and will provide the citizens with an incomparable venue for the appreciation of music and the arts.

H. F. JENSEN
Lord Mayor of Sydney

The Sydney Opera House marks the beginning of a new phase in Australian history. This imaginative structure in a beautiful setting will attract and inspire the great artists of the world and stimulate the rapid growth of our native culture. It will be not merely a striking landmark on the shores of Sydney Harbour, but also a symbol that our cultural thought is keeping pace with national expansion. Country as well as City people will enjoy its benefits and the people of other States will watch its progress with interest and pride.

DAVIS HUGHES
Leader, N.S.W. Country Party

The conception behind this Opera House has given a marked fillip to music, opera and the theatre.

Many people have been captivated by its striking boldness of design. It has attracted wide interest overseas and greatly enhanced our cultural standing.

The Opera House will further establish the capital of New South Wales as one of the world's truly beautiful cities.

It does pose a very big challenge, however—that of producing cultural works of a continuing standard worthy of the structure in which they are presented. This challenge will, I know, be met.

P. H. MORTON
Leader of the State Opposition

It is ten years since I first discussed the building of an opera house for Sydney with Sir Eugene Goossens.

A Sydney Opera House such as we are going to build at Bennelong Point was Sir Eugene's " vision splendid ". Above all else he saw it as a home for his beloved Sydney Symphony Orchestra.

As we go along towards the realisation of his dream we should not forget Sir Eugene's early campaigning and his success in persuading people that an opera house was not only desirable but essential to the State's cultural growth.

I am proud that I was a member of the original Opera House Committee appointed by the Premier (Mr. Cahill) and am one of the three originals remaining on the present Committee.

CHARLES MOSES
General Manager, Australian Broadcasting Commission

Comments (1 of 3)

COMMENTS

Architecture is the mistress art. We now have the opportunity to produce a building which could rank among the great buildings of the world. We have a fine site, an imaginative design and a practical solution to the problem.

Behind the design towers an imaginative architect in Joern Utzon, supported by Ove Arup, an engineer of world renown.

It should be appreciated that this original and magnificent scheme has received acclaim all over the world and comprises a significant contribution to the development of the architecture of our own time.

H. INGHAM ASHWORTH
Professor of Architecture, University of Sydney

The past twenty-five years have seen a remarkable transformation in Australia's musical life; but during that time no single event has had the influence that we can expect the building of the Sydney Opera House to exercise in the future.

It is common knowledge that the expansion of concert audiences has far outstripped the facilities available for the performance of opera, symphonic and chamber music. Indeed, not the least remarkable feature of music making in Australia is the fortitude of performers and public alike in the face of inadequate accommodation. Opera in Australia has yet to be enjoyed in surroundings where a full orchestra is properly situated in relation to the singers and the audience; and it is no exaggeration to say that the Sydney Symphony Orchestra has never been heard in conditions which do justice to its quality.

The Sydney Opera House has attracted world-wide interest as an architectural adventure; but for Australians it must surely represent the beginning of a new and exciting period of cultural and artistic development.

BERNARD HEINZE
Director, State Conservatorium of Music

Even one building may make a difference to a city. In 1920 the City of Stockholm commissioned an architect to design a new City Hall. From the day that building was finished the face of the city began to change.

For the architect had seen the soul of Stockholm and turned the people's minds to the beauty of the waterfront and the possibility for improvement.

When architects work they try to express the climate and the personalities of the people who will live and use a house. The architect must be inspired.

I am sure the people of Sydney will understand when I say how deeply I feel my responsibility and how much I am inspired by it.

JOERN UTZON
Architect

The Sydney Opera House is one of the outstanding civic enterprises of our times. Its conception has already inspired a design of singular beauty. As a cultural and social meeting place for the people of Sydney and as a gesture of confidence in the vitality of the arts in Australia the Opera House will take its place among the foremost buildings of the world.

I am proud that the Elizabethan Theatre Trust has been associated with its planning.

HUGH HUNT
Executive Director Australian Elizabethan Theatre Trust

The Opera House will be unique not only in its beauty, but because it will provide for every taste and enrich the whole life of the community.

It will bring together under one roof (and what a superb one!) all who enjoy the performing arts, all who like to be entertained. The musician, the theatre-goer, the opera enthusiast, the common man and the connoisseur will be drawn together in bonds of pleasure and achievement and will share their pride in this great building.

ROBERT QUENTIN
Director, School of Dramatic Art

Comments (2 of 3)

COMMENTS

The importance of the Opera House to the cultural life of this city cannot be underestimated.

We have created through our activities musically and otherwise, a pattern which is to be envied in most parts of the world, including America, and we should be happy to complete a venture that has been long overdue. With the influx and absorption into our cultural life of many peoples whose habits have been handed down traditionally, we must, and soon, reacquaint them with their normal activities and provide for our musicians a suitable centre of performance requirements.

ERNEST LLEWELLYN
Leader of Sydney Symphony Orchestra

The theatrical profession is greatly exhilarated by the knowledge that our mighty new State Opera House has at last been commenced. It is our great hope that the smaller auditorium, particularly, will prove the home of many play productions now without proper stage accommodation. It is a challenge to us to provide theatrical fare worthy of this great centre. If theatregoers will also make this House their Mecca, then our Opera House will indeed be the envy of many other nations. All honour to Sir Eugene Goosens, to our Premier, to Mr. Utzon and to all citizens of vision who have translated a great ideal into an exciting reality.

JOHN ALDEN
Actor

I think the building of the Opera House a wonderful idea, for we are such a musical race and have so many lovely voices here.

The Opera House will provide our artists with both incentive and opportunity.

This is a great step forward in the cultural development of Australia and one which we can and will support.

I hope to be there on the first night.

GLADYS MONCRIEFF
Soprano

OVERSEAS PRESS

"Time" New York—February 25th, 1957

"Sydney, Australia, which staged one of the world's biggest international competitions, has emerged with the most pleasing and original design of all for its harbour-front site.

. . . So many opera houses look like boots. There is the high proscenium arch, then the low part which is the audience. Utzon has solved the problem."

"Architects Journal" London—February 14th, 1957

"Joern Utzon, the Danish winner of the Sydney Opera House Competition, promises to contribute as impressive a development in concrete shell construction, as Candela is producing in Mexico. Here is the epitome of romantic sculpture on the grand scale.

. . . No doubt there will be controversy over this design — controversy over competition results is inevitable nowadays anyway. But the citizens of Sydney should congratulate themselves. The design will always be of interest, however the theorists may argue, and will be worth travelling many a mile to see, admire and wonder at. Sydney need have no doubts that its policy in holding an International Competition was absolutely right."

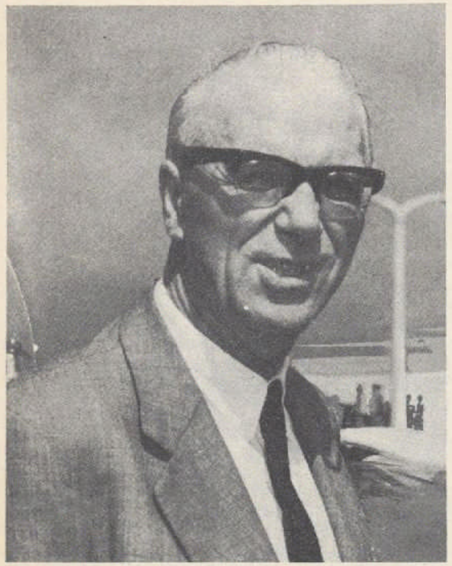
"The Observer" London—February 17th, 1957

"The whole conception is one which cynics may ridicule for no better reason than that it is unorthodox, it will lend itself to parody, it may change in the course of building, but will remain in its essentials as an example of grace; exciting and as functional as need be. It has an ever rarer quality; it is poetic."

Basil Spence, Architect, London

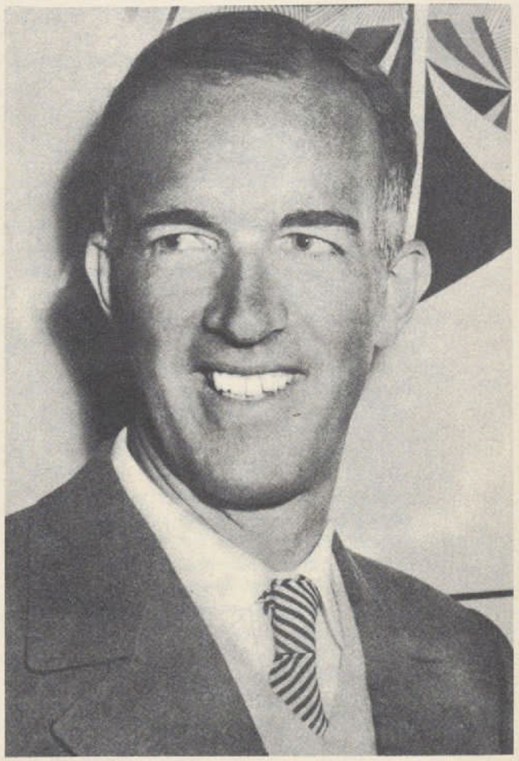
"The plan is broad and simple, sensitive and at the same time imaginative and I am certain it will be one of the great buildings."

Comments (3 of 3)



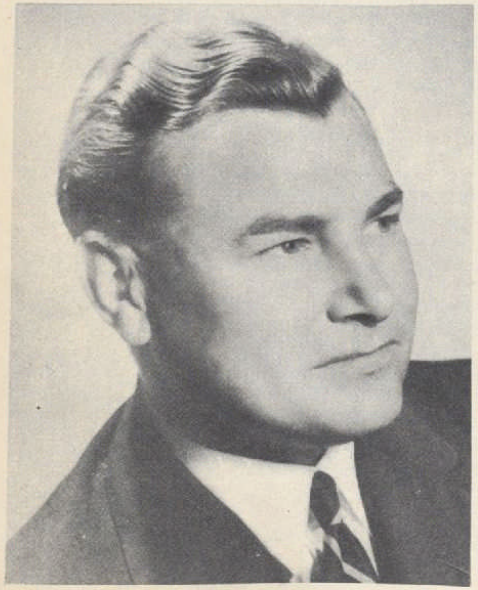
Mr. OVE ARUP, C.B.E., M.Ing.F., M.I.C.E., M.I.Struct.E., Senior Partner of Messrs. Ove Arup & Partners, London, who have been appointed Consulting Engineers for the Opera House. Mr. Arup is an Engineer of world renown.

Photo by courtesy "Sydney Morning Herald"



Mr. JOERN UTZON, M.A.A., A.R.A.I.A., winner of the recent international competition for the Sydney Opera House and subsequently appointed as Architect. Mr. Utzon comes from Hellebaek, Denmark, and is recognised as one of that country's most brilliant young architects.

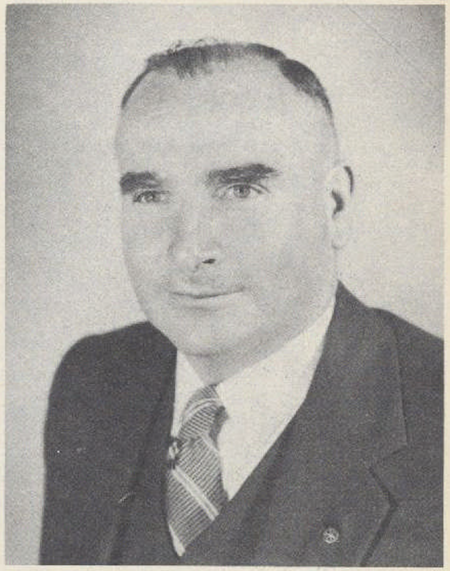
Photo by courtesy QANTAS



Mr. STANLEY JONES, D.F.C., A.R.I.C.S., A.I.Q.S. (Aust.), Resident Partner in N.S.W. of Messrs. Rider Hunt & Partners, of London, Sydney, Melbourne and Adelaide, who are Consultant Quantity Surveyors for the Opera House.

Photos of Ove Arup, Jorn Utzon and Stanley Jones

The Rt. Hon. Lord Mayor of Sydney, Ald. H. F. JENSEN, Chairman of the Sydney Opera House Appeal Fund.



Mr. S. HAVILAND, C.B.E., Under Secretary for Local Government, Chairman, Sydney Opera House Executive Committee.

Photo by courtesy Government Printer, Sydney

Professor H. INGHAM ASHWORTH, M.A., F.R.I.B.A., F.R.A.I.A., M.A.P.I., Professor of Architecture and Dean of the Faculty, University of Sydney, Chairman of Assessors, Member of Sydney Opera House Executive Committee, Chairman of Technical Advisory Panel, Member of Traffic Sub-committee.

Photo by courtesy Government Printer, Sydney

Photos of H..F Jensen (Lord Mayor), S. Havilland and H. Ingham Ashworth

THE COMPETITION

ALL Architectural Competitions are a gamble. The Promoters hope the Competition will produce a new and original solution to the problem while each Competitior hopes he will be the fortunate winner. Between the Promoters and the Competitors are the Assessors upon whose judgment they must rely. It is the duty of the Assessors to ensure that all things having been considered the selected winning scheme is the best solution to the problem—and the Assessors in turn hope that amongst the schemes submitted there will be one which in the widest sense will make a significant contribution to the development of Architecture.

A world-wide Competition open to all architects was decided upon in an effort to find an imaginative concept and an architect of the highest calibre to carry it out. This broad objective was made quite clear in the conditions controlling the Competition. Mandatory requirements were reduced to a minimum in order to give architects as much freedom as possible in the submission of their ideas.

Prizes of £5,000, £2,000 and £1,000 were offered to the authors of the designs placed first, second and third.

The Assessors appointed to judge the Competition were:

Professor Henry Ingham Ashworth, M.A.(Arch.), F.R.I.B.A., F.R.A.I.A., M.A.P.I. (Sydney), Chairman.
Dr. Cobden Parkes, F.R.I.B.A., F.R.A.I.A. (Sydney).
Sir Leslie Martin, Ph.D., M.A., F.R.I.B.A., (London).
Eero Saarinen, Esq., A.I.A. (Michigan, U.S.A.).

This great International Competition fired the imagination of architects the world over—more than 700 sought the conditions, and 223 schemes were finally received from thirty countries. Among the entries were 61 from Australia. Indeed it was a major task reviewing the thousands of drawings submitted. When the Assessors had made their decision the schemes were shown at a public exhibition in the Sydney Art Gallery—an exhibition which commenced one of the greatest controversies in the history of Sydney.

It is not unimportant to mention that approximate estimates were prepared for all the schemes which the Assessors considered worthy of final consideration and the winning scheme proved, in fact, the most economical scheme of any submitted, on the basis of such estimates.

THE SITE

PERHAPS it was the magnificence of the site which more than anything else inspired the architect to his great design and this will always remain one of the most exciting features of the Sydney Opera House. Many possible sites were rejected and there were many discussions with theatre experts, traffic authorities and planning officials before the choice was made of historic Bennelong Point on the extremity of the eastern arm of Sydney Cove, where the First Fleet anchored after Governor Phillip had had the satisfaction, as he put it, of discovering the finest harbour in the world.

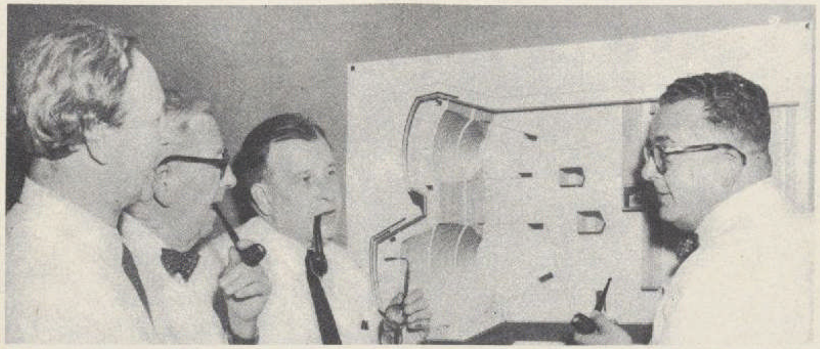
The Opera House will overlook this harbour from one of its best vantage points; from the foyers and restaurant the whole expanse of Port Jackson will be seen and, when the great ocean liners come through the Heads and round Bradley's Point, a new landmark will welcome visitors and home-coming Australians will look eagerly for the white sails of the Opera House roofs against the green background of the Botanic Gardens and the Domain.

Circular Quay, Sydney's main traffic focus for buses, ferries and suburban trains, is but a short walk from the site and the latter allows an ample forecourt for the manoeuvre of private cars and taxis. Because Bennelong Point is a peninsula there is no through traffic to congest the approaches and users of the different halls and theatres, who will be coming mainly in the evening, will be able to park their cars near-by in the extensive areas used by day-time city workers. Through the co-operation of the Maritime Services Board the Opera House will have its own deep water quay for direct ferry services from points around the Harbour and there is also the delightful prospect of theatre parties travelling by launch.

The Competition. The Site.

BENNELONG POINT LOOKING TOWARDS THE SOUTH-WEST

Bennleong Point Looking Towards the South-West



Sir Leslie Martin, Dr. Cobden Parkes, Eero Saarinen, Esq., Professor Henry Ingham Ashworth.

THE SELECTED DESIGN

THE conditions of the Competition emphasise that it was unlikely that the winning scheme would be built without alteration or variation and that the main purpose of the Competition was to select a sound basic scheme and a competent architect. Thus, the conditions were deliberately set out in the simplest form, leaving the competitor the widest possible scope.

This decision obviously presented the Assessors with the problem of judging the relative merits of schemes in which many different assumptions had been made. New ideas are always on the brink of disqualification and in this Competition, considerable thought was given to stating clearly the intention or aim to be achieved and leaving the manner of their achievement to the competitors.

The drawings submitted by the winner were simple to the point of being diagrammatic. Nevertheless, the Assessors stated that they returned again and again to the study of these drawings, as representing the most original and creative submission. Because of its very originality, it was clearly a controversial design. It has the merit of great simplicity of arrangement.

A massive stone base emphasises the character of Bennelong Point. The auditoria are arranged like Greek Theatres under this rising base and are approached either underground from cars, or externally along a magnificent ceremonial approach. This approach and the auditoria steps, form a rising plateau in which the highest point of seating is about forty feet above the ground. This conception solves by elimination, all the complex needs of escape which form so much dead space in a multi-storey building.

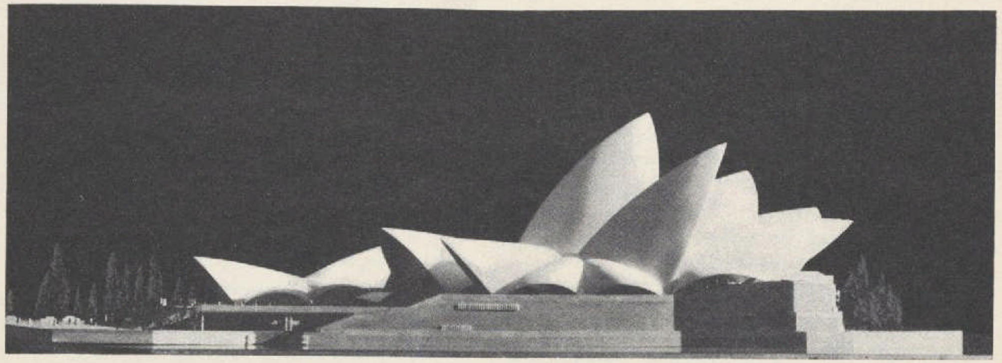
Within this plateau are the workshops, the rehearsal rooms and the dressing rooms. The workshop areas are adequate and well placed in relation to the stages. They are placed in positions which would allow problems of sound insulation to be effectively solved in the developed scheme.

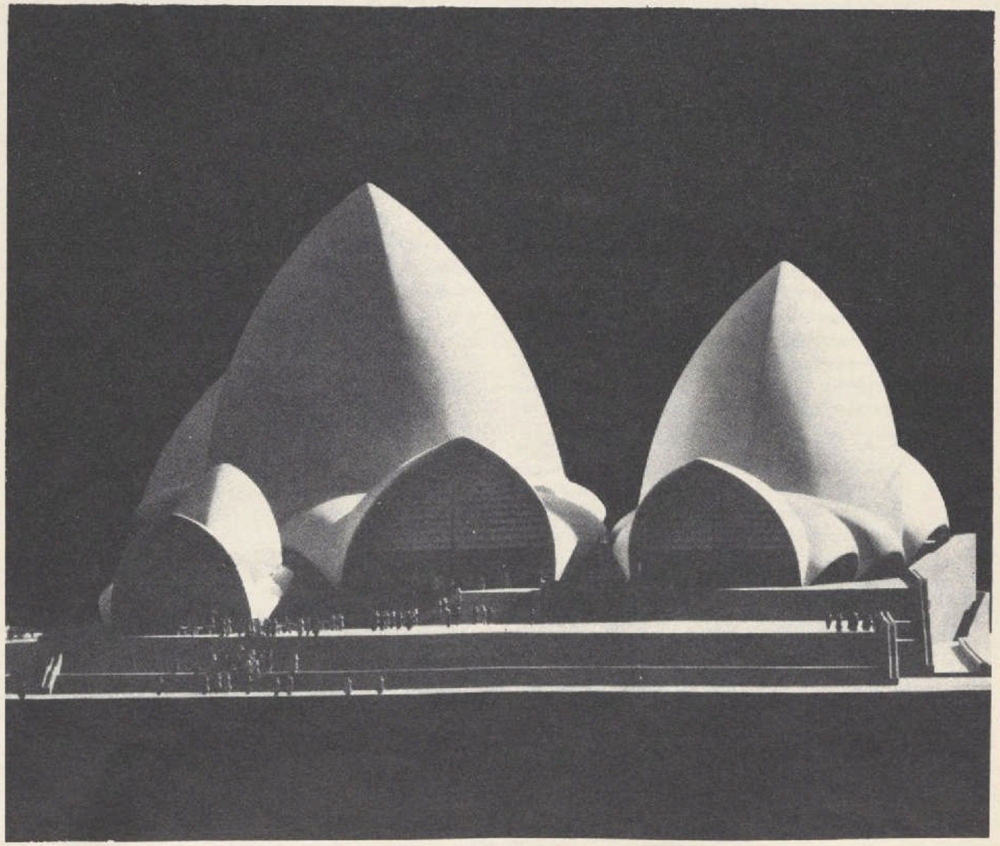
The great merit of this building is the unity of its structural expression. One of the most difficult problems of opera house design, is to relate the stage tower to the separate and surrounding buildings, and this becomes of particular importance on this exceptional site which can be viewed from all directions around the Harbour.

The solution suggested in this scheme is that the two auditoria should be roofed by a series of interlocking concrete shell vaults, in which the high stage tower is within one of a series of separate shells.

This creates a striking architectural composition admirably suited to Bennelong Point. The sail-like forms of the shell vaults relate as naturally to the Harbour, as the sails of its yachts. It is difficult to think of a better silhouette for this peninsular. The dynamic form of its vaulted shape contrasts with the buildings which form its background and gives a special significance to the project in the total landscape of the Harbour.

The Selected Design





Photos by courtesy Carl E. Rosenberg

Model of the Selected Design

THE OPERA HOUSE AS FINALLY CONTEMPLATED

As a result of the Competition and to further the development of the scheme, the following Professional Consultants were formally appointed, namely:

Joern Utzon, Architect — Hellebaek, Denmark.

Messrs. Ove Arup & Partners, Consulting Engineers—London.

Messrs. Rider Hunt & Partners, Quantity Surveyors—London and Sydney.

Consultants for mechanical services and acoustics:

J. Varming—Mechanical services.

M. Balslev—Electrical installations.

V. J. Jordan—Acoustics.

Consideration of the acoustics of both halls has been undertaken for some time to ensure that the acoustics will be right for the various uses of the building.

The combined efforts of the Consultants ultimately led to the approval of the final sketch plans for the Opera House by the Executive Committee. It should be stated that the approved sketch plans still retain the essential characteristics of the concept illustrated in the competition drawings. Such modifications as have occurred are in the main technical in character, or, alternatively, comprise additional facilities considered desirable by the Committee.

The original priorities of use intimated in the competition conditions were reaffirmed and have not been varied. Thus, there are still two main halls—one large, one small. The large hall is contemplated as being the new home for the Sydney Symphony Orchestra and therefore, the symphony concert has been accepted as priority No. 1, while large-scale opera, and ballet, will also be provided for.

The capacity of the large hall will comprise an audience of 2,800 for concerts, and 1,700, a reduced number, in the case of opera. This conversion of the hall for opera is effected mechanically and results in a reduction of the audience area and a vast increase in the stage area. This is an ingenious solution of the ever-prevalent difficult problem of using one hall effectively for a dual purpose.

Associated with the scheme will be a fine restaurant seating 250 and sited independently of the two halls, but in close juxtaposition, thus the restaurant will cater for patrons of the Opera House and at the same time will afford a much needed facility for the citizens of Sydney during the day. It will comprise a main restaurant and a grill room, and in suitable weather it is felt that some out-of-door seating will be possible. The restaurant overlooks the Harbour and Circular Quay, affording interesting vistas both by day and by night.

It is contemplated that facilities will be provided for a port of call for a ferry from the other side of the Harbour on appropriate occasions and that ultimately when all the old wharves are moved, there will be a fine boulevarde walk from Circular Quay to the Opera House site.

The landscaping and planting associated with the building must of necessity be somewhat formal and restrained to be compatible with its dignity.

It has been decided to erect the building in two, or possibly three, stages, each comprising a separate contract. Contract No. 1, which has now been let to Civil & Civic Contractors Pty. Ltd., Sydney, comprises the foundation work, marine engineering to the wharves and perimeter of the site, and all incidental engineering site works, and will terminate at the level of the podium.

The Architect feels strongly, and the Committee agree, that in clement weather the processional pedestrian approach to this great building via a magnificent flight of steps leading to the plateau upon which the buildings are sited, is a very essential factor in creating the atmosphere associated with attending what should be an inspiring occasion.

The target date for the formal opening of the Opera House, is the 175th Anniversary of Australia Day, namely, 26th January, 1963.

The Opera House as Finally Contemplated (1 of 3)

It should be reiterated that although the building has been termed the Sydney Opera House, which is indeed a dignified title, in essence the buildings comprise a great centre of music and drama in which opera will play a small though, of course, not insignificant part. It is felt essential that this should be stated in view of the misconception which obviously still exists in the minds of many.

Similarly many people have the impression that the Opera House is a relatively small low building, but this is not so. The major shell soars to a height of 216 feet above the ground. Relating this height to that of Unilever House at 175 feet, the I.C.I. Building at 139 feet and the deck of the Harbour Bridge at 178 feet affords a more accurate concept of the scale of the Opera House.

The first structural aspect to strike the eye of the traveller arriving by sea or air will be the two series of delicately shaped large reinforced concrete shells forming the outer covering of the major and minor halls. On a closer approach a similar formation of smaller shells over the restaurant will become apparent. These shells are quite unique and present to the Engineers a succession of difficult and interesting problems with little precedent. To decide on their thickness and to carry out the necessary structural calculations relating to their stability and stresses and also later to build them it was first of all necessary to define them geometrically in a way that satisfied the Architect that his intentions were to be realised. What are called the main shells consist of two symmetrical halves meeting in a ridge in the vertical plane of the longitudinal axes of the halls. The shape of these and shells bulging out at the sides of the halls are technically described as elliptic paraboloids.

By thus defining the surfaces of the shells each point of the surface can be given spacial co-ordinates.

A considerable amount of research work is now under way in connection with testing models in wind tunnels to find the distribution of wind pressure for all directions of winds up to the maximum recorded velocities. Aerodynamic phenomena arising from periodic eddy shedding will also be investigated by these tests. Much of the numerical work for structural design is being programmed for electronic digital computation. The Engineers have also found it necessary to undertake a theoretical study to extend calculation of shells to these not previously used shapes.

The key to their general stability has been to make use of the louvred vertical surfaces in the open sides of the main shells as major structural members. It is intended to confirm the theoretical and numerical calculation by structural model loading tests on representative sections.

The small hall, with a seating capacity of 1,100, is primarily associated with dramatic presentations, intimate opera, recitals, and in consequence, every effort has been made to capture the intimacy so essential to such uses.

A very significant addition to the original scheme is the provision of a small experimental theatre in the basement, with separate external access. This small theatre will seat 430 and has its own foyer, and complete stage facilities suitable for its purpose. It is intended to satisfy the needs of many amateur theatrical societies who at present have no suitable theatre for their performances. This experimental theatre will satisfy an existing need and indeed will stimulate development in this field. It is quite likely that there will be suitable accommodation associated with the experimental theatre to house a School of Dramatic Art, should this facility prove necessary.

Similarly, it was decided to abandon the two separate meeting rooms originally contemplated and in their place provide one large well-designed room which could be used independently for chamber music or social functions as required.

Bars, lounges, foyers, rehearsal rooms, dressing rooms, workshops, stage facilities and all the necessary facilities associated with the scheme, have all received detailed attention and are considered adequate and appropriately sited. It is perhaps worthy of mention that foyers and lounges to each of the halls will face over the Harbour. The mechanical

The Opera House as Finally Contemplated (2 of 3)

requirements have also received similar attention; air conditioning has been considered an essential, lifts for physically handicapped or aged people have been provided and the most modern stage machinery compatible with requirements in Sydney, is being included.

Visitors arriving on foot or by car will begin by having a good view of the shells but their immediate impressions on arrival will be of the sweeping concourse area. This area consists of a stone paving supported by long span prestressed concrete beams. When viewing the underside of the concourse the Architect-Engineer collaboration will become immediately apparent to the expert. For architectural and structural reasons these large spans have been designed as folded slabs, the folds being arranged in such a way that the distribution of material corresponds with the ideal structural requirements at any position. Thus, at mid-span, where the bending moments are positive, most of the horizontal portion of the slab is situated at the top, whereas at supports over which there is continuity it is situated at the bottom. This results in a comparatively light structure since the material is placed in a way which is most advantageous structurally.

The folded slabs are prestressed by cables of high tension wires. The folds of the slab form channels through which rainwater which seeps in between the joints of the stone paving slabs can be led away. In different parts of the building these large spans are supported in different ways because of intervening stair openings and differences in the supporting walls, etc., and these differences are directly reflected in the corrugations of the ceiling so that it is possible to visualise the whole structural action.

The remainder of the structure, little of which will be visible, is of a conventional nature. The halls are separate structures inside the shells so that a two-layer system is reached for the exclusion of external noise. Lower down as much use as possible has been made of necessary walls made structural to carry the large spans involved by such things as rehearsal rooms and the experimental theatre under the main hall.

The foundations of the building presented little problem in view of the excellent sandstone underlying Bennelong Point.

The function of the Quantity Surveyor is to maintain strict financial control over the contract through all its stages on behalf of the Architect and the Opera House Committee. This control is exercised by a series of steps which provide not only constant budgetary review of the expenditure but also ensure that the maximum value is obtained from every pound spent on the work.

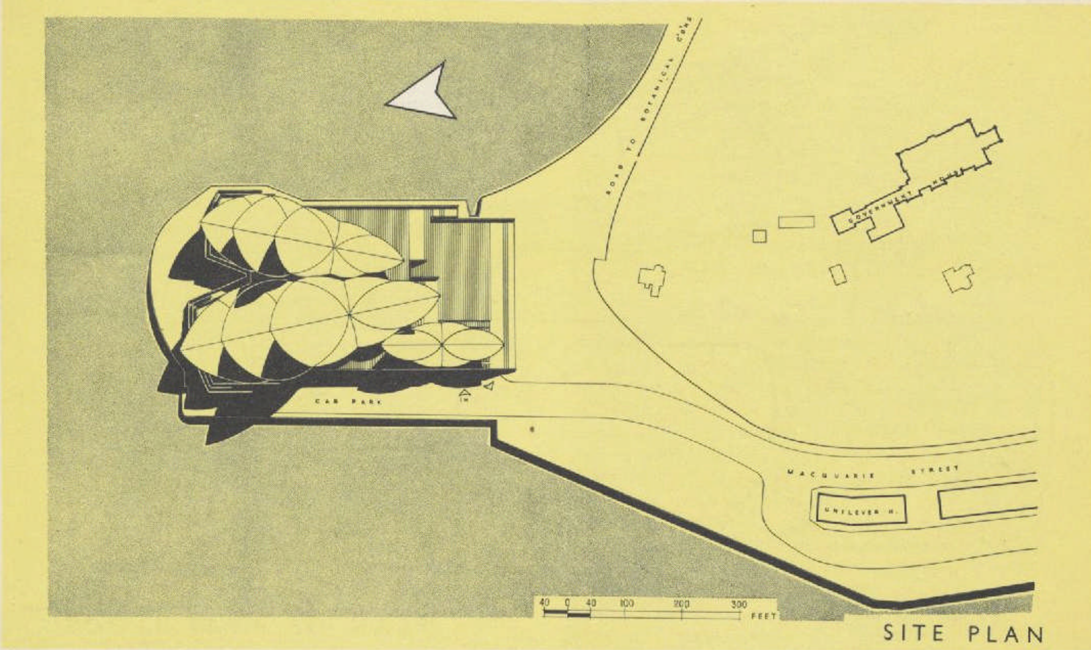
The first step is the preparation of a series of detailed approximate estimates of cost. These estimates are prepared initially in Sydney and later checked and reviewed with the Architect and Engineers in Copenhagen and London. All estimates are constantly reviewed through the planning period and both the Architect and the Opera House Committee are kept informed of the effect on costs of design modification that may occur.

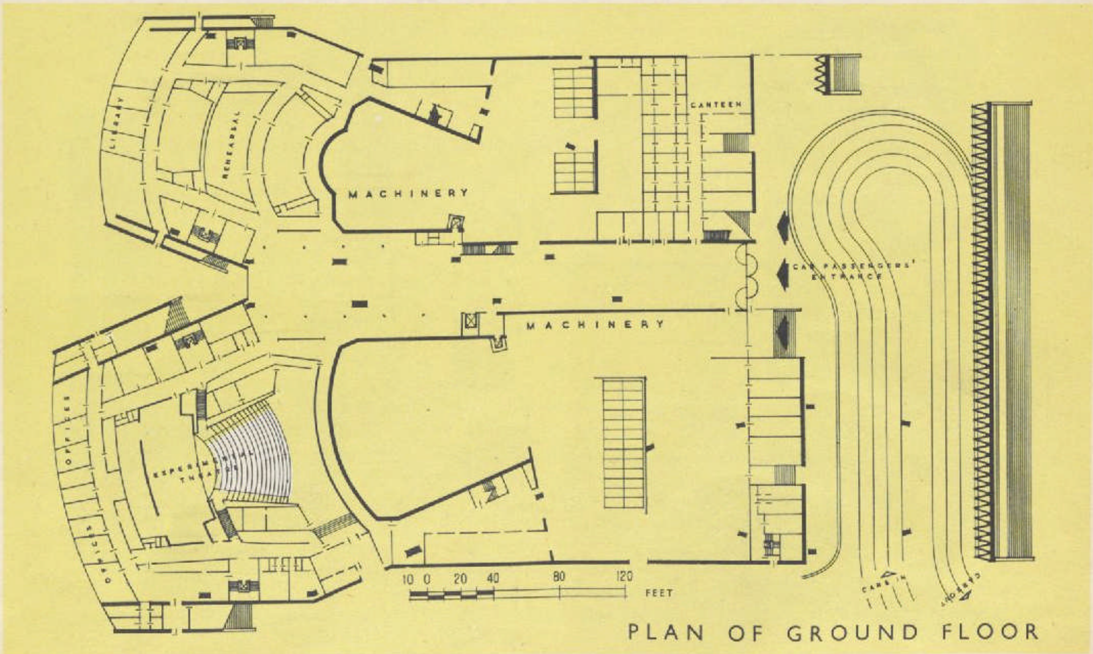
Contract documents are then drafted to ensure that maximum economic advantage is obtained from competitive tenders. To this end, the Quantity Surveyors prepare a document called a Bill of Quantities which is a detailed list of every item of labour and material necessary for the construction of the building. The Bill of Quantities is priced by each tendering contractor and the priced Bill of the successful tenderer provides the basis for all subsequent dealings on the contract. As construction proceeds, the Quantity Surveyor is responsible for the proper certification of progress payments to the builder.

Concurrently he controls the cost of variations on the contract and reports progressively through the Architect to the Opera House Committee on their value. The priced Bills of Quantities are used to determine both progress payments and the value of variations.

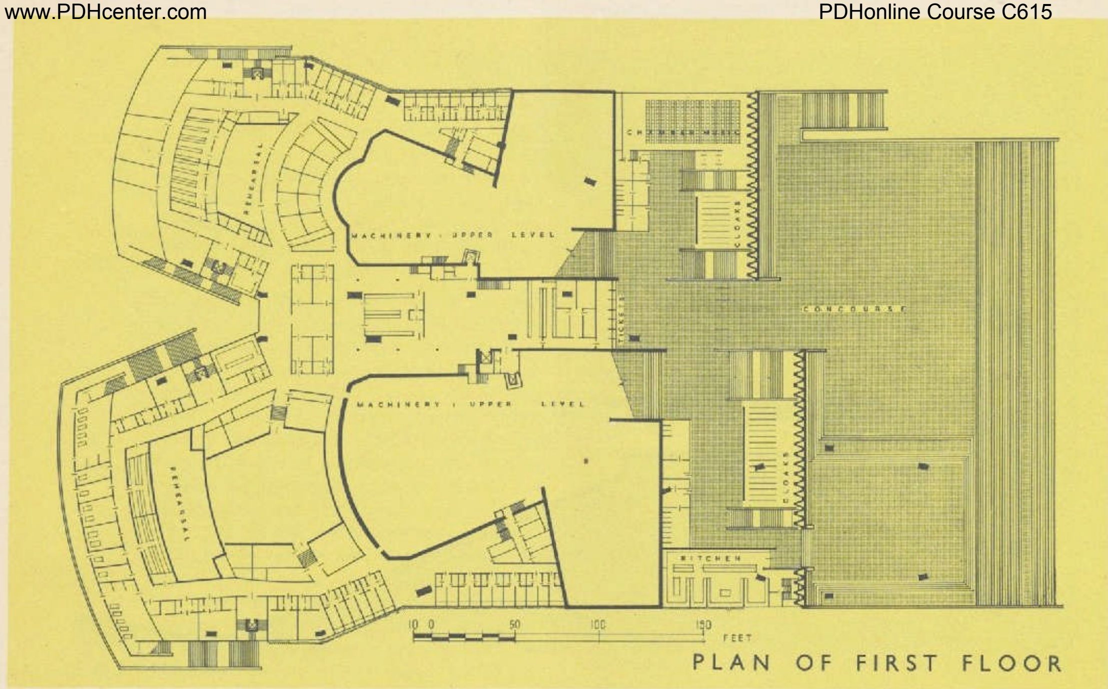
Finally the Quantity Surveyor prepares and presents a detailed statement of the final cost of the building showing exactly how every penny has been spent.

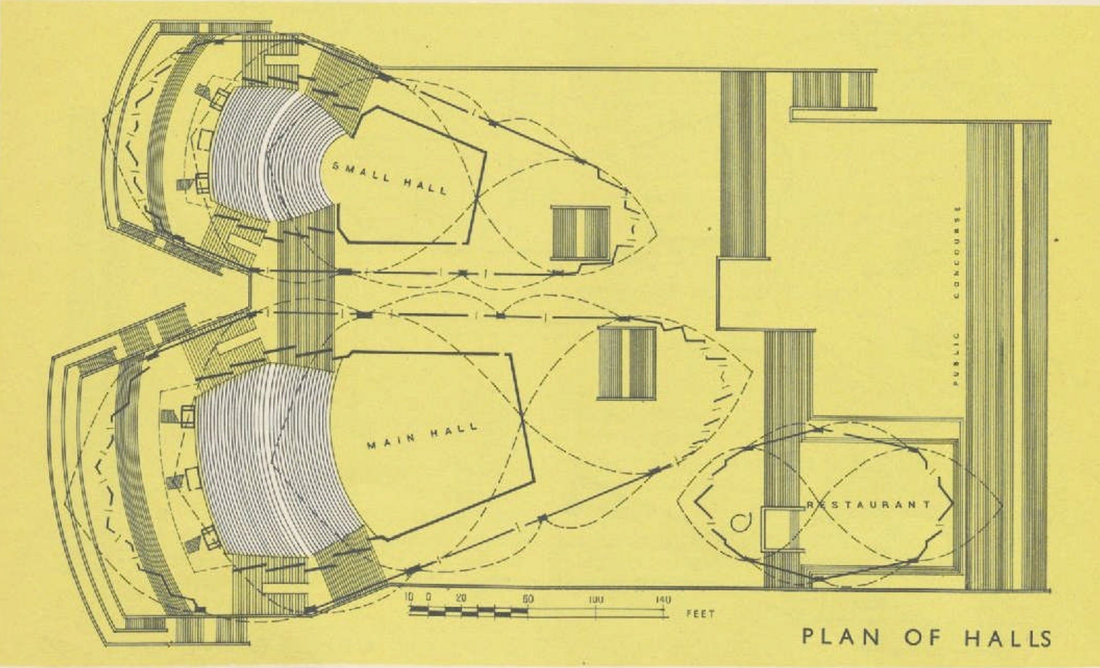
The Opera House as Finally Contemplated (3 of 3)



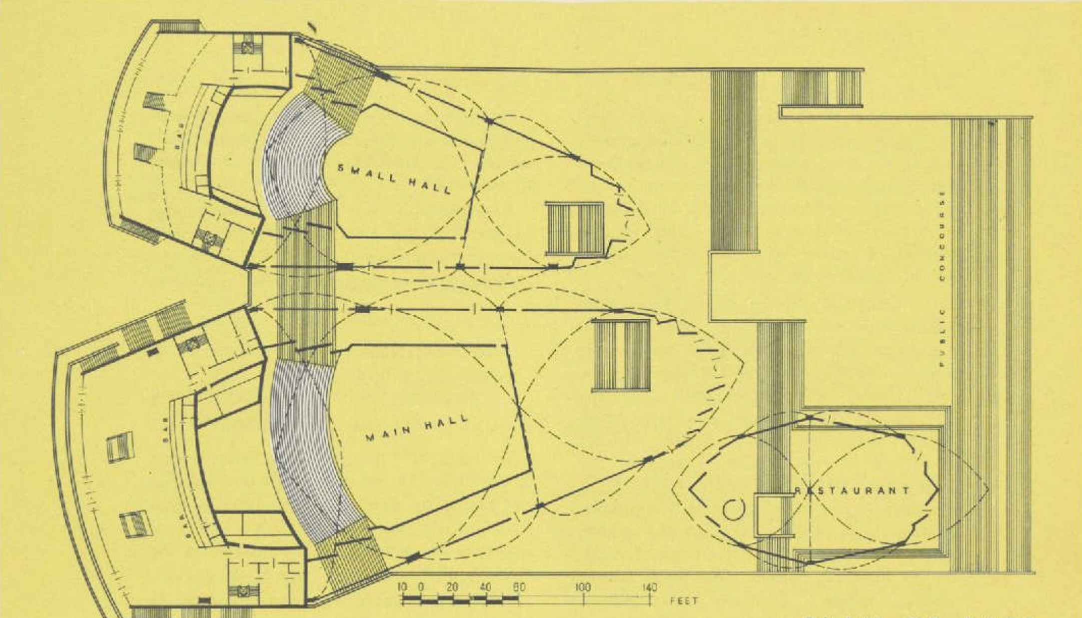


Site Plan and Plan of Ground Floor

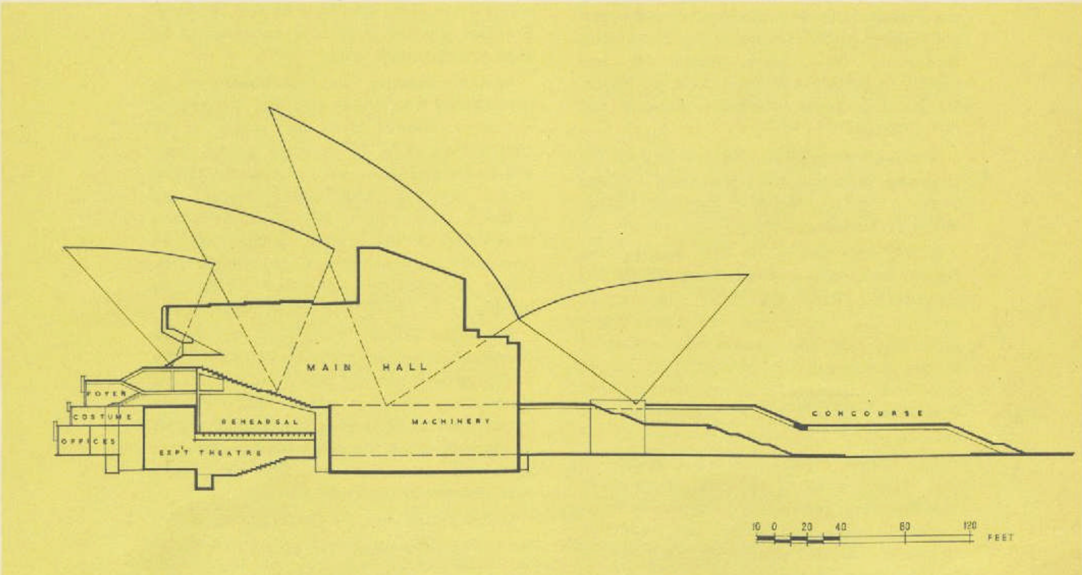




Plans of First Floor and Halls



PLAN OF BARS



SECTION THROUGH MAIN HALL

Plan of Bars and Section Through Main Hall

THE APPEAL FUND

TO organise an appeal for funds from organisations, firms and individual citizens and at the same time publicise the proposal was considered of vital importance in the initial stages. Accordingly, the Lord Mayor of Sydney called a public meeting for the purpose of setting up "The Sydney Opera House Appeal Fund".

The inaugural meeting in the Town Hall, Sydney, held on 7th August, 1957, attracted a capacity attendance of 2,400 enthusiastic citizens. As Chairman of the meeting, the Lord Mayor was accompanied on the platform by the Premier of New South Wales, the Hon. J. J. Cahill, M.L.A.; Mr. P. H. Morton, M.L.A., Leader of the Opposition; Sir Richard Boyer, K.B.E., M.A., Chairman, Australian Broadcasting Commission; Professor S. H. Roberts, C.M.G., M.A., D.Sc., Litt.D., Vice-Chancellor, University of Sydney; Mr. S. Haviland, C.B.E., Chairman, Sydney Opera House Executive Committee; Mr. J. Utzon, winning designer of the Sydney Opera House; Mr. E. Andersson, Mr. Utzon's partner.

After the formal business of the meeting the Premier launched the Appeal and urged full support of all sections of the community throughout New South Wales. He was supported by addresses from the Lord Mayor, Sir Richard Boyer, Professor Roberts and Mr. J. Utzon.

A musical programme was provided by the following artists: Joan Hammond, Elaine Sheffer, John Alden, Ruggiero Ricci, Warwick McRaffey.

During the course of the meeting the Premier handed in a cheque for £100,000 as a contribution from the State Government towards the Appeal, and the Lord Mayor announced that The Council of the City of Sydney proposed to contribute a similar amount in instalments over five years. Other donations promised at the meeting totalled £35,500.

The Premier was appointed President of the Fund; Leader of the Opposition, Vice-President; and the Lord Mayor, Chairman, while 100 prominent citizens and leaders in all sections of the community were elected to form a General Committee.

From this auspicious inauguration and with the help of a Ladies' Committee subsequently set up, the fund has continued to advance its objects.

Arrangements were made for contributions to the Fund to be deductions for Income Tax purposes.

At the present time the Appeal Fund stands as follows:—

	£	s.	d.
Donations received ...	257,593	11	5
Promises and deferred donations	95,429	12	4
	£353,023	3	9

To assist in publicity, three scale models of the Opera House structure were obtained and placed on exhibition in various venues, including London. At the present time the largest of the models is on exhibition in the Museum of Modern Art, New York.

The Committee of the Fund expresses its gratitude to the various organisations, business firms and citizens, who have so generously supported the Appeal, in many cases by subscriptions of substantial amounts, and to voluntary workers who have by their personal activities, enabled organising expenses to be kept at a minimum level.

As an incentive to subscribers to be permanently identified with the project, it has been decided that the names of all contributors of £1,000 or more to the Fund, will be inscribed on a name-plate and attached to a seat in the Opera House. In addition, the names of all contributors, irrespective of the amount donated, will be inscribed on parchment to be subsequently bound in a volume and placed permanently on display in the Opera House foyer.

An organisational survey as to future potentialities regarding the Appeal is currently being carried out at the direction of the Committee and it is hoped that with the commencement of building operations, interest in the project will be heightened to a degree that will accelerate the flow of public subscriptions to the Fund.

Subscriptions may be forwarded to the:

Joint Hon. Treasurers,
Town Hall, Sydney.

The Appeal Fund

CONTROL OF THE PROJECT

THE principal body associated with the Sydney Opera House project is the Executive Committee under the Chairmanship of Mr. S. Haviland, C.B.E., Under Secretary for Local Government. The Committee was first established in November, 1954, and has progressively reported to the Government upon the action to be taken upon the various matters requiring decision, commencing with the selection of the site.

The other members of the Committee are as follows:—

Mr. E. W. Adams, Town Clerk, Sydney.
Professor H. Ingham Ashworth, M.A., F.R.I.B.A., Dean of the Faculty of Architecture, University of Sydney.
Mr. John Glass, C.B.E., General Manager, Hoyts Theatres Limited.
Sir Bernard Heinze, Director, State Conservatorium of Music.
Mr. Hugh Hunt, Executive Director, The Elizabethan Theatre Trust.
The Honourable J. D. Kenny, M.L.C., General Secretary, Trades and Labour Council.
Dr. Nicolai Malko, Musical Director, Sydney Symphony Orchestra.
Colonel Charles Moses, C.B.E., General Manager, Australian Broadcasting Commission.
Dr. Cobden Parkes, C.B.E., F.R.A.I.A., F.R.I.B.A., former State Government Architect.
Dr. H. S. Wyndham, M.A., Ed.D., Dip.Ed., Director General of Education.

The Secretary and Executive Officer is Mr. R. J. Thomson, Special Officer, Department of Local Government.

The original Committee had a membership of five, namely, Mr. Haviland, Professor Ashworth, and Colonel Moses, who are still serving, together with Mr. Roy Hendy, C.M.G., former Town Clerk, and Sir Eugene Goossens, former Director of the Conservatorium of Music. The membership was subsequently increased to enable the Committee to cope with the new problems which arose as the project developed through its various phases.

The following subordinate bodies have been established to advise the Executive Committee on matters requiring specialist attention:—

Technical Advisory Panel:

Professor Ashworth (Chairman) and Dr. Parkes, members of the Executive Committee.
Mr. W. R. Laurie, B.Arch., F.R.I.B.A.
Mr. G. L. Moline, F.R.I.B.A.
Mr. Kelvin Robertson, F.R.A.I.A.
Professor J. W. Roderick, M.A., Ph.D., M.Sc., A.M. Inst. C.E., A.F.R.Ae.S., M.I.E. Aust., F.A.A., Professor of Civil Engineering, University of Sydney.
Professor Denis Winston, B.Arch., M.A., F.R.I.B.A., M.T.P.I., Professor of Town and Country Planning, University of Sydney.

Music and Drama Advisory Panel:

Sir Bernard Heinze (Convener), Dr. Malko, Colonel Moses and Messrs. Glass and Hunt, members of the Executive Committee.
Mr. Harald Bowden, General Manager, J. C. Williamson Theatres.
Mr. Alec Brown, Shand Electricity Company, Melbourne.
Mr. Herbert Cannon, F.R.C.O., Director of Music, Australian Broadcasting Commission.
Miss Doris Fitton, Director, Independent Theatres Limited.
Mr. Bruce Macfarlan, O.B.E., Q.C., President, Musica Viva Society.
Mr. William Orr, Director, Phillip Street Theatre.
Professor D. R. Peart, M.A., B.Mus. (Oxford), Hon. F.R.C.M., Professor of Music, University of Sydney.
Mr. Joseph Post, Associate Conductor, Sydney Symphony Orchestra.
Mr. Robert Quentin, General Manager, Australian National Opera Company.
Mr. John Sumner, General Manager in Victoria, The Australian Elizabethan Theatre Trust.
Sir John Tivey, President, Sydney Symphony Orchestra Subscription Committee.

Traffic Sub-committee:

Mr. Haviland (Chairman), Professor Ashworth and Mr. Glass, members of the Executive Committee, and Professor Winston, a member of the Technical Advisory Panel.
Professor W. R. Blunden, B.Sc., B.E., A.M.I.E. Aust., A. Inst. P., Professor of Traffic Engineering, University of New South Wales.
Mr. M. W. D. M. Chaseling, Superintendent of Traffic.
Mr. R. D. L. Fraser, Chief County Planner, Cumberland County Council.
Mr. S. Robinson, Superintendent of Planning, Department of Government Transport.
Mr. Commissioner J. Simpson, Maritime Services Board of New South Wales.
Mr. R. D. Stevenson, A.M.I.E., M.I.S., City Engineer, Sydney.
Mr. G. Webster, Assistant General Secretary, National Roads and Motorists' Association (N.S.W.).

Traffic Survey Panel.

Representatives of the—
Cumberland County Council,
Department of Government Transport,
Department of Motor Transport,
Department of Traffic Engineering, University of New South Wales,
Maritime Services Board,
Police Traffic Branch,
Sydney City Council.

The members of the Executive Committee, the two Advisory Panels, the Traffic Sub-committee, and the Survey Panel all serve in an honorary capacity.

All Government Departments, semi-government authorities, councils and private organisations and individuals who have been approached for advice and assistance have readily co-operated and the opportunity is taken to express the Committee's appreciation of much valuable work.

Control of the Project

ULTIMATE MANAGEMENT

THE Premier (the Hon. J. J. Cahill, M.L.A.) has already announced that a trust or similar such body will be established to control and manage the Sydney Opera House. He said "Whilst it is much too early to say exactly what the composition of the controlling body will be, it can quite definitely be stated now that it will be specially constituted and as widely representative as possible of the various interests concerned not only with administrative matters but also the various branches of the Arts which will be performed in the building".

The trust will not be concerned with the actual production of entertainment but will direct and supervise the letting of accommodation such as the various auditoria, meeting rooms, rehearsal rooms, the restaurant and grill room, liquor bars and administrative offices. The trust will have its own permanent headquarters within the building.

It is not envisaged that the trust will be a profit-making body. On the other hand, there is no suggestion that it will need to be subsidised. It cannot be too strongly emphasised that there will be no capital charges associated with the Sydney Opera House and that the controlling body will merely need to meet the cost of day-to-day maintenance and administration. There is every reason to believe that the income from rentals will be sufficient to cover this and that at the same time such rentals will be low enough to compare more than favourably with the rentals for existing accommodation of comparable capacity. This will be despite the fact that the very attractiveness and quality of the accommodation to be provided in the Opera House will be a major attraction to potential users.

No doubt the public has been misled by reports that opera, both locally and overseas, cannot be produced without being subsidised. These reports are not doubted but they have no bearing on the economics of the Sydney Opera House. In fact, the House itself, by virtue of the excellence of its accommodation and equipment, may well benefit the economics of those bodies engaged in the production of opera.

Whilst, as stated by the Premier, it is too early yet to establish the trust, it is appreciated that it should be established well before completion of the building.

The Elizabethan Theatre Trust offers congratulations to the Government and Premier of New South Wales and to the Opera House Committee on the occasion of the commencement of construction of the Sydney Opera House.

The Trust is proud to have been associated with the planning of this great building and looks forward to the day of its opening.

In the post-war years Australia has shown capacity for creative work in both opera and drama. Indigenous talent in these fields is no longer in doubt and the Opera House will not only be a fitting home for artistic endeavour but will serve as an international symbol of our growing maturity.

H. C. COOMBS

Chairman, The Australian Elizabethan Theatre Trust

Ultimate Management (1 of 2)

The Australian Broadcasting Commission, one of the world's biggest concert-giving organisations, will be the Opera House's most frequent tenant.

To begin with, the A.B.C.'s annual subscription series by the Sydney Symphony Orchestra will occupy the main auditorium for 40 nights each year.

In addition, the A.B.C. will use the main auditorium for the orchestra's eighteen Youth concerts, its twenty concerts for schools, its summer festivals and other special concerts plus, of course, annual performances of The Messiah and other oratorios.

Apart from orchestral use the A.B.C. hopes to use all four auditoria of the Opera House at various times throughout the year for recitals by overseas and Australian artists.

CHARLES MOSES
General Manager

Whatever its name, a building of the type which has been designed for Sydney can be made a centre for a number of cultural activities. Indeed, the size of the community's commitment in this project makes it desirable that it should have a diversity of use within the limits imposed by its primary purpose.

Thus, in addition to providing a home for the Sydney Symphony Orchestra and for opera, the "Opera House" will be designed to provide facilities for music of a more intimate type, including chamber music and soloist recitals. It will be able also to fulfil a long-felt need in Sydney for a suitable place for the exhibition of documentary and similar non-commercial films. Further, it could be equipped, as is the Royal Festival Hall in London, to provide a hall and all necessary facilities for international conferences and so meet an increasingly urgent need in this country.

Dr. H. S. WYNDHAM
Director-General of Education

The Opera House, as the architectural symbol of the musical achievements and aspirations of the State of New South Wales, will be a fitting permanent home for the orchestra which has added such lustre to our reputation throughout the musical world.

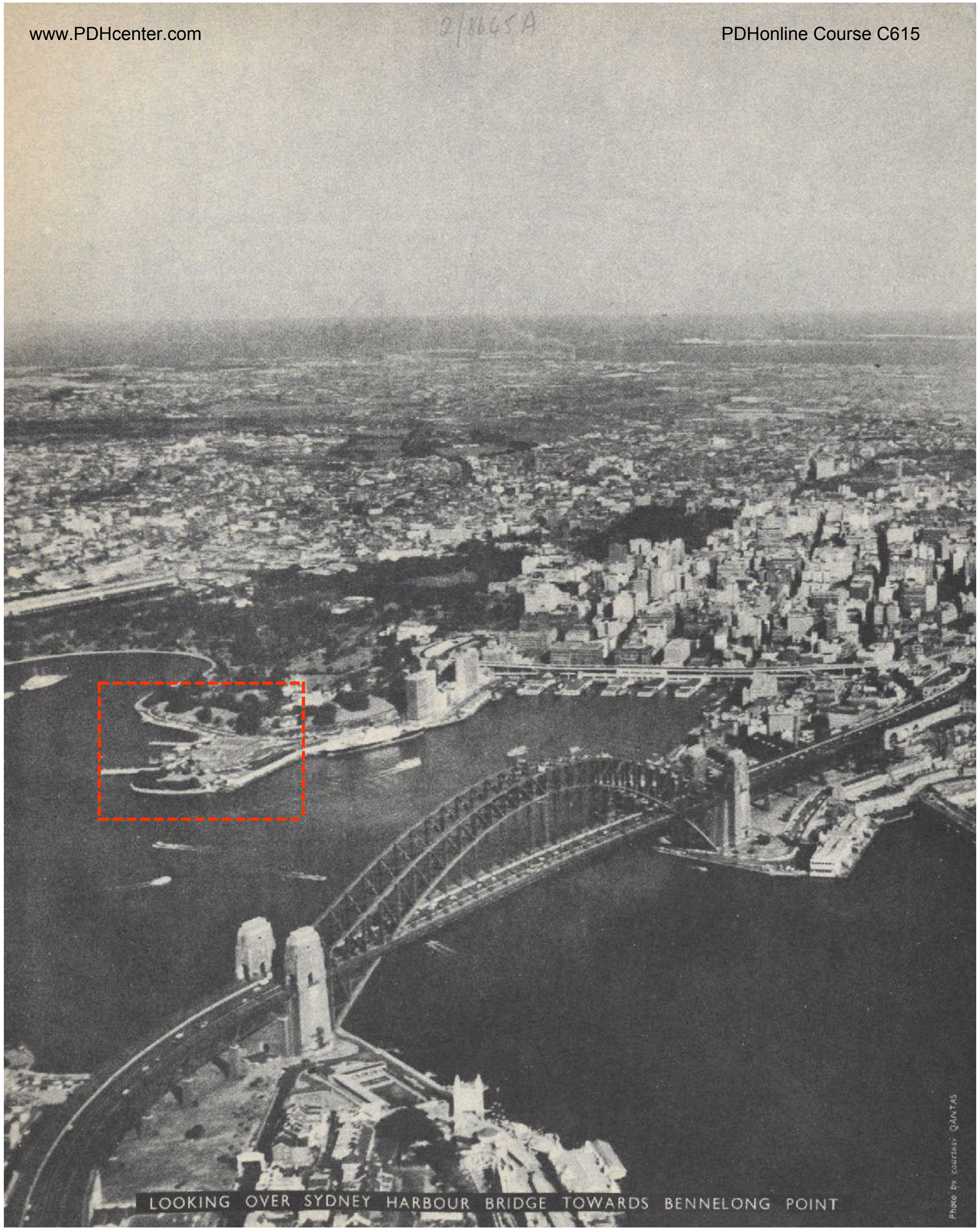
To accommodate subscribers, each concert in the main A.B.C. Subscription series must be given five times, each Youth Concert three times. The greater capacity of the new concert hall will make it possible to reduce considerably the number of these "repeat" performances and so the orchestra will be available for additional concerts in city and country. Furthermore, it will be possible to provide urgently needed storage facilities for orchestral instruments and pianos, together with rehearsal and practice rooms and excellent amenities for the orchestral musicians.

HERBERT CANNON, F.R.C.O.
Director of Music, A.B.C.

I am confident that this great building is destined to become a cultural centre, the importance of which will be acknowledged not only in this community but throughout the world. It will symbolize the tremendous developments in public appreciation of the operatic, musical and theatrical arts that have been so conspicuously apparent in this country during the last thirty years. It will enrich the city by the stimulus it is bound to give to rising talent and to established artists, both here and overseas.

Professor M. S. BROWN
Professor of Sociology, University of New South Wales

Ultimate Management (2 of 2)



Looking Over Sydney Harbour Bridge Towards Bennelong Point

<u>Part 6</u>

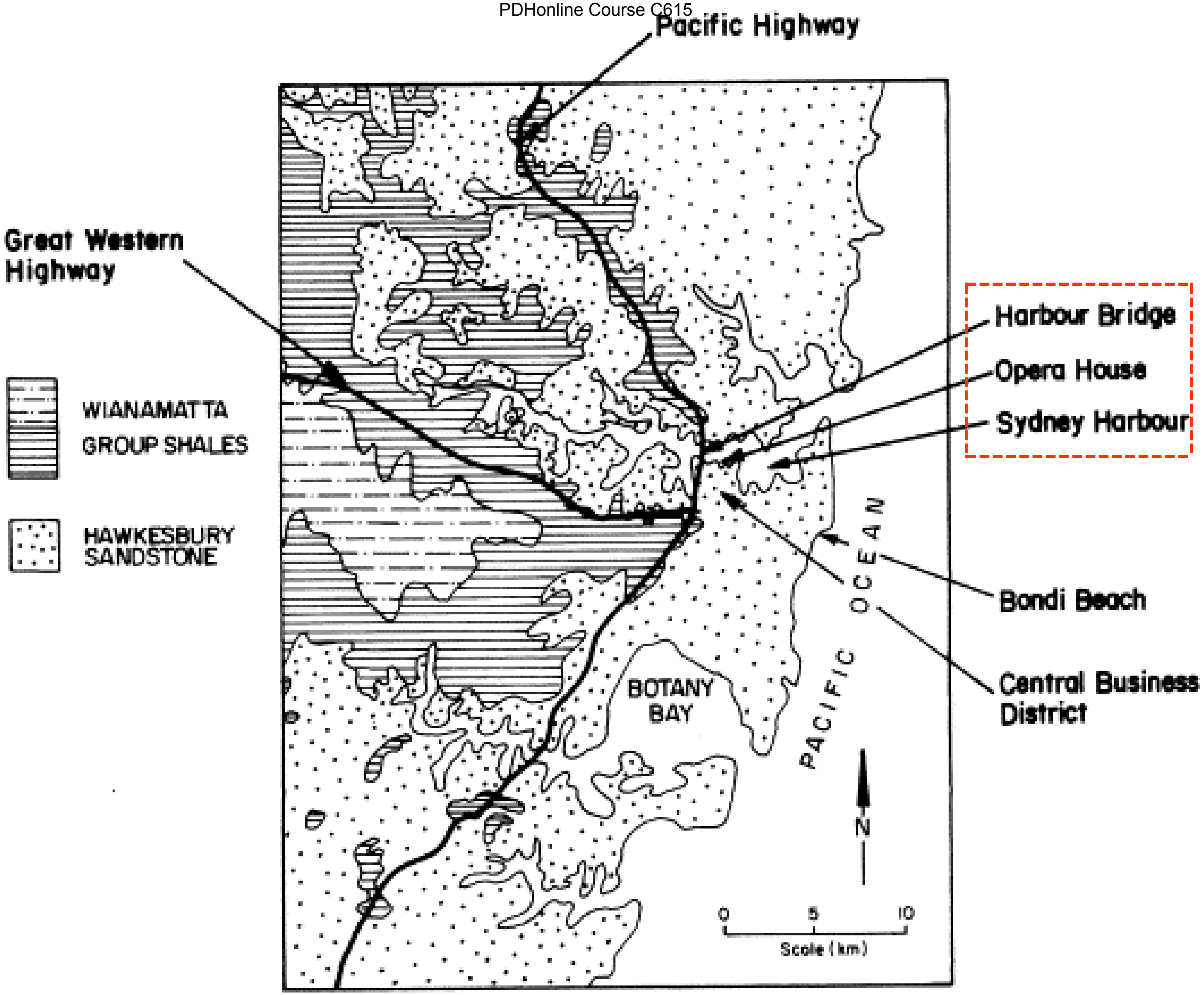
The Platform

Mother Earth?

"…The honeymoon was not, however, to last very long. The winner had barely been announced when Dr. Colin Roderick, A Sydney historian, turned up at a meting of the opera house committee with some disquieting news. 'Bennelong Point isn't mother earth,' he said. 'It's nothing but old boots and bedsteads.' The opera house site, he explained, was merely a narrow sandstone pit that, back in the 19th Century, had been enlarged and filled in with rubble. On such a site the foundation alone would cost millions extra, Roderick claimed. The committee members acknowledged that there had been some fill on Bennelong Point, but thought Roderick was unduly pessimistic. They produced records of borings they'd taken which showed a rib of bedrock running right beneath the major hall…"

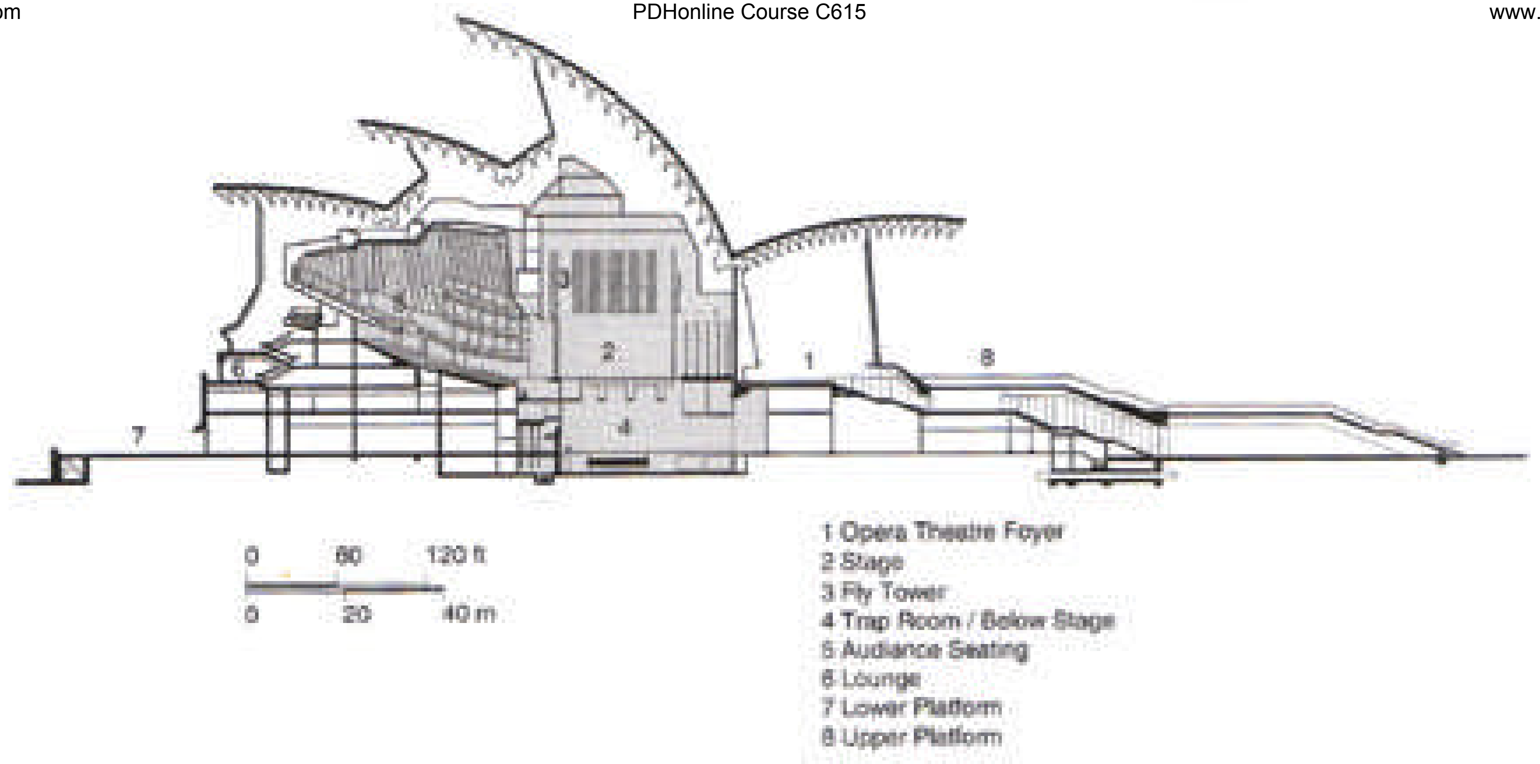
***Life* Magazine, January 6th 1967**

It turned out Dr. Roderick's concerns were not unfounded. The geology of Bennelong Point had not been properly surveyed at the time the Brown Book was prepared. The competition brief assumed that the peninsula was composed of a *Triassic* rock-bed of *Hawkesbury Sandstone* (left), much like the surrounding landscape. In fact, it was made of loose alluvial deposits dating back to the construction of Fort Macquarie. Permeated with sea water, it was entirely unsuitable for the support of any large structure placed on it. Seven-hundred steel-cased concrete shafts (piers), three-feet in diameter were bored down into the perimeter and northern half of the site. Divers were needed to pump water from pier formwork and cofferdams were constructed to prevent water penetration into the massive concrete foundation which filled in the unstable rock in the central area of the site. Additionally, an old ferry terminal required blasting for removal.



Triassic geology of the Sydney region

The architecture of *Monte Alban*, and *Chichen Itza* which Utzon had visited in 1949 had a profound influence on him and is most evident in the Podium (sub-structure) of SOH. Featuring a long procession of stairs leading up to a plateau, it is evocative of the ceremonial platforms of Mayan and Aztec temples which elevated people above the forest canopy and their daily lives. So too would patrons of SOH be elevated above their daily lives by the art created in the building and by the art of the building itself. Utzon's "Plateau" sketches from 1957 (at top).



Much of the workings of the SOH are out of sight, beneath the public and performance spaces of the Podium – an ingenious element of Utzon's design. Changing rooms, rehearsal spaces, the smaller theatres as well as much of the stage machinery are contained in this substructure. The podium gives the impression of a strong base from the outside while inside it's a maze of rooms and corridors with actors, dancers, musicians and administrators all sharing this relatively confined space. Paradoxically, the Podium endured fundamentally unchanged from the competition through to the finished building.

The Taj Cahill

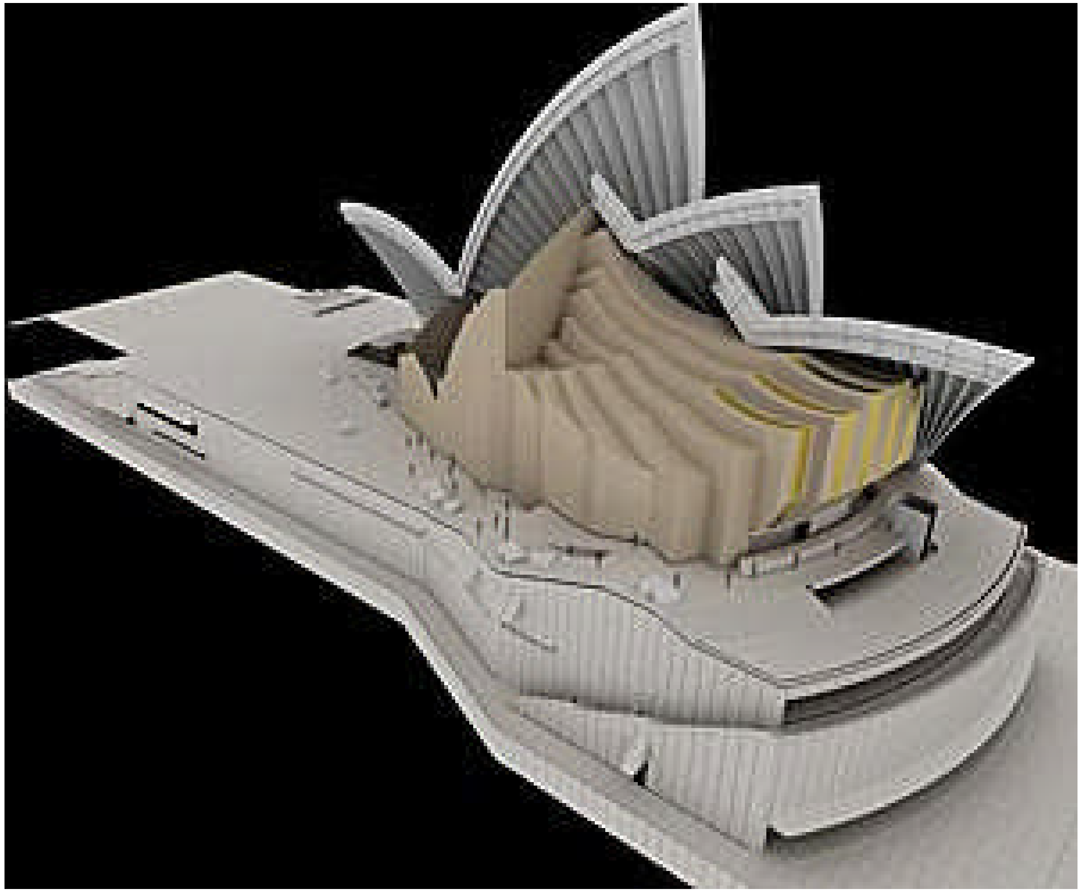
The October Scheme provided detailed level-by-level working drawings of the structure and its interiors (Utzon's office produced these "working" drawings). The work would then be tendered to a construction firm (under the supervision of Ove Arup and Partners and SOHEC). The firm of *Civil and Civic* (who had submitted the low-bid of $2.8 million for Stage One) would eventually seek to recapture their losses from the NSW Government through arbitration. They succeeded in their "unforeseen work" claim for $2.5 million. This came as both an annoyance and prophecy realized to Ove Arup who had warned against starting construction prematurely. In the end, Stage One would take five years to complete (rather than three) and require significant modifications to support the final roof design. The press dubbed the project: *The Taj Cahill*.

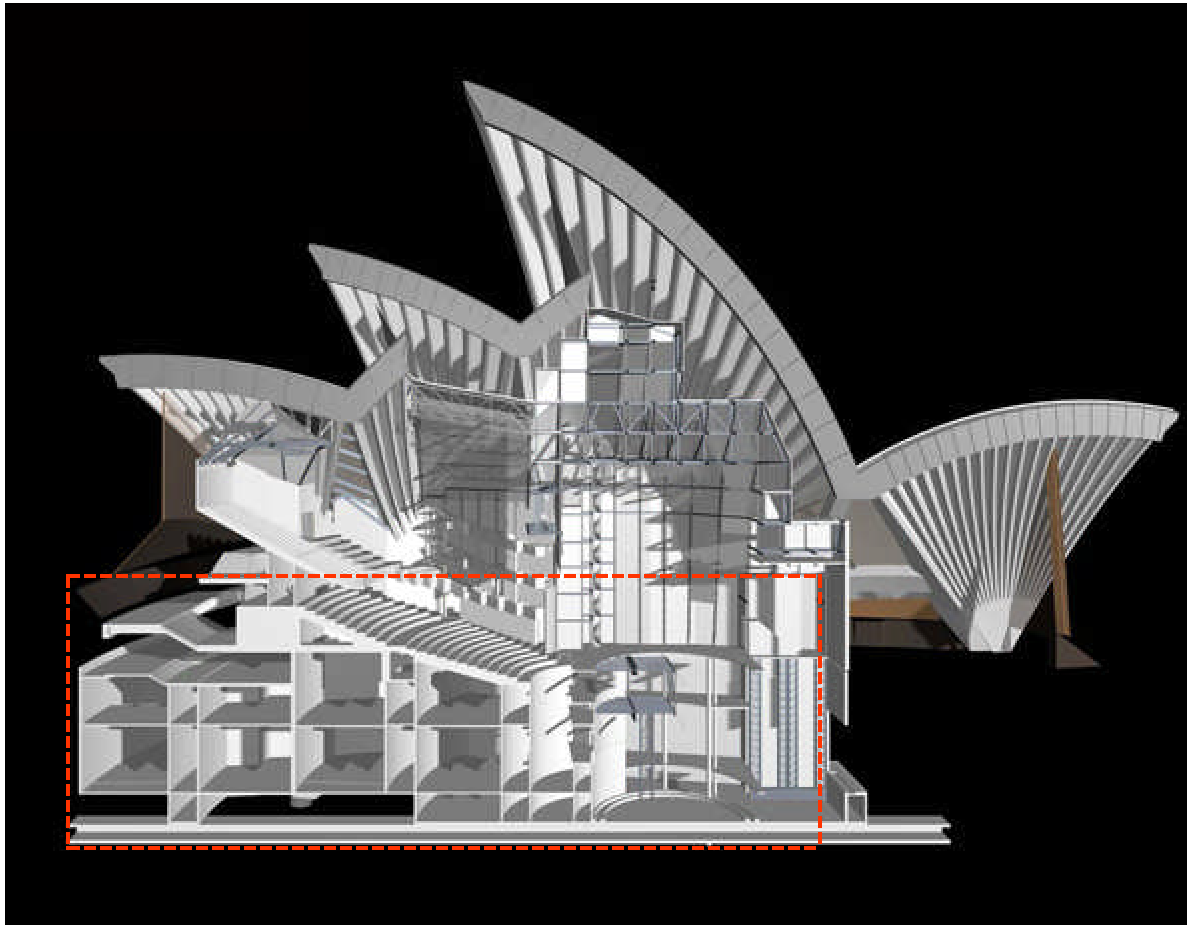
<u>Left</u>: entry podium construction (1962)

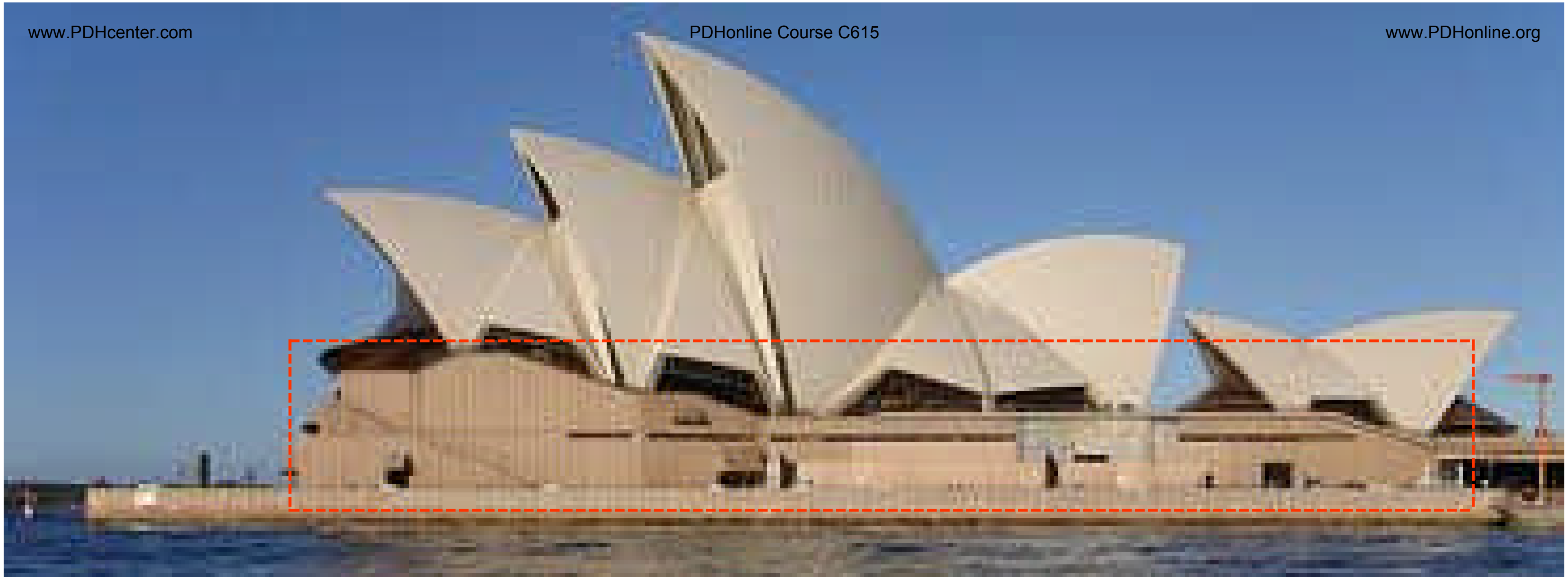
"The foundations were going in very soon after the competition had been won, and certainly before any of the technical problems had been solved, and certainly before the planning problems had been developed to any degree of finality."

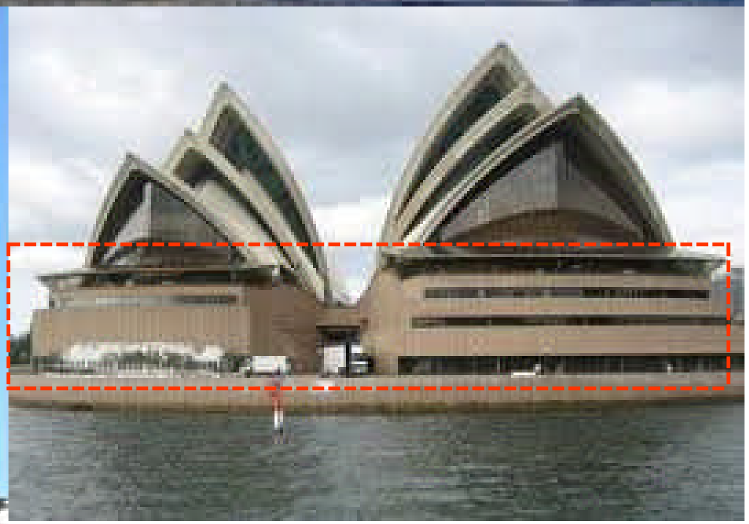
John Nutt, Engineer - Ove Arup & Partners

The Podium covers 4.5 acres measuring 600-feet long by 312-feet wide (at its southern end). The highest point of the Podium is 66-feet above mean sea level.

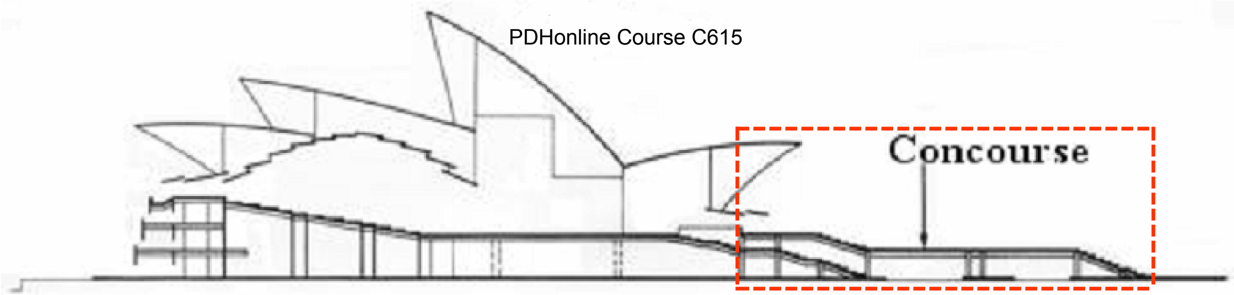




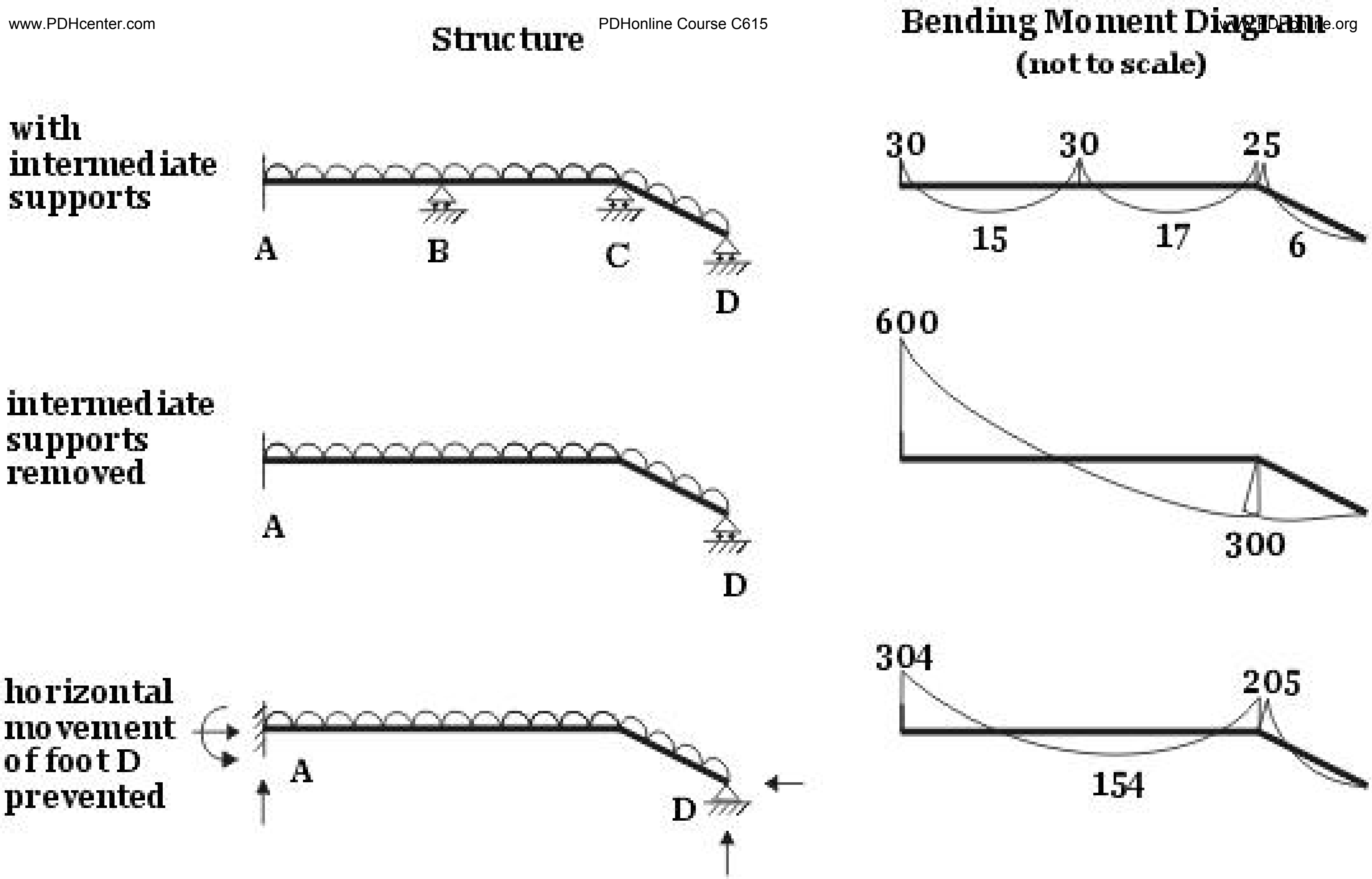




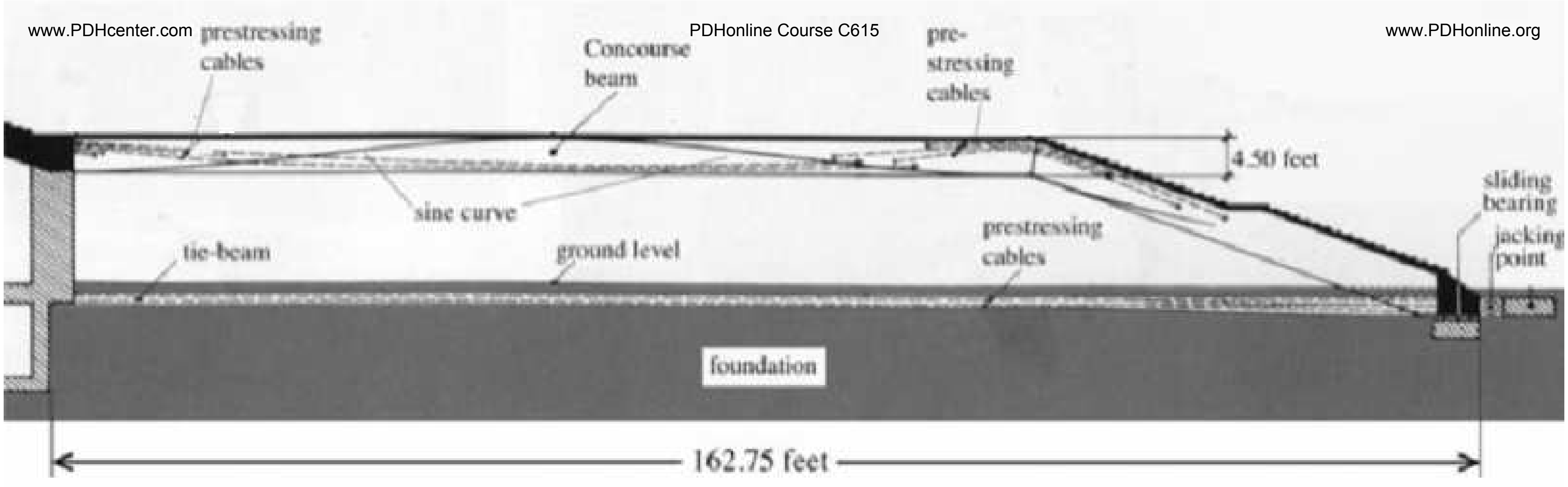
The Concourse



The *Concourse* consists of a series of broad steps leading to a large flat area beyond which are more steps leading to the top of the Podium (a roadway runs under the Concourse to allow vehicles to deliver patrons to the lower entrance halls). Originally, Utzon had allowed for columns under the center of the Concourse. However, In his initial discussions with Ove Arup, he asked if it would be possible to omit not only the central columns, but even those under the junction of steps and Concourse. Arup responded that it would be possible to omit them, but expensive and hard to justify since the columns posed no obstruction to traffic flow. Utzon responded that his intention was to: "express the structure honestly," and since he was going to omit finishes (i.e. tiling) under the concourse thus saving money, he felt entitled to spend it elsewhere; why not on a bold, impressive form for the Concourse support beams? This would require the beams to span approximately 50-meters (the beam depth was required to be a minimum due to clearance requirements over the roadway). Without intermediate support columns, the bending moment on the first flight of steps and Concourse beams would increase dramatically. To resolve the issue, Arup's solution was to prop the bottom of the steps against the sandstone substrata (to prevent horizontal movement) thus relieving the bending moments (on the Concourse beams) and allowing axial forces to develop in the structure.

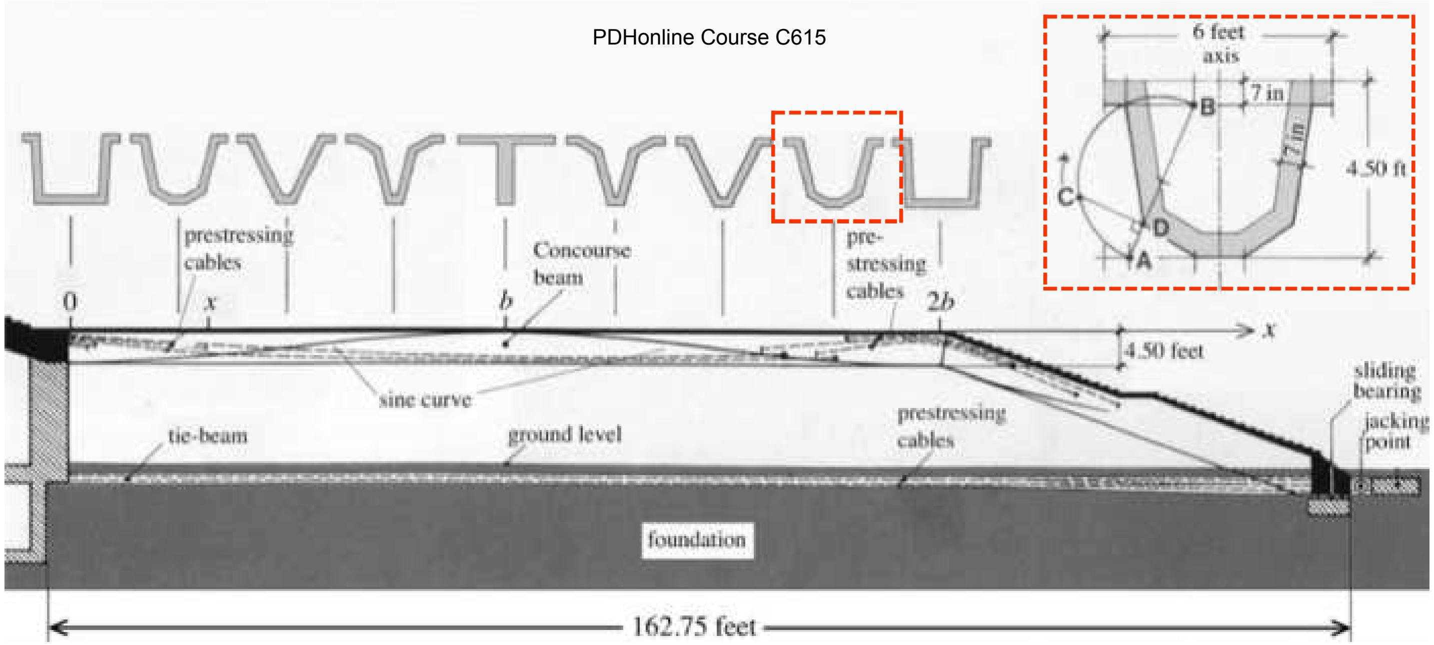


A simplified diagram of the Concourse beams showing results of removing intermediate supports (middle) and benefit of preventing outward movement of the foot (bottom)



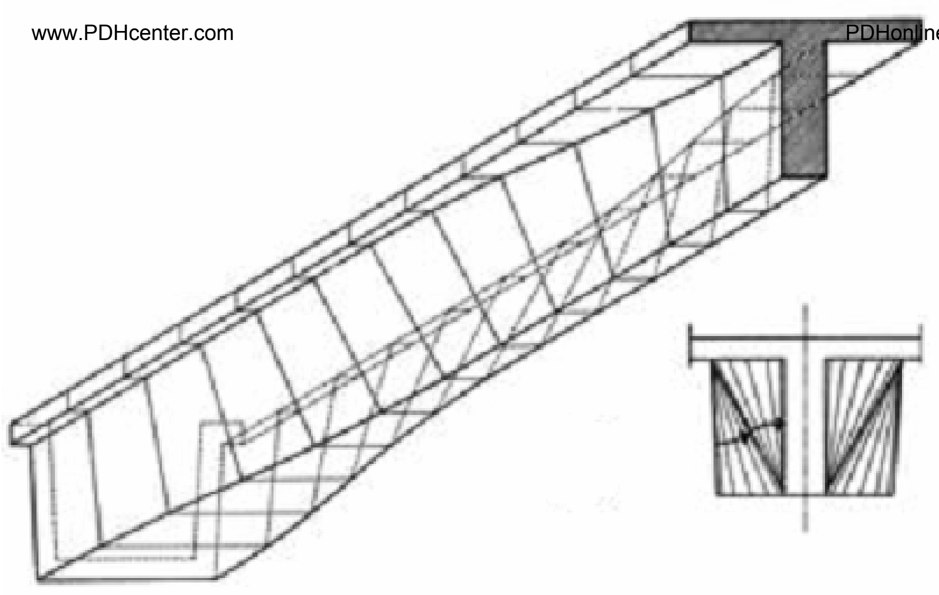
Utzon also decreased the slope of the steps resulting in a greater horizontal reaction required to maintain equilibrium. Also, later it was discovered that the sandstone substrata dipped away at the southern end of the steps. For these reasons, Arup inserted tie-beams (under the road) to tie the bottom of the steps back to the main structure. To gain an additional advantage, the tie-beams were extended out past the bottom of the steps and the superstructure was pre-stressed by jacks which pushed inwards against the bottom of the steps and forced the ends of the tie-beams outwards, placing them in tension before the connection was made rigid. Thus was the problem posed by the removal of the central columns solved with considerable expense in time and money.

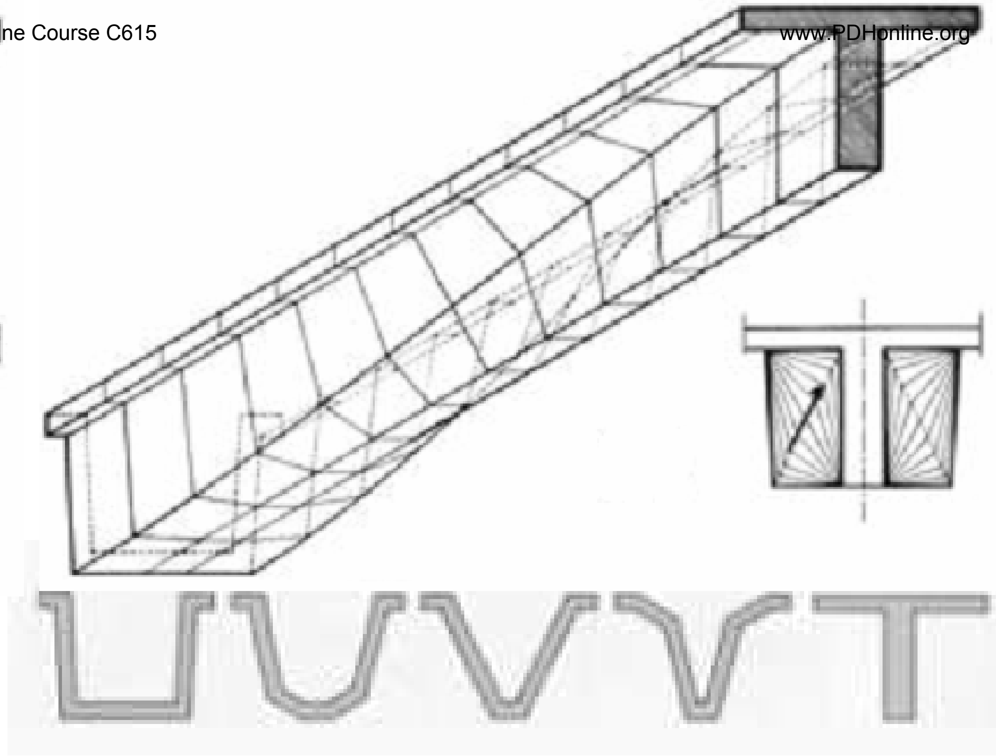
Ove’s Invention



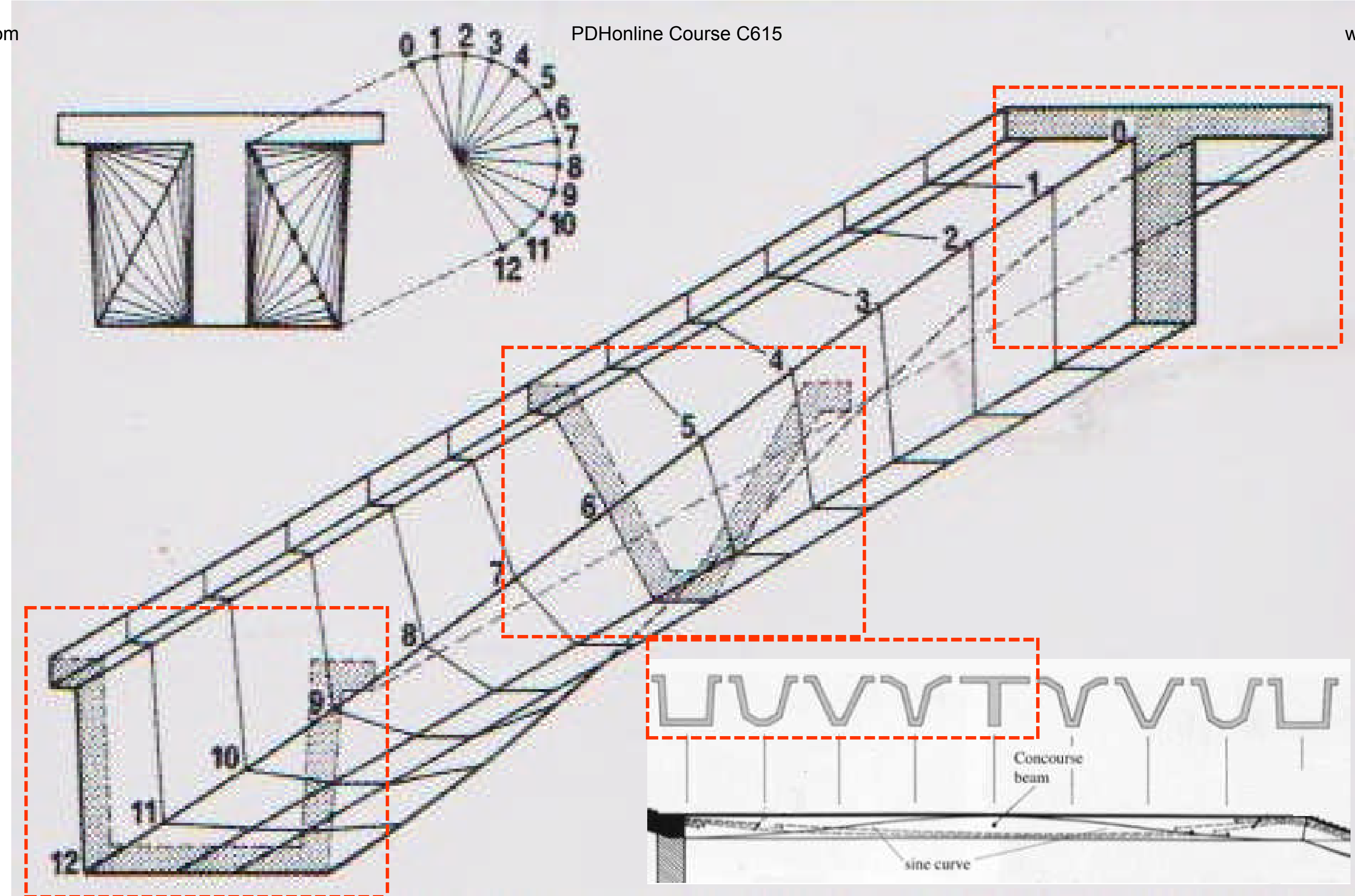
Utzon wanted the design of the Concourse beams to express their structural properties and to dispense with the slope normally provided for drainage. He proposed to use perfectly flat, pre-cast paving slabs supported so that rainwater would drain through the joints and be carried away from below (by the concrete beam's web) while the depth of the Concourse remained constant. This criteria led Arup to propose a series of webs (at the appropriate spacing) supporting the edges of the paving slabs, with a horizontal flange varying in position so that it would be near the top of the webs at mid-span and near the bottom at each end thus providing a slope for drainage. The idea developed through a number of stages resulting in a scheme which provided the required drainage channels. The cross-section of the Concourse beam/s varies with the magnitude and *sine* of the bending moment. Utzon referred to the beams as "Ove's Invention."

"The roundness or voluptuousness which the Architect was looking for…while still being reasonably easy to fabricate"
Ove Arup, Engineer
RE: cross-sectional profile of the pre-cast concrete Concourse beam/s

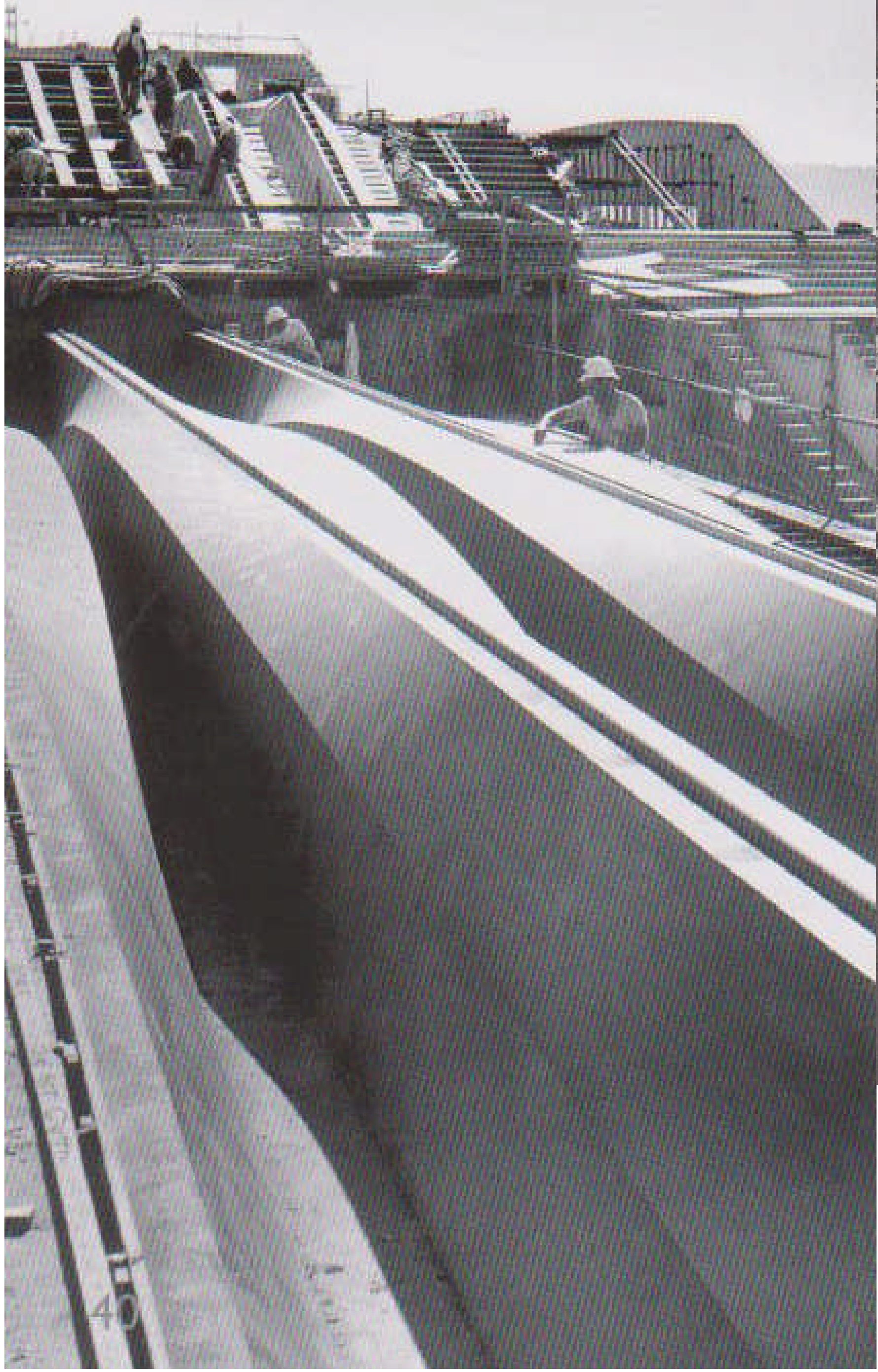


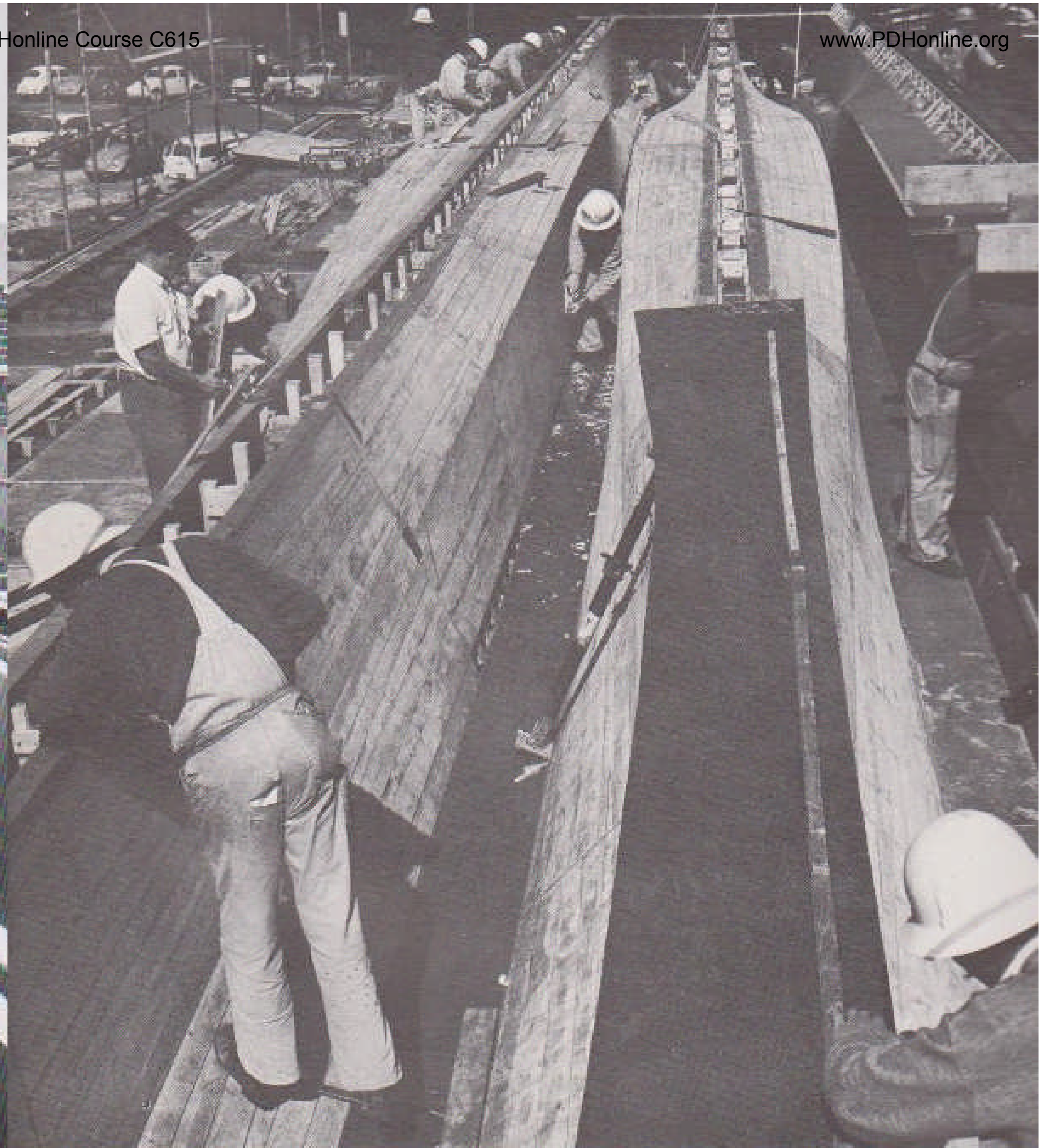


The question arose as to the geometrical definition of the transition from one section of Concourse beam to another. Utzon didn't like the scheme originally proposed by Arup (left). Utzon wanted the sharp edges rounded-off making fabrication difficult and expensive. The solution provided by Arup (right) provided (somewhat) the aesthetic refinement Utzon was looking for.

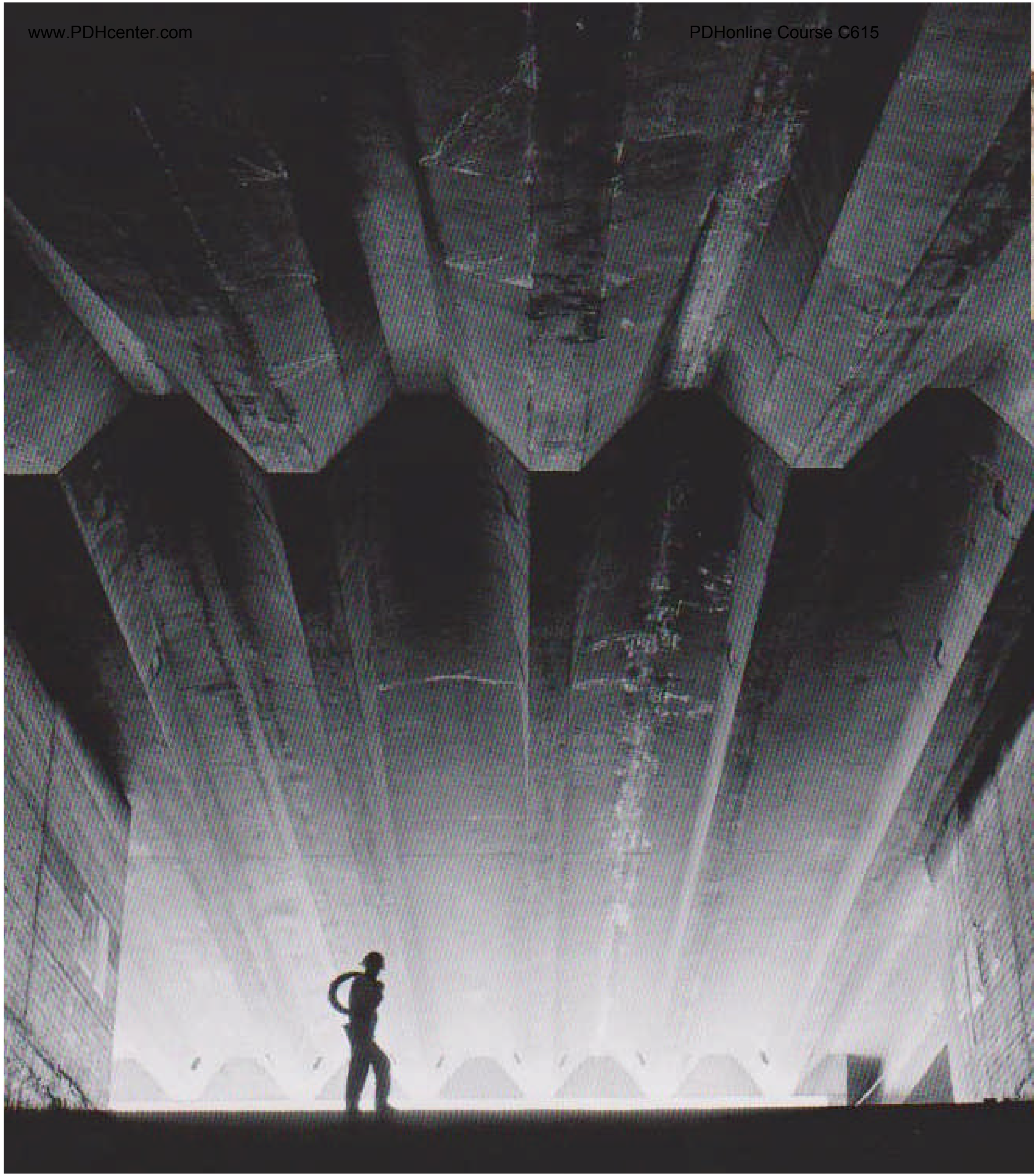


<u>Above</u>: cross-section of a half-length of installed Concourse beam. The U-shape at the end/s (where the beam is supported) places most concrete at the bearing-point where it is needed. Conversely, the T-shape in the middle places most concrete at the top where it is needed most. Like a smooth sea-wave, the transition (from *U-V-T-V-U*) follows the *Sine Curve* on each side of the beam

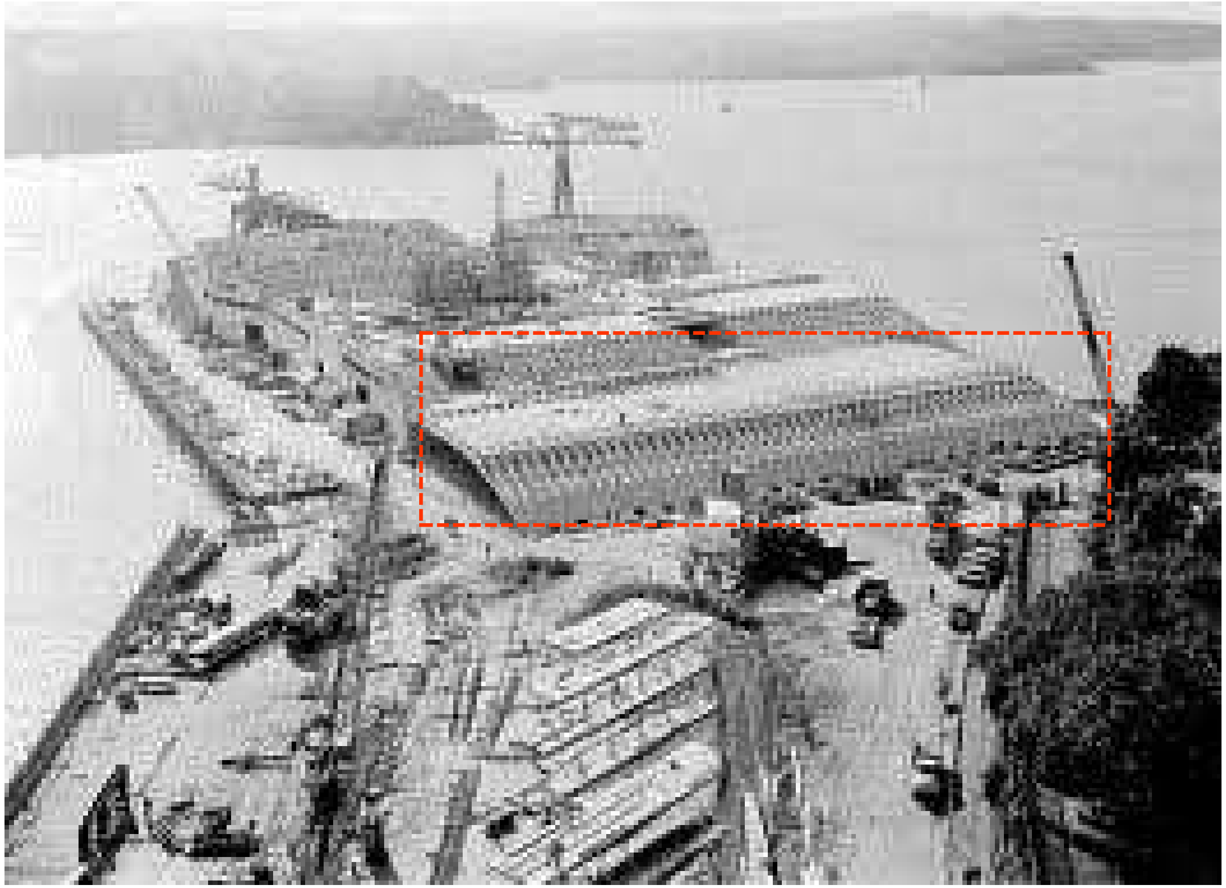


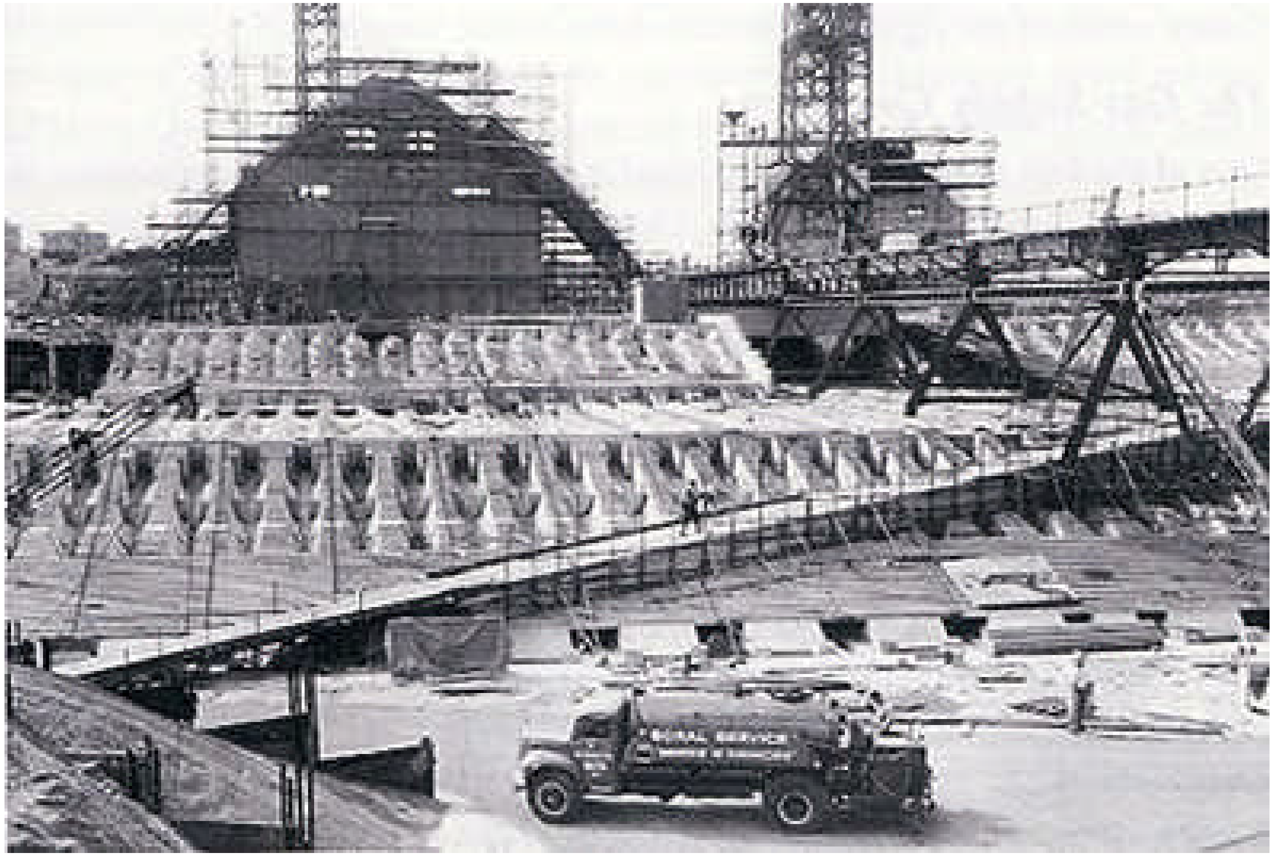


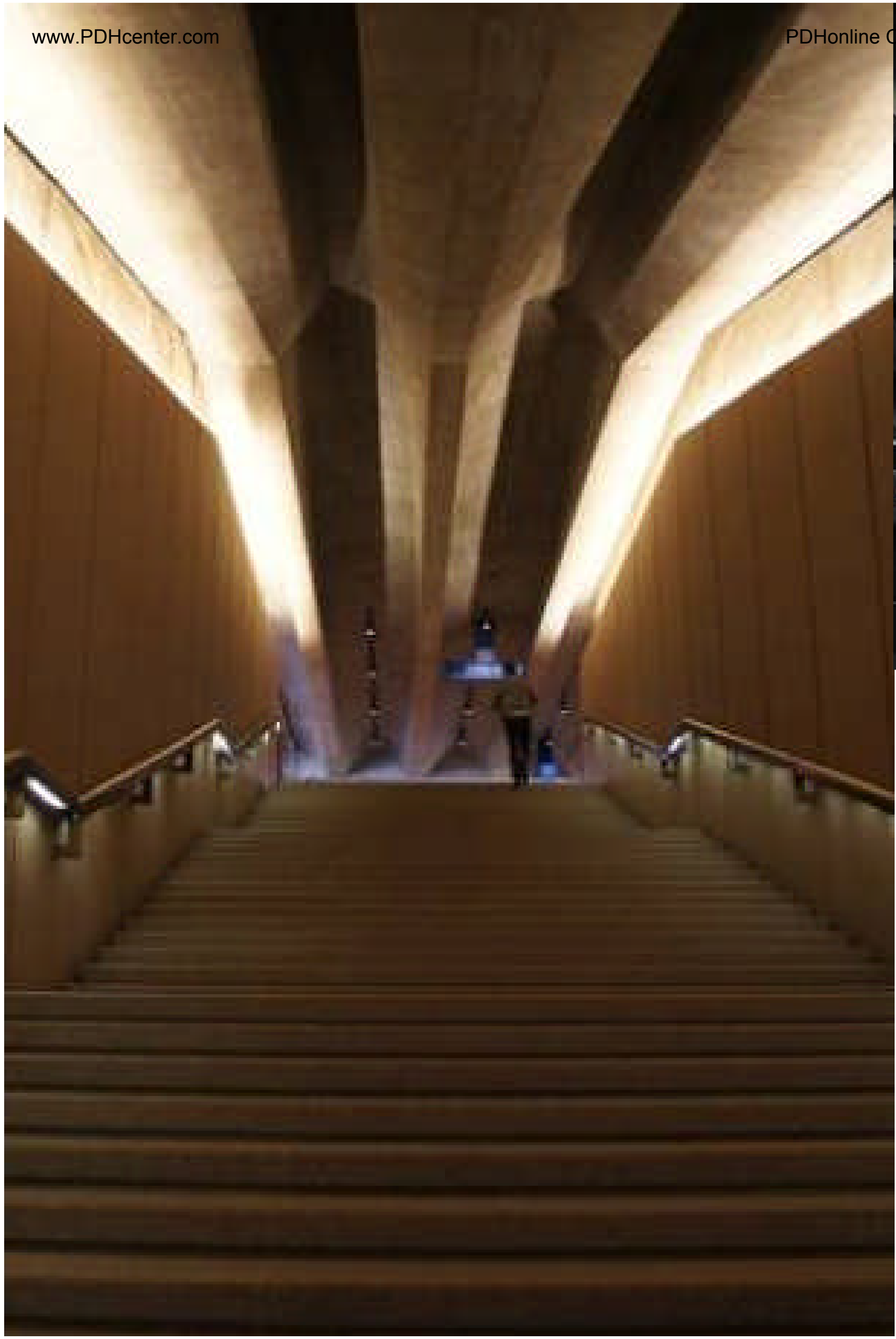
<u>Left</u>: resin-coated plywood forms for pre-cast concrete Concourse beams
<u>Above</u>: forming the sculptural post-tensioned Concourse beams

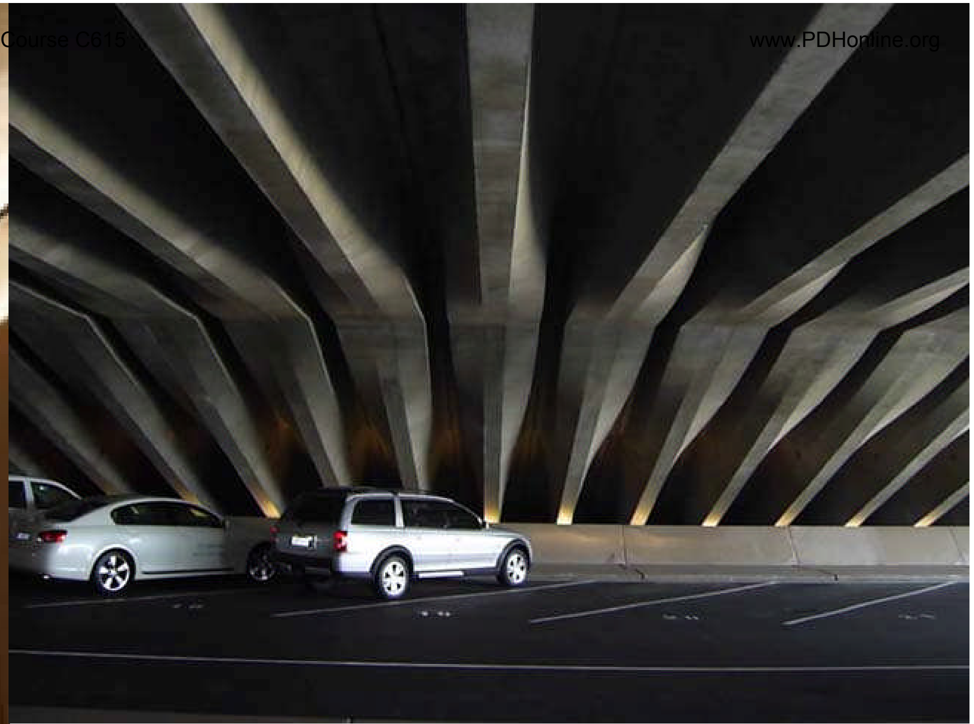


Left: a workman is silhouetted in a underside view of the post-tensioned pre-cast concrete beams of the vehicular Concourse which extends from the main access stairs to the Box Office foyer.
Above: close-up view of the sloping section (for main access stairs)









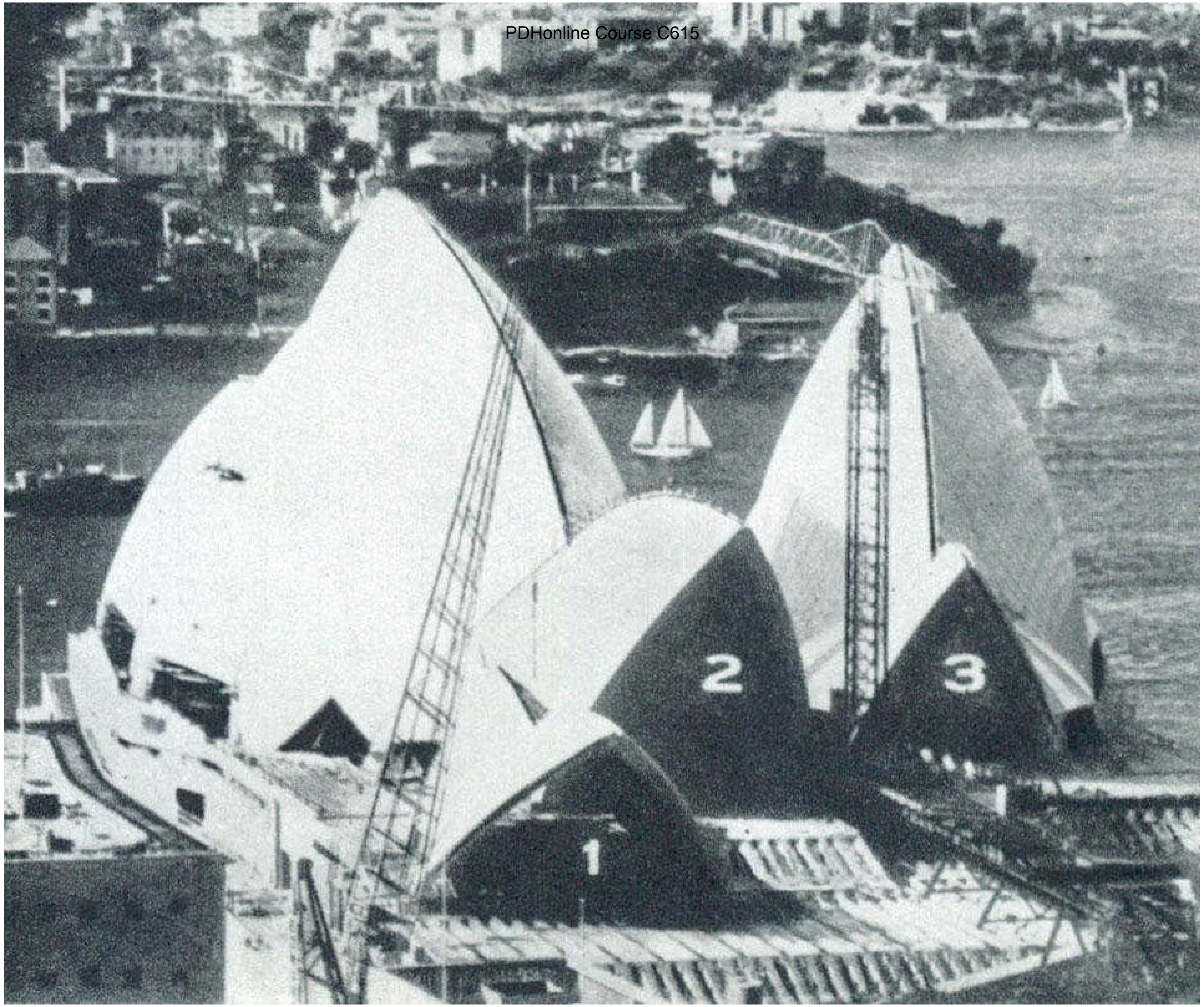
<u>Left</u>: Concourse staircase with post-tensioned (sloping) concrete beams above
<u>Above</u>: Concourse beams above parking space and below ceremonial staircase

Structural Honesty (?)

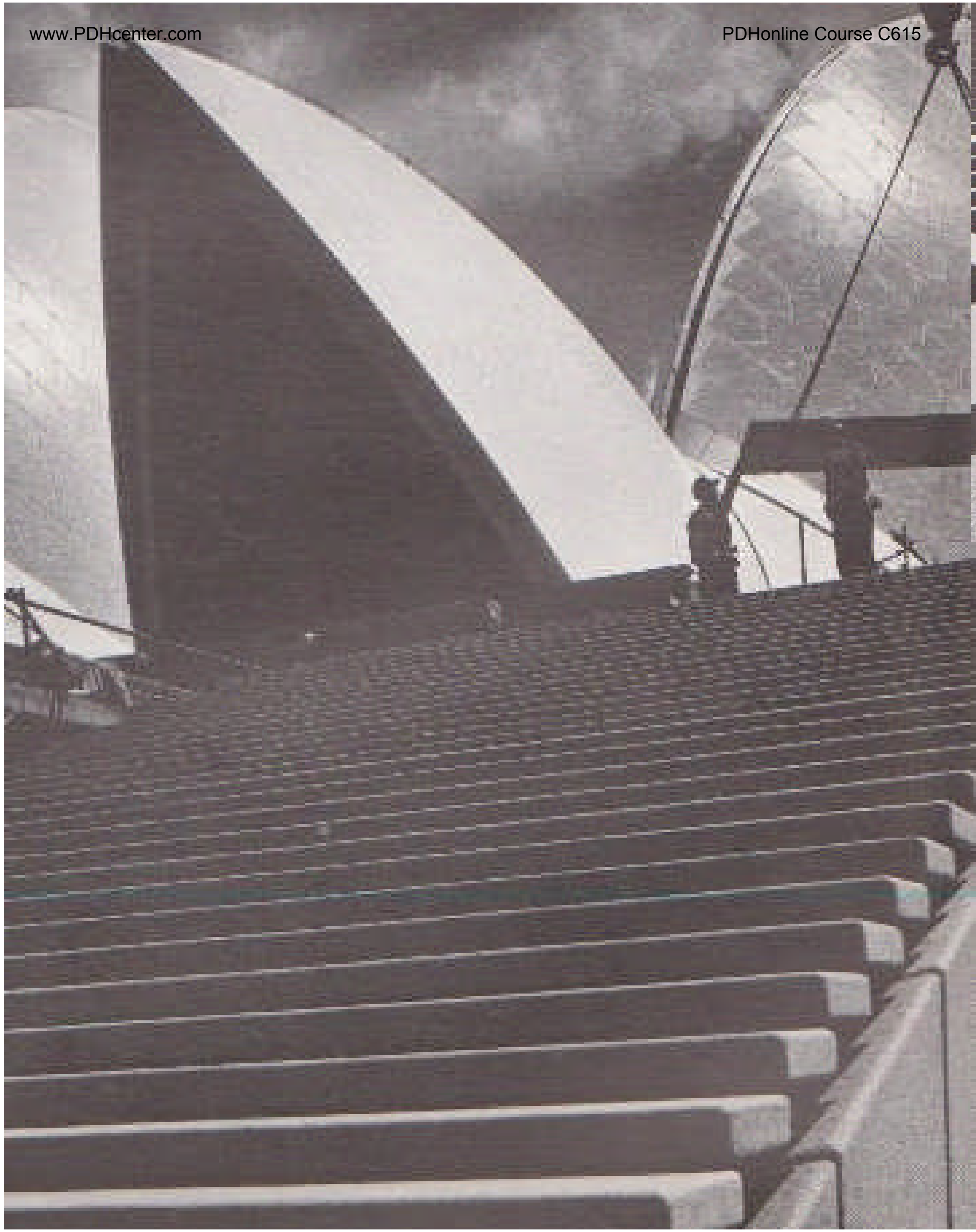
"The very considerable cost, and the disturbance it would cause to an already critical situation would be too high a price to pay for something which after all would not be missed by anybody. However the Architect was insistent and the Engineers were bracing themselves to attempt a solution to the problem, when the Heating Engineers intervened with a demand for space over the slab in which they could accommodate their pipes and services."

Ove Arup, Engineer

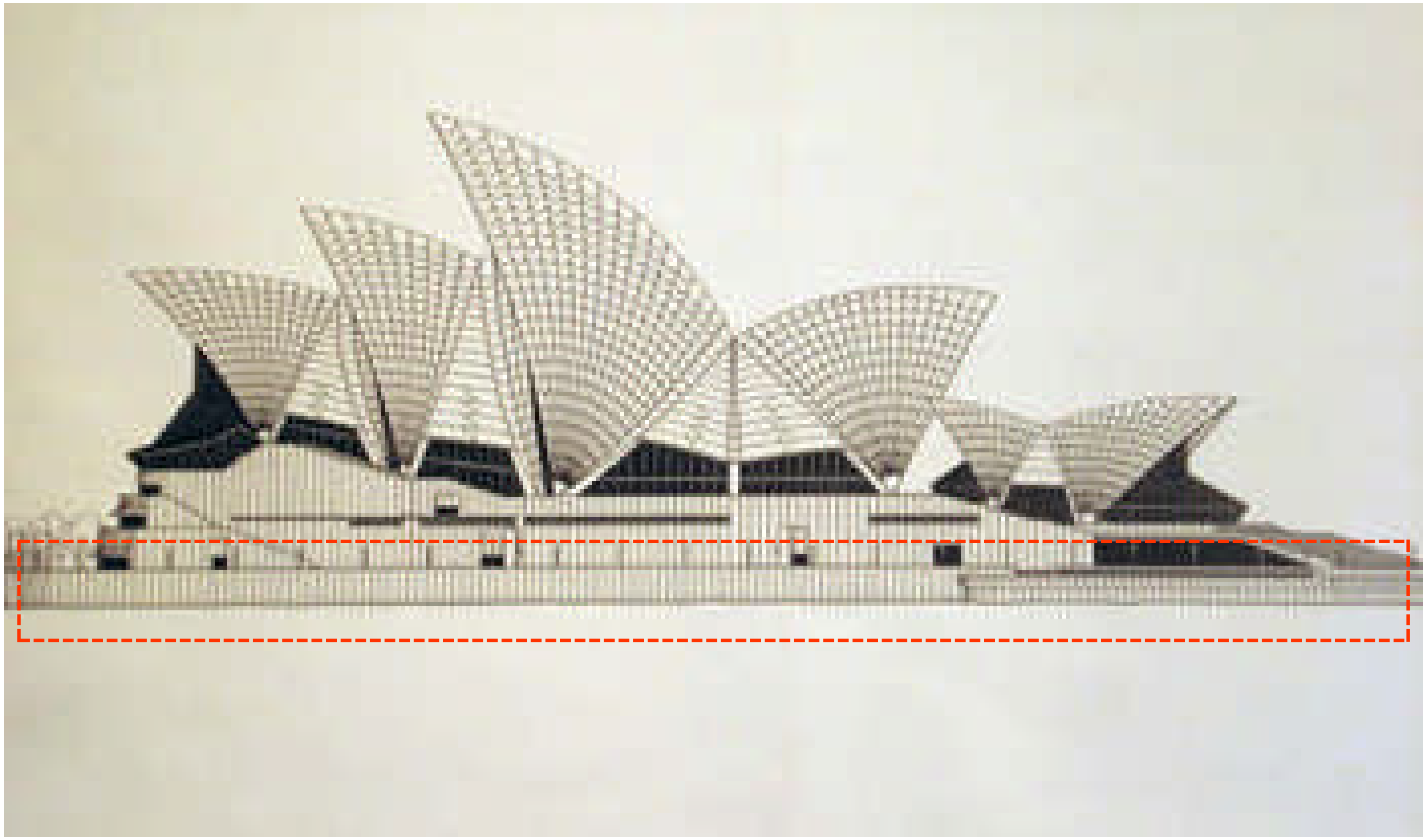
RE: Utzon wanted some of the beams which run under the restaurant raised because the restaurant floor was higher than the Concourse's floor level and in keeping with his policy of "structural honesty," he was opposed to the idea of building a raised platform over the beams to accommodate the change in level (a much simpler and cheaper solution). This posed serious engineering problems since five non-standard beams would have had to have been inserted. Being asymmetrical, their pre-stressing would have created torsional moments which would have to be absorbed by adjoining beams already highly stressed. When the mechanical engineer requested a plenum space above the slab in the restaurant to accommodate pipes and services, Utzon relented and a platform was built instead (to his disappointment and Arup's relief).



1. Restaurant 2. Major Hall 3. Minor Hall (1967)



Later finish work on the Podium;
<u>Left</u>: ceremonial steps with wide treads and low-rise for easy access to the "Broadwalk"
<u>Above</u>: finishing touches to the pink granite aggregate paving slabs covering the Podium steps and Broadwalk
Originally, the pink stone cladding to the Podium was not to extend down to the waterline, but that was revised.

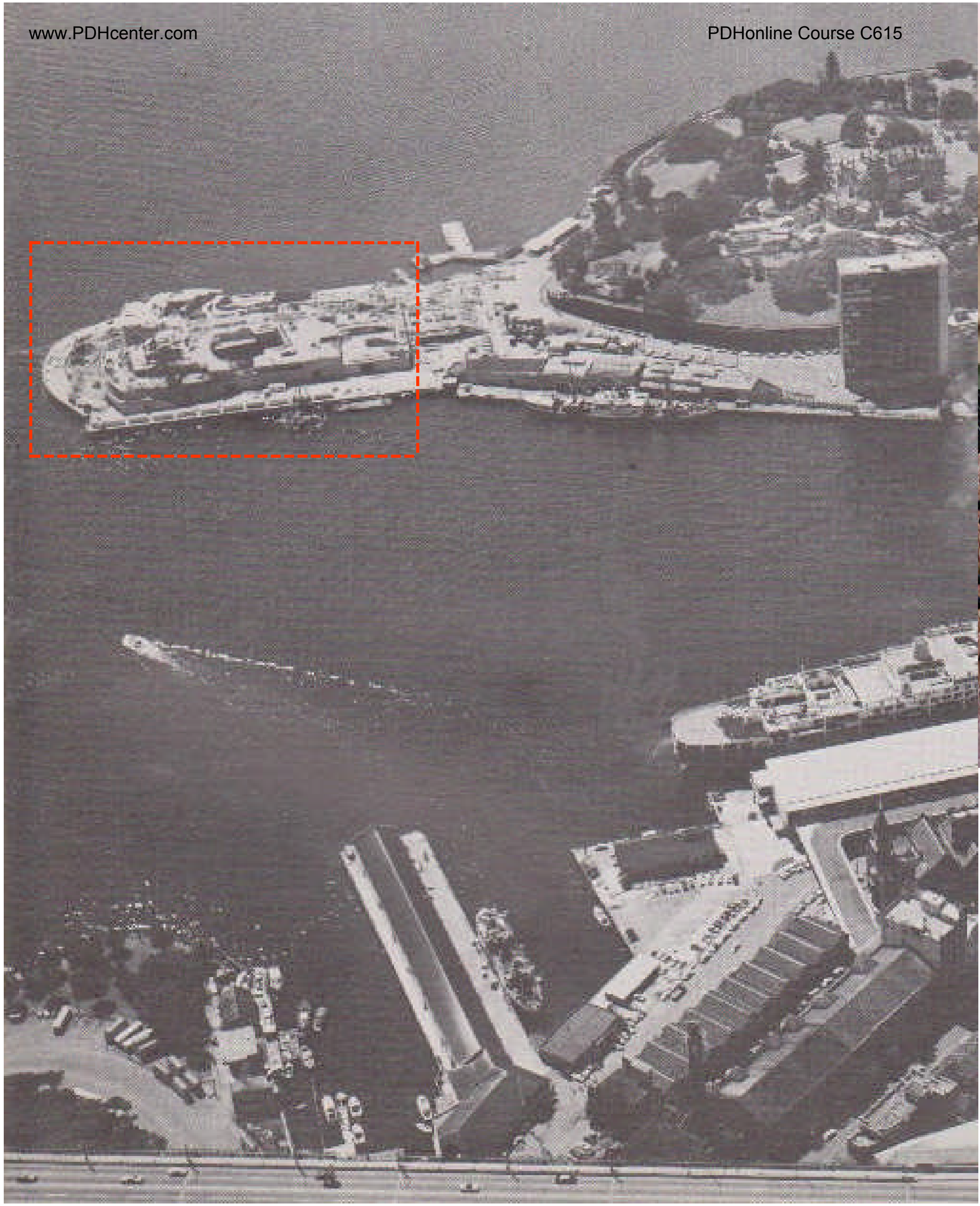


The Podium as it appeared upon completion (looking south; February 1963). Robert Heffron (successor to Joe Cahill) announced during the construction of the Podium the formation of the *Sydney Opera House Trust* which would be responsible for the operation of the complex. *Waagner Biro* – an Austrian firm, was awarded a contract for $A3.4 million to construct and install the stage machinery. As well, the anticipated completion date was moved from January 1963 to sometime in late 1965 with a final cost projected to be $A25 million.

"…It was politics that both created and fettered the Opera House. If its cost to date of $148.5 million* seems and is astronomical – it is, after all, nearly one-third of what the citizens of New South Wales annually spend on booze – the first estimate was absurdly low. The New South Wales Premier, J.J. Cahill, who wanted the government irrevocably committed to the project, announced in 1957 that it would cost $9.8 million, deliberately falsifying the sum…"

*** The cost of New York City's *Lincoln Center* which includes six buildings: $152 million**

***Time* magazine, October 8th 1973**



<u>Left</u>: Aerial view of the completed Podium (February 1963)
<u>Above</u>: a large group of nudists assembled on the ceremonial steps and forecourt of the SOH Concourse (Jan. 2010)

The remaining problem for the Podium related to the yet-to-be determined weight of the roof shells. The anchor points of the roof were still vague during the Podium's construction and the load/s they would have to bear remained an unknown quantity. In March 1962, Utzon flew from the U.S. to Sydney accompanied by Arup engineer *Jack Zunz.* Delayed by work, they had missed their flight from New York to Los Angeles. The *American Airlines* 707 they would have been on crashed on take-off killing all aboard. After a ten-week holiday in the U.S. and Tahiti, Utzon returned with his family (as migrants) in March 1963; just one month after the Podium's completion. *Queen Elizabeth* and *Prince Phillip* were in Sydney Harbor (on the royal yacht *Brittannia*) at the time of their arrival and invited Utzon and his wife to tea. Utzon had been incommunicado much of the time he was on holiday and certain decisions about Stage Two had to be taken without his input/consent, something Arup and the contractor preferred not to do. Henceforth, Utzon would be in an on-site office (next to Ove Arup & Partner's office) on Bennelong Point. Previous to this arrangement, Utzon was working from a rented townhouse in *Hellebaek* (on the Danish island of *Zealand*). The Arup engineers often spoke of the great pleasure they felt in leaving the commotion of *Fitzroy Street* (Arup's office in London) for the peace of Hellebaek (it's surrounded by a beautiful Beech forest and lakes). In Hellebaek, life revolved around long days working on the project at the drafting tables. Young architects came to Hellebaek from all over the world to work with Utzon. Aside from Danes, architects from *Japan, Italy, Britain* and *Australia* worked on SOH. At the beginning (1958), there were about nine architects on-staff. During 1960, the staff had grown to twelve. By late 1961, there were upwards of twenty full-time design staff.


Jorn Utzon at his desk (left) and making a sketch (for the auditorium ceiling design, right) at the Utzon studio in Hellebaek, North Zealand (1960). Despite the fact that he was an excellent draftsman, Utzon rarely drew plans. Instead, he provided his staff of young, talented and idealistic architects with hand-drawn sketches. Utzon would distribute these sketches among his staff and brief them on his concepts behind the sketches (akin to how *Frank Lloyd Wright* worked with his apprentices). Utzon would often take staff members for walks into the Beech forest eagerly pointing out subtle forms found in nature which found their way into his designs. Outstanding among the young architects who worked for Utzon (between 1958 and 1961) was *Yuzo Mikami*. Utzon had written to *Kunio Maekawa*, a leading Japanese modernist architect, asking for an assistant who had worked on the *Japanese Pavilion* for *Expo 58* which Utzon much admired. Mikami seized the opportunity. Mikami worked with Utzon on the *Red Book* and drafted hundreds of designs and schematics, including many of the most important (i.e. never-realized roof of the main theater auditorium). From 1962, Mikami worked with Ove Arup, drafting working drawings for the final design, to the disappointment of many in Utzon's office.

A New Kind of Architecture

"We had a big space in the house rented by Utzon. We not only drew but we built a lot of models because Utzon liked to develop his ideas by building models as well as sketches, and we enormously enjoyed creating a new solution to a new kind of architecture, and also creating new forms. It was really exciting."

Yuzo Mikami, Architect

"Instead of making a square form, I have made a sculpture - a sculpture covering the necessary functions…If you think of a Gothic church, you are closer to what I have been aiming at…"

Jorn Utzon, Architect

"No doubt you are enjoying life in Hellebaek, the 'kolde bord' in the 'badehotel' and bathing and sailing in Jorn's boats. Who knows, you may even find some time for some work now and then."

RE: excerpt from a letter between two Arup engineers (*Hugo Molman* to *Povl Ahm*) working from Arup's London office. Despite the beautiful setting Hallebaek provided, it wasn't a vacation they went there for and work on SOH was the order of the day. Up to 1962, Ove Arup and Partners estimated that the work undertaken, even before beginning the construction of the roof shells, totaled more than 150K man-hours; the equivalent of more than one-hundred years of full time work for a single engineer. Working for Arup on the SOH project were engineers of twelve different nationalities. Utzon was convinced that his client: the NSW government, would support him in his efforts to design and build the SOH to the highest standards. As the project progressed, his client was demonstrating an increased willingness to compromise on Utzon's high-minded, idealist approach. Ove Arup and Partners would be caught in the middle between these two increasingly opposing points of view as the project moved into Stage Two.

Part 7

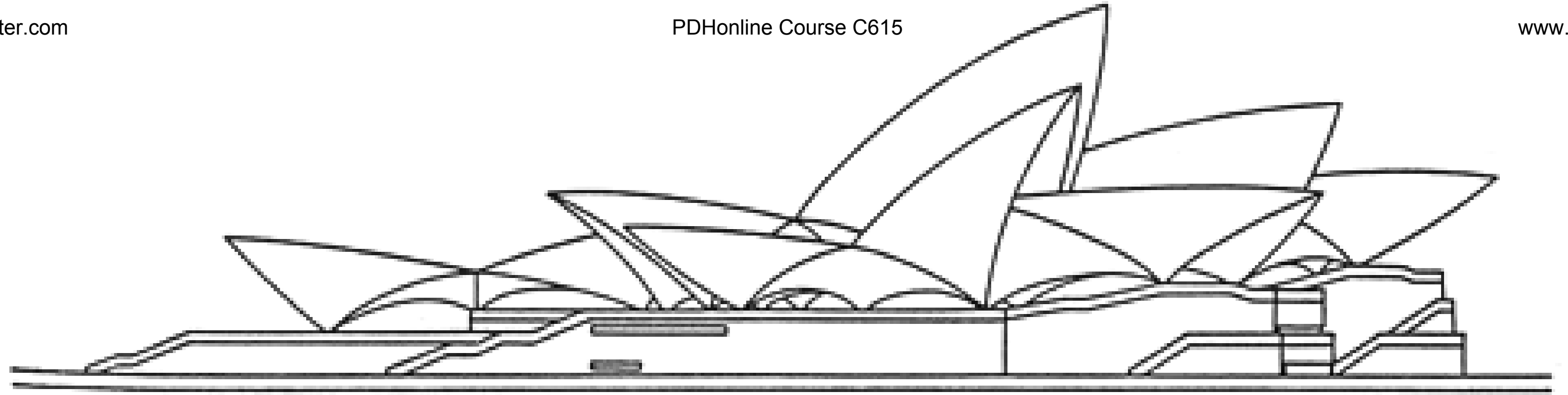
The Spherical Solution

The Omnipotence of Shells

"Many architects allege that form has dominated function to the detriment of the scheme, the unusual roof was really only the outward expression of an inner plan which provided an ingenious solution to the competition problem…the then prevailing faith amongst architects in the omnipotence of shells "

Ove Arup, Engineer

RE: Utzon had conceived the shell scheme with minimal engineering advice. To ensure membrane action, a shell must follow a prescribed form in order that all forces produced by distributed loads, in particular the weight of the shell itself, are transmitted through the plane of the membrane. A wide range of possible forms meet this criteria, but any deviation from the disciplined form imposed by *Statics* introduces bending moments which a thin shell cannot resist. Utzon's shells were drawn freehand and therefore did not correspond to a recognized shell form. Also, they had a ridge (along the center) which made it impossible for forces to be transmitted smoothly (across the top) within the plane of the shell. Therefore, they could not be described as "shells" in the true engineering sense of the word. Additionally, the shells were not balanced longitudinally thus they had an inherent tendency to fall end-on-end.



<u>Above</u>: Utzon's original conception (1957 Competition Scheme) showing softer outlines of the roof-scape (single-skin reinforced concrete shell). In early meetings, the first ideas exchanged included the use of non-pointed arches, double-curved shells (covering each hall) or even a single roof over both halls. Arup stated that to design a dome-like structure covering both halls would probably have been easier than pursuing the original concept. However, it was a consensus whereby both architect and engineer agreed that such changes would diminish the sculptural quality of Utzon's original scheme and as such, all efforts should be directed towards reproducing it as closely as possible. As originally drawn, the shapes of the shells (each unique) were not definable by mathematical formula/s. Thus, it would have been practically impossible to analyze them mathematically and extremely difficult to fabricate them. After much debate, agreement was reached to define the curves of the shell forms as *Parabolas*.

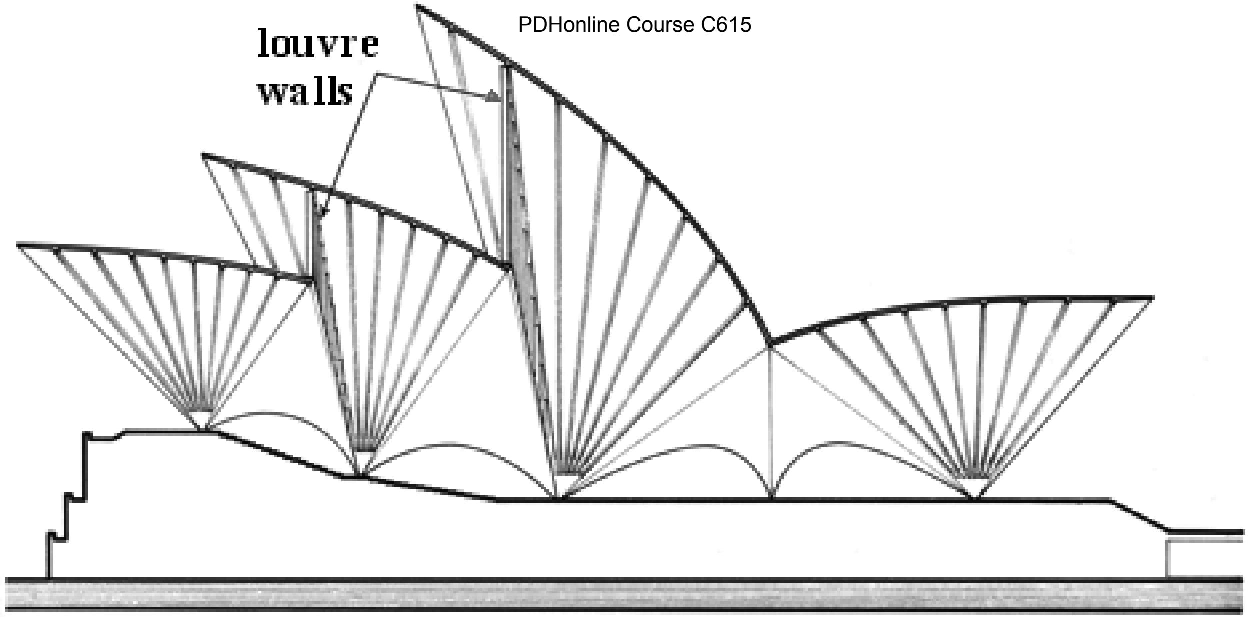
Early model of Utzon's 1957 Competition Scheme (with free-form shells)

In Situ

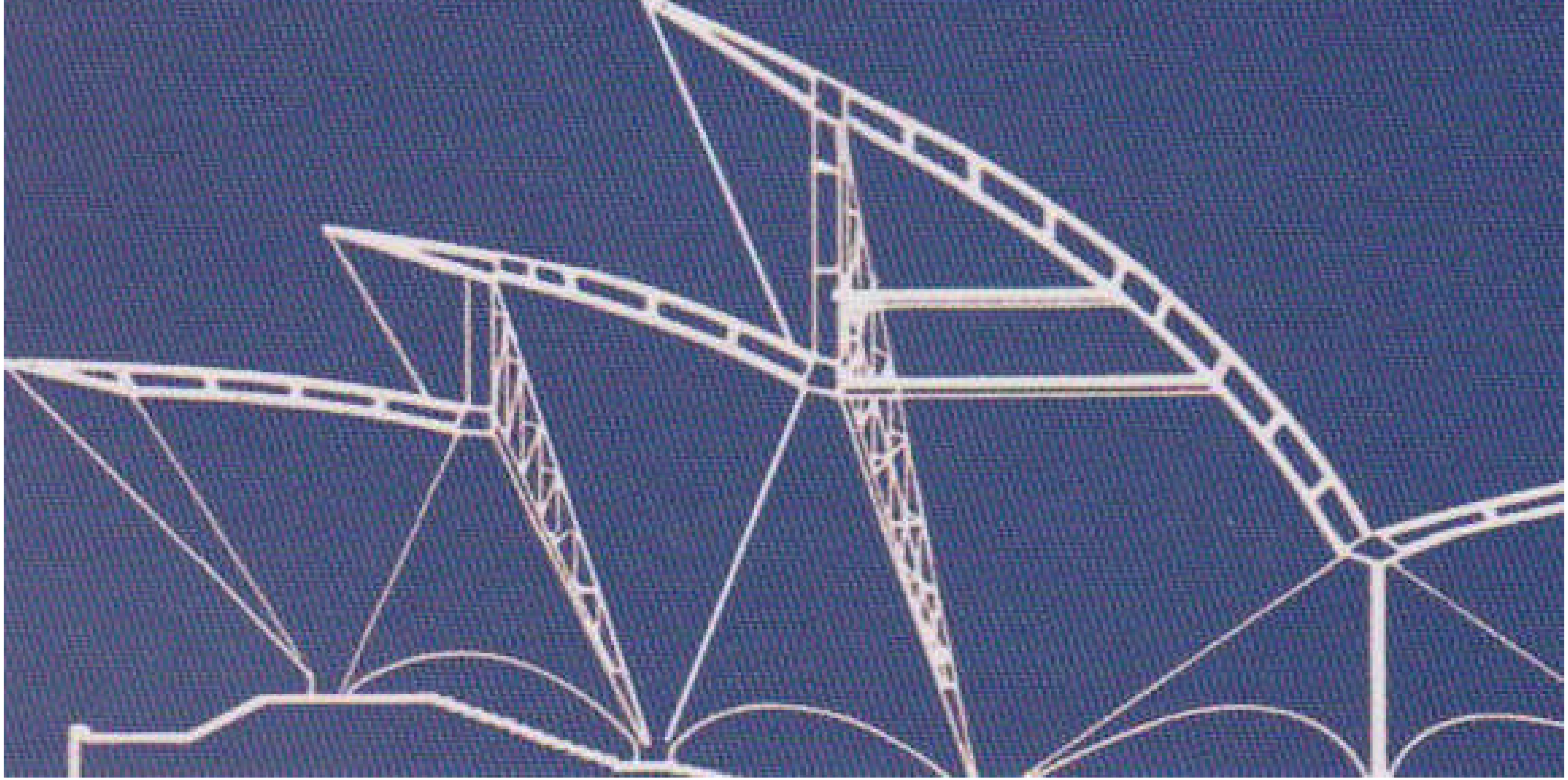
"…The English firm of Ove Arup & Partners spent more than 300,000 man-hours calculating and revising the vaults before the concept of a double-membrane concrete roof cast 'in situ' on aerial formwork was abandoned…"

***Time* magazine, October 8th 1973**

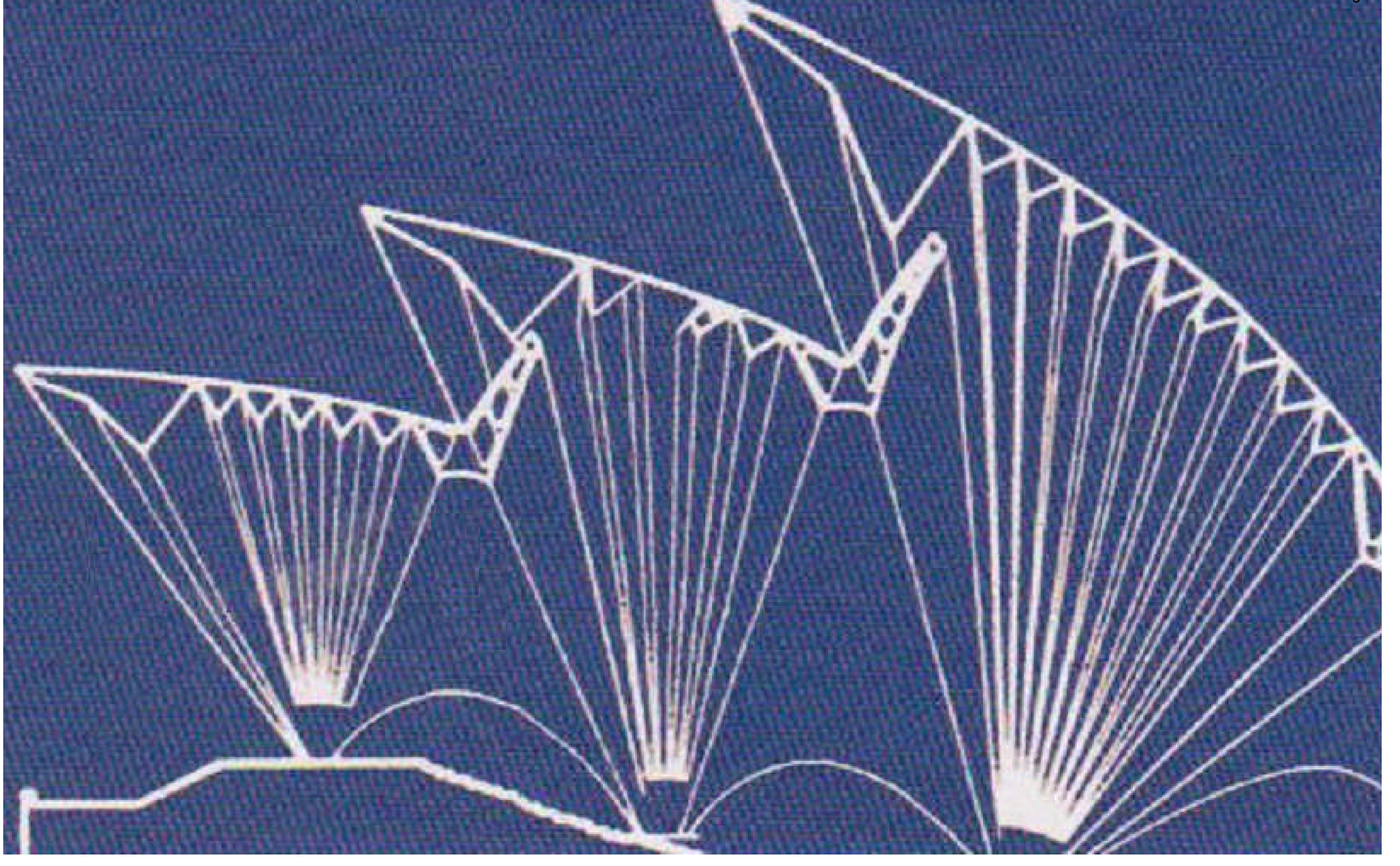
RE: Utzon originally conceived the shells as being cast-in-place (in situ) via formwork supported by immense scaffolding. Reinforcing steel would be placed in the formwork and when cured and self-supporting, the scaffolding would be removed (akin to an arch or dome which uses *falsework* support during erection). Computers were used in stress calculations with the shells described (geometrically) as a *Parabola* (path of an object thrown into the air) at first and later as *Ellipsoids* (an *Ellipse* in three dimensions). The path of a satellite in orbit around the earth is representative of an Ellipse. *PERSPEX* models of the shells were made for load and wind tunnel testing. The results revealed shear forces and bending moments much greater than expected. A new scheme consisting of two shells (1.2-meters apart and separated by a web) was tested. For fear of a "domino effect" (if one of the interconnected shells failed) and on the basis of test results, this scheme too was abandoned. A steel framework with a concrete "skin" was an alternative but Utzon dismissed it as "dishonest" since the concrete served no structural purpose other than to keep out the rain. More in-line with Utzon's structural design ethos were roof shells made from giant pre-fabricated concrete ribs, but the cost was prohibitive since very many forms would be required to accommodate the changes in curvature over the surface/s of the Ellipsoid/s.



<u>Above</u>: early Parabolic roof scheme (1958) inclusive of single-skin, ribbed, reinforced-concrete shell/s with Parabolic profiles for ridges and ribs, and "Louvre Walls" connecting the shells. The attempt to cope with bending moments by adding "ribs" to the inside skin of the shell membrane proved insufficient and a double-skin was proposed (with two-way ribs). At the same time, Louvre Walls (enclosing the ends of the shells) were designed to transmit loads from one shell to another, ensure longitudinal stability and provide all possible support for the edges of the shells. Originally, the shells sprang vertically from their supports atop the Podium. It was soon demonstrated that a slight inward inclination greatly reduced bending moments.



<u>Above</u>: Parabolic Scheme (1959-61). Parabolic ridge/rib profile. Double-skin reinforced concrete shell with two-way ribs and structural Louvre Wall. Both *Ronald Jenkins* and *Hugo Mollman* of Arup were strongly committed to the Parabolic approach in their attempts to define Utzon's shells structurally. In June 1961, Ronald Jenkins was dismissed from the SOH project by Arup personally and Hugo Mollman – Jenkins' associate, resigned in protest. Ronald Jenkins was a renowned mathematician and a recognized expert on shell structures.



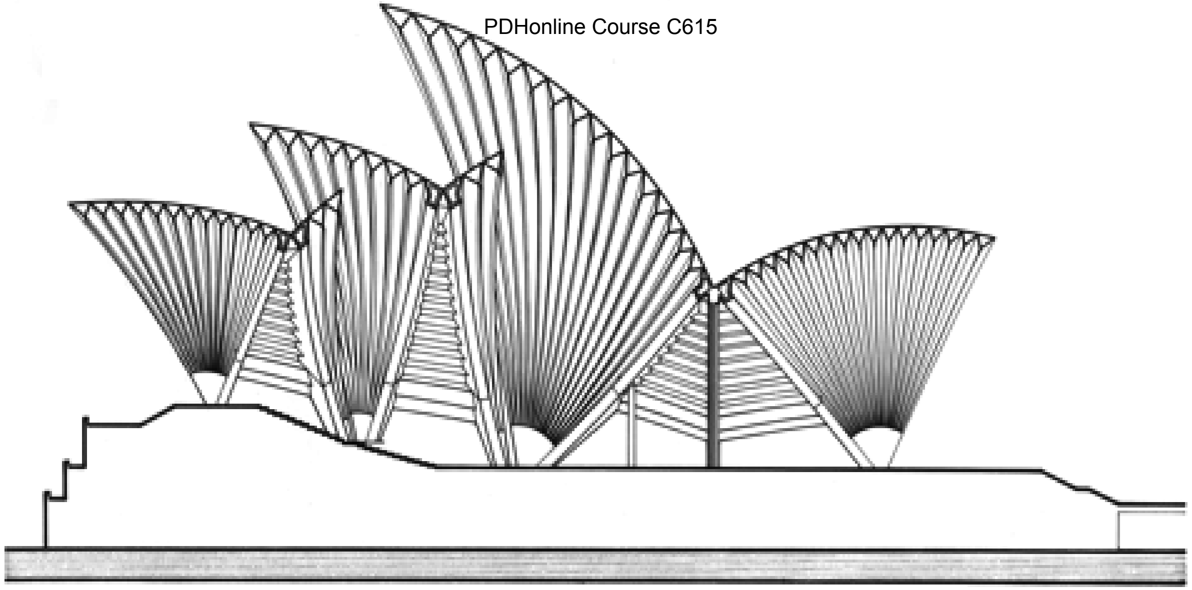
Ellipsoid Scheme (1961). Elliptical ridge/rib profile. Steel space-frame with reinforced concrete skin.

In mid-1961, results from the PERSPEX model tests suggested that the original system of load-transmission produced foundation loads which could not have been predicted analytically. Increasing dimensions to cope with this (and excessive bending moments and shear stresses demonstrated in the model testing) would have the effect of increased dead loads resulting in a "snowball effect" of ever increasing size and weight of the shells. It was at this point that Utzon, who had been pre-occupied with the Podium, turned his attention to the roof shells. He expressed dissatisfaction with the current scheme, particularly the Louvre Walls and the internal appearance of the shells. He preferred a ribbed surface (under the shell) and a better method of closing the gaps between shells since elsewhere in the world, problems where glass walls met shell roofs were popping up. The whole scheme was reviewed and it was decided to abandon the initial structural (Parabolic) concept. Improvements were made by moving the center of gravity of each shell closer to its points of support, thus reducing the bending (overturning) moment. The flat Louvre Walls were largely replaced with curved surfaces (facing the opposite way). Finally, the articulation of the roof was entirely changed so that the three sets of shells were structurally independent and stable. The adopted "rib pattern" fanning-out from the supports was described: "like a pair of hands with fingertips pressed together."

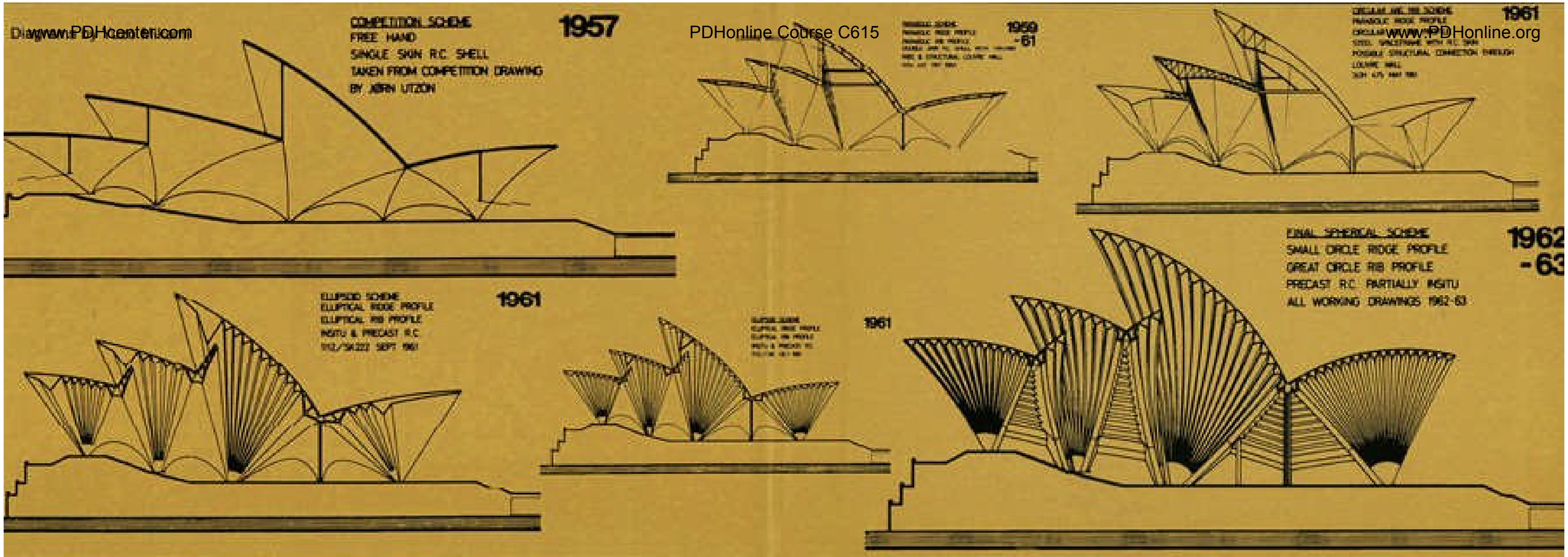
***PERSPEX* model of SOH**

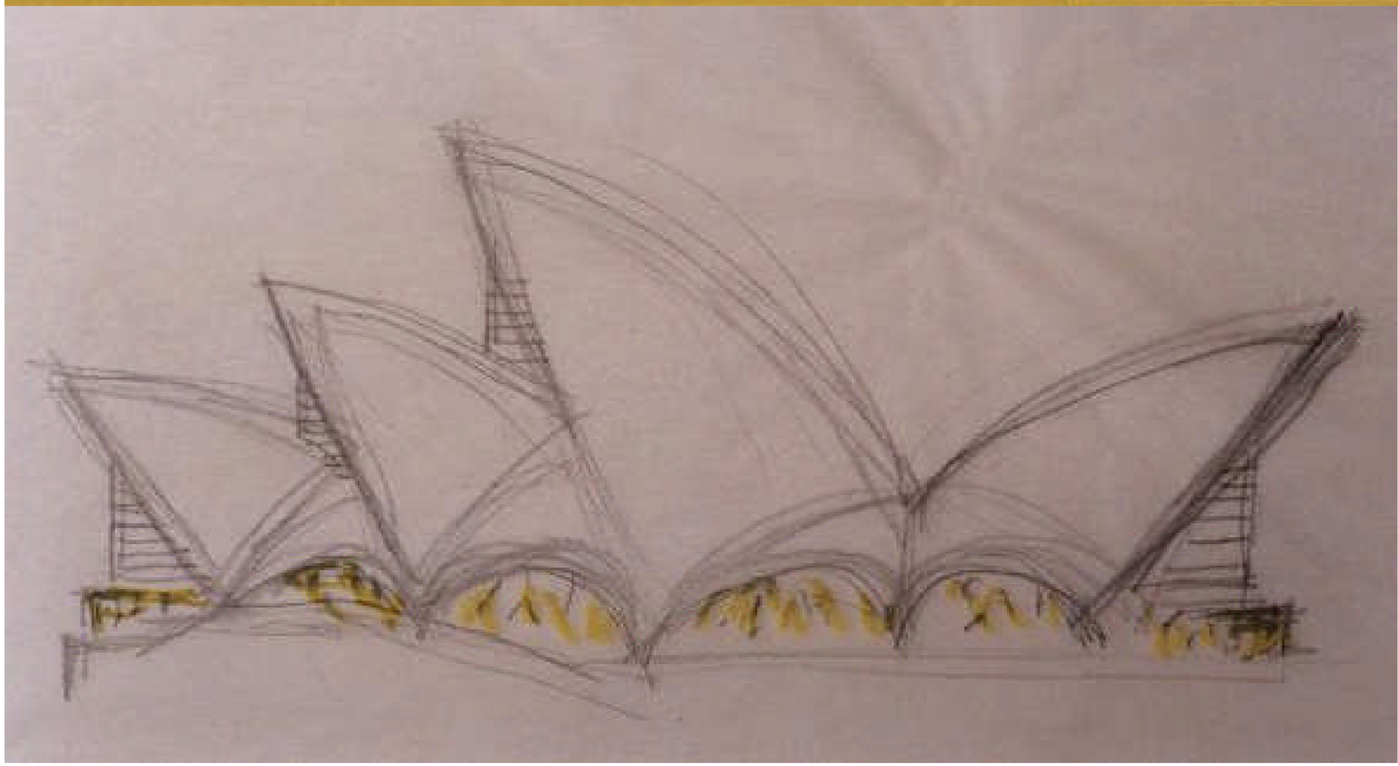
Circles Great and Small

Arup assigned *Jack Zunz* to take over the roof design team and complete Stage One. Zunz suggested a new structural design that separated the shells into three structures (major hall, minor hall and restaurant). In August 1961, Utzon visited Arup and Zunz in London where Zunz presented two proposals; a double-skinned shell structure and a ribbed form (resurrected from 1958 when Ove Arup was principal engineer). It was no surprise to Ove Arup that Utzon chose the ribbed approach since it dramatically expressed the roof shell/s' function. However, though both options continued to treat the form of Utzon's shells as unalterable, neither qualified for a prefabricated approach. Utzon returned from his meeting with Zunz and Arup excited by the ribbed expression of the soffit (inside) of the shells. However, because of adherence to the existing *Paraboloid* geometry, each rib remained unique and difficult to fabricate. Zunz and his assistant; *John Lethebridge,* discussed with Utzon the "geometric straitjacket" that a non-repetitive form yielded, and explained that repetitive structure could only be extracted from Spherical or *Toroidal* forms (in fact, it can also be derived from Ellipsoid geometry). Ove Arup's consistent advice to Utzon to look for a repetitive geometry for the roof shells - reinforced by Zunz and Lethebridge, left Utzon with little doubt that they were right.



<u>Above</u>: final Spherical Scheme (1962-63). *Small Circle* ridge profile, *Great Circle* rib profile (pre-cast reinforced concrete, partially in situ). The shells were mainly pre-cast while the ribs follow “great circles” and the ridges “small circles” of a *Sphere*. Utzon was presented with two versions of this scheme; double-skinned shells with an internal steel space frame, or a series of pre-cast arched ribs springing from the supports like fans. The former was preferred by Arup’s engineers as being much easier to analyze and construct and providing, in the end, the outward appearance of Utzon’s initial sketches. However, Utzon was a purist and keen on the idea of a ribbed internal surface. He considered the steel space frame to be structurally dishonest and not in keeping with his theme of “structural honesty.” Arup therefore agreed to pursue the design of the ribbed alternative. The change involved the abandonment of three years’ work by Ove Arup and Partners on the analysis and design of Utzon’s original concept.





<u>Above</u>: evolution of the shell schemes (1957-63)
<u>Left</u>: preliminary sketch by Utzon (1960)

"…heartily disliked by Utzon and I did not really like the idea either…faced with the choice the architect had no doubt what he wanted…it is quite a sacrifice for a man at the height of his power to dedicate five years of his life to one job which demands so much and to see so much of his work thrown aside because of altered disposition or because the difficulties ahead are insurmountable."

Ove Arup, Engineer

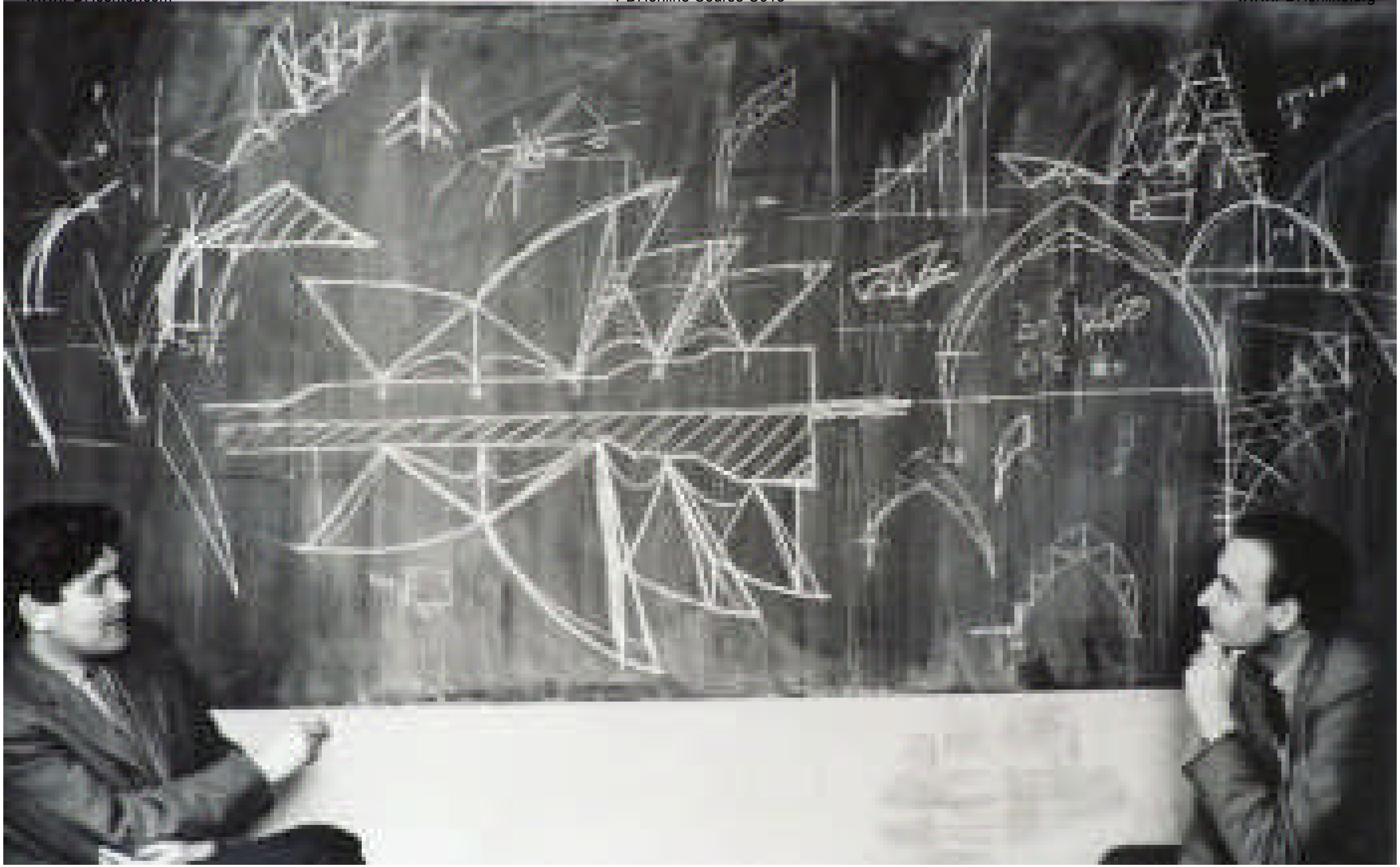
RE: the decision to scrap all design work to-date caused a split in the Arup organization. Arup had difficulty in persuading his staff to start from the beginning once more and there were some resignations. Despite Ove Arup's personal efforts to persuade his staff that Utzon's decision concerning the shell re-design was for the best, Utzon's relationship with him began to deteriorate in 1963. Utzon felt that Arup was trying to take over the running of the project (in collision with the *Public Works Department*) and capture the limelight as to who was the creative force behind SOH. The PWD Minister had asked Arup for a report on the shells and had been given the engineers' version of their development.

"…After a long period I succeeded in convincing the engineers that the first scheme was absolutely hopeless, and that together we had not been able to achieve honest structure at the same time as we had not been able to fulfill the expectations the competition scheme had promised. My new scheme which I developed in my office as the last of a whole series of schemes was brilliant enough to stand up to any criticism the structural engineers could bring forward…You might have been misled by Arup's recent report…to the extent that you do not really understand that every detail in the existing work carried out, and in the whole scheme down to the last dimension and shape, has been formed by me. "

Jorn Utzon, Architect

RE: excerpt from a letter to the *Minister for Public Works* (1965). The newly elected NSW government and the new PWD Minister began to shift control away from the part-time SOHEC towards the PWD. This process ended with the PWD Minister taking over the authorization of payments to the Architect (due to concerns over the rising costs).

Ove Arups' role as a primary agent had been established from the start of the SOH project and had been emphasized by both the NSW government and the competition judges (back in 1957) in recognition of Utzon's inexperience with a project of this size. In early 1963, Arup moved to terminate his company's management obligations on the project so that they could concentrate exclusively on their role as consulting engineers. Traditionally, the architect is responsible for design, documentation and supervision of the work as a whole (as well as managing the various consultancies). To a significant extent (in good faith), Arup's firm had been operating on Utzon's behalf in this role, but at a cost which had become unsustainable. Ove Arup had literally gambled the company he founded on the SOH and his partners were insisting that they revert to the more traditional role of supervising engineers to ensure the financial stability of the firm. As of December 1962, Ove Arup and Partners work on SOH constituted 175K man-hours, fifty-five engineers and assistants engaged and required approximately 300K additional hours to complete Stage Two.



Peter Rice **and** ***Geoffrey Booth*** **of Ove Arup & Partners working on the structural behavior of the SOH's roof shells (ca. 1958)**

"The time has come to cast away pretence and make-believe and face the facts about the organization of the job, of who is responsible for what, and accept the consequences in the allocation of executive power and fees…He is no ordinary architect, and this is no ordinary job…What we want is to do our utmost to make Utzon's dream come true, at whatever costs to ourselves, as long as we can bear it."

RE: excerpt from a March 26th 1963 "Letter of Demand" from Ove Arup & Partners to the NSW government. The response was quick and revised responsibilities for Arup on the SOH project were enacted assuming a more traditional role as engineering consultants rather than construction managers. However, the management/oversight role played by Arup for so long now reverted to Utzon's less-than-capable hands. Arup tactfully reminded DPW Minister Ryan that the Brown Book had included a clause whereby the winning architect might be required to enter into a joint-venture with another architect to design and supervise the work. Nevertheless, Arup held Utzon in high regard considering his great talent and the difficulties of the job.

The Easiest Part of the Job

"Management is in a way the easiest part of the job, something which most people can learn"

Jorn Utzon

RE: management did not come easily to an artist like Utzon, with so many design concerns and no experience managing a mega-project, he was out of his element. In retrospect, Osmond Jarvis' suggestion that he should take on a job architect (to manage the construction process) in Sydney would prove an enlightened suggestion.

<u>Left</u>: Utzon and DPW Minister Ryan on-site (1964)

"Unlike you and Ove I have not learnt to love Jorn yet and I doubt very much I ever will."

Michael Lewis, Engineer – Head of the Arup Office in Australia

RE: excerpt from a letter Lewis sent to Jack Zunz in late 1963. In May, Lewis unwisely forwarded a memo from Ove Arup to Utzon which outlined four options for Arup's role subsequent to their revised role on the project. The consensus at Arup was that the third and/or fourth options were best; either Arup could hand over full control and responsibility for Stage Two to Utzon or continue to administer the entire job. In any eventuality, Utzon regarded these internal deliberations at Arup as subterfuge and believed that any option would only contribute to a growing perception that he was incapable of administering the contract. Utzon retaliated by setting out his intentions to supervise the rest of Stage Two and Stage Three, clearly delineating the tasks with which Arup should concern themselves with as structural engineers. Zunz admonished Lewis suggesting that everyone in Sydney appeared prepared to ensure the job would never be completed owing to their irreverent attitude towards Utzon. The open doorway between the Utzon's and Arup's office was bricked-up and the Arup engineers were required to make appointments to see Utzon and/or his staff.

From left to right: *Michael Lewis*, *Ove Arup* and *Jack Zunz.* On-site during Stage Two construction.

In What Way are They Gods?

"That romantic view is, however, a very real view, and that's what I walked in on. I said – please, in what way are they gods? Why is everyone seduced around here? And I suppose that also affected my approach."

Michael Lewis, Engineer – Head of the Arup Office in Australia

RE: Lewis was a pragmatist who felt strongly that too many people on the SOH project had been seduced by Utzon. The reality of the Arup/Utzon relationship in Sydney was in stark contrast to the one that had existed in the Hellebaek days.

Blame Game

The blame for the rising cost of the SOH project and its chaotic state of organization was placed, fairly or unfairly, on Utzon's shoulders. In retrospect, this was somewhat unfair since many problems were inevitable due to the forced early start of the project (to keep it alive) and the part-time nature of the large Executive Committee which made it difficult to organize meetings and obtain timely decisions. Communication was also hampered by the fact that Ove Arup and Partners was contractually responsible directly to SOHEC – not to Utzon, thus Arup could not resolve important matters directly with Utzon. This led to attempts being made to obtain spot decisions from influential members of the Executive Committee with resulting problems. Utzon was a perfectionist and his willingness to abandon an old idea for what he perceived to be a better one no doubt added to organizational confusion. The situation led to complaints from Arup's engineers to the PWD Minister and appeals for a more rational organization. The PWD was also recommending changes and was beginning to screen more and more of Utzon's proposals. Henceforth, when conflicts occurred, Arup and the PWD typically found themselves on the same side in opposition to Utzon. In particular, a controversy developed over Utzon's desire to use structural plywood for the acoustic ceilings of the halls. The engineers questioned both the structural integrity of this scheme and his proposal to give the order for the plywood (without tender) to a bankrupt firm which he asserted was the only one in the world capable of fulfilling it. The Sydney representatives of Arup, being perhaps more typical of engineers in general than Ove Arup himself, failed to show the same sympathy for Utzon's aspirations and changeability. A complex political situation developed with Utzon accusing Arup of bad faith.

The Central Difficulty

"…most of the alterations which have occurred on this job – and they are numerous – are due to the cropping up of new design considerations owing to clients' wishes, unforeseen difficulties and especially the work of other specialists on heating, theatre techniques or acoustics, etc. impinging on the structure or vice-versa. The interdependence of all these 'trades' makes it impossible for any of them to go forward with a clear brief – the briefs for each have to be gradually developed through a process of trial and error. This is the central difficulty. It wouldn't be so difficult if one were only looking for a technical solution, but every possible solution has architectural or aesthetic repercussions, and all the easy ones are probably taboo on that score. Sometimes the only real satisfactory answer is to start all over again from the beginning, incorporating the new requirement."

Ove Arup, Engineer

The Beginning of the End

On April 17th 1964, Utzon's eldest brother *Leif* died suddenly of a heart attack in Paris. Utzon left for Europe to help his brother's family relocate to Denmark and was away for about six weeks. He returned to Australia in early June to heightened levels of stress surrounding the SOH project. Utzon took Leif's death hard and it had a detrimental affect on him. Later in 1964, he relocated to *Palm Beach*, setting up a new studio in a boat shed which was removed from the intensity and stress of the on-site office. To some extent, the more peaceful surroundings of Palm Beach recalled the peace and tranquility of the Hellebaek days he sorely missed. From November 1965 forward, Utzon spent most of his time at the boat shed, keeping only a skeleton team at the Bennelong Point site office. He traveled to Sydney twice a week and refused to install a phone (at the boat shed). His going "incommunicado" caused additional friction to an already increasingly tense situation.

"It is abundantly evident that a vast amount of work remains to be done in the form of dimensioned and working drawings and specifications. The information contained in the narrative description is interesting and enlightening but totally inadequate to permit the quantity surveyors to make more than an approximate estimate of cost. In order to prepare the necessary drawings and other data the Architect needs a staff of some 30 persons to cope with the situation."

RE: assessment by Government Architect *Bill Wood* of the *Descriptive Narrative* to the Minister of Public Works (February 22nd 1965). In January 1965 (following Utzon's return from vacation), DPW Minister Norman Ryan conducted a meeting barely veiling his anger and frustration and demanding progress from Utzon. One week later, Utzon produced a "Descriptive Narrative" in response to Minister Ryan's complaint that there were still no completed drawings detailing Stage Three (interiors). In it, Utzon explained that the designs could not be finalized without further prototypes, which could only be made by *Ralph Symmonds*, the bankrupt plywood manufacturers Utzon had worked with to create the hall ceilings. In turn, Symmonds needed assurance that they would be the sub-contractors for the ceiling work. On May 1st 1965 - after twenty-four years in power, Labor was defeated and Ryan was be replaced by *Davis Hughes* as Minister for Public Works. For Utzon it was the beginning of the end.

The Craft Approach

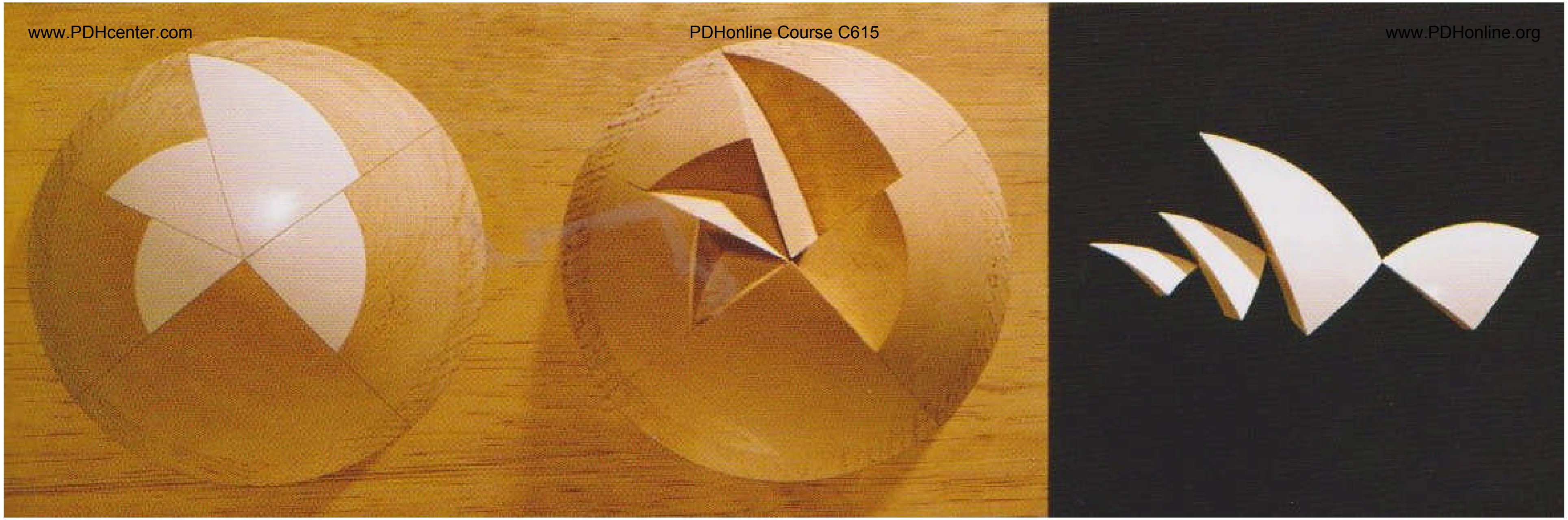
A deep divide existed between the European (especially the *Scandinavian*) "craft approach" to architecture that Utzon embraced versus the less individualistic approach of the Anglo-Saxon model of construction which was widely adopted in Australia; England's most devoted former colony (now a *Commonwealth* nation). The craft approach involved working intimately with other skilled individuals and/or companies dedicated to work of the highest quality. A good example of the Scandinavian craft approach can be found in Utzon's work with the Swedish company *Hogonas.* A slow and careful process which lasted three years for designing and producing the tiles that cover the roof shells of SOH with a magnificent result. On his first visit to Australia in 1957, Utzon saw the possibilities of working with Ralph Symmonds in this very way (Symmonds' company was the worldwide leader in innovative plywood manufacturing at the time). This attention to quality inherent in the craft approach had less prominence in Australian construction practice in the mid-1960s. Inherited from the British system, the approach to construction was characterized by an impersonal process of tendering with work typically awarded to the company which submitted the lowest bid. This was an alien practice to Jorn Utzon who was trained in the craft approach from his earliest days at his father's shipyard.

"The European way of working, especially on major projects, is not quite as hard and fast or clear-cut as maybe the American and consequently Australian routine would suggest. In Europe when they are engaged in such work and when they realize it is like building a cathedral they take their time, and they will not settle for standard routine answers but really aim to make this a monument of all time because such buildings have stood historically for hundreds of years. And that's the attitude that Utzon applied to this building, and quite rightly so."

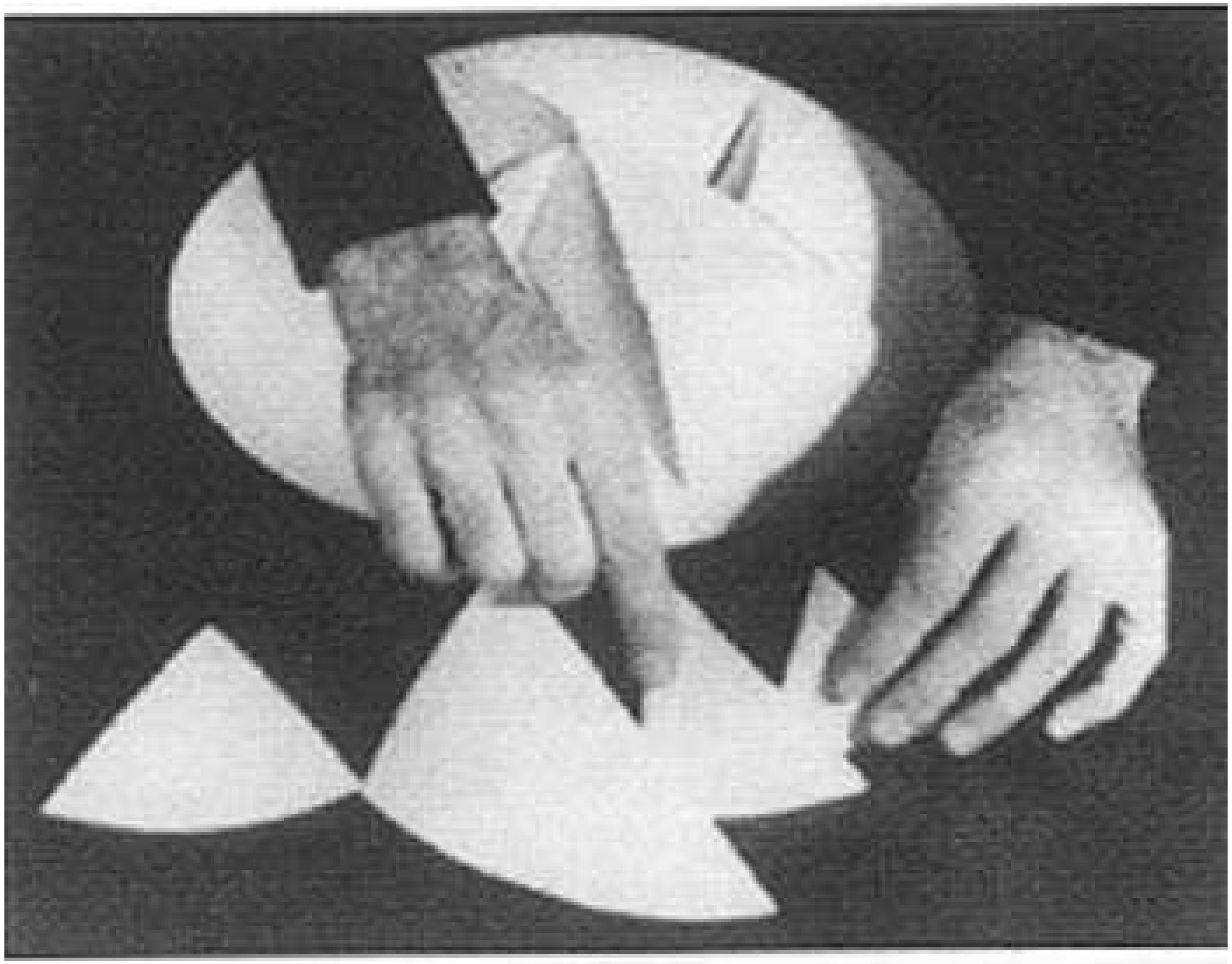
Harry Seidler, Australian Architect

The Universal Geometry of the Sphere

Starting in 1958, Utzon was concerned with the tiles covering the roof shells which also called for a repetitive geometry solution. He even suggested to Yuzo Mikami that they should pursue the same round tiles Eero Saarinen had used on the TWA Building in New York (leaving the pattern to the tilers; evidence that Utzon was struggling with the problem). One evening, Utzon was alone in the Hellebaek studio. Needing to make space, he was stacking the shells of the large model and noticed how similar the shapes were. Prior to this, each shell had seemed unique and distinct from each other, but now it struck him that if they were very similar, perhaps each could be derived from a single, constant geometric form such as a Sphere. The simplicity of the idea and its relationship to a "natural form" appealed to Utzon. The concept could also be applied to the tiling of the exterior surface of the shells. Utzon's breakthrough realization shifted the underlying principle of the design away from the expression of an architectural "style" (i.e. "Shell Architecture") to the more natural idea inherent in the universal geometry of the sphere. After all, the entire universe is composed of spheres in the form of planets and stars. Except in scale, the roof shells of the minor hall of SOH are identical to the major hall thanks to Spherical geometry. Utzon phoned Arup in London, shouting excitedly that he had solved the problem. Unable to seize the concept over the phone, Arup promised to come to see him asap. In the meantime, Utzon had the Helsingor Shipyard create a wooden model of the top of a sphere, with meridian lines emanating from the pole at a constant angle of 3.65 degrees. These showed the ribs, each identical to the other and therefore ideal for prefabrication. Each shell was clearly demarked and emanated from the Zenith point of the spherical model.



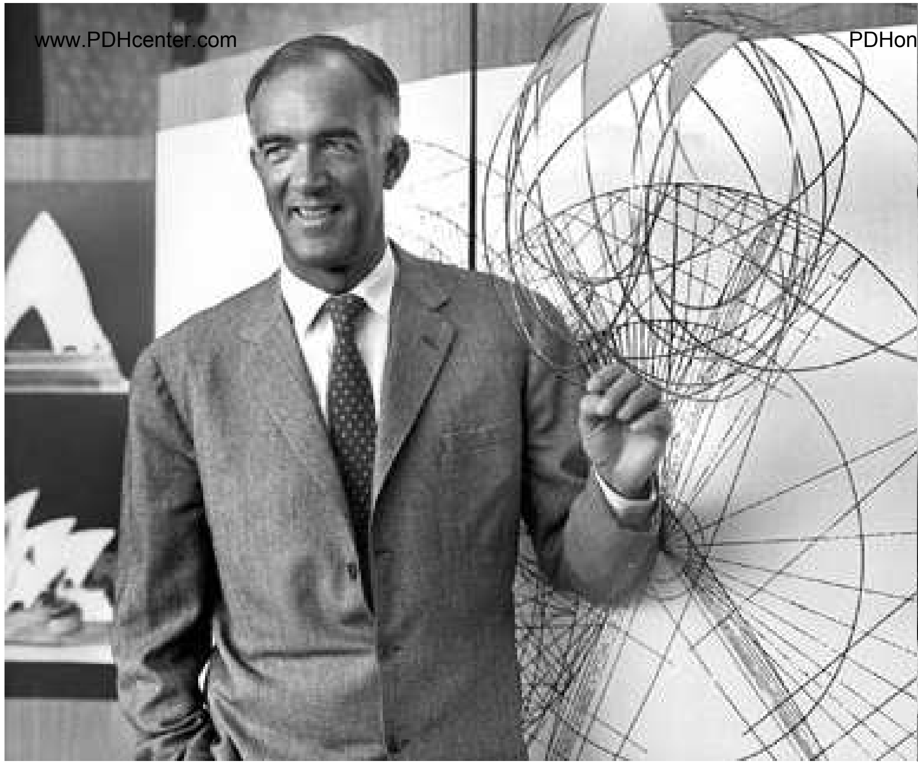
Utzon's great contribution to the resolution of the shell design scheme (in keeping with his own high-standards) was to pre-fabricate the ribs from a Sphere rather than an Ellipsoid. Thus, since each shell was part of the greater whole, much fewer forms would be required than if the shells were based on an Ellipsoid. The simplicity of the idea can be expressed in the peeling of an orange. No matter what size the peel, the external curvature remains the same since it originated from the same Sphere. This came to be known as "The Spherical Solution." It would prove to work well, but now the shape of the roof shells was altered as was the space within the halls which could/would affect the sticky subject of seating capacity in the major and minor halls.



The Key to the Shells

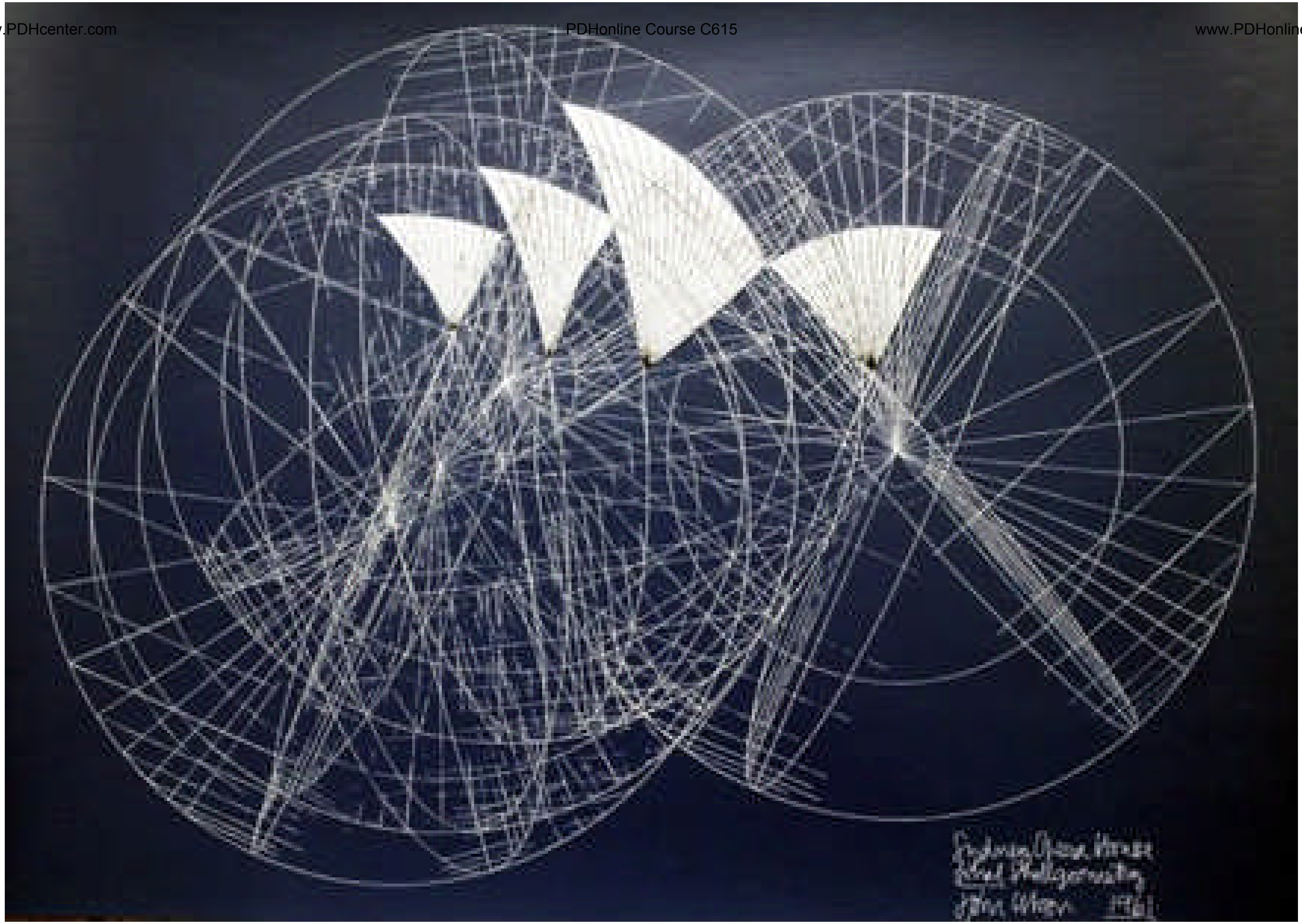
"After three years of intensive search for a basic geometry for the shell complex I arrived in October 1961 at the spherical solution shown here. I call this my 'Key to the shells' because it solves all the problems of construction by opening up for mass production, precision in manufacture and simple erection and with this geometrical system I attain the full harmony between all the shapes in this fantastic complex."

Jorn Utzon, Architect



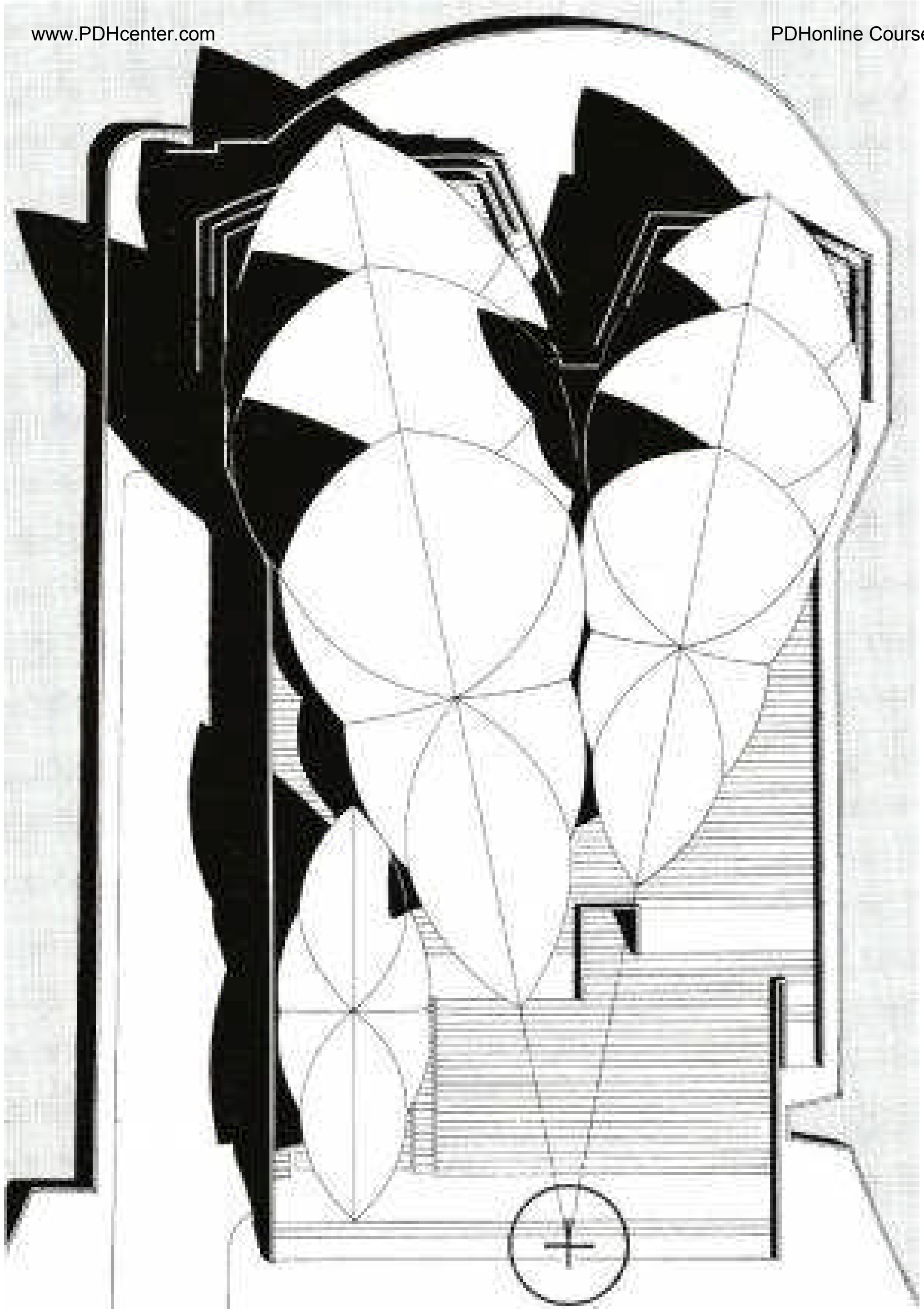
"We were riding two horses for a long time. The last six months the real solution for everything technically and aesthetically was developed and it was even the cheapest way of making it you could dream of...Of course, all the work during the past three years has been the background for arriving at this magnificent solution"

Jorn Utzon, Architect



“Great and Small” Spherical Geometry of the Shells (1961)

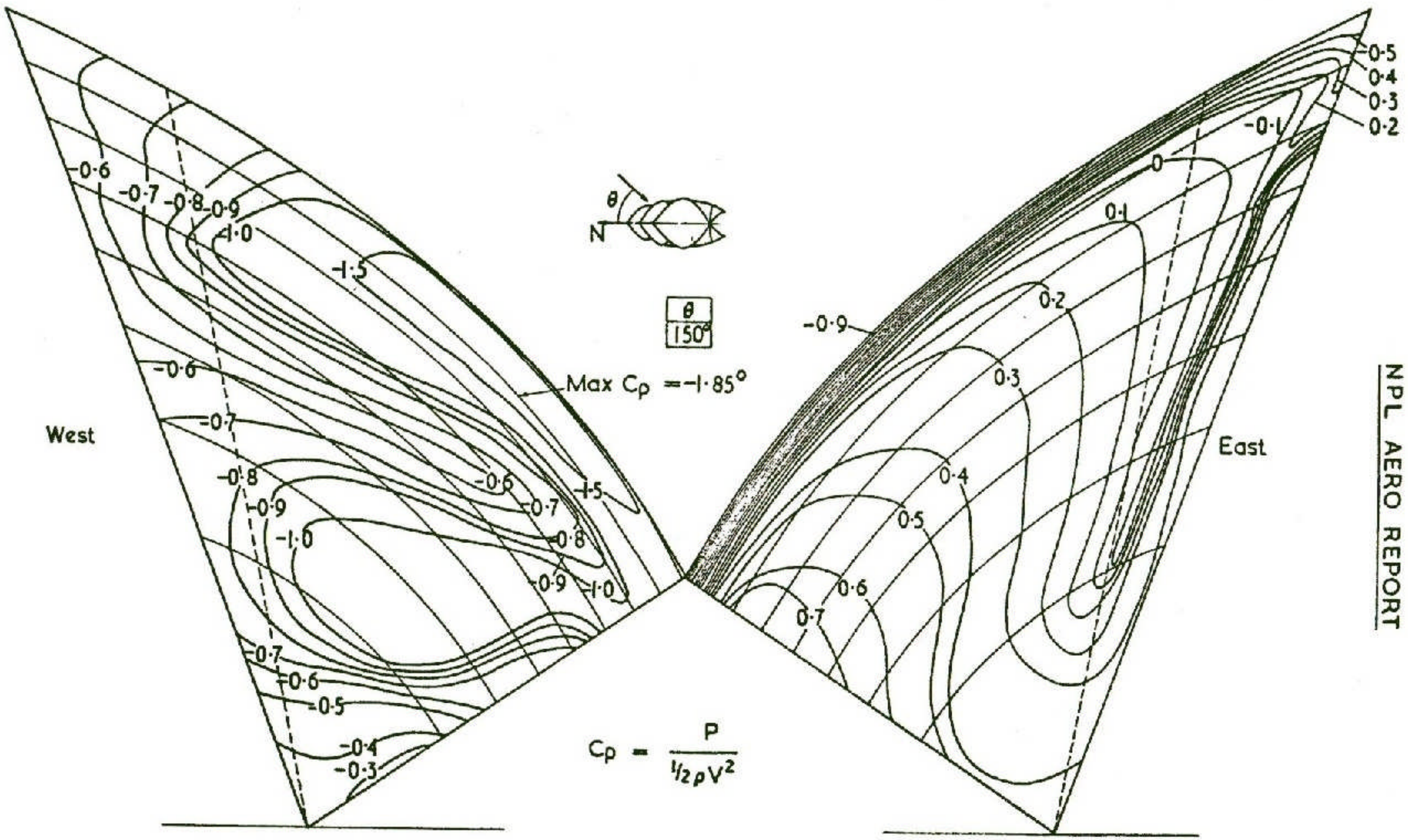
Upon seeing "The Spherical Solution" for himself, Arup was both impressed and disillusioned by Utzon's use of a simple geometric shape for the complex form of the roof shells. He was bewildered that Utzon would so easily accept the substantial change to the profile of the shells now required. Ove Arup and his design team/s had consistently treated the shape of the shells as untouchable and as a result, had not seriously pursued other geometries over the previous three years. Arup was genuinely dismayed that Utzon was capable of changing the shape and profile of the roof unilaterally considering what he and his engineers had been going through to remain true to Utzon's vision. Arup understood the solution was brilliant and would solve the problem of the roof shells, but he felt let down by Utzon nonetheless. Arup noticed immediately that the new shape altered considerably clearances in areas that were already congested and reduced the internal volume of the auditoria at ground level. However, they assumed Utzon would solve these new problems as he had the shells and both Arup and Zunz were grateful that a rational solution to the roof shells had finally been found. At the end of 1961, Ove Arup had become very ill, suffering fainting attacks brought on by low blood pressure and compounded by work-related stress. The fact that Ove Arup and Partners was close to failing financially, due in large part to the effort invested in the SOH roof shell design, took its toll on Arup and he left for Austria to try and regain his failing health. The new form was presented but it was not taken lightly. Newspaper editorialists had a field day and by August 1962, the government had decided that a second opinion should be sought. Zunz petitioned the great French engineer *Yves Guyon* to report to the government. His report asserted that he found the Spherical scheme and approach was sound.



"The structural scheme is basically sound and attainable provided the members are of the correct dimensions and reinforced adequately...The erection procedure which has been devised is in my opinion sound"

Yves Guyon, Consulting Engineer RE: excerpt from his report to the NSW State Government concerning the soundness of *The Spherical Solution*

<u>Left</u>: shell roof plan



Sydney Opera House

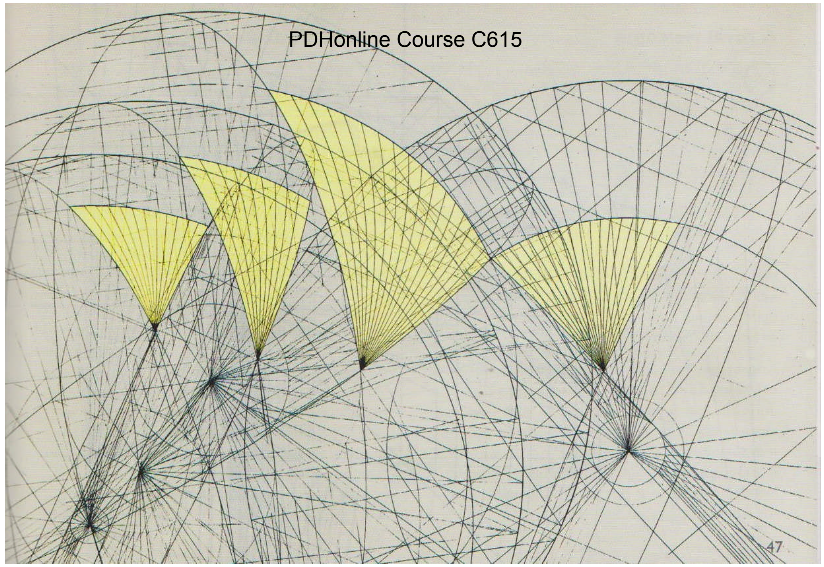
Pressure distribution on Shell 2 major

(stress analysis)

The *Australian Broadcasting Commission* (ABC) produced a half hour long studio presentation (*ABC Innovation*) of the new design principle outlined in the *Yellow Book* in which Professor Ashworth (right) interviewed both Jorn Utzon (left) and Jack Zunz and the two explained "The Spherical Solution" to a skeptical public (Utzon's "right-hand man" – architect *Bill Wheatland,* above at center)

I Am the Job Architect!

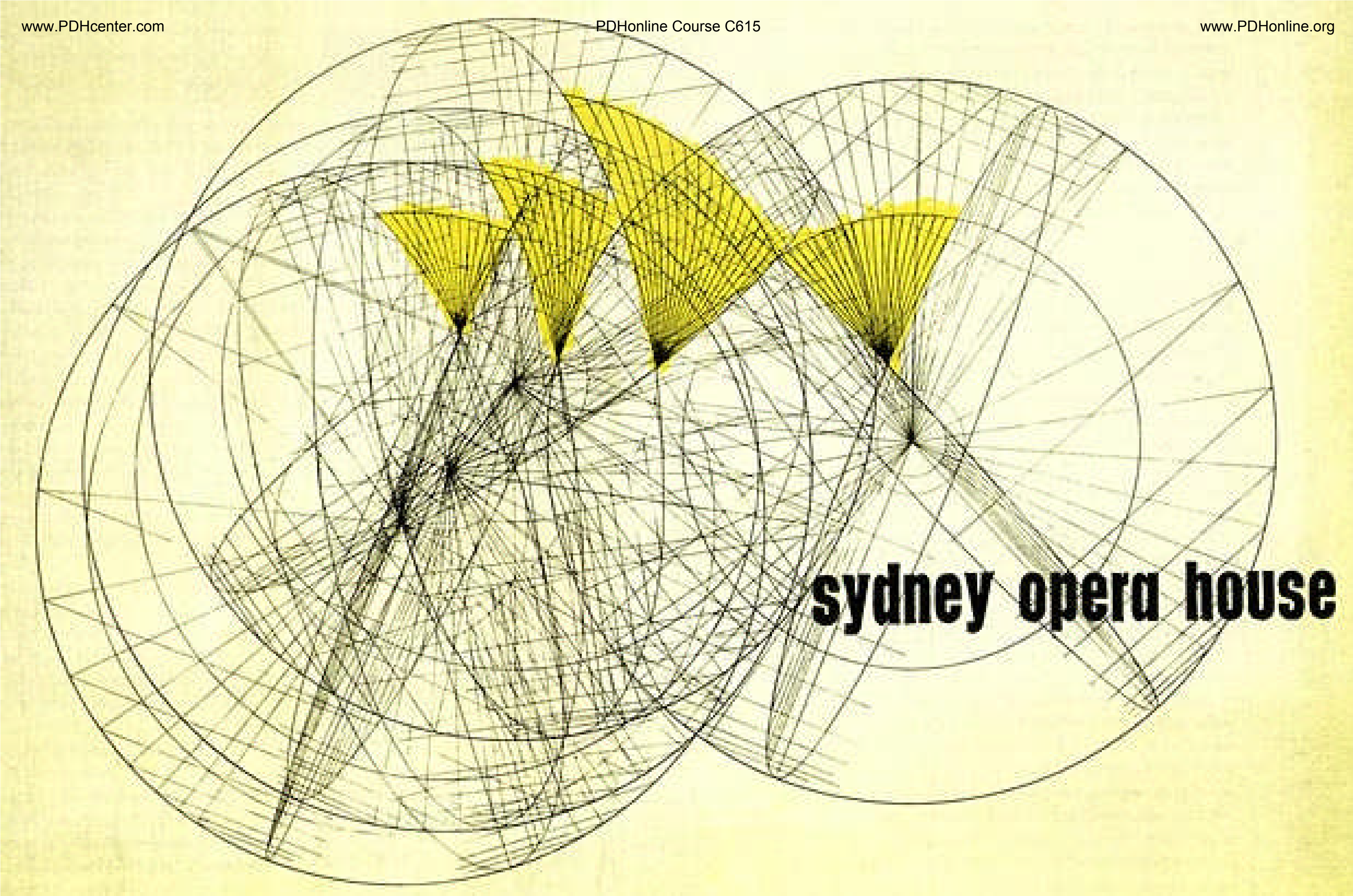
After the acceptance of the Spherical Solution, more than a year of design preparation followed. With the Podium nearing completion, the stage was set for Utzon's move to Sydney to oversee the shells and interiors. In December 1962, Utzon closed the Hellebaek office. It was the end of an extraordinary period in the life and career of not only Jorn Utzon, but the many architects and engineers who had so faithfully worked with/for him; some for many years. Only four of Utzon's inner group of nine architects went to Sydney; *Jakob Kielland Brandt, Mogens Prip Buus, Jon Lundberg*, and *Oktay Nayman*. *Paul Schooboe, Knud Lautrup-Larsen*, and *Aage Hartvig Petersen* all ended their association with Utzon at this time. Many of his inner circle had suggested to Utzon that perhaps he was underestimating the work-load and would benefit from hiring a firm to work as job architect, particularly when he arrived in Sydney and set up shop. When *Osmond Jarvis* had suggested this (in 1960), Utzon raised his voice exclaiming: *"I am the job architect!"*



In March 1962, Utzon and Zunz arrived in Sydney (less Ove Arup) with a book outlining design modifications which came to be known as the *Yellow Book.* It was submitted to and accepted by NSW Minister for Public Works *Norman Ryan*. It outlined the scheme for three shell systems; one over the major hall, one over the minor hall and one over the restaurant. The shells would be made of pre-cast concrete ribs with a narrow, triangular shape cut from a sphere with a radius of 75-meters. Cast in “beds” (forms) on-site which could be re-used. The shells were independent of one another and the failure of one would not cause the failure of any other. A fee-based management contract ($150K) for the shells was awarded in October 1962 to *M.R. Hornibrook, Ltd*. of NSW. Hard lessons were learned from the Podium contract (Stage One) whereby the NSW government had to pay the contractor (*Civil & Civic*) nearly half-again the contract amount due to “unforeseen work.” This time around, the NSW government would pay-for directly all labor, plant and material costs for Stage Two: the roof shells.

Yellow Book

This 1962 report (commonly known as the *Yellow Book*) comprises plans submitted by Jorn Utzon and consultants. The plans include, in addition to plans of the minor and major halls, geometrical construction showing the shells of the major hall, details of precast lid, tiling on shells and development of shells.



Front Cover

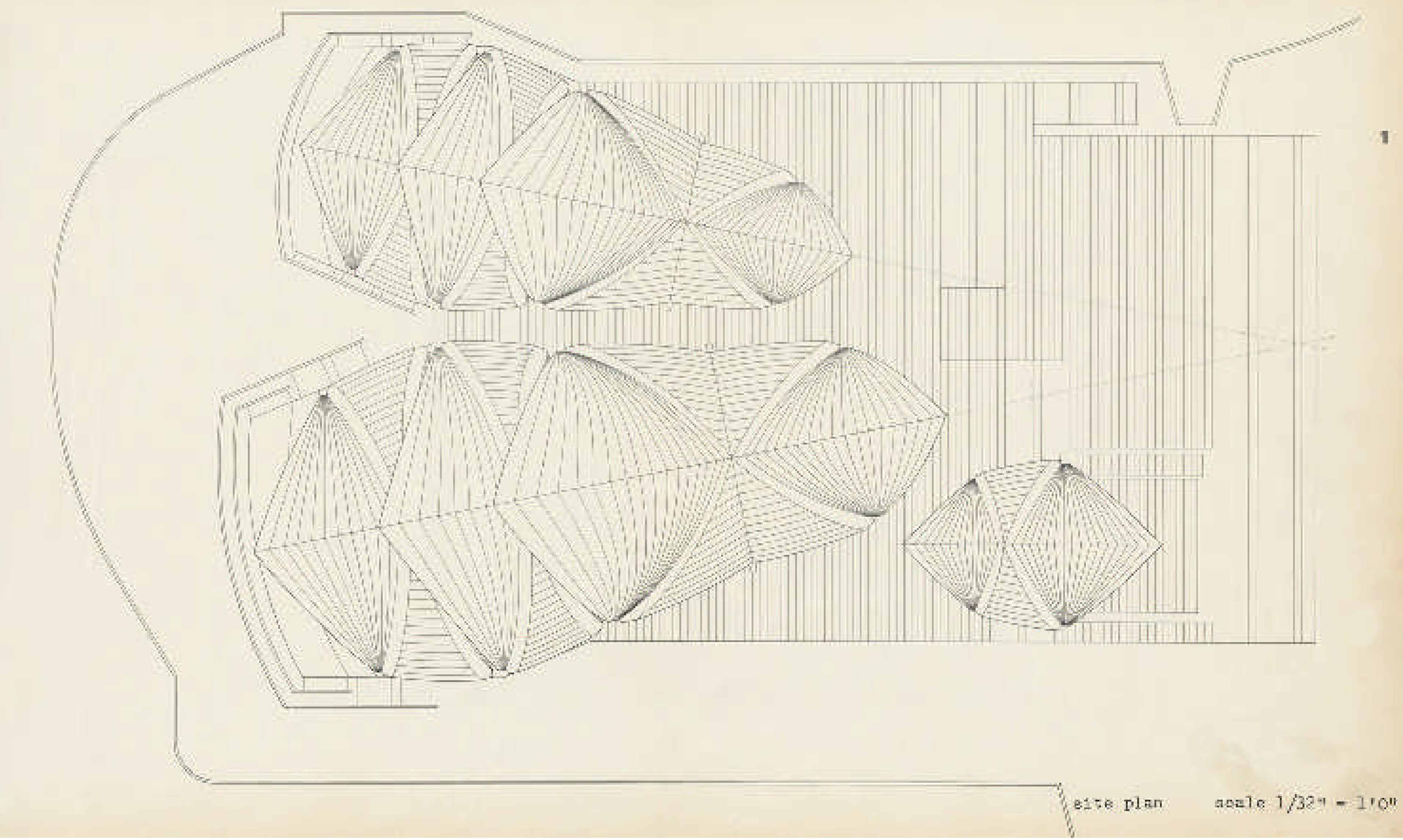
january 1962

sydney opera house

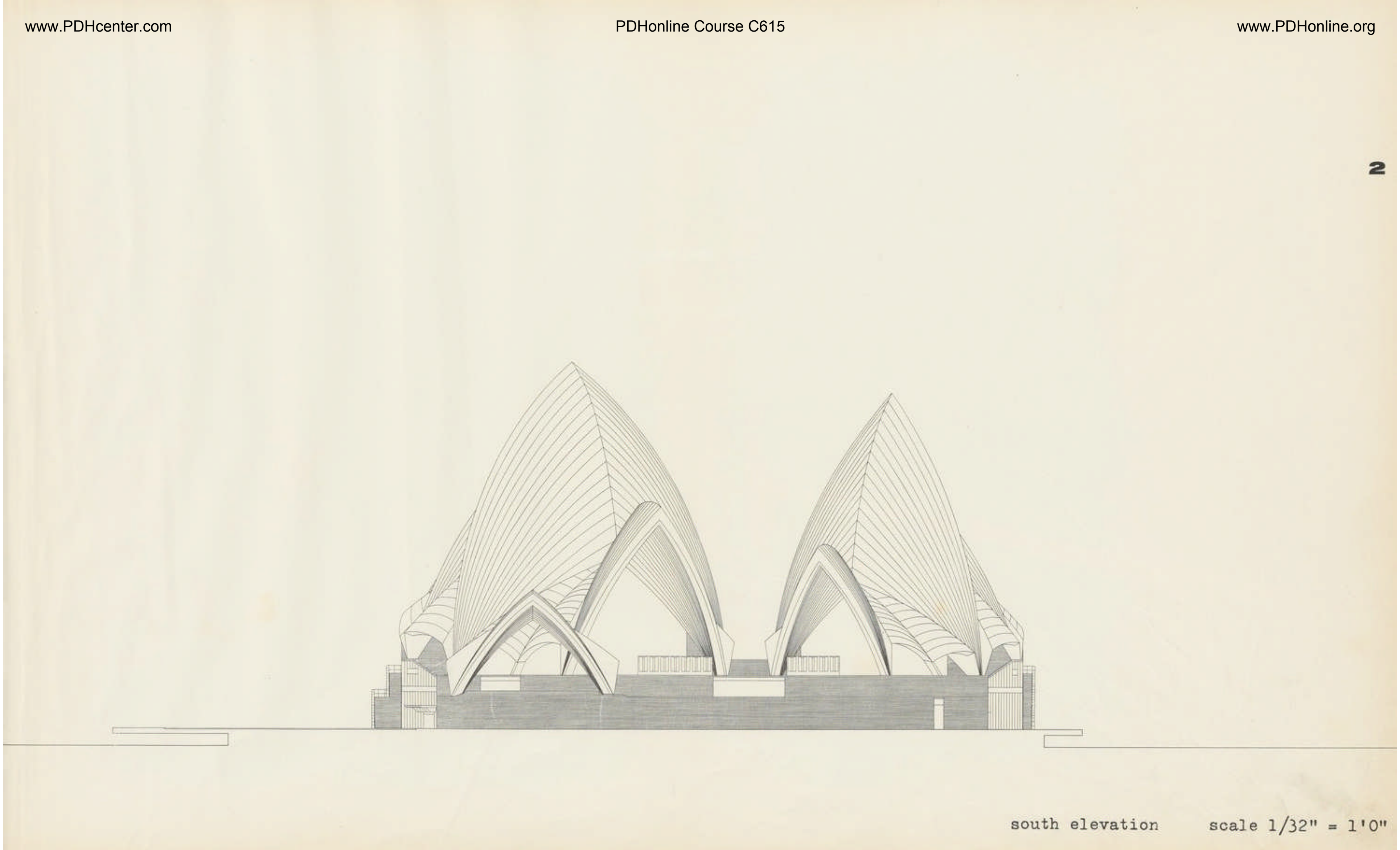
architect jørn utzon

consultants	
structures	ove arup
mechanical services	steensen & varming
electrical installations	zeuthen & sørensen
theatre technique	w. unruh
acoustics	v. l. jordan

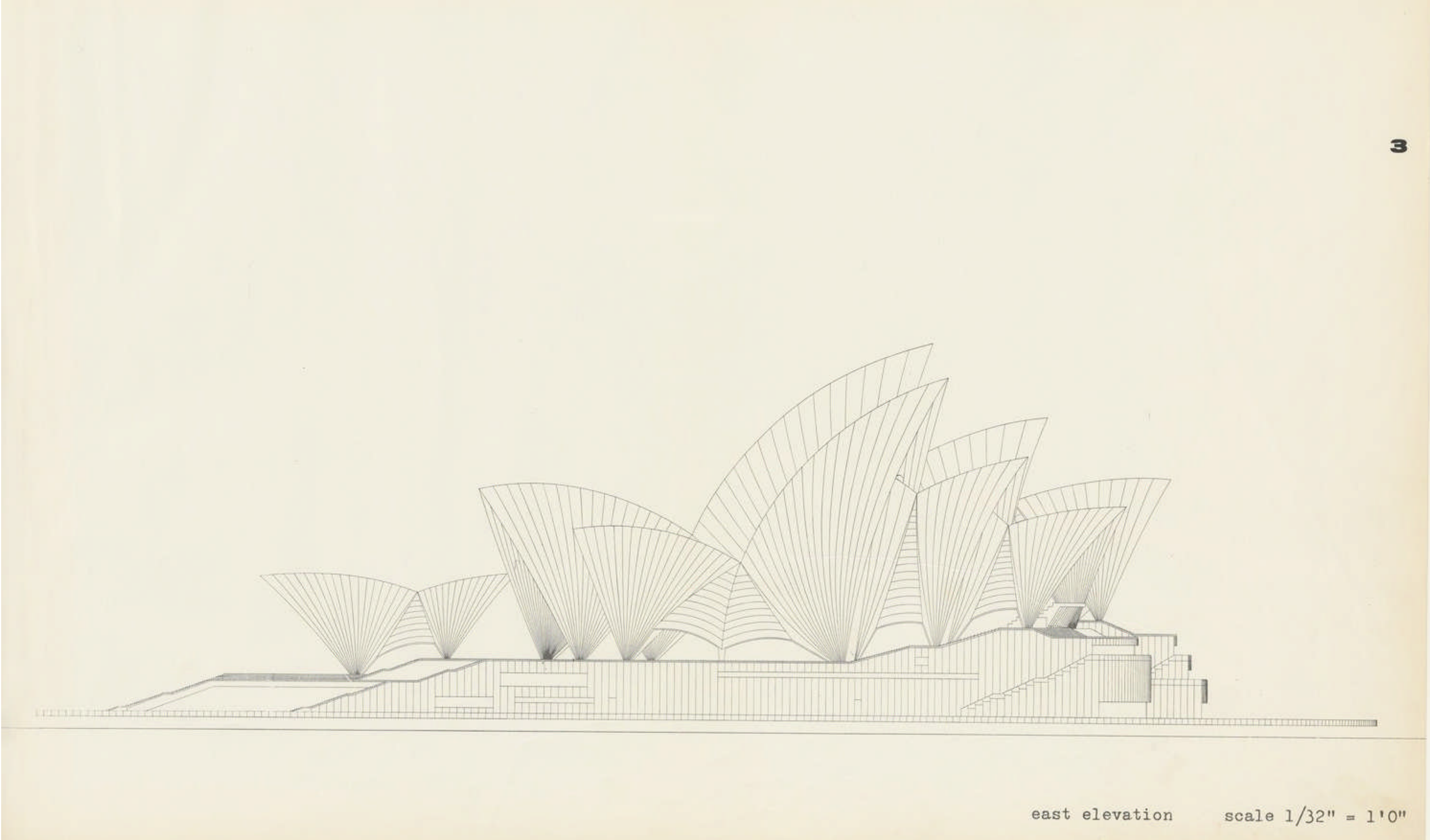
Inside Cover



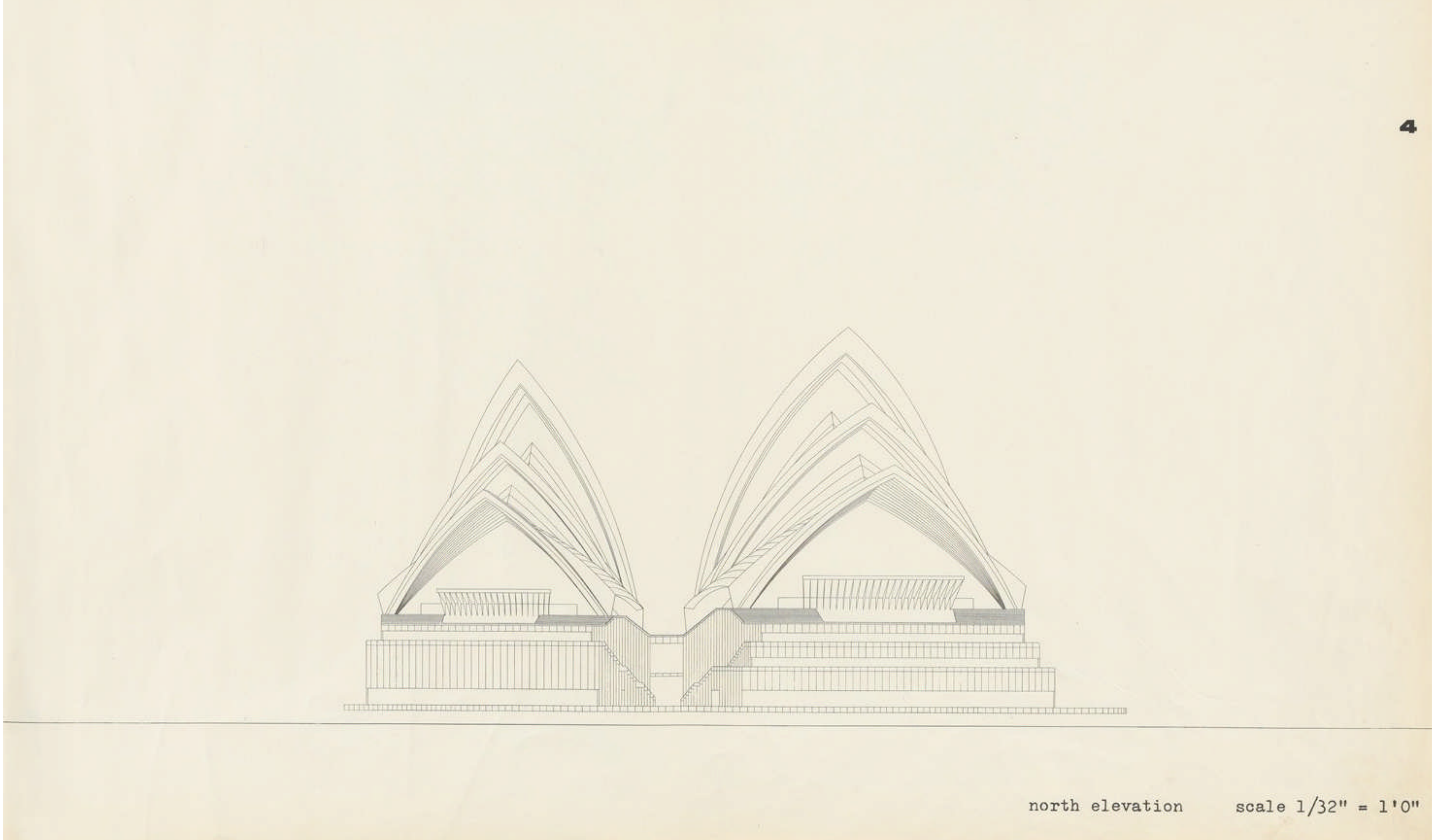
1. Site plan



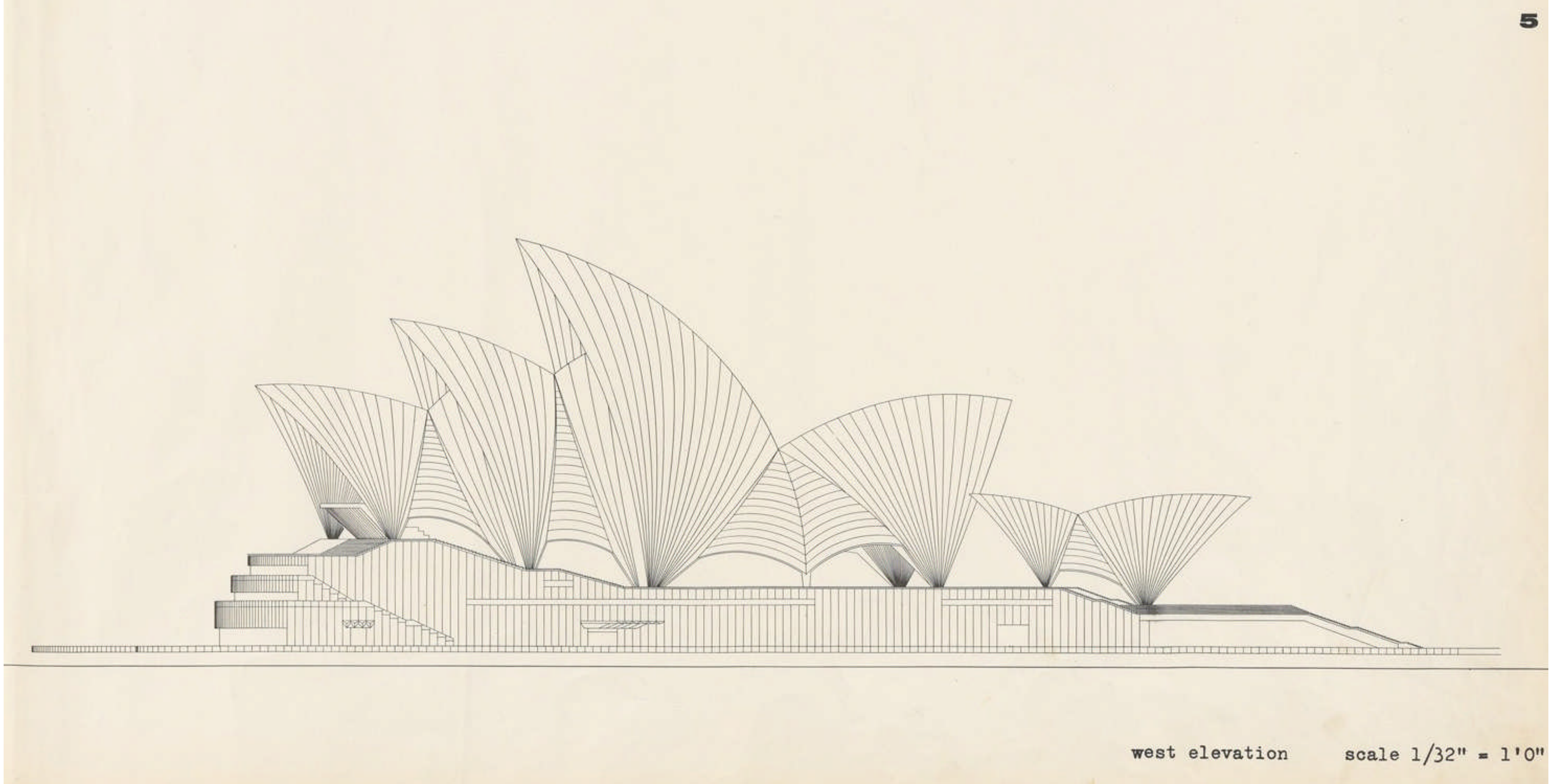
2. South Elevation



3. East Elevation

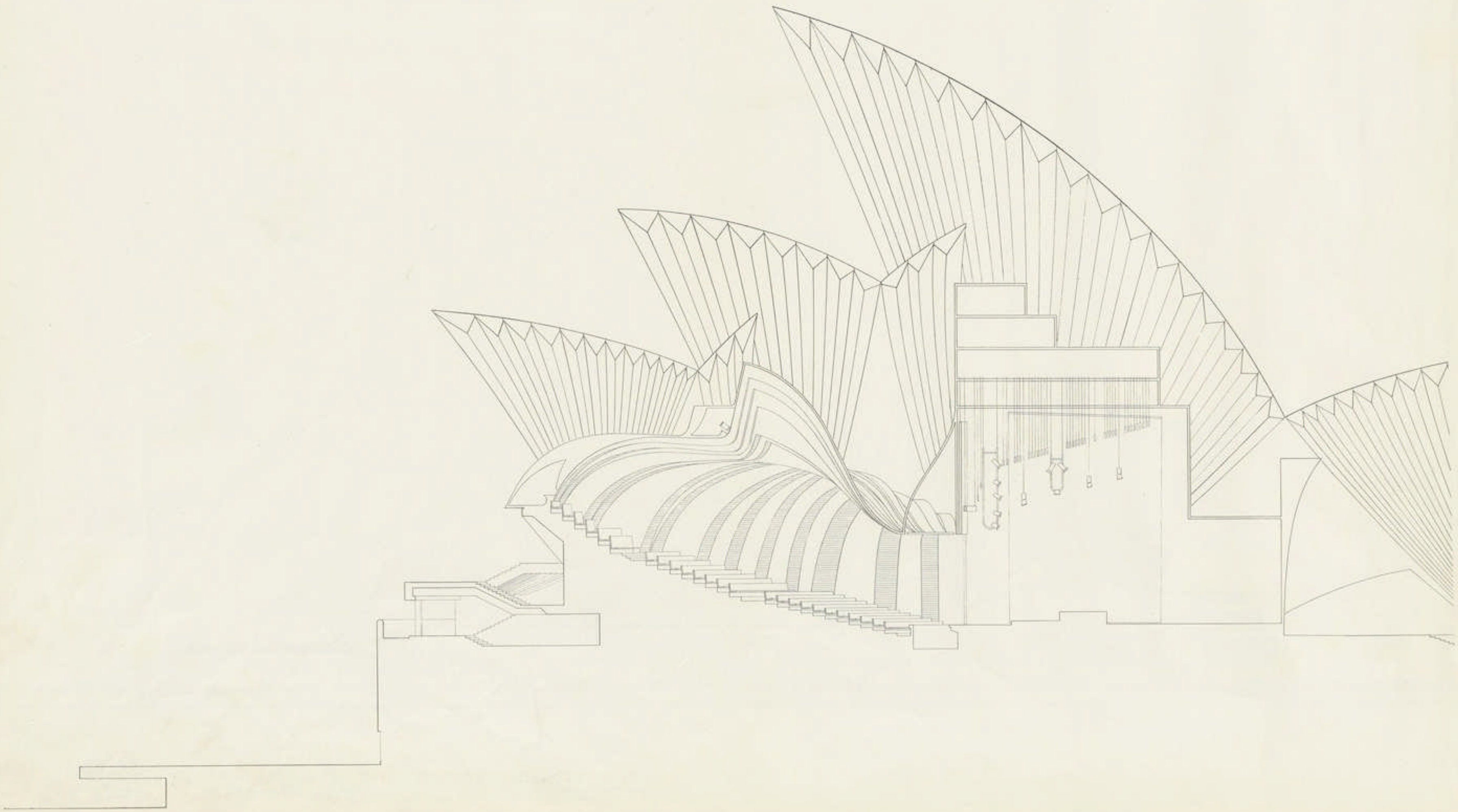


4. North Elevation

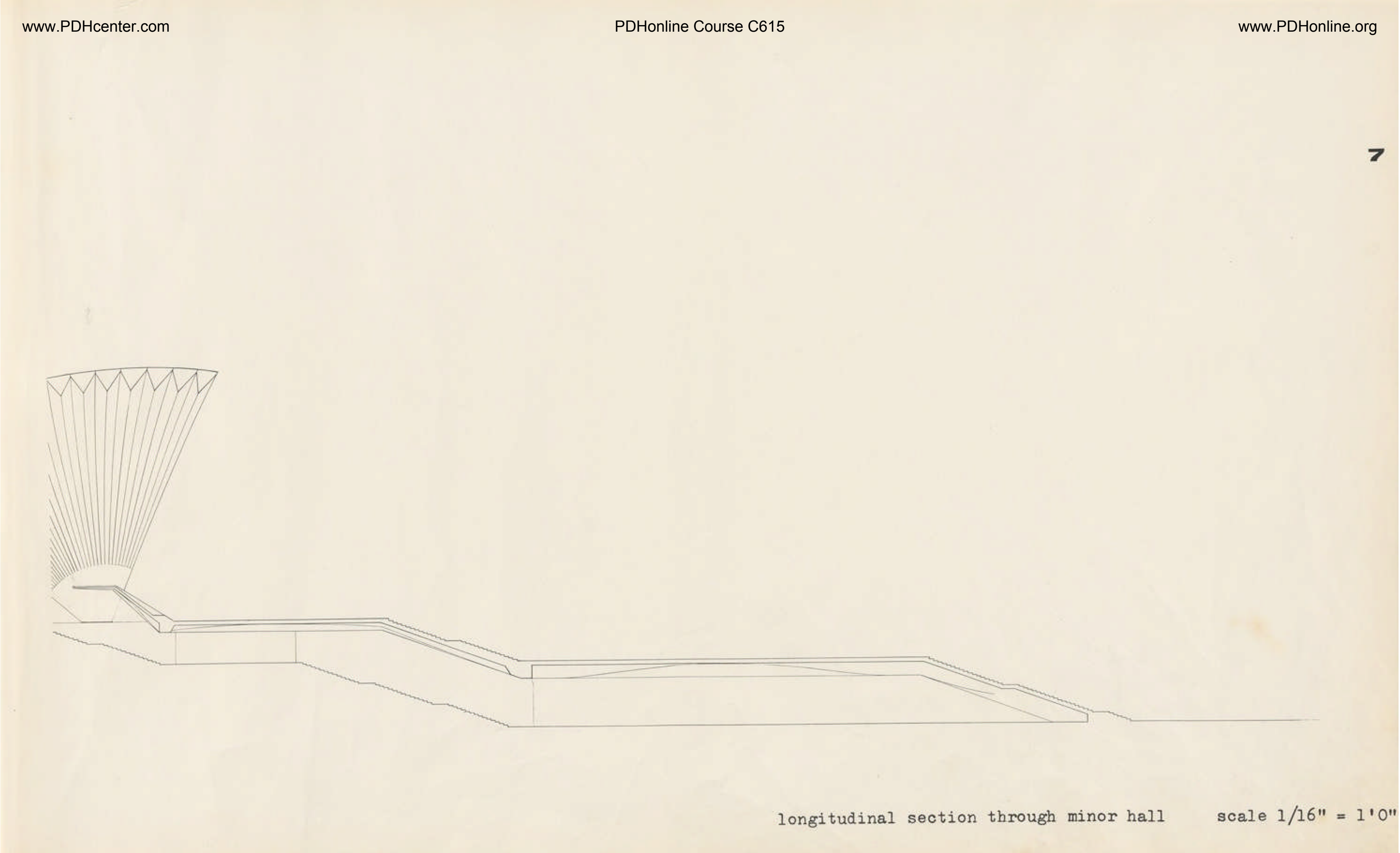


5. West Elevation

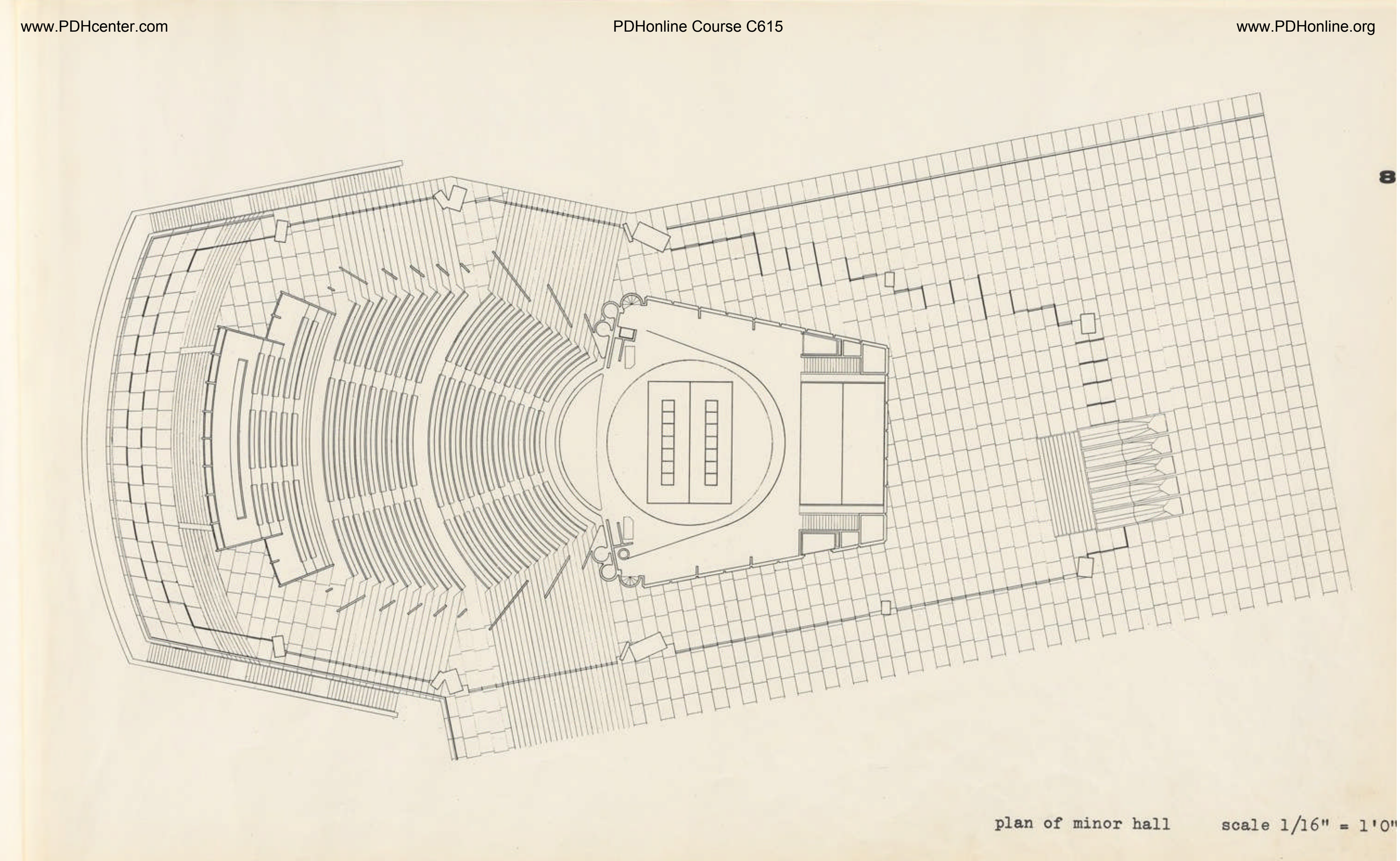
6



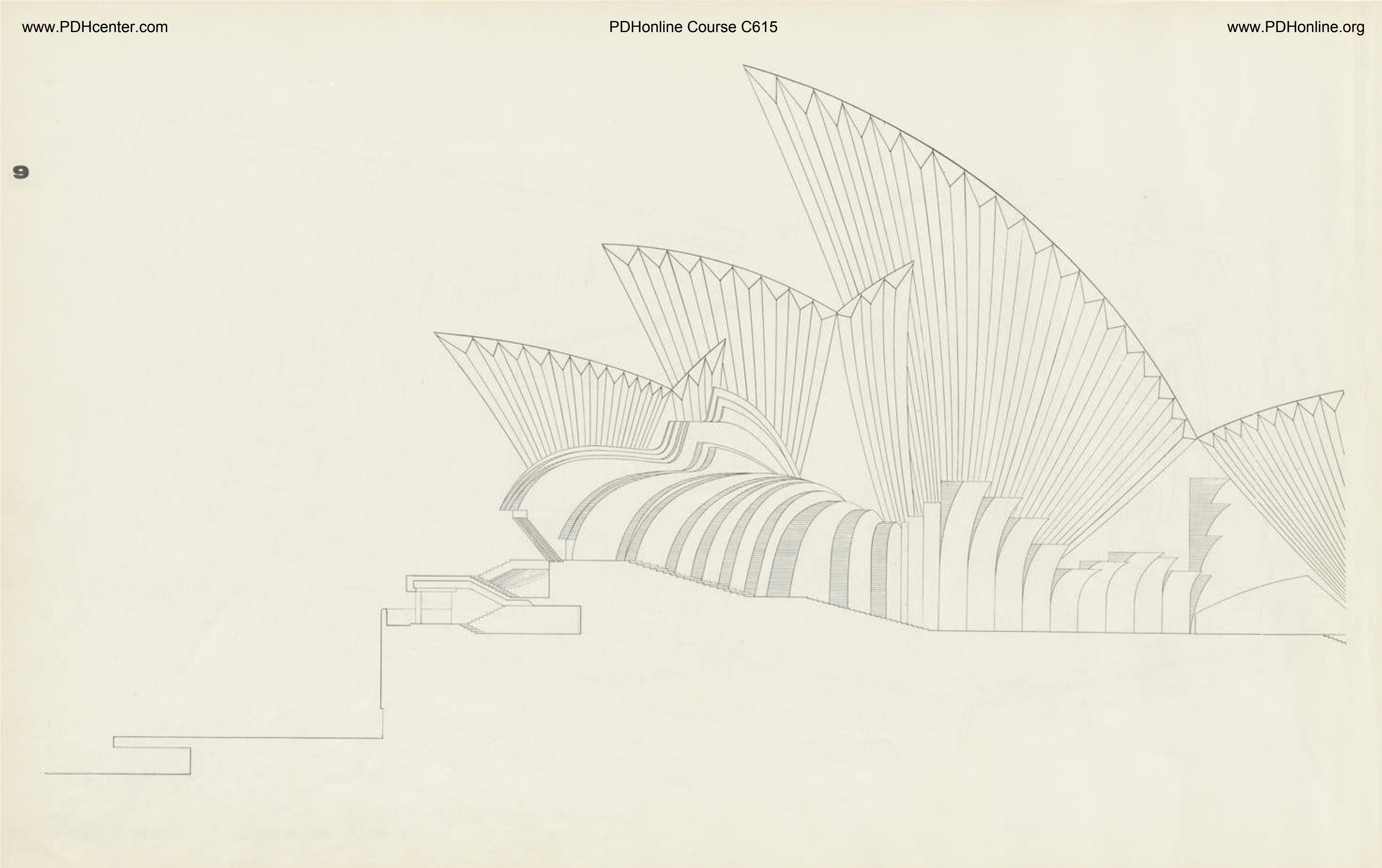
6. Untitled



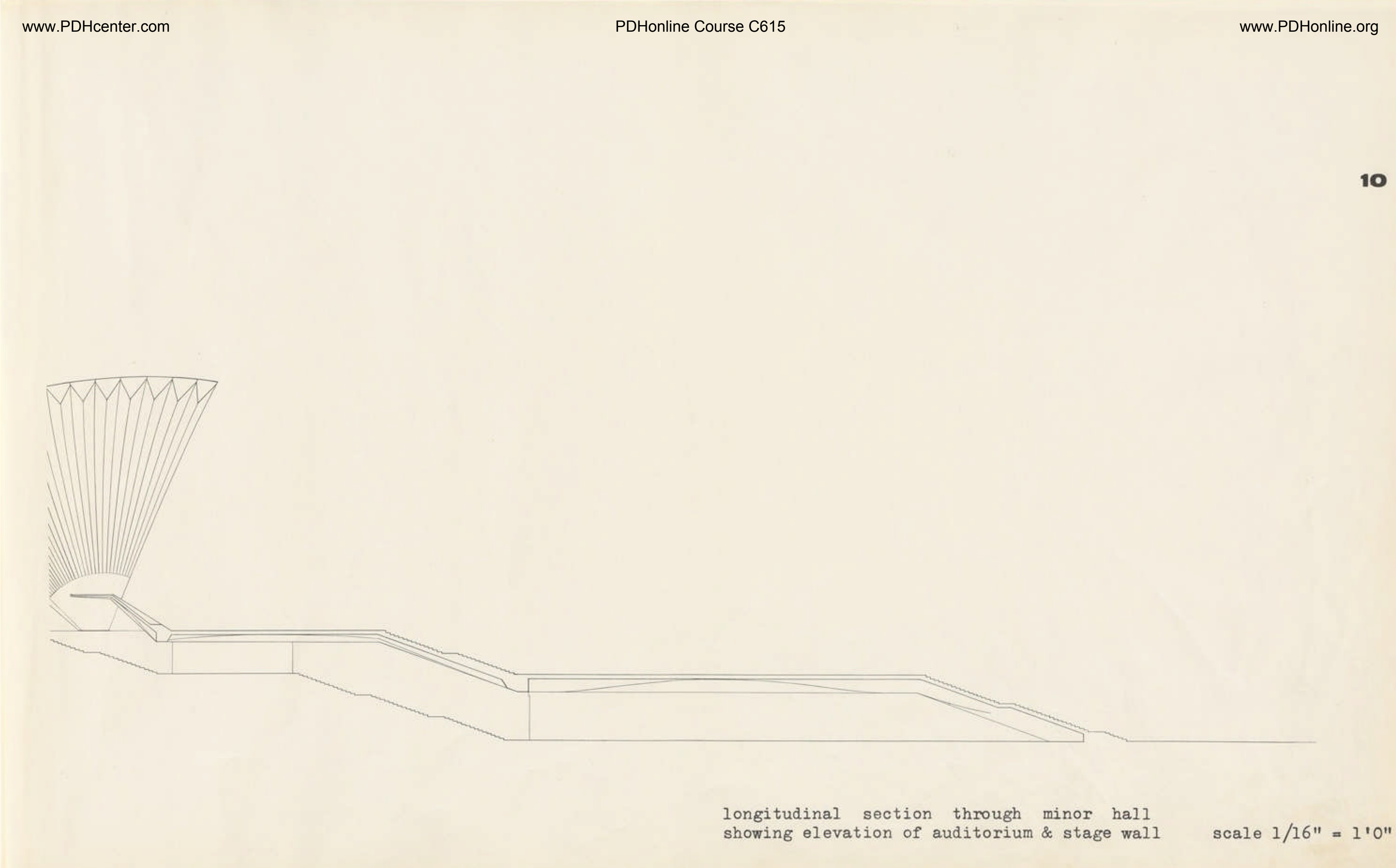
7. Longitudinal Section Through Minor Hall



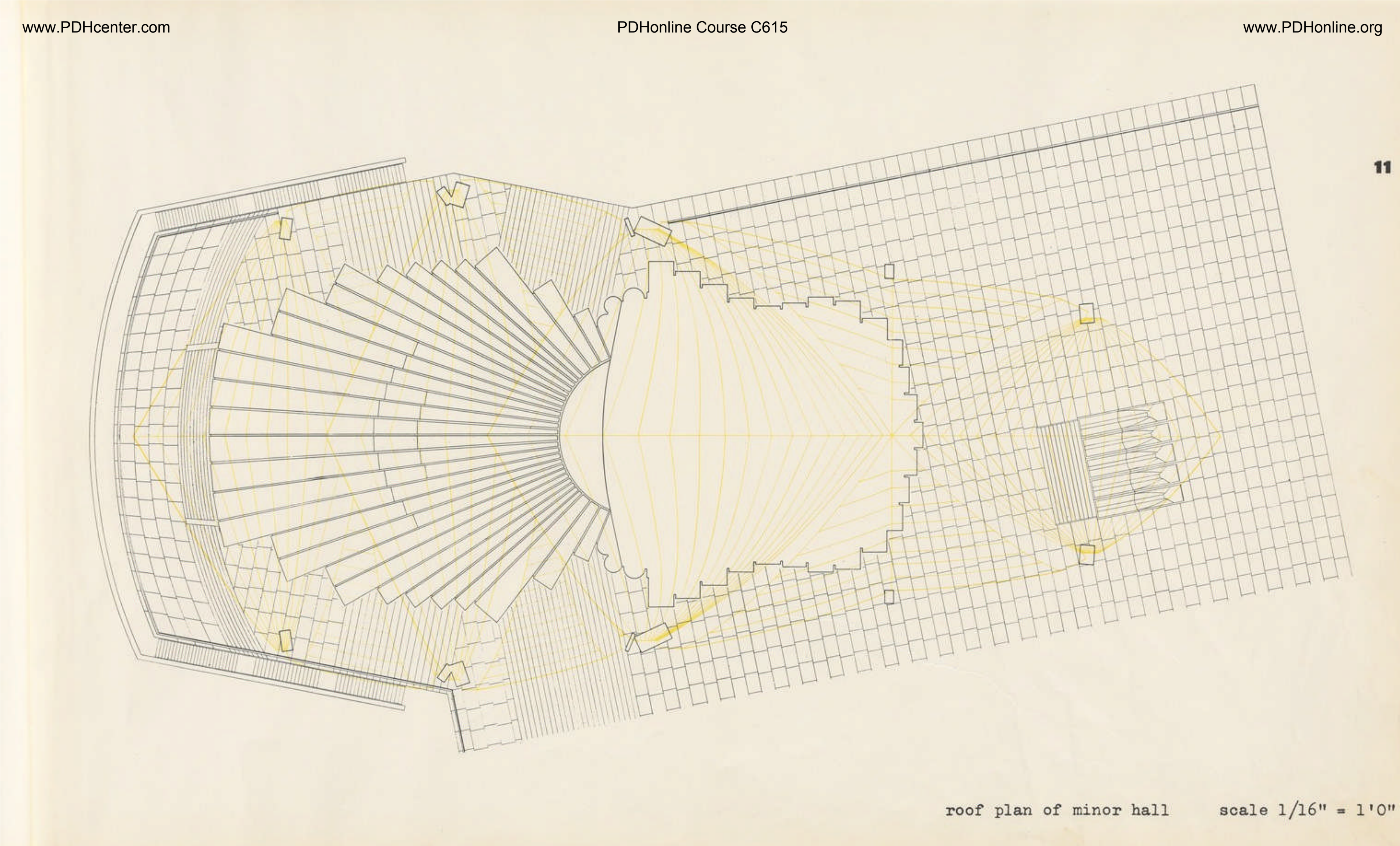
8. Plan of Minor Hall



9. Untitled

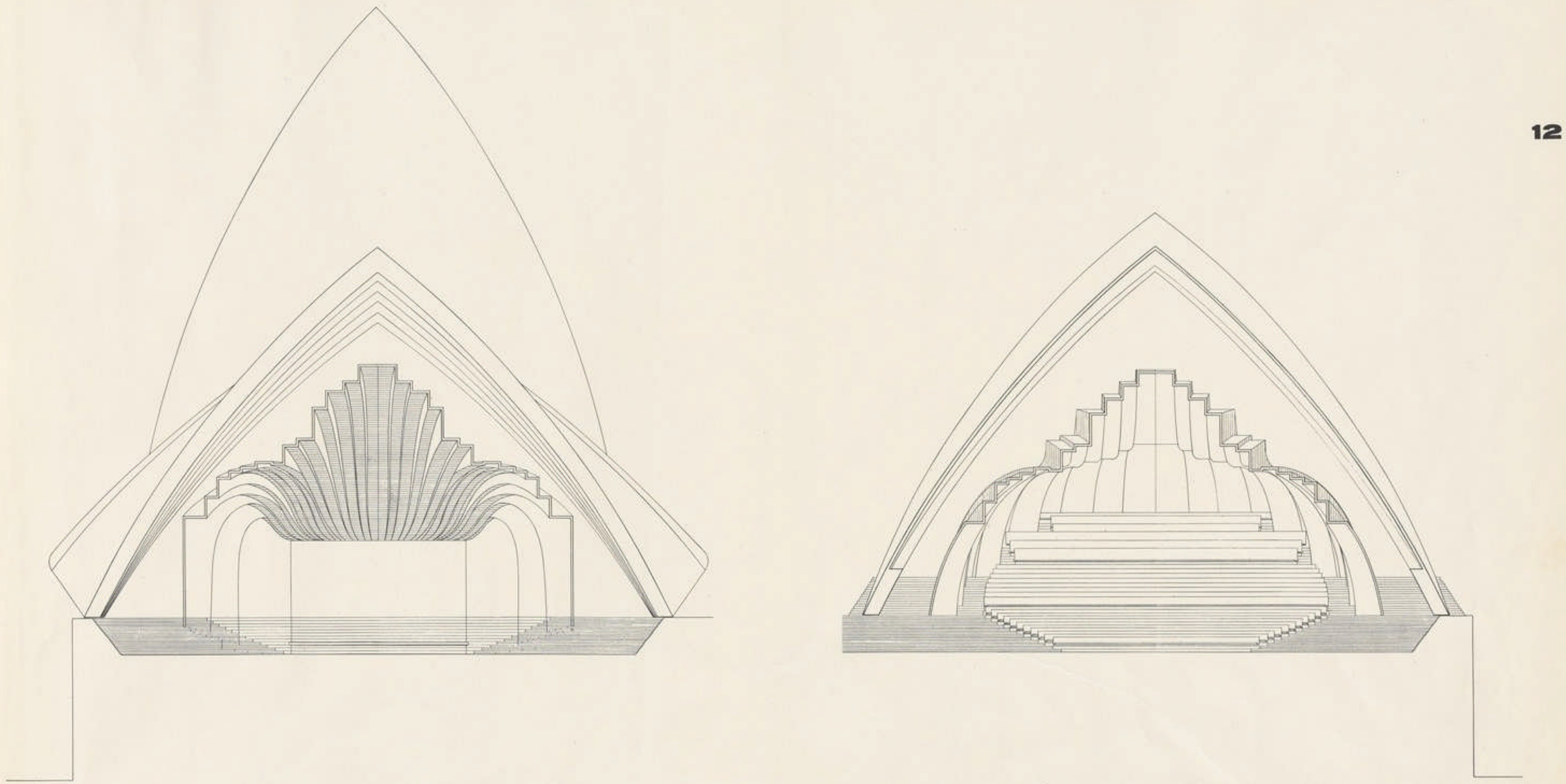


10. Longitudinal Section Through Minor Hall Showing Elevation of Auditorium and Stage Wall



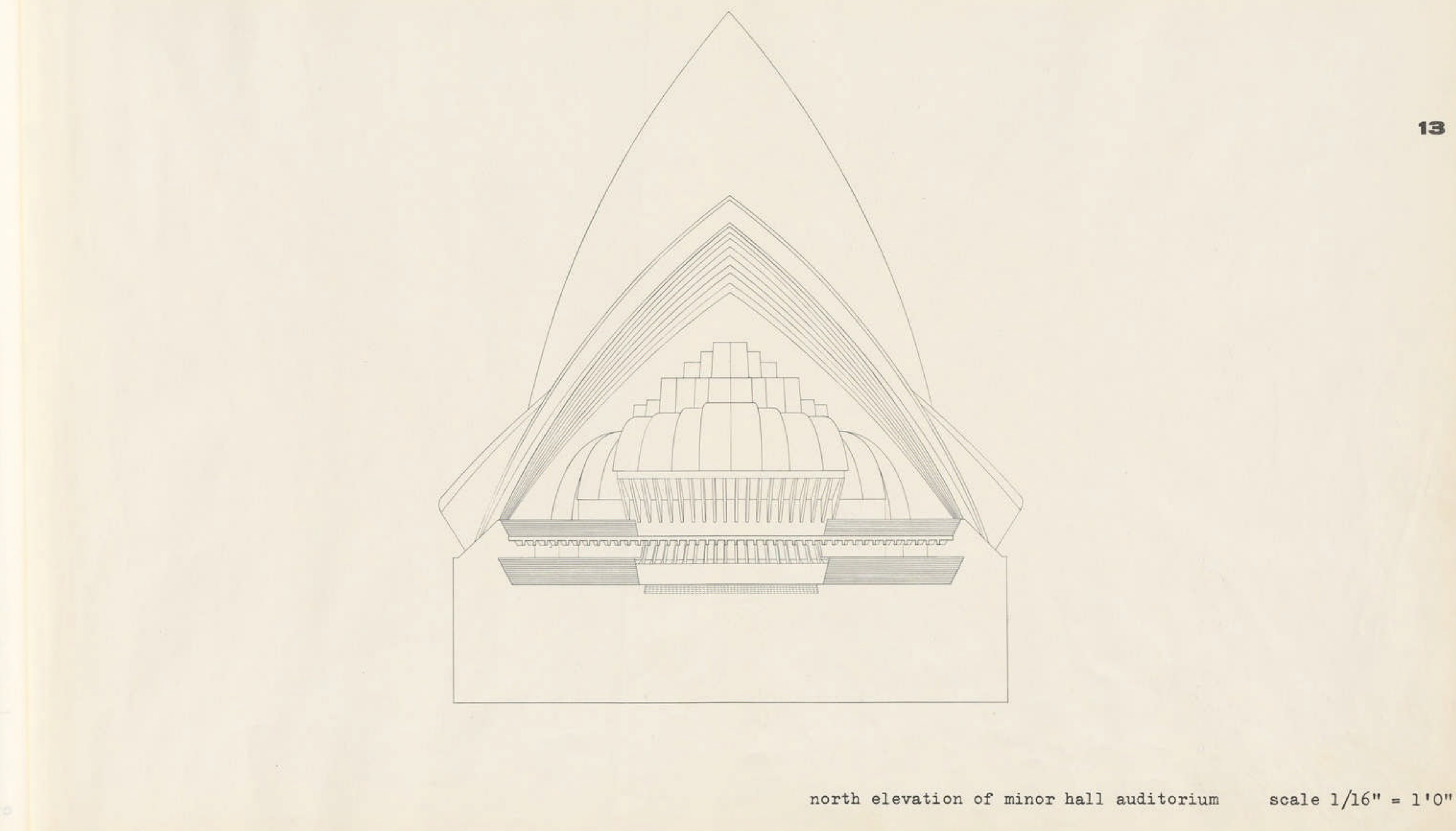
11. Roof Plan of Minor Hall

12



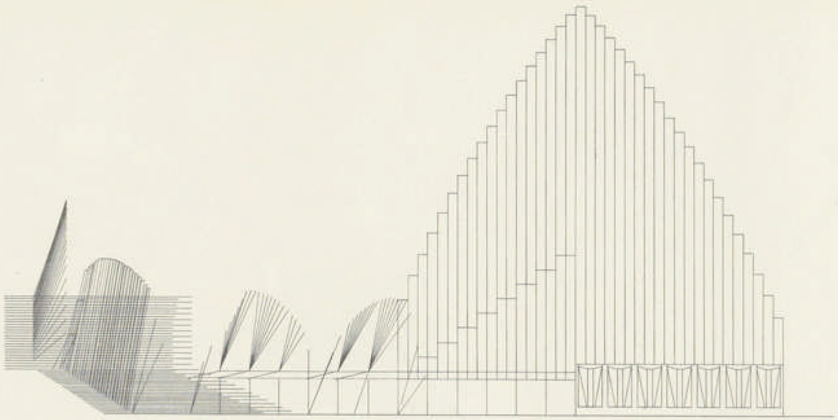
cross section of minor hall auditorium towards stage   cross section of minor hall auditorium towards rear wall   scale 1/16" = 1'0"

12. Cross Section of Minor Hall Auditorium Towards Stage/Towards Rear Wall



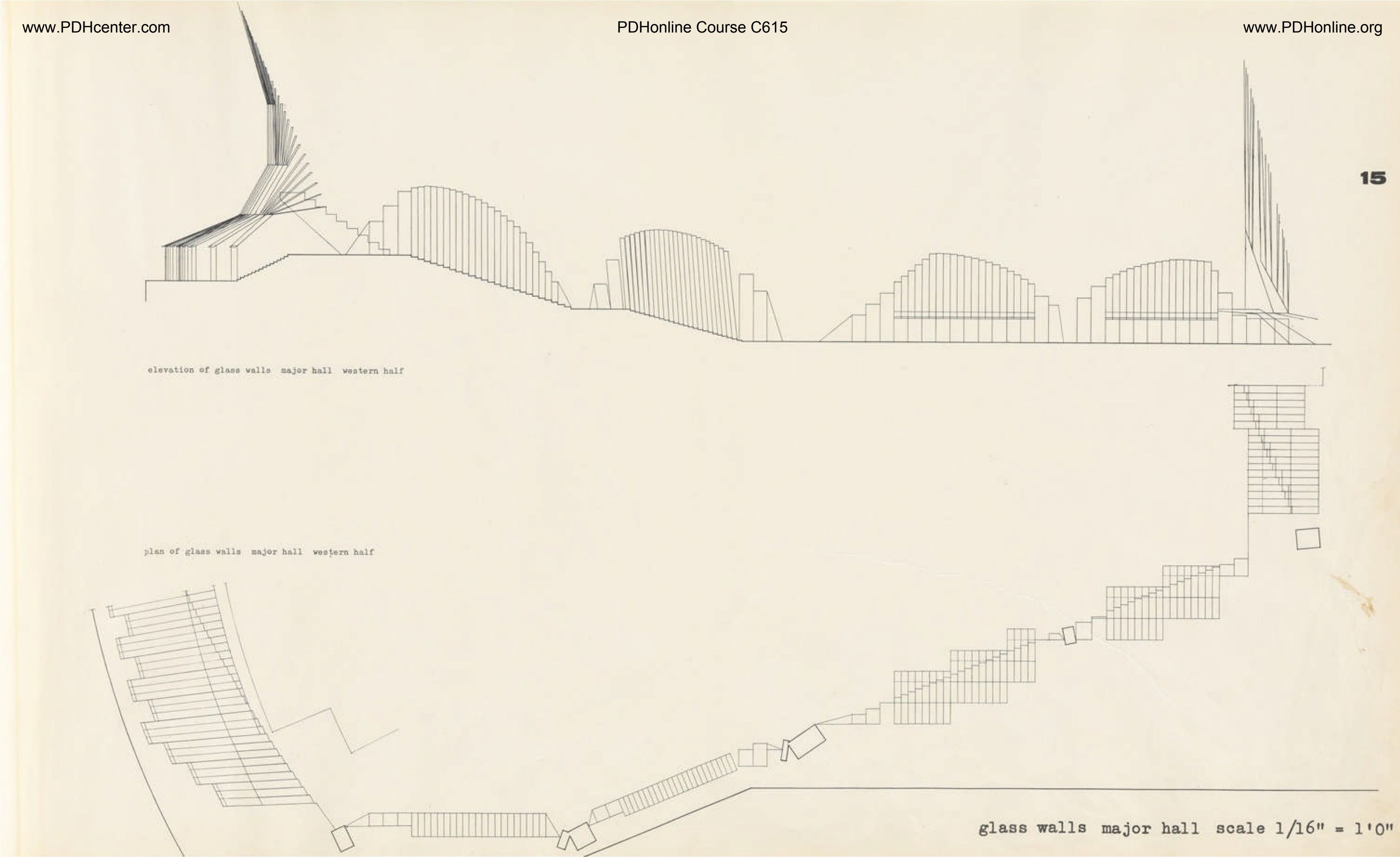
13. North Elevation of Minor Hall Auditorium

14

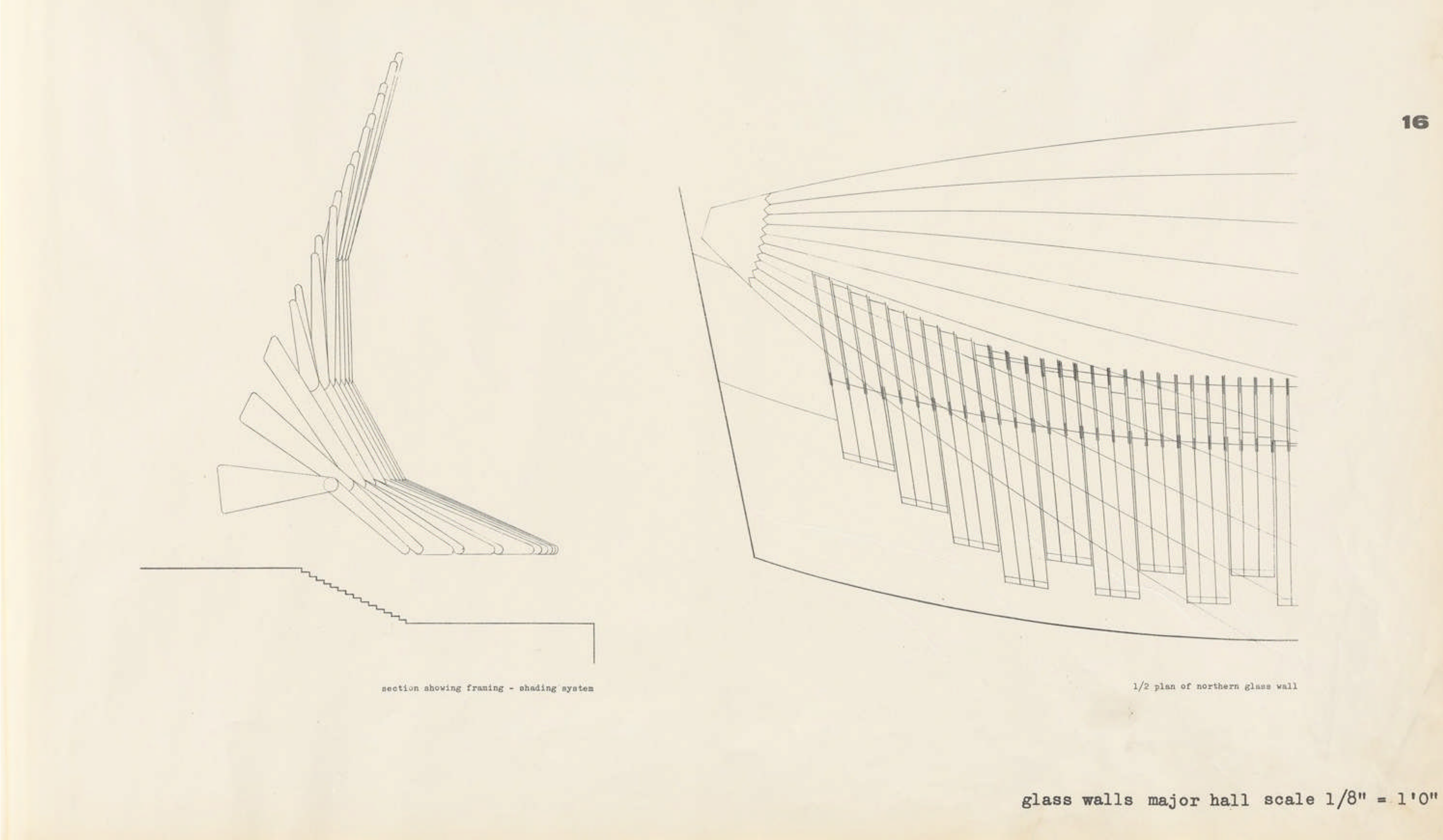


elevation of southern glass wall

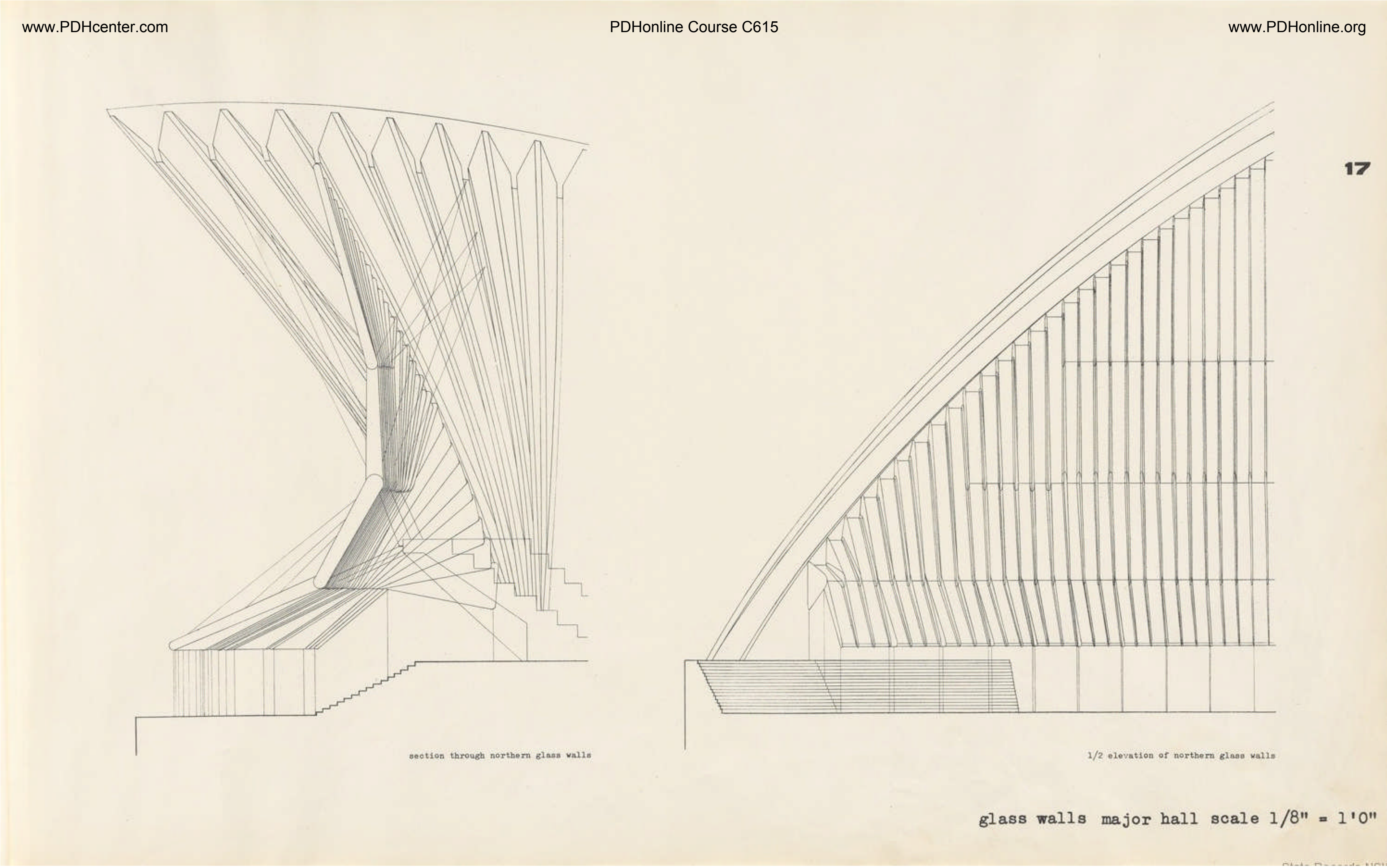
14. Elevation of Southern Glass Wall



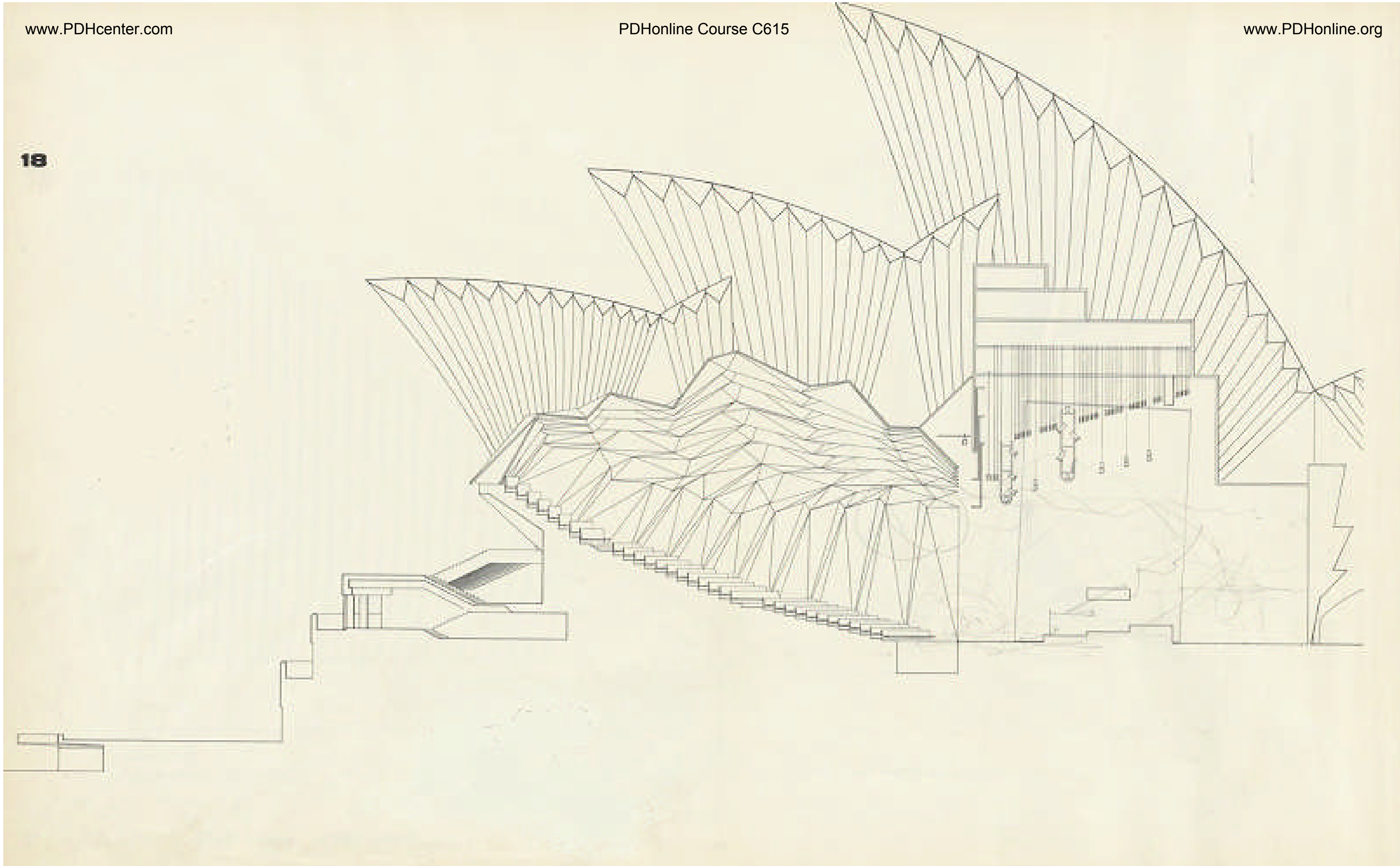
15. Glass Walls Major Hall



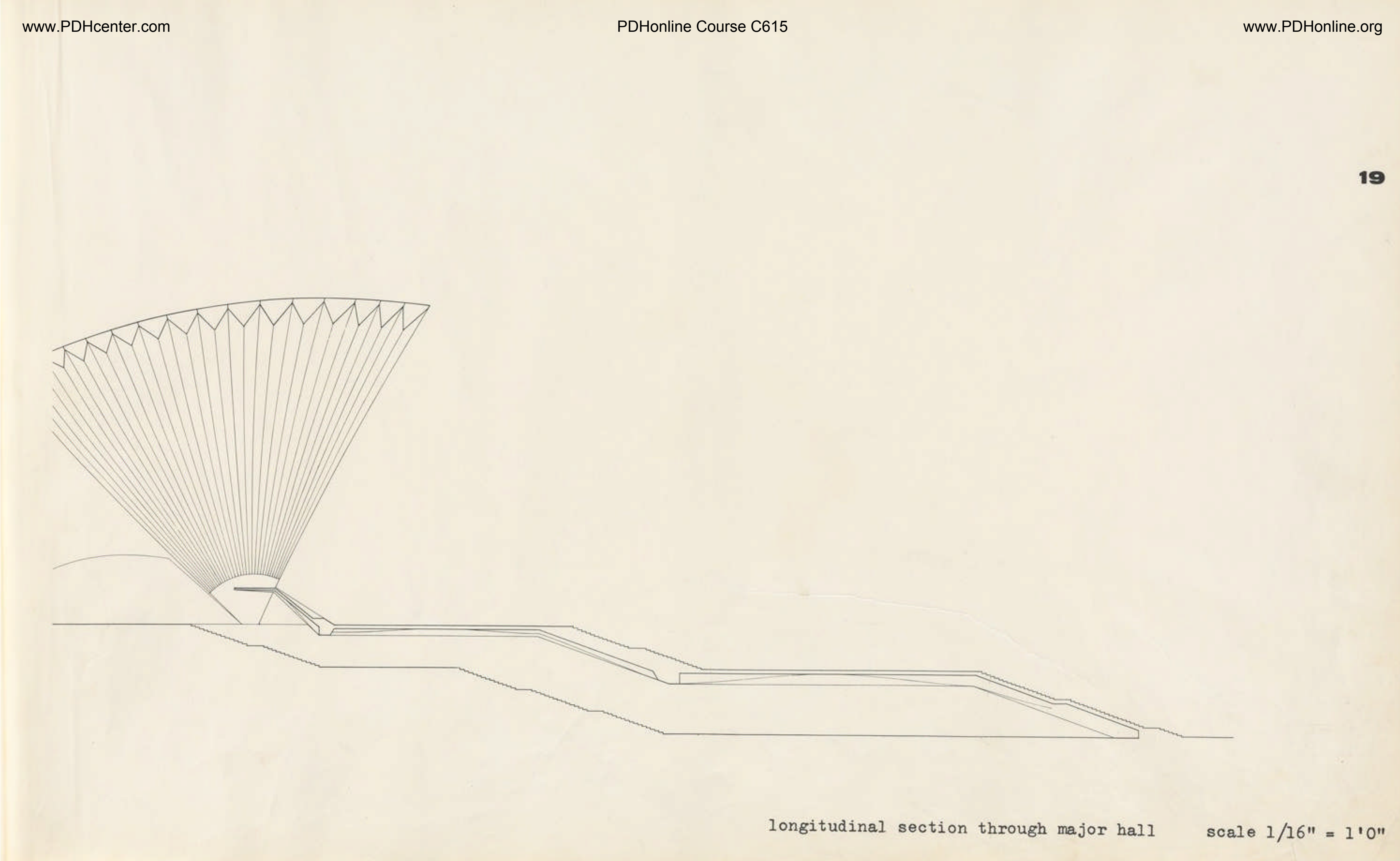
16. Glass Walls Major Hall



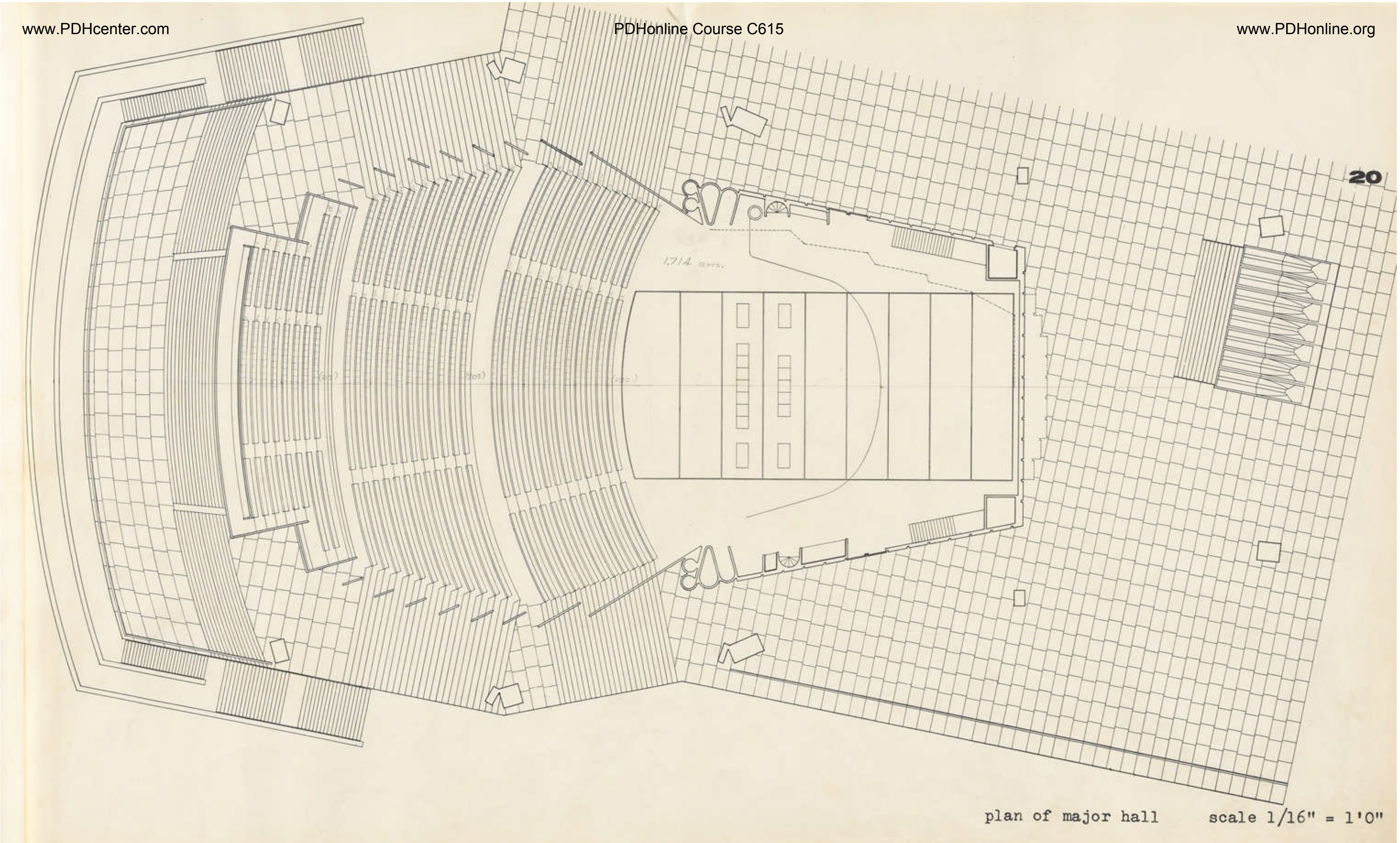
17. Glass Walls Major Hall



18. Untitled

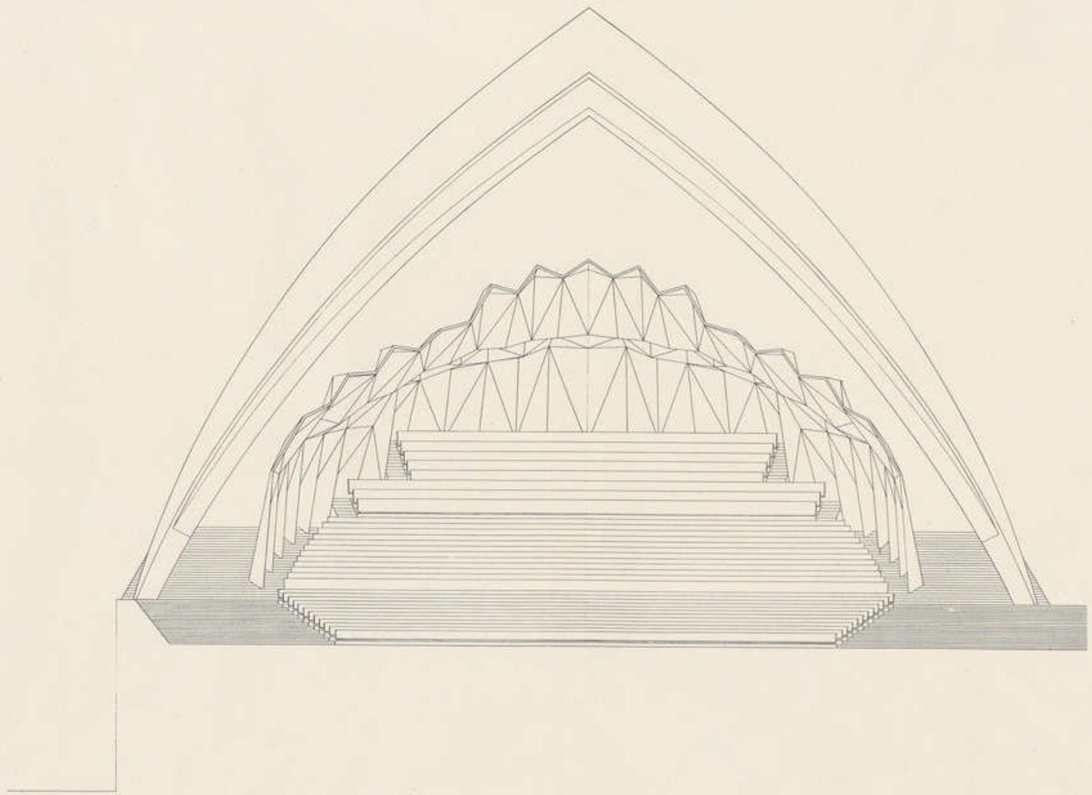


19. Longitudinal Section Through Major Hall



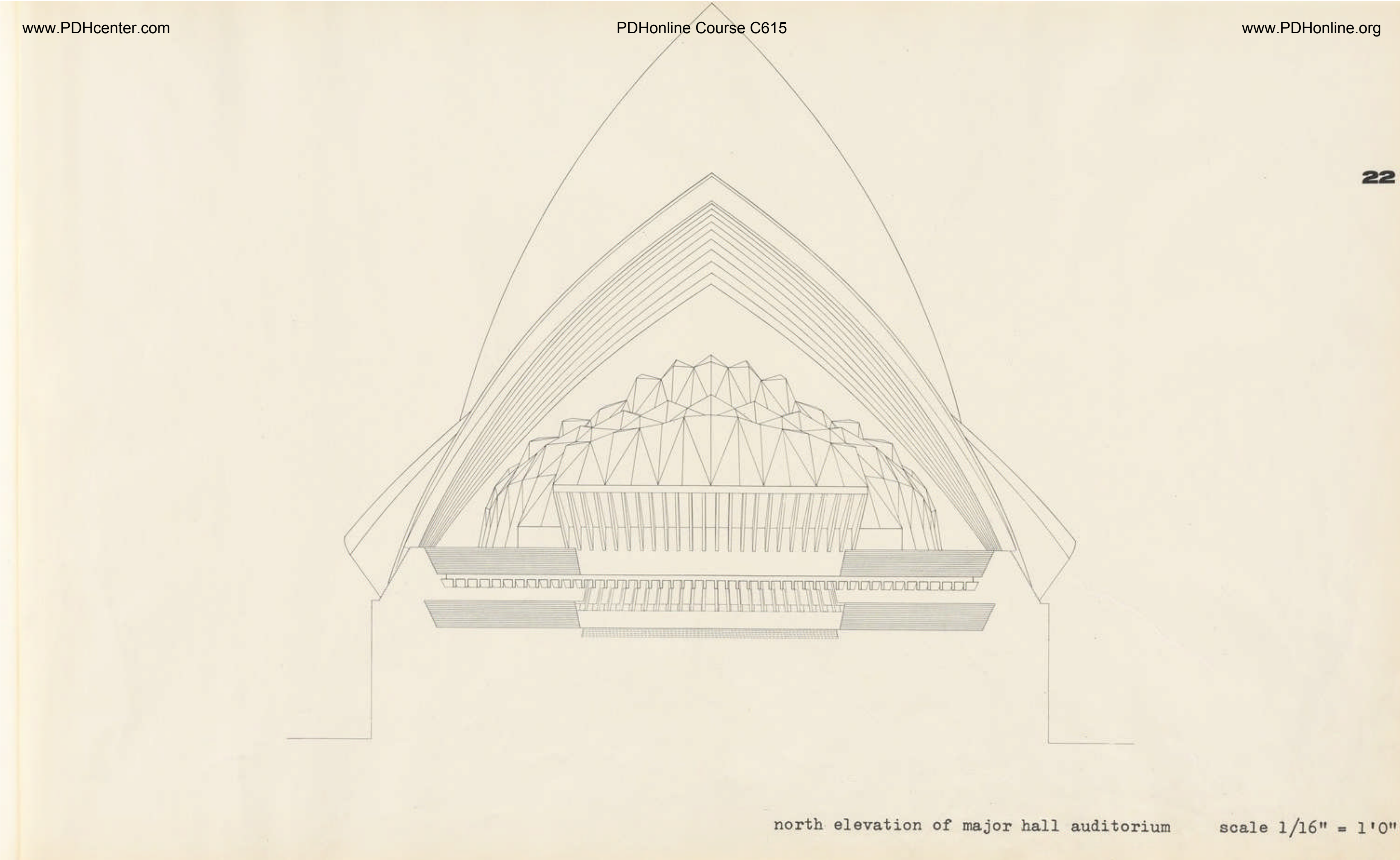
20. Plan of Major Hall

21

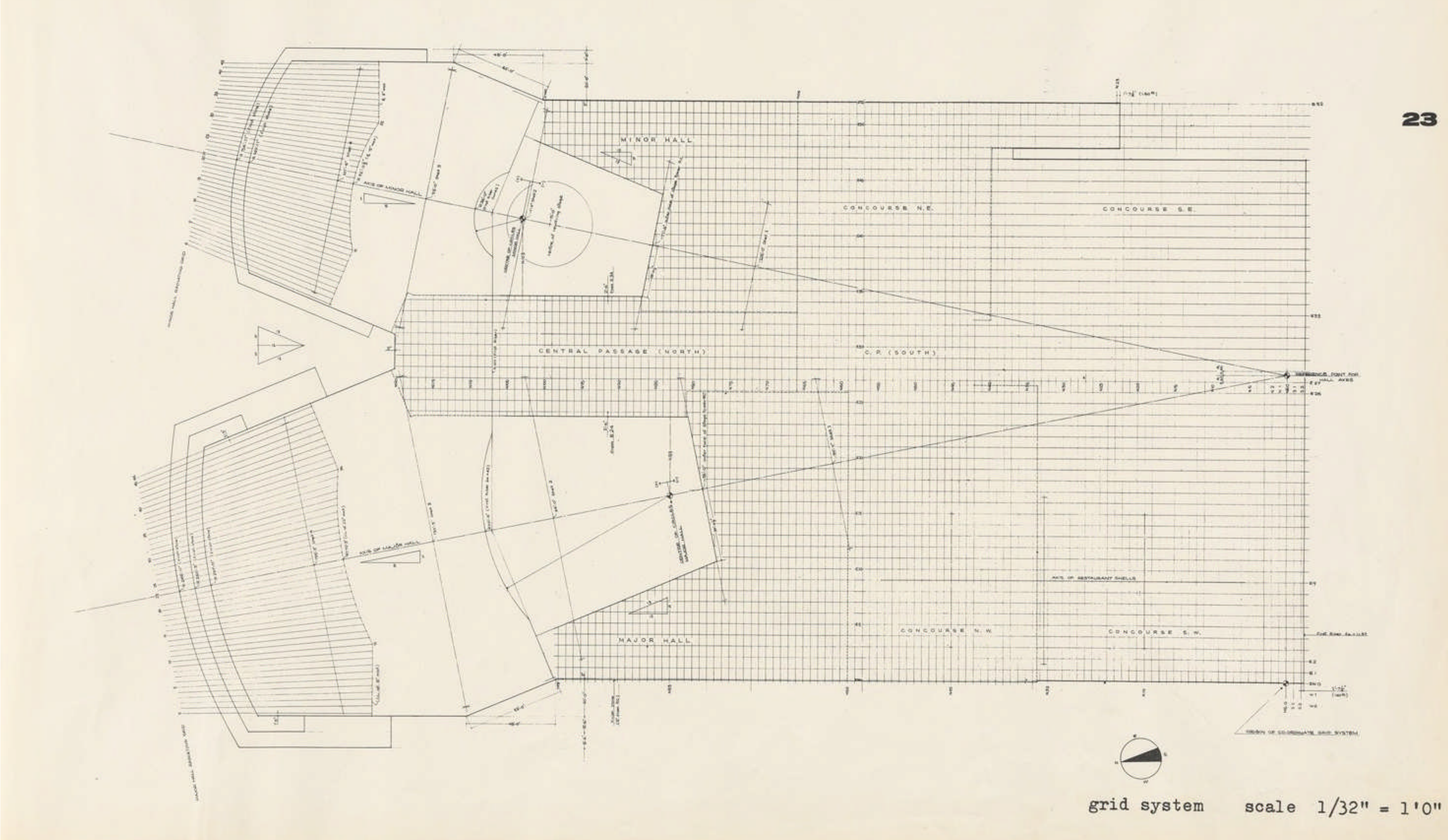


cross section of major hall auditorium towards rear wall scale 1/16" = 1'0"

21. Cross Section of Major Hall Auditorium Towards Rear Wall

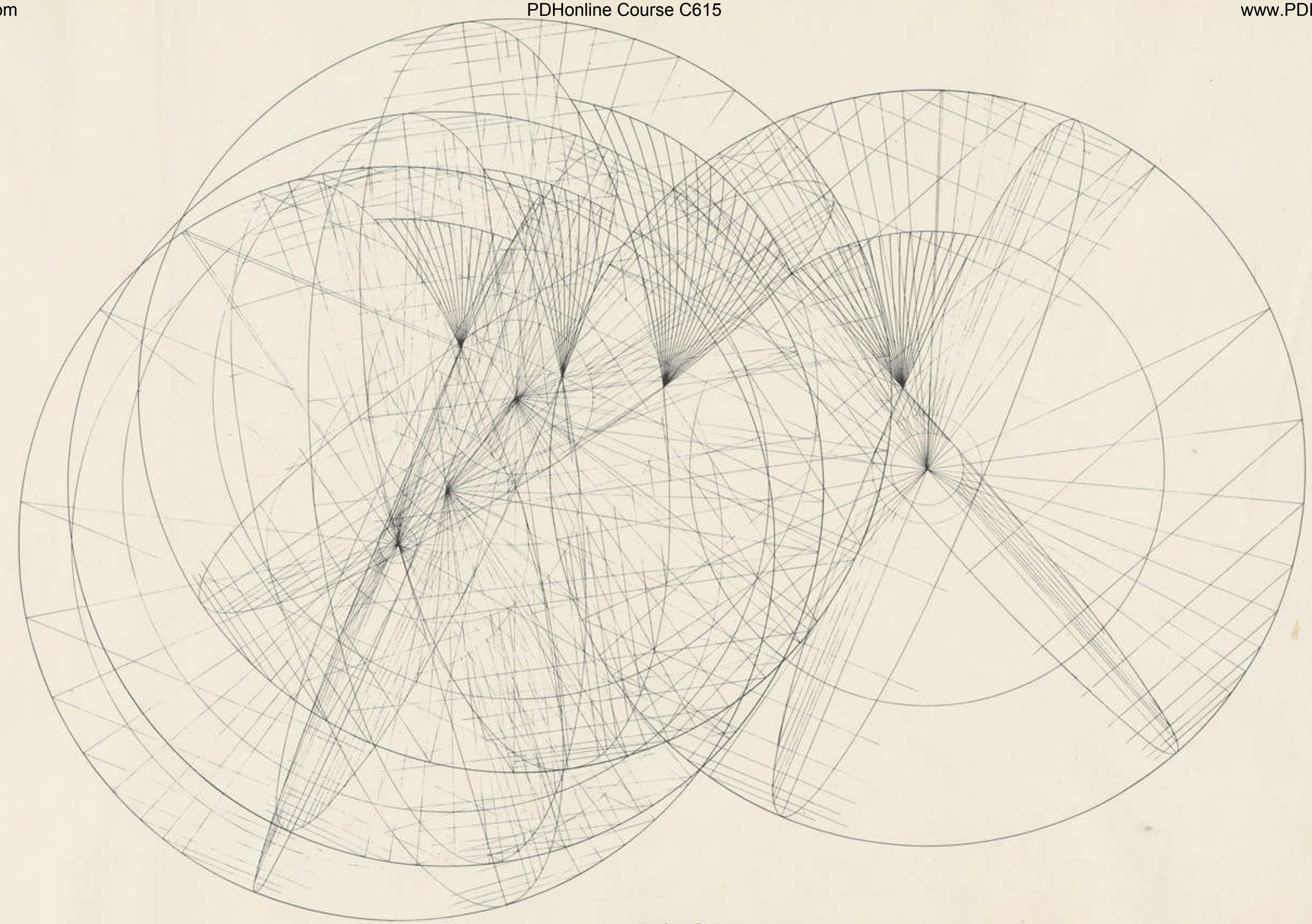


22. North Elevation of Major Hall Auditorium



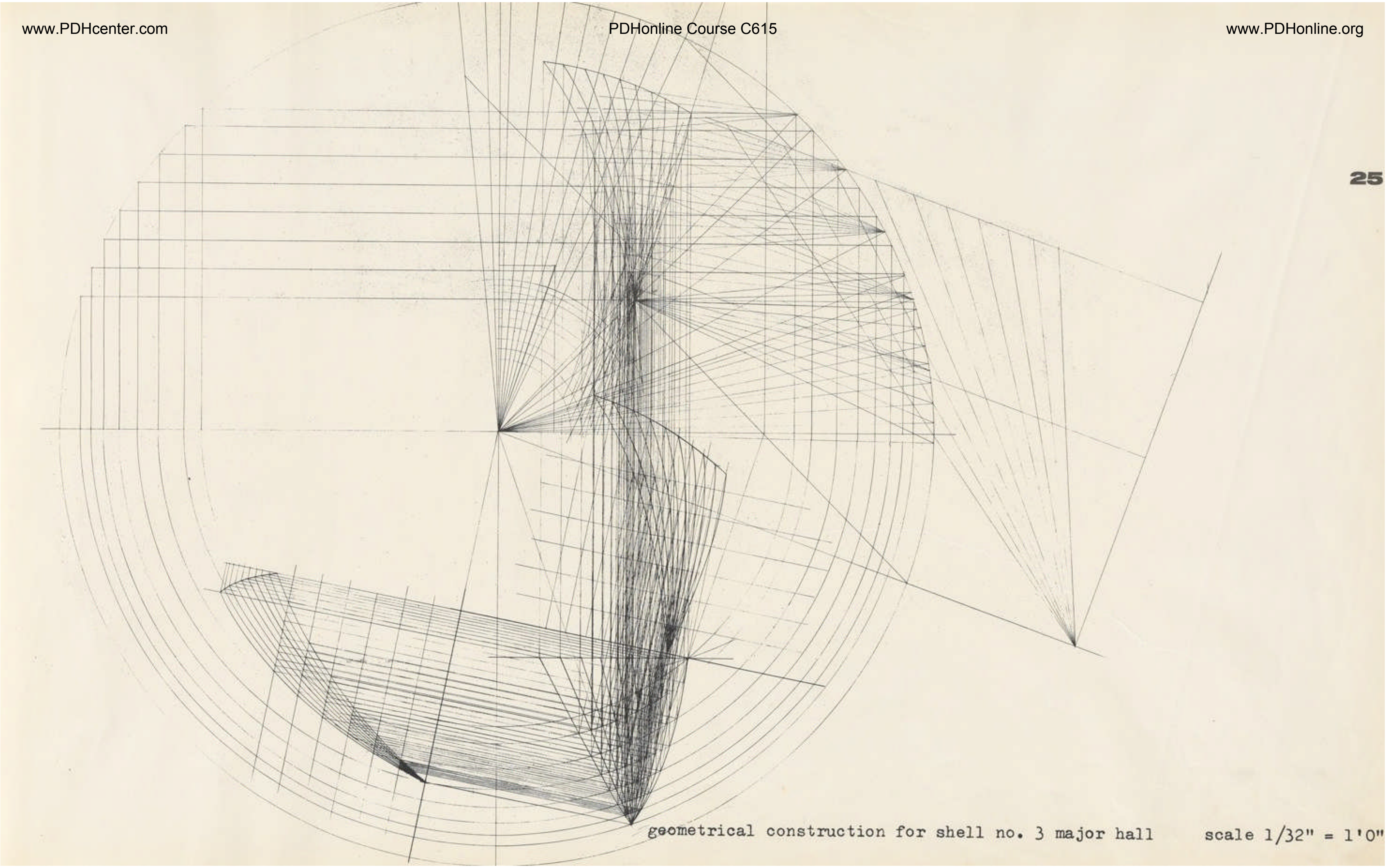
23. Grid System

24

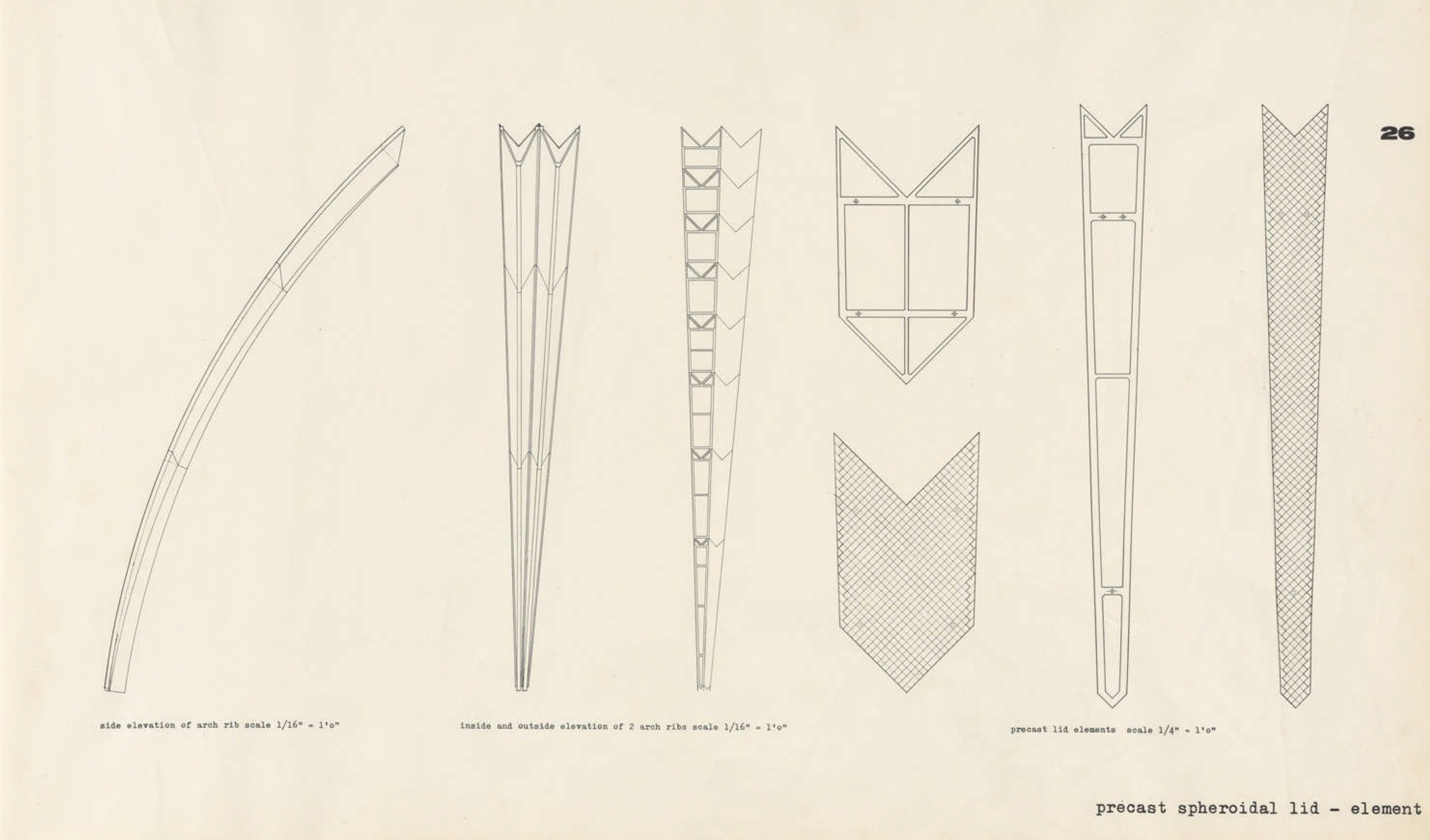


geometrical construction showing the shells of the major hall (elevation)

24. Geometrical Construction Showing the Shells of the Major Hall (Elevation)

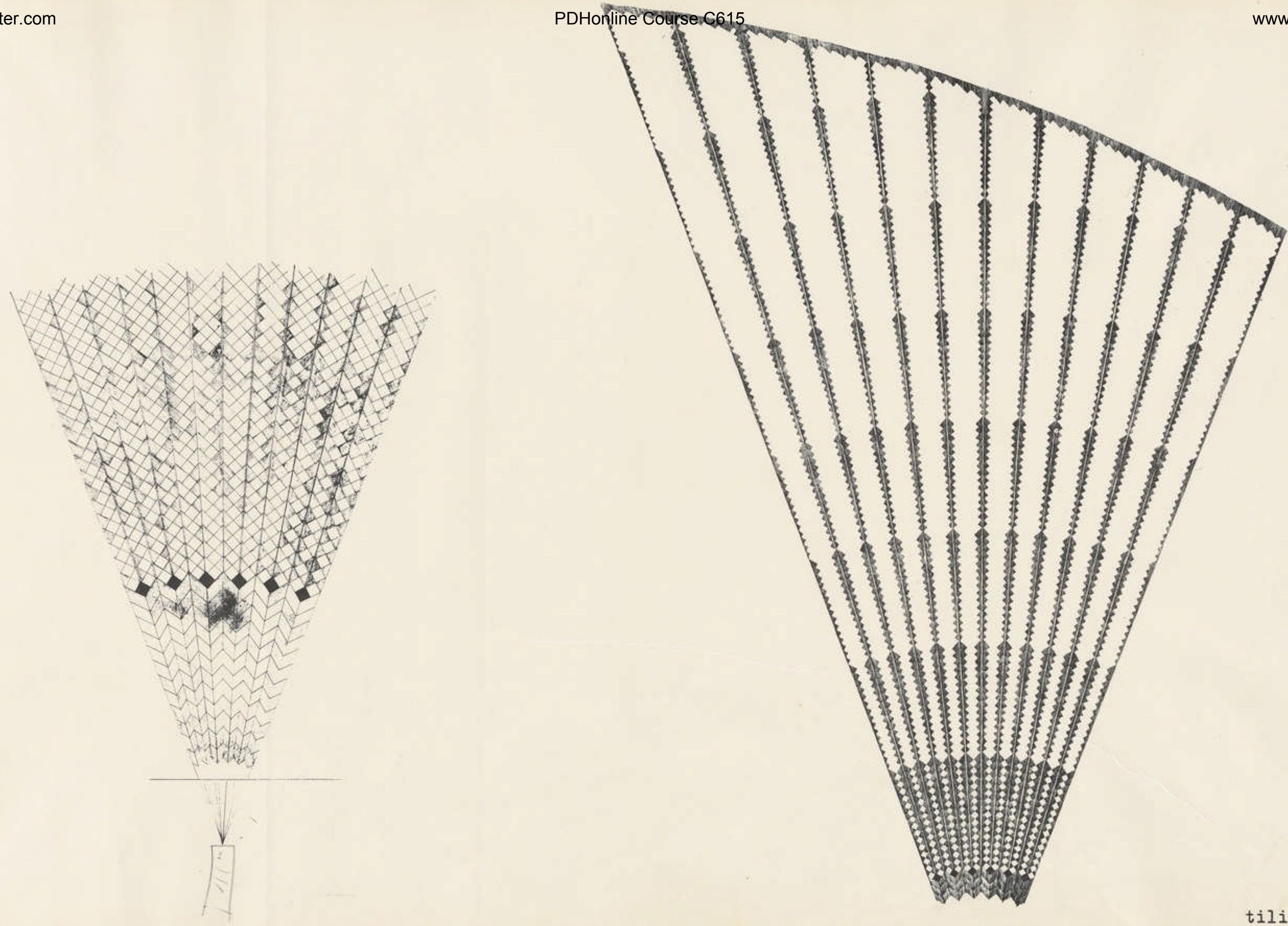


25. Geometrical Construction for Shell No. 3 Major Hall



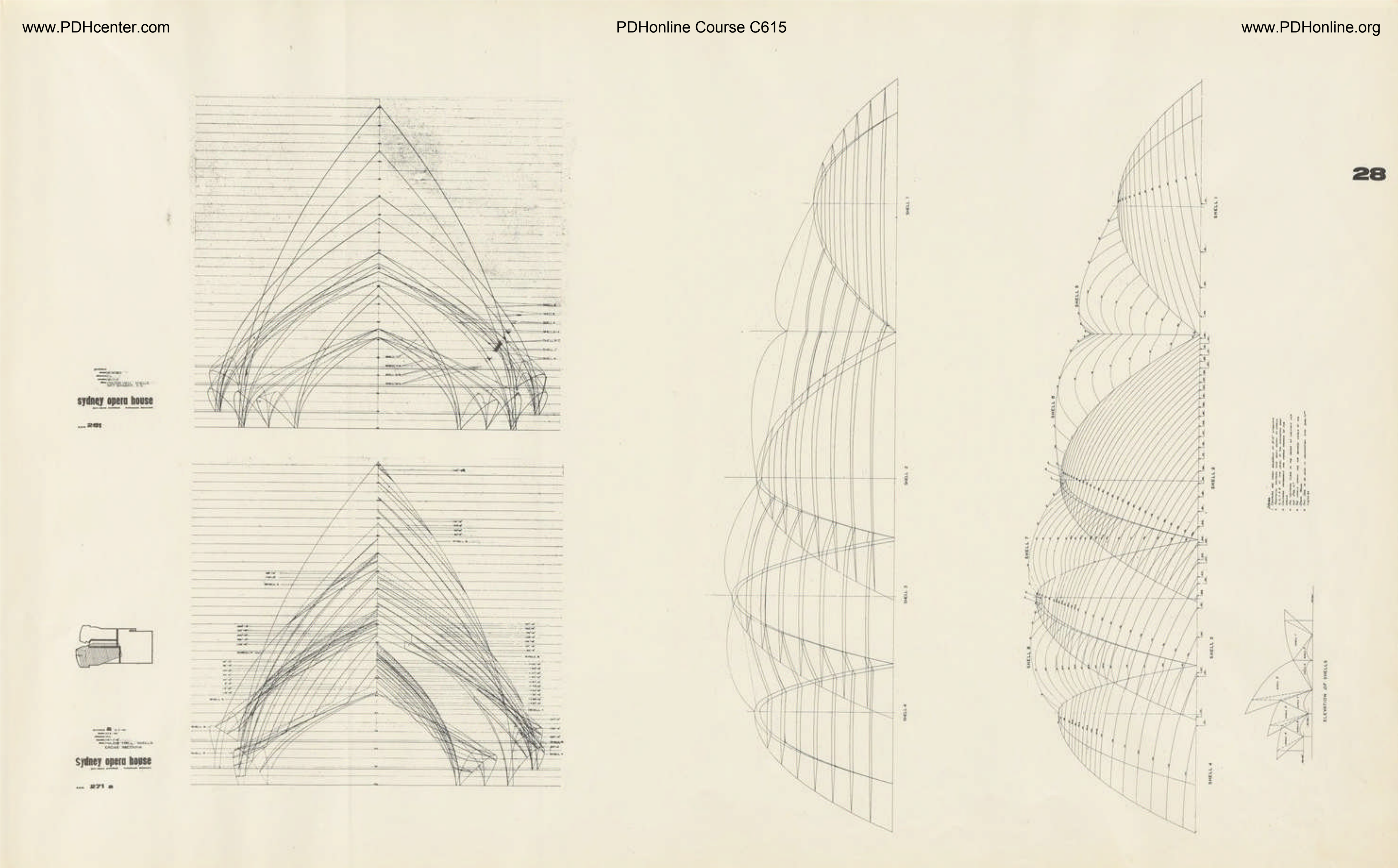
26. Precast Spheroidal Lid – Element

27

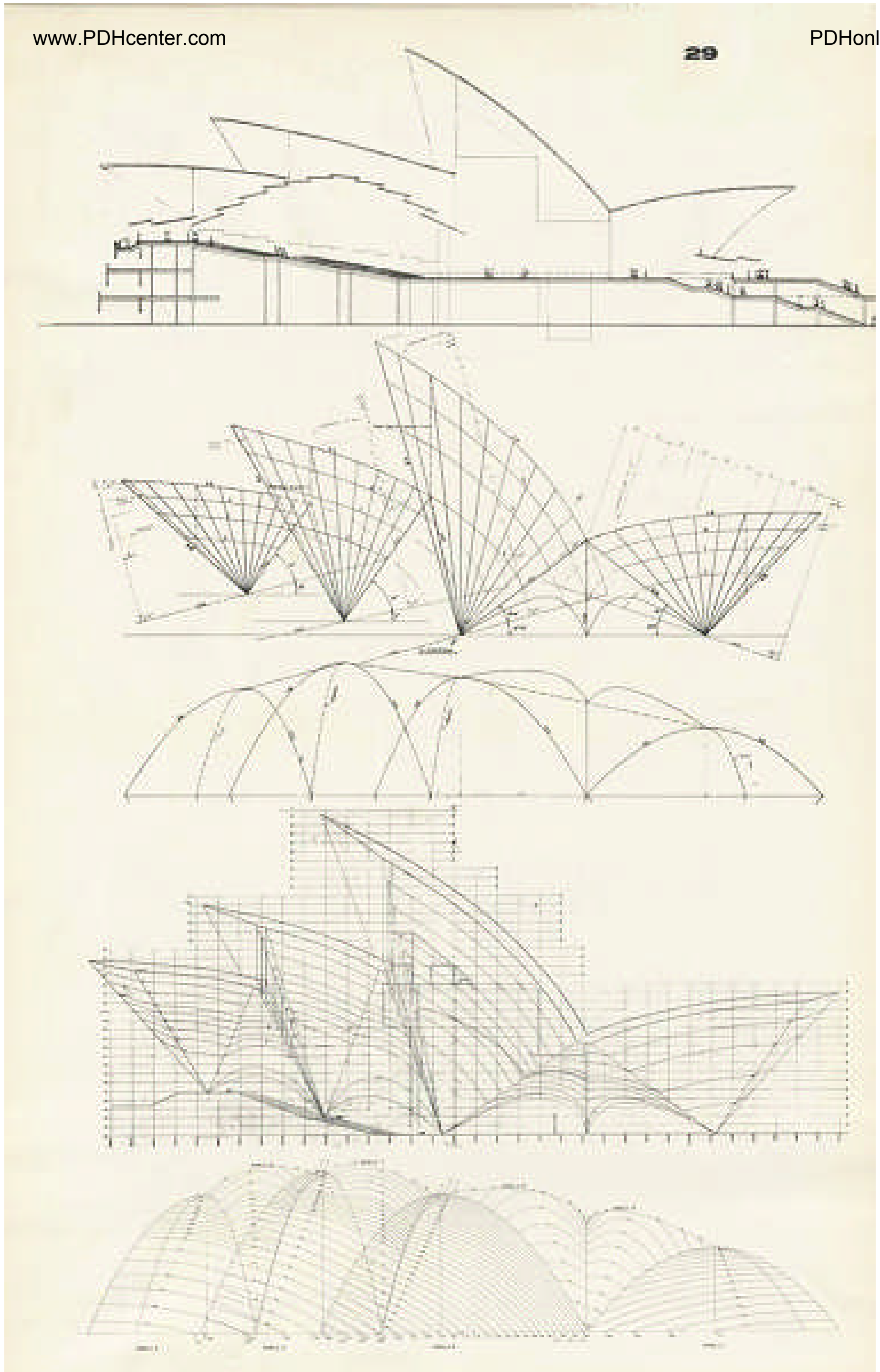


tiling on shells

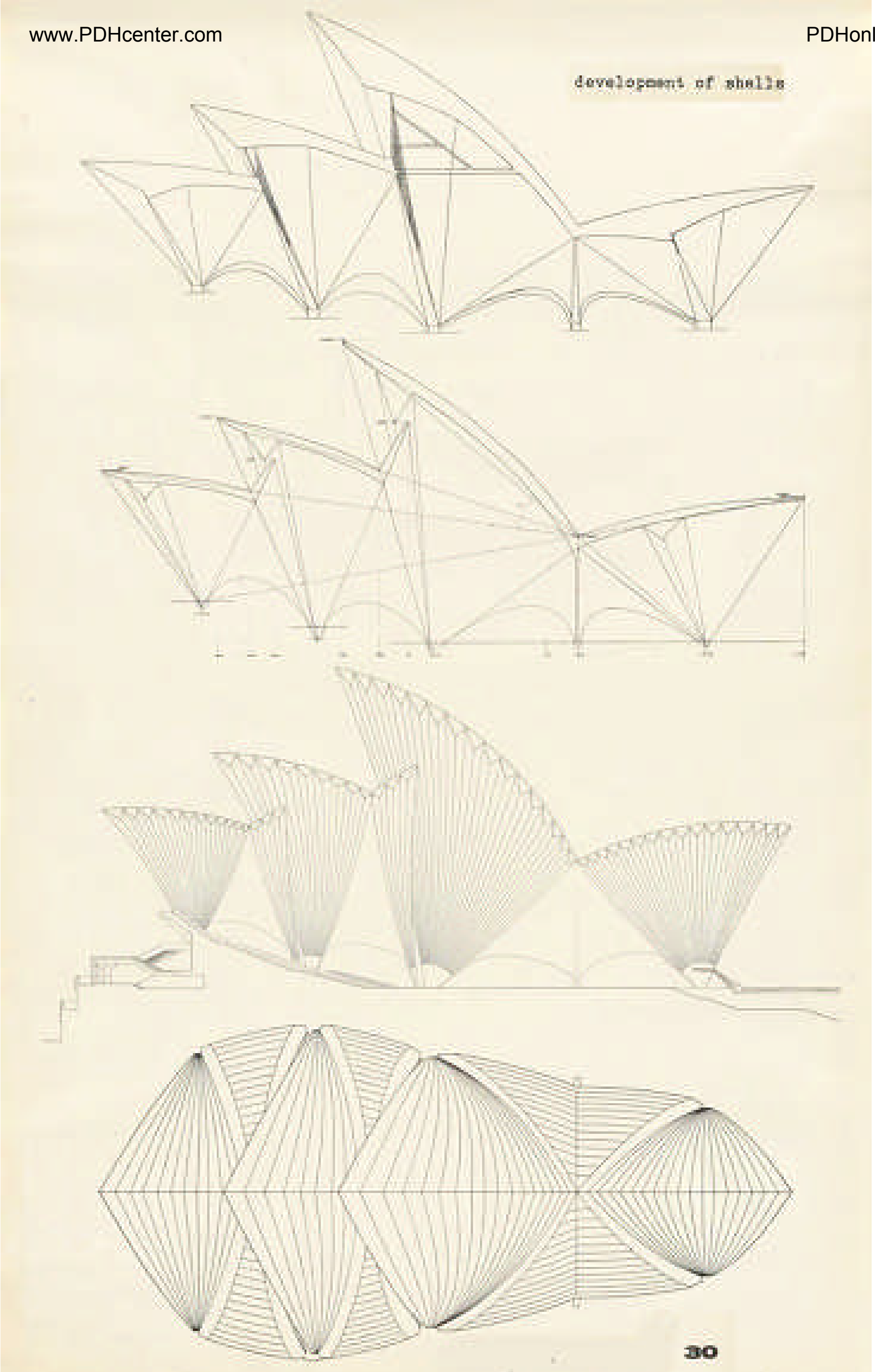
27. Tiling on Shells


28
sydney opera house
Sydney opera house
ELEVATION OF SHELLS

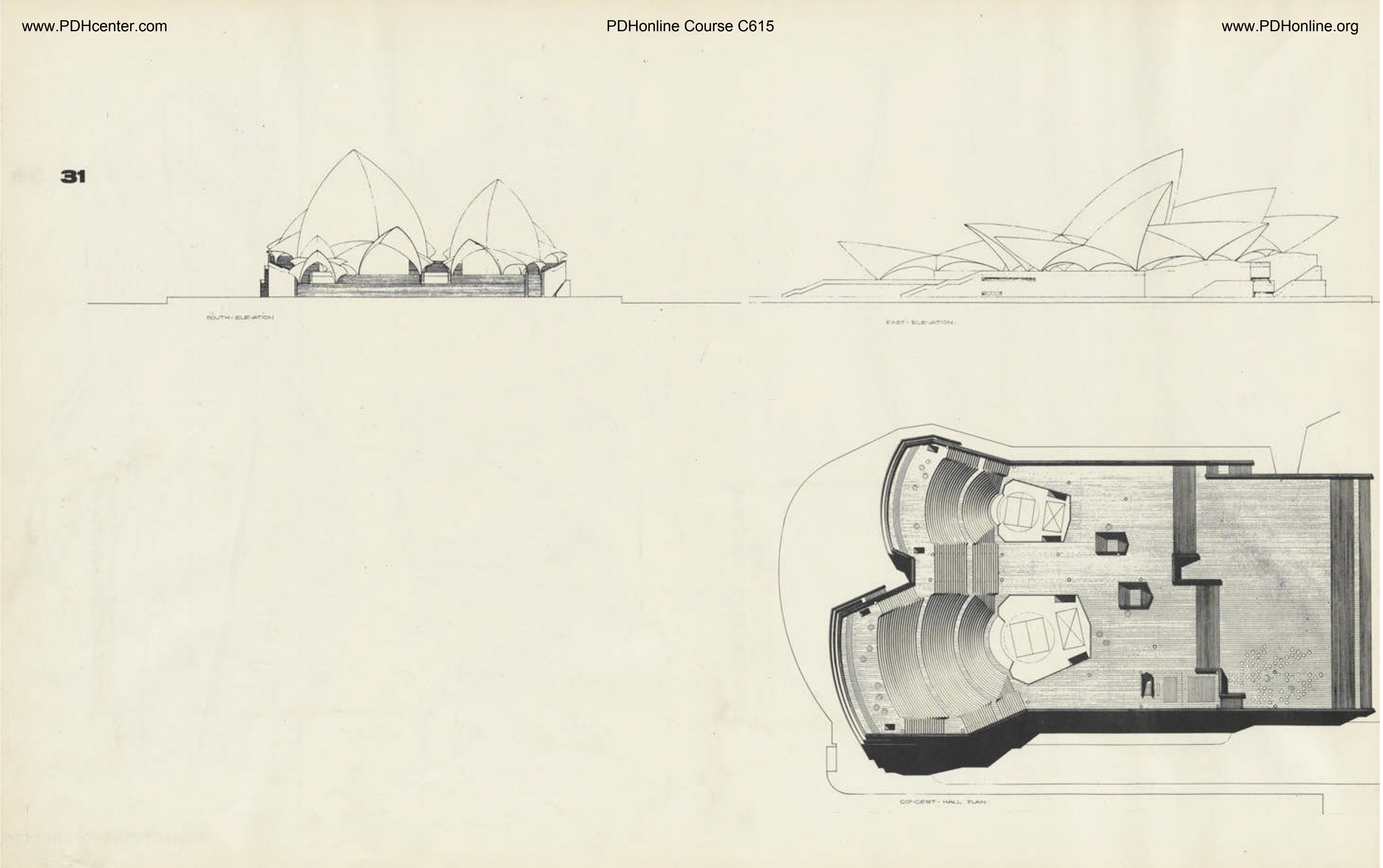
28. Untitled



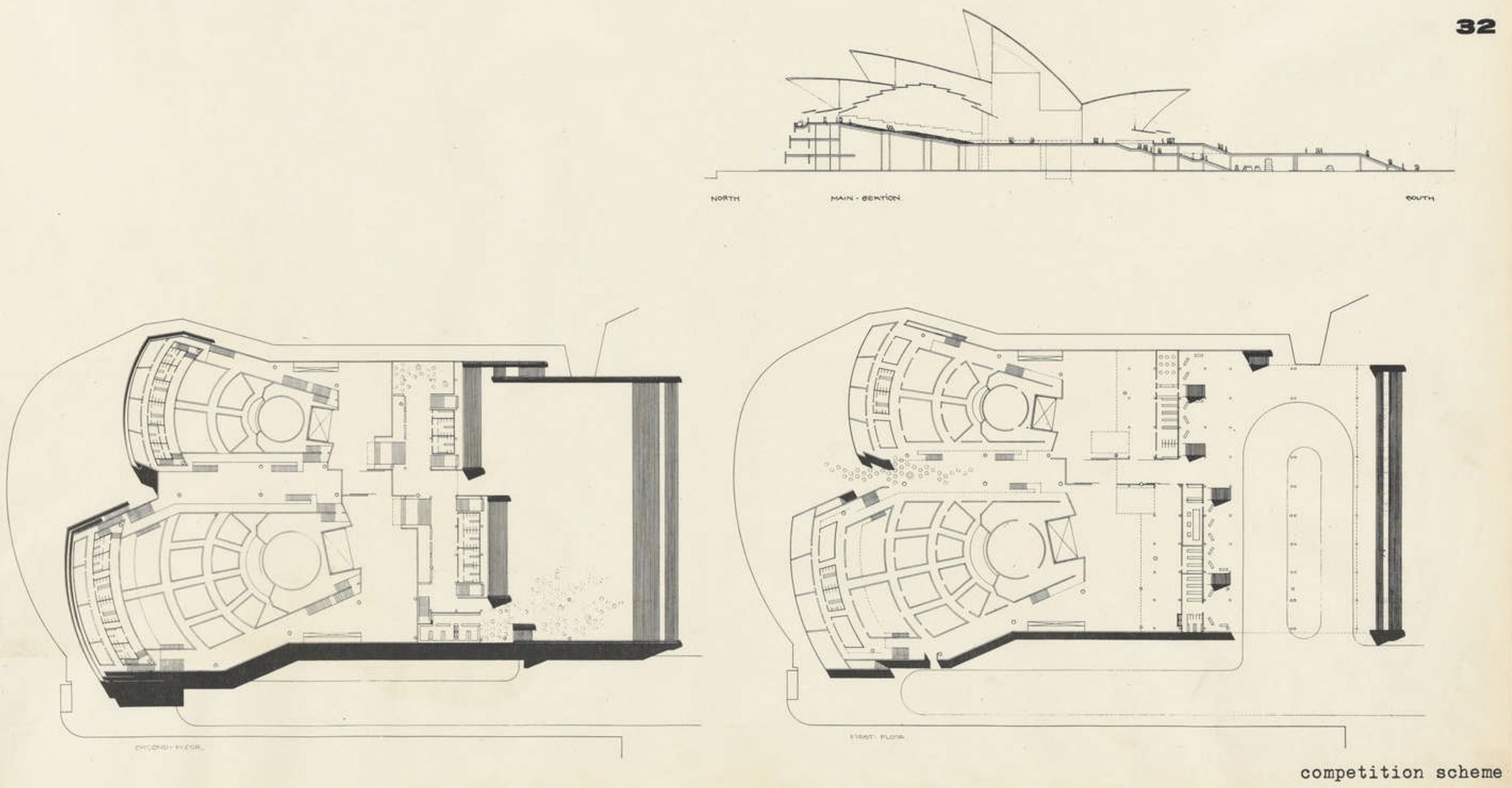
29. Untitled



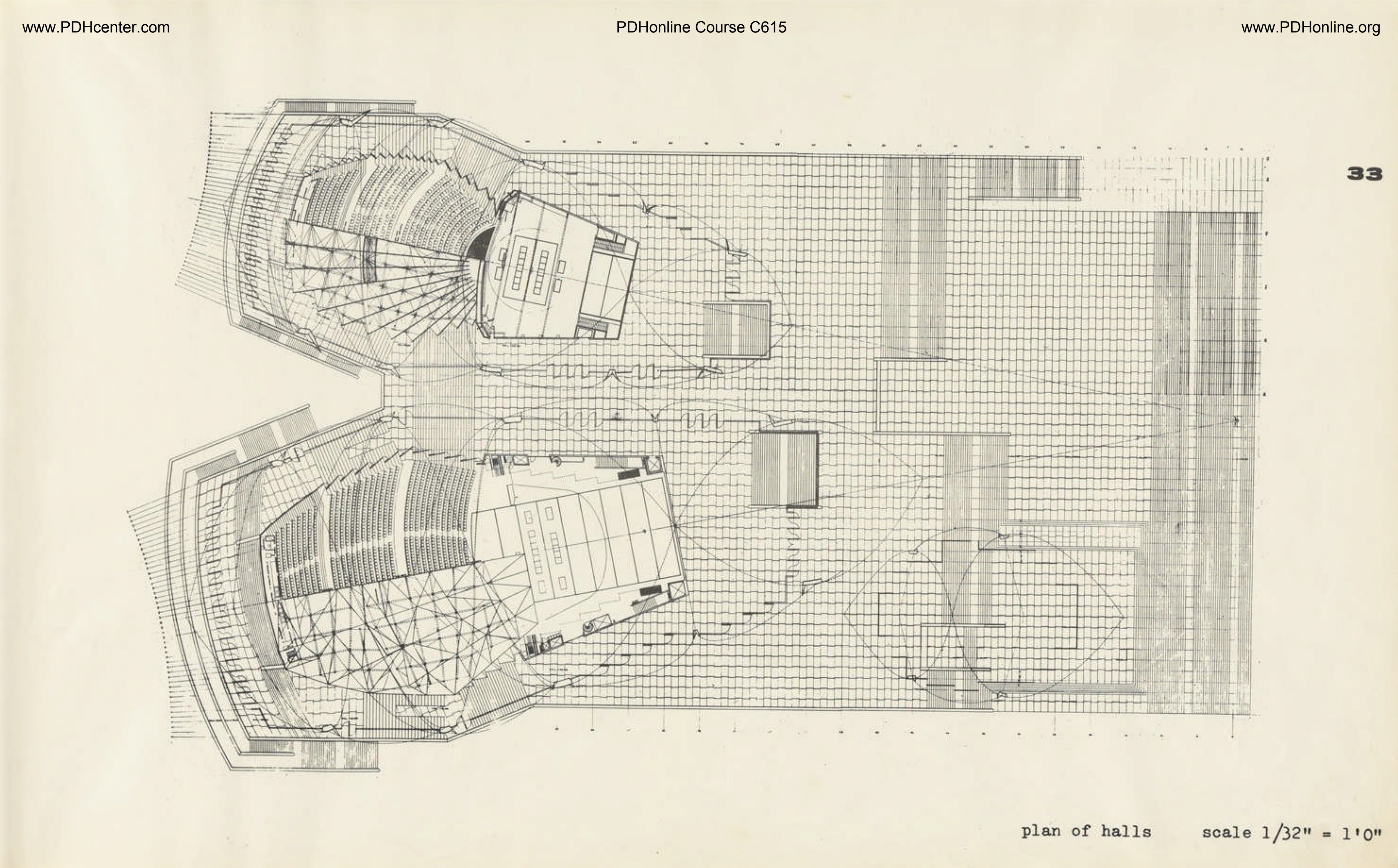
30. Development of Shells



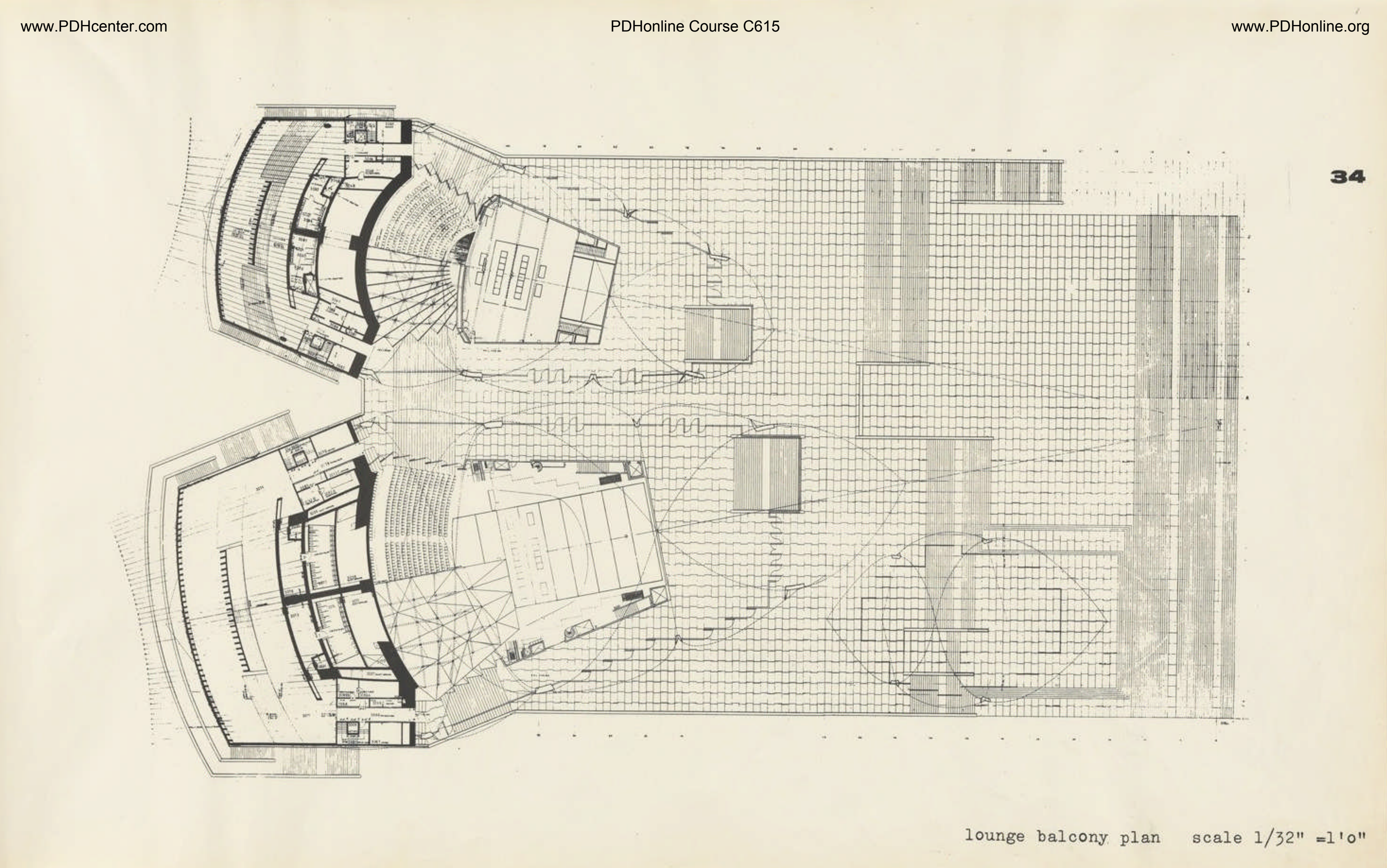
31. Showing South Elevation, East elevation, Concert Hall Plan



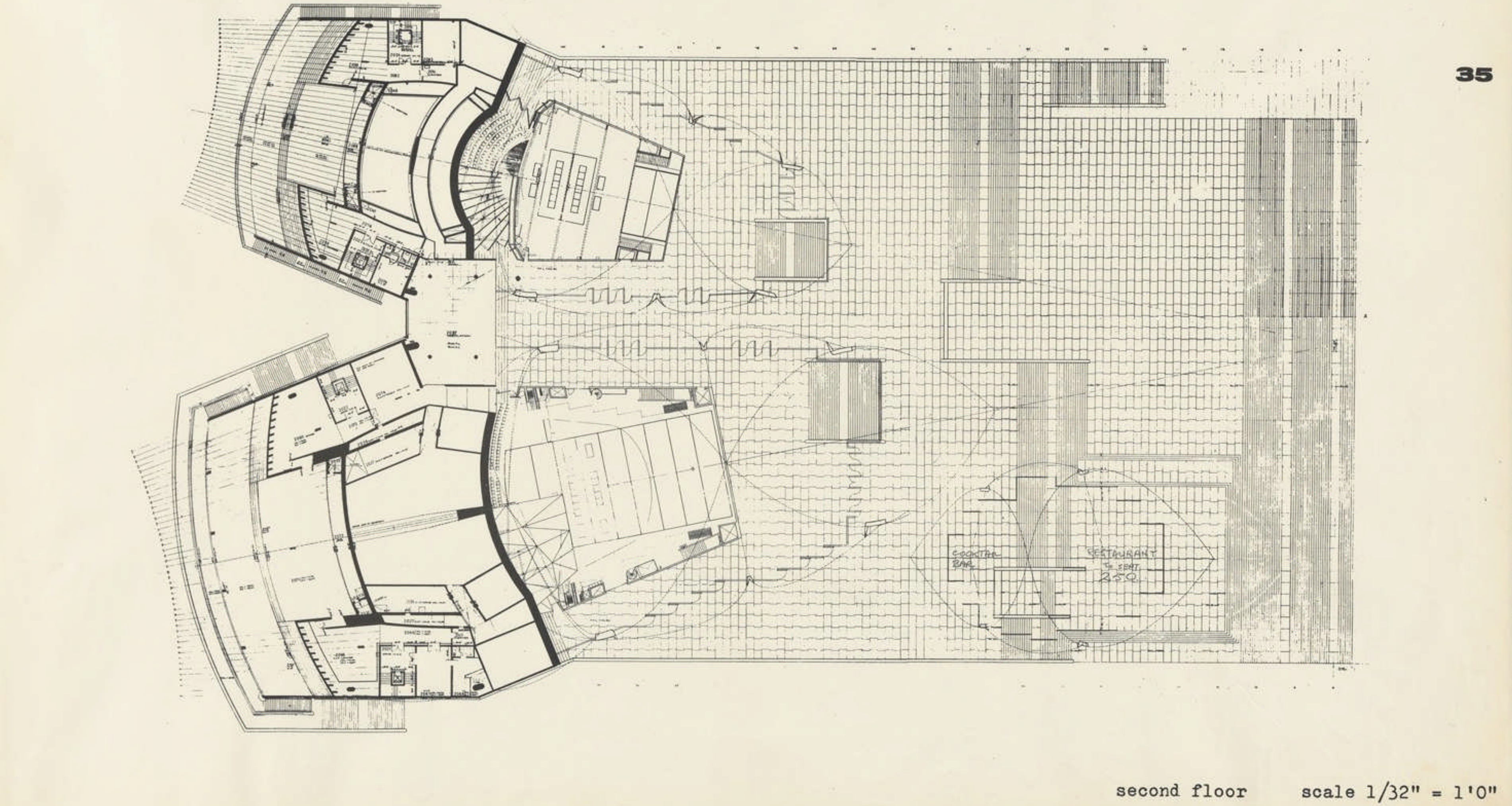
32. Competition Scheme



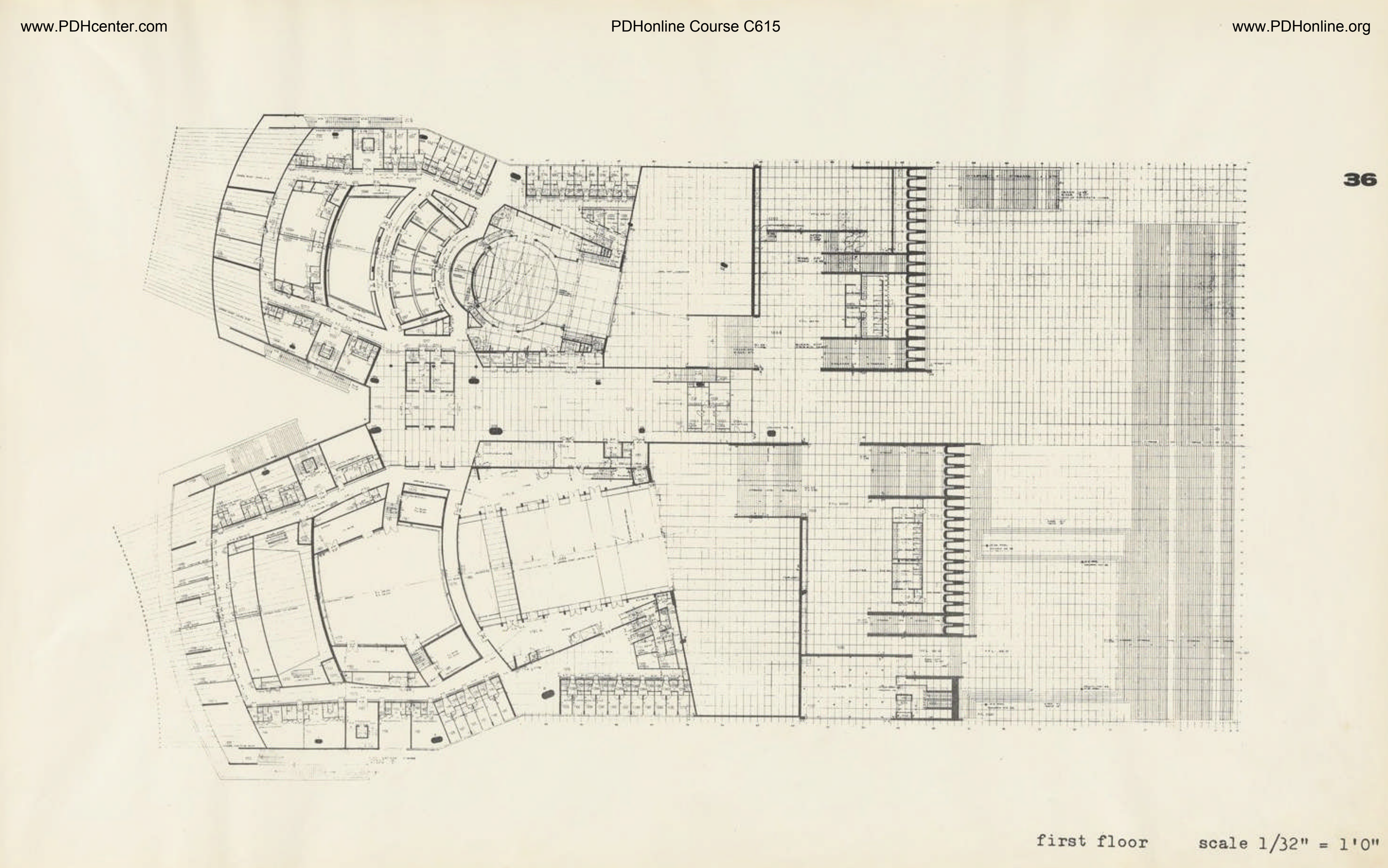
33. Plan of Halls



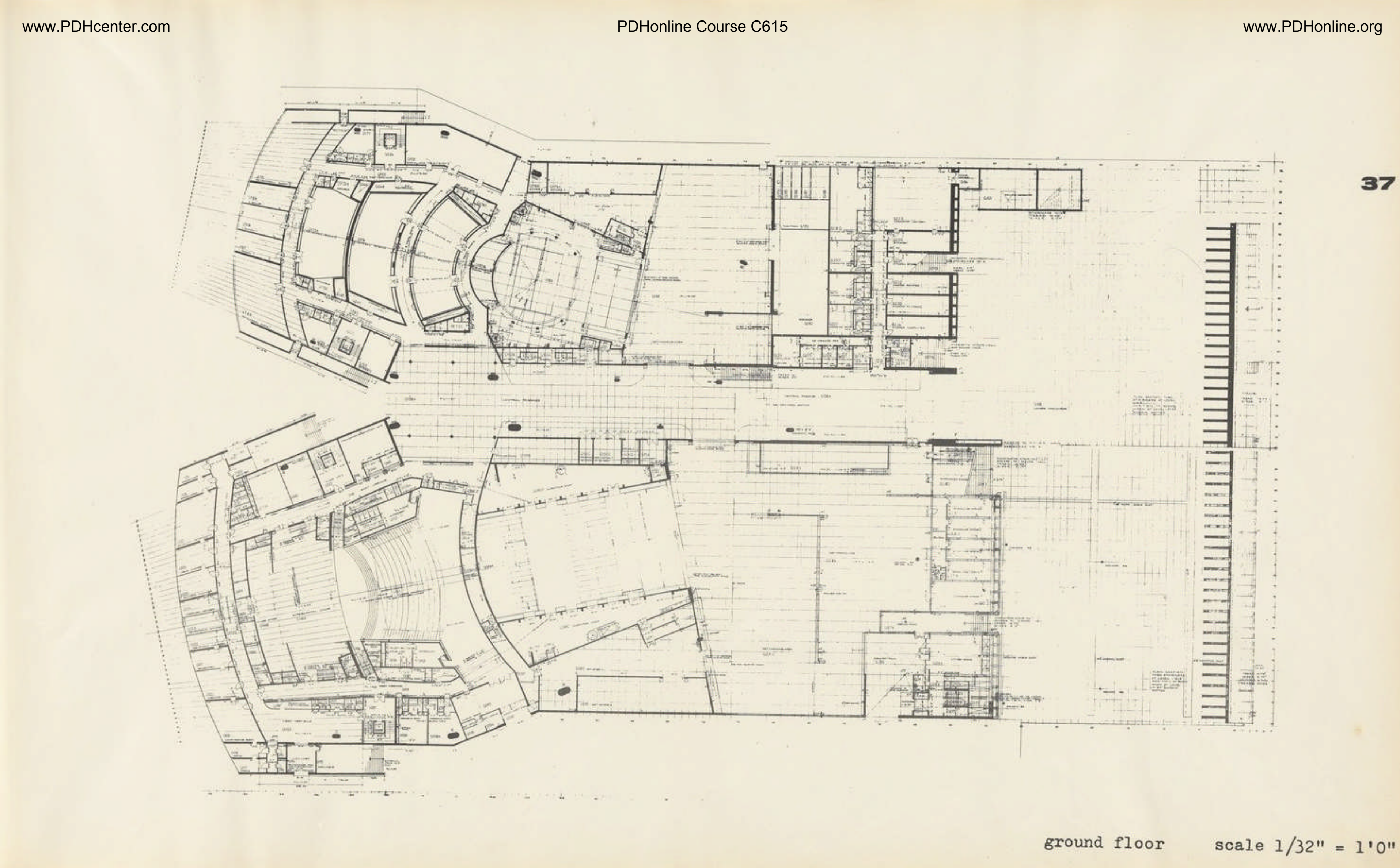
34. Lounge Balcony Plan



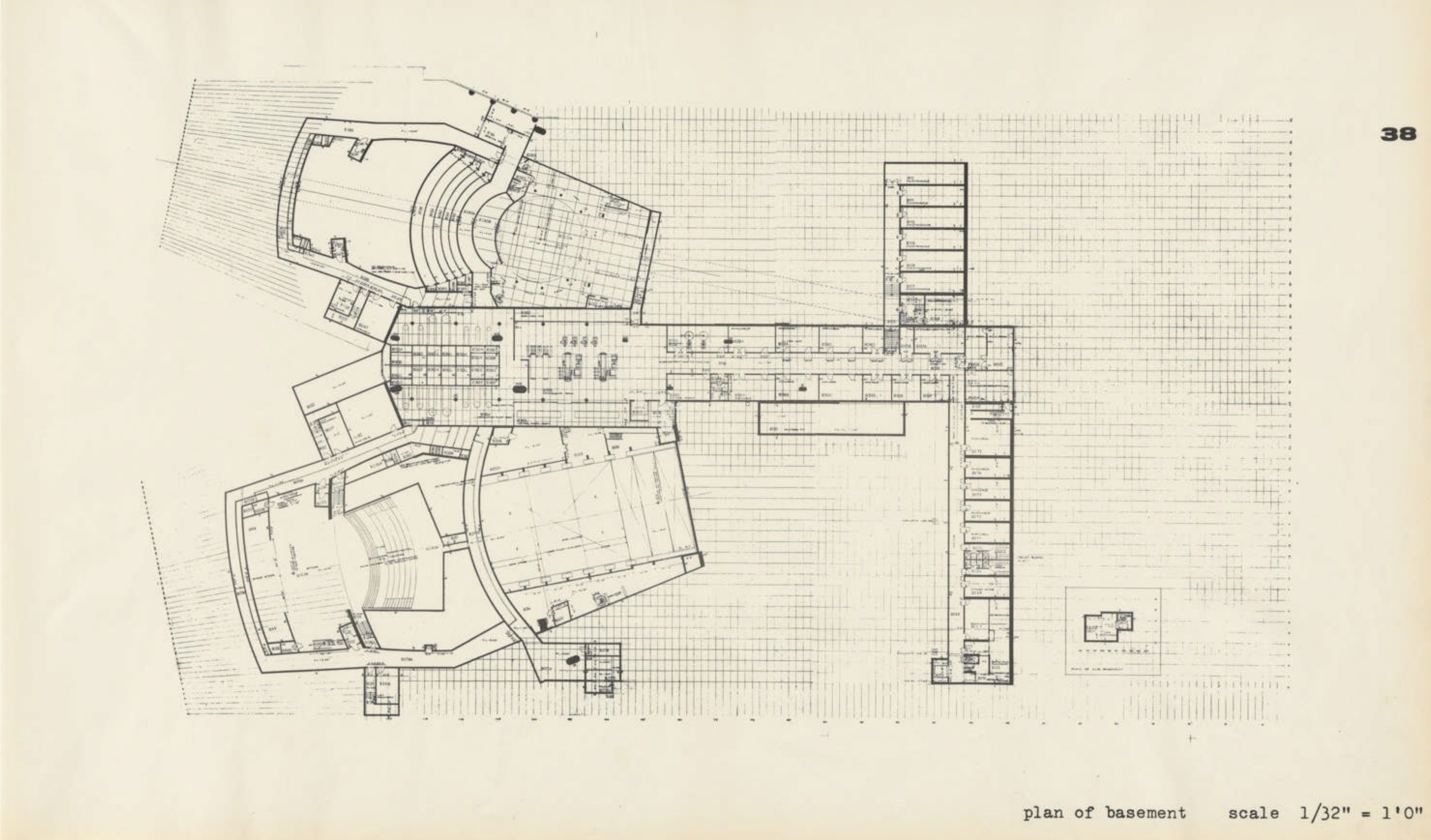
35. Second Floor



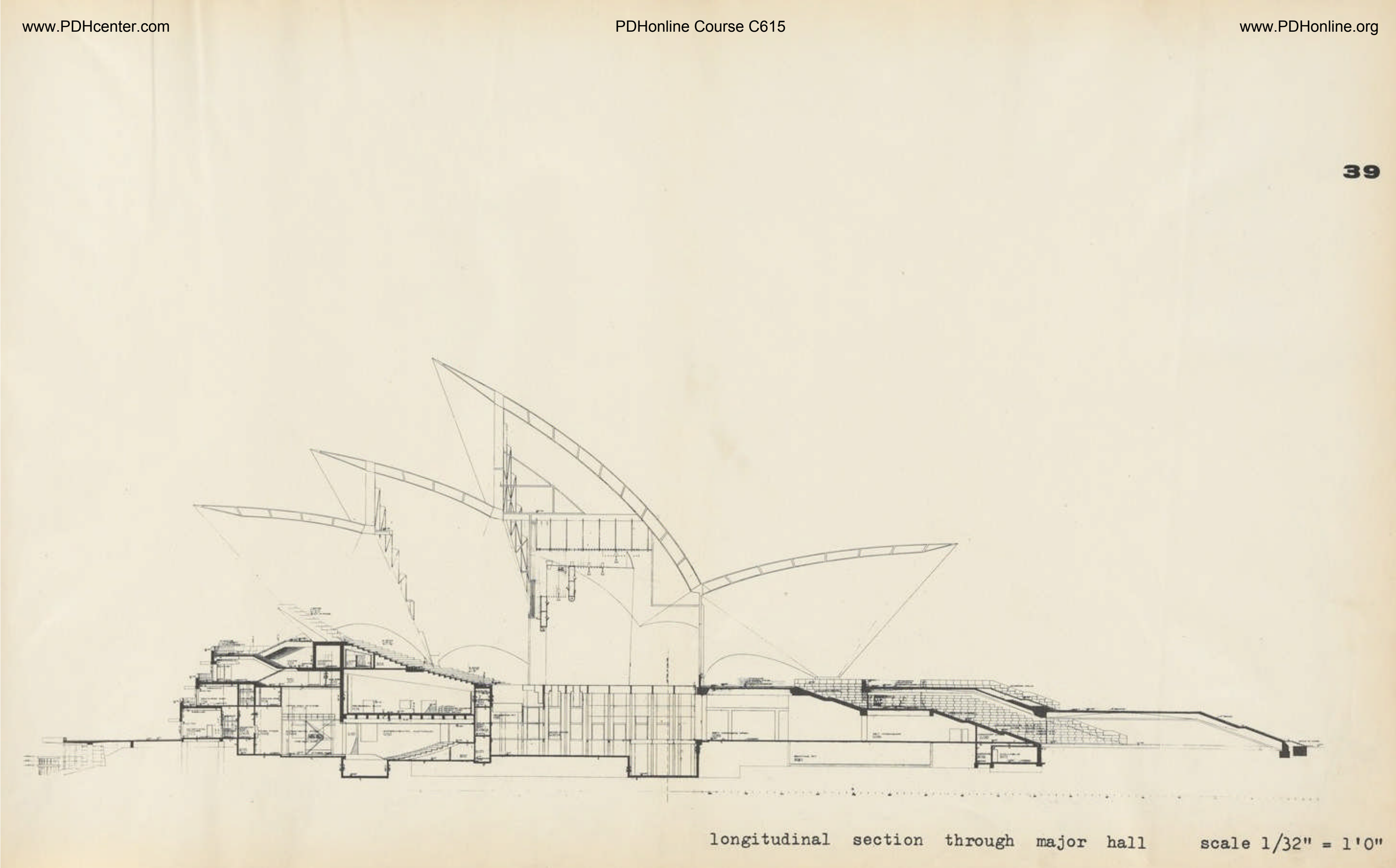
36. First Floor



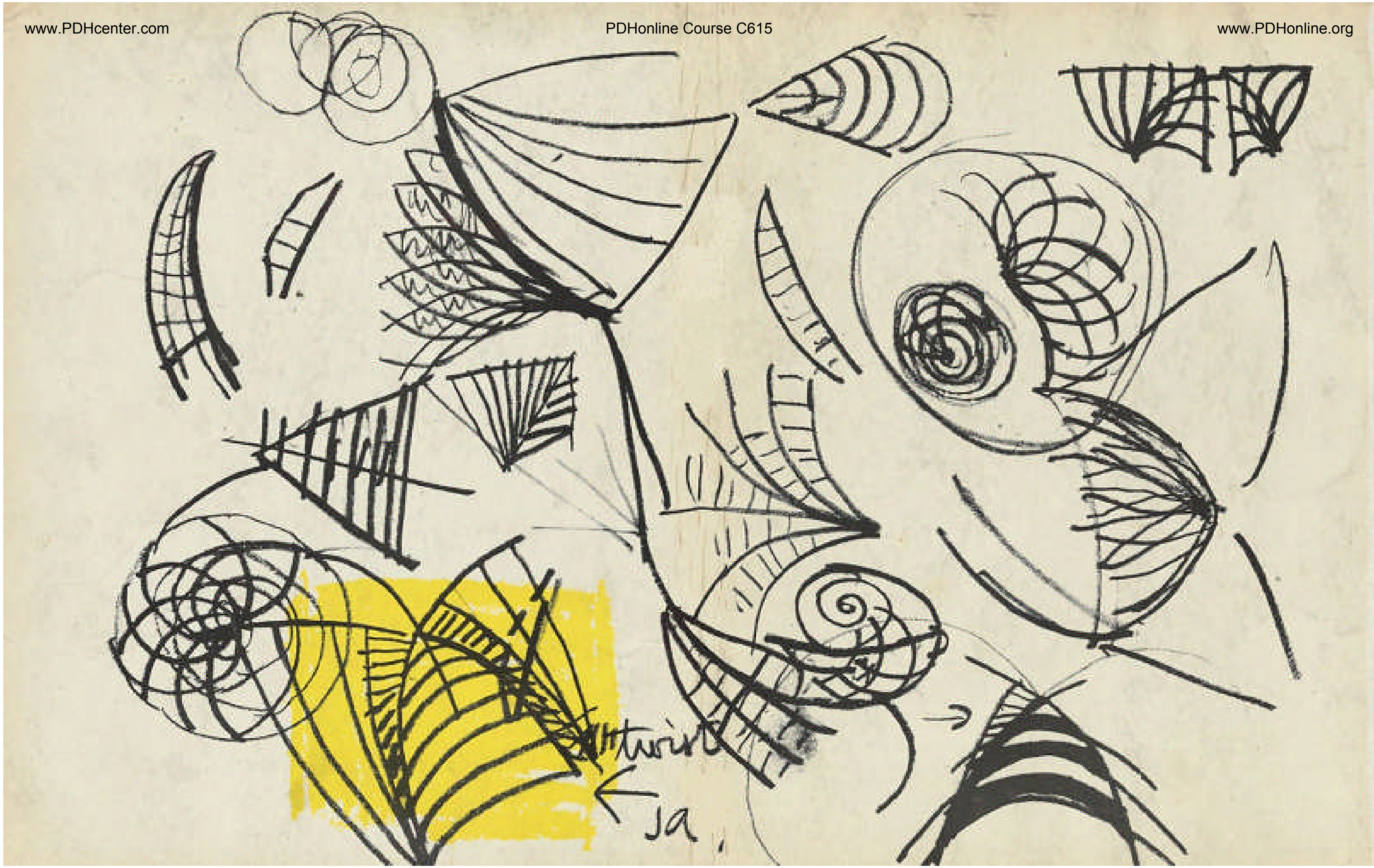
37. Ground Floor



38. Plan of Basement



39. Longitudinal Section Through Major Hall



Back Cover

Part 8

Phantom of the Opera House

The Limits of People’s Patience

"…What Sydney has instead is one of the most implausible and ambitious buildings in history. Still not more than two-thirds finished, it is a soaring, sweeping, eye-popping creation that covers four and a half acres of land, towers 220 feet high over Sydney's beautiful harbor and resembles nothing ever before conceived by the mind of man. Yet, sadly, this testament to man's imagination has not produced any great feelings of elation in Sydney but the sour aftertaste of a long and rancorous argument. The Sydney Opera House is, in fact, a classic example of what can happen when artistic vision collides with the hard realities of money, political necessity and the limits of people's patience. From the very outset, the opera house proved to be the most cantankerous and difficult-to-build structures in the annals of architecture. By the time it is finished it will also have the distinction of not only being the most costly building in Australia but the most expensive opera house in the world…"

Life **Magazine, January 6th 1967**

"The best thing that could happen now would be to saw the thing off and let it sink to the bottom of the harbor"

RE: comment regarding the SOH by a disillusioned Sydneysider (ca. 1967)

"…Over the past ten years the poor building has been so ridden by feuds and calamities that the architect who conceived it finally abandoned all hope and went home to Europe. Meanwhile, the city of Sydney, as the building gradually metamorphosed from civic pride to national disaster, has got so edgy that the mere mention of the opera house calls forth the kind of fervent partisanship that the Aussies have hitherto reserved for horse racing, rugby and war…"

Life **Magazine, January 6th 1967**

The Culture Pitch

"…A newspaper columnist, appalled at the amount of money being spent on the opera house while Sydney needed schools, housing and expressways, snapped that the project was 'an iron lung to end all iron lungs' and accused Sydneysiders of being 'the biggest collection of backwoodsmen, sausage manufacturers and hillbilly politicians ever to fall for the culture pitch…"

***Life* Magazine, January 6th 1967**

Check Book Control

"This I have always termed 'cheque book control' and no other method is equally efficacious...It is very doubtful whether Mr. Utzon has or foresees the engagement of a staff adequate to meet the needs of this gigantic project...These would have to be controlled independently of the Contractor, and in collaboration with Mr. Utzon...To replace him as the designer would present serious difficulties and would cause a scandal with worldwide reverberations."

Bill Wood, Government Architect

RE: excerpt from his report to DPW Minister *Davis Hughes*. By August 1965, Hughes had formulated a strategy to take-back control of the SOH project based on his own convictions and supported by many individuals. Foremost among these supporters was the "bureaucratic method" favored by *Bill Wood*, the Government Architect who was resident in Utzon's office and reporting directly to the government (essentially a spy). Wood's report to Hughes advised the text-book bureaucratic solution of "cheque book control." Whether Intentional or not, it was designed to strip Utzon of his authority as project director by establishing an office of architects to be controlled independently of him. Utzon would either follow the path the powers-that-be decided upon or be forced out. Utzon had been appointed by an act of Parliament thus coercing him to leave of his own accord would be the easiest, least cumbersome way to get rid of him. The "cheque book control" had severely constrained Utzon's ability to operate and he faced a staggering bill from the Australian tax department. Without cooperation from the government, Utzon would be forced to resign and leave the country.

"…it is possible that the action outlined above could lead to friction with the architect...It may be that the government will be faced with the architect not cooperating or, ultimately, wishing to withdraw from the project. Whilst this would indeed be regrettable and have the most serious repercussions both local and international, there can be no justification for permitting the present unsatisfactory position as to preparation of drawings for Stage 3 to continue."

Davis Hughes, NSW Minister for Public Works (August 25th 1965)

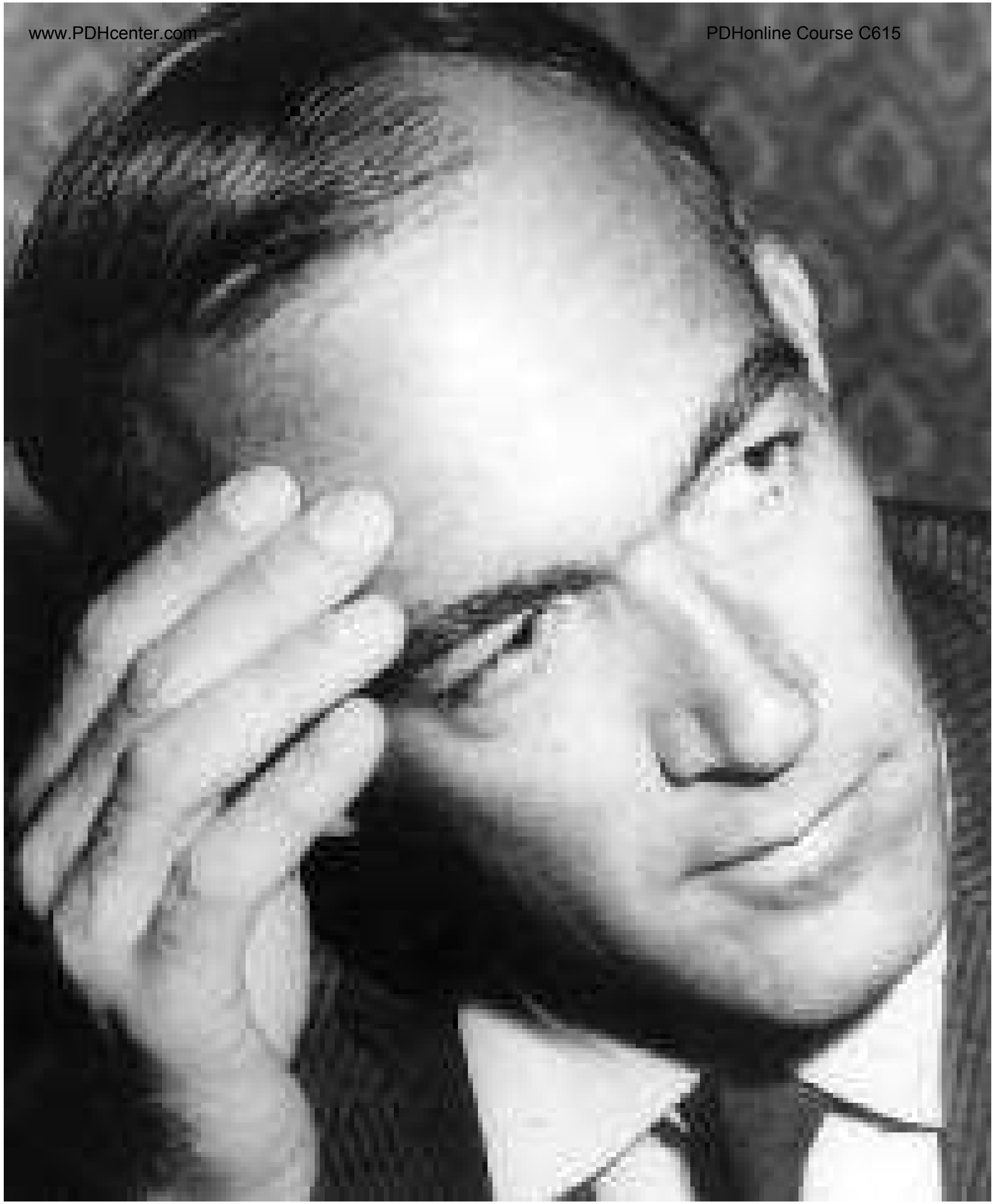
RE: excerpt from report to his Cabinet. Hughes advised his Cabinet that his proposal to bring the project under control might alienate Utzon. For his part, Utzon was beginning to perceive and resent Hughes' blatant lack of respect for both himself and his craft approach to architecture. Another blow came from the Australian taxation office in the form of a ruling stating that he was not exempt from paying taxes on earlier income for which he had previously paid taxes on in Denmark. Effectively, Utzon was being "double-taxed" to an amount equal to his Sydney/SOH income.

"If you resign, all is lost…would be the most dangerous thing to even think of it."
Ove Arup, Engineer

"You obviously do not realize that everything that exists at Bennelong Point today I have been doing personally in my office. Every single piece of concrete has been completely designed and controlled by me...if you do not accept my way of working, I am sorry but you will have to find another architect to carry out the rest of the job."

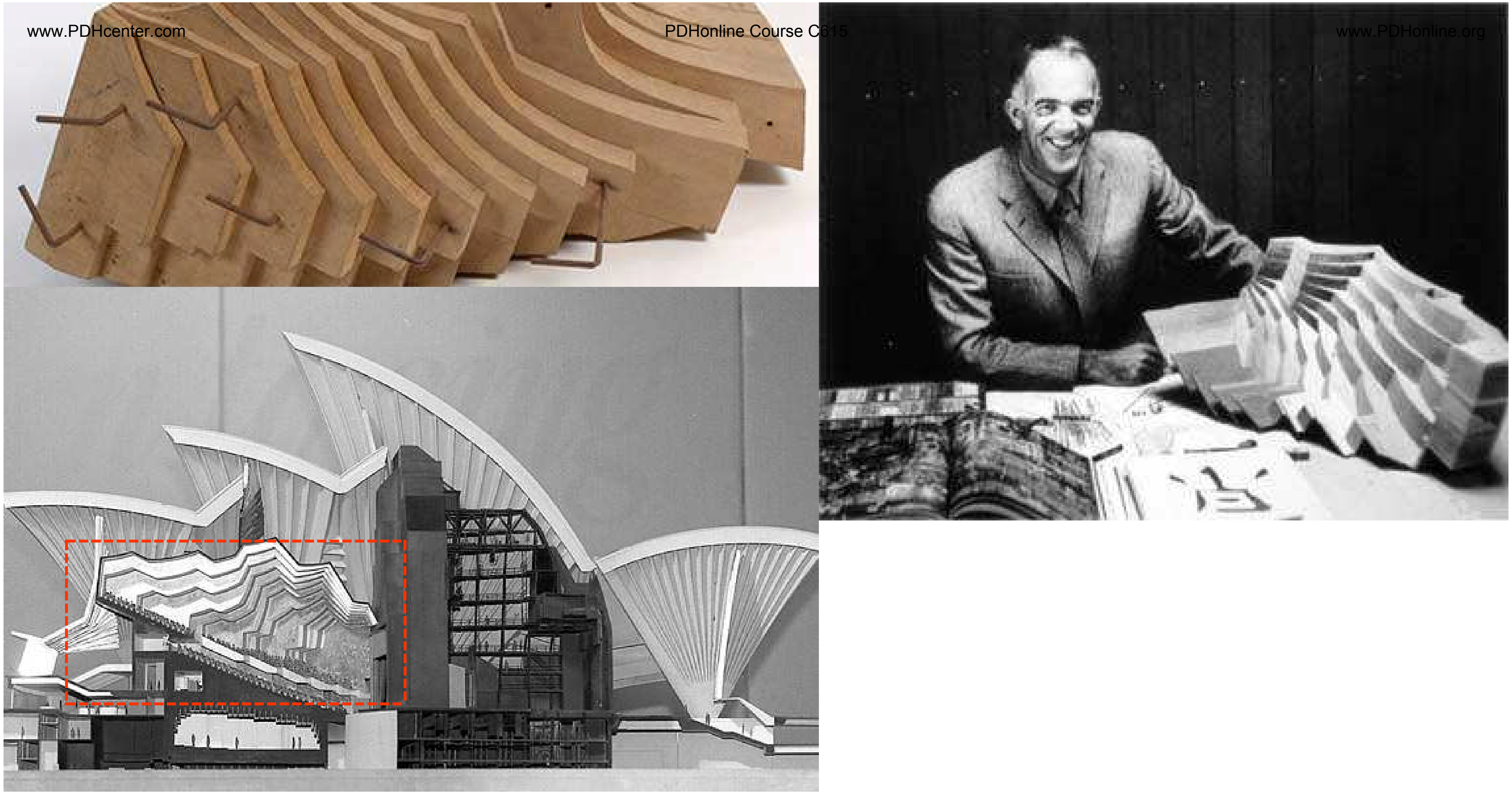
Jorn Utzon, Architect

RE: excerpt from Utzon's letter to Davis Hughes (August 27th 1965). Hughes responded by employing Wood's "cheque book control," stripping SOHEC of the power to pay Utzon and requiring payments be specifically measured against completed work. This was disastrous for Utzon. Toward the end of 1965, Utzon required funds to pay for the prototyping and modeling of his final solution for the ceilings of the halls that would use large continuous plywood beams suspended from the underside of the shells. Before the government would release the funds, Hughes required Utzon to have Arup's approval that the scheme was viable. Arup engineer *John Nutt's* report on viability was sent directly to Hughes, bypassing Utzon; it did not support Utzon's approach. Arup's engineers feared that the proposed plywood ceilings, through the sheer weight of the suspended forms, might bring the roof vaults down. Whether the finished plywood could be delivered from the harbor (through the open vaults of the superstructure) and fitted in place without damaging the finishing was also questioned seriously. When Hornibrook's Director of Construction *Corbett Gore* expressed his doubts as to whether the work could be performed at all and if so, it could certainly not be done economically (in his professional opinion).



"There was a change, to the extent that Utzon was trying to do everything himself. For instance all through 1965, Utzon was developing the interior ceilings and we had virtually no part of it, and so by the time they had reached the stage they had no engineering input from us at that point of time, and we were really the only people who knew the restraints of what could be supported and the like. By bringing the architectural and engineering approach together, solutions could have been evolved but it almost certainly would have been different."

John Nutt, Engineer - Ove Arup & Partners



Utzon with study model/s of the hall ceiling (top left and right) and full model (lower left) of major hall featuring suspended plywood "wave" ceiling that was never realized.

Malice in Blunderland

"…Meanwhile, a new state government, the conservative Liberal-Country party coalition, won the 1965 election and one of its promises was to 'get some sense into the Opera House,' which was now several years behind and $57.8 million above its original estimate. Utzon now had to deal with a new minister for public works, Davis Hughes. One of Hughes' first acts was to tighten up on Utzon's money: in effect, plans had to be produced before any more advances on his fees were given. When Hughes refused to take prompt action on $142,800 that Utzon claimed he was owed, Utzon flung down his resignation. Hughes happily accepted it. Utzon closed his office, had his name removed from the site board at Bennelong Point and in April 1966 flew back to Denmark to become a phantom of the Sydney Opera…"

Time **magazine, October 8th 1973**

"You have forced me to leave the job. As I explained to you, and as you also know from meetings and discussions, there has been no collaboration on the most vital items of the job in the last months from your Department's side, and this also forces me to leave the job as I see clearly that you do not respect me as an architect. I have therefore today given my staff notice of dismissal. I will notify the Consultants and Contractors and I will have cleared the office of my belongings and you will receive my final account before March 14 1966."

Jorn Utzon, Architect

RE: on February 26th 1966, Utzon told his secretary that without cooperation from the government, he would be forced to leave the country. Two days later, under severe stress from the many converging issues, Utzon stood before Davis Hughes, frustrated and angry, and threatened to resign. Hughes told Utzon he could not keep repeating the threat and that it was no way to address a Minister of the Crown. The lack of empathy was too much for Utzon to bear and he walked out. A few hours later (without legal counsel) Utzon had a letter of resignation delivered to Hughes' office in which he accused the Minister of forcing him out capriciously. Utzon would later (famously) describe the whole sorry affair as "Malice in Blunderland."

"Anticipating that this position may arise I have discussed the method whereby the Opera House could be completed with the Government Architect and Senior Officers of the NSW Chapter of the Institute. I am satisfied that a means can be found to complete the planning and supervision of the work... I have already taken steps to ensure that progress on Stage 2 will not be interrupted."

Davis Hughes, NSW Minister for Public Works (March 1st 1966)

RE: on Tuesday, March 1st 1966, the Minister for Public Works rose to his feet in Parliament and announced that Jorn Utzon had resigned from his position claiming he was forced to do so. Hughes had achieved exactly what he had hoped for. Although Utzon remained convinced that Hughes would plead for him to return to the job, the Minister instead wasted no time in shoring up his position. That same afternoon he phoned *Corbett Gore* of Hornibrook and *Michael Lewis* of Arup and was given assurances from both men that their firms would not walk away from the SOH project now that Utzon was gone. Despite the veiled attempts at reconciliation that followed to bring Utzon back as a consultant (with limited oversight), Davis Hughes' strategy appears to have been cleverly orchestrated to deliver a very specific outcome.

The name of architect Jorn Utzon, designer of the Sydney Opera House at Benelong Point is removed from the site board after he resigned his position.

"No architect in the world has enjoyed greater freedom than Mr. Utzon. Few clients have been more patient or more generous than the people and the Government of NSW. One would not like history to record that this partnership was brought to an end by a fit of temper on the one side or by a fit of meanness on the other…It was not his fault that a succession of Governments and the Opera House Trust should so signally have failed to impose any control or order on the project...his concept was so daring that he himself could solve its problems only step by step...his insistence on perfection led him to alter his design as he went along."

The Sydney Morning Herald, **March 1965**

"He didn't want to resign from the project but he had to do something desperate, in fact he even said to me after we were walking back from the last meeting with Davis Hughes 'I'll bet they come running after me.' And of course they didn't."

Bill Wheatland, Architect – Utzon's Office (1964-66)

"Asken had to grasp at every issue that would pull him over and give him victory. It was life or death for Asken. So he ruthlessly exploited perceptions, ignorant perceptions about the Opera House project, and he also knew that he could create a lot of problems for the Labour leadership."

Philip Drew, Architectural Historian

RE: The *Liberal-Country Party* coalition led by *Robin Asken* won the NSW State Government election in May 1965. One of their major campaign promises was to "fix" the SOH. Davis Hughes became Minister for Public Works in Asken's conservative government. Their victory was very controversial and changed the coarse of the SOH's history, for better and for worse.

<u>Left</u>: Minister for Public Works Davis Hughes (left) and Premier Robin Askin (right) tour the Concert Hall of the SOH during construction (1972)

"Had we listened to what Davis Hughes was saying in his electorate, saying how he was going to take over the Opera House, had we heard that we might have been a bit more wary. But it was just a gradual process that overtook us, where Davis Hughes brought in another architect from the Public Works Department to oversee what Utzon was doing. They just simply wanted to control him. They just wanted to take over and control him and of course you see the results. They eventually controlled him right out of the place."

Bill Wheatland, Architect – Utzon's Office (1964-66)

"At an election night dinner party in Mosman, Hughes' daughter Sue Burgoyne boasted that her father would soon sack Utzon. Hughes had no interest in art, architecture or aesthetics. A fraud, as well as a philistine, he had been exposed before Parliament and dumped as Country Party leader for 19 years of falsely claiming a university degree. The Opera House gave Hughes a second chance. For him, as for Utzon, it was all about control; about the triumph of homegrown mediocrity over foreign genius."

Elizabeth Farrelly, Australian Architecture Critic

"Utzon was thirty-eight when he won the competition for the Opera House – how would the work of the mature master have enriched our lives? We'll never know. That's the high price Sydney has imposed by its incompetence in building the Opera House."

Professor Bent Flyvbjerg

That Awkward Creature

"…When Utzon was forced out, his supporters raised a storm of protest; architects of the caliber of Louis Kahn, Richard Neutra, Walter Gropius and Paul Rudolph cabled their petitions to reinstate him; there was even a street demonstration in Sydney **(left)** ***involving 1,000 people, against Davis Hughes. It had no effect. The government wanted to be sure of finishing the Opera House without that awkward creature, the architect as uncompromising artist…"***

Time **magazine, Oct. 8th 1973**

"…The Sydney University Architecture Club, to show Utzon he wasn't alone, printed some of Michelangelo's disgruntled letters about his problems with the Philistines over St. Peter's. A prominent Sydney sculptor went on a three-day hunger strike, and one impassioned partisan kept writing letters to the premier headed, 'Do Not Crucify Utzon this Easter!'"

***Life* Magazine, January 6th 1967**

"No one can replace Mr. Utzon, the perfectionist with fantastic integrity...No consortium, no committee, has ever – or ever will – create a work of art."

Bruce Rikard, Sydney Architect

"The only architect technically and ethically able to complete the Opera House as it should be completed…"

RE: quote from the petition signed by 75 (of 85) Government Architects, Public Works Department. Written by Ted Mack, Architect (later Mayor of North Sydney). National and international associates, famous architects, friends and strangers alike were calling for his return and many supporters (1K) took to the streets in protest. To some, the treatment of Utzon was indicative of a wider social malaise that prevailed in Australia at the time. Utzon's very personal creative battles seemed to symbolize the increasing irrelevance of many "establishment" values. Utzon's treatment became another cause for tension and dissent in a time when ethical, social and political questions were being raised alongside the generational division of sentiment concerning Australia's involvement in the Vietnam War. Prominent Australian Architect *Harry Seidler* and *Hall Missingham*, Director of the *Art Gallery of New South Wales*, rallied other architects, students, intellectuals and laborers onto the streets, converging at Bennelong Point for speeches then marching to Parliament House to deliver a petition of 3K names to Premier Askin calling for Utzon's reinstatement. *Patrick White* and *Denis Winston*, Dean of Architecture at Sydney University, led the march alongside Seidler and Missingham. Utzon described the protest as "Marvellous." The idea of SOH had, for almost a decade, been a powerful symbol of cultural aspiration. Now it seemed to embody an ideological divide between the old and the new in Australian society.

"It would seem I am merely to prepare designs in accordance with instructions and leave it to others to supervise construction. Such a proposal is not only unpractical but quite unacceptable to me. I am at all times prepared to work with them as your representatives, but not under them...It is not I but the Sydney Opera House that creates all the enormous difficulties."

Jorn Utzon, Architect

RE: throughout the affair, Utzon maintained publicly that he was the only man to finish the job. Behind this outward facade, he was conflicted about returning to the job under the government's new terms as a subordinated design consultant, Utzon warned Hughes that the architects who took over in his absence would be starting from zero and coming straight back to the minister "as soon as they realized the difficulties." On March 7th 1966 (after meeting with Premier Askin the previous day), Utzon had a long meeting with DPW Minister Hughes in which a proposal was made to Utzon offering him reinstatement as the architect responsible for design (contingent upon a critical review of practicality by a panel of architects and Arup) – all other matters, especially management, would be handled by the government appointee/s. Utzon refused the offer outright.

To Kill an Opera House

"I am out of it, it is finito and there is nothing I can do about it. I have already designed every line, every corner, every piece of surface. To kill the Opera House may take a long time. But it is dying and sick on the bed now."

Jorn Utzon, Architect

RE: On March 10th 1966, the president of the *Royal Institute of Architects* convinced Davis Hughes to meet Utzon in secret. They met in a motel room in *Lane Cove* where Hughes made a slightly modified offer than that of March 7th and gave him until March 15th to decide to accept it or not. Many people; friends, family, colleagues etc., pleaded with Utzon to return. Jack Zunz sent a telegram to Utzon stating that SOH without him would be "too black to contemplate." Ove Arup told *The Sydney Morning Herald* that it was all attributable to "a clash of personalities." On the 15th, Utzon wrote to Hughes ruling out the Lane Cove proposal but made a proposal of his own. He (Utzon) would continue as the design architect with the assistance of a panel of architect/consultants to be appointed by the Minister for Public Works. Hughes was unwilling to compromise the government's position and on March 19th 1966, the announcement by Davis Hughes of the appointment of a panel to complete SOH closed the door on Utzon's return once and for all.

"How can you leave this child of yours to be messed up by other people?"

Ove Arup, Engineer

RE: Utzon terminated his Sydney staff, closed the Palm Beach office and sent Hughes a bill for $480K for outstanding fees. Hughes promised to investigate the matter while Utzon responded that he would not release his Stage Three plans unless and until the bill was paid in full. Later, a compromise was reached whereby Utzon received $150K and turned over the Stage Three drawings to the DPW. Utzon's fees included 4% of the cost of work when a consultant was involved, 6% when only he was involved. From these fees, Utzon paid his SOH staff slightly over $A1.25 million.

This Crazy Mad Shape

"Nobody has pinned down the details of what's to fill the spaces. You have to have a three-dimensional mind to fit things into this crazy mad shape. You look at the drawing and you get scared stiff."

SOH staff architect (post-Utzon)

Why Worry?

"Went to Yucatan. The ruins are wonderful. So why worry? Sydney Opera House becomes a ruin one day. "

Jorn Utzon, Architect

RE: postcard inscription from *Jorn Utzon* to *Bill Wheatland*, May 1966. On the April 28th 1966, Utzon and his family flew out of Sydney in secrecy. He would never return to Australia. Stopping in the Yucatan, he revisited the Mayan temples that had inspired his vision for the SOH. For Utzon, the sense of loss and disappointment would endure for many years. A decade before, he had won the competition and though young and inexperienced, he had risen to the occasion. Yet, it was his relentless pursuit of perfection that caused his undoing. Utzon withdrew from the project as an artist unwilling to compromise his vision and/or contemplate anything less than his imagined ideal. Thus, he never wished to set eyes upon the imperfect result.

Strike Breaker

"He will inevitably solve every problem that has arisen since he took over – and every one that arises from now on – differently from the way Utzon would have solved them. His solutions will certainly be more rational, more predictable, and probably much more in line with the consensus in world architecture at this time"

Robin Boyd, Architectural Critic (1967)

RE: the appointment of 34yo *Peter Hall*, as design architect for the SOH project to replace Utzon. Hall was a bureaucrat at heart but an admirer of Utzon. In 1959, hoping to work in his design studio on the SOH, Hall traveled to Hellebaek, but was unable to spend enough time to be of use to Utzon. The "consensus" referred to was *Functionalism.*

"...I don't think I have a philosophy of architecture so much as an approach to it...I do not see merit cultivating a style and imposing it...rather the reverse should apply - the problem should influence the way in which the spaces and materials are arranged...to produce a work which gives the users a good experience."

Peter Hall, Architect

RE: excerpt from a letter to a friend. Hall had little patience for architectural critics and/or his peers who espoused their "Philosophy of Architecture"

Even before Utzon had left Australia in April 1966, Davis Hughes and Government Architect *Ted Farmer* began organizing a team to take over the SOH project. Farmer planned to select a partner from two separate firms. *David Littlemore* would manage construction and, on Davis Hughes' personal recommendation, *Lionel Todd* would oversee the contract documentation of the project. Farmer offered the critical role of design architect to both *Col Madigan* and *Ken Woolley* - both turned him down. He then turned his attention to *Peter Hall* who had recently assisted him in designing the *Goldstein College Dining Hall* and had won the prestigious *Sulman Award* from the NSW *Royal Australian Institute of Architects.* Peter Hall, until this time, led a charmed life. He attended Sydney's prestigious *Cranbrook* and went on to obtain a combined architecture and arts degree at *Sydney University*. At the end of his studies, he was awarded a travel scholarship which afforded him twelve months in Europe during which time he visited Utzon in Hellebaek. Upon his return to Australia, Hall went to work for Ted Farmer at the DPW, resigning in early 1966 to pursue his own practice. It was at this point in time that Farmer approached him with the SOH offer. Hall accepted the position on the condition that there was no possibility of Utzon returning. After getting a confirmation directly with Utzon that he would not be continuing, Hall accepted the position. Eight days later, Utzon and his family left Australia for good. when Peter Hall had accepted the job he was under the impression that he would be following Utzon's plans. Hall, Farmer and Littlemore reviewed Utzon's work to-date and were unanimously shocked by what they found. There were sketches and designs, but no working drawings. Hall had accepted the job believing that he would simply be following Utzon's plans.

The Long Opera House Opera

"Somebody someday should write an opera about Sydney's Opera House. Since Danish architect Jorn Utzon, whom many colleagues call genius, won the $10,000 contest with a set of unfinished drawings, the venture has been full of excitement and uncertainties. Nowhere have builders made a roof so tall and daring in shape, and many problems remained unresolved when the contract work began. The first estimate (not by Mr. Utzon) of the full cost was $7,200,000. Later it was decided that the base of the building should be of concrete instead of sandstone and the roof assembled instead of being poured on the spot, and its shape somewhat altered. Engineers worked on in a seventh heaven of technical challenges while the public steadily bought tickets in the lotteries which paid the bills; but human strains have mounted with the cost. Current climax in the long Opera House opera – now is the third of its scheduled four acts - came with uproar over architect's resignation announcement. Estimated date of completion of job, 1969 (it had been originally expected to take something over four years). Estimated cost, $50,000,000, plus a million or two for a car park."

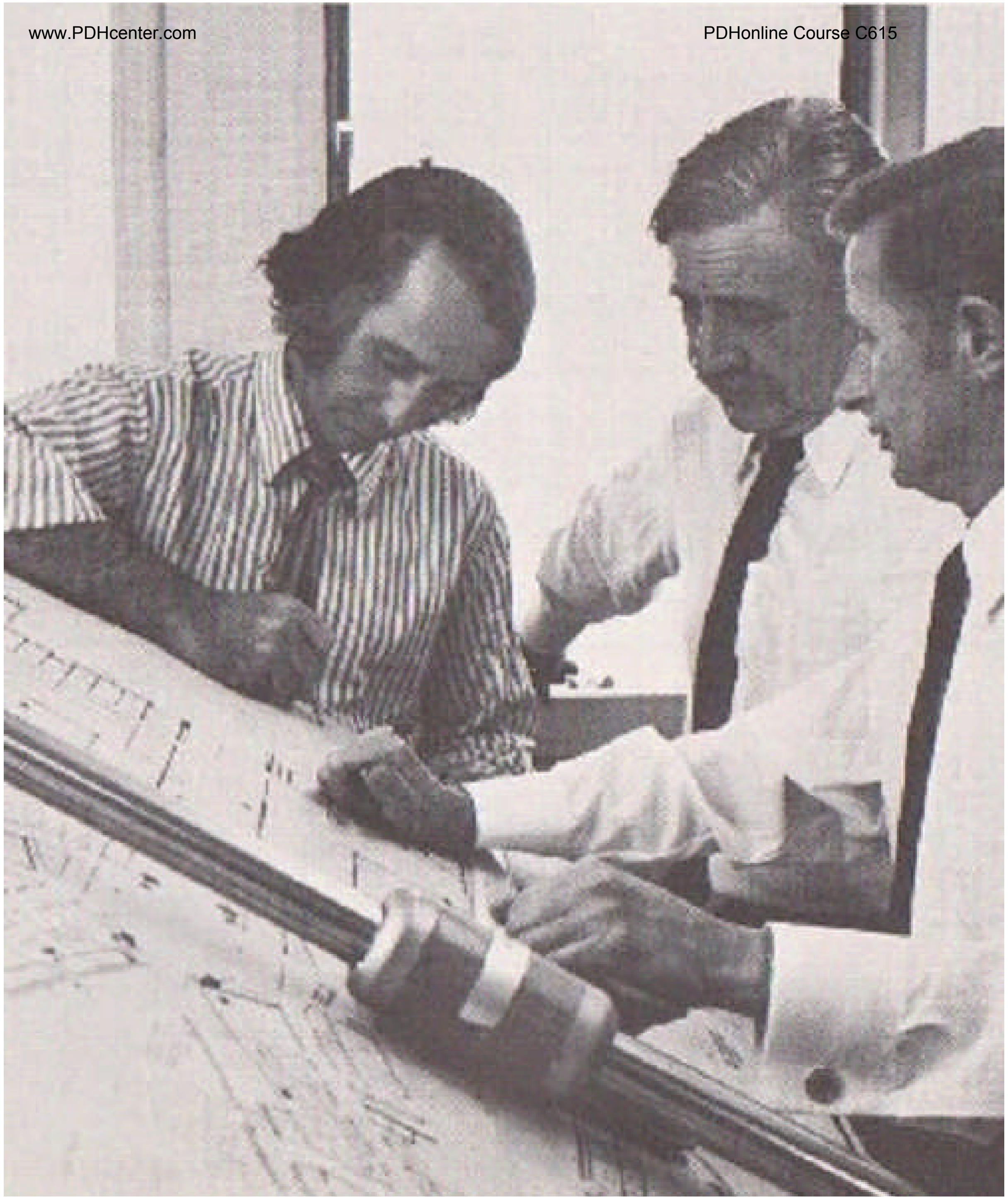
***The Australian Woman's Weekly*, March 16th 1966**

RE: in fact, an "opera about the opera" entitled: *The Eighth Wonder*, whose subject is the SOH, premiered at the SOH in 1995

"I'm overwhelmed – but I think I can finish the Opera House"

Peter Hall, Architect

RE: quote to *The Daily Mirror*, April 20th 1966. Hall faced an enormous task. He had to complete all of Stage Three, including the interiors of both halls (as well as the glass walls) and all supplementary spaces. It came as a shock to discover that the scope of the work required would be on a much larger scale. Hall spent three months overseas visiting Utzon's SOH consultants and *Willem Jordan* with whom he would collaborate on the hall's acoustics. He also visited concert halls in Japan, Europe and America. His first conclusion was that the dual-purpose concept for the major hall was unworkable and should be abandoned, relegating opera to the minor hall. The *Elizabethan Theatre Trust* did not take this suggestion lightly arguing that the major hall – dating back to the competition, was intended to host Grand Opera. On the other hand, ABC was pleased that the SSO would be the primary client of the major hall, with certain provisos.



"...They have only been given prints of old drawings relating to what has been built and nothing on all the new parts..."

Prip-Buus, April 3rd 1966

RE: not only were working drawings and proper contract documents missing, but drawings and/or sketches illustrating Utzon's most recent thinking on Stage Three were nowhere to be found. Approximately 5K sketches and drawings were placed in storage by Utzon's main assistant *Bill Wheatland*, where there they remained unseen until 1972.

<u>Left</u>: Hall, Farmer and Littlemore at work (ca. 1967)

"This is disappointing. This was an issue that deeply divided the profession at the time, and it's regrettable that its been brought to the surface again now. Leading members of the profession at the time were extremely unhappy for any architects to take on work that Utzon was forced to abandon. If no one had done it, Utzon might have come back. This is contrary to the spirit of the earlier award."

Ken Maher, former president of the NSW Royal Australian Institute of Architects

RE: Maher, the institute's 1992 president, had bestowed upon Jorn Utzon a commemorative *Sulman Medal* (for a public building) in 1992. He resented the fact that Peter Hall was posthumously awarded a "25-year award" for his work on the Concert Hall and Opera Theatre (eleven years after his death) in January 2006.

"…Among the major achievements of Australian architects of the 1960s and 1970s…stand with Utzon's great vision and magnificent exterior, together forming one of the world's great working buildings"

RE: jury citation for Peter Hall's posthumous "25-year award." The interiors designed by Hall have long been criticized as ordinary compared with the exterior and Hall is still seen as a strike-breaker by Jorn Utzon's fans and disciples for willingly working for the NSW state government as Utzon's replacement after they had made circumstances too difficult for Utzon to stay-on (by cutting off his funding to pay his staff).

"…And on the 28th of April, Jorn Utzon – with his wife and three children – stole out of the country, reportedly under an assumed name. Though Utzon was gone, the troubles of the Opera House were not…Among other things, the committee in its original plans had not called for a parking lot, and building one now could require blasting space for a thousand cars out of solid rock. When a new team of local architects took over Utzon's brainchild, they found they couldn't make head or tail of much that Utzon had left behind for them to work with. Some parts of the building he had only sketched, leaving undefined how large areas were ultimately to be treated…"

***Life* Magazine, January 6th 1967**

RE: Utzon departed Sydney with his family on April 28th 1966, leaving behind many questions and ambiguities concerning the design of the SOH

"…Utzon had left a lot unsolved – the detailing of the glass walls, the seating, the ceilings. It was not an easy legacy, but Hall and his partners settled for what Utzon would never have tolerated: less than complete control over the building. The result was a series of compromises with Utzon's ideas, varying between efficiency and tattiness. For example, the problem of operatic staging in the main hall was not solved but simply dismissed – by moving opera to the second theater and demoting the main hall to concert use only…"

***Time* magazine, October 8th 1973**

<u>Caption</u>: ***"What about this compromise? We use it only for concerts but you can still call it 'Opera House.'"***

"The new government wanted the halls to be exchanged. The large was to be the Opera House, and the ABC who had a lot of influence in the new government, they said 'no it should not be a concert hall, the small hall should become the Opera House' and that meant enormous re-planning. Virtually the whole interior of the building was altered beyond recognition. The kind of structure, the ceiling, the waves that Utzon had inside which would have been quite magnificent to see really, has been altered beyond any resemblance. And now of course people are really sorry that that's what happened because you know they can't put Aida on in the Opera House as it is, so they have to make do with a makeshift affair inside the concert hall, if they have a really grandiose opera that requires enormous spaces."

Harry Seidler, Australian Architect

"I understand that your Government has now finally decided to abandon the idea of using the Major Hall for opera. It is a very dramatic – almost one might say, tragic – decision because it makes a nonsense of the whole form of the shells, which were meant to house the stage tower."

Ove Arup, Engineer

RE: excerpt from correspondence to *Davis Hughes*, March 28th 1967. Through 1966, *Hall, Farmer* and *Littlemore* worked to establish a new brief for Stage Three. It would need to incorporate the revised requirements of the principal users of SOH, particularly the *Australian Broadcasting Commission* which, the government insisted, should be convinced that changing its venue from *Sydney Town Hall* would be worth the effort. The ABC required both a sufficient concert hall in which the SSO could perform for 2,800 people while providing an appropriate recording environment. In December 1966, they submitted their proposals for Stage Three. They recommended the major hall be designed purely for concerts and not as a dual-purpose venue as originally conceived. When Hughes accepted their approach, *Ove Arup* wrote to Hughes, dismayed over the decision. The change was of profound significance. While alleviating the complexity of having to create a dual-purpose hall with different reverberation times for opera and concerts, it also meant that the complex and expensive stage machinery already installed would have to be removed. Opera productions were consigned to the minor hall, and theatre to the smaller spaces within the Podium, beneath the main hall. At the time, the decision had the further implication (for the performing arts) of establishing opera and theater as subordinate to concert productions.

"It is a pity that the ABC had not stated these requirements before the competition in 1957. This would have avoided the principal difficulties of the project which arise from the planning of two multipurpose halls of different capacity."

Professor Lothar Cramer, Acoustical Consultant

RE: excerpt from a letter to *Peter Hall* date August 30th 1966. On February 24th 1966, *Professor Cramer* had shocked Utzon telling him that even with the latest changes, SOH was unsuitable as a venue for the SSO.

"In the years that followed I was often asked questions about the Opera House, questions that kept the building very much alive for me and my family. No other work I have been involved in since my work with the Opera House has so changed my life…"

Jorn Utzon, Architect

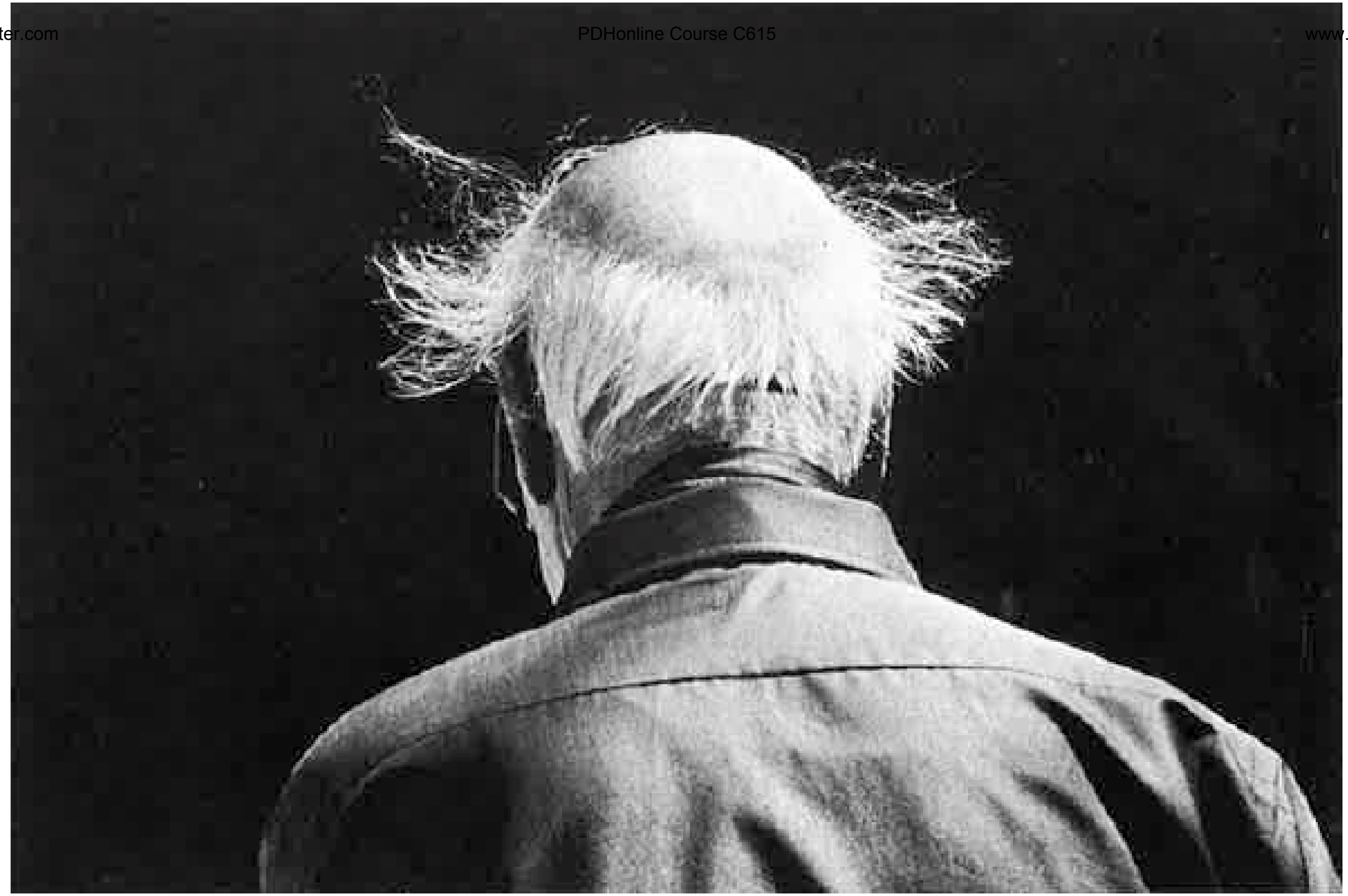
RE: comment made in 2006. To those who worked closely with *Jorn Utzon* in the heady days of the mid-1960s, it became clear to some of them that he was more interested in the solution to problems than the problem itself. Utzon was inclined to say he had solved problems. In fact, what he really meant was he had done so in principle only (Ove Arup would later say that he was allergic to Utzon's extensive use of this statement). While lying on a Hawaii beach (in 1962), Utzon told *Jack Zunz* that he didn't care if the SOH was never finished. To his way of thinking, the problems had already been solved and he could already see the completed building in his mind's eye. Utzon would repeat this mantra many times in the coming years. It was as if the physical realization of the actual building was less important to him than the idealized image of it in his mind.

Total Architecture

"... the two men - and their teams - enjoyed a collaboration that was remarkable in its fruitfulness and, despite many traumas, was seen by most of those involved in the project as a high point of architect/engineer collaboration."

Peter Murray, Author

RE: *Ove Arup* believed that in *Jorn Utzon* he had found the perfect architect with whom to collaborate in his personal quest for "Total Architecture," an approach which dissolved the gap between engineers and architects which he had been seeking his entire career. At the height of the Sydney drama, Ove Arup traveled to Sydney and offered Utzon his resignation in order that he and the project get a new start with a fresh structural engineer. Utzon declined the offer and told Arup he would not work with anyone but him. Many years later *Povl Ahm*, a mutual friend of both Arup and Utzon, took Arup to Hellebaek. Leaving Arup in the hotel room, he went alone to see Utzon at his home in the Beech forest. Utzon refused to see his former colleague. In 1978 (at a reception in London for Utzon's winning of the *Royal Gold Medal for Architecture),* the two men met for the last time. They shook hands and spoke a few words. The brief exchange was characterized by the profound loss experienced by both men on the project that had made both of them famous.



"We have realized that only intimate integration of the various parts or the various disciplines will produce the desired results"

Ove Arup, Engineer

An Ongoing Process

"Some years ago I was walking with my father around the great Cathedral in Palma, Mallorca and we were admiring the construction space, the windows and the glazing and so on. My father asked one of the custodians 'when was this church commenced, when did they start building this church?' and the guy said eleven hundred and something and my father said 'when did they complete the building?' completed the guy said 'oh, it hasn't been completed yet it's an ongoing process!' After that my father turned to me and said 'look this is why I think it has been a wonderful event in my life to have been allowed conceiving the idea of the Sydney Opera House, to have been allowed to work on the Opera House and with the Opera House for so many years. To know that it is continuing and that people are fond of the building and that it will be a centre for the arts for people in Australia for many years to come. It is because of that, I am not that sorry I wasn't there to complete the building as I envisaged. Because as you can see this church has been created by someone and other people have taken over after the initial architect and builders started the building and then that has been going on for centuries and we still have a wonderful building that everybody loves in the centre of the city.'"

Jan Utzon, Architect

Part 9

Shell Game

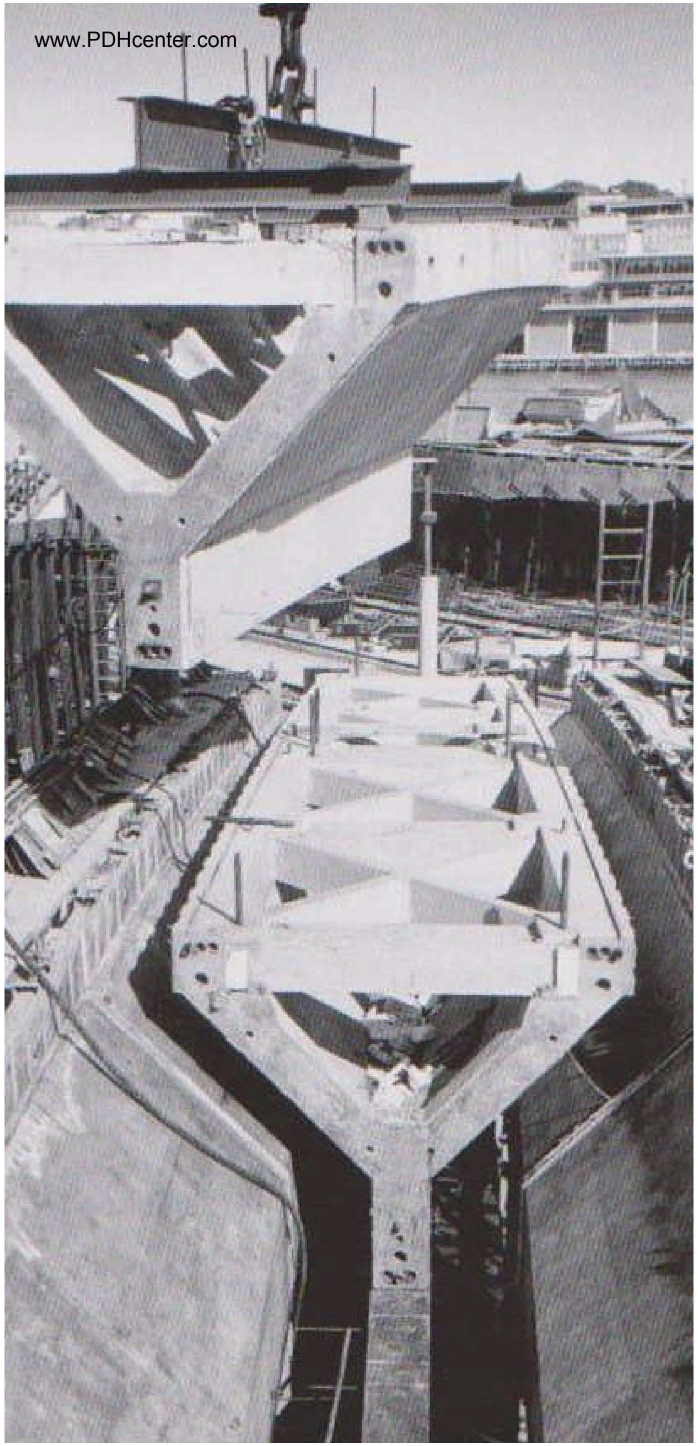
Officially, Stage Two commenced at the beginning of 1963 though the site seemed unchanged until the first pedestal was positioned in November 1963. This added to the public perception that little in the way of progress was being made; the opposite was true. The Podium columns (bearing the load of the roof shells) were too weak and required strengthening; a process which lasted into the spring of 1963. *Jack Zunz* fell on his sword declaring the delay and additional cost his own fault since increased gravity load/s on the Podium columns resulted by dividing the roof into three distinct structures (pursuant to the *Spherical Solution*). The Queensland-based firm *Hornibrook Ltd*. (which had won the contract for the superstructure) moved onto the site on March 24th 1963 to begin construction. Hornibrook's job foreman was *Corbett Gore -* a highly capable and impressive personality. Under Gore's leadership (along with four engineers from Arup), the superstructure began to take form. Stage Two took three years to complete; an entire year longer than anticipated.

A Most Amazing Thing

"Although pre-cast concrete was being used in much of the world, building such geometry wasn't, and I think it was quite remarkable the way these unusual shapes were harnessed to be able to be made by consistent formwork. And the whole idea of putting these elements together like a string of pearls and threading high tensile steel through them and tightening them up as it were; it's really the pre-stressed concrete that holds up the whole structure. People call it a shell but it's not really that. It was claimed very much in all the technical press – both structural and architectural – that it was a most amazing thing that was happening in Australia."
Harry Seidler, Australian Architect

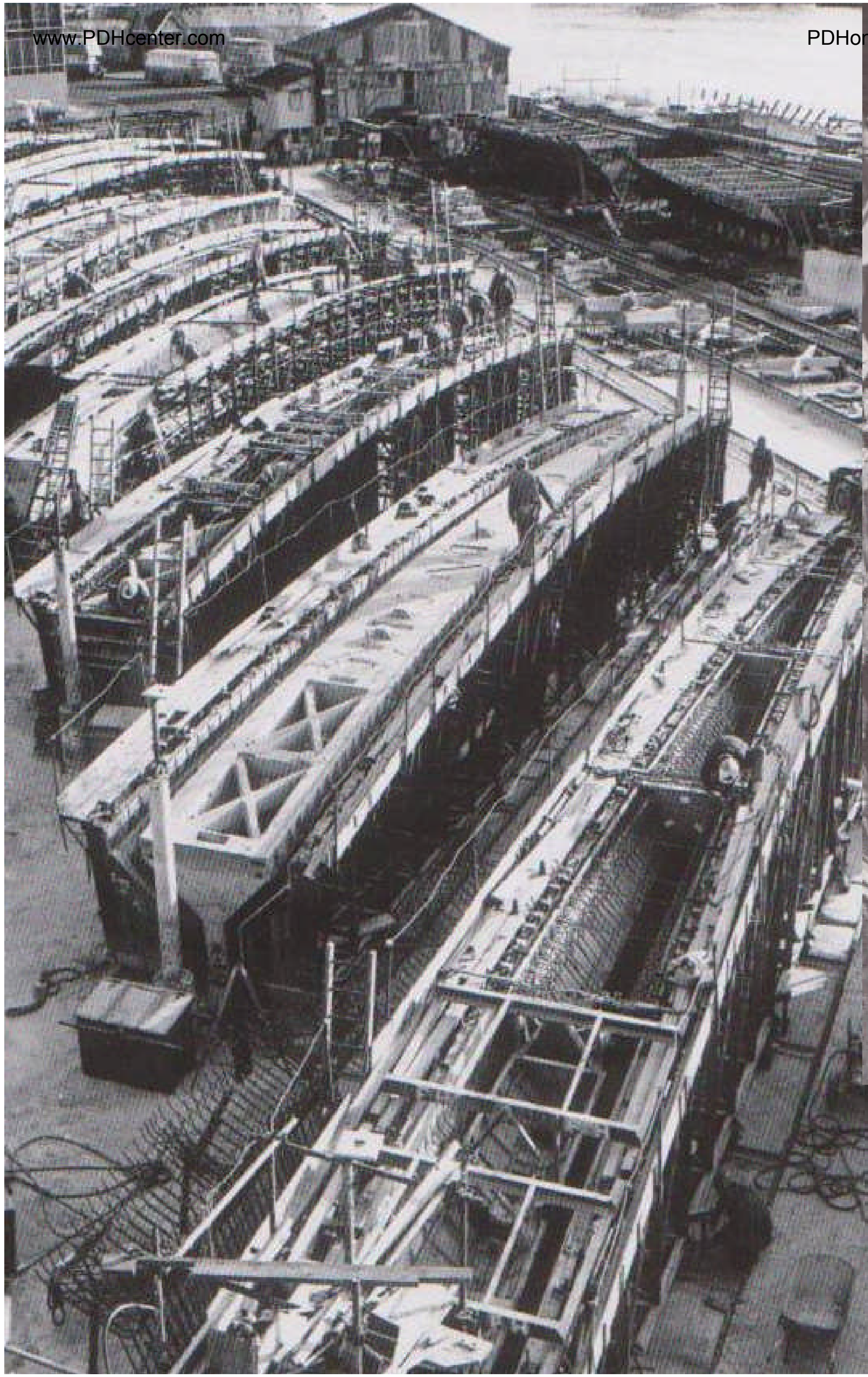
The Podium had been built hurriedly and was designed to support thin shells – not the Spherical Solution's heavy pre-cast ribs. To accommodate the additional weight, about twenty existing piers would need to have their diameters increased, this required blasting. So as not to attract unwanted attention, the blasting was done during the Sydney rush hour/s in an attempt to mask the noise. A piece of flying concrete landing on a nearby passenger ferry gave the game away (the work took four months to complete). Another major problem came about in September 1963. SOHEC was now rejecting a previously accepted plan submitted by Utzon for 900 seats situated behind the orchestra in the major hall (ABC was concerned about filling these seats). In response, Utzon created three tiers of steeper seating (which allowed for cantilevering of the additional seating over the outside stairs). Also, he reduced the spacing between rows to allow for additional rows. However, this steeper-seating scheme had the effect of raising the auditorium's floor above the Podium thus decreasing air volume to the detriment of reverberation time in the major hall. In violation of the dual-purpose concept, this seating configuration meant that the decreased volume of the major hall now required a redesigned ceiling, one without room for adjustable panels (to vary air space) to accommodate the different acoustic requirements of operatic vs. orchestral performances.

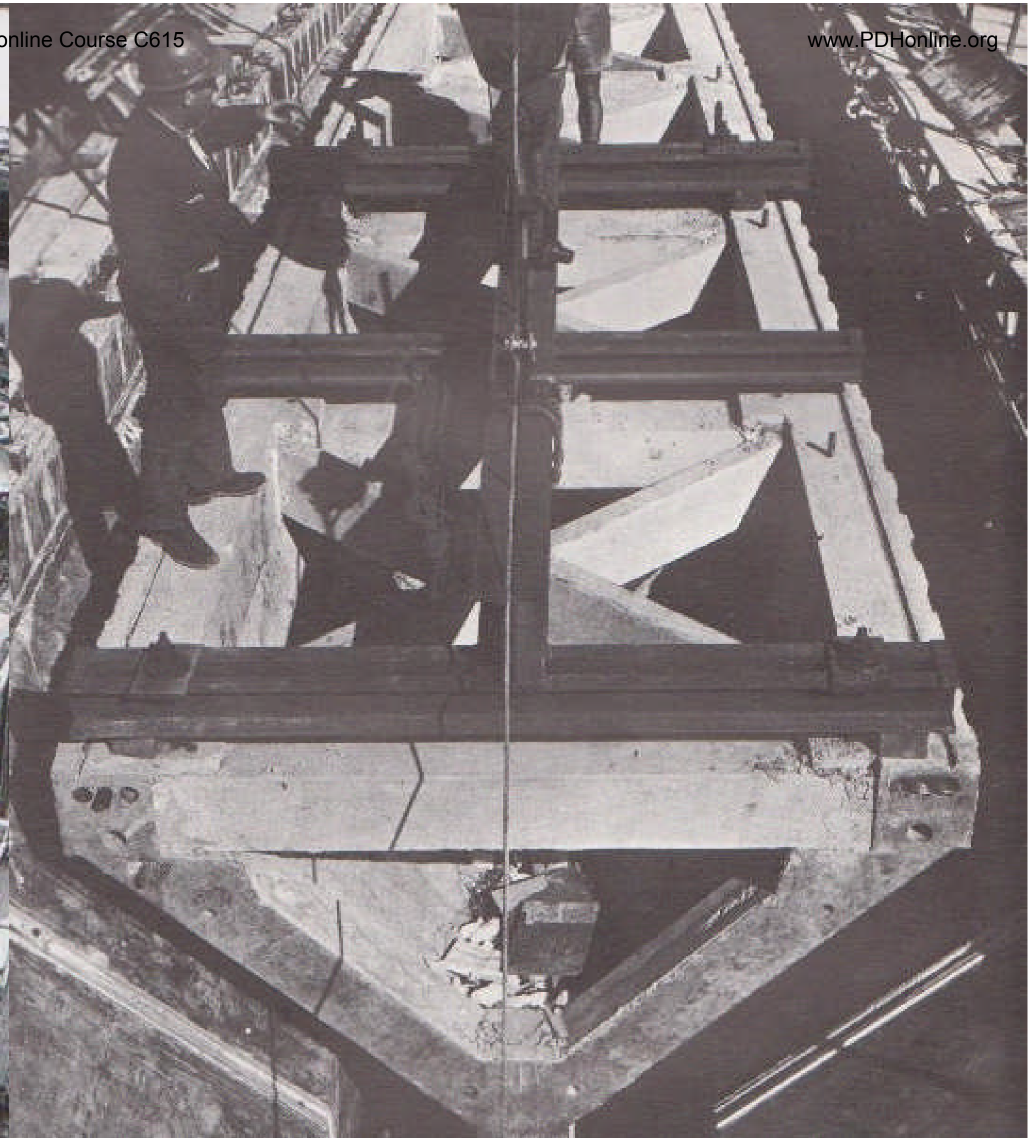
Rib Job



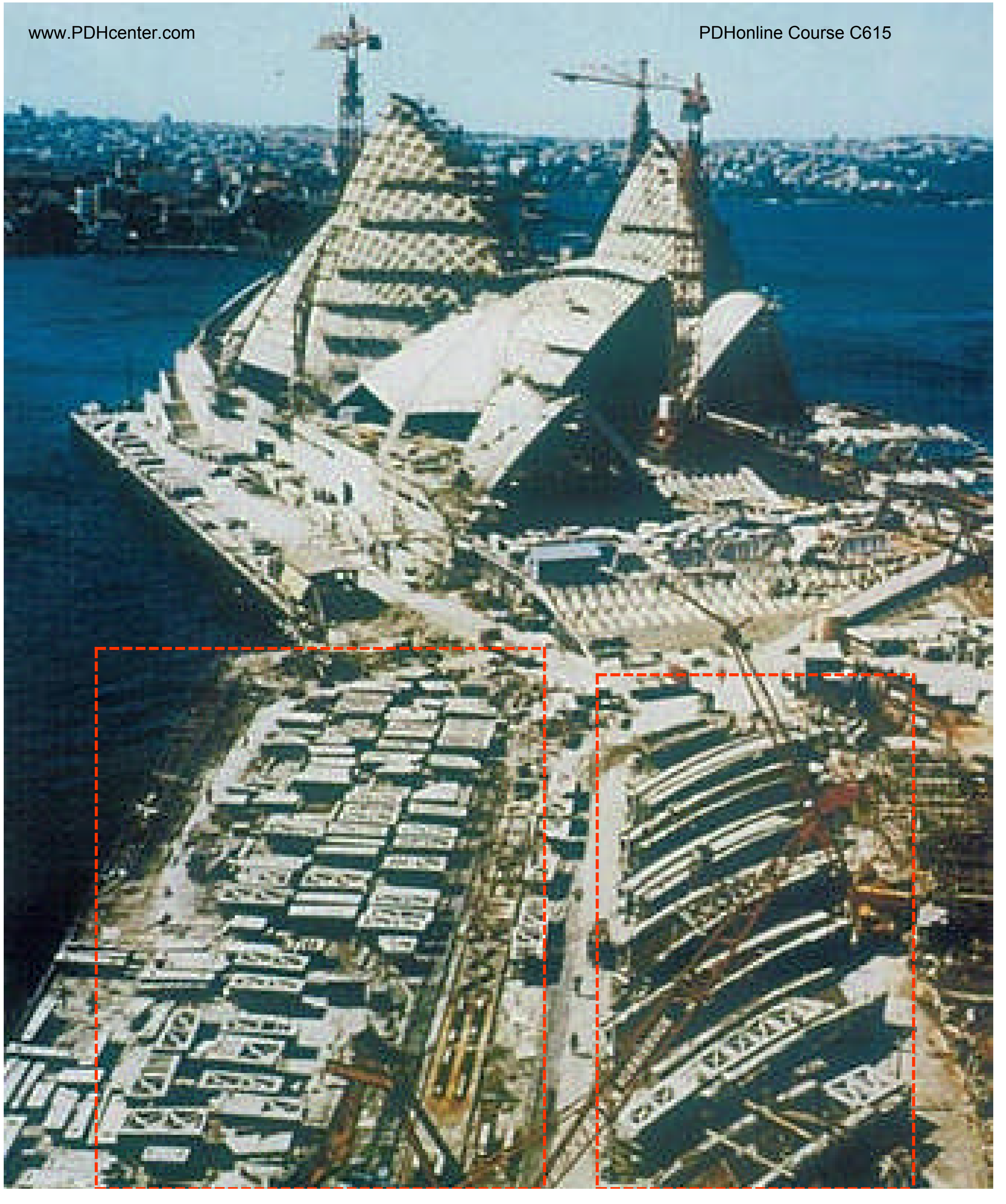
Whether a roof rib was being placed in the shortest span (above the restaurant) or the longest span (above the major hall), it consisted of segments made in one of three types of 23-meter long, resin-coated, steel-reinforced plywood form (bed). The process to form the longest rib began with the placing of pre-fabricated concrete “diaphragms” (in a vertical orientation) in the first bed thus dividing it into five equal-length segments numbered consecutively one to five (number one being the segment forming the bottom of the rib). Pre-assembled reinforcing steel (a.k.a. “re-bar”) was placed in position and then concrete was poured into the segments and allowed to cure. Once properly cured, segment numbers one through four were removed from the bed and stored, ready for installation. Segment five was placed in a second bed (in the number one position), diaphragms were installed, re-bar set in place and concrete poured and allowed to cure forming segments two through five in the second bed. Now, segment five (from the second bed) was placed in position one in the third bed and the process repeated to form segments two through five. Thus, thirteen segments were produced (5+4+4=13) to form the longest rib. The concrete diaphragms guaranteed an exact fit from one segment to another. The contractor (Hornibrook) used multiple beds to expedite rib production. When storage became a problem, the garden at *Long Bay Prison* was used as a storage yard.

Above: rib-segment re-bar cage being lowered into position in the concrete diaphragm
Left: rib-segment/s in-place in bed being made ready for concrete pour



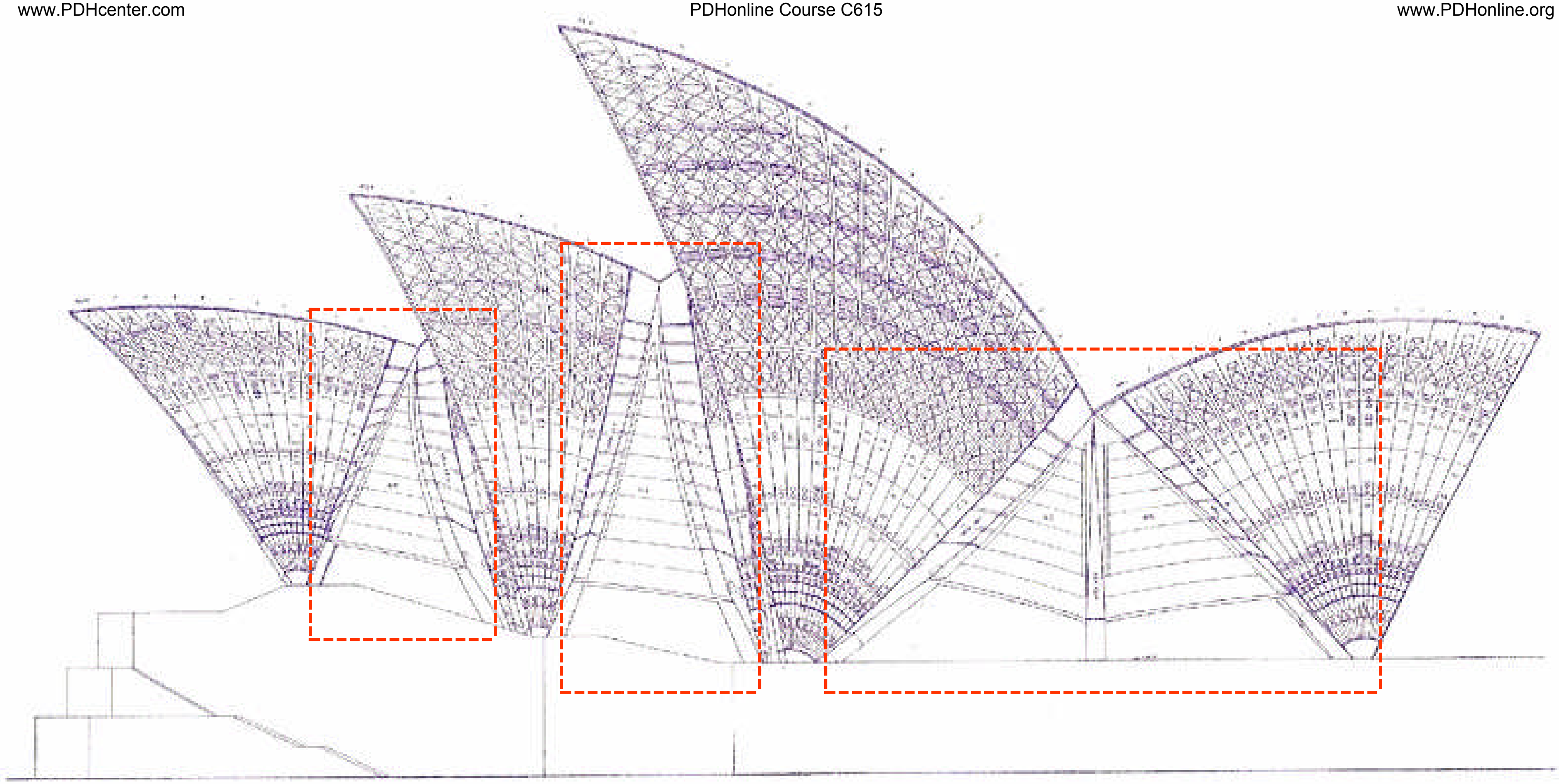


<u>Above</u>: rib-segment cured and ready for removal from bed
<u>Left</u>: multiple rib-beds (note the taper of the bed/s)

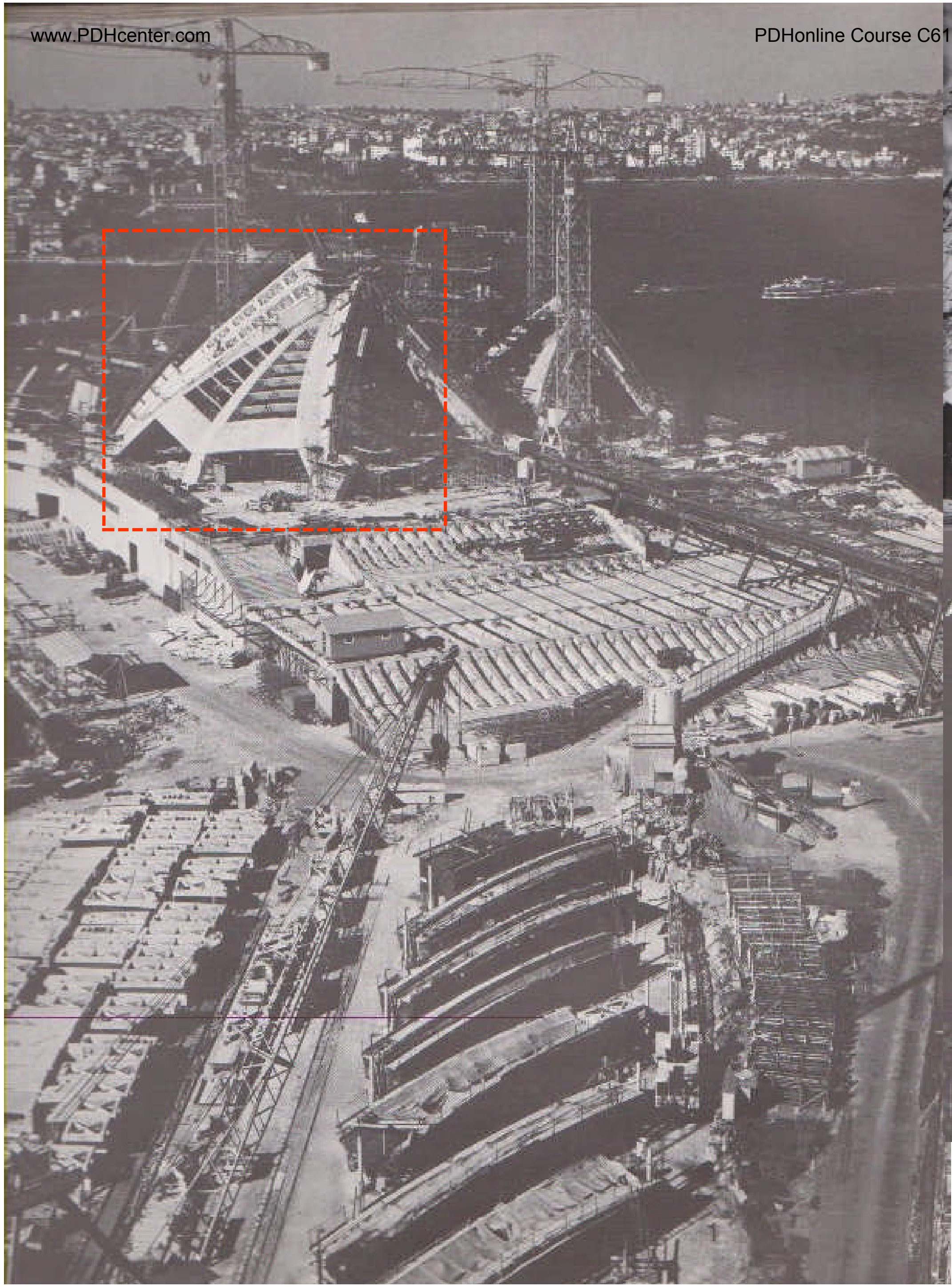


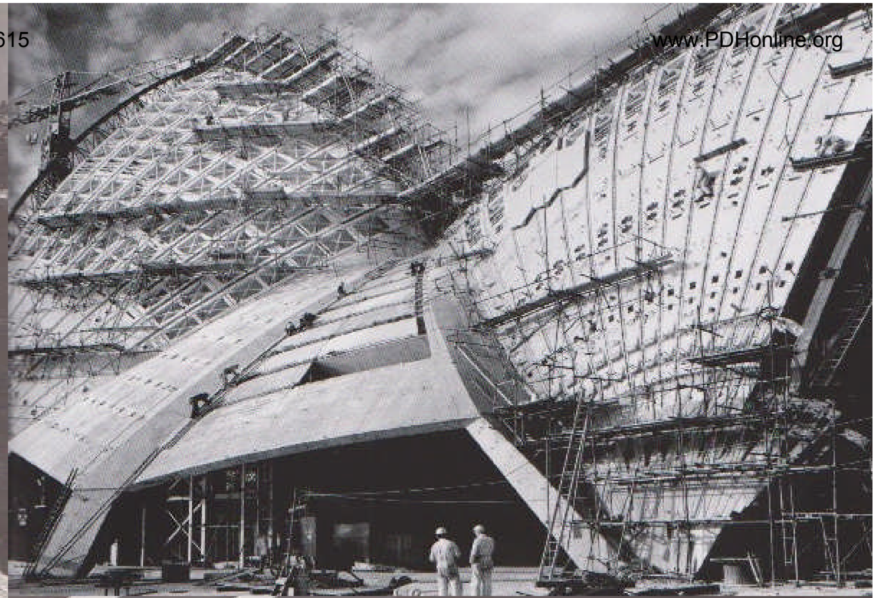
<u>Left</u>: multiple rib-beds (lower right) and storage yard (for completed ribs (lower left) in forecourt area of SOH on Bennelong Point. The rib-bed forms were made from plywood and were covered with polyester for a "high" finish. Then, they were coated with "Shellmoid Compound" (manufactured by the *Shell Company of Australia*). This coating allowed the rib-segment forms to be stripped cleanly from the concrete of the rib segments after curing. Utzon spent a great deal of time ensuring that the finish of the pre-cast concrete rib elements would be of the highest quality. Hornibrook had to devise new ways of sealing the rib-forms to ensure the smooth finish of the concrete. Utzon reminded them that the concrete ribs would be a finished interior surface exposed to view and expressive of the structural form. The idea of exposed concrete as a finished surface was difficult to imagine for Australians at that time. Each rib segment was fifteen-feet long with five rib segments capable of being cast in a single bed. Crown tips were cast in a separate mold.

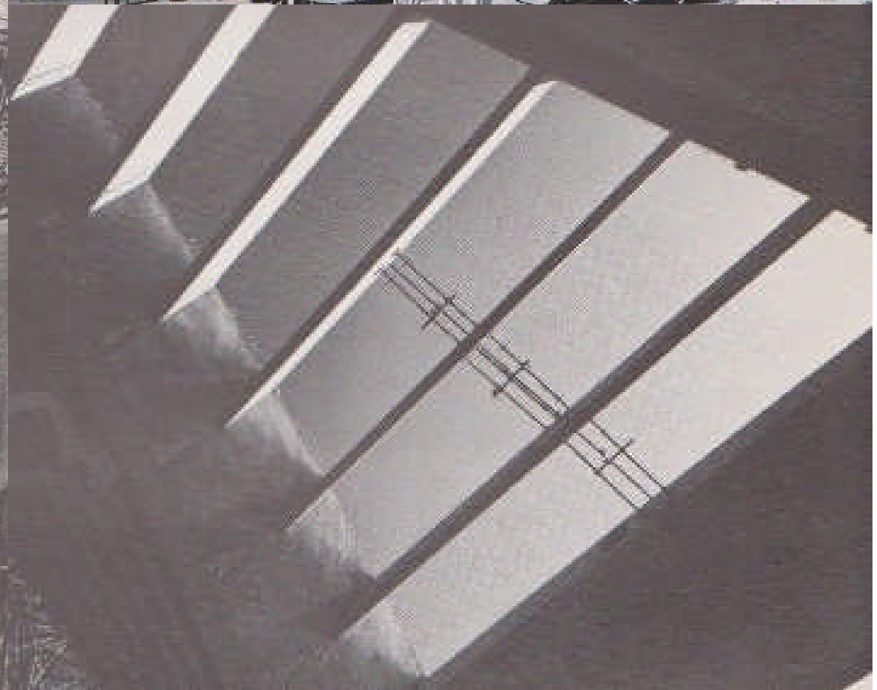
Superstructure

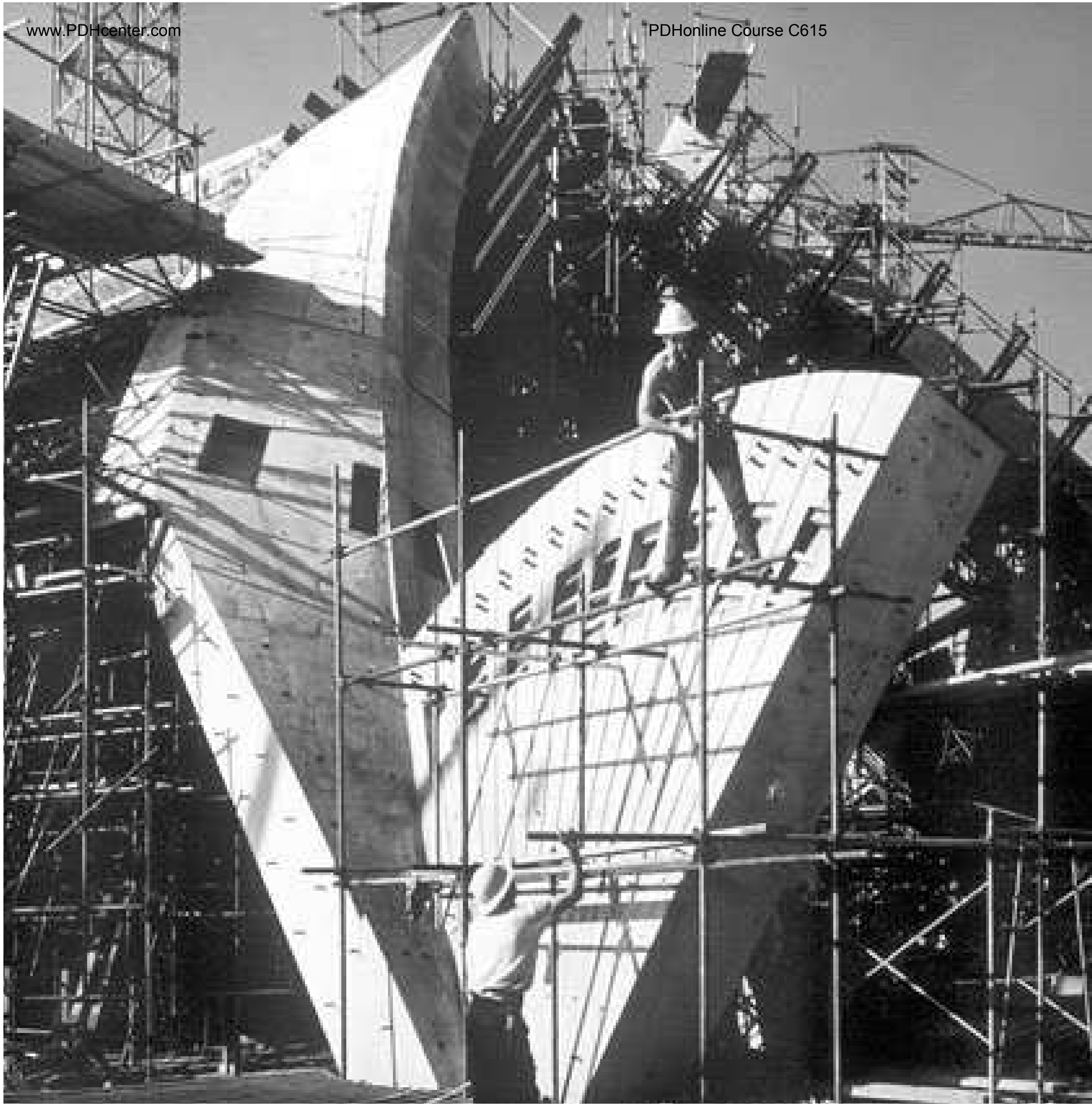


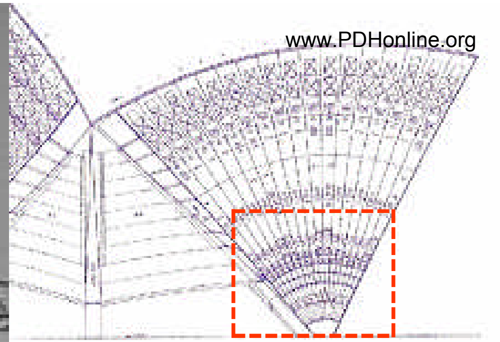
The first element of the superstructure to be put in place were the "Warped" (reverse) side shells (which had replaced the *Louvre Walls* of the early schemes). The concrete pedestal (upon which the ribs would radiate) were constructed off of them.

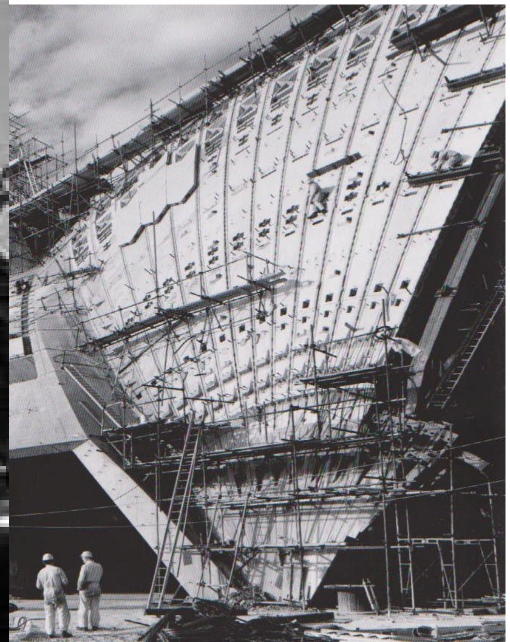




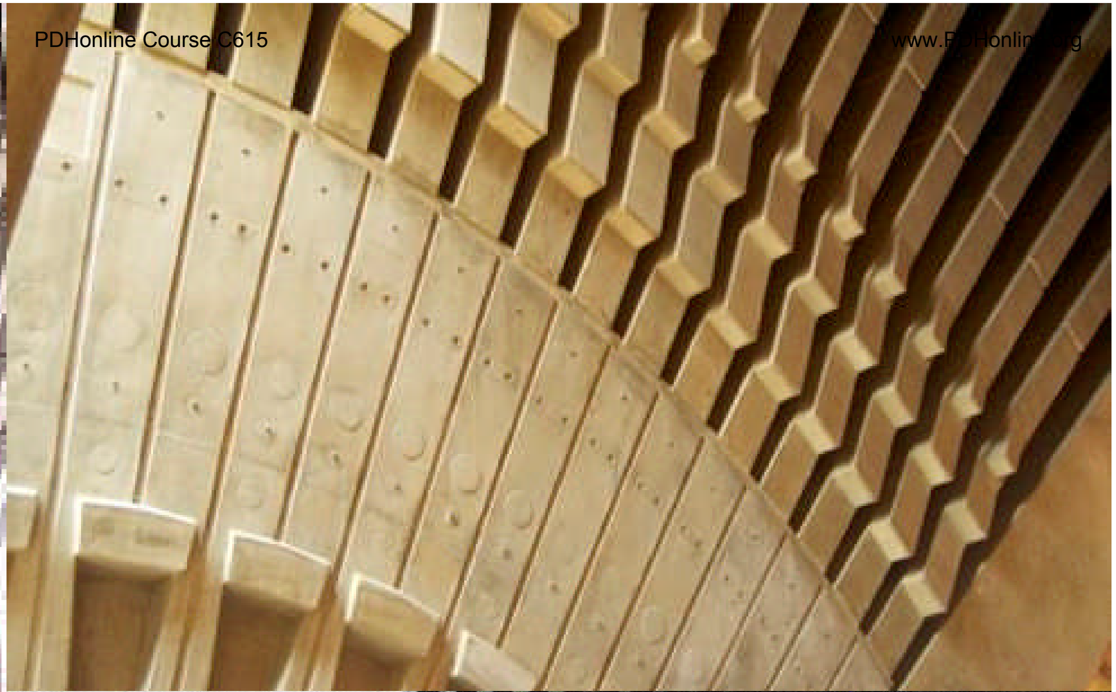




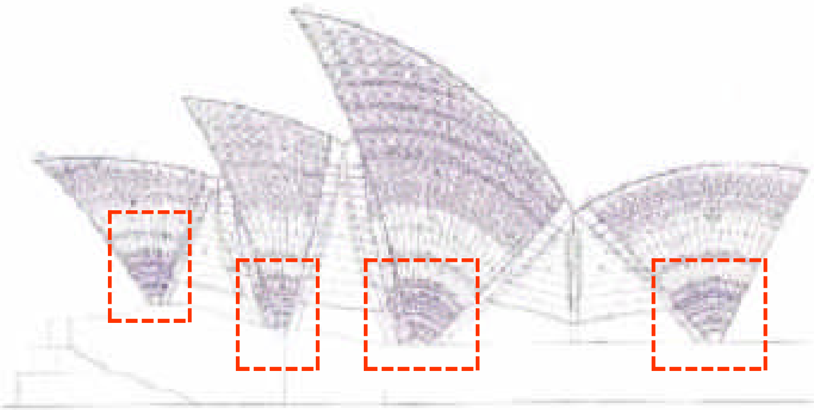


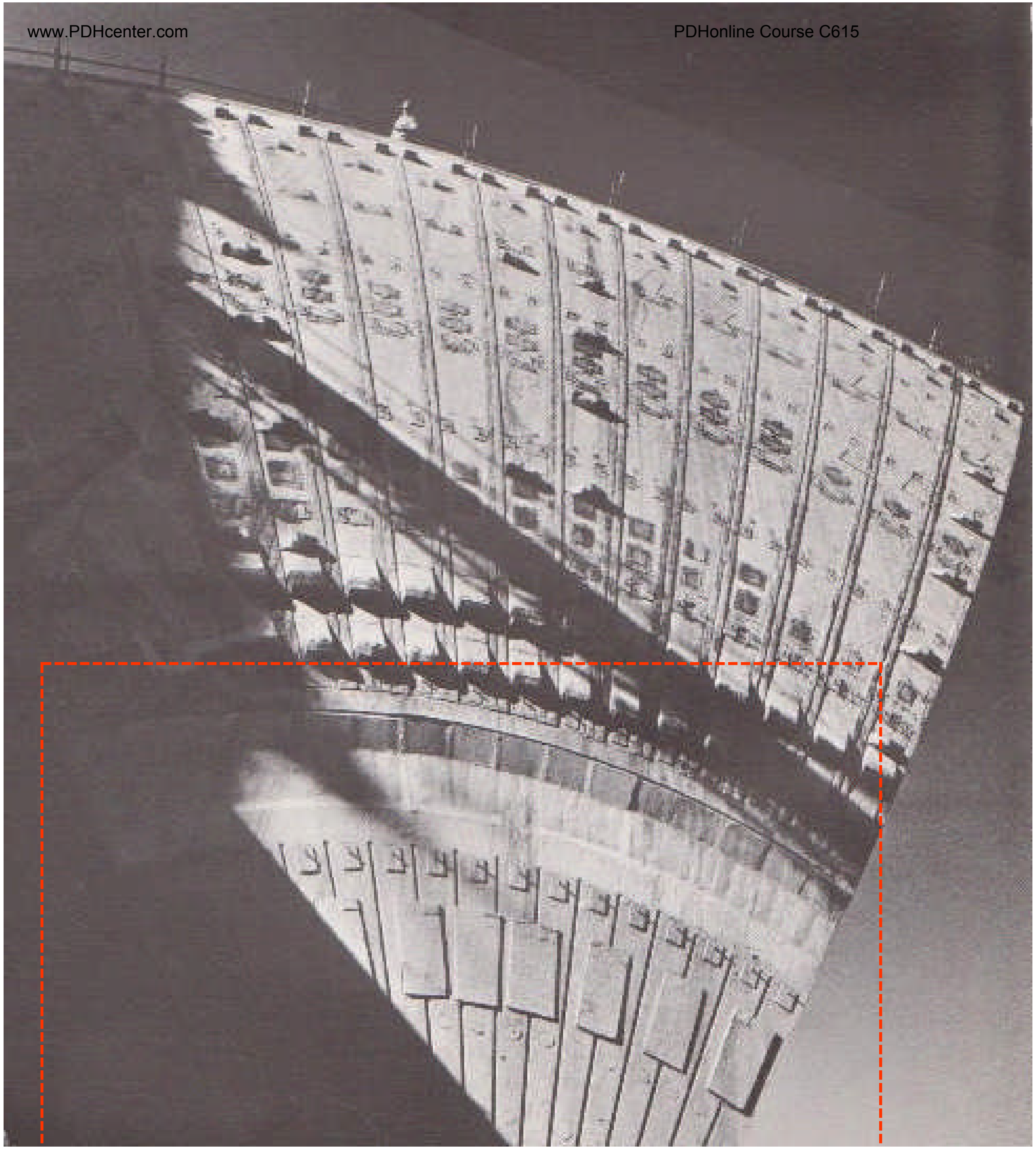


Rib Pedestal

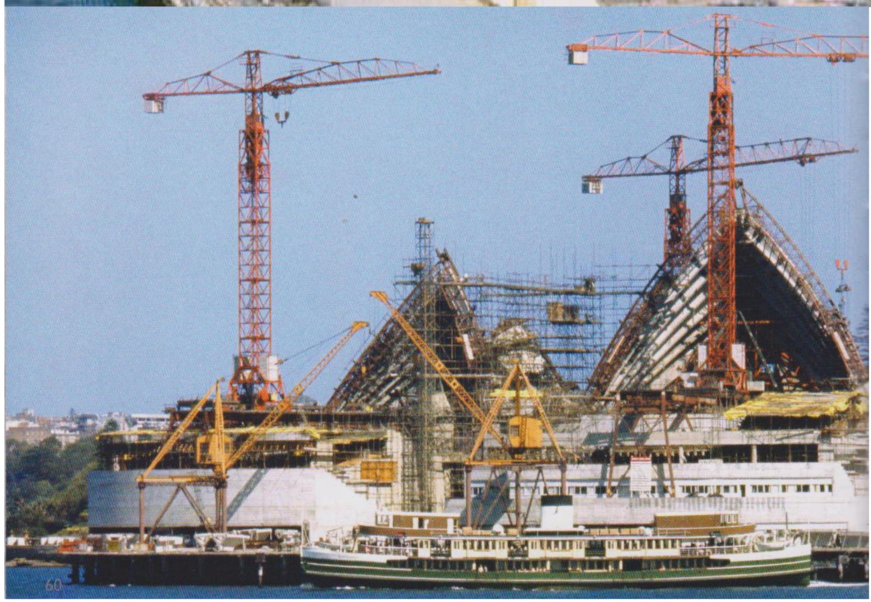


Pedestal (interior views)

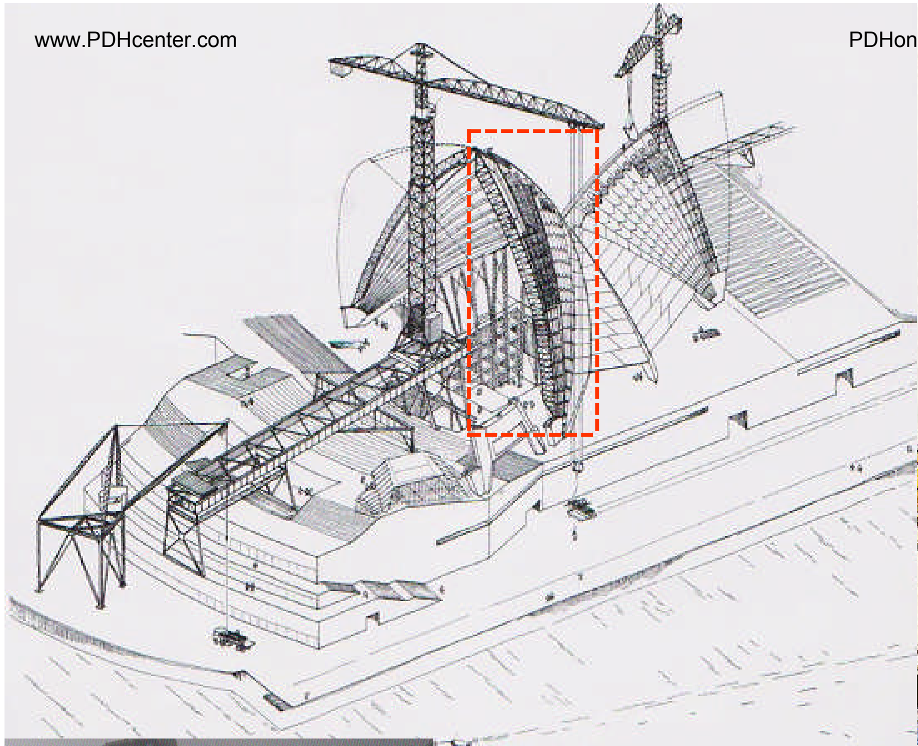


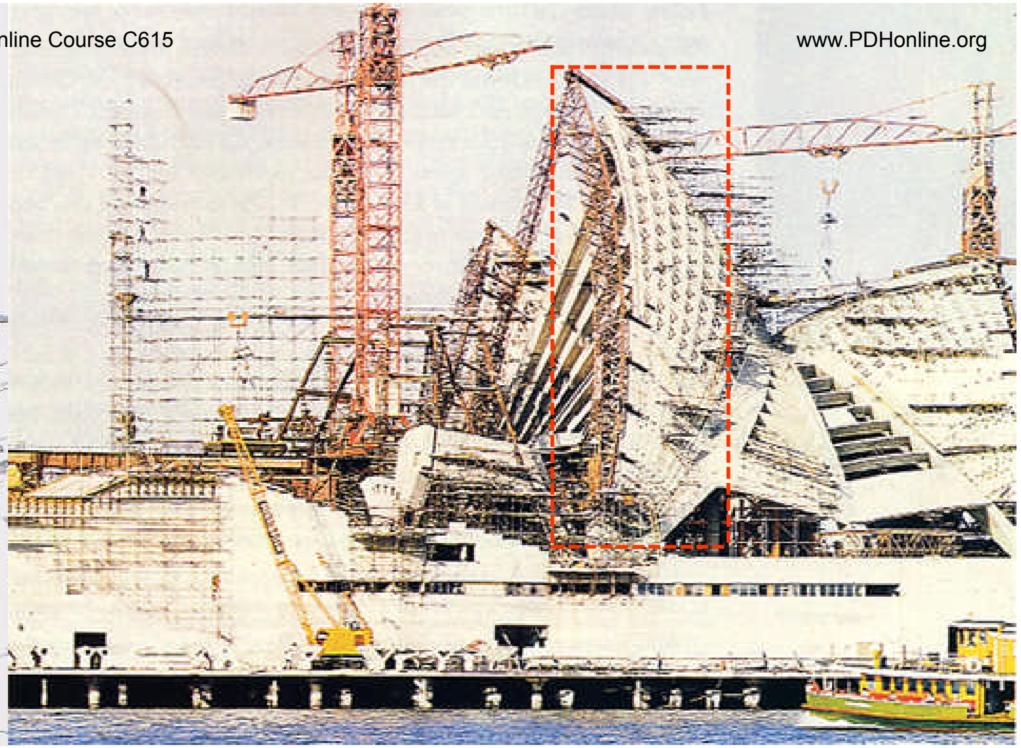


Pedestal (exterior view)

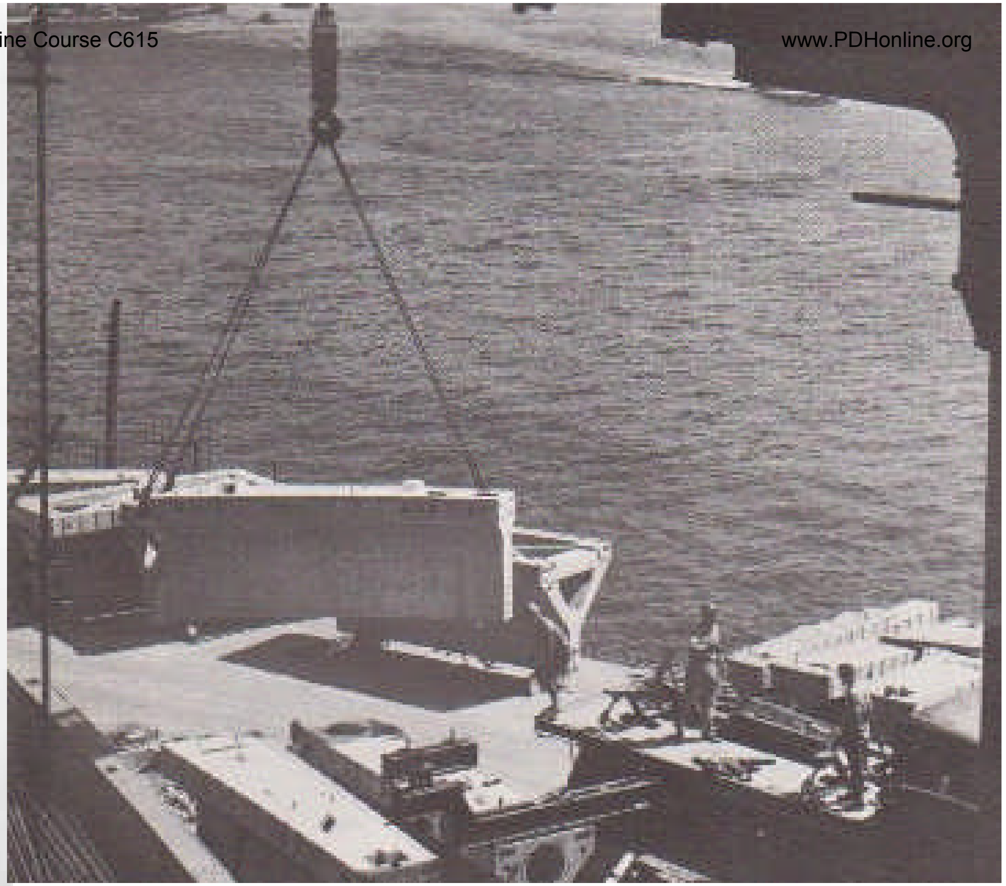


Three 250-foot (75m) high rail-mounted tower cranes (made in France) lifted rib segments into position. Rather than acres of scaffolding to provide support for the ribs, *Hornibrook* developed an ingenious steel *Erection Arch*. Each of the four telescoping arches on-site could match the curve of the of the shell as it developed.





Example: *Rib Two* was constructed via support from completed *Rib One* on one side and the Erection Arch on the other side (in the contour shape of what would be adjoining *Rib Three*). To prevent each rib segment from falling through the gap, across the back of each rib segment pins held it in place. Once *Rib Two* was complete, the erection arch was pivoted and shaped to match *Rib Four* thus allowing for the assembly of *Rib Three*. An epoxy resin was used to glue the rib segments together. Arup and Hornibrook endorsed the novel method after stress tests revealed that the concrete of the rib segment failed before the resin joint.



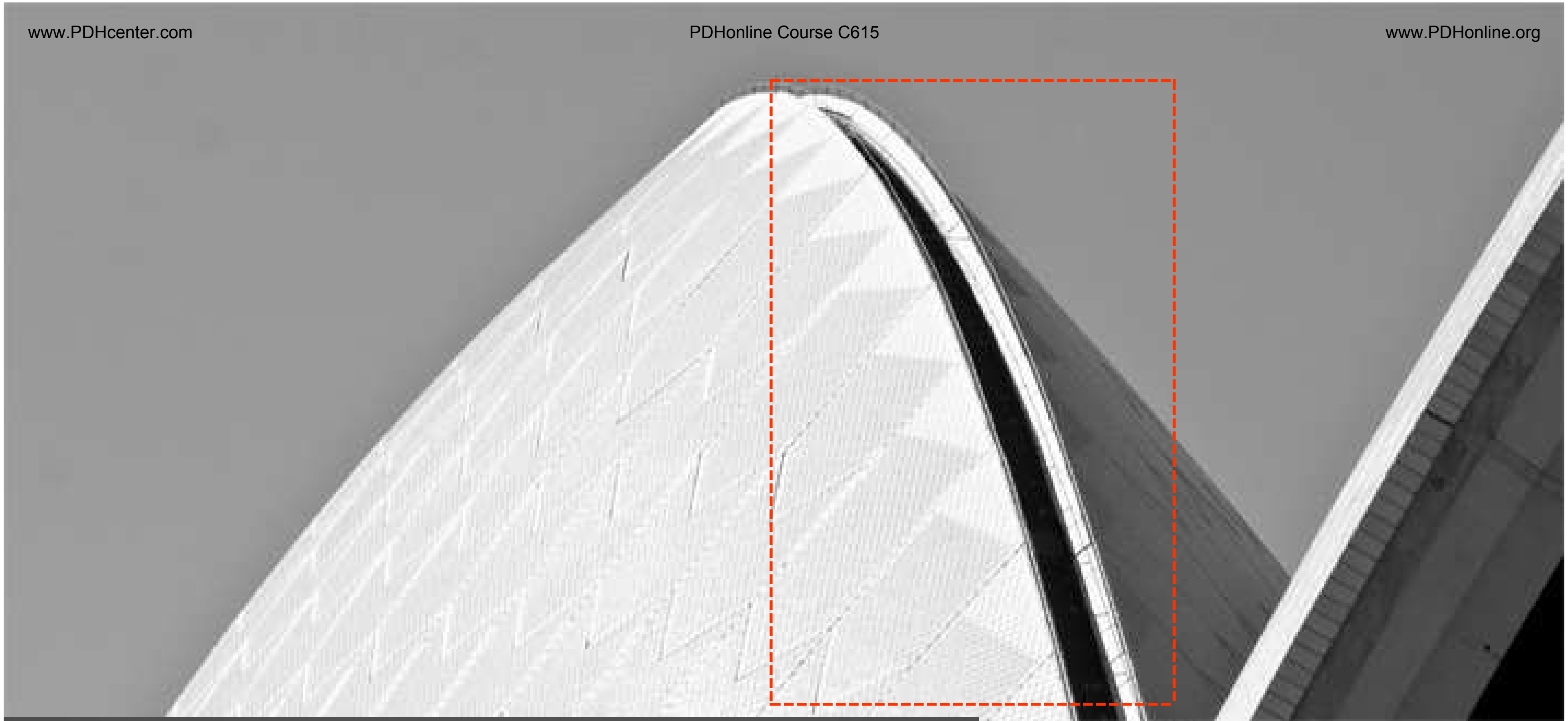
Tower crane lifting 15-foot long rib-segment into position. Individual rib components could not exceed ten-tons since this was the maximum lifting-capacity of the three French cranes on-site which were, at the time, the strongest cranes in the world.

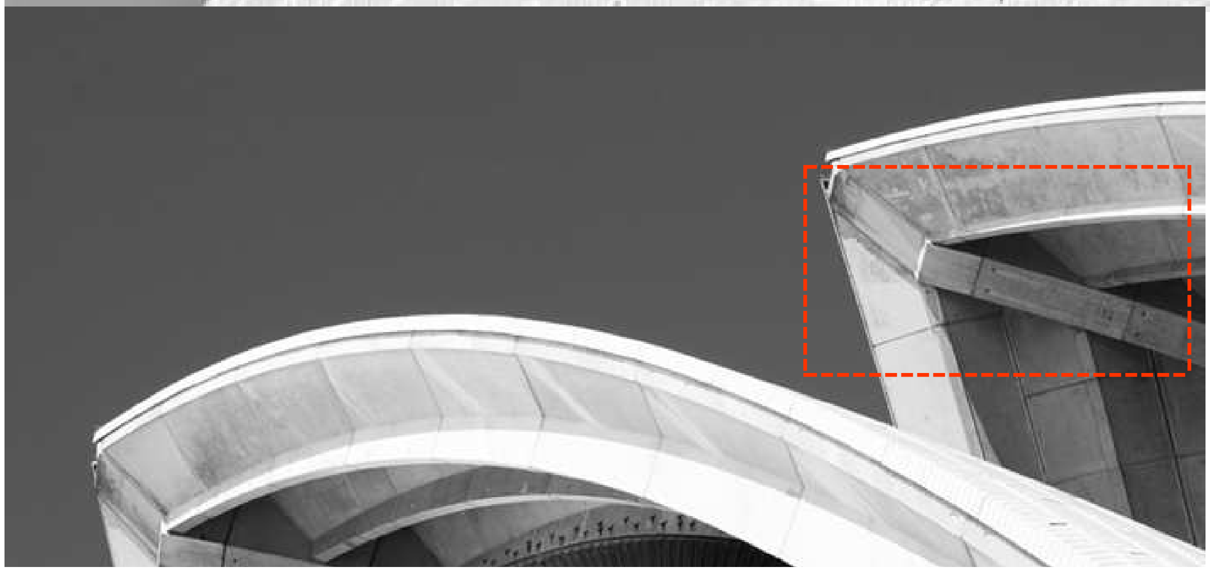
"…During the middle of the hullabaloo, as if fatigued by the whole affair, one of the costly erection arches on the major hall sagged, teetered and collapsed…"

***Life* Magazine, January 6th 1967**

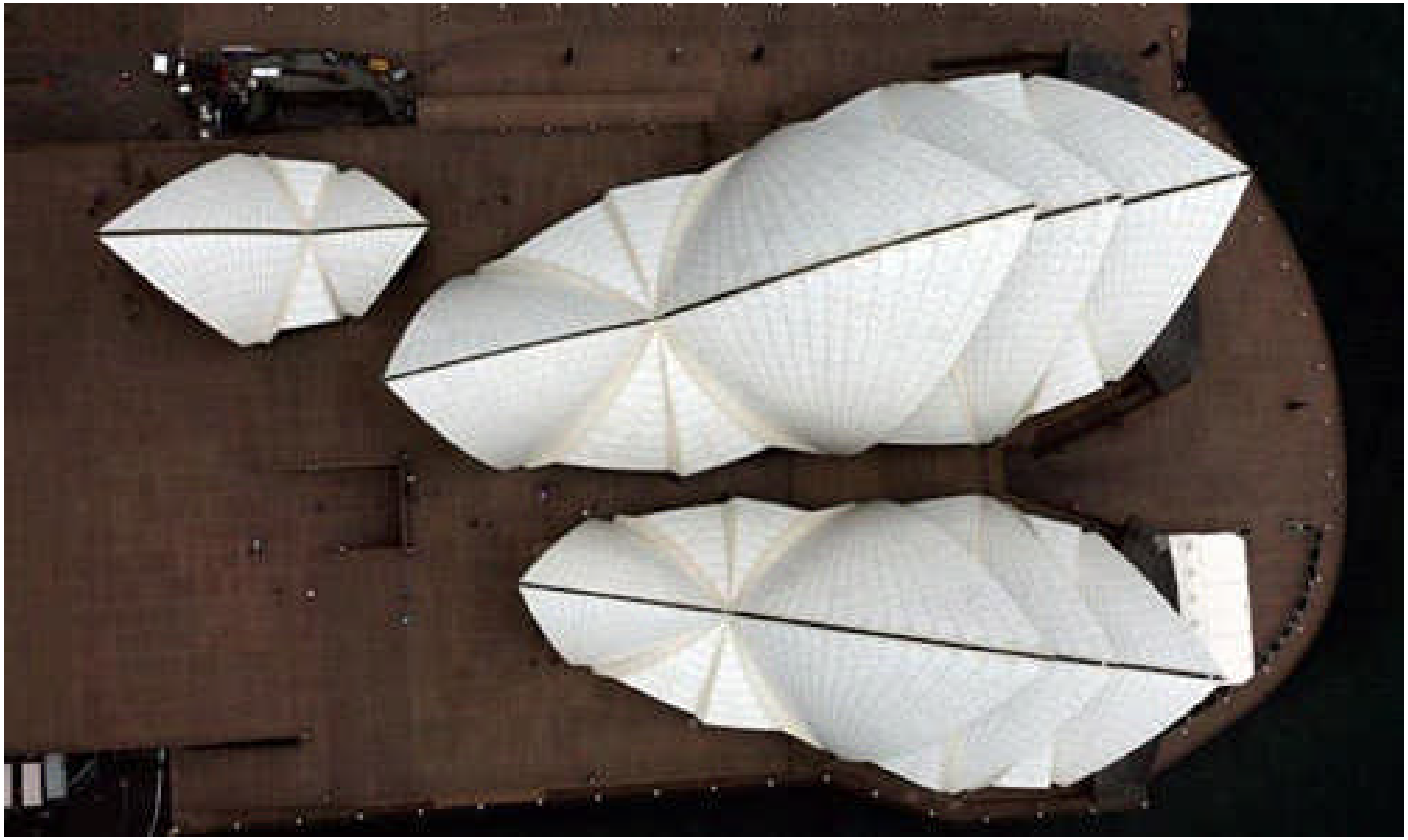
RE: the collapse on March 2nd 1966 of the top-half section of one of the erection arches after it was left un-braced during a wind-storm. It narrowly missed hitting six riggers falling onto a roof fifteen meters below. Utzon had resigned just a few days earlier (February 28th) and on the next day (March 3rd), the public protest/march was held calling for Utzon's reinstatement. On another occasion, a rigger fell thirty-five meters from a major hall stage tower. Fortunately for him, his fall was broken by metal mesh.

Pre-cast ridge beam section being maneuvered into position (left) and in-place (above). Note the holes for the high-tensile strength steel cables that tied the whole roof shell structure together. Since the shells have ridges, they act like a *Vault* rather than a shell. The early roof schemes were true shells, but not the final Spherical Scheme that was built. Despite the dangers and minimal safety precautions, there were no recorded deaths on-site during the fourteen years of construction.

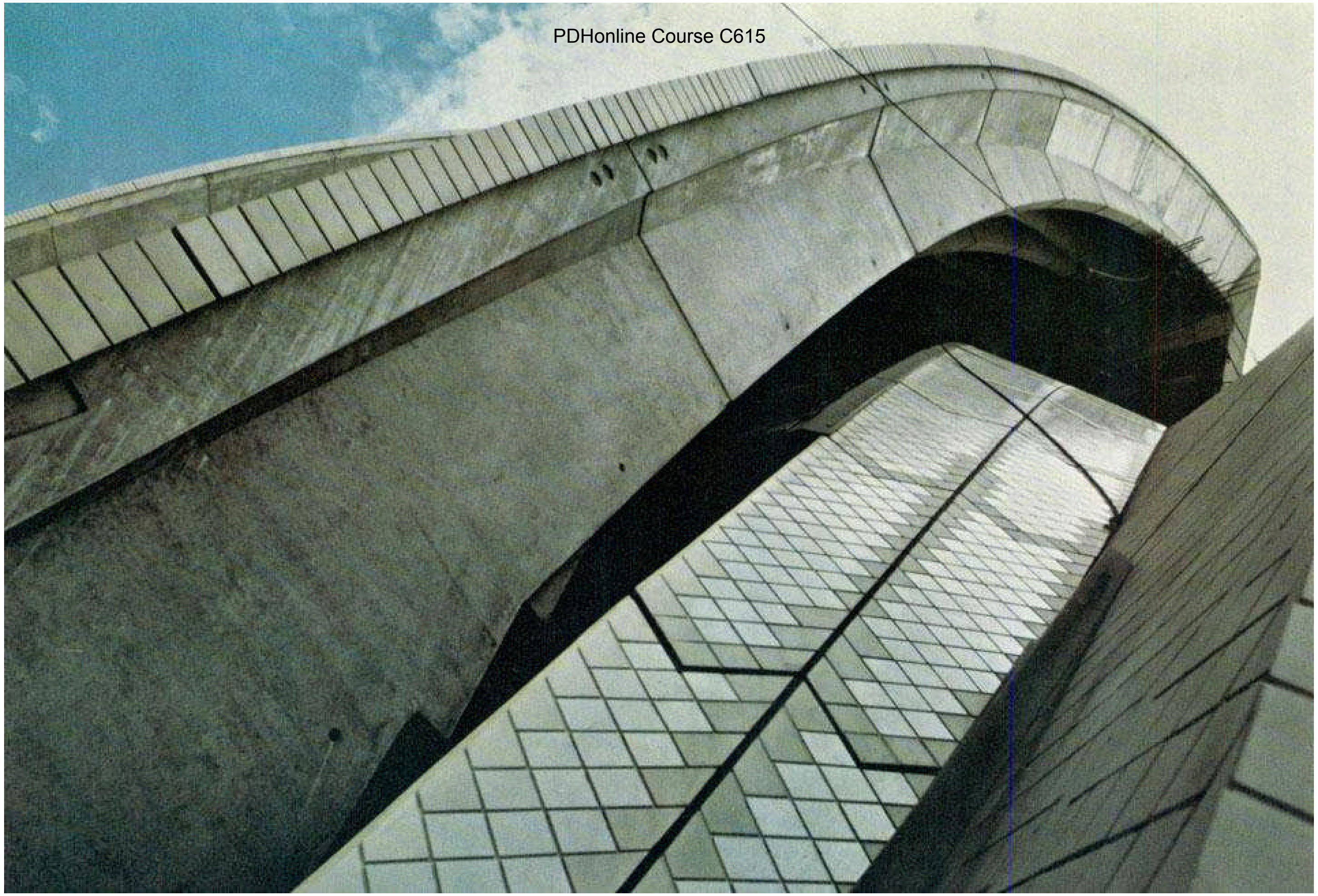




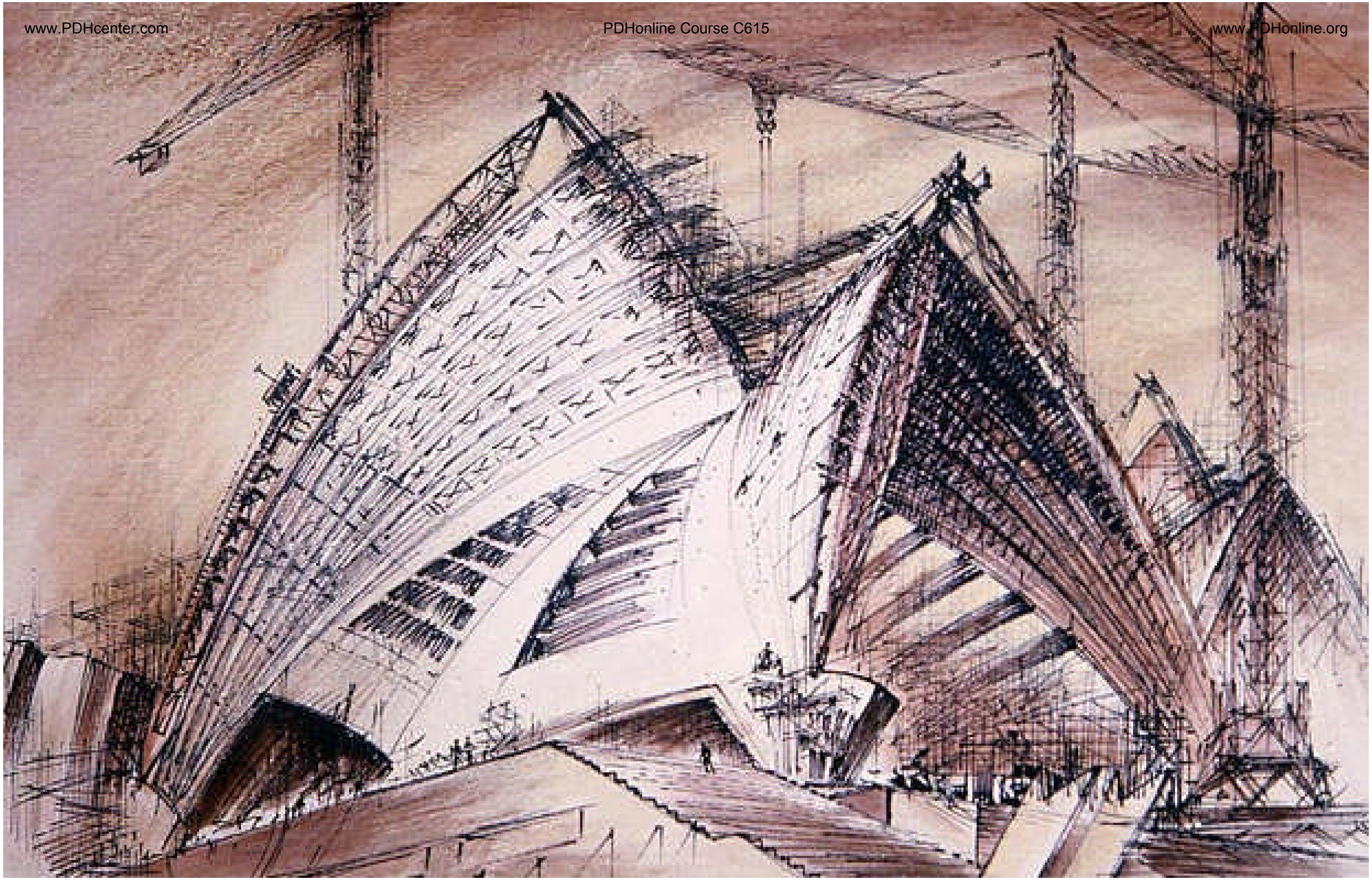
<u>Above</u>: shell vault ridge (topside view)
<u>Left</u>: shell vault ridge (underside view)



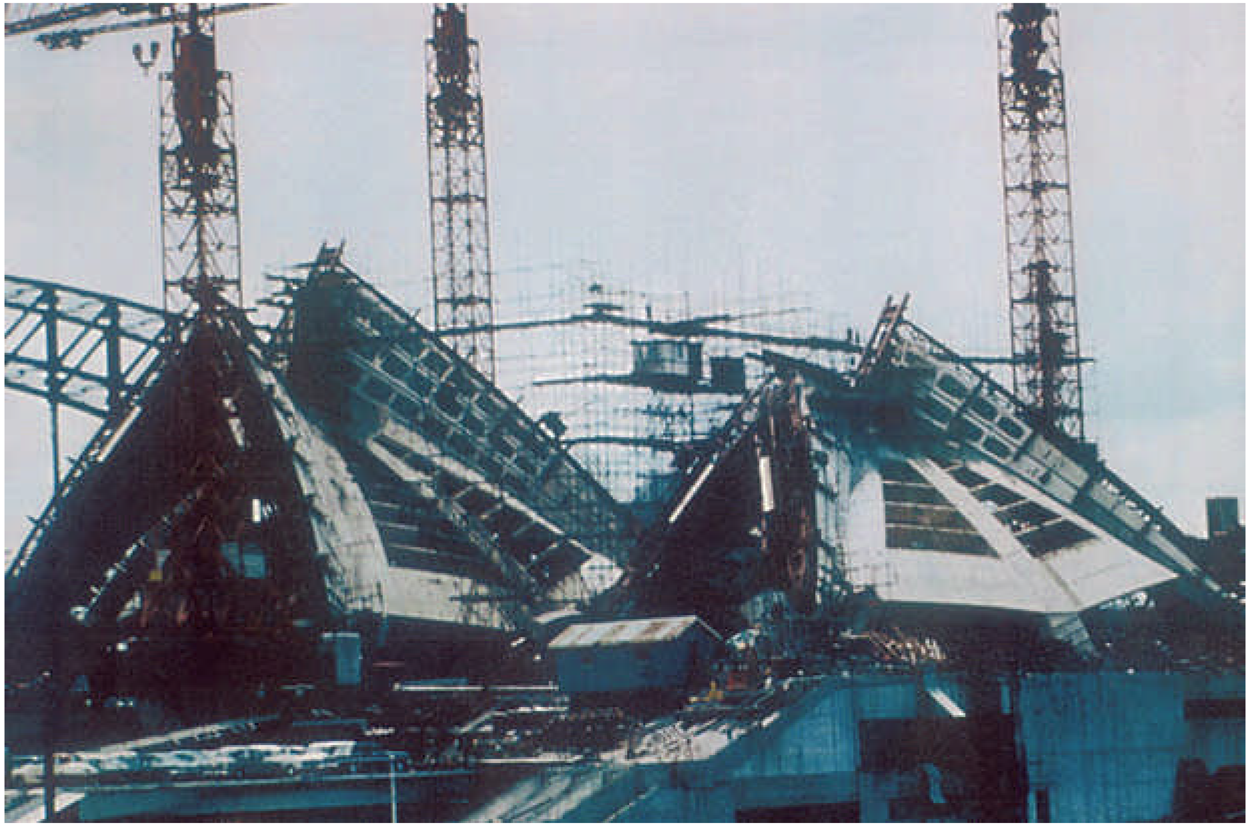
Aerial view of SOH under construction (December 1964)

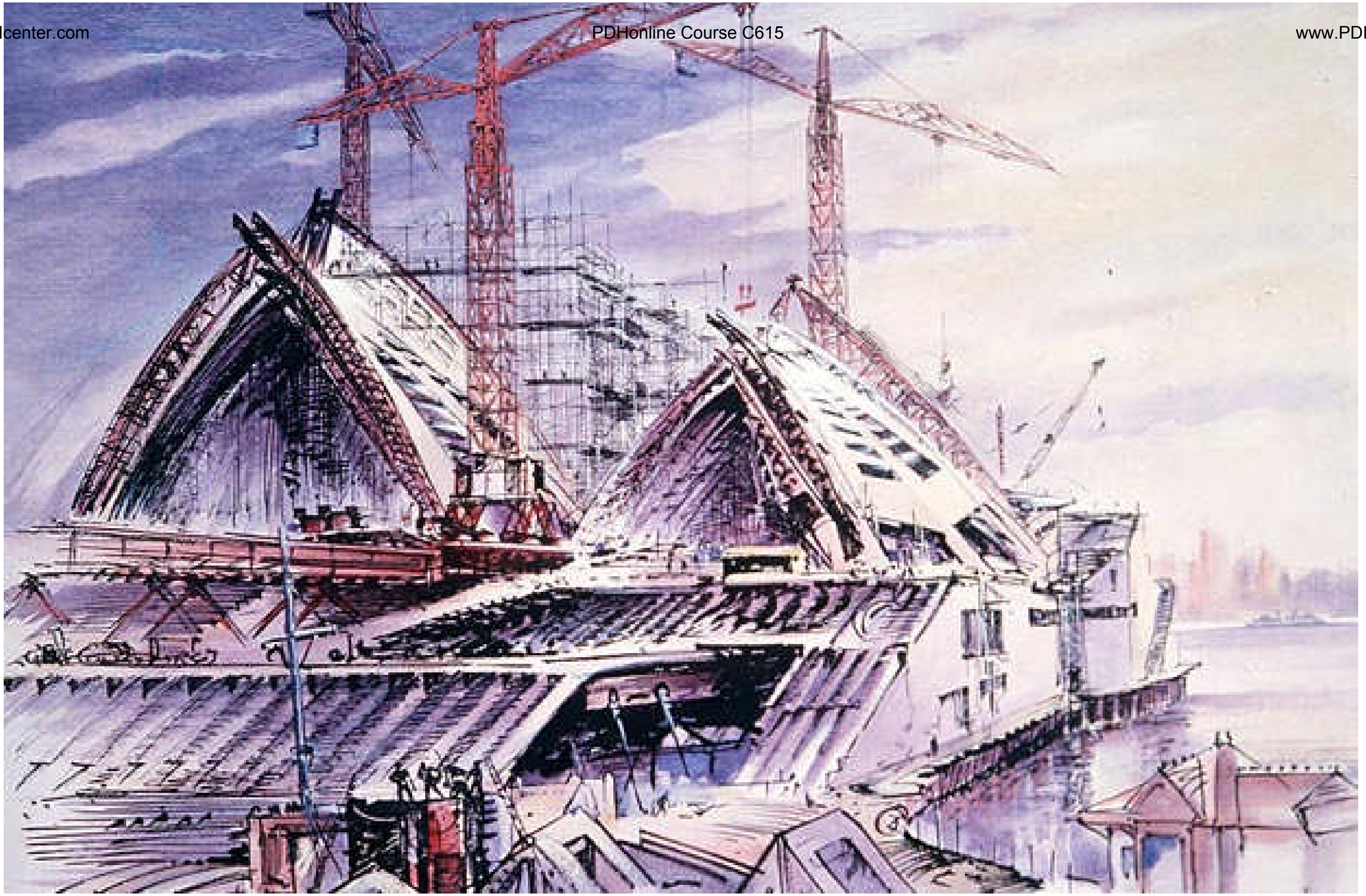


During construction, rib segments were stressed via nine steel cables (running from the bottom rib segment to the top rib segment). Once all segments of a rib were in place, up to twenty-one additional cables were stressed in three locations from the pedestal to the crown. Additional cables ran horizontally between ribs. On January 17th 1967, the last of 2,194 rib segments went into its position at the top of the major hall.[565]

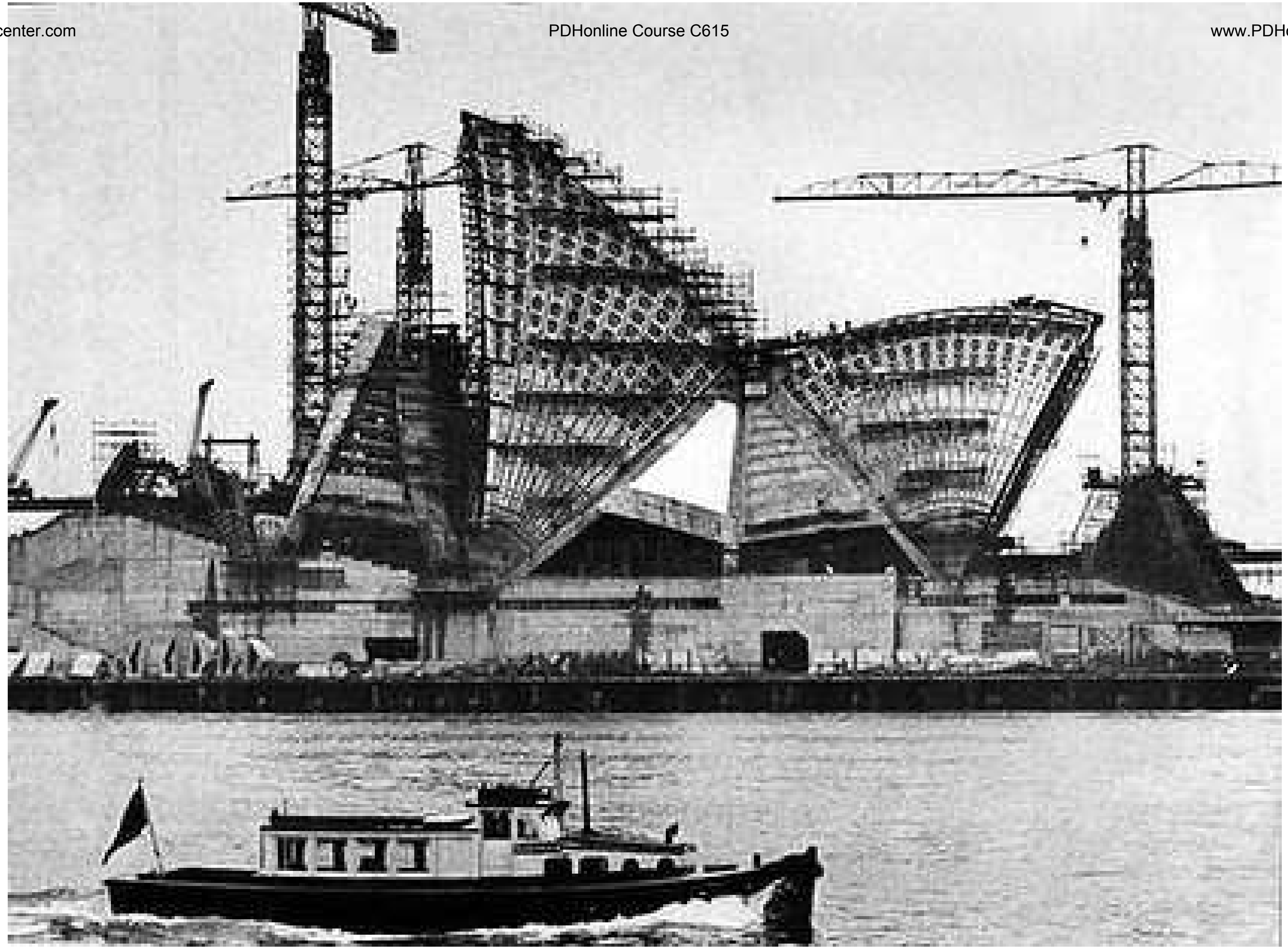


Drawing by artist and writer *Robert Emerson Curtis* (1898-1996) of SOH shell superstructure under construction (ca. 1965)





As the shell superstructure developed, the space-age forms gave the worksite a sculptural appearance. Artists like *Robert Emerson Curtis* were naturally drawn to the site to document for posterity the creation of the great edifice.

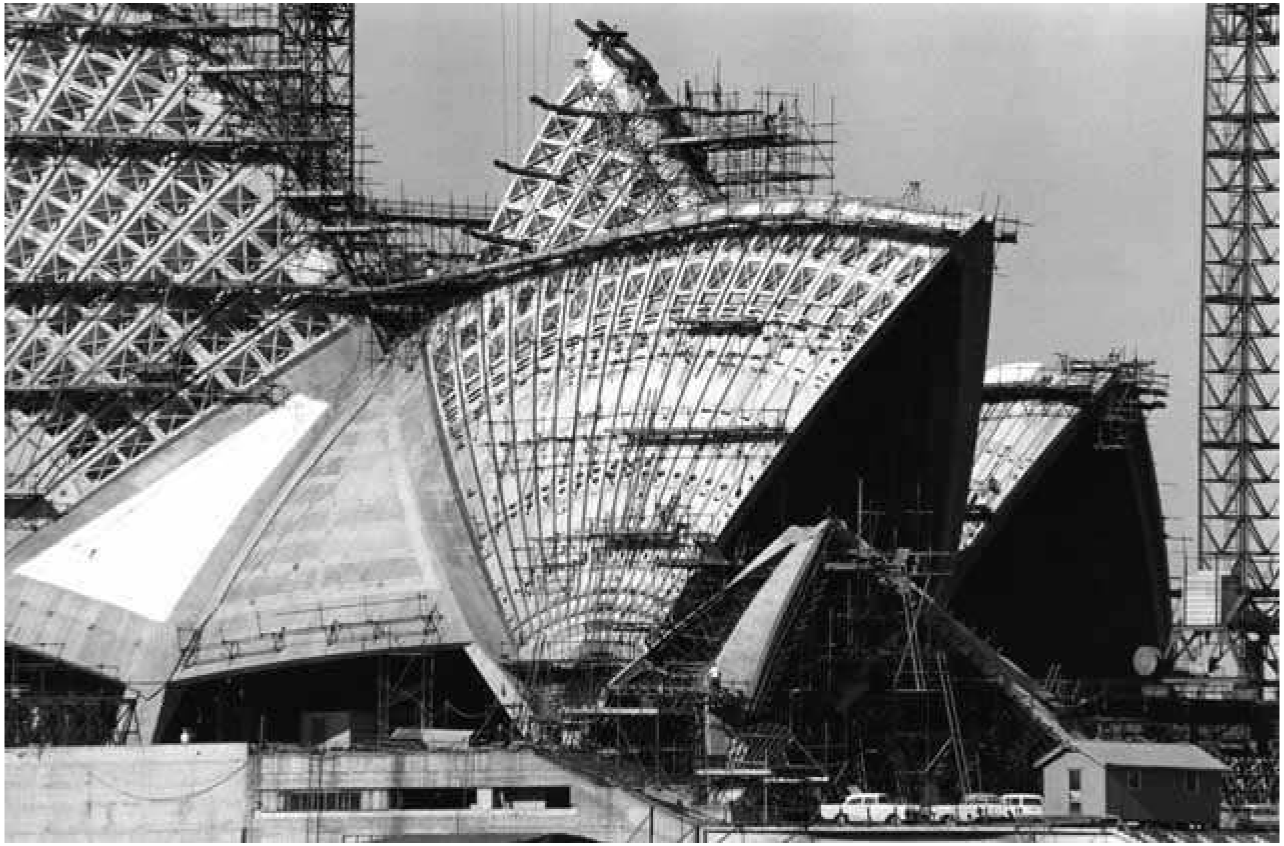


1965

"The structure and strict geometry express the logic of the building"

Jorn Utzon, Architect

September 1965



During the fourteen years of construction (1959-1973), around 10K workers from ninety different nationalities contributed to the building of SOH. The high visibility of the worksite also meant that it became a focal point for workers' rights activists. Translators were employed to ensure more involvement from different language groups and seminars were held to inform workers of their rights. The diversity of cultures at the worksite led to an equally diverse range of celebrations and overall, the site offered relatively long term employment to many of its workers. Many safety precautions that would be required today were absent on-site.

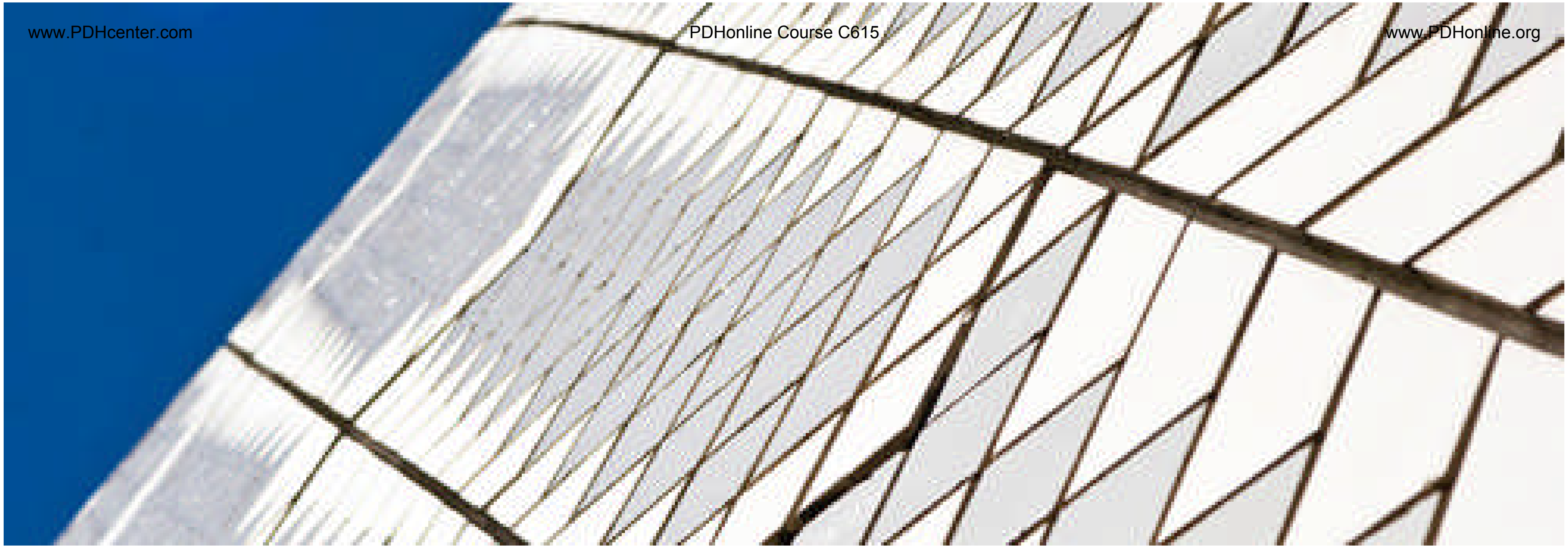
Aerial view of the SOH shells nearing completion (1967)

The Sydney Tile

"I felt a bit ashamed when I first met him because one of the first questions I asked was 'why do you want to cover a building with tiles on a curved surface like that, it could be sprayed?,' and he looked surprised and said 'tiles are the best.' And he looked all over the world for them, and he looked in the Middle East where there were mosques covered in gleaming tiles, and then he traveled to China and Japan. And he had seen the marvelous styles, and he was very concerned with the quality and the actual materials that made them up, and he gave very stringent requirements as to what material, where they got the clay from, and what mixes they used in the clay till it eventually satisfied him. That it gave a slightly rough surface, and this was the natural color, the white, and over that surface was a clear glaze, a very shiny glaze which you can see gleams in the sun."

Elias Duek-Cohen, Author

Utzon's vision for the finish of the roof shells was to be a stunning contrast between the azure blue of the Australian sky and the dark, deep waters of Sydney Harbor. Like the clouds above and/or the sails below, the shells would be white, made from tiles able to as Utzon prophesed: "glimmer in the dark." Without causing excessive glare, the tiles required a semi-gloss finish like the ceramic bowls he found in Japan which had a subtle coarseness created by the granular texture in the clay they were fired from. *Hoganas* of Sweden experimented for three years until they finally achieved the effect Utzon was looking for. Made from clay with a small percentage of *Chamotte*, each tile was 120mm square and came to be known as "The Sydney Tile." Utzon ruled out field applying the tiles from scaffolds fearing the heights and difficult access would result in uneven surfaces. Instead, he called on two principles from Additive Architecture; prefabrication and repetitive form. One of Utzon's employees at the Hallebaek office stayed in Denmark when the office relocated to Sydney. He sorted every tile for SOH and was at the tile factory in Sweden whenever the firing of tiles was being done. There were a total of 1.056 million Tiles made for SOH.



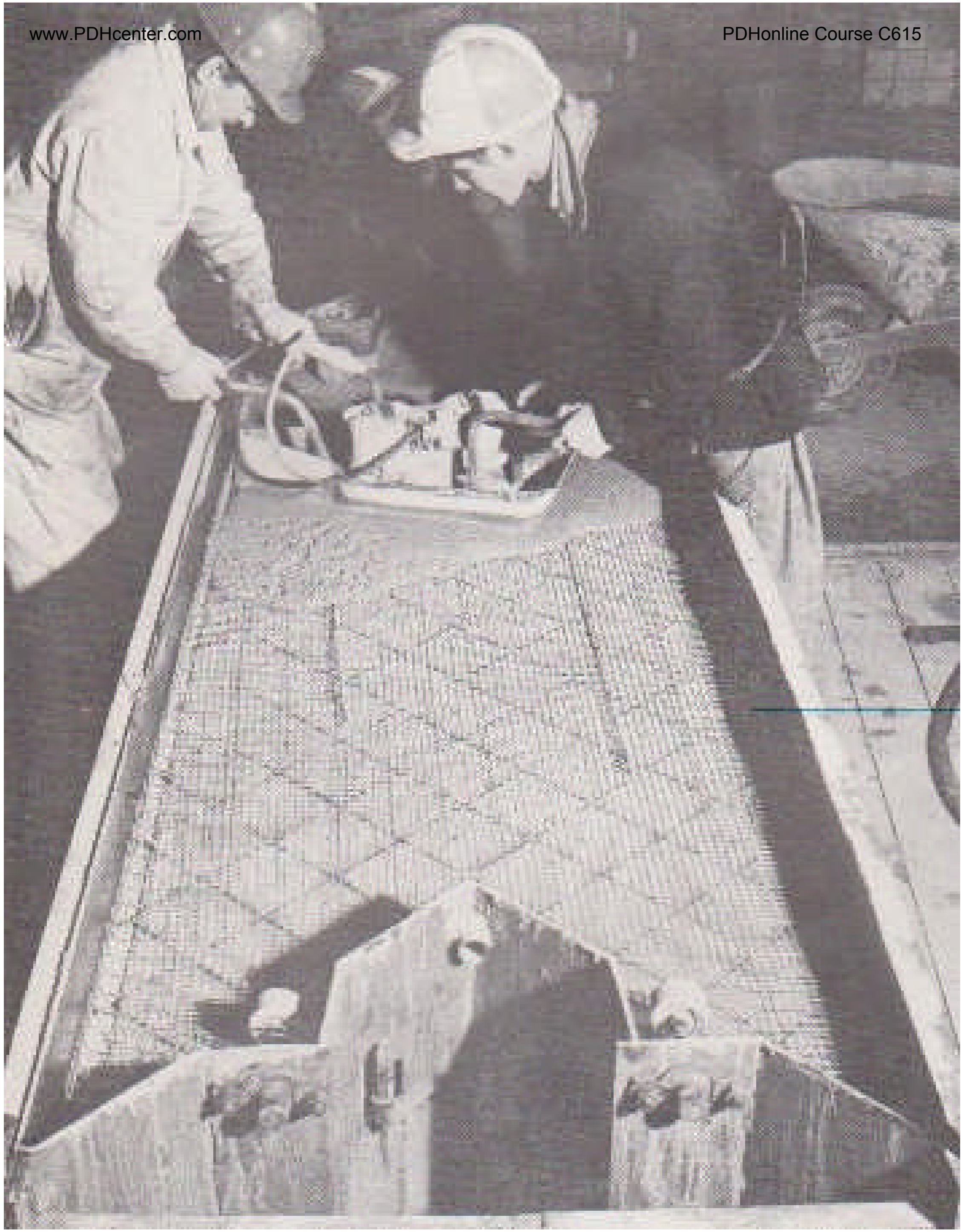
"One day my father was walking in the town of Helsingborg in Sweden and by accident he met the famous Swedish architect Sigurd Lewerentz on the street and as a gesture he bent over and said 'It is an honor to meet you Mr. Lewerentz.' As his eyes looked down onto the pavement he was walking on, he saw that the tiles were set in a diagonal pattern rather than a straight checkerboard pattern. He thought to himself 'ahh if we set them diagonally that would be much better.'"

Jan Utzon, Architect

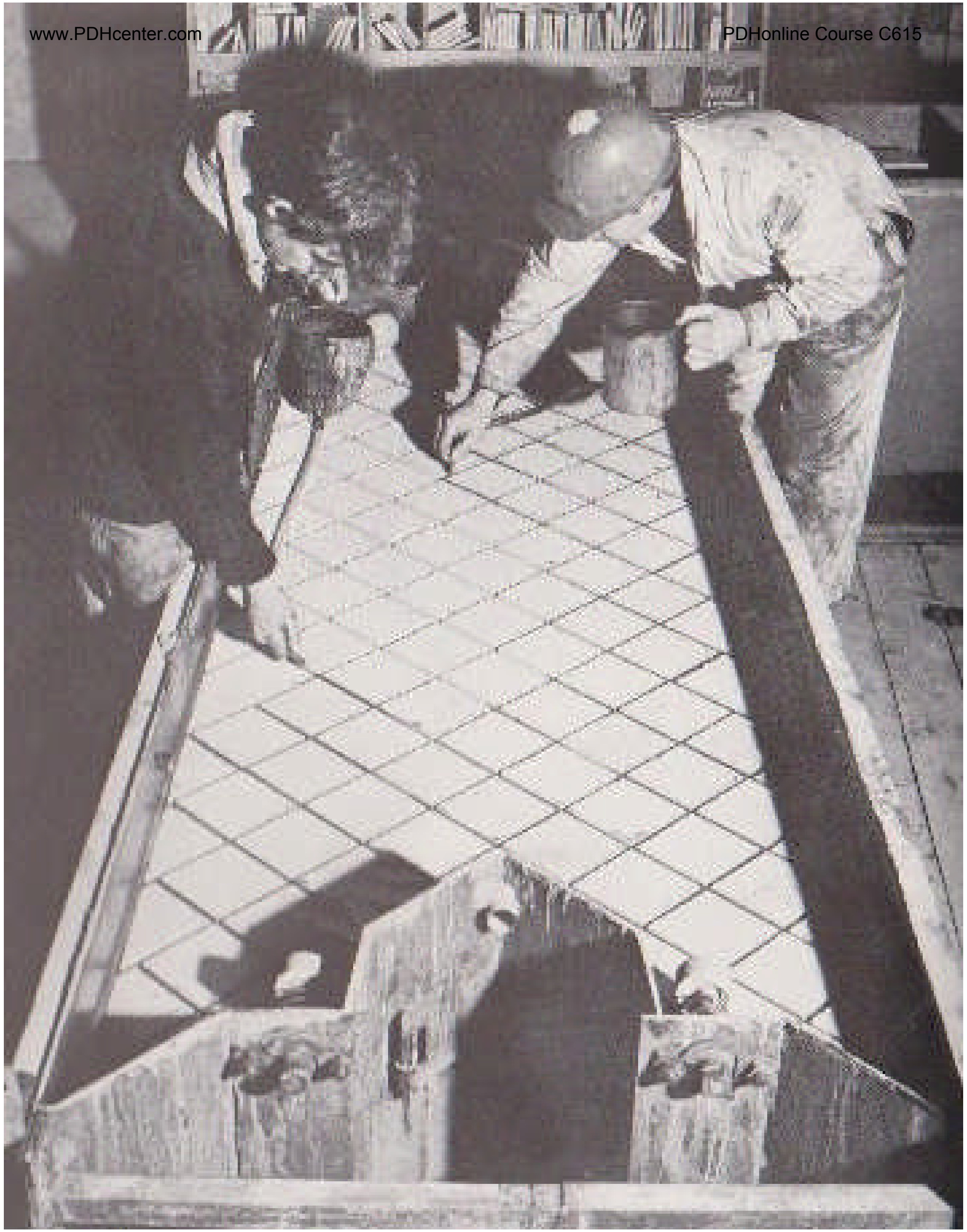
Snow and Ice

"Tile Lids" were used to assemble pre-fabricated sections of tile with the proper curvature and equal spacing between tiles. The tower cranes would lift them into position and then they were secured (with phosphor-bronze bolts) to integral corrosion-resistant aluminum-bronze brackets set into the rib segments when they were cast. A "factory" was established below the Concourse stairway for the manufacture of the 4,228 Tile Lids required to cover the entire surface of the shells. Tiles measuring 4.75 x 4.75 x 0.63-inches were placed face-down in one of twenty-six chevron-shaped beds each having a contour to match the contour of the roof shell it would be applied to. Like "snow and ice," buff colored tiles (with a matt-finish) formed the border around a field of glazed off-white tiles. Animal glue was heated and poured into the gaps between tiles and allowed to solidify. Then, three layers of galvanized steel reinforcing mesh was placed over the tiles and grout was poured to a proper thickness. Steam-curing overnight melted away the animal fat leaving a clean groove between tiles on the face-side. The clean groove was filled with epoxy and the back of the chevron-shaped lid was covered with polyurethane foam insulation. The ingenious use of animal fat to prevent mortar from seeping between tiles and leaving a clean groove behind after melting was the idea of a SOH workman (a carpenter) who was awarded $A100 for his very good idea. Ultimately, approximately one million tiles covering four acres of roof shells would be consumed.

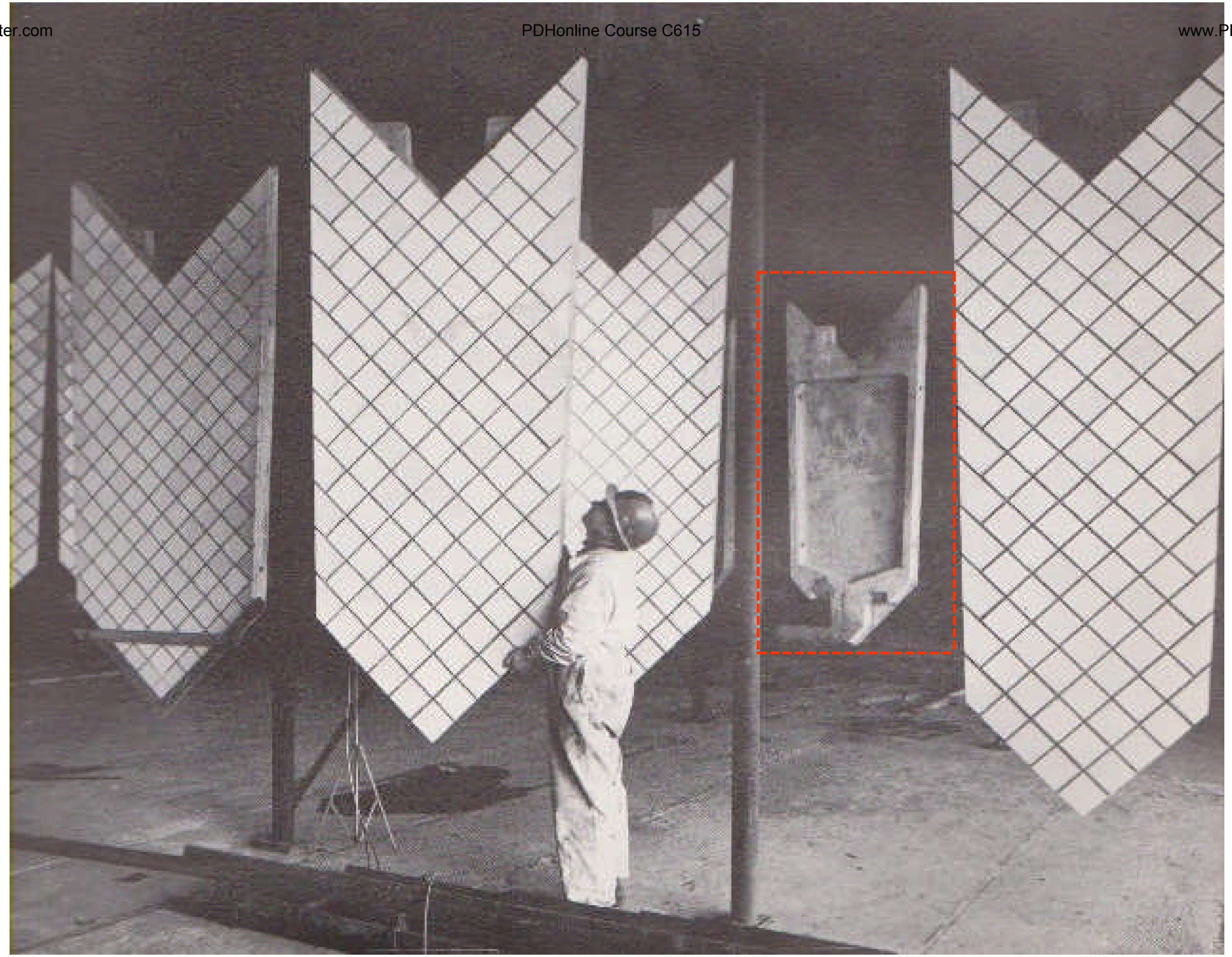
Laying the tiles in Tile Lid



Pouring grout over the reinforcing mesh and back-surface of tiles in chevron-shaped Tile Lid

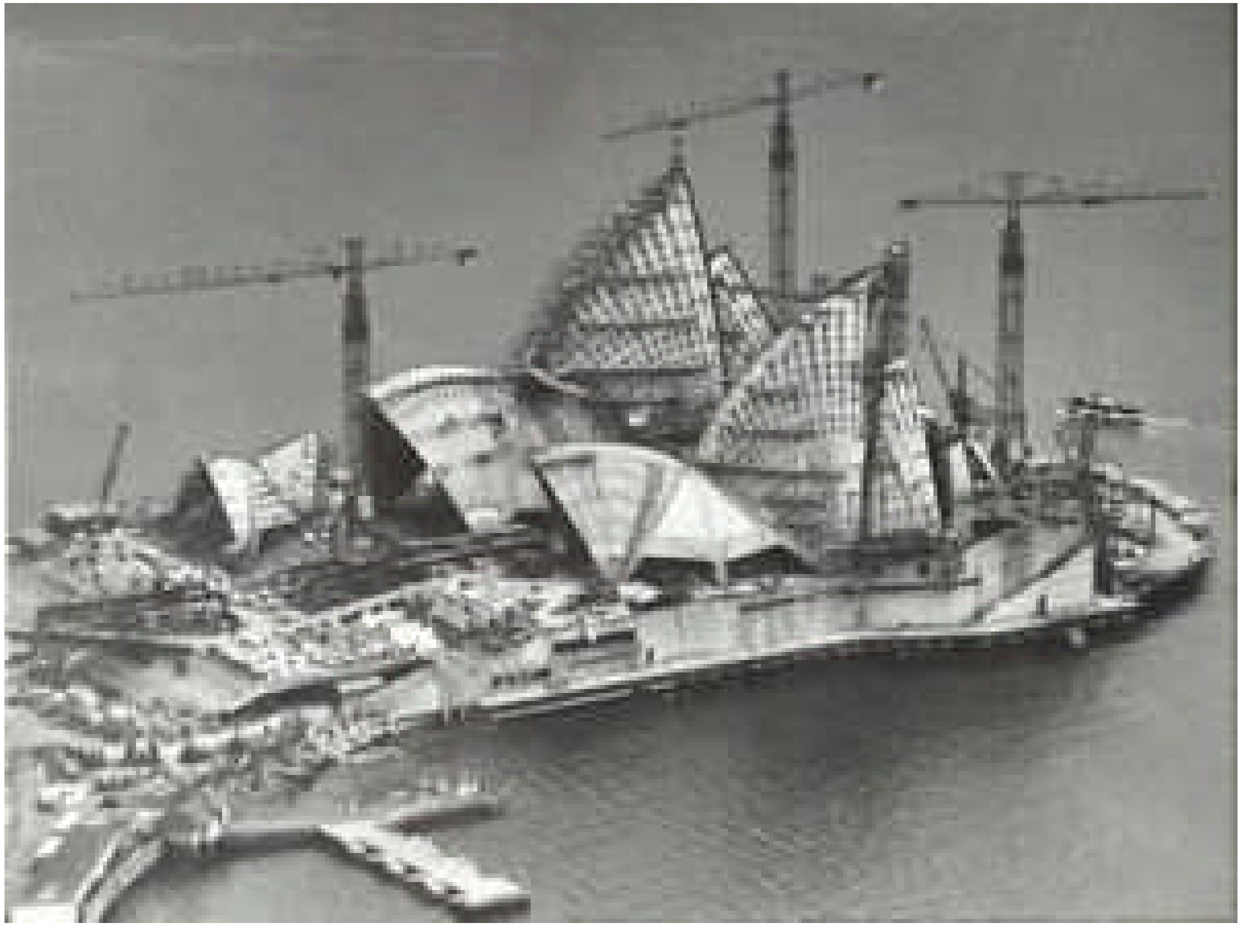


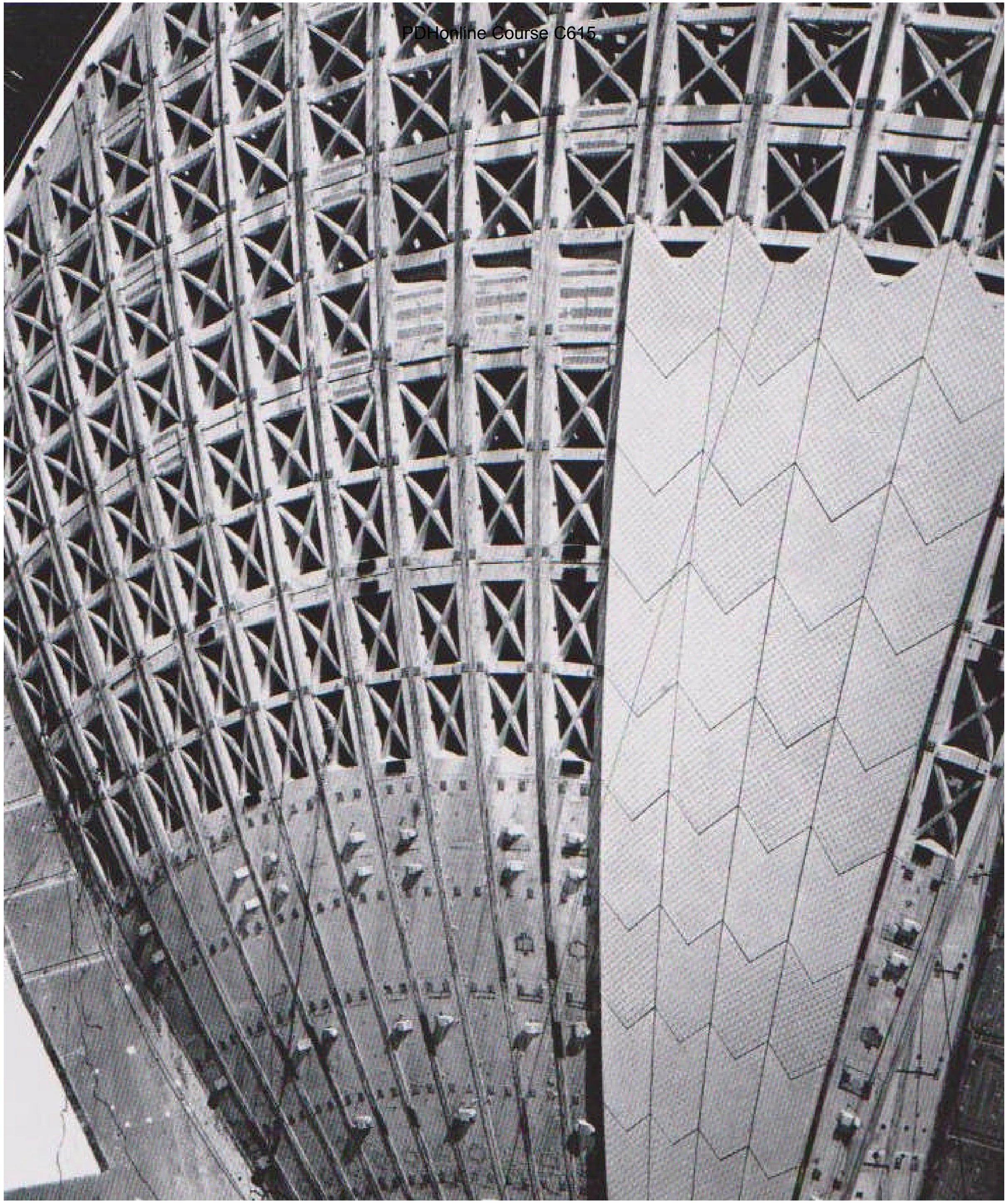
Sealing the clean grooves between tiles (face-side) with epoxy after overnight steam-curing has melted away the animal fat

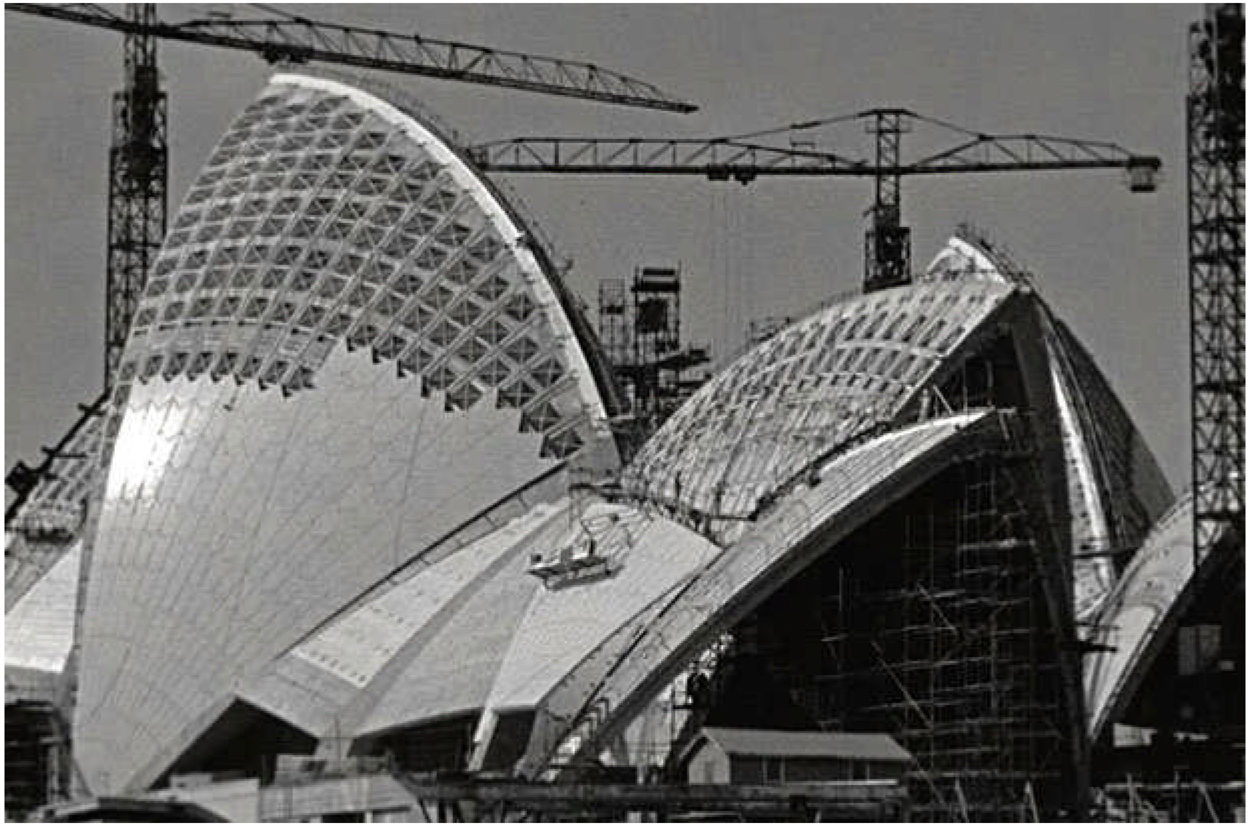


Completed Tile Lids (note the exposed back-face at right)

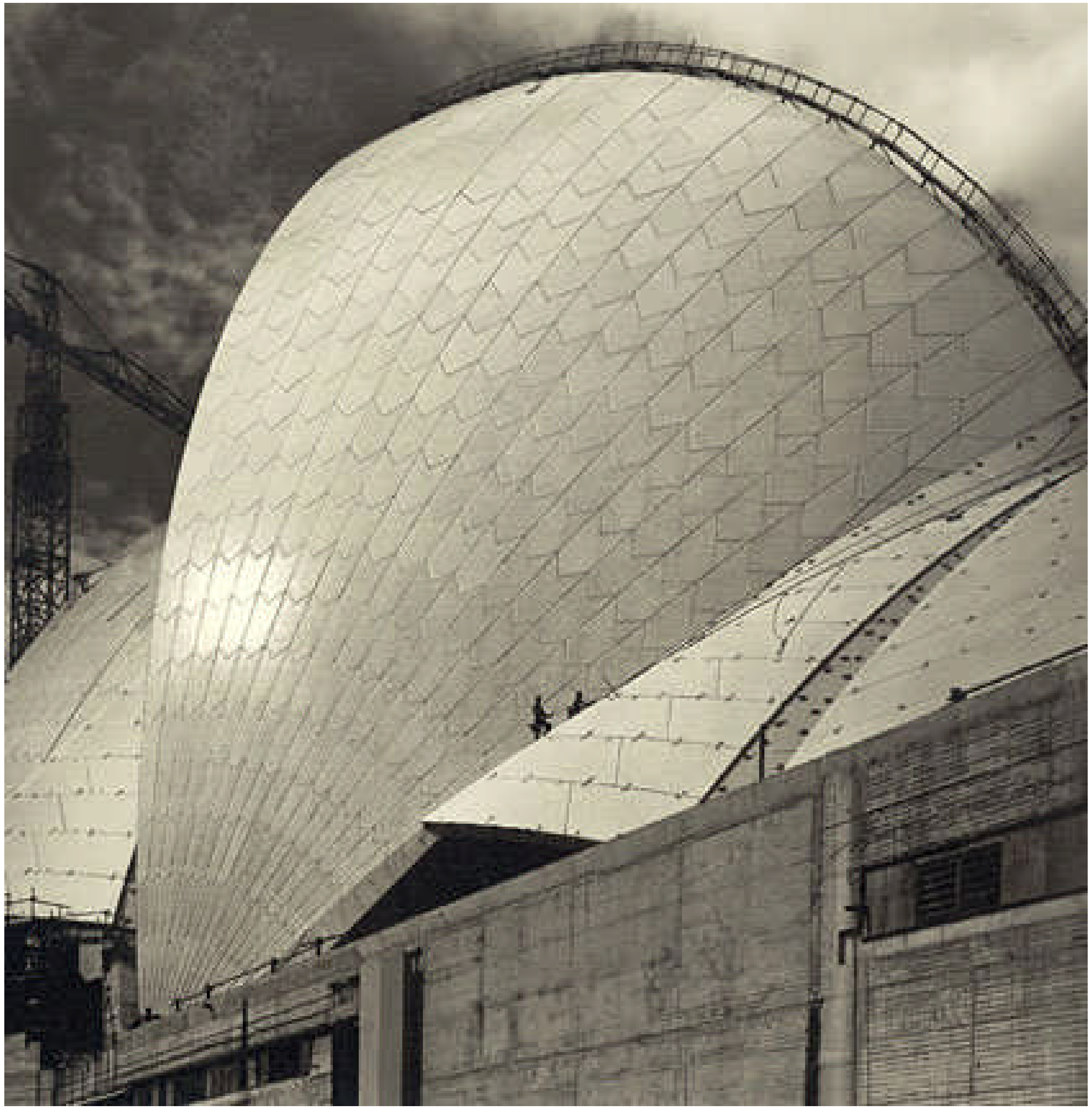
Installation of the lower Tile Lids went well, but minor manufacturing errors and/or curing deformations resulted in the Tile Lid hardware and rib segment/s not mating properly higher up. To solve the problem, surveyors pinpointed the position of rib bolts on already completed shells. The survey data was fed into a computer which determined the exact position of the bolts and provided matching Tile Lid hardware configurations. From mismatched Tile Lids, hardware was removed, recast and refitted. Workmen placed the appropriate number of "packing pieces" between Tile Lids upon placement to ensure a perfect curve from one Tile Lid to the next. Joints between Tile Lids were sealed with *Monolastomeric* (on a plastic backing strip) which allowed for thermal movement between sections.

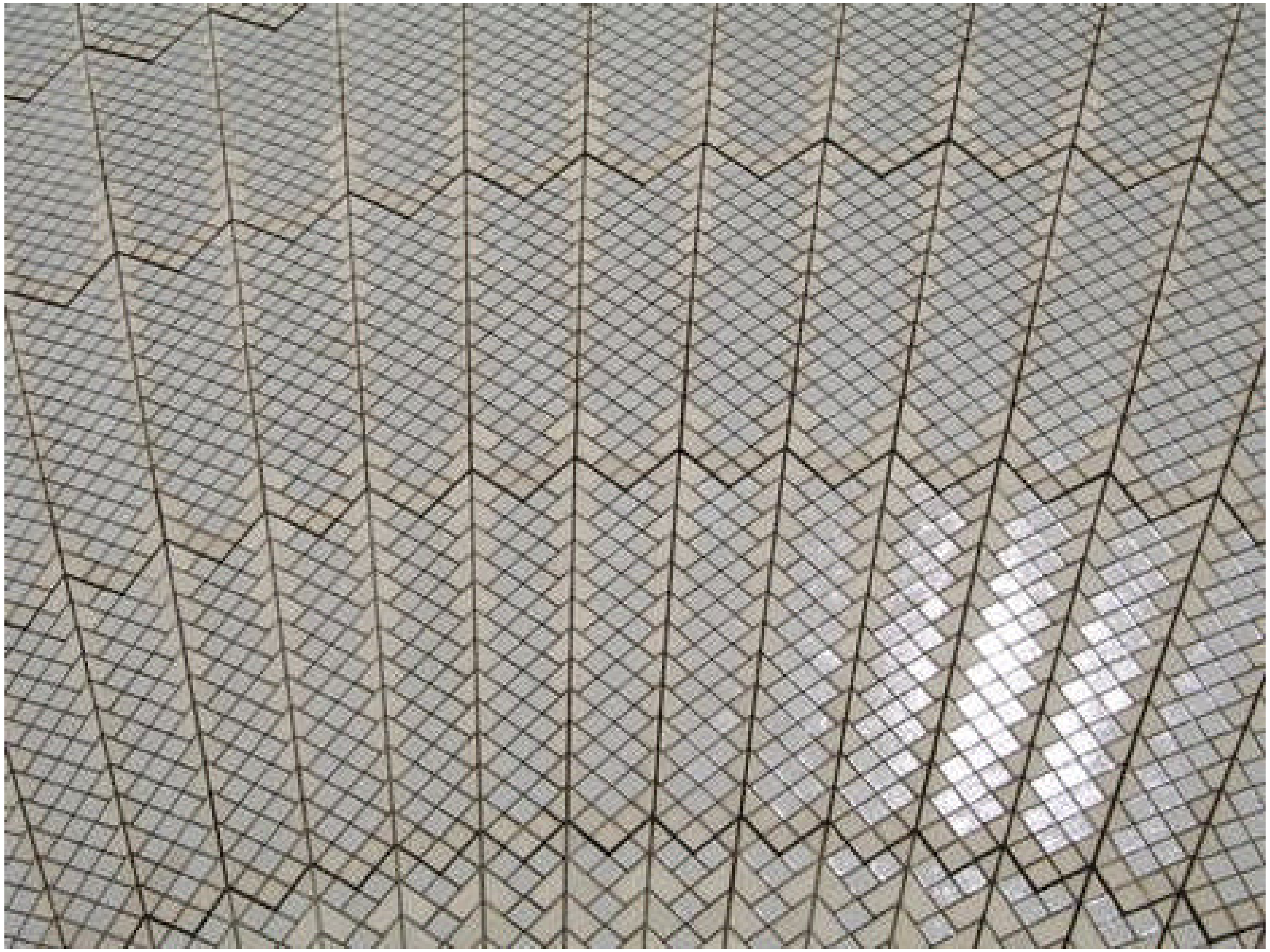


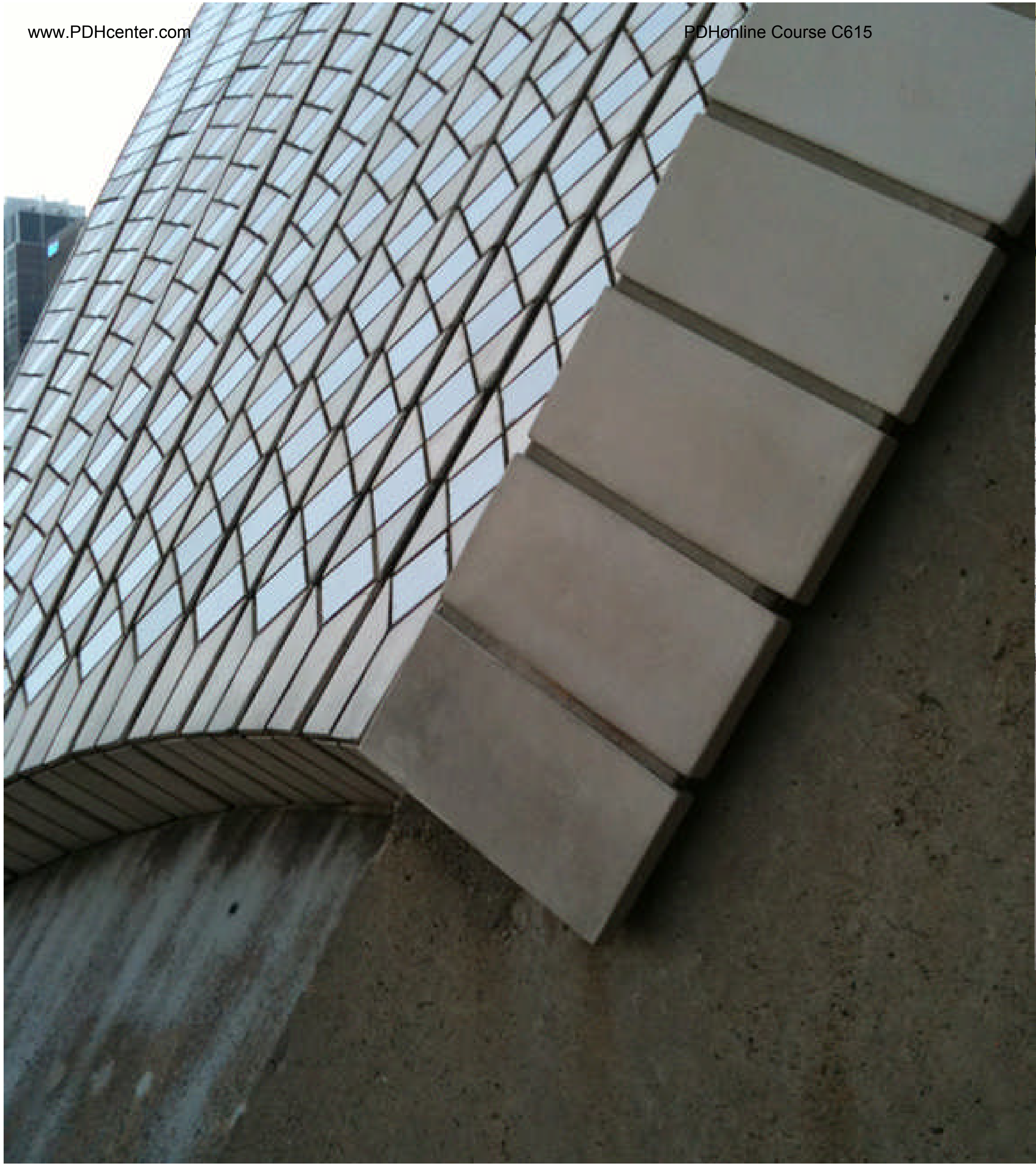


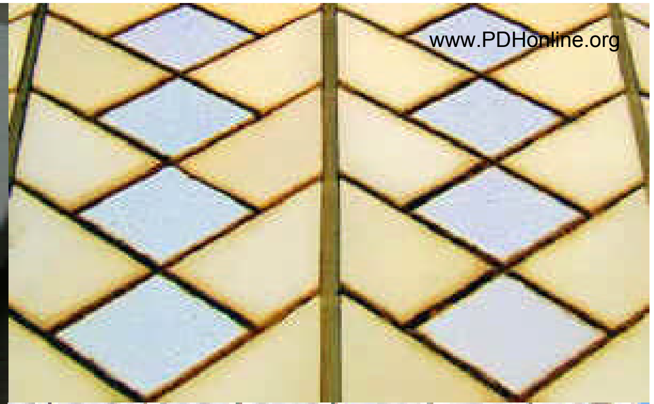


1966





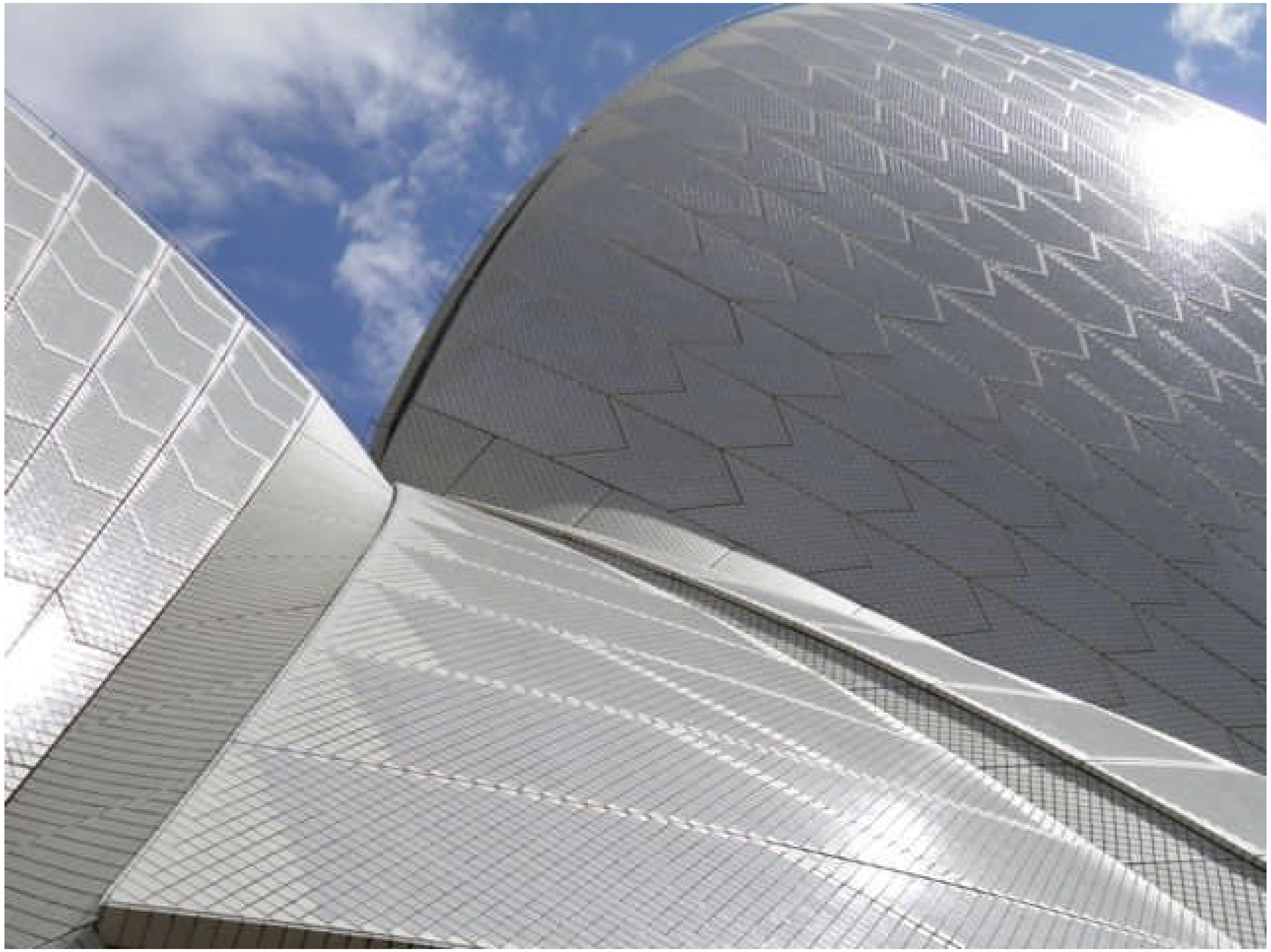


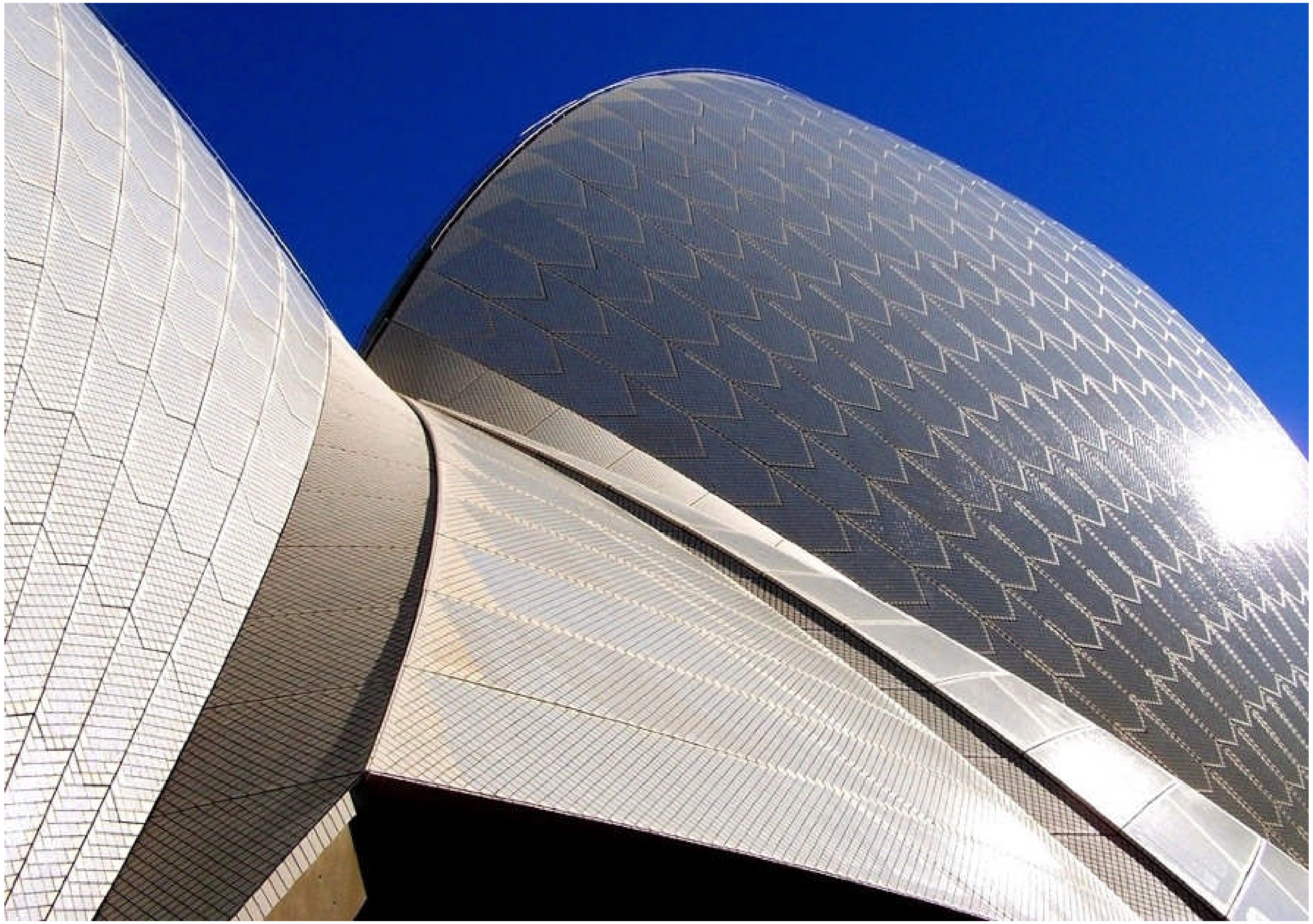


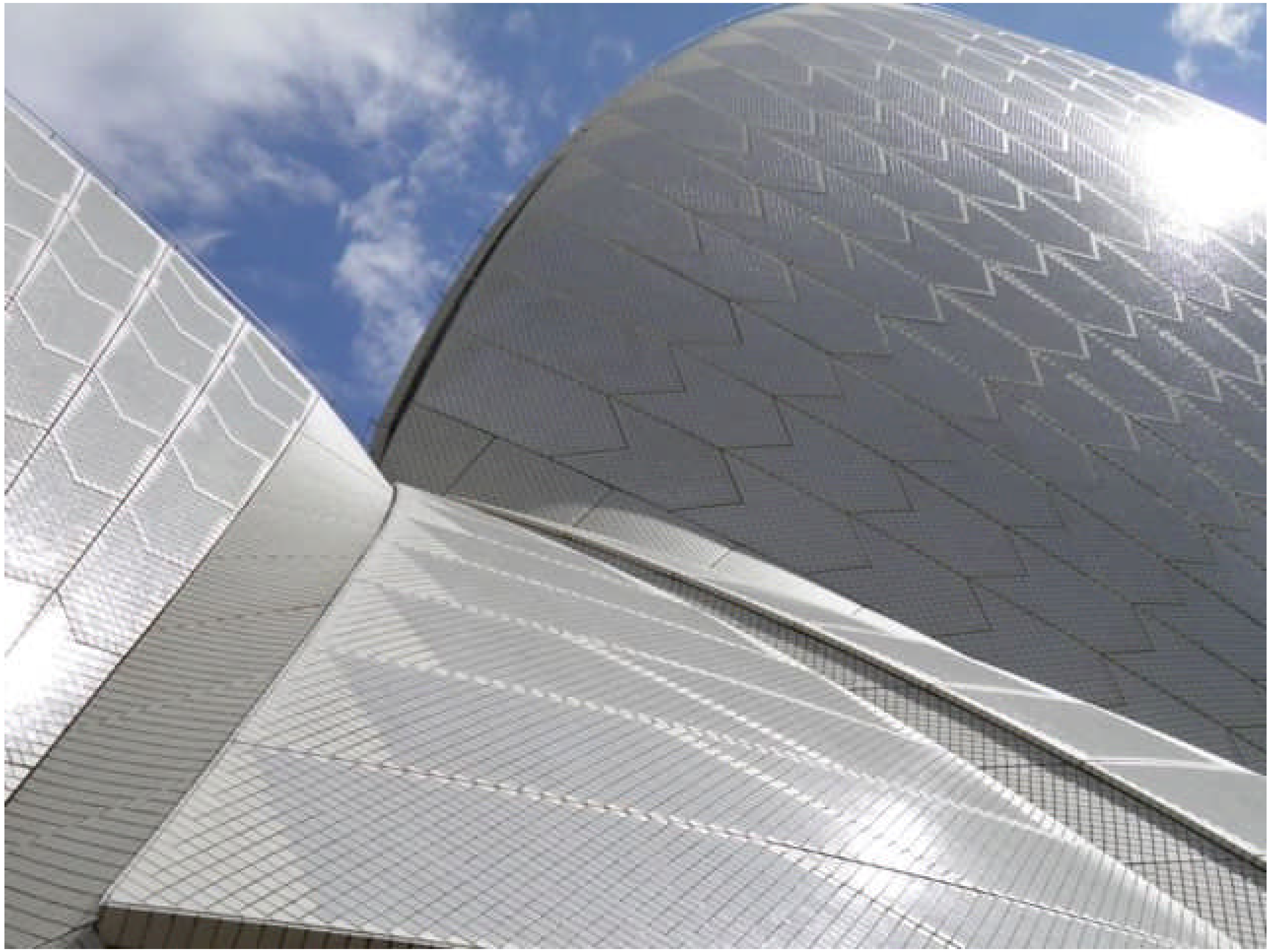
Pedestal Base (with cream-colored and white tile/s pattern)

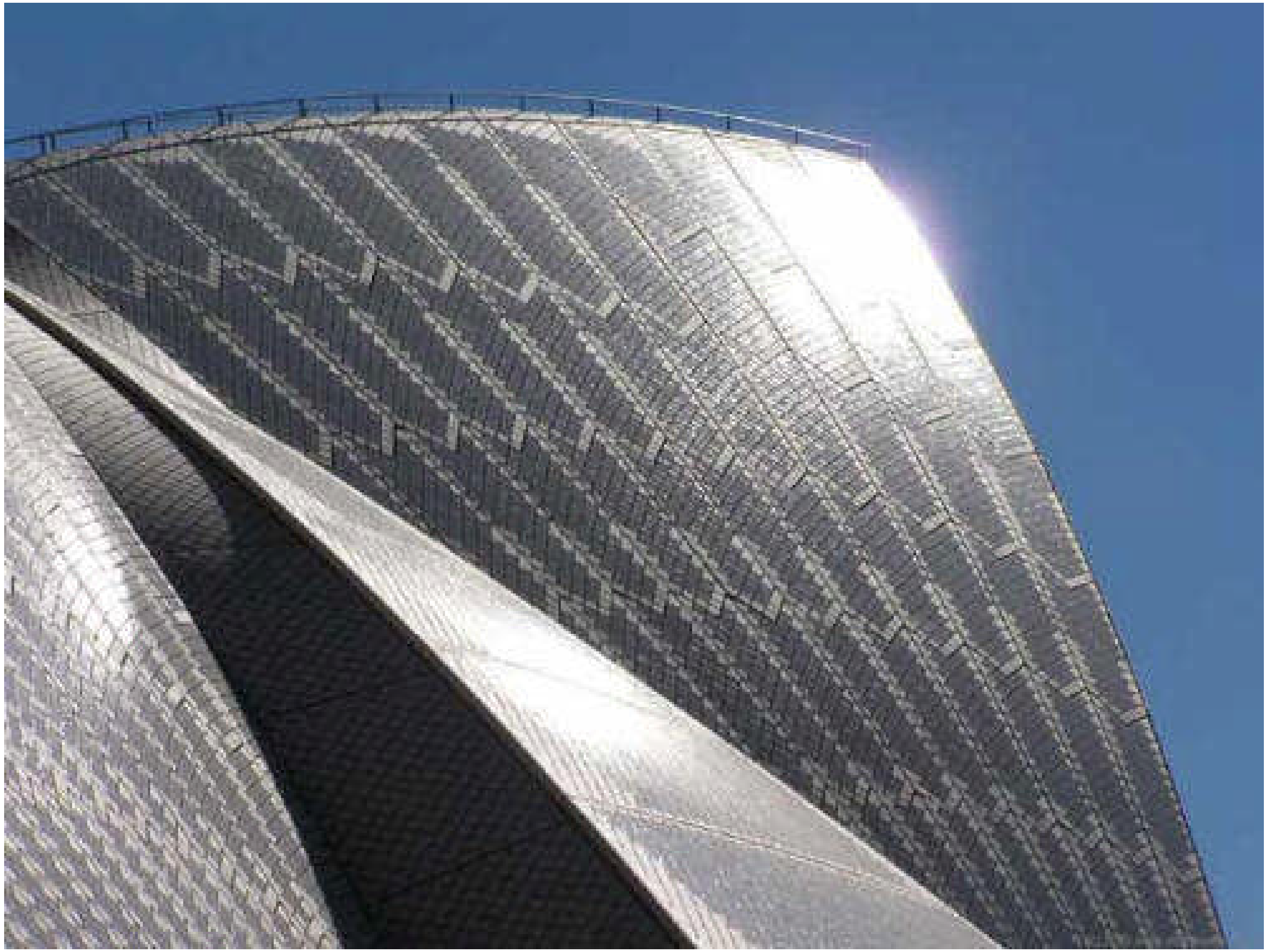
"The sun did not know how beautiful its light was until it was reflected off this building"

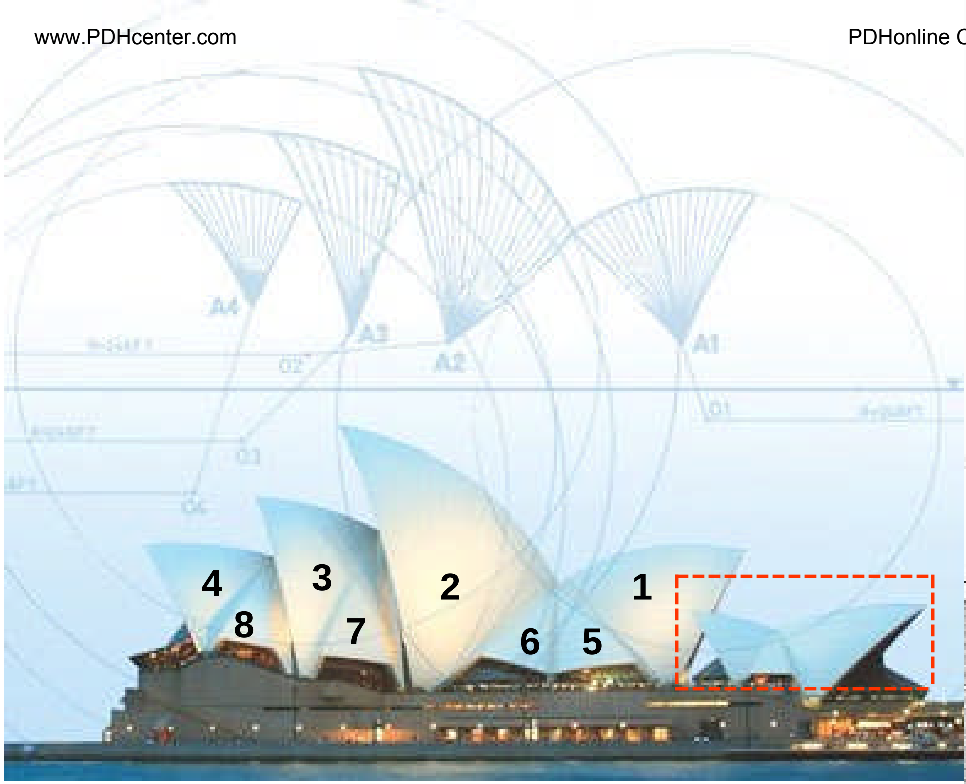
Louis Kahn, Architect

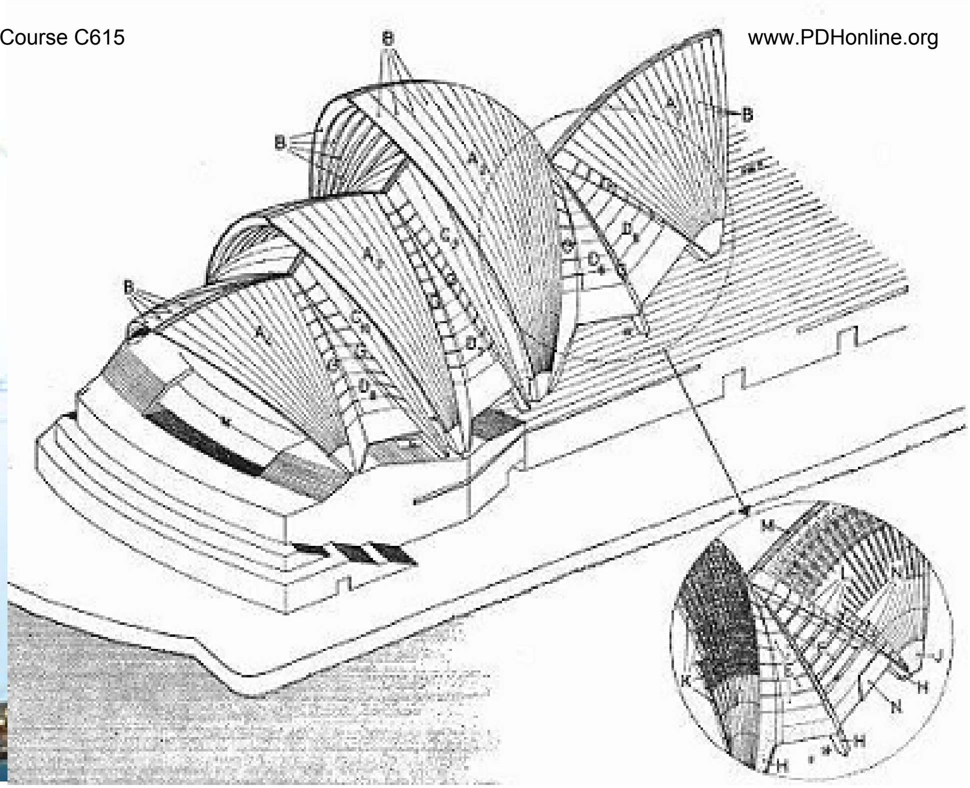




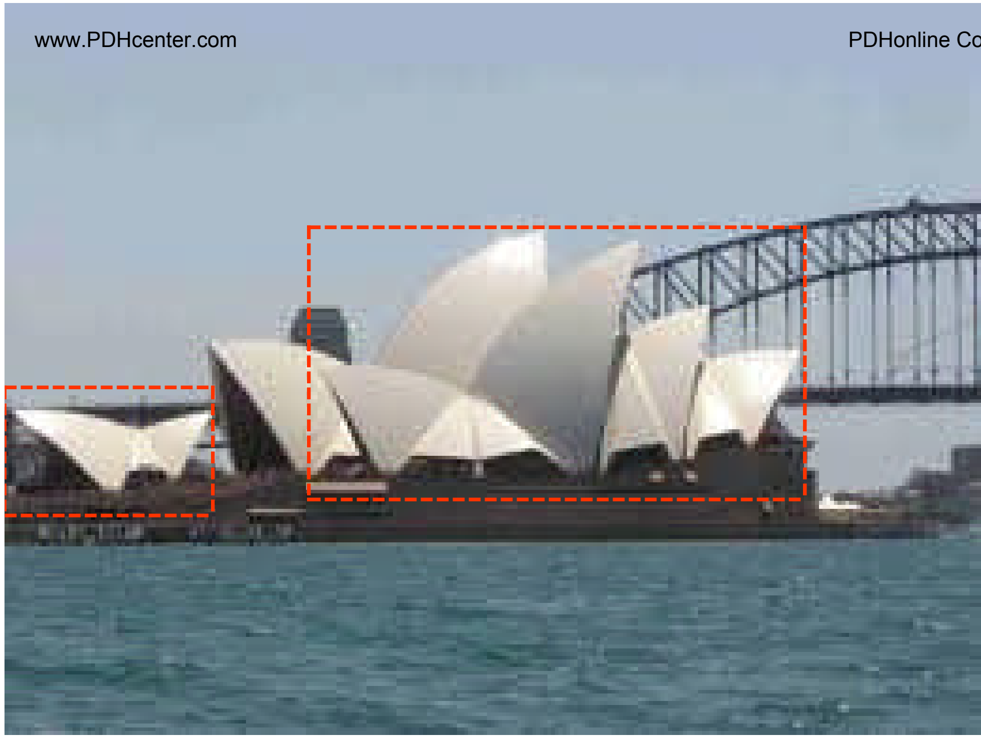


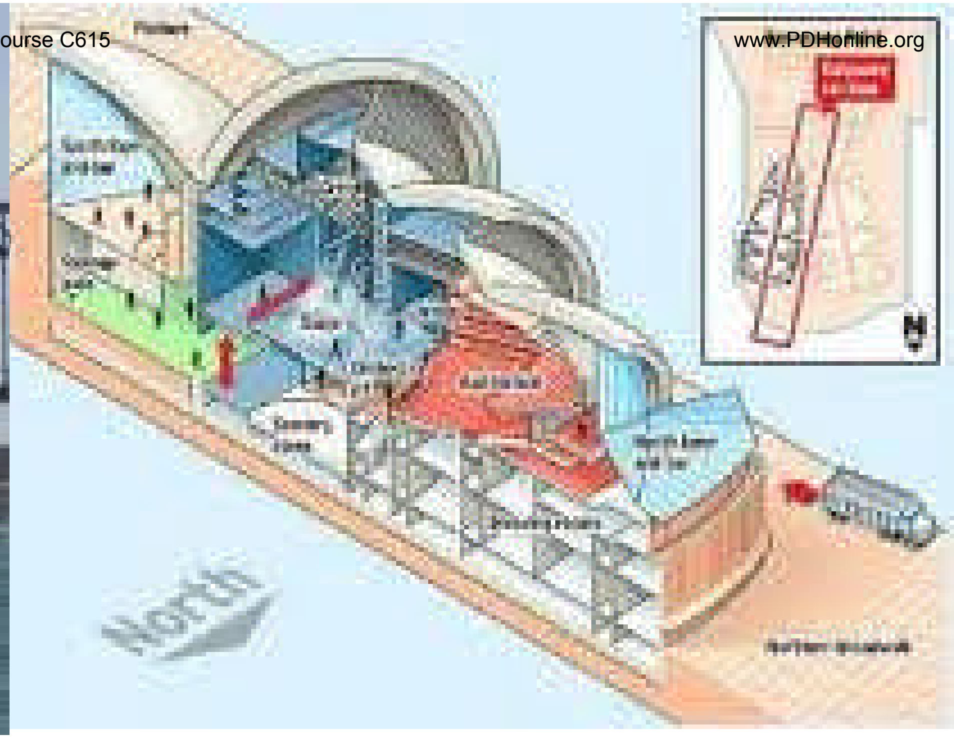




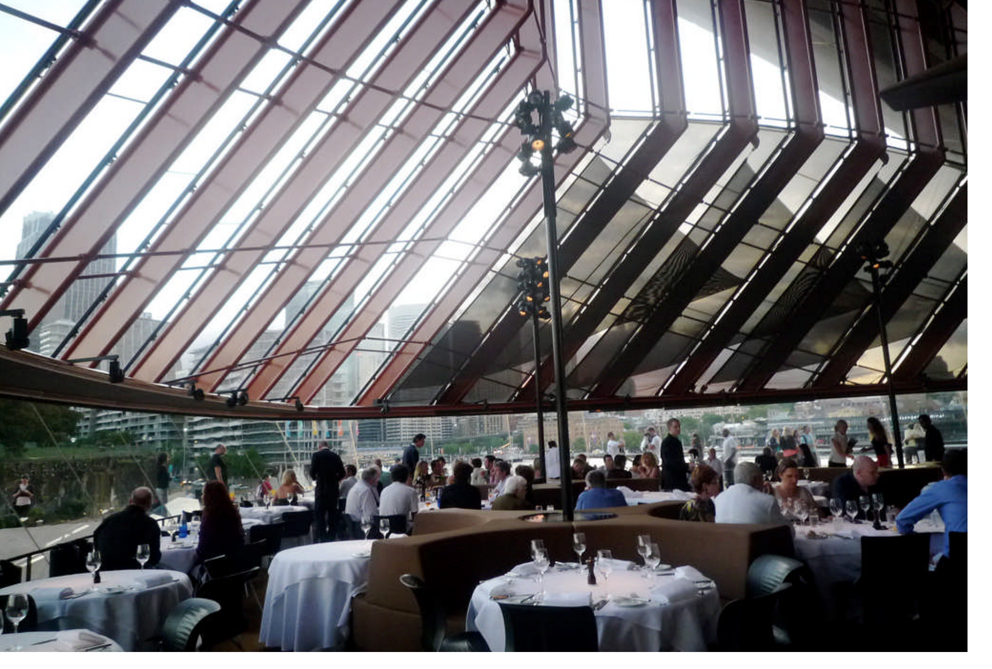


<u>Left</u>: Western view. The roof shells of the major hall; Shells 1 and 2 (A1 & A2) stand back-to-back on their own legs. Integral side-shells 5 & 6 (supported by a cross-wall in the middle) fill the space between and were the first to be erected (Shells 1 & 2 erected from). Shell 3 (A3) stands on its own legs and is back-to-back with Louvre Shell 9 (out-of-view) which rises backwards into the mouth of Shell 2 and both are joined by Side-Shell 7 which is supported by four legs. Shell 4 (A4) stands on its own legs and is back-to-back with Louvre Shell 10 (out-of-view) which rises backwards into the mouth of Shell 3 and both are joined by Side-Shell 8 which is supported by four legs. The minor (opera) hall (opposite side) has a similar arrangement albeit on a smaller scale. The restaurant roof (outlined) consists of back-to-back shells. Shell 2 (A2) is highest reaching a height of 221-feet. The shells weigh a total of 21K-tons while the Podium which supports them weighs 10K-tons.

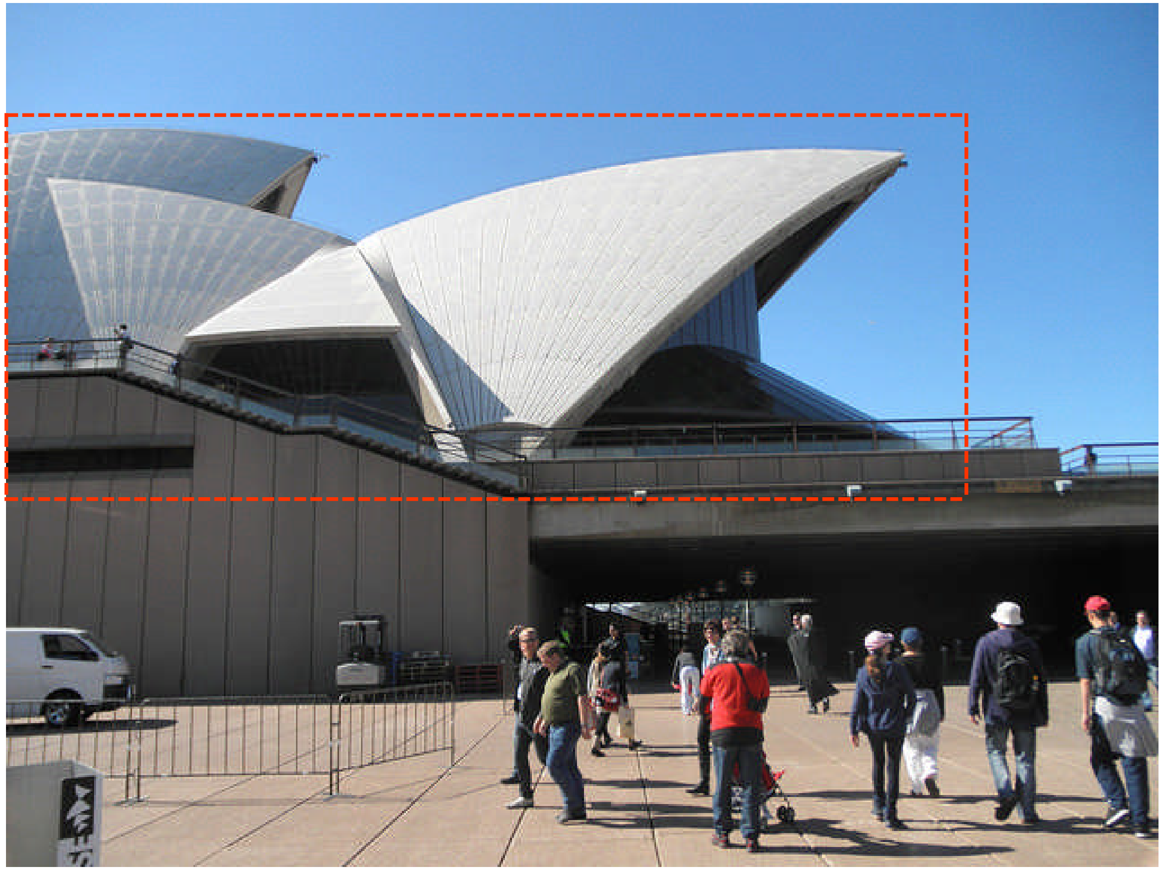




Eastern view (left) and cut-away view (right) of the minor (operatic) hall/shells. While the major hall shells cover an area measuring 400-feet (north-to-south) by 176-feet (east-to-west), the minor hall shells cover an area measuring 352-feet by 128-feet. The tallest shell (housing the fly tower) over the minor hall rises to a height of 186-feet above mean sea level, about the height of an eighteen-story building. The low-rise back-to-back shells of the restaurant (supported on four legs) can be seen to the left (top left photo).



***Guillaume at Bennelong* (restaurant)**



Despite the dramatic departure of Utzon in late February 1966, work on SOH continued unabated until the completion of Stage Two a year later in February 1967 at an official total cost of $A13,165,955. In a letter that month to *The Australian* newspaper, Utzon appealed to *Davis Hughes* to let him finish his work on the SOH. Premier Askin rejected the offer as "impractical." Once the final Tile Lids were in place, the tower cranes stood like lonely sentinels while the site was dormant for two years, until the commencement of Stage Three in 1969. It was nearly two years since Hall, Farmer and Littlemore had submitted their recommendations for Stage Three to Davis Hughes. The three architects advised the Minister in September 1968 that the SOH would cost an additional $A85 million and would not be completed until the end of 1972. In March 1969, the SOH Bill was passed stating that to-date, $A32 million had been spent and that a total of $A85 million would be allocated to complete the project. The final cost (in 1972) was $A102 million.

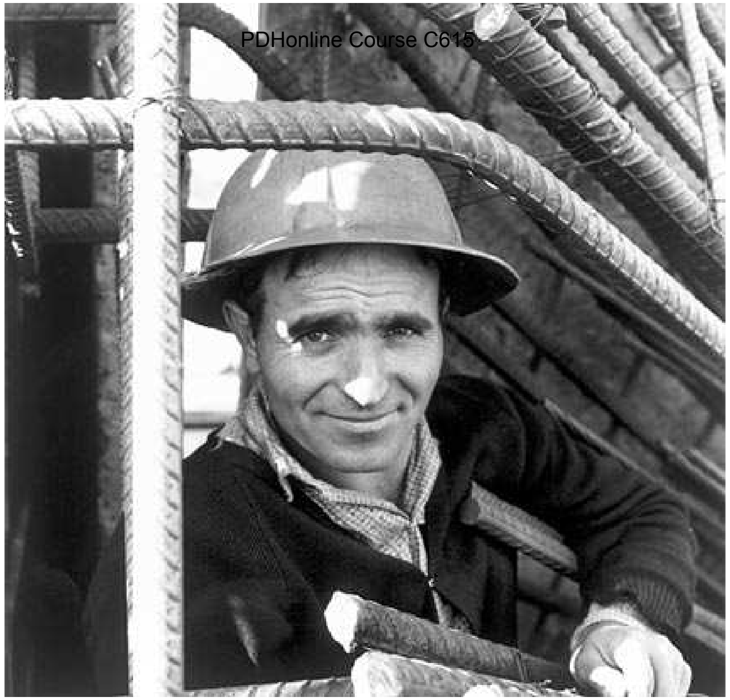
Sydney Opera House: Cost and Time Estimates

Date of Estimate	Estimated Cost ($A million)	Estimated Completion
January 1957	7.20	January 1963
January 1959	9.76	
October 1961	17.94	
August 1962	25.00	Early 1965
June 1964	34.80	March 1967
August 1965	49.40	
September 1968	85.00	End of 1972
November 1971	93.00	
March 1972	99.50	
May 1974	102.00	October 1973

In 1973, *The Hornibrook Group Ltd.* provided the following cost break-down assessment of the $A102 million overall cost of SOH:

- **Stage One (Podium): approximately $A5.5 million;**
- **Stage Two: (Roof Shells): approximately $A12.5 million;**
- **Stage Three (Completion): $A56.5 million;**
- **Separate Contracts; Stage Equipment, Stage Lighting and Organ: $A9 million;**
- **Fees and other costs $A16.5 million;**

The original cost estimate (in 1957) was $A7 million. The original completion date set by the government was January 26th 1963 (*Australia Day*). Thus, the project was completed ten years late and over-budget by more than fourteen times (1,400 percent) the original estimated cost.



At the peak of construction (mid-1972), there were over 1,200 workmen on site with many more around the world involved with fabricating materials and equipment. Many of the SOH workers were migrants to Australia and materials and equipment were supplied from around the world. Exterior tiles came from Sweden while interior tiles came from Japan. Stage lighting and curtains came from Germany and heat pumps from America. Closer to home, Victoria and NSW provided carpeting.

"I believe the sacking of Utzon was the greatest tragedy that happened in the history of the Opera House...We know that, from the outside, the building is an architectural masterpiece. The building will be false if the present plans are implemented. It will be architecturally false: it will not be the building it should have been."

Norman Ryan, former Minister for Public Works – March 1969

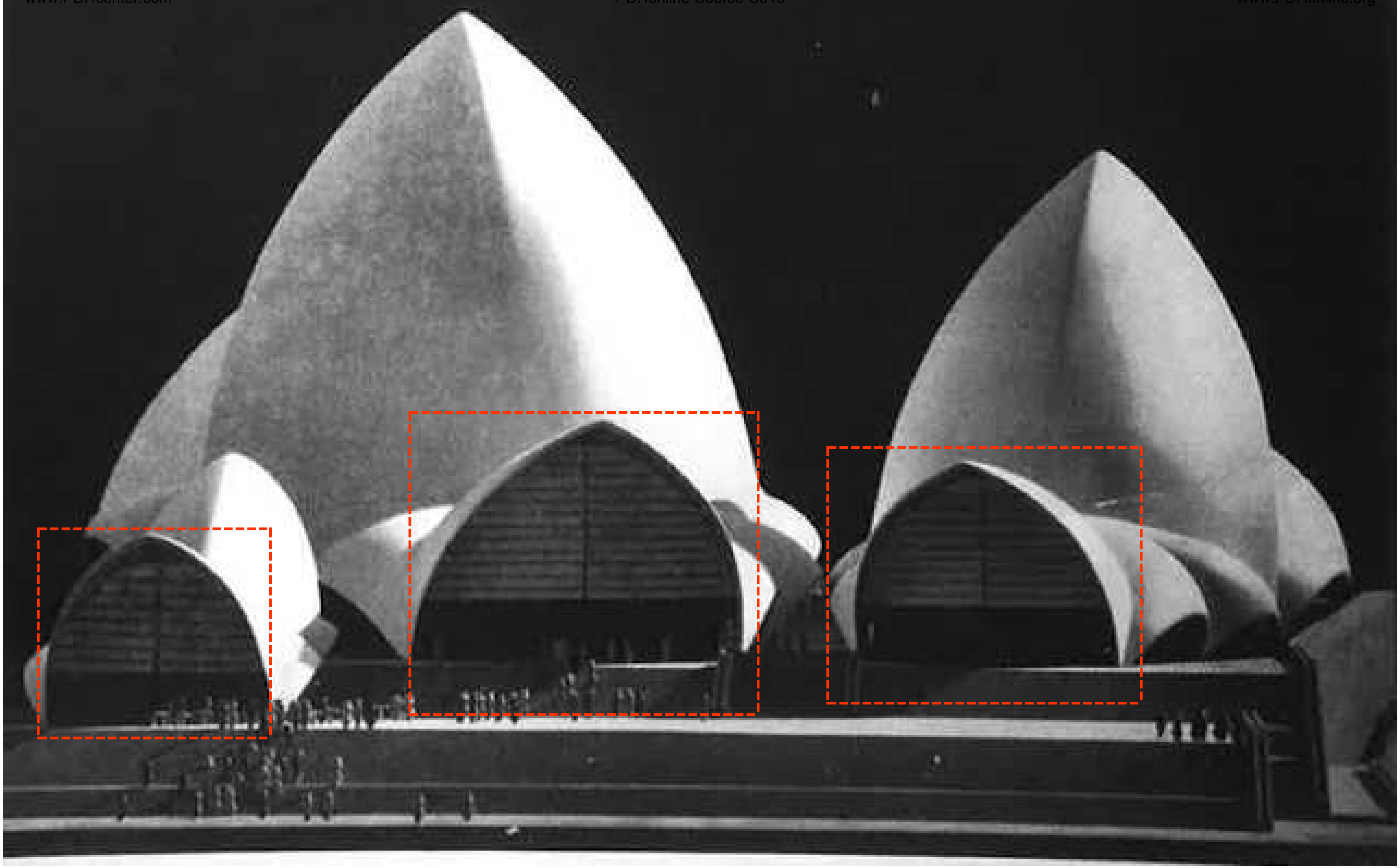
RE: for all the complaints about soaring costs that Ryan had leveled against Utzon when he was DPW Minister, the cost of Stage Three alone ($A56.5 million) – absent Utzon, would dwarf the expenditure of the previous two stages. For *Peter Hall* who, despite professional recognition for his achievements a generation later, never recovered from the animosity many of his peers in the architectural, design and cultural communities felt towards him for accepting the position held by *Jorn Utzon.*

Part 10

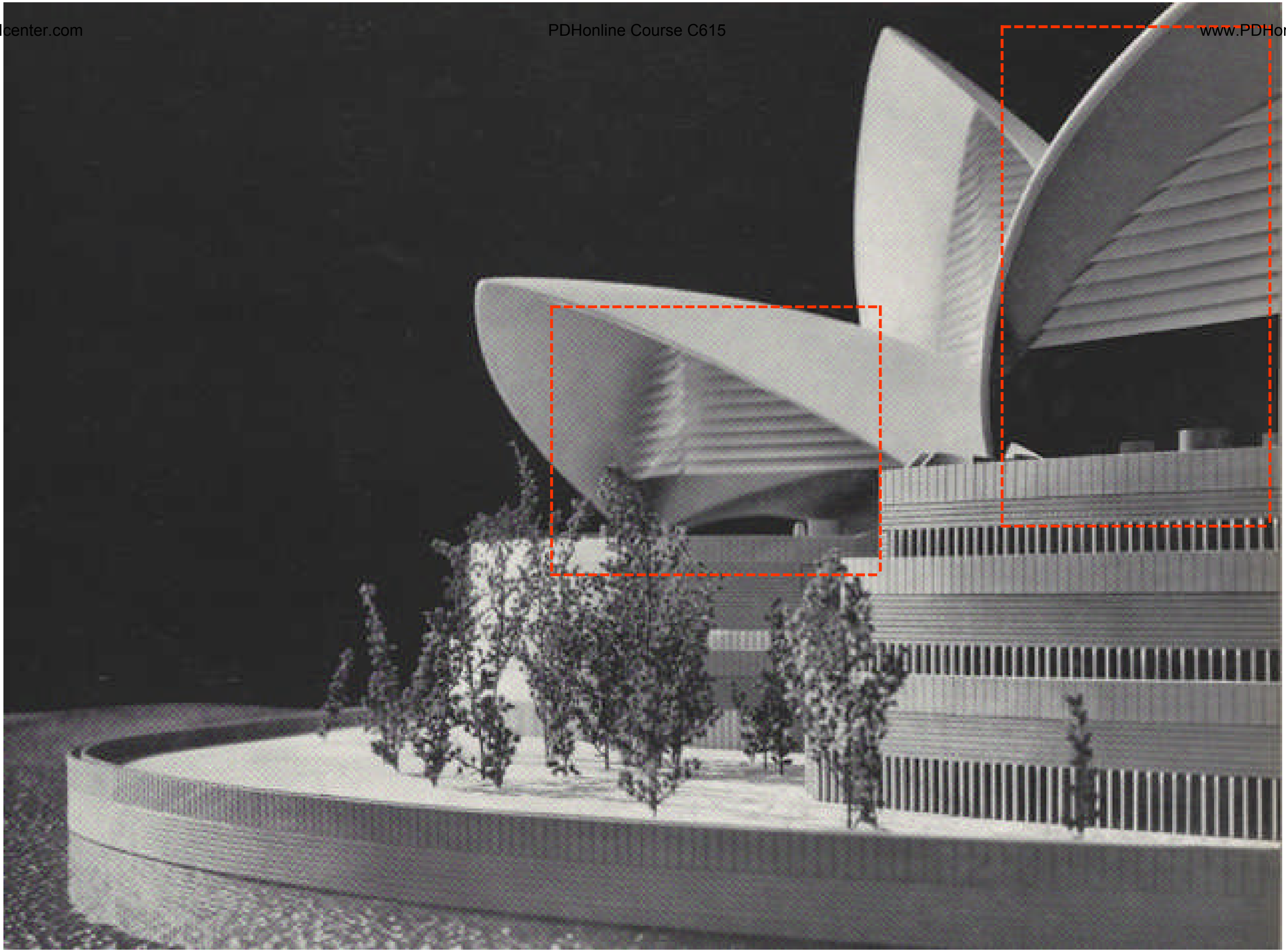
Fenestration

The Evolution of an End Wall

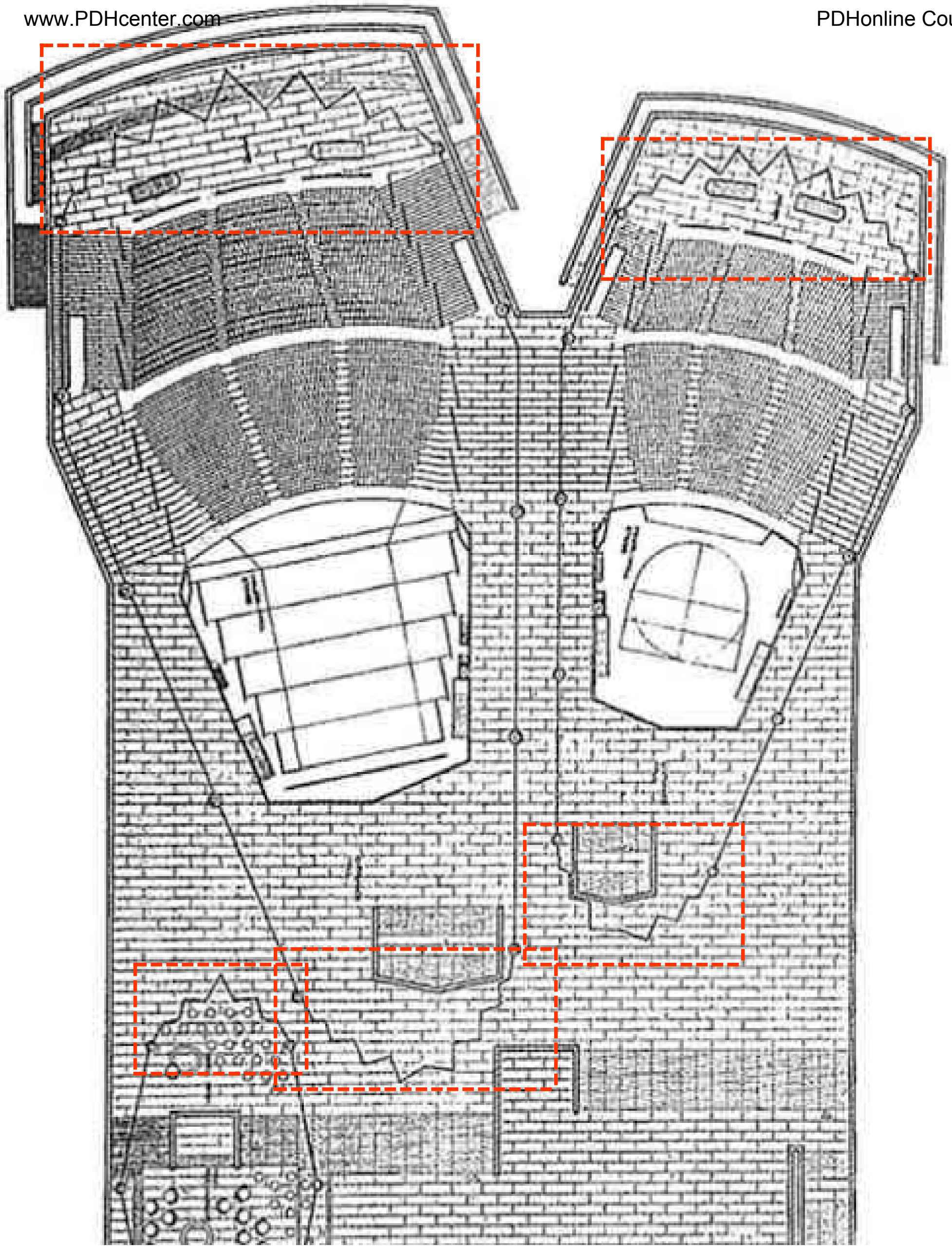
Internal natural light was not a critical requirement for the major and/or minor halls since performances occur primarily at night and require a darkened space or controllable artificial light sources. However, since the views of the Sydney Harbor were not to be missed, Utzon's competition design featured a receiving end and a viewing end for each hall. A drawing of a longitudinal section showed vertical glass walls hanging from the outer shells and thrusting out to become nearly horizontal glazed canopies. At the seaward (harbor) side, the glazed canopies cover the space of the back foyers. On the opposite (city) side, they are part of the entrance space receiving visitors. When Utzon won the competition, he rushed the preparation of additional drawings and a model (the first) to take with him for his initial trip to Sydney. The north (harbor-side) shells were now taller, and the south (city-side) were shorter. The model was the first visualization of the glass walls. They appear to be a simplified version of the competition scheme; there are no horizontal glazed canopies and the upper part of the glass walls is covered with what appears to be horizontal louvers. In Australia, which is in the southern hemisphere, the sun's rays are strongest on the north side yet louvers appear on both north and south sides in the model.



First model (1957) by Utzon of SOH (south/city-side view). From left to right: Restaurant, Opera Hall entrance, Theater Hall entrance.

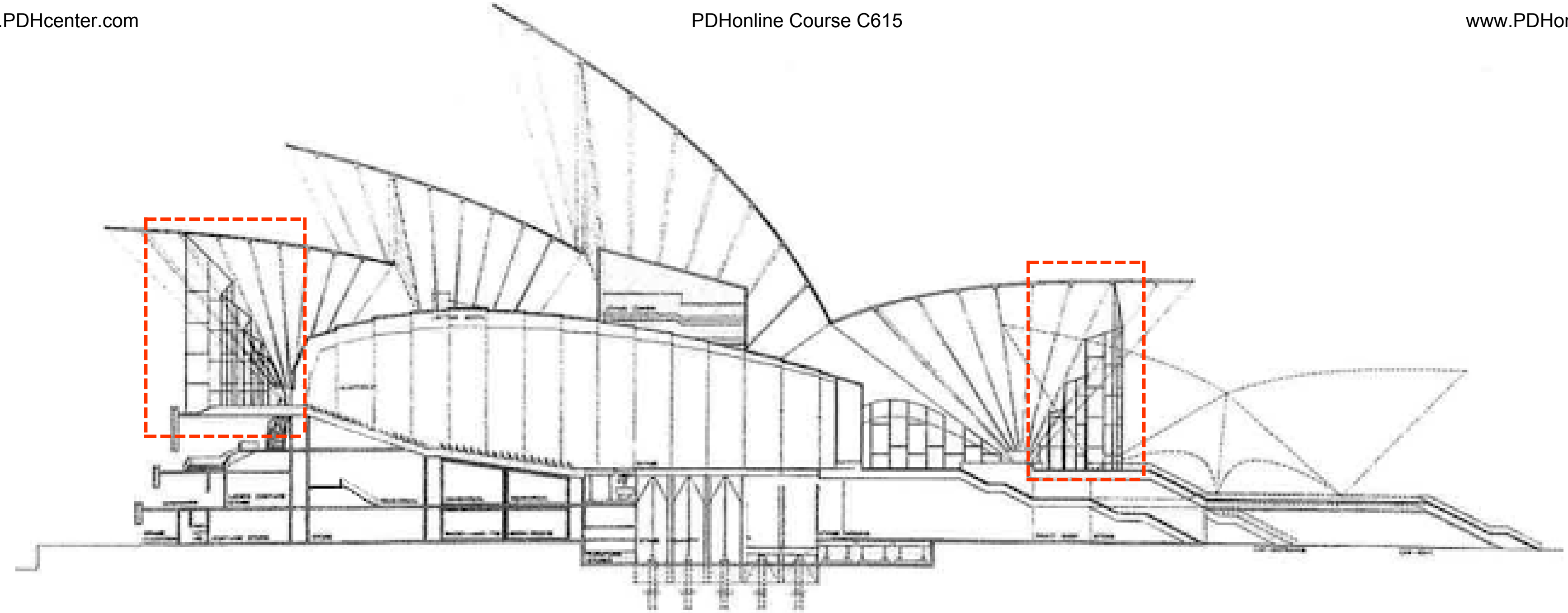


First model (1957) by Utzon of SOH (North/harbor-side view). Left; Theater foyer, Right; Opera Hall foyer

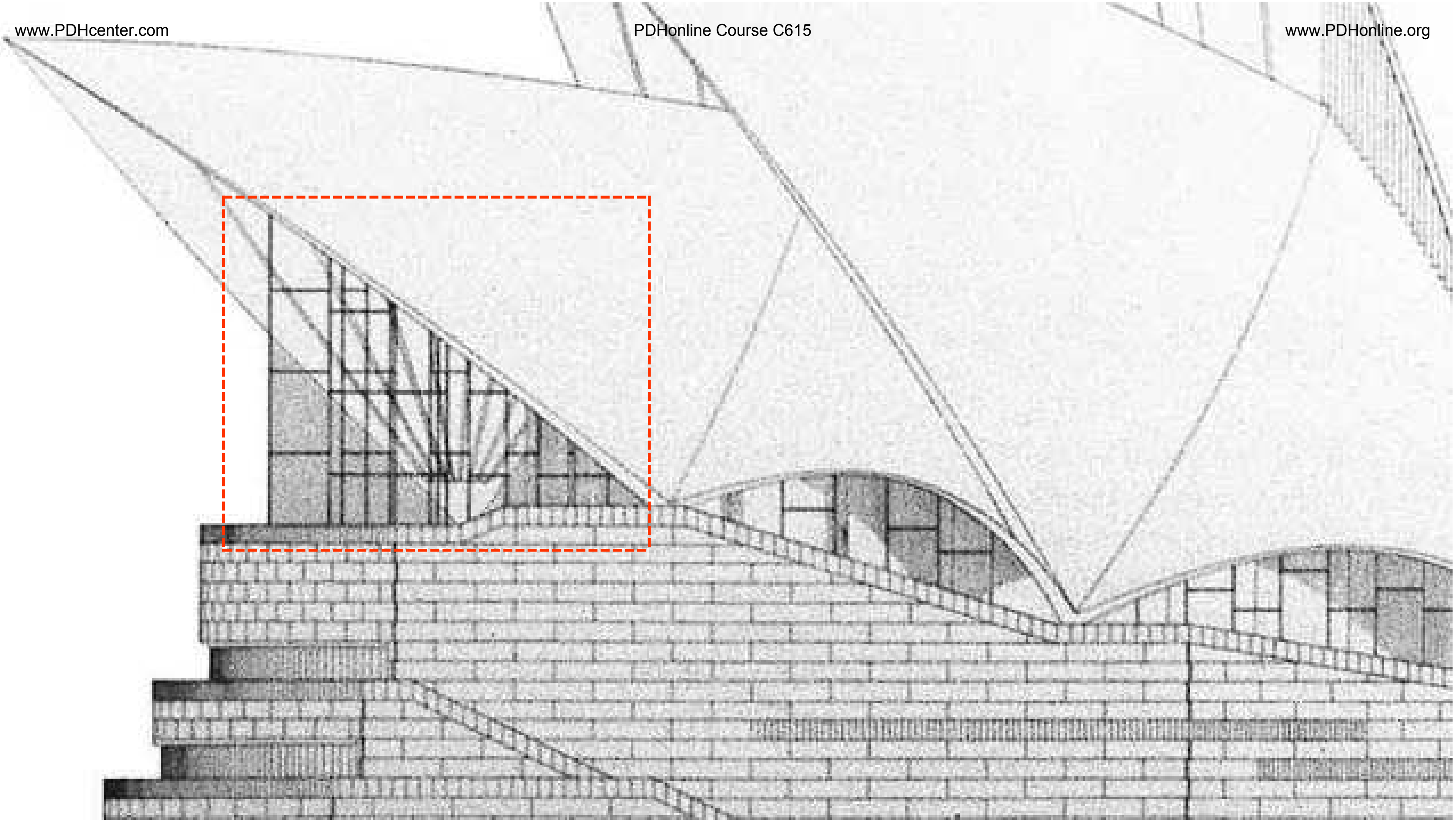


Platform Level Plan (1958)

For the *Red Book* (1958) The design for the glass end-walls adopted a different configuration: In plan, they are now zig-zaging and vertical in section (looking something like a folding screen). From a structural point of view, this makes a lot of sense since the folded planes of the wall help stiffen one another against wind loads. The Red Book roof shells were still relatively low requiring edge support at the point where the shell and glass wall/s interface. Utzon was probably considering some kind of structural (load-bearing) steel mullion to transmit roof loads from the shells to the Podium.



<u>**Above**</u>**: longitudinal section through the Concert Hall (*Red Book*, 1958). Note the folding screen-like glass ends. The longitudinal section demonstrates one of the future problems of the glazed end walls; how to connect them to the curved underside (soffit) of the roof shells. It appears that Utzon (in the period between 1956 and 1962) was focusing on developing the general concept of SOH, then the Podium and finally the shell roofs. By necessity, the glass end walls as well as many other design elements would have to wait.**



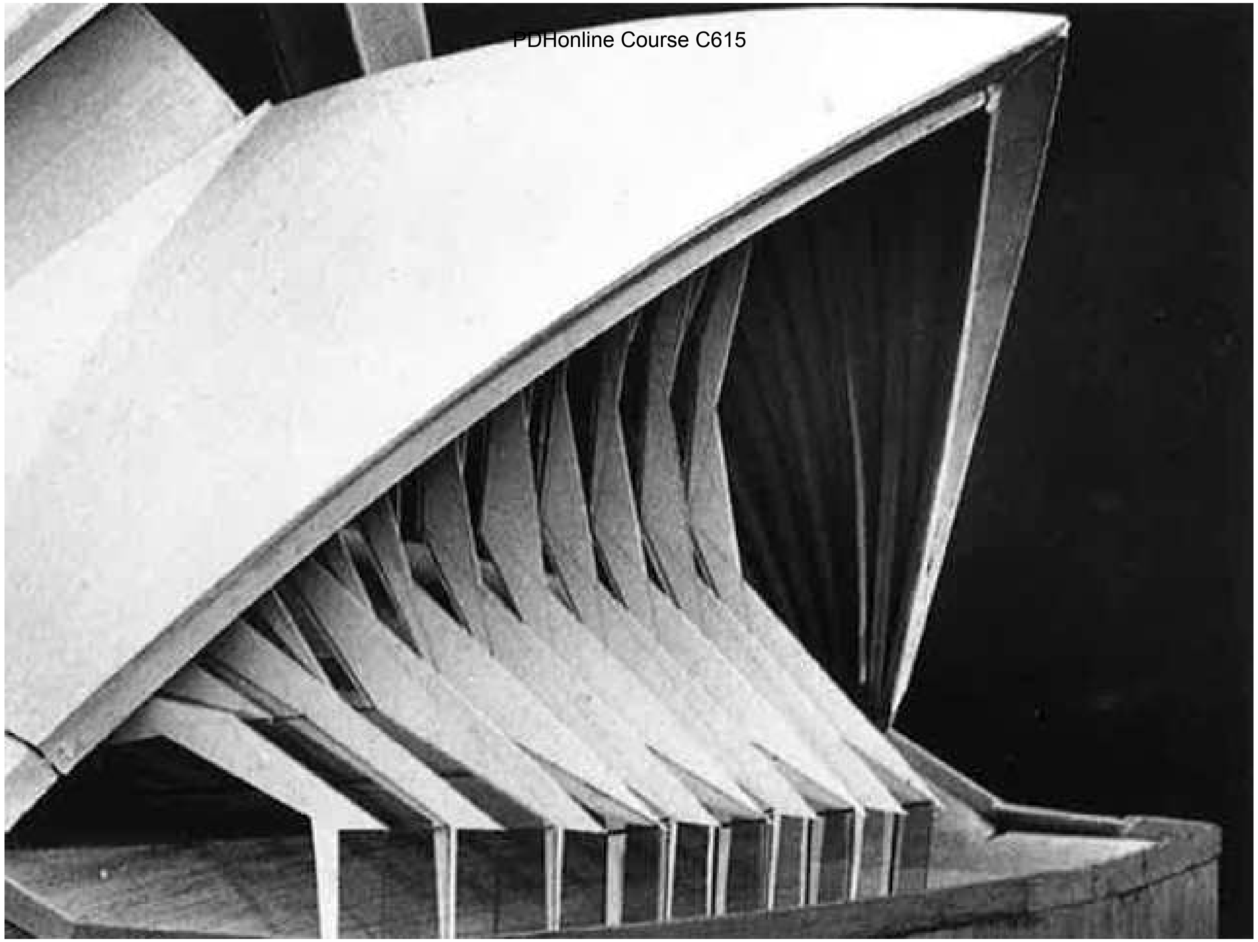
West elevation of the Concert Hall (*Red Book*, 1958). Transoms are located at varying heights and the folding screen glass end-wall (at left) masks roof-supporting columns for the shell roof.

The geometry of the shells presented in the 1958 *Red Book* was based on a Parabolic scheme. In the fall of 1961, Utzon came up with the *Spherical Solution* which allowed Arup's engineers to produce calculations and construction drawings for the shells (in 1962-63). In the spring of 1962, Utzon presented the *Yellow Book*. Unlike four years earlier with the Red Book, this time Utzon presented a well thought-out proposal for the glass end-walls (in geometrical terms). Now the shells (based on a Spherical shape) are higher and more pointed. The self-supporting superstructure no longer required supplemental support via hidden elements. Utzon had envisaged the end walls as "light membranes suspended under *Ogival* arches, formed by blades of glass mounted in slim frames." The glass end-walls could now be non load-bearing curtain walls whose only function was to provide a view of the beautiful scenery all around, keep the elements out and let natural light into the building.

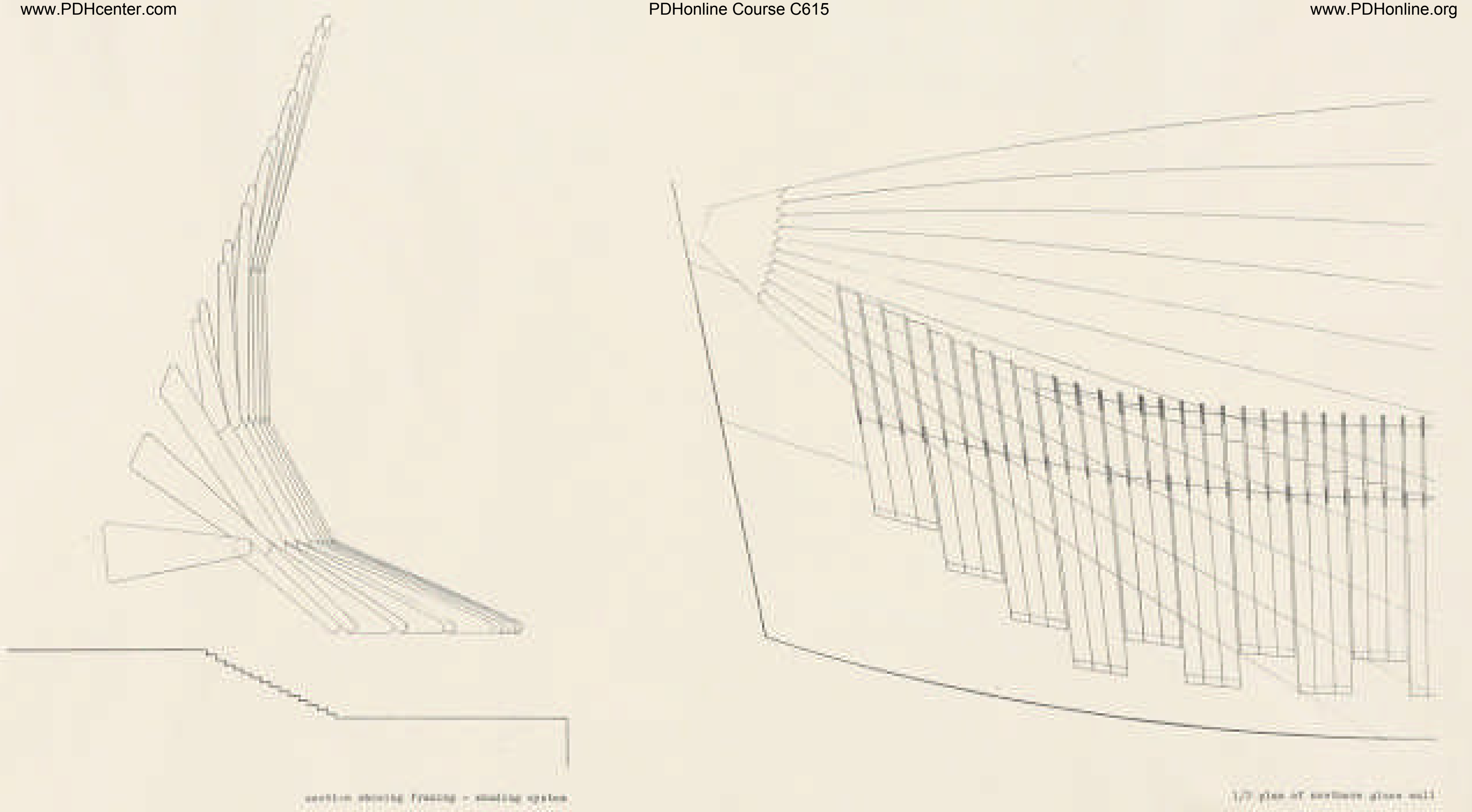
"The problem that faced me was to create a glazing system sufficiently flexible to make up the irregular overall shape and have sufficient strength to resist the wind loads imposed over such a vast area. Our early attempts to use composite structures of concrete and steel or bronze were too complicated and too rigid. The answer was to be found in a simple geometrical system consisting of a series of glass panels of modular size held between flexible mullions which can be adjusted to any shape and portion as required."

Jorn Utzon, Architect

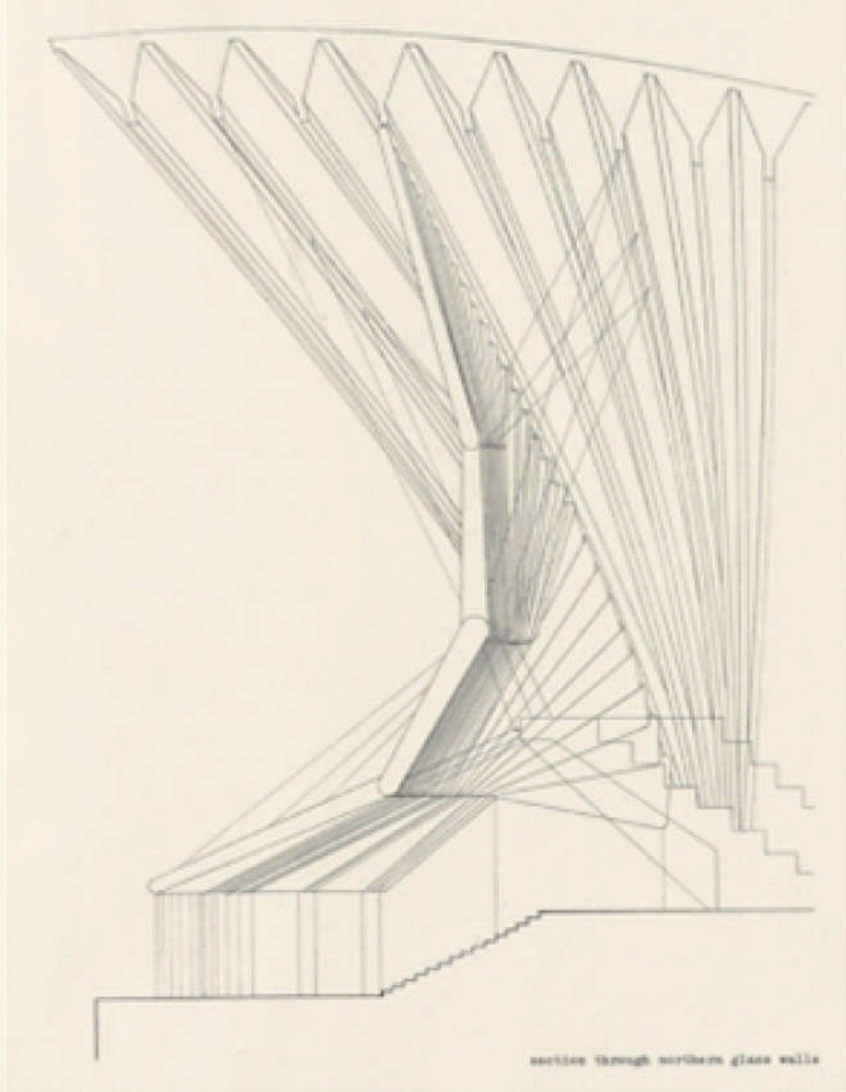
RE: for these "flexible mullions," Utzon selected tubular plywood as the preferred material. He also abandoned the vertical orientation of earlier schemes coming up with an articulated profile/membrane inspired by "the wings of a bird."



<u>Above</u>: glass end-wall (model) from the *Yellow Book* (1962). Utzon illustrated this flight metaphor with the image of a seagull in flight. The glass walls now curved out in overlapping sections (from top to bottom). Vertical at the summits of the vaults to off-horizontal above the Podium. At the lower end, their tales formed transparent canopies over the glass doors that provided access to the Hall foyers. The folding mullions eliminated glass reflections and appear (accurately) to carry only their own weight rather than the shell above.

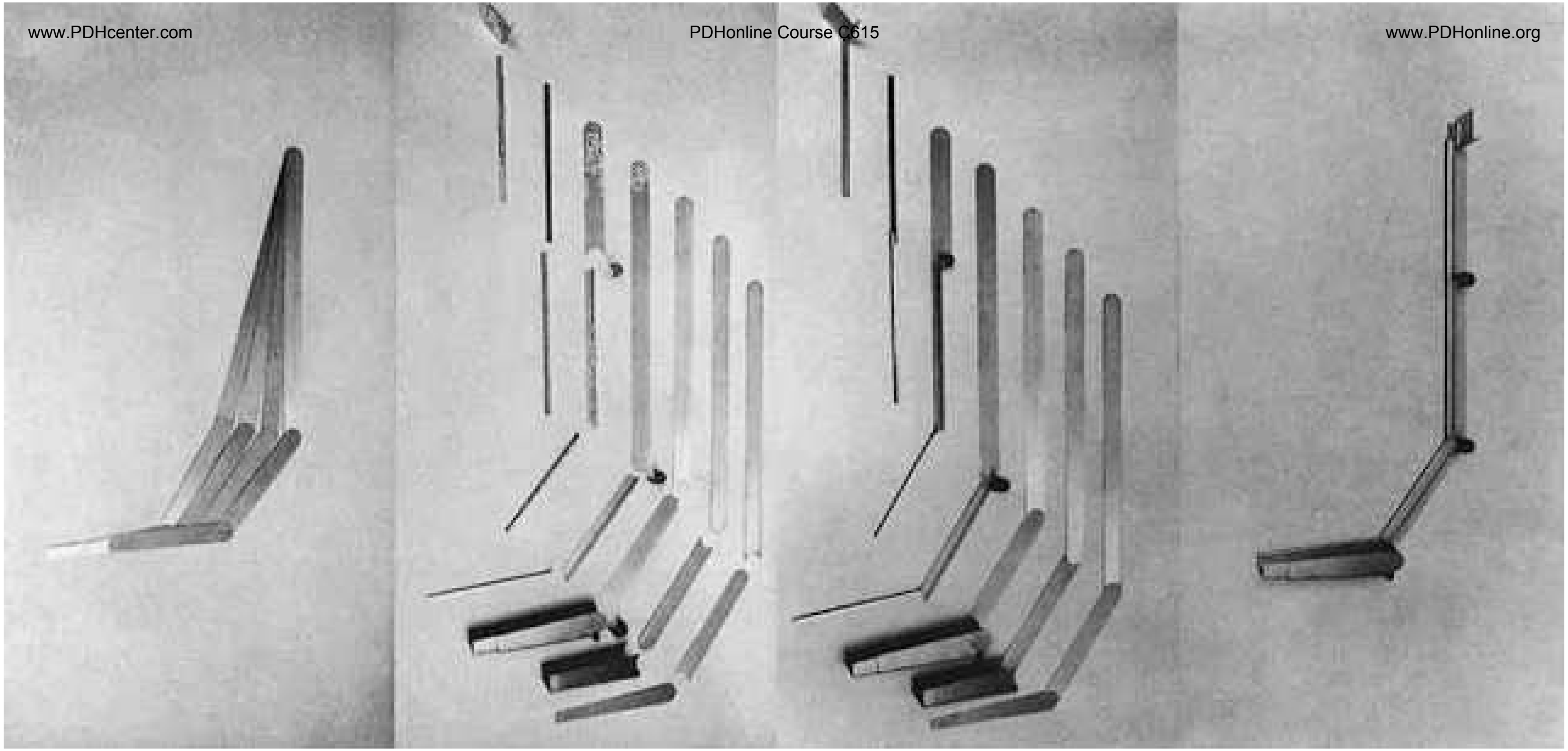


Side elevation (left) and plan (right) of the northern glass end wall framing (from the *Yellow Book*, 1962)

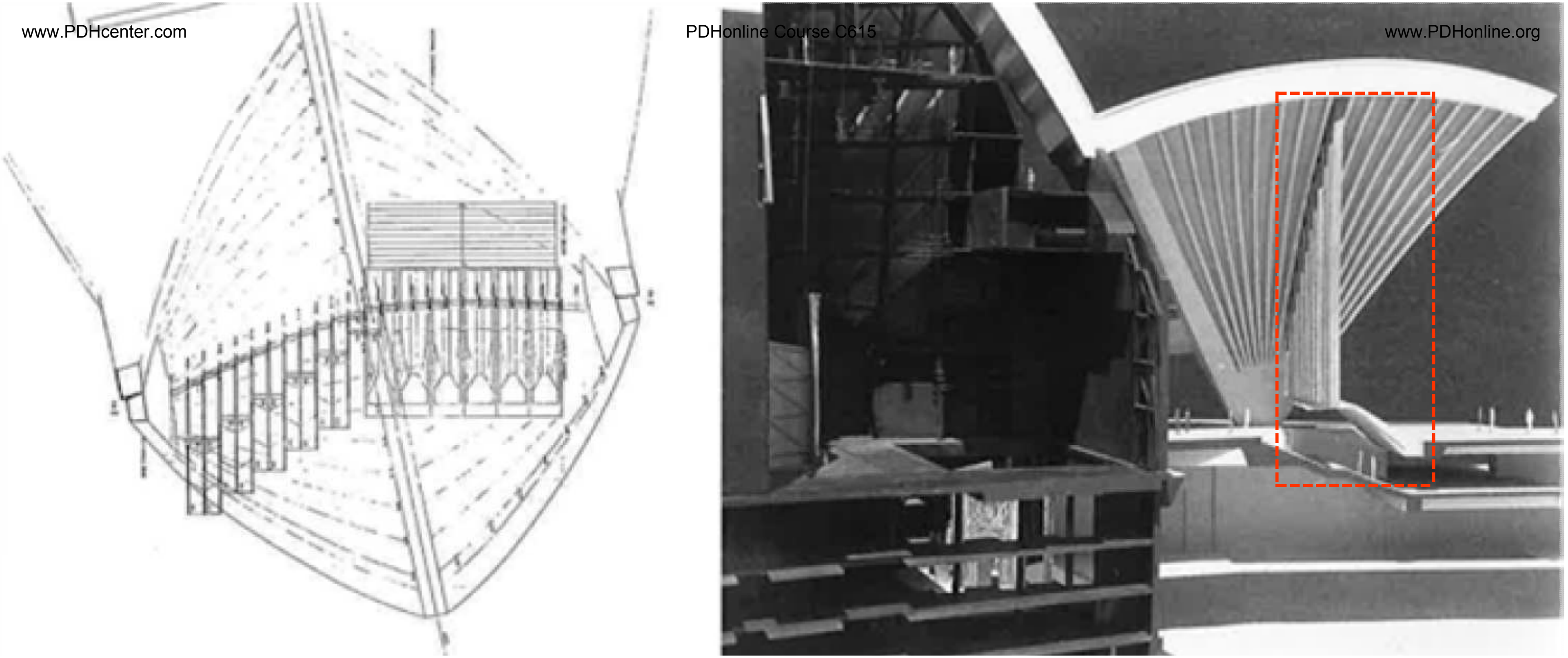


Section (left) and front elevation (right) of the northern glass walls (from the *Yellow Book*, 1962)

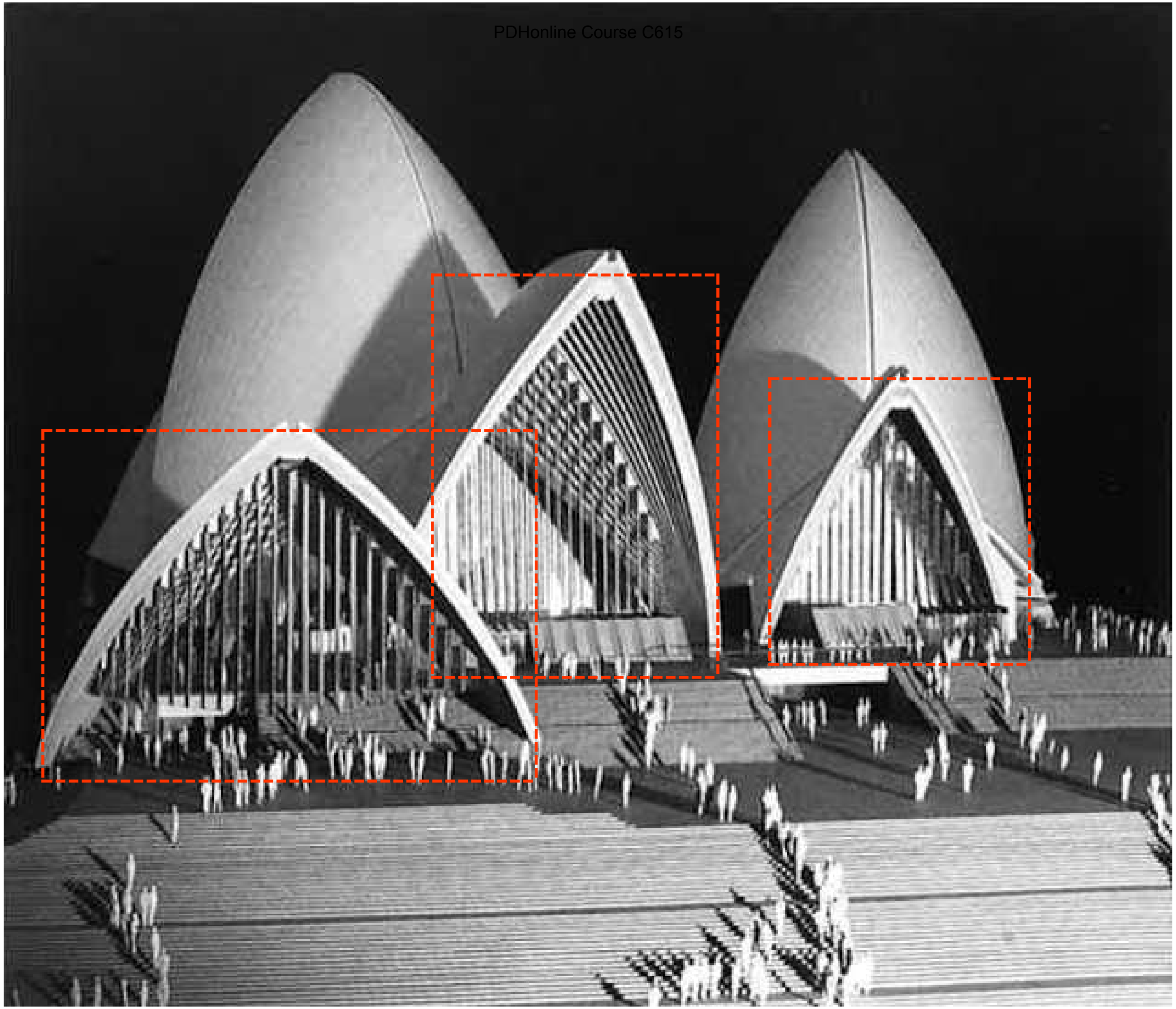
By March 1963, Utzon had moved to Australia with his family. Construction of the SOH roof shells was underway and he was occupying his time developing the glass end-walls and the interiors. For both, Utzon decided to use innovative plywood technology. It followed joint research by Utzon with the Australian company *Ralph Symonds Ltd.*, the recognized experts in reconstituted wood for industrial use. Ralph Symonds had set up a vacuum bagging process and very large presses so that plywood could be made in 50-foot long sheets which was, at the time, an enormous length of plywood. Utzon realized that by using Symonds' vacuum bagging process he could achieve large sections in plywood capable of spanning long distances. These sections could/would be used in the "wave" ceilings of the auditoria and for the mullions at the glass end walls (as far as *Jorn Utzon* was concerned).



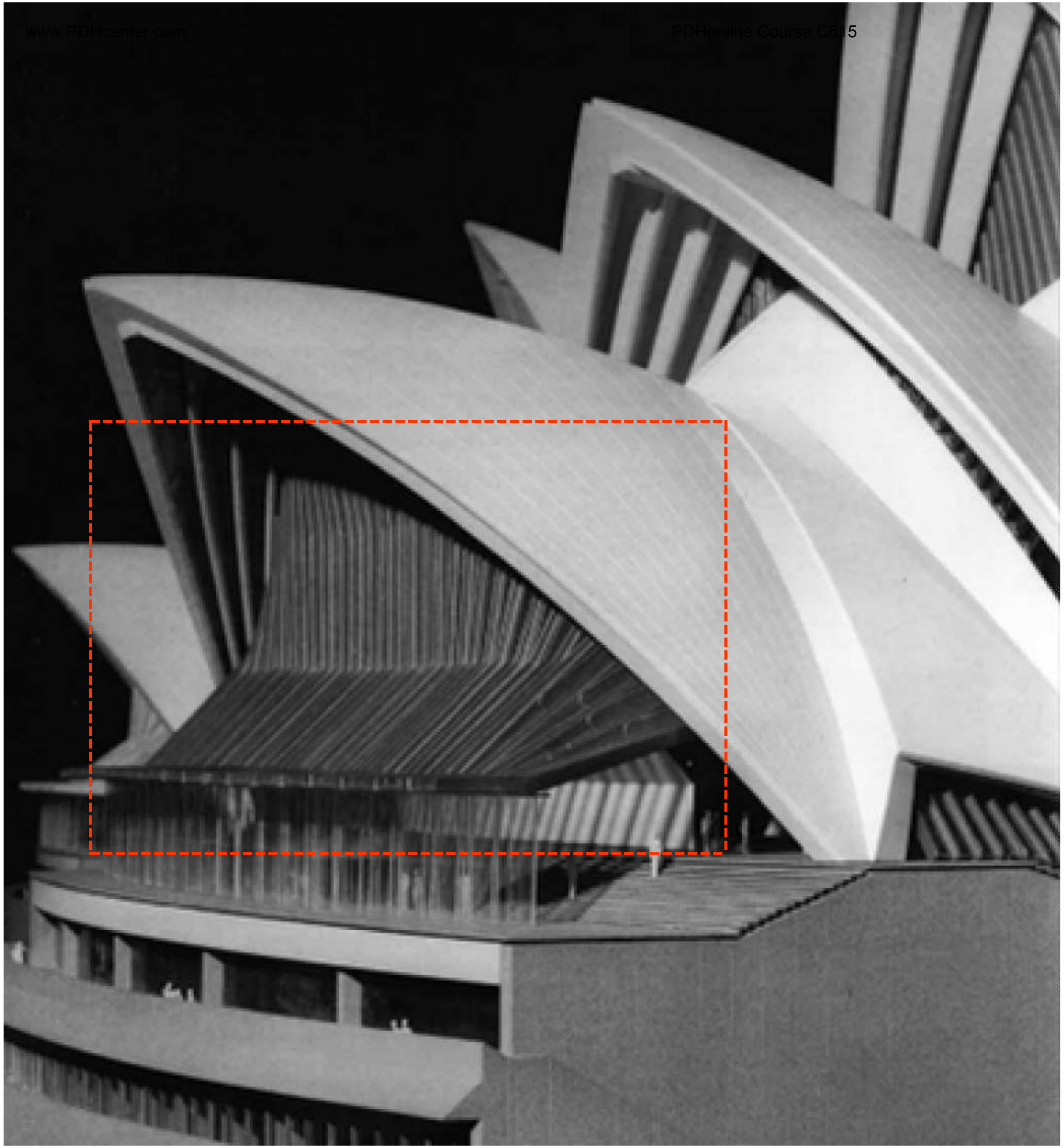
Plywood mullions as standard elements – Architect’s model (1964)



<u>Above</u>: Plan-section (left) and model (right) from 1964. The mullions would be built-up by bonding seven layers of 13mm white *Soraya* pine plywood sheet into 600mm deep by 90m wide sections. The layers could be stepped to accommodate any/all mullion configuration/s. On either side of the composite wood mullion, the external layer would be curved to form a U-shaped channel to which the glass would be fixed by a normal screwed-on clip system. Lastly, a U-formed cover piece would enclose the outer mullion front. To resist corrosion, these cover pieces would be finished in hot-bonded Bronze sheets. The mullion sections would be prefabricated and assembled on site. The whole process was the embodiment of Utzon's "craft approach" to architecture.

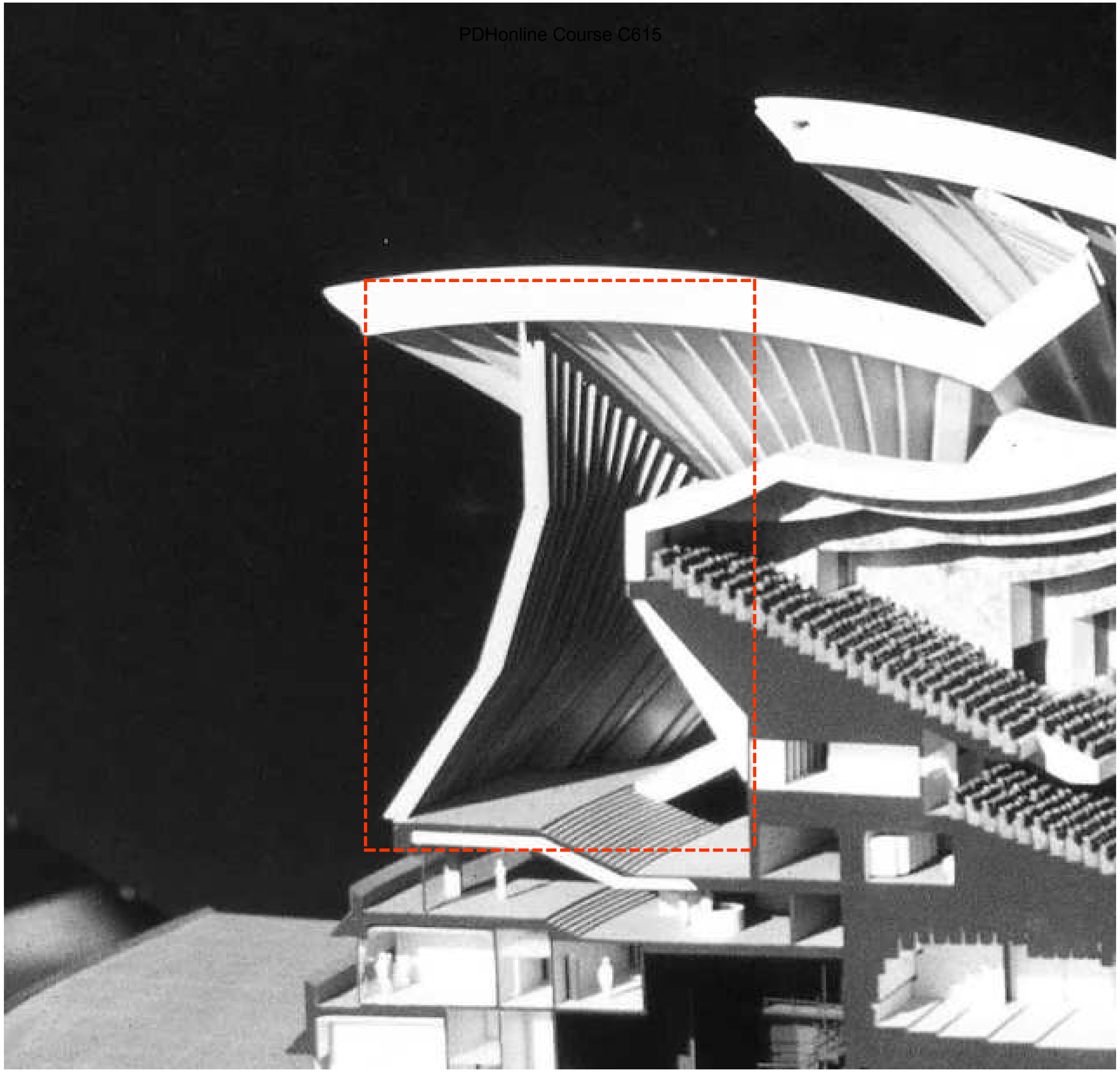


Model (Concourse view) with plywood mullions (1964)

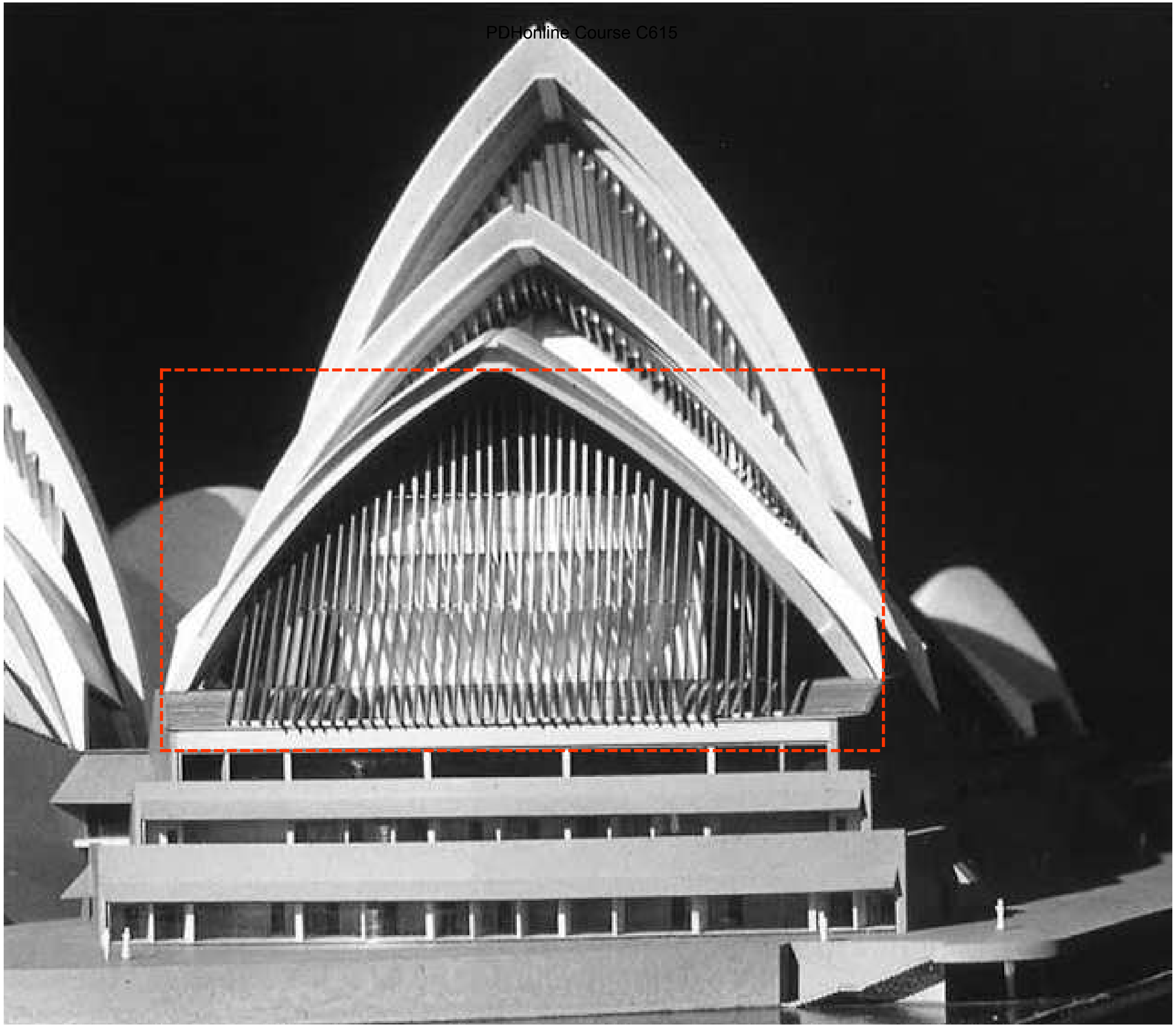


View (model) of Opera House Foyer end wall (at North end; 1964)

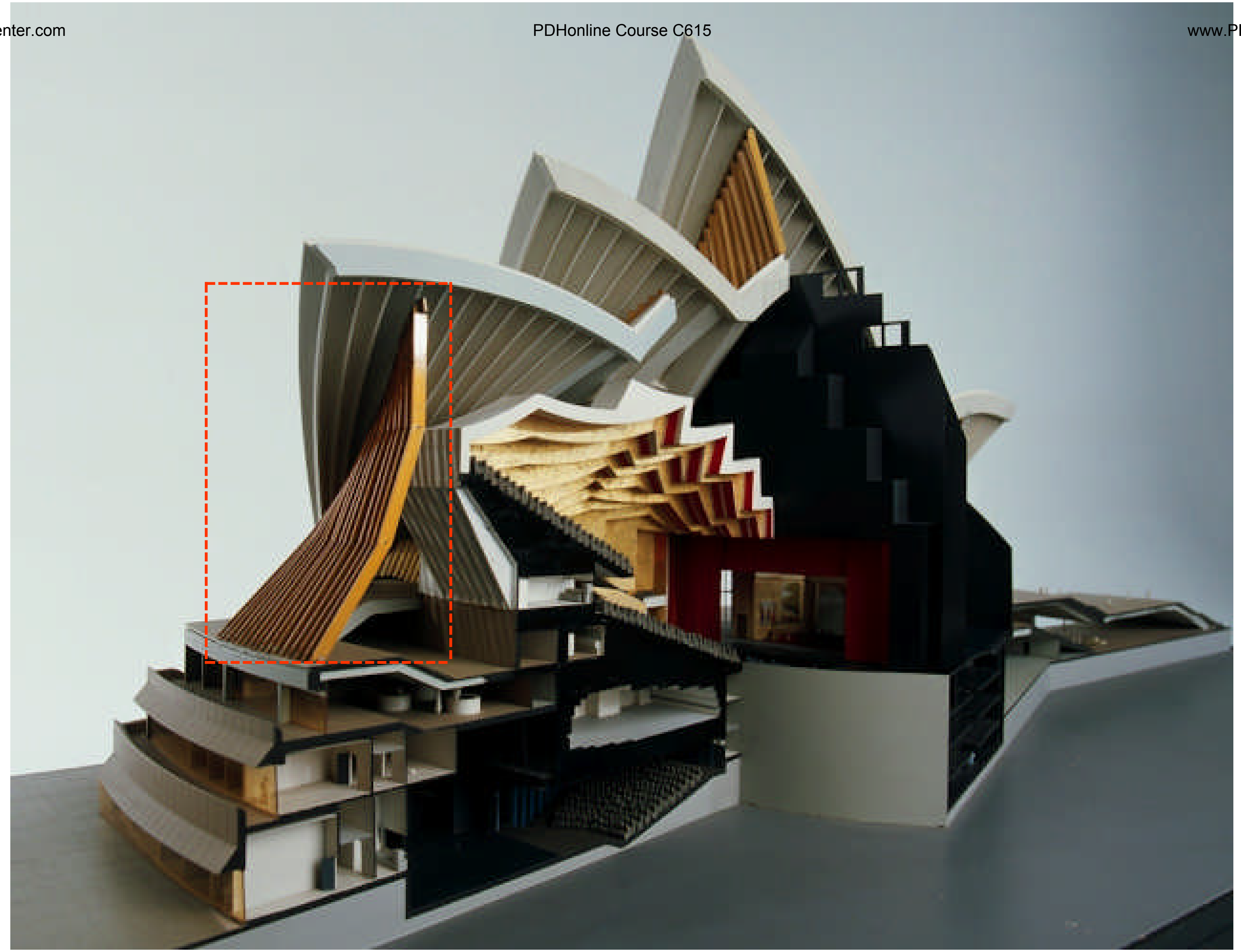
The drawings prepared by Utzon between 1964 and 1965 show all glass end-walls in the same 1.2 meter-wide grid of the Podium's paving slabs thus conveying, visually, this dimension up to the peak of the shell vault/s. In the last drawings from 1966, the glass width was reduced to 91cm (3-feet). Glass would be laminated for safety reasons, the panels being specified in commercially available dimensions. In the last model produced under Utzon's supervision (dated early 1966), the glass end-walls have a more masculine quality; transoms have been totally suppressed and the mullions terminate directly onto the Podium. The mullions are thin and deep and when viewed from the side, appear as an opaque layering.



Section through the Major (Opera) Hall foyer (model). Note how the mullions come down to the foyer floor (1966).



North view (model) of Major (Opera) Hall foyer end-wall (1966)



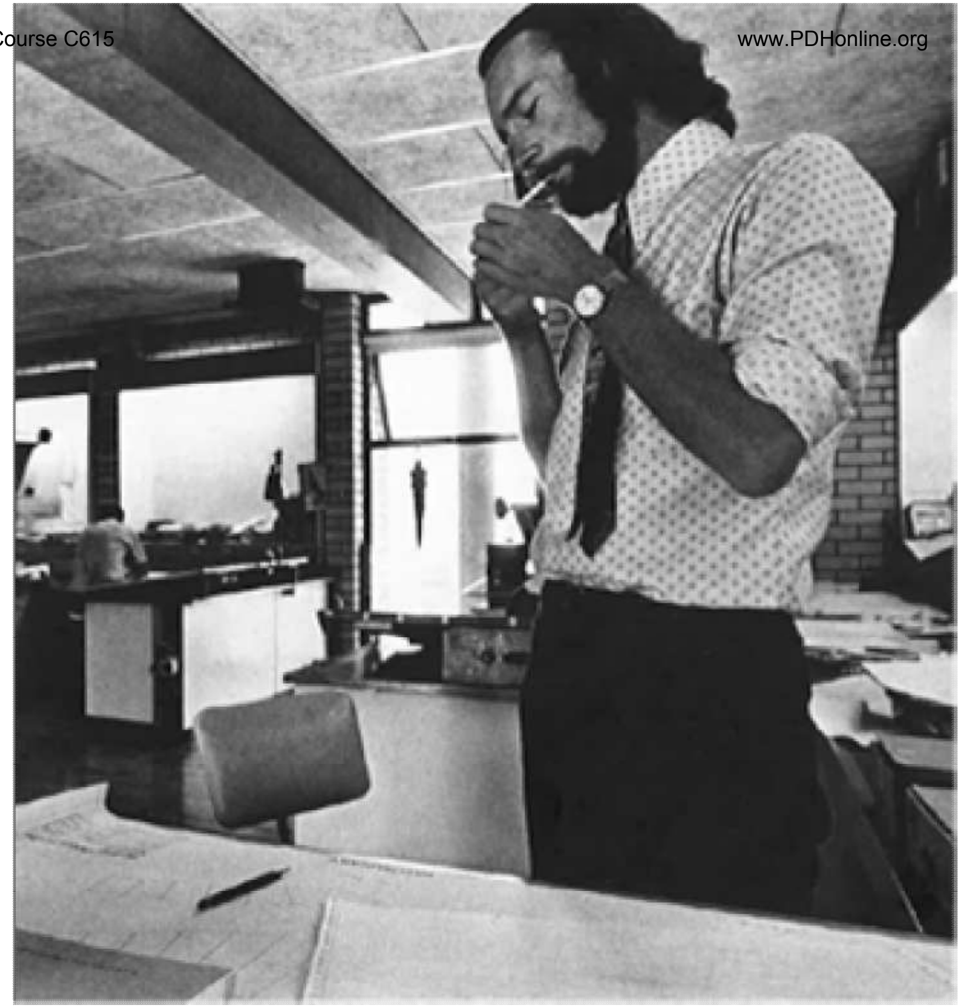
The last sectional model prepared under Utzon's supervision showing Opera House foyer end-wall with plywood mullions (1966)

Whether or not Utzon's ideas for the glass end walls were feasible from a technical point of view has been debated since he conceived them and the fact that they nor the plywood ceilings were ever made makes them enigmatic. For *Jack Zunz* of Arup, the answer was always a definite "No." If we apply 21st Century know-how and technology to this mid-1960s conception, the likely answer is that Jack Zunz was probably right, for a number of reasons. First, the spans were excessive. Next, there was no lateral stiffness included. Third, the geometry was not solved yet and last, it is highly doubtful that bonded plywood would have resisted de-lamination for the long-term in the salt-air, marine environment of Sydney Harbor.

"The glass walls are an epitome of the problems of the whole of the Opera House...Every day I find it more complicated than it was before. The more you do the more there is to do."

David Croft, Ove Arup & Partners

RE: dating from mid-1967, the concept of the scheme finally selected for the glass end-walls (by *Peter Hall*, with the able assistance of the Arup team headed by David Croft) was a continuous glass surface enclosing a steel structure. This concept was developed for over two years and involved extensive research.



Michael Lewis **(head of Arup's Sydney office) uses his hands to draw the glass walls in the air (left) and David Croft (lead Arup design engineer for the end-walls) at his office on-site (right).**

Sydney Opera House Glass End Walls

The following slides are excerpts from an article written by *David Croft* and *John Hooper*, both Arup engineers during the construction of the SOH. It was published in the *Arup Journal* in October 1973 and describes in depth and detail the geometrical, structural, glass-related and construction issues concerning the glass end-walls of SOH.

Introduction

"The Glass Walls of the Sydney Opera House is the name given to the glass surfaces that enclose the openings between the roof shells and the podium structure…one of the major technical problems outstanding was that of the glass walls…Construction started in 1959 and was divided into three stages:

- ***Stage 1 – Construction of the foundations and podium***
- ***Stage 2 – Completion of the podium structure and construction of the shells***
- ***Stage 3 – Construction of the louvre walls and glass walls, the auditoria, the cladding to the podium and the installation of services and finishes***

Utzon resigned from the project in 1966 and was replaced by the architectural firm of Hall, Todd and Littlemore. Although by this time the construction of the shells was almost complete, no satisfactory solution to the glass walls had yet been found. Numerous alternative geometrical forms and materials had been investigated during and after the design of the shells…The concept of the scheme finally selected, namely that of a continuous glass surface enclosing a steel structure, dates from 1967. This concept was developed and involved much research into a wide range of materials and techniques…"

***Arup Journal*, October 1973**

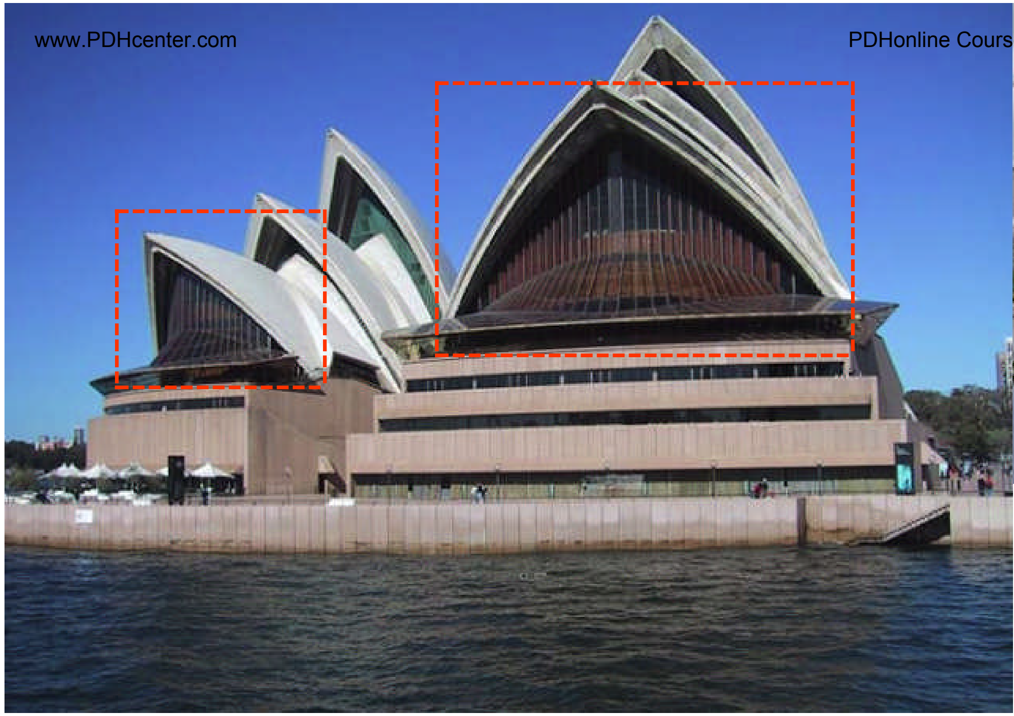


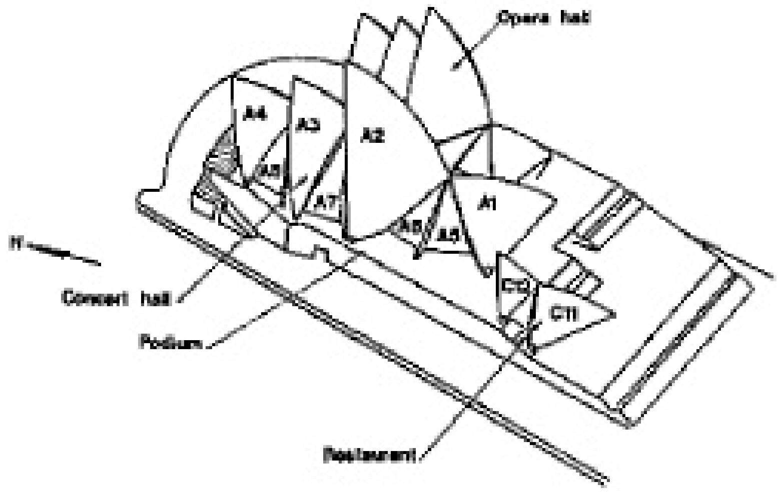
Figure 1: View from harbour showing glass walls A4 (right, Concert Hall) and B4 (left, Theater)

Above: SOH ca. 1968; shells complete and glass walls for A4 (right, Concert Hall) and B4 (left, Theater) yet to be installed

"…Construction of the glass walls began in 1970 and was completed in 1972 (Fig. 1). The total cost of the glass walls was approximately 1.9 million pounds, made up of 300K pounds for the concrete and steelwork, 1.1 million pounds for the supply and erection of the glass (including sealing), and 500K million pounds for the supply and fixing of the bronzework…"

***Arup Journal*, October 1973**

Technology



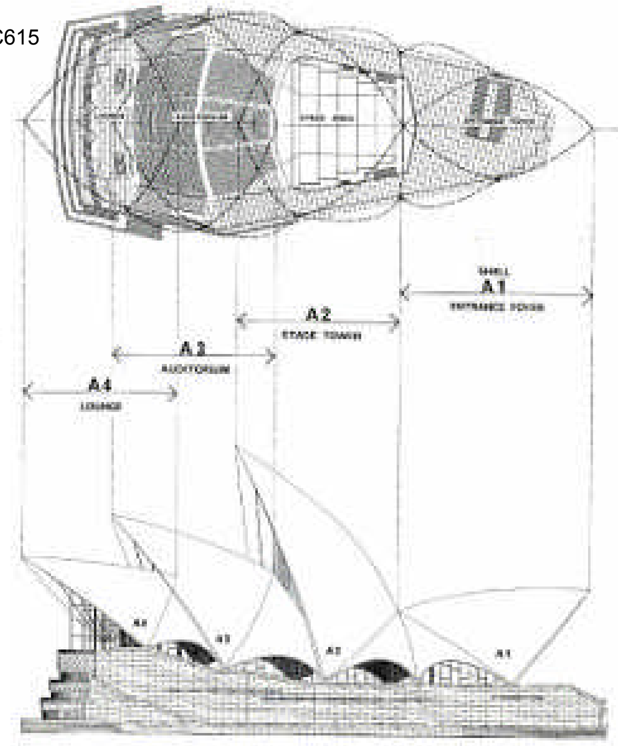
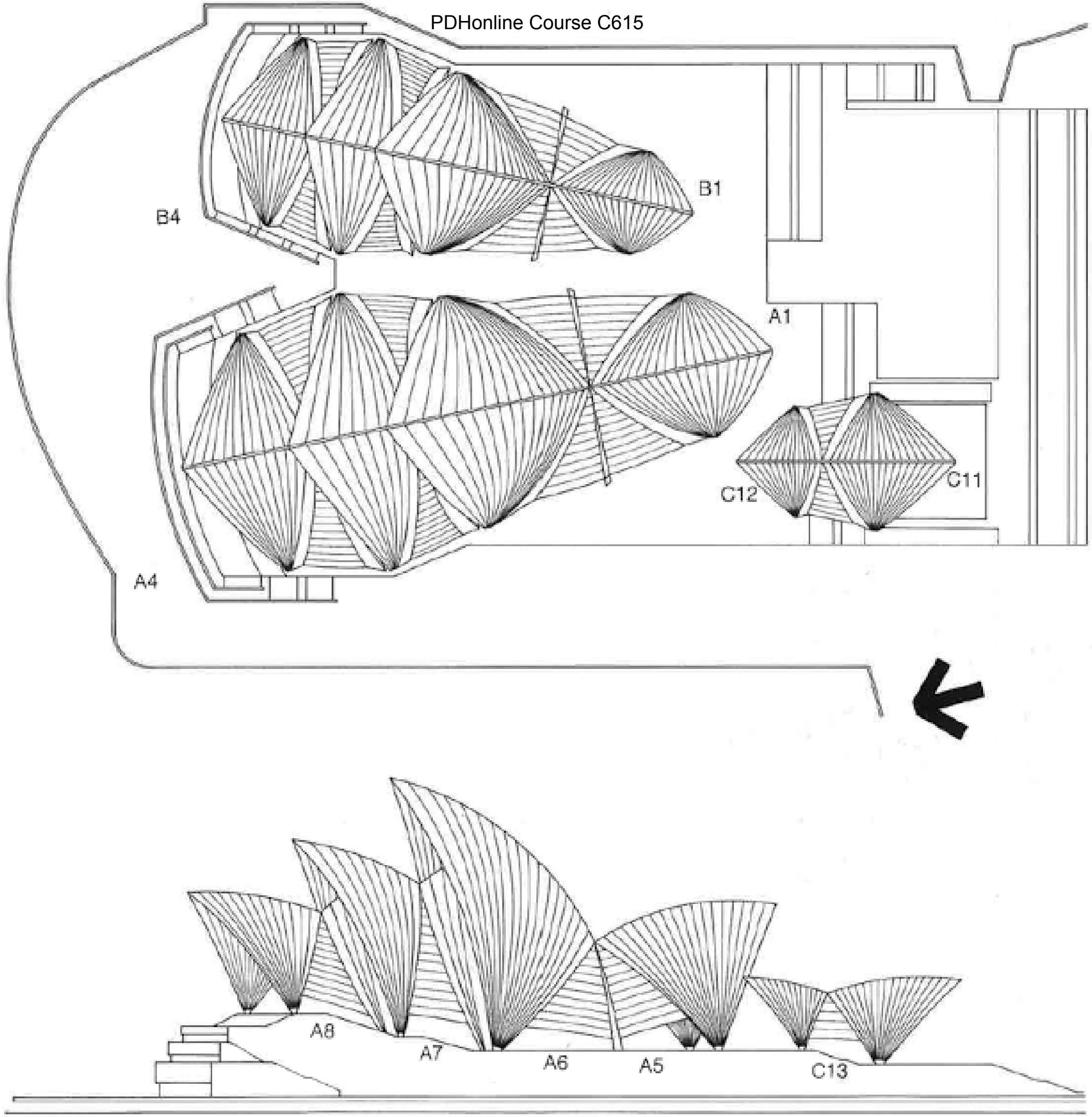


Fig. 2
General layout

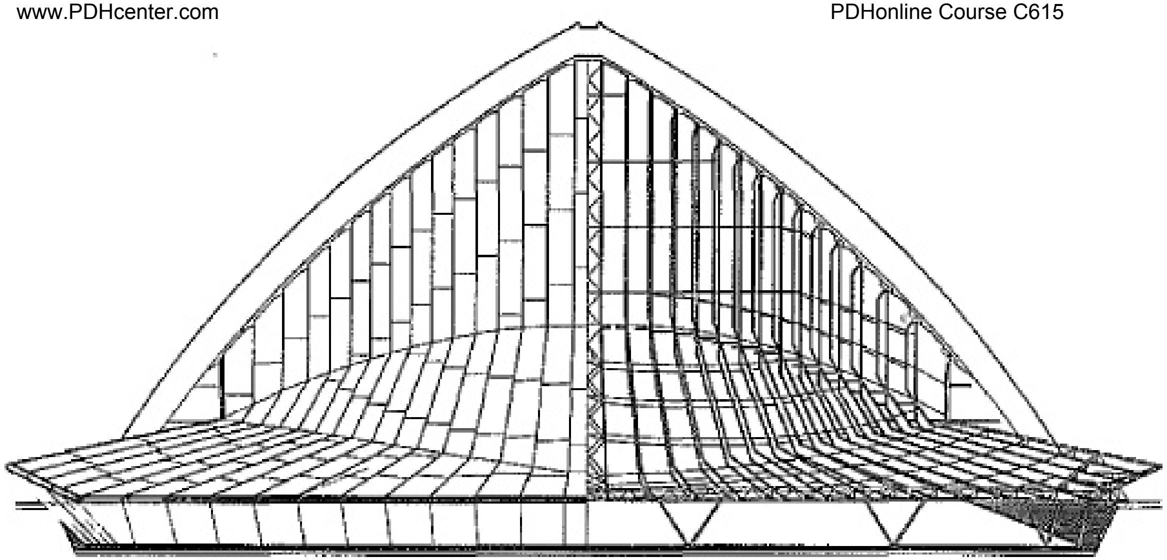
"…The layout of the Opera House is shown in Fig. 2. The main buildings are the Concert Hall, Opera Hall and Restaurant which stand on the podium substructure. The Opera Hall is geometrically similar to the Concert Hall, but smaller, and the shells are numbered in the same way but prefixed with the letter B. The glass walls are referred to by the names of the shells they enclose. Each shell has a glass wall except A2, A3, B2 and B3 which are connected to the shells below by the bronze louvre walls. The shells themselves are not strictly shells in the structural sense. On the Concert Hall the main shells A1, A2, A3 and A4 are made up of ribs which spring from the pedestals on the podium, east and west sides meeting at the ridge beam at the top. The side shells A5, A6, A7 and A8 span between the main shells on each side. Except for small transitional warped surfaces the outer surfaces of all the shells are segments of a single sphere. The Opera Hall complex is similar and the Restaurant has two main shells C11 and C12 and a side shell C13…"

Arup Journal, **October 1973**

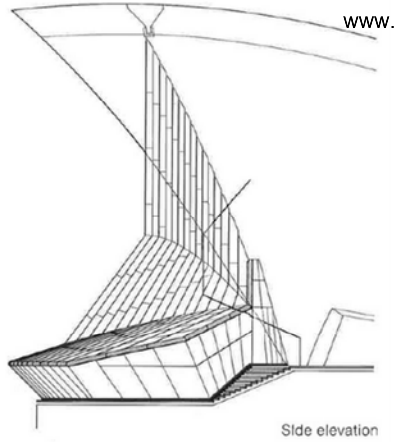


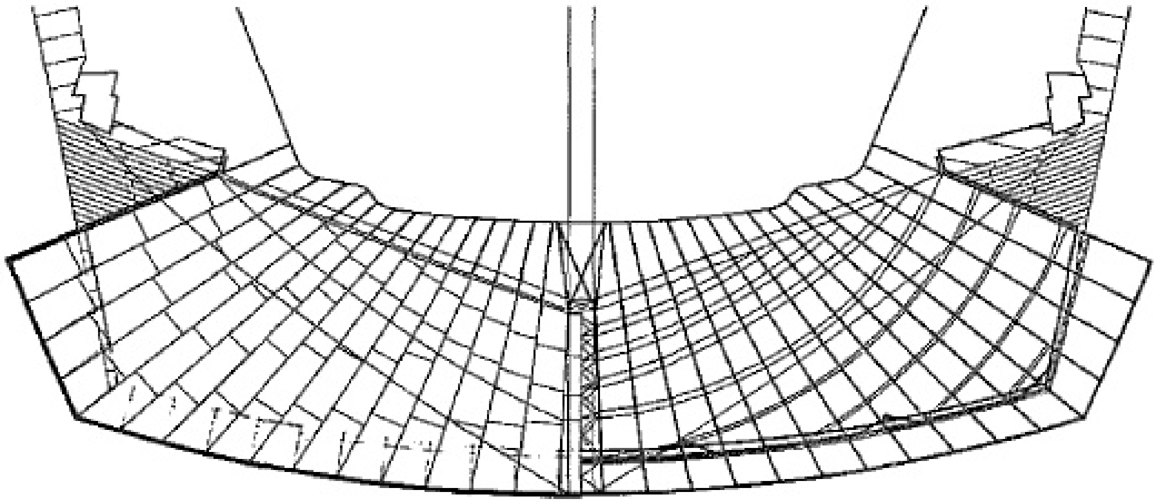
Code names for the various glass end-walls (1967-1970)

Glass Walls A4 and B4



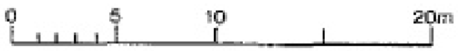
Glass wall A4 (Concert Hall foyer). Elevation with (left) and without (right) glass panels





Glass wall A4. Plan with (left) and without (right) glass panels. (note the horizontal bracing at the central axis.

Fig. 3
Glass wall A4: plan and elevation



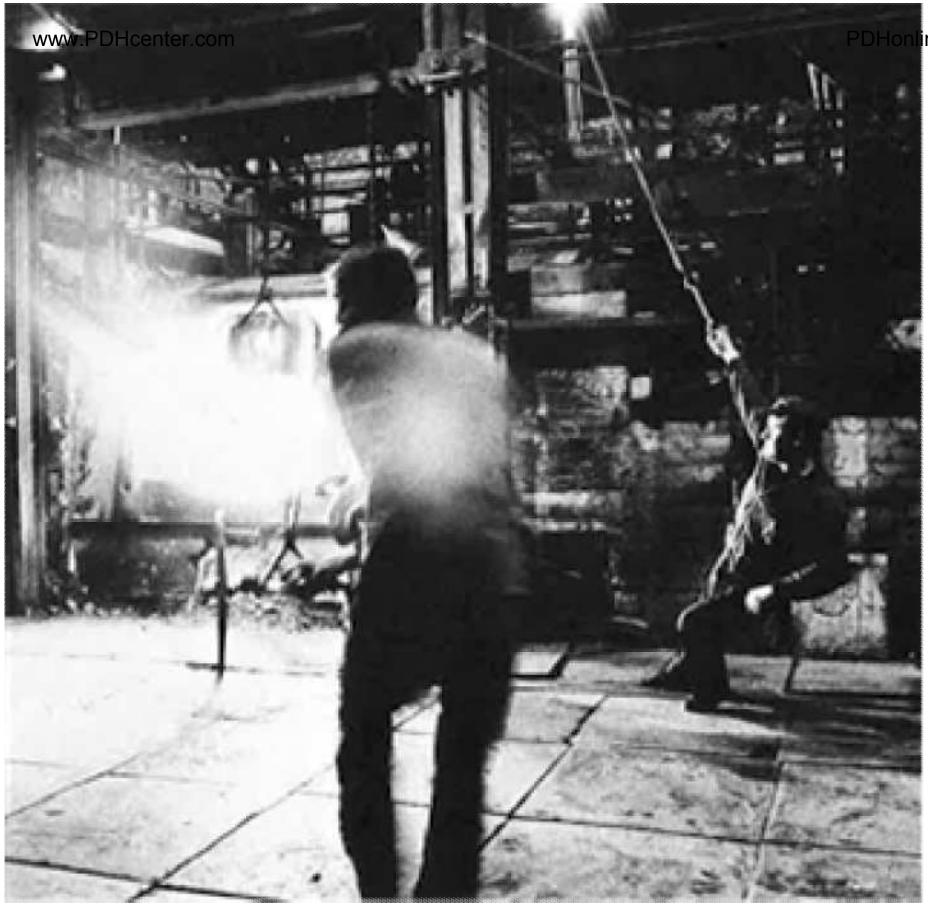
"…The design of the glass walls was carried out in parallel with their construction. This was necessary, as time was running out, and weather-proofing the building was critical on the overall construction programme. Design work was, therefore, initially concentrated on A4 (Fig. 3), bearing in mind that the details as they evolved would also have to apply to the other walls…"

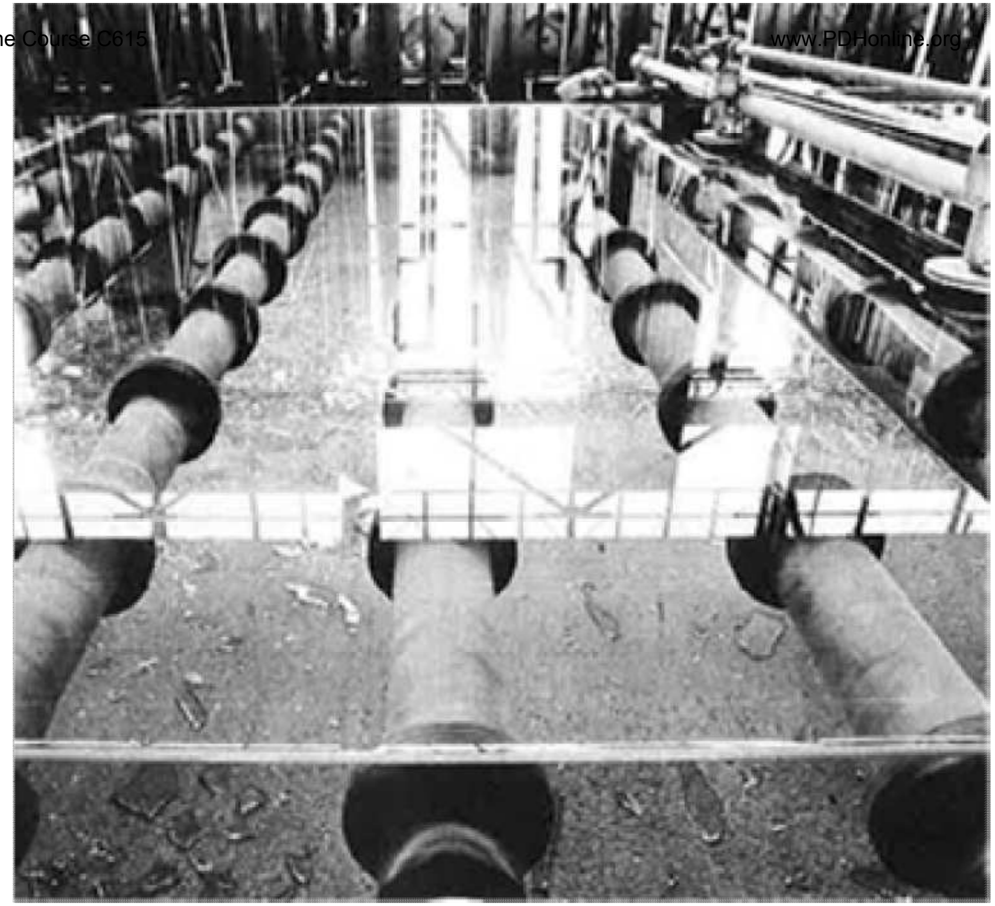
***Arup Journal*, Oct. 1973**

Choice of Glass

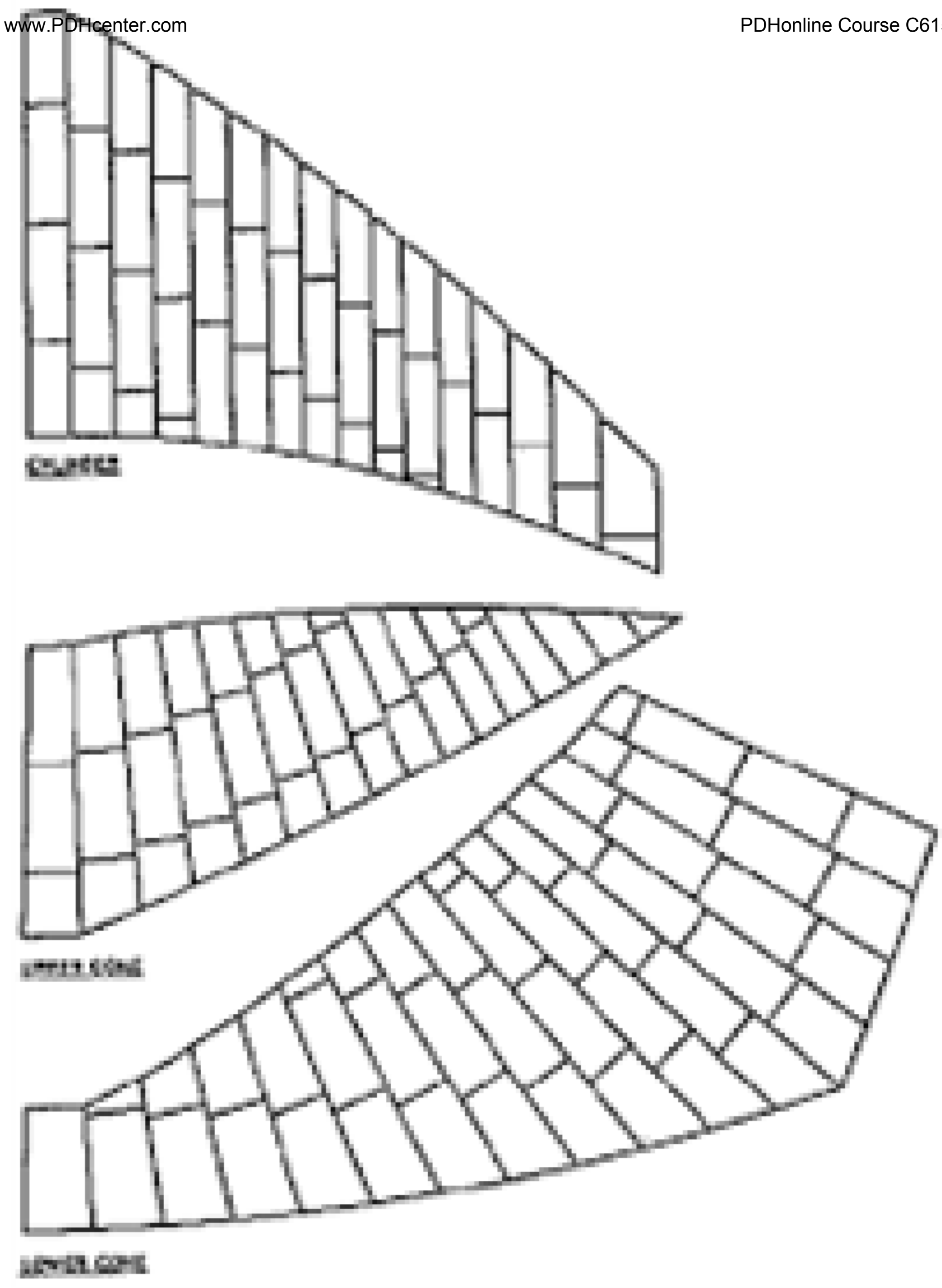
"…The main requirement was for a safety glass that could be cut to shape on site…Toughened glass was rejected in view of the variety of shapes and sizes that were required and the fact that the toughening process would have had to have been carried out after the sheets were cut to exact shape. Laminated glass was therefore chosen, although at that time there was little information available on its use in buildings…The laminate finally selected consists of a layer of clear plate or float glass and a 6mm thick interlayer of clear polyvinyl butyral. In order to achieve the precise colour required by the architect, the tinted glass (referred to as 'demi-topaze' by the manufacturers) was produced by the very traditional process of pot-casting. This process is described in greater detail elsewhere. Two thiscknesses of clear glass were used, giving a standard laminate thickness of 18.8mm and a thicker section of 20.8mm which was used in certain areas where greater strength and stiffness were required. The maximum sheet size was approximately 4.0m by 2.1m…"

***Arup Journal,* October 1973**





Above: Pot-cast glass (left) and float glass (right): manufacturing the two lites of the laminated piece. The precise tint (demi-topaze) was created by a glass supplier in France and applied through a process called “pot-casting,” then the 6mm tinted lite was laminated to a 12mm clear lite in a different factory (near Paris) and finally, the laminated sheet/s were pre-cut and shipped to Sydney. The maximum sheet size required on-site was approximately 4.0m by 2.1m.

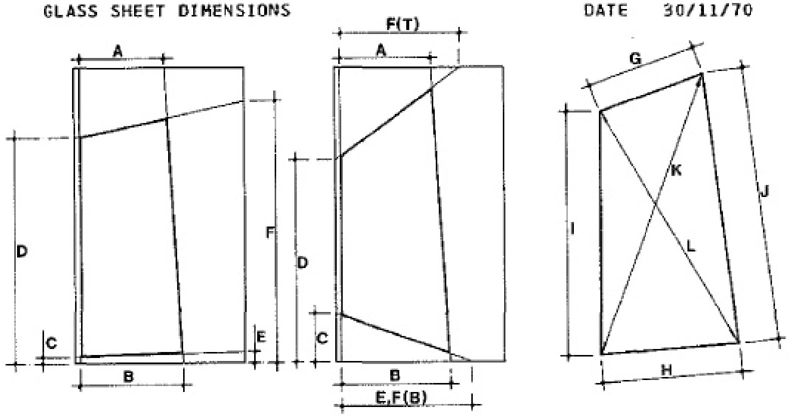


OVE ARUP AND PARTNERS — SCHEDULE NO.

SYDNEY OPERA HOUSE STAGE III — 1112/7280/T1

GLASS WALL A4 — PAGE 53 OF 132

GLASS SHEET DIMENSIONS — DATE 30/11/70



SHEET NO A4/206 U/CONE

SET OUT DIMENSIONS

	WEST SIDE	EAST SIDE
A	5.206	5.197
B	5.925	5.916
C	0.065	1.857
D	7.433	7.269
E	2.715	B 6.252
F	7.640	7.476

CHECK DIMENSIONS

G	5.507	I	7.335	K	9.294
H	6.158	J	5.444	L	7.850

ALL DIMENSIONS IN FEET. REFER DRG. NO. 1112/7473

Above: typical glass sheet schedule
Left: Glass Wall A4: developed surfaces

Glass Support System

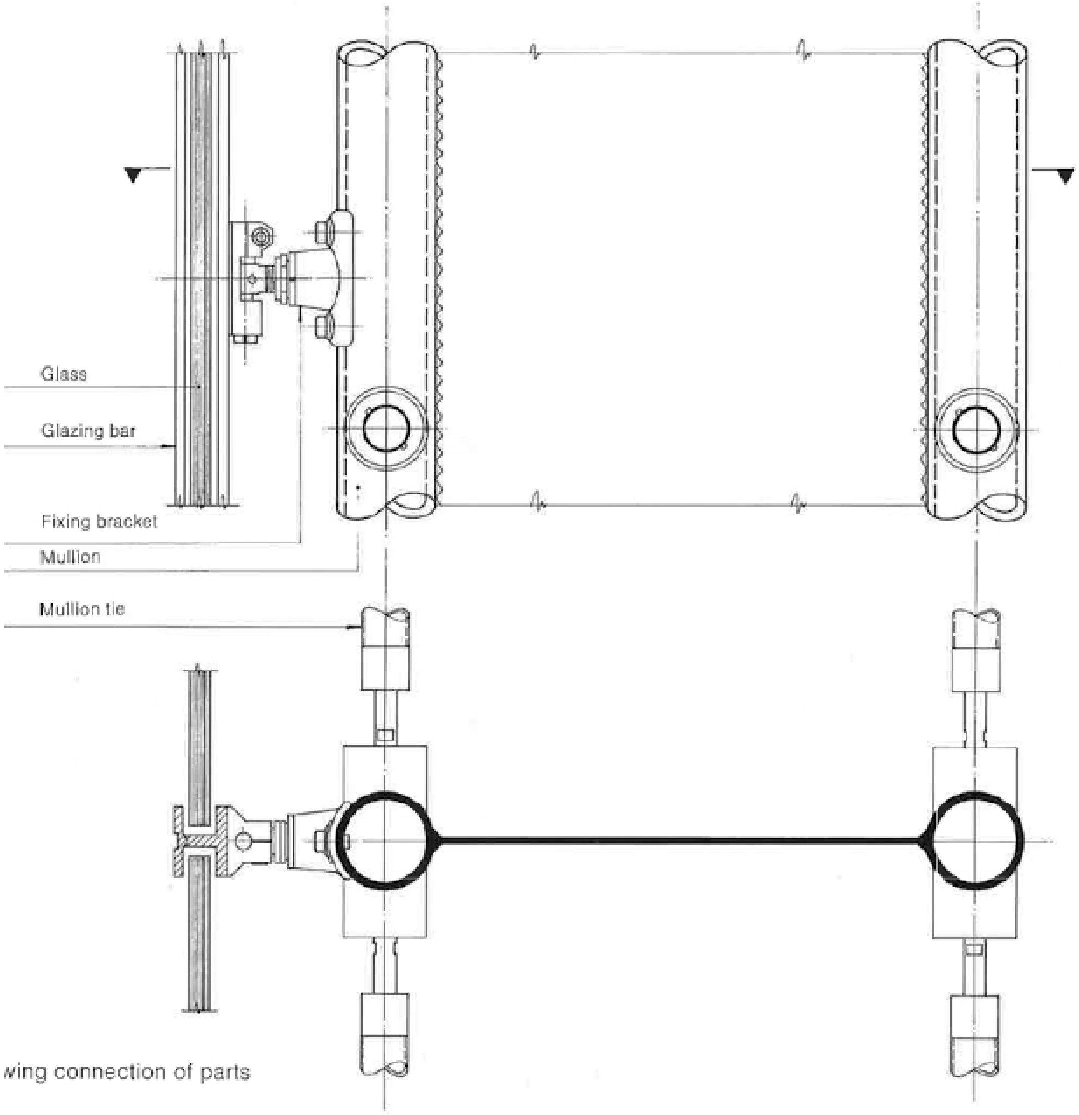
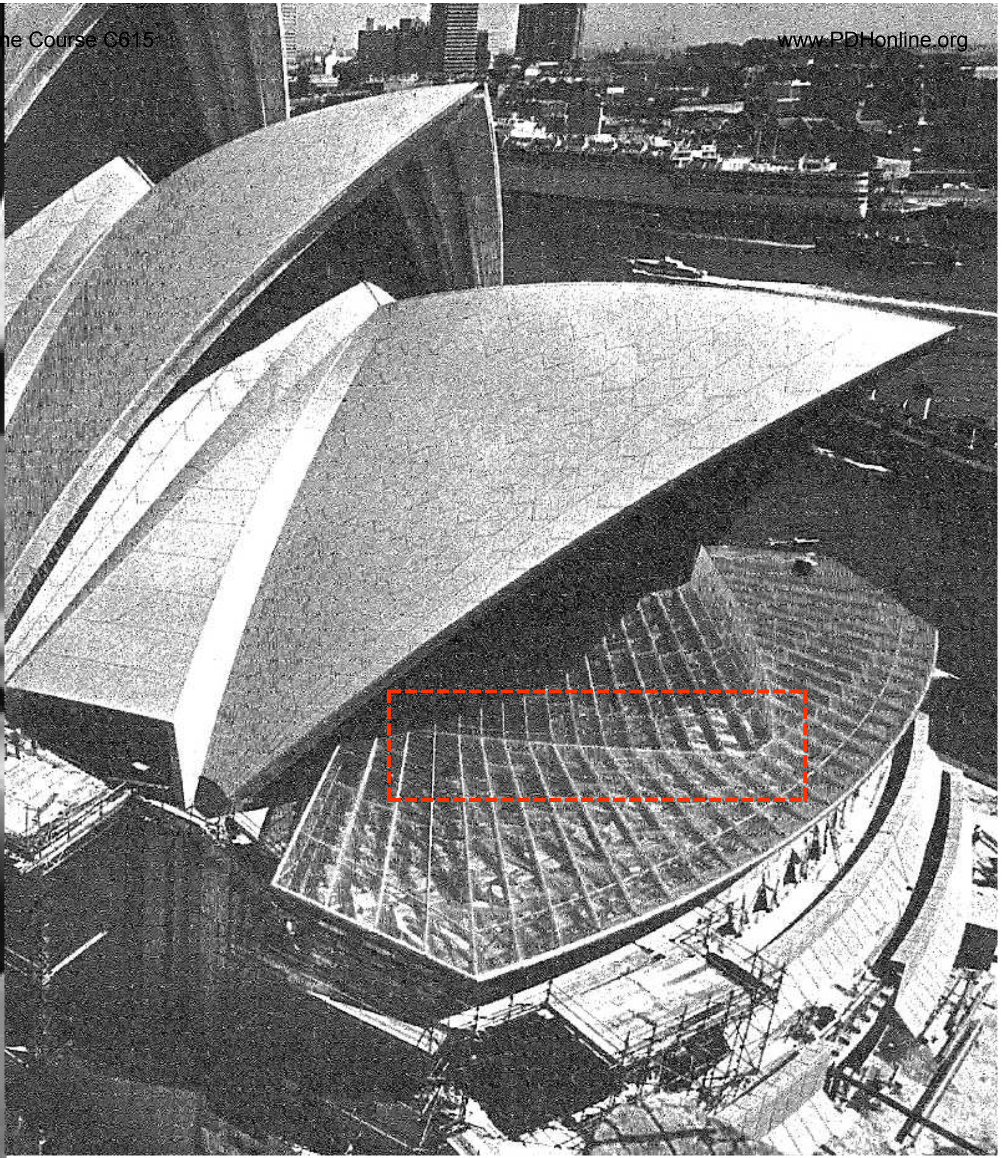


Fig. 4
Detail of glazing and structure

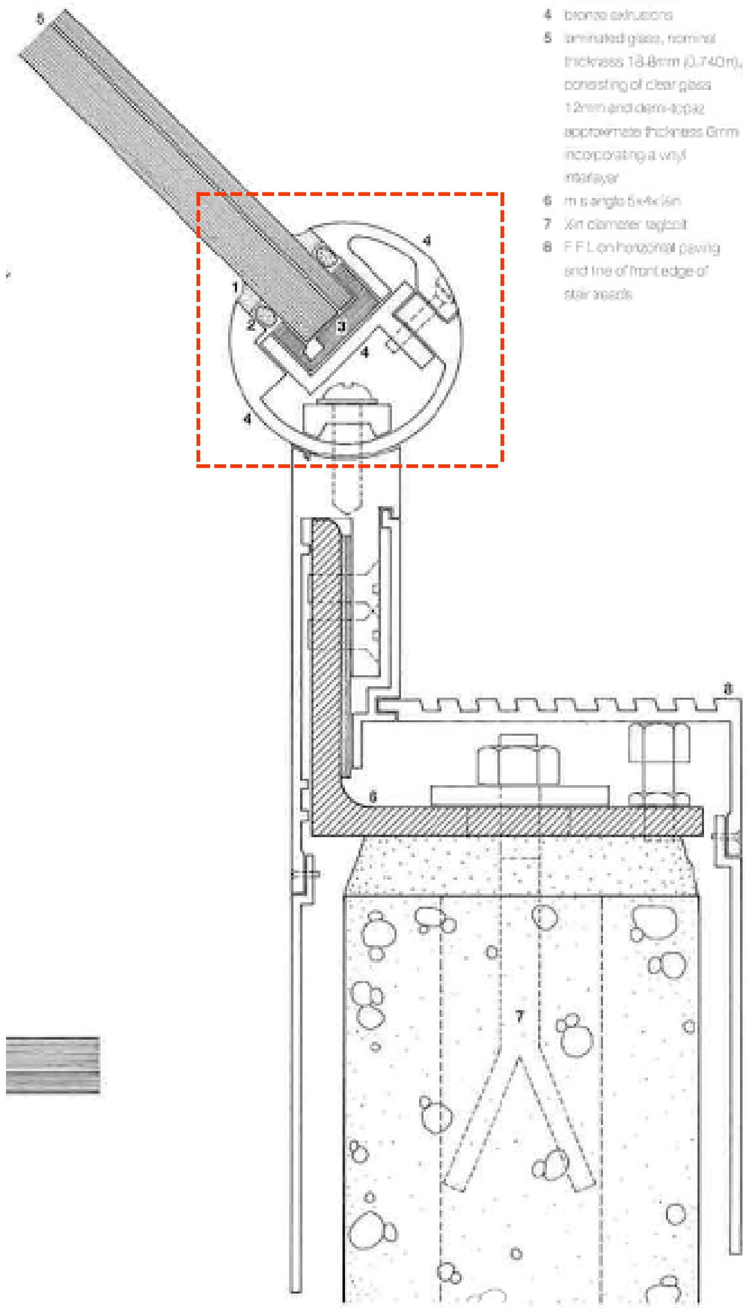
"…In the main surfaces, each glass sheet is supported along its two 'vertical' sides by glazing bars, and the top and bottom joints are filled with silicone rubber sealant. The glazing bars were extruded from manganese bronze and in their 'standard' form consist of a T-section and a cover piece screwed on after the final positioning of the glass. The combined sections act together as an I-section (Fig. 4). The glazing bars follow the lines of the supporting structure inside and each glass sheet is held vertically by two steel pins projecting from the flange of the T-piece..."

***Arup Journal*, October 1973**

Fig. 5
Detail at junction of cylinder and cone (A4)



"…Figure 5 illustrates the details at the junction of the vertical and inclined surfaces on A4…"
***Arup Journal,* October 1973**



Detail of sill, infill glass walls to sides of shells

1 silicon rubber
2 neoprene sponge backing
3 neoprene extrusion
4 bronze extrusions
5 laminated glass, nominal thickness 18.8mm (0.740in), consisting of clear glass 12mm and demi-topaz approximate thickness 6mm incorporating a vinyl interlayer
6 m s angle 5×4×½in
7 ½in diameter ragbolt
8 F F L on horizontal paving and line of front edge of stair treads

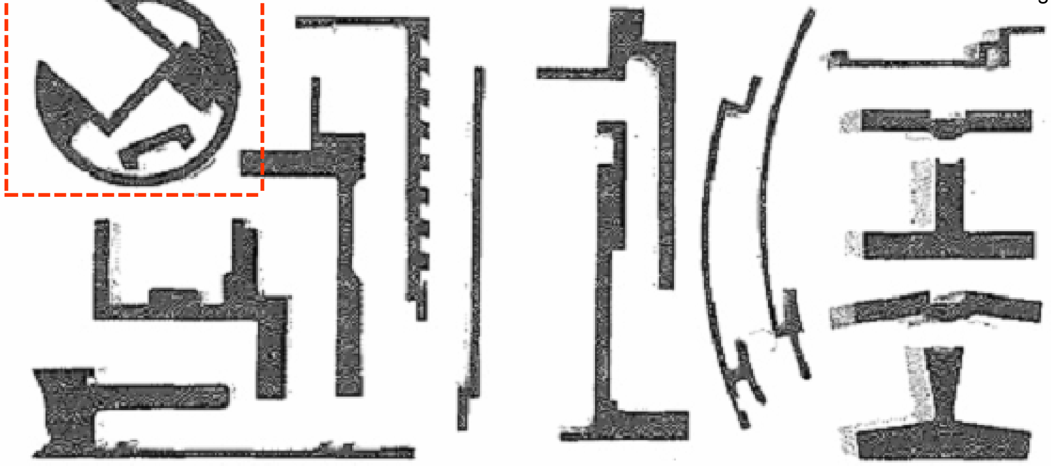
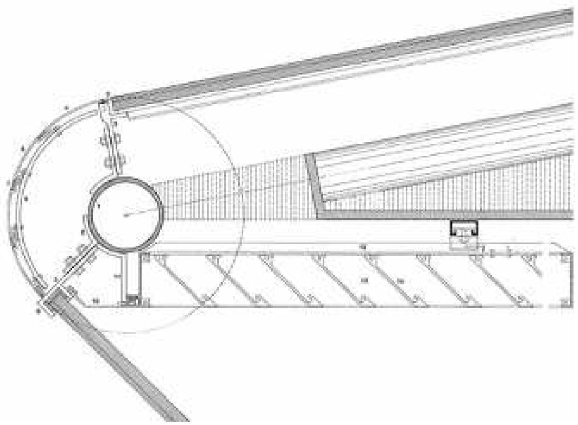


Fig. 6
Bronze extrusions

"…For all other surfaces, e.g. the view windows, the glass support system had to be modified. In all, over 40 different shpaed bronze extrusions were used; a few of them are shown in Fig. 6…"
***Arup Journal,* October 1973**

<u>Left</u>: sill detail; infill glass wall to sides and/or bottom of shells



<u>Above</u>: nose detail between the inclined glass roof and the bottom glazed strip (Restaurant)
<u>Left & Top</u>: view/s of restaurant end wall (showing nosing)

Adjustable Fixing Bracket

"…The glazing bars are attached to the structure by means of fixing brackets at roughly 0.9m centres. These had to be adjustable to accommodate the geometrical variations in angle and distance between structure and glass. They also had to take up the tolerances in the fabrication and erection of the structure. Allowing for the difficult fabrication involved and after discussions with the main contractor, it was accepted that even with the sophisticated surveying techniques they had developed, any point on the erected structure could be as much as 15mm out of its theoretical position. On the other hand, the distances between adjacent glazing bars had to be correct to 1.5mm so that the glass sheets would fit…"

***Arup Journal,* October 1973**

<u>Left</u>: glass fixing bracket connecting the T-shape (top) to steel mullion (bottom)

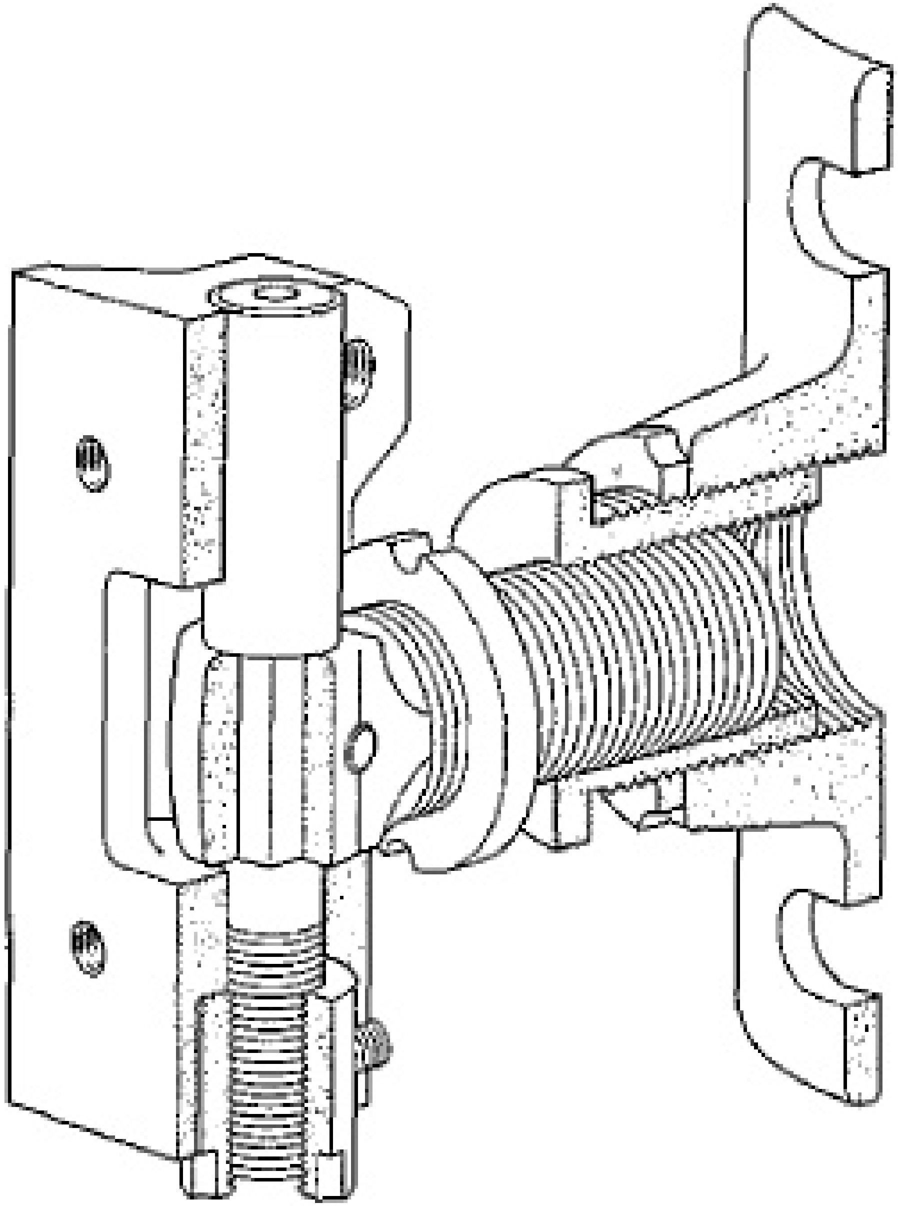


Fig. 7
Detail of adjustable fixing bracket

"…The fixing proved to be quite a complex piece of machinery (Fig. 7) and advice was sought from the aircraft industry. The design was developed in conjunction with Hawker de Havilland (Aust.) Pty Ltd. And the fixings, of which there were 2,310, were manufactured by them. The material used was aluminum bronze which offered strength together with resistance to stress-corrosion and fatigue, and was also suitable for casting and machining…"

***Arup Journal*, October 1973**

The Structure

"…Steel was chosen for the main structural material on account of its strength and stiffness. The standard elements, or mullions as they came to be called, were fabricated from two parallel 90mm diameter tubes at 530mm centres joined by a 6mm plate web. This section had the advantage that the geometry could be solved along the centre line of the outer cord and standard connection details could be developed that would apply to the whole range of orientations that would occur…"

***Arup Journal*, October 1973**

Connection to Shell Ribs

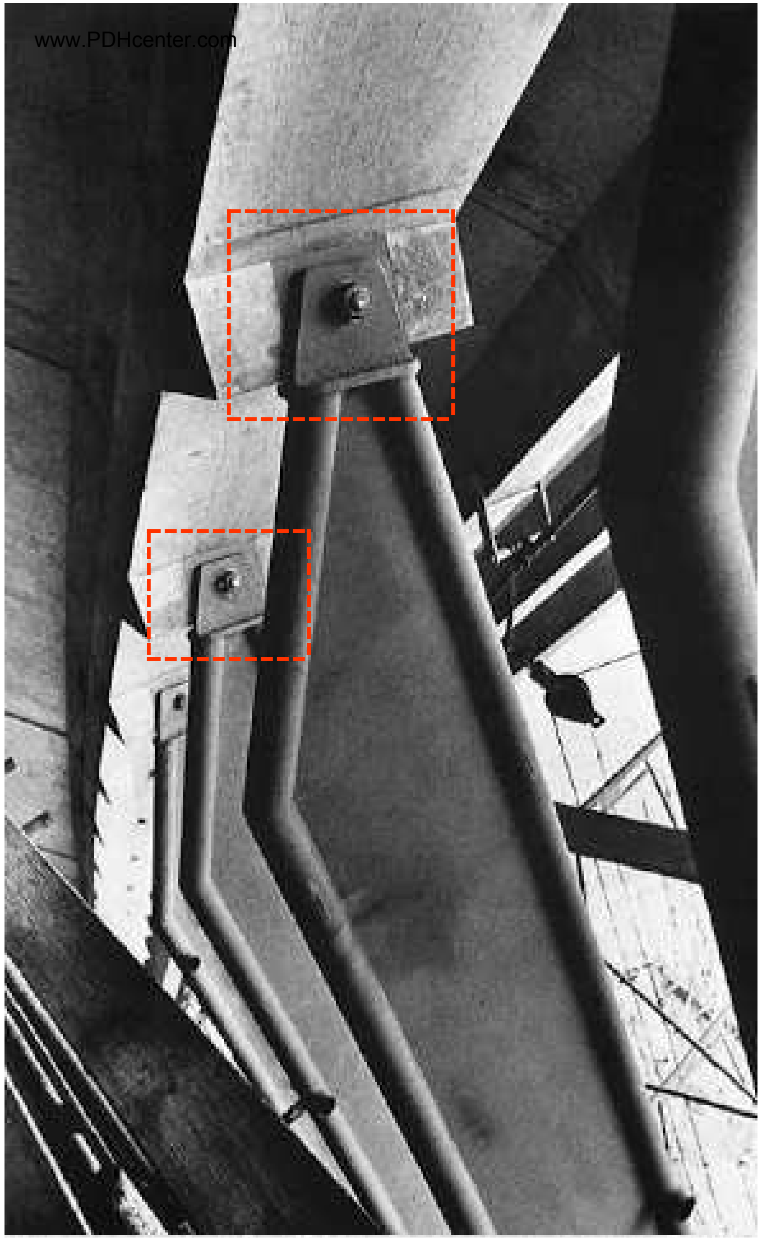
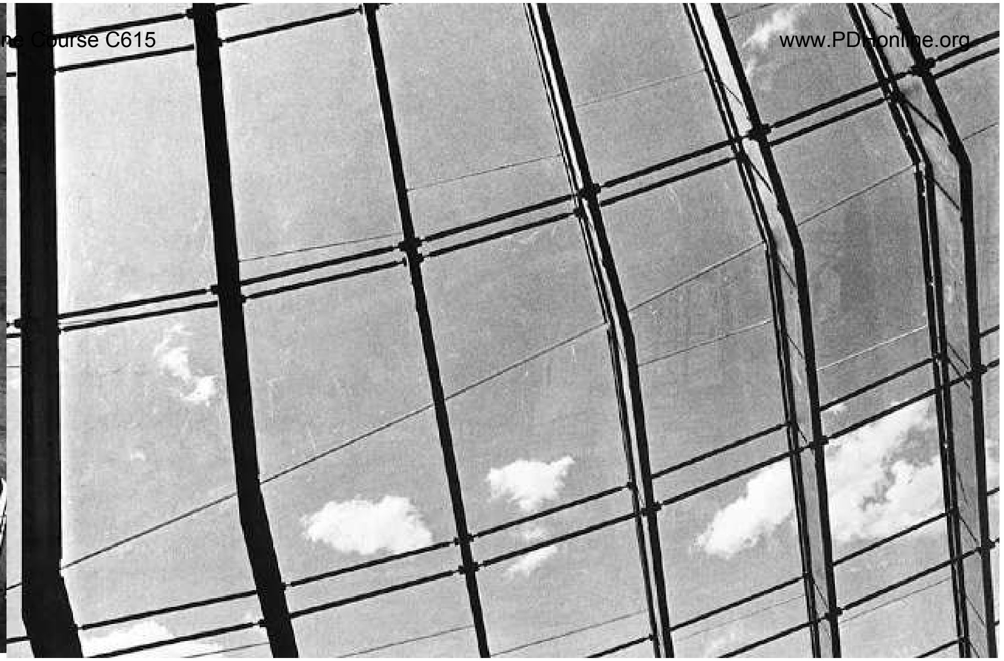
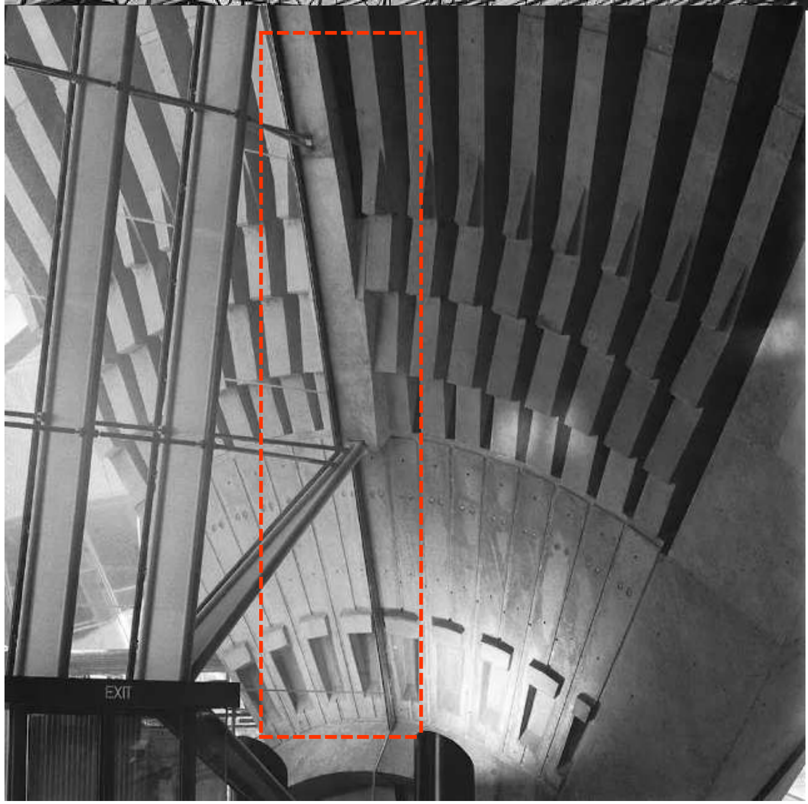


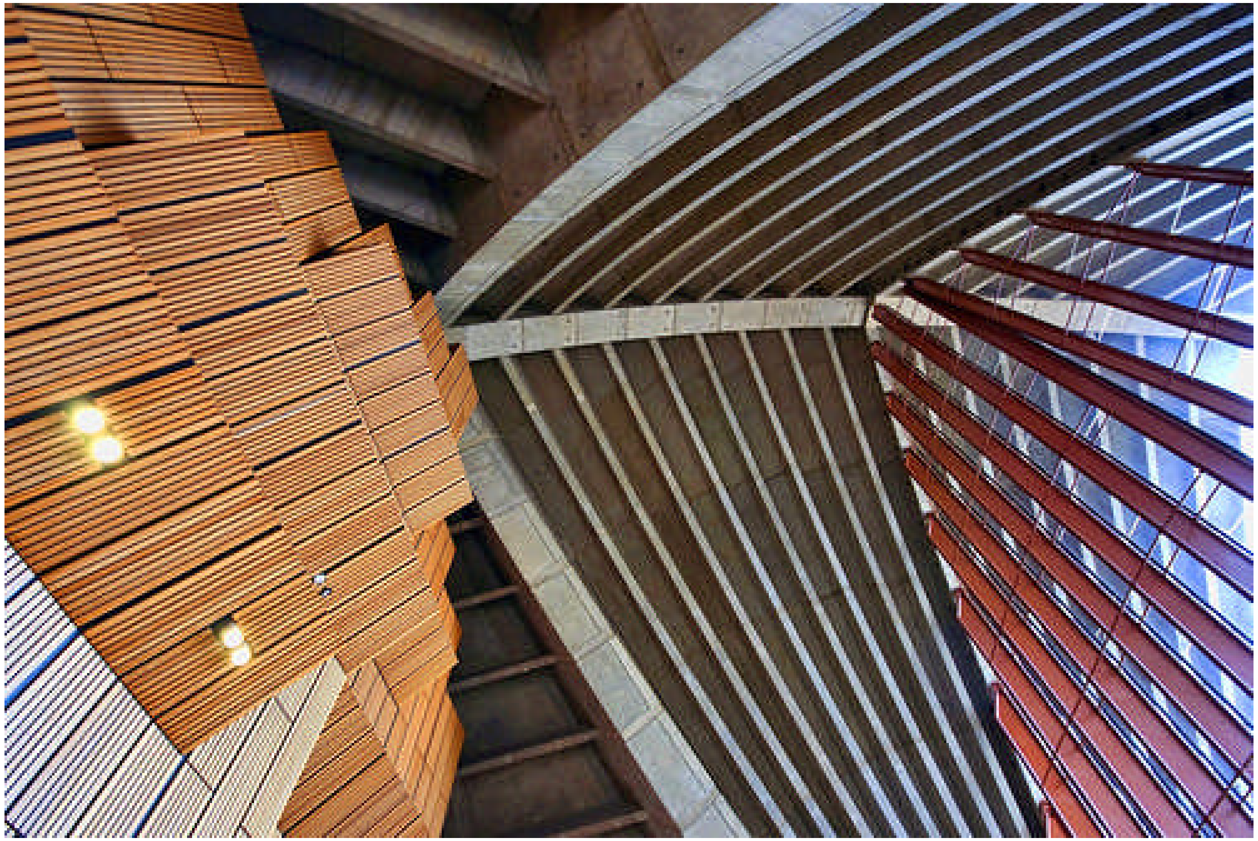
Fig. 8
Detail of corbels (A4)

"…One of the critical details of each of the walls was the method of connecting the mullions to the shells. The position of the cables in the pre-stressed ribs prohibited any form of drilling into the rib to make a fixing. However, during the design of the shells, certain ribs had been chosen to support the glass walls. These had been specially strengthened and extra holes cast into them to allow for subsequent fixing of the glass walls. Naturally, these holes did not coincide with the positions of the mullions, and it was therefore decided to cast on to the rib a strip of in situ concrete. This 'continuous strip' as it was called, was bolted to the rib using the existing holes and was thickened out into corbels to support the mullions (Fig. 8). No two corbels are identical, nor is the interval between corbels constant and in situ concrete was therefore the most suitable material…"
***Arup Journal*, October 1973**





<u>Top Left</u>: glass end wall A4 from inside Concert hall foyer (glass installed)
<u>Top Right</u>: glass end wall A4 from inside. Without transoms, total transparency was achieved
<u>Right</u>: connection between glass end-wall and the shell pedestal/ribs (glass end-wall A4)



Development of the Geometry

"…The design thus developed into a composite assembly of concrete, steel, bronze and glass. Each material had its own discipline and, just as the geometry of the shells themselves was determined by the precasting requirements for the concrete segments, so the design of the glass walls was dependent on the properties of these four materials. The most important of these material limitations was that of the glass. While glass can be cut into almost any desired shape it would be quite impractical to have sheets of glass that were curved or warped. Each glass sheet, therefore, had to be defined in space by two straight line generators that were coplanar. The simplest curved surfaces satisfying this requirement are the cylinder, formed by parallel generators, and the cone, formed by connecting a set of points on a curve in space by generators to a common apex. The A4 glass wall is made up of a cylinder and two cones. Starting from the rib, the surface is a vertical elliptical cylinder, defined by the next horizontal projection of the circular rib. Next comes the upper cone which forms a transition surface between the cylinder and the lower cone. The base of the lower cone is related to the geometry of the podium…"

***Arup Journal,* October 1973**

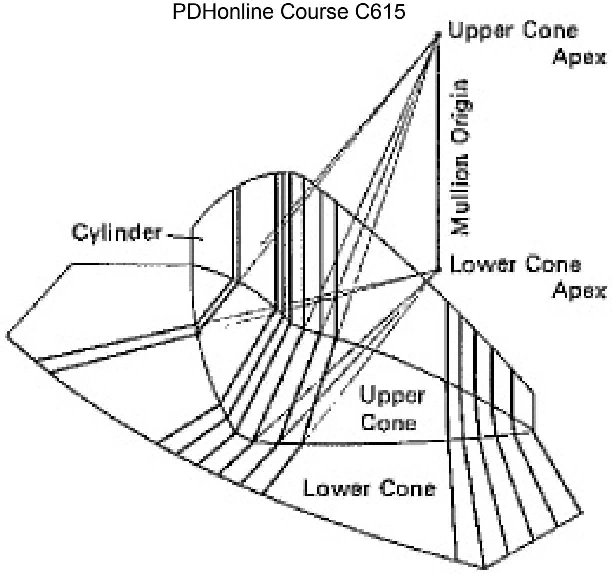


Fig. 9
Glass wall A4 : geometry

"…The relationship between the shapes of the shells and the podium is mathematically arbitrary and the glass wall is, in effect, an independent geometry that satisfies the boundary conditions of the shell rib at the top and the podium at the bottom. The apex of the upper cone is vertically above that of the lower cone. The axis through them is called the mullion origin and through it pass the vertical planes containing the mullions. The geometry is shown in Fig. 9…"

***Arup Journal*, October 1973**

Structural System

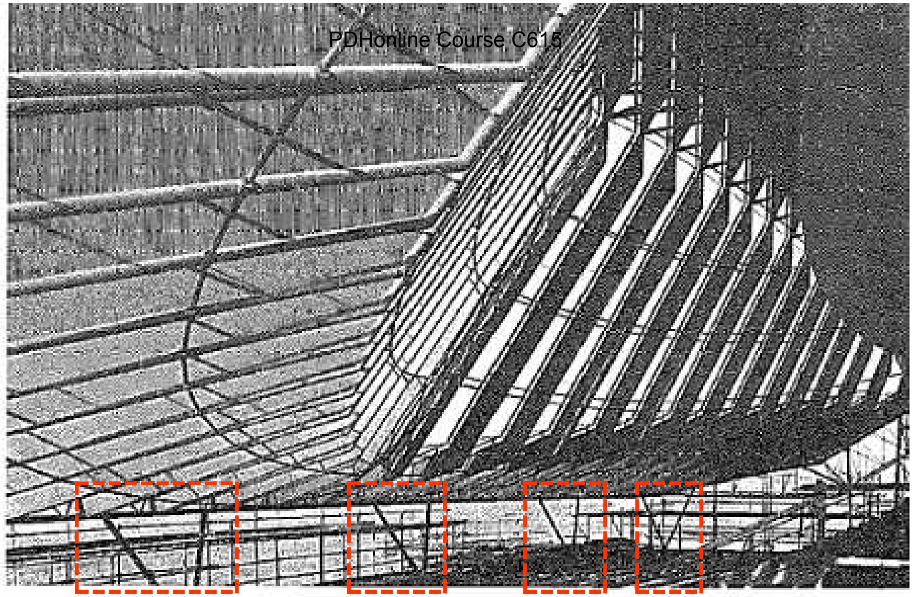
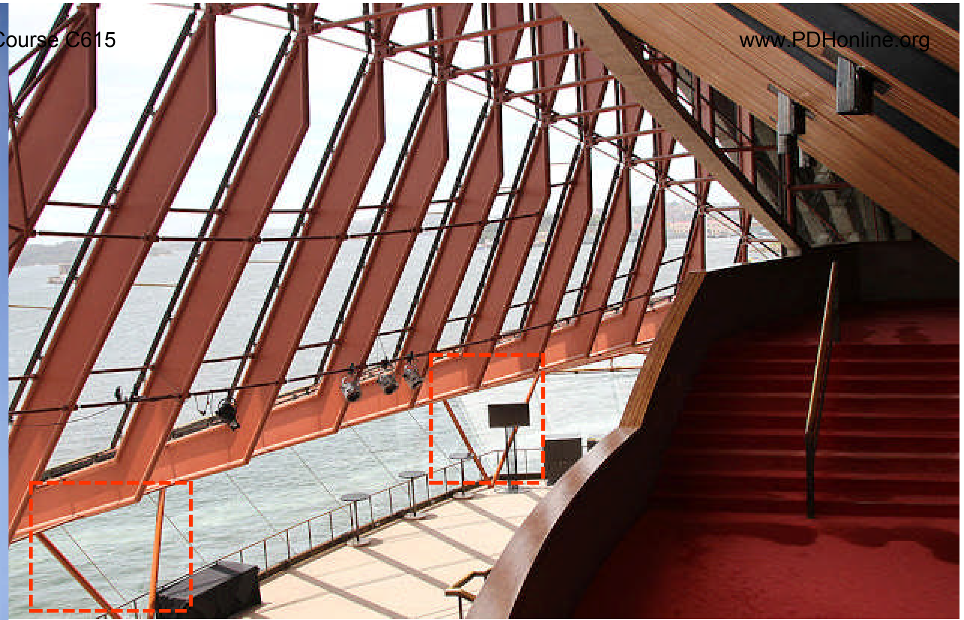


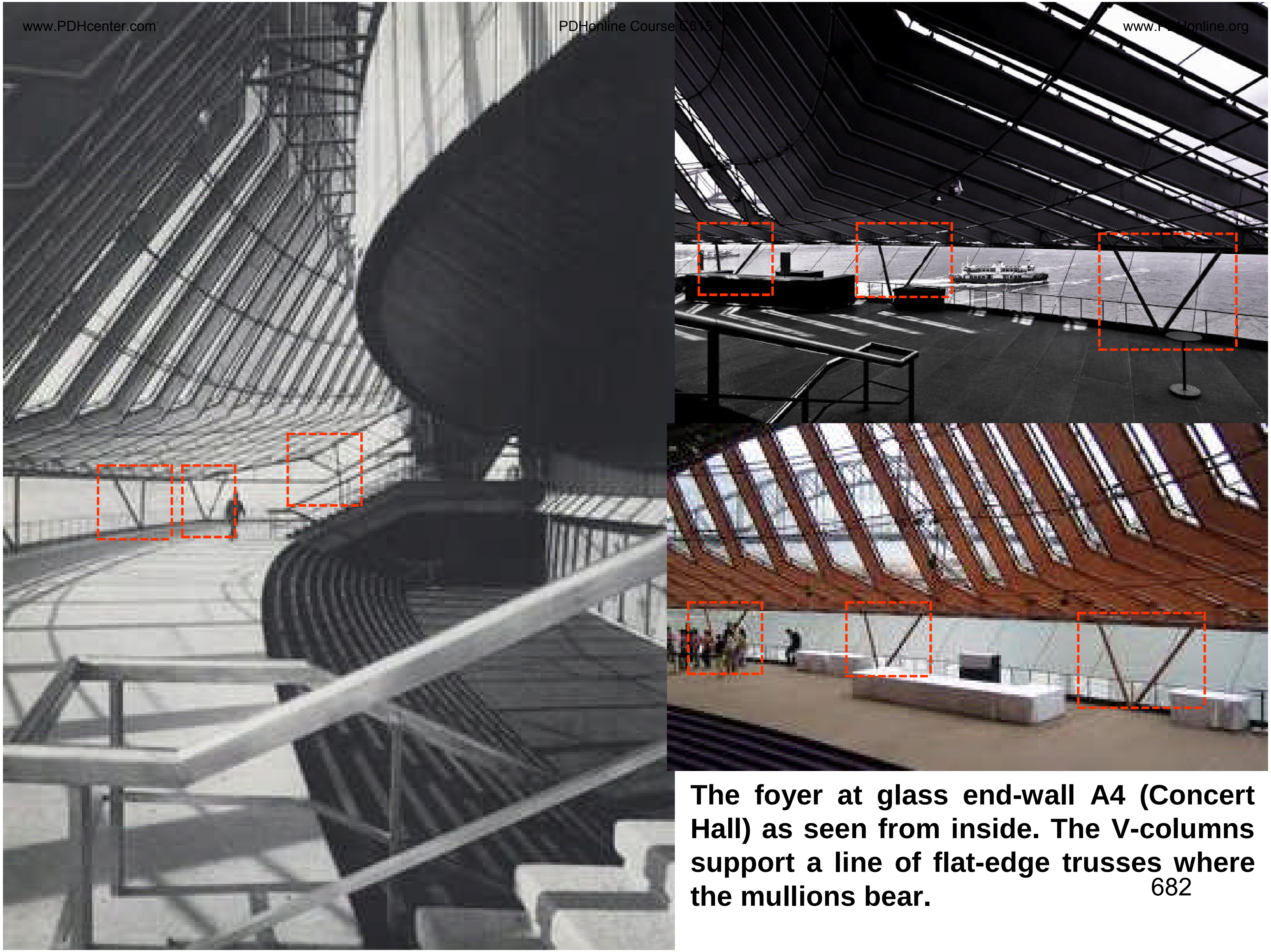
Fig. 10
Glass wall A4 : structure

"…The structural system evolved concurrently with the development of the geometry. The mullions were fabricated in two sections, one for the cylinder, the other for the upper and lower cones. The upper sections are bolted to the corbels and tied back at the bottom by struts to the rear wall of the auditorium. The lower sections are bolted to the upper sections and are supported at the lower end by the trusses supported, in turn, by V-columns on the podium (Fig. 10). Wind load components out of the planes of the mullions are transmitted through the ties between mullions to the centre mullions braced diagonally together so as to assist sideways loading. These ties also restrain the mullion chords in compression against buckling laterally…"

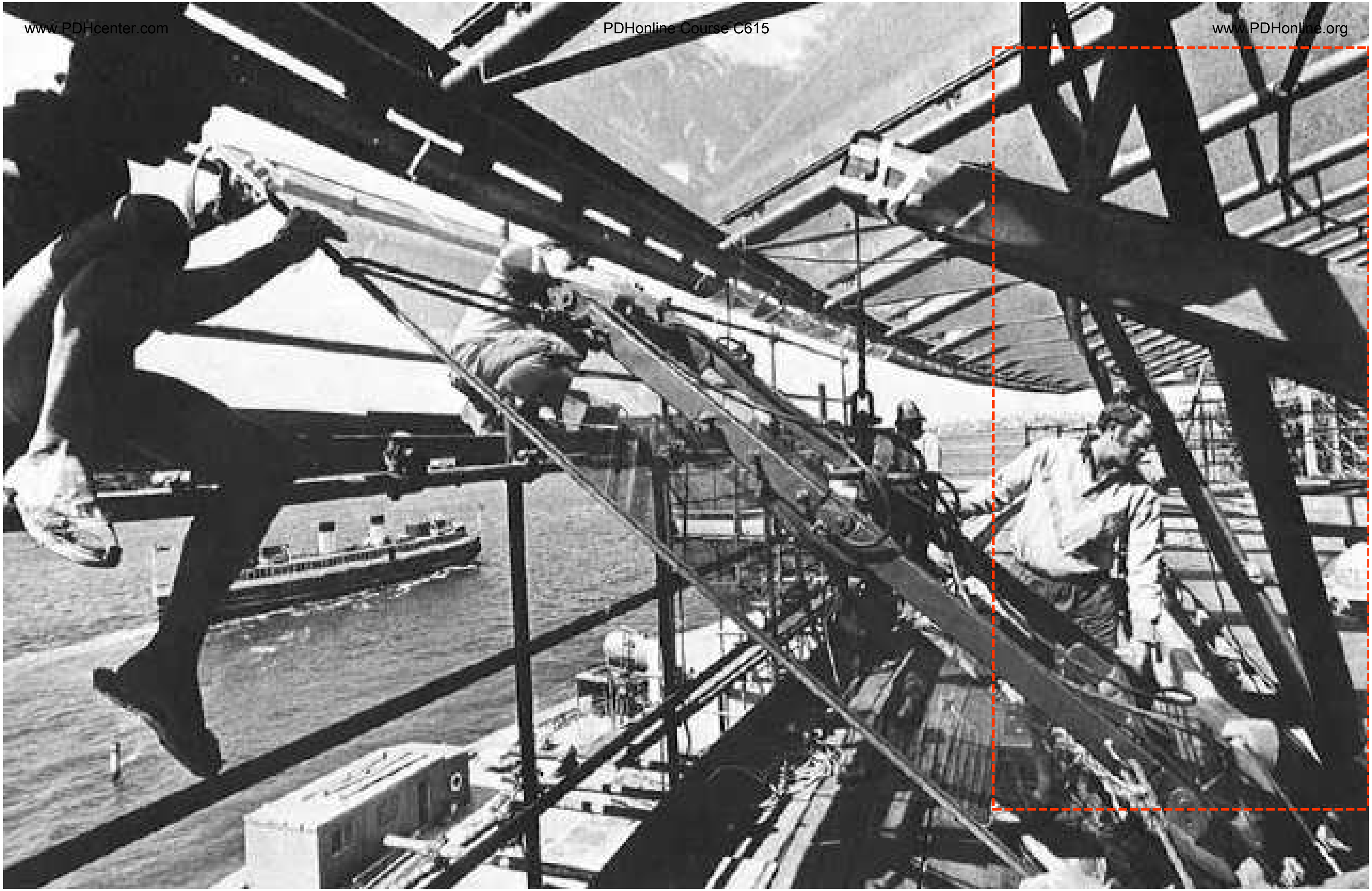
***Arup Journal,* October 1973**



<u>Above</u>: Theater (minor) Hall foyer glass end-wall (note V-columns)
<u>Left</u>: Theater Hall glass end-wall at sunset



The foyer at glass end-wall A4 (Concert Hall) as seen from inside. The V-columns support a line of flat-edge trusses where the mullions bear.



Installing inclined glass in wall A4 (V-Columns at left: 1972)

Glass Walls A1, B1, C11, C12 and Side Walls

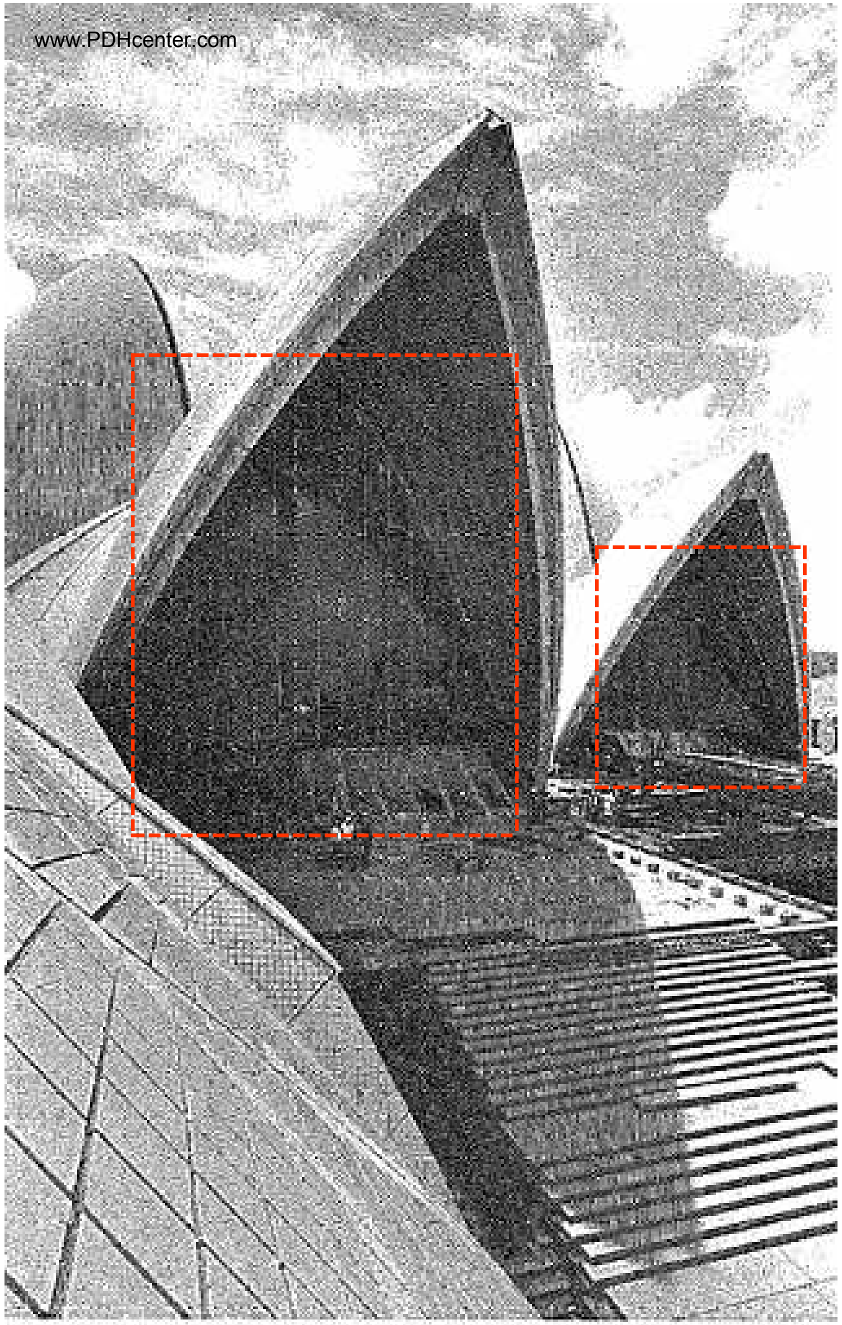


Fig. 11
Glass walls A1 (left) and B1 (right)

"…These other walls differ considerably in shape from A4 and B4 as not only are the proportions of the shells themselves different but so are the functions of the areas they enclose. Most of the details developed for A4 were used throughout although some simplification was possible, particularly on the side walls, owing to the smaller scale and simpler geometry. Figs. 11 and 12 show the glass walls A1 and B1, Fig. 13 shows the restaurant wall C11, and the view through side wall A5 is shown in Fig. 14…"

***Arup Journal*, October 1973**

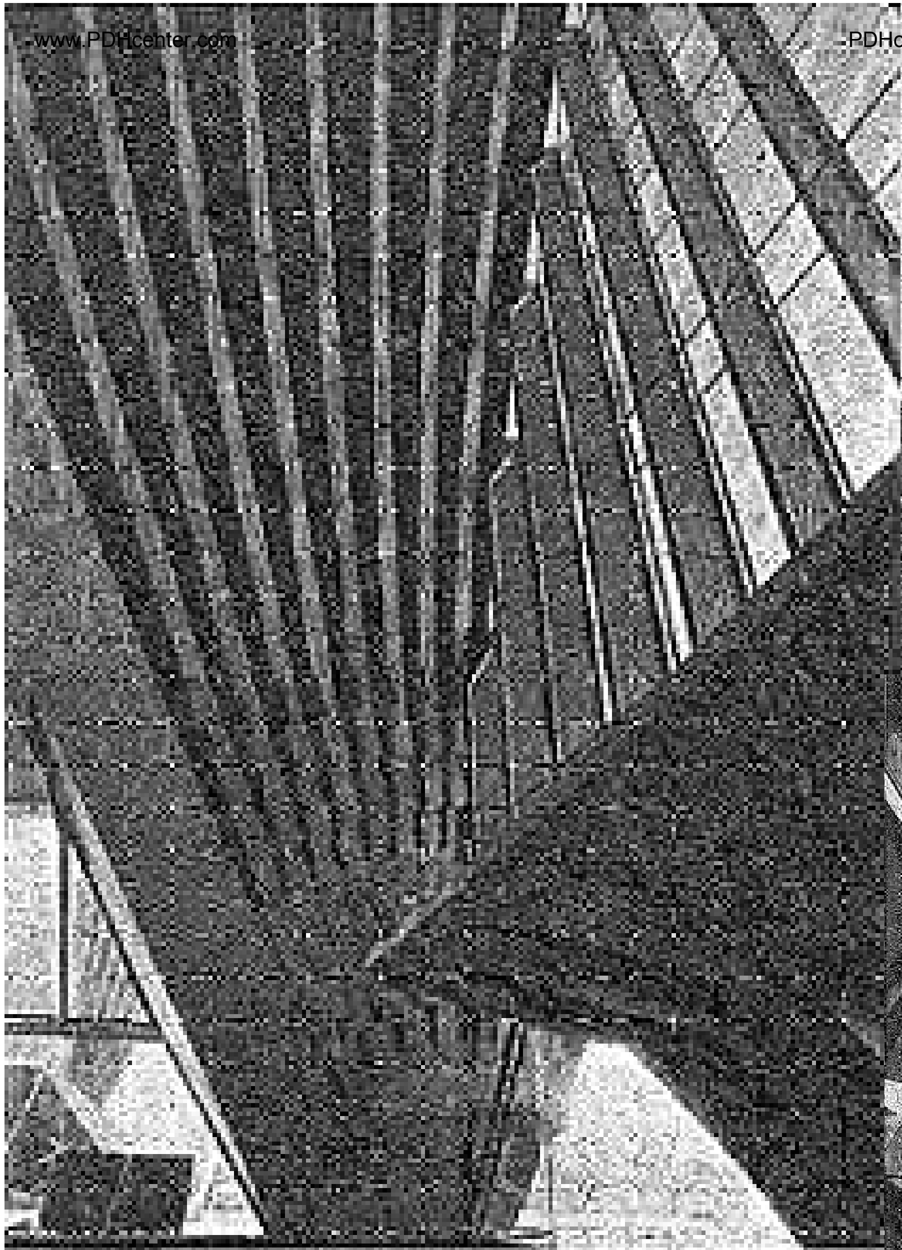


Fig. 12
Entrance foyer (A1)

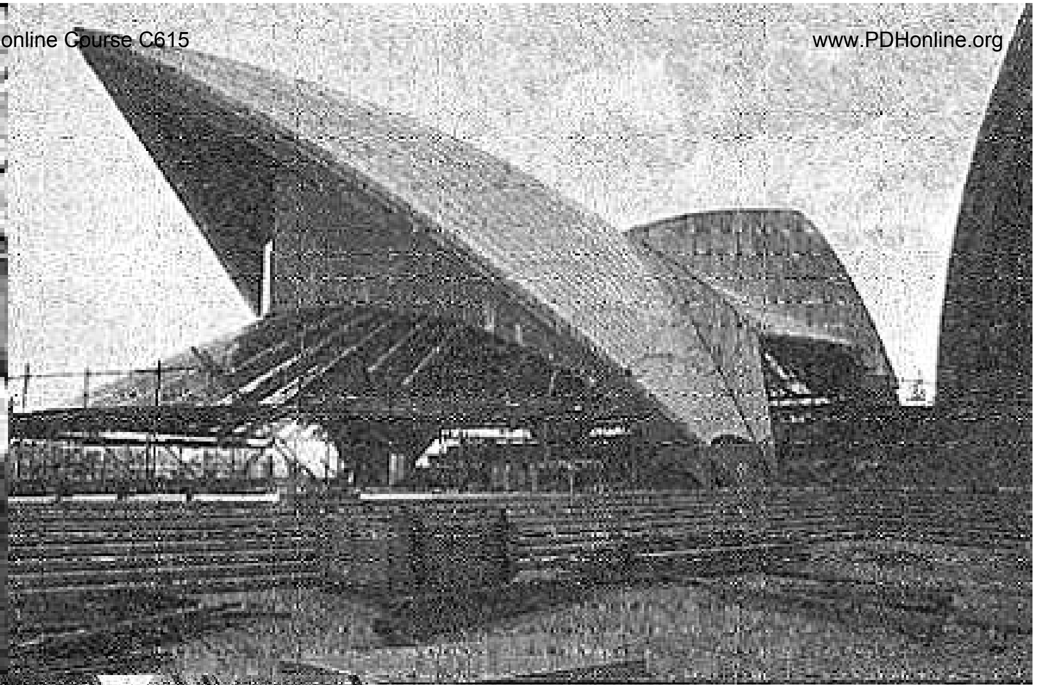


Fig. 13
Glass wall C11

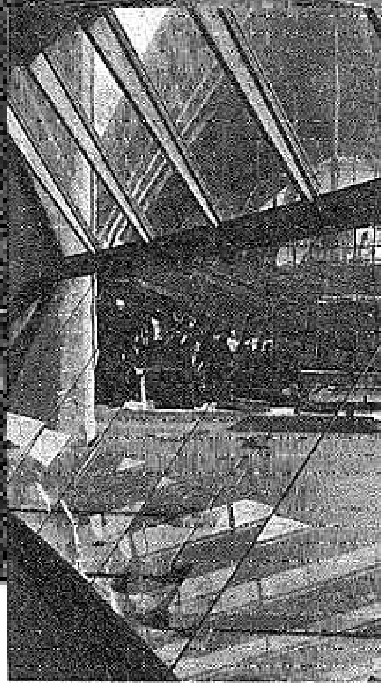


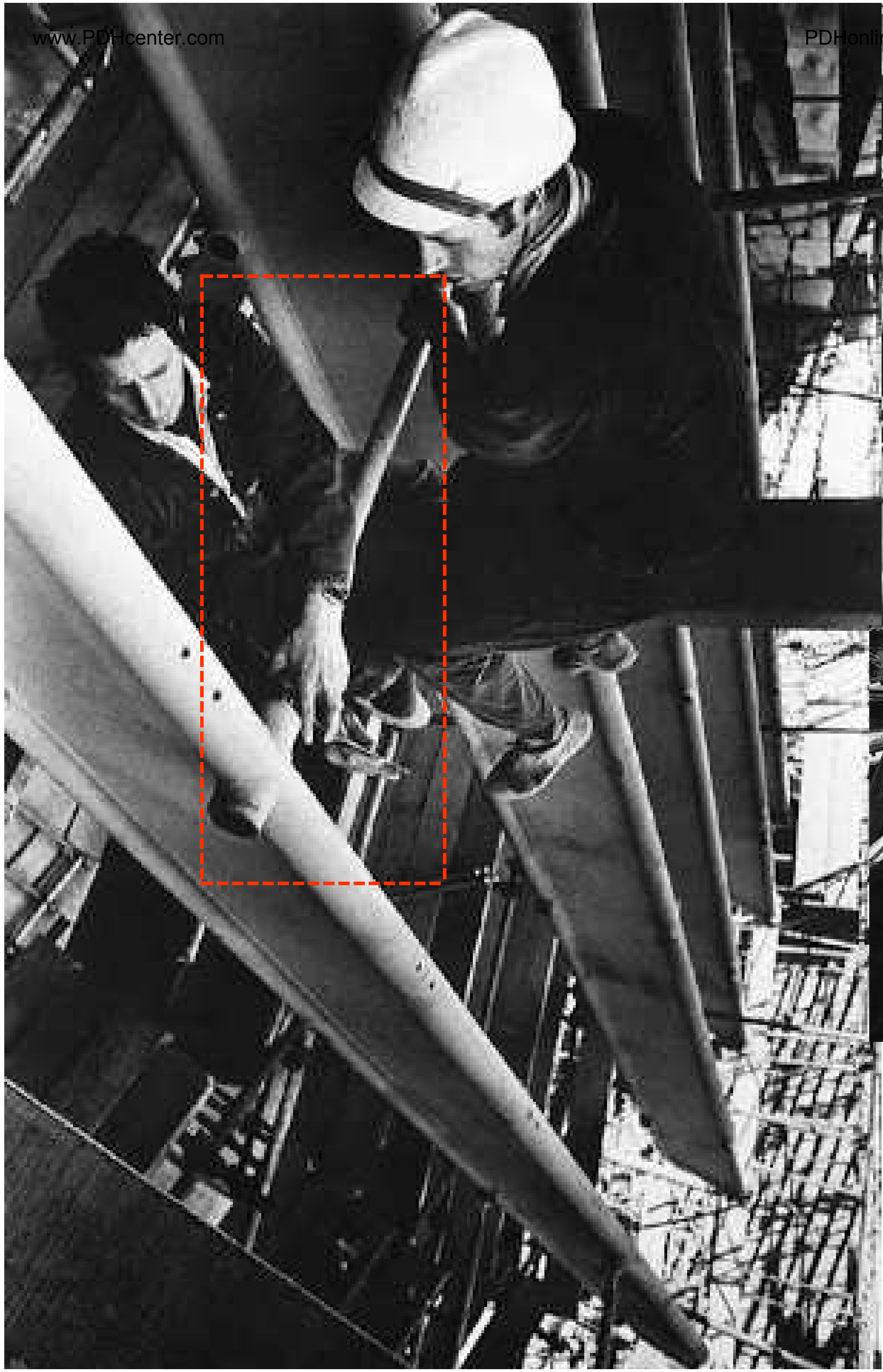
Fig. 14
View through glass wall A5 towards Restaurant

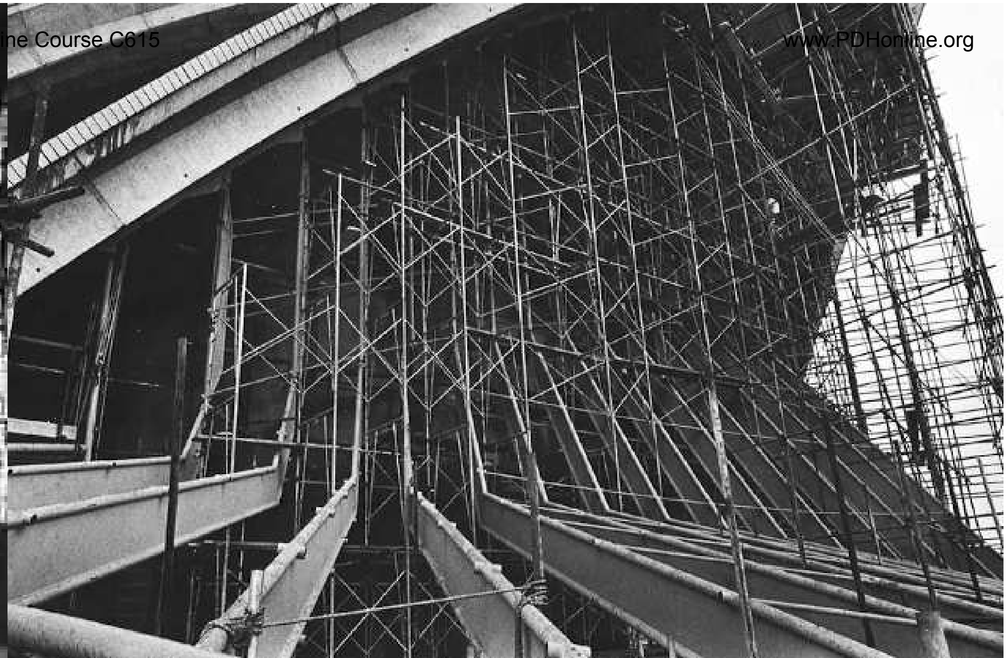
The restaurant side and end-wall/s (from the Broadwalk)

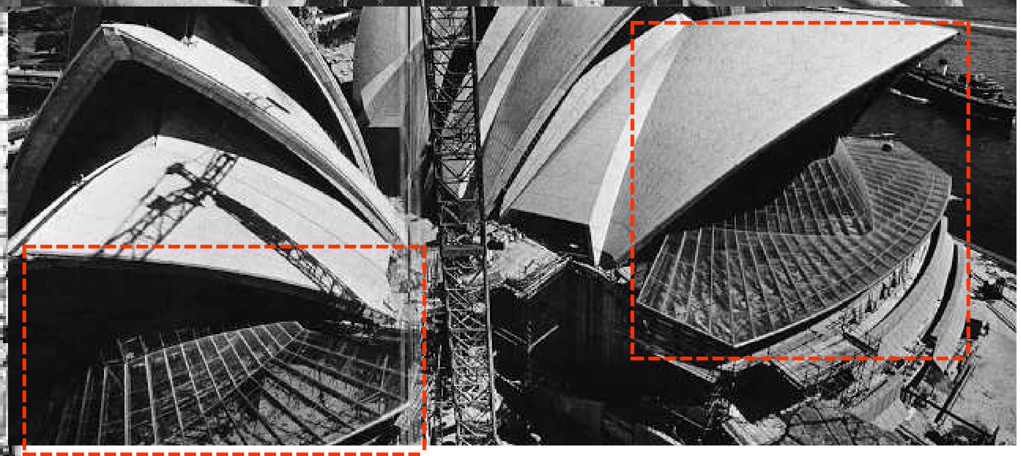
Erection Procedure

"…The shuttering and reinforcement to the continuous strip, prefabricated in short lengths to the calculated dimensions, were lifted up and attached to the rib. Survey stations on each mullion plane had been established, enabling the formwork to be moved up or down the rib until the face of the corbel lay in the mullion plane. The section of concrete was then cast. When the continuous strip was complete, each corbel bolt was surveyed and the coordinates fed into the computer program. This calculated the position on the steel mullion where the hole for the corbel bolt should be drilled. The prefabricated steelwork could then be erected and would automatically be located in its theoretical position, independent of the deviations of the shell rib itself. The steel ties between the mullions were adjustable in length to allow for tolerances. However, such was the quality and accuracy of the steel fabrication that the full range of adjustment was generally not required. On the other hand it was invaluable as a means of aligning the mullions into the surveyed planes as they were quite flexible in the lateral direction After the steelwork had been painted, the fixing brackets and glazing bars were attached. Both mullions and glazing bars were aligned using plywood templates made to dimensions calculated in the same way as the dimensions of the glass sheets, and check surveys were made on specified points. The edges of the glass sheets adjacent to the continuous strip, and around the corbels, were templated to allow for deviations of the shell rib from its theoretical position…"

***Arup Journal*, October 1973**







Left: installation of ties between mullions
Above: fixing mullions on-site with scaffolding (wall A4) / aerial view of B4 (left) and A4 (right) glass end-walls nearly complete (1972)

"…The glazing was carried out from the top downwards from working platforms supported on scaffolding. The laminated glass sheets, having been sawn to shape on site, were hoisted onto the platform, normally in groups of three or four. On the platform itself, individual sheets were moved by means of a purpose-built mobile crane with suction lifting equipment. Special jigs were clamped onto the glazing bars in order to provide temporary support for the glass and to enable the glass sheet to be accurately aligned. Each jig incorporated a drill attachment which was then used to drill holes in the glazing bar flanges to take the push-fit glass support pins. With the glass in its correct position and held against the glazing bars by means of temporary clamps, the joints were sealed with silicone rubber, as described in the following section…"

***Arup Journal*, October 1973**

Sealing and Waterproofing

"…With much of the glass inclined to the horizontal and situated directly above areas used by the public, it was particularly important that the walls should be completely watertight. Use of the best available type of sealant was essential, and silicone rubber (translucent type 3B) was selected for this purpose. The choice of silicone rubber was really dictated by the presence of the horizontal glass-to-glass butt joints. These joints are directly exposed to the atmosphere and silicone rubber, besides having an excellent adhesion to glass, has a high resistance to ultra-violet radiation and other weathering agencies. Furthermore, its elastic properties ensure that it remains permanently in place on the inclined glass surfaces; most other sealant materials exhibit time-dependent flow properties which would cause them to sag and perhaps disappear from the joint altogether…"

***Arup Journal*, October 1973**

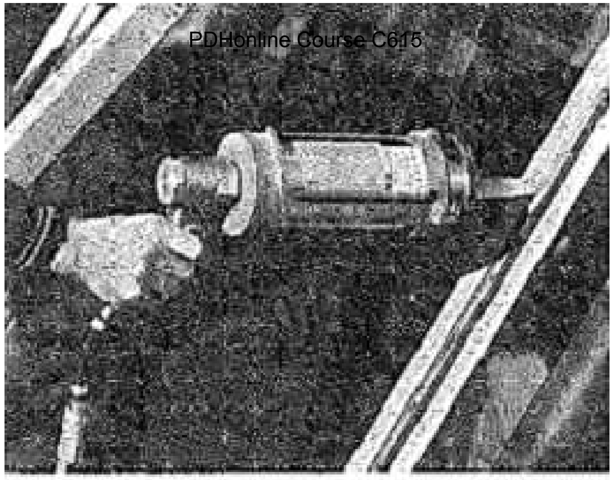


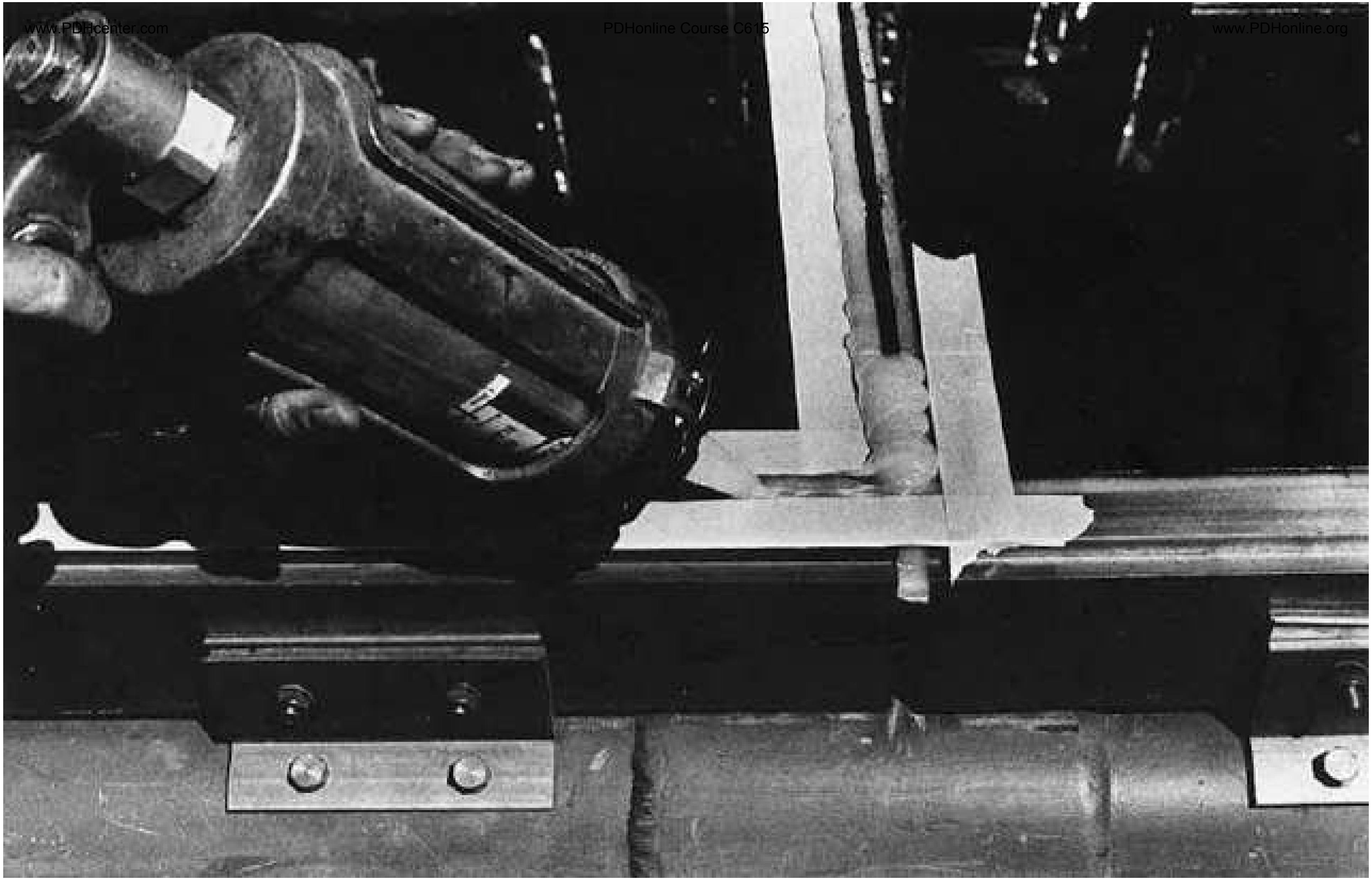
Fig. 27
Application of silicone rubber seal

"…Silicone rubber, being a one-part sealant, is relatively easy to apply; compressed air guns were used on site, as illustrated in Fig. 27. However, its use as a construction sealant poses difficulties in that the substrates have to be cleaned and prepared to quite stringent standards. In the present case, for example, the sawn edges of laminated glass had to be provided with protective covers during handling and storage, and carefully cleaned just prior to glazing. In addition, the glazing bar surfaces had to be abraded, solvent cleaned and primed prior to application of the silicone rubber. Some experimentation was even required in selecting the most appropriate primer; it had to be insensitive to surface moisture and was required to resist attack from the acetic acid which is given off by the silicone rubber during curing…"

***Arup Journal*, October 1973**

"…On the main glass surfaces, the primary seal is provided by the horizontal glass-to-glass butt joints and by the vertical joints between the glass and the web of the glazing bar T-section. As a second line of defence, the glazing bar cover strip was assembled in such a way as to effect a form of mechanical seal. In this arrangement, the cover strip was left loose during application of the outer silicone rubber seal; when the rubber had cured, the cover strip was screwed down on to the web of the T-section, thereby causing compression of the rubber and giving a continuous external gasket along the joints in the vertical plane. At joint locations with no cover strip, such as those near the lines of intersection between the principal glass surfaces, the silicone was made to bridge between adjacent glass edges by cutting back the web of the glazing bar. The silicone rubber should maintain a durable and watertight seal for a great many years. Some future maintenance and repair work is inevitable, but evidence from both accelerated weatherometer tests and outdoor exposure tests strongly suggest that the useful life of silicone rubber is well in excess of 20 years…"

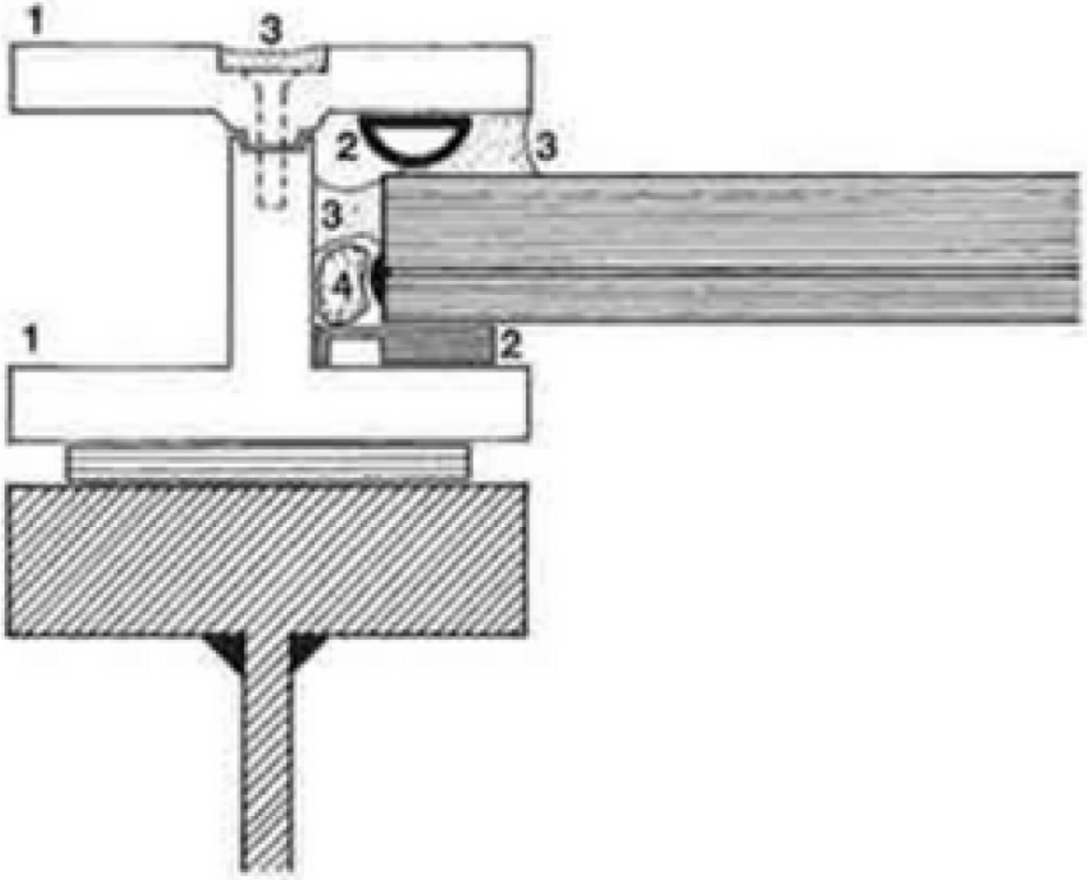
Arup Journal, **October 1973**



Silicone sealant being applied to the extruded bronze T-joint prior to installation of the glazing bar

Left: glazing of the Concert Hall A4 (1972), Right: cleaning and protecting the joints from dust prior to silicone sealing. About a month after the first sealing was complete in wall A4, it was observed that the sealant was separating from the Bronze glazing bar. The most likely reason appeared to be poor preparation of the Bronze work or atmospheric contamination prior to sealing. The faulty material was cut out, a series of site tests conducted and the areas resealed. It soon became apparent that the problem was much more serious. As it turned out, it was practically impossible to achieve a permanent adhesion of silicone to Bronze which could withstand water immersion. *Rhone-Poulenc* (maker) was consulted and other primers were tested and a successful technique evolved. The problem appeared to be that the silicone joint was too deep in relation to its width. The volume of silicone on the joint was excessive in relation to the free surface area from which *acetic acid* (generated during curing) could disperse. The acetic acid was able to attack the Bronze through the primer, and the result of this action dissolved out when the joint was immersed.

Problem Solved



Glazing bar detail

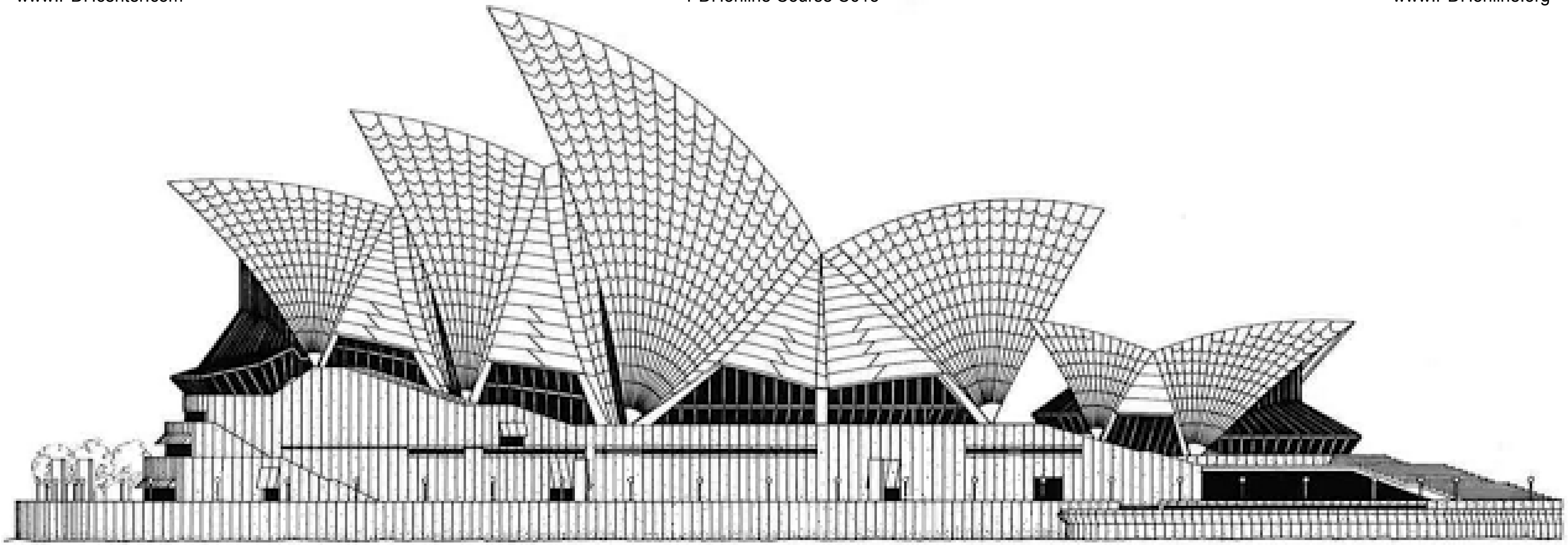
1 bronze extrusion

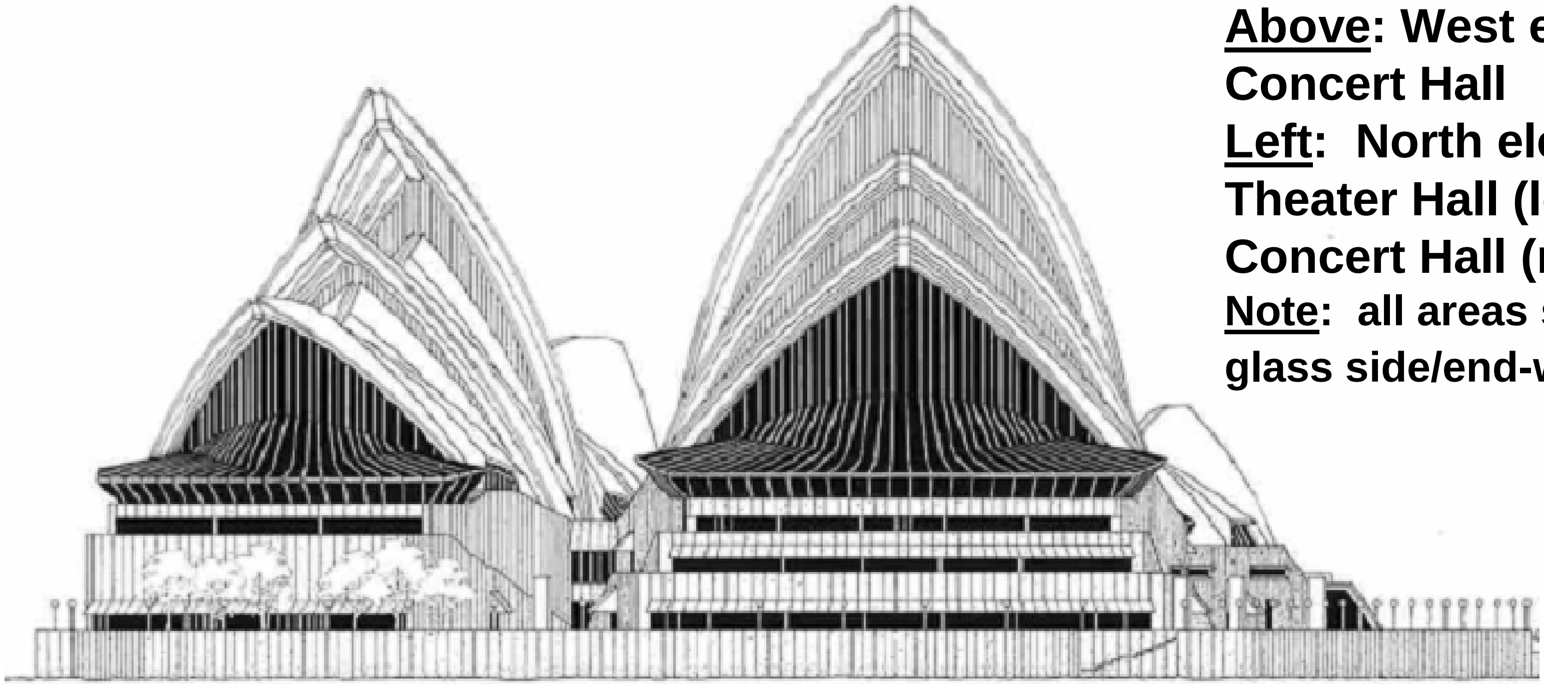
2 neoprene extrusion

3 silicon rubber

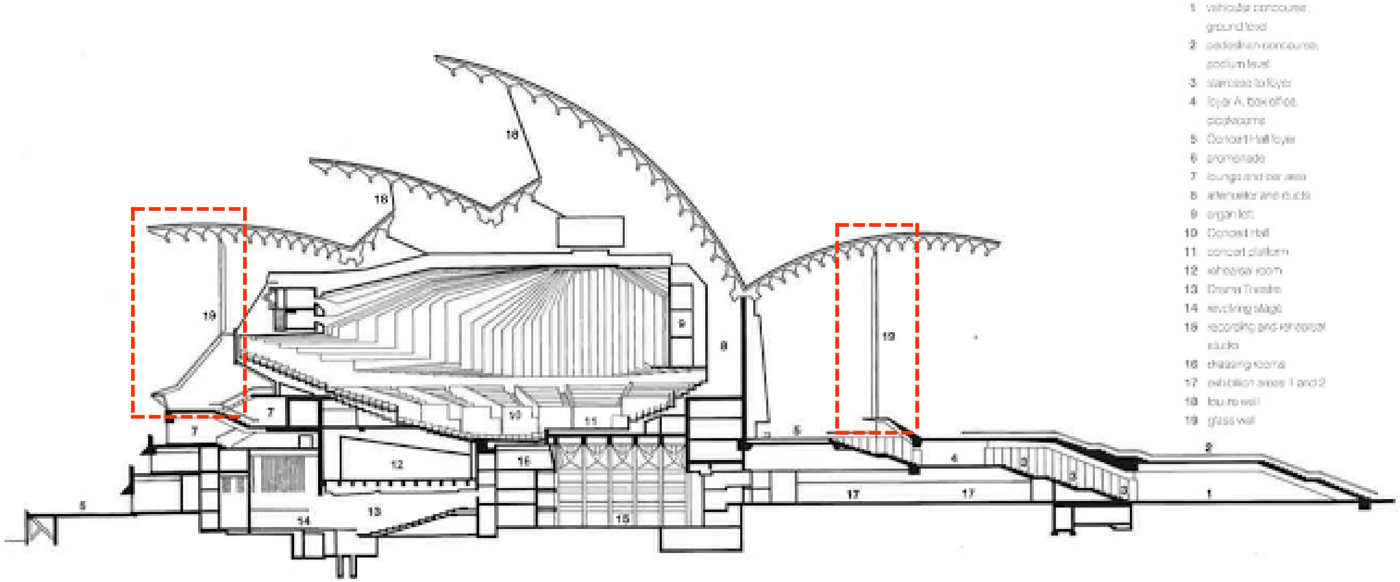
4 polysulphide seal

To resolve the problem, the cross-section of the joint was revised to allow a greater surface area of sealant (relative to the volume) to facilitate dispersion of acetic acid. Also, the method of clamping the cover strip down onto the sealant was introduced. More time had to be allowed for curing of the primers before the silicone was applied and much more time given for the silicone to cure and the generated acetic acid to disperse before the cover strip was installed. It was also important to protect the joint from water until curing was complete. To do this, strips of *polythene* were sealed down to the glass (covering the joint) and they remained there until the scaffolding was removed. The perfected joint was now watertight,

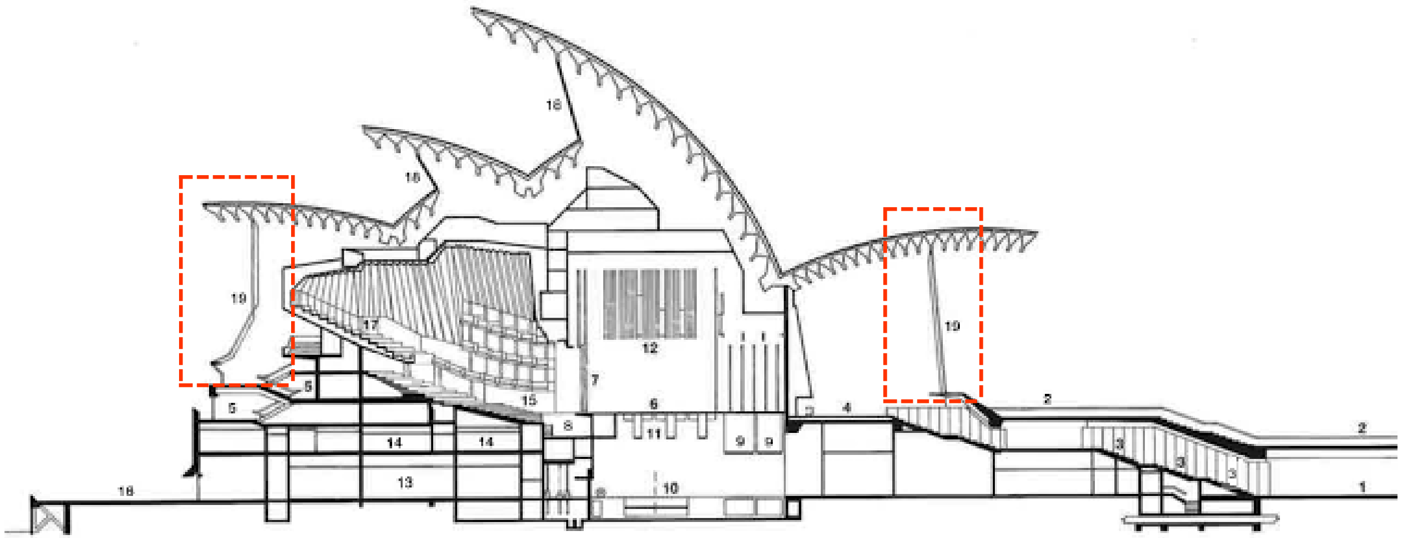




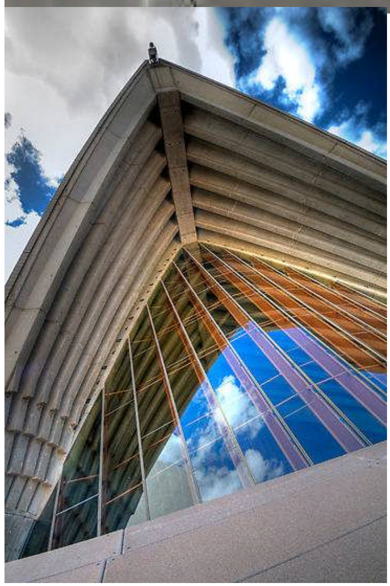
<u>Above</u>: West elevation of Concert Hall
<u>Left</u>: North elevation of the Theater Hall (left) and Concert Hall (right)
<u>Note</u>: all areas shaded black are glass side/end-walls



Longitudinal section through Concert Hall. Glass end-wall/s A4 (left), A1 (right)

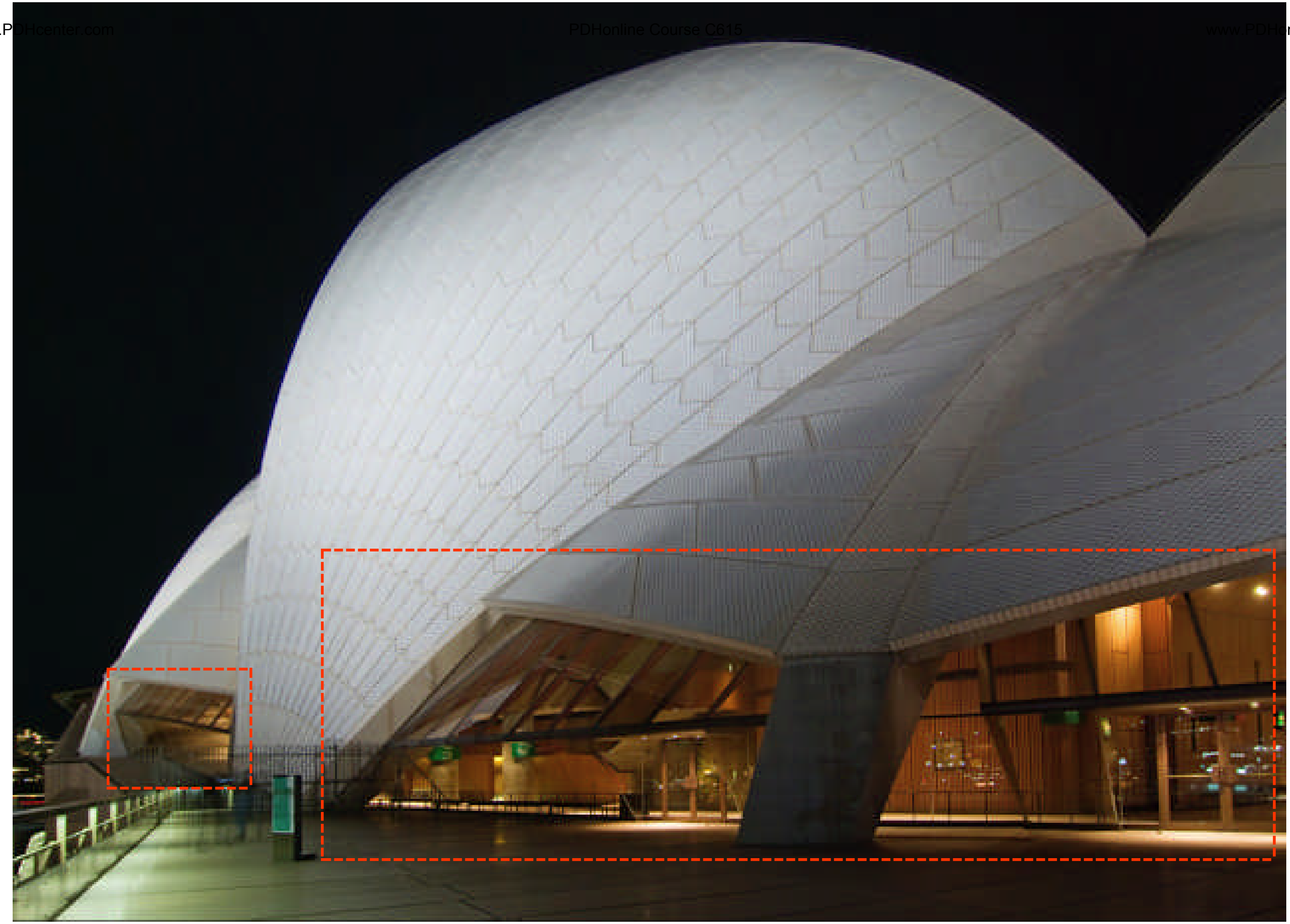


Longitudinal section thru Theater Hall. Glass end-wall/s B4 (left), B1 (right)



<u>Top</u>: view from south (city-side): Restaurant (left), Concert Hall entrance (center) and Theater Hall entrance (right)

<u>Left</u>: Theater Hall entrance glass end wall



Concert Hall side walls

Part 11

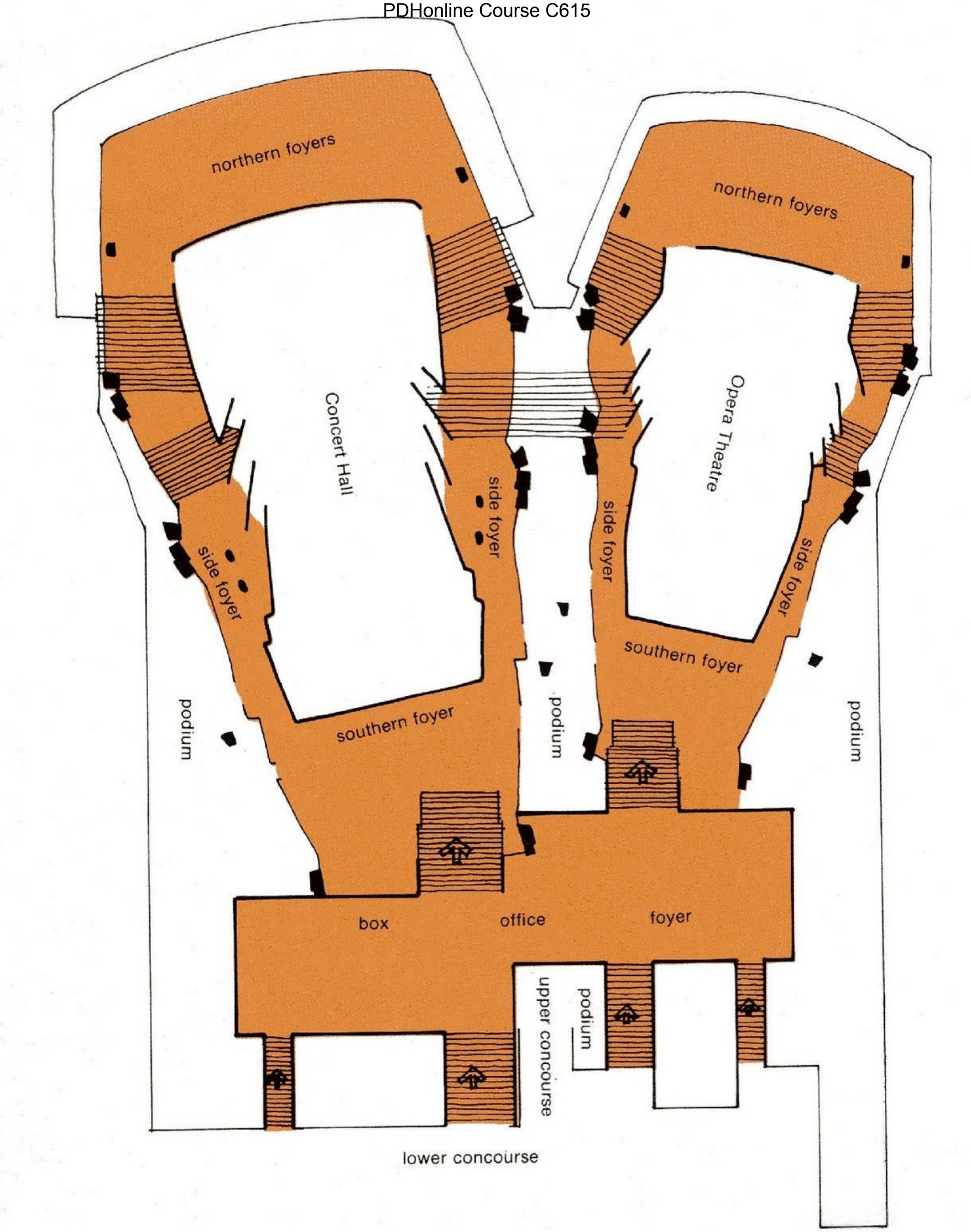
Problems & Solutions

In Between the Racket

"… As the new architects grappled with Utzon's design, more problems kept cropping up. British conductor Sir Malcolm Sargent stopped by for a casual visit and went away shaking his head – it would, he reckoned, take a staff of 1,500 to man the place. (More like 400, say officials). Although Utzon's topflight consultants maintained that the acoustics of the hall would be superb, another expert took some sound-level readings and found that ship-whistle noises from the harbor hit 104 decibels at the Opera House site – approximately the level of noise when a jet airplane takes-off over your head. 'Utzon's glass end walls,' said the man, 'would never cut out that much noise.' And besides, he went on, in between the racket of the boats the music was going to sound dry and brittle…"

***Life* Magazine, January 6th 1967**

RE: In January 1967, the architects presented DPW with their "Review of Program." Hall had consulted with Utzon's acoustic consultant *Vilhem Jordan* as well as American theater consultant *Ben Schlanger* in preparing the review. The major hall would be a Concert Hall *only* with a reverberation time of 2.0s. The proscenium arch and stage tower would be removed allowing the large space below the stage (for machinery) to become a large rehearsal room. In the minor hall, galleries would be added increasing seating capacity from 1,100 to 1,500 and the orchestra pit enlarged to make room for eighty musicians. Reverberation time would be 1.3s - very suitable for opera. Contradicting their earlier call for competitive bidding, the contract for Stage Three was awarded to *The Hornibrook Group Ltd.* (given their familiarity with the very complex SOH project).

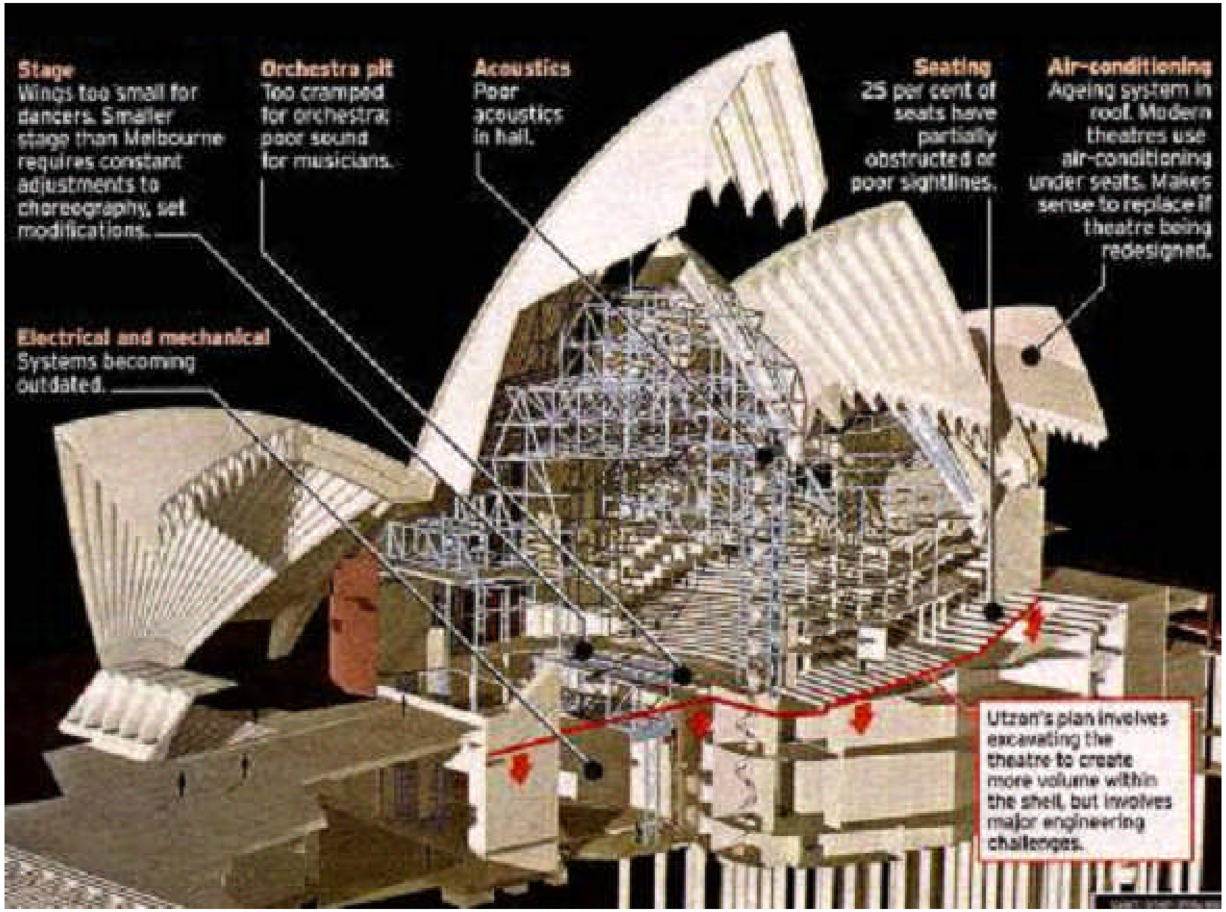

northern foyers
northern foyers
Concert Hall
Opera Theatre
side foyer
side foyer
side foyer
side foyer
southern foyer
southern foyer
podium
podium
podium
podium
box office foyer
upper concourse
lower concourse

Striving for Excellence

"And with a few moments like that, with doubt from here and there, and within ourselves we were just striving for excellence. We had somehow understood and felt that all the musicians who would come to the House later on, that all the singers, the big artists, were striving for excellence in their life and we thought a house for them, there's no limit to the excellence it should have because it should match their strive for perfection."

Jorn Utzon, Architect

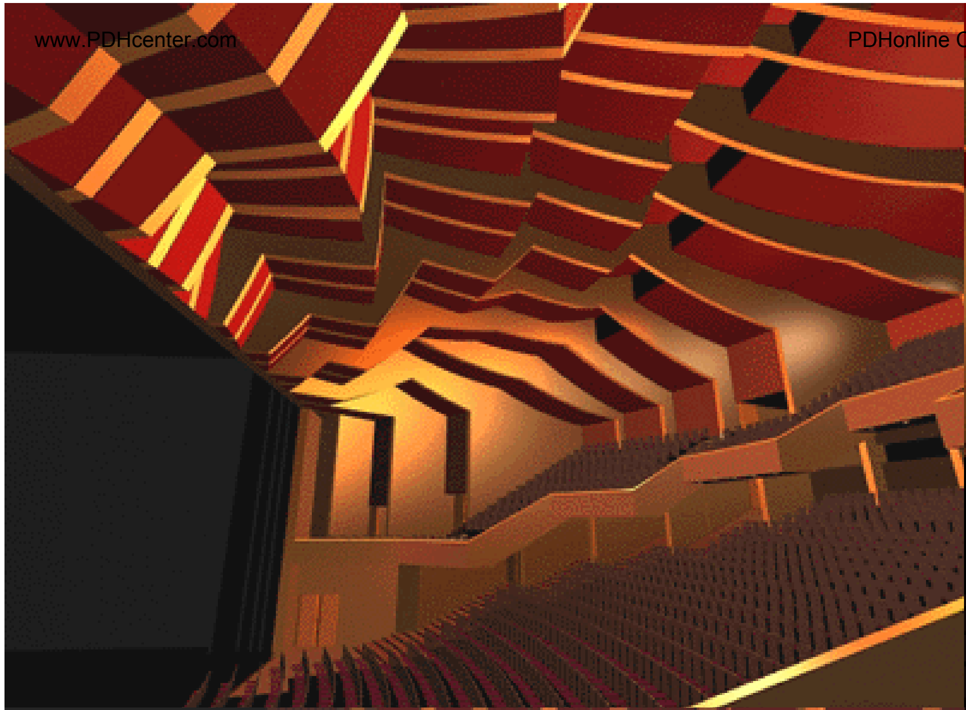
RE: comment made in 1998. Despite the predictions of acoustical doom, at the time of its opening (October 1973) the Concert Hall was praised for its world-class acoustics (two-second reverberation time at SOH's opening in late 1973). In 2004, SOH attained a high ranking in *Leo Beranek's* index of fifty-eight Concert Halls around the world. However, the halls have some problems with acoustics, particularly for the performing musicians. The orchestra pit in the *Joan Sutherland Theatre* (the renamed *Opera Theater*) is cramped and dangerous to musicians' hearing and is inadequate to stage large-scale productions of opera and ballet. The minor hall (originally for stage productions only), had the added function of opera and ballet to deal with. The added theater, cinema and library were later changed to two live drama theaters and a smaller "in the round" theater. These now comprise the *Drama Theatre*, the *Playhouse*, and the *Studio*, respectively.

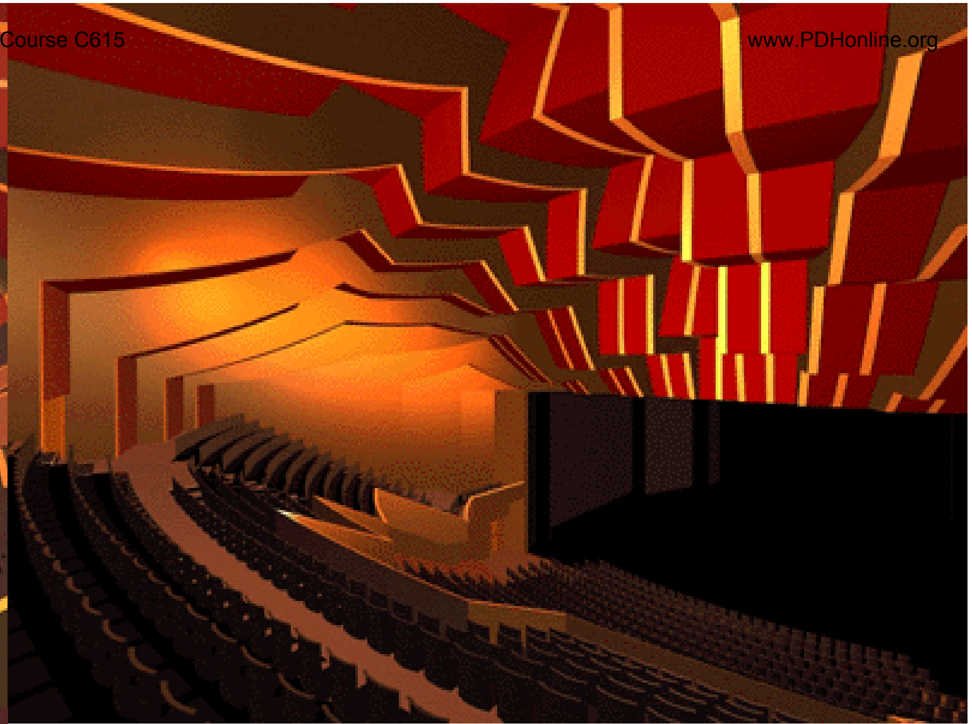

Stage
Wings too small for dancers. Smaller stage than Melbourne requires constant adjustments to choreography, set modifications.
Orchestra pit
Too cramped for orchestra; poor sound for musicians.
Acoustics
Poor acoustics in hall.
Seating
25 per cent of seats have partially obstructed or poor sightlines.
Air-conditioning
Ageing system in roof. Modern theatres use air-conditioning under seats. Makes sense to replace if theatre being redesigned.
Electrical and mechanical
Systems becoming outdated.
Utzon's plan involves excavating the theatre to create more volume within the shell, but involves major engineering challenges.

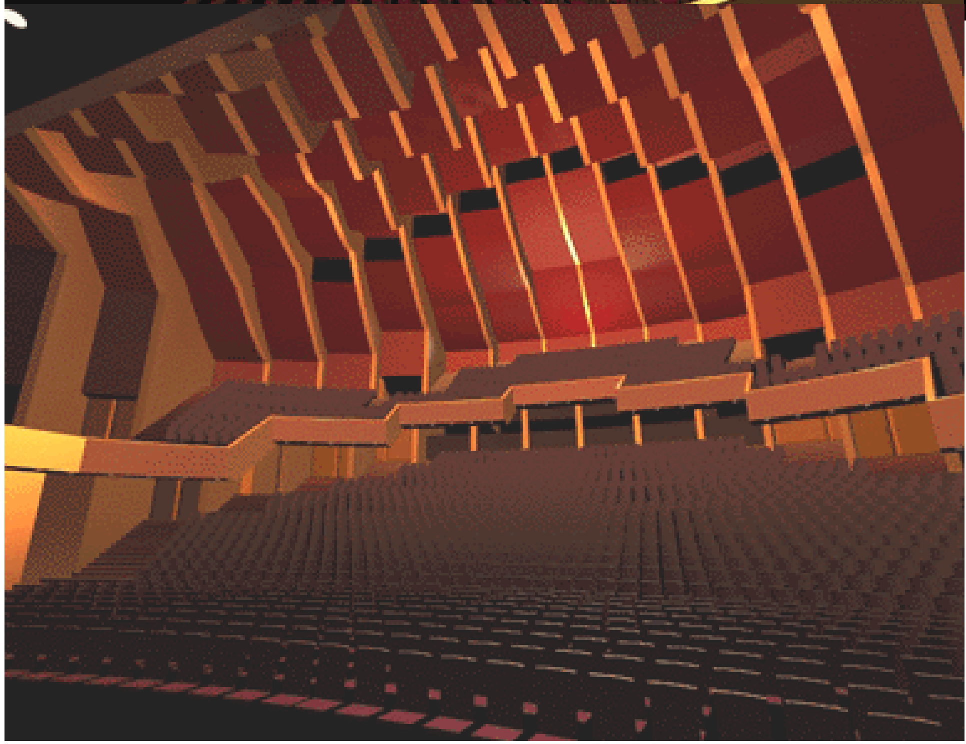
"Australia has the best opera house in the world – it's a pity the outside is in Sydney and the inside is in Melbourne"

RE: the unpopularity of the SOH interiors with arts administrators, performers, and stage crews

Utzon had, form the very beginning, envisioned timber as the primary finish material for the interiors with the warmth and color of timber providing a stark contrast with the heavy, monochrome concrete of the Podium and shell pedestals/ribs. The ceiling was to consist of a series of plywood box-beams radiating out from the stage and suspended at points from the concrete arches of the shells. Each box-beam was to be made up of two plywood box-beams bolted together (with acoustic insulation in the cavity within each beam). Spanning horizontally between the box beams was to be panels of plywood reinforced with hot-bonded aluminum. These horizontal elements were attached to the top of one beam and the bottom of the next creating a stepped form to the ceiling. On the top of these panels was to be bonded 2mm of lead (for low frequency sound insulation). The underside of the box-beam would be convex. The airtight boxes were to be transported to the site by barge and hoisted into position via the tower crane/s. The DPW's insistence on competitive bidding (when only *Symonds* was capable of producing the large sheets of plywood required) was, to say the least, problematic (they wanted Symonds to share their research with potential competitors). The fact that Symonds was in receivership (bankrupt) didn't help matters. Symonds had also developed a tubular plywood product that Utzon intended to use to support the glass end walls.



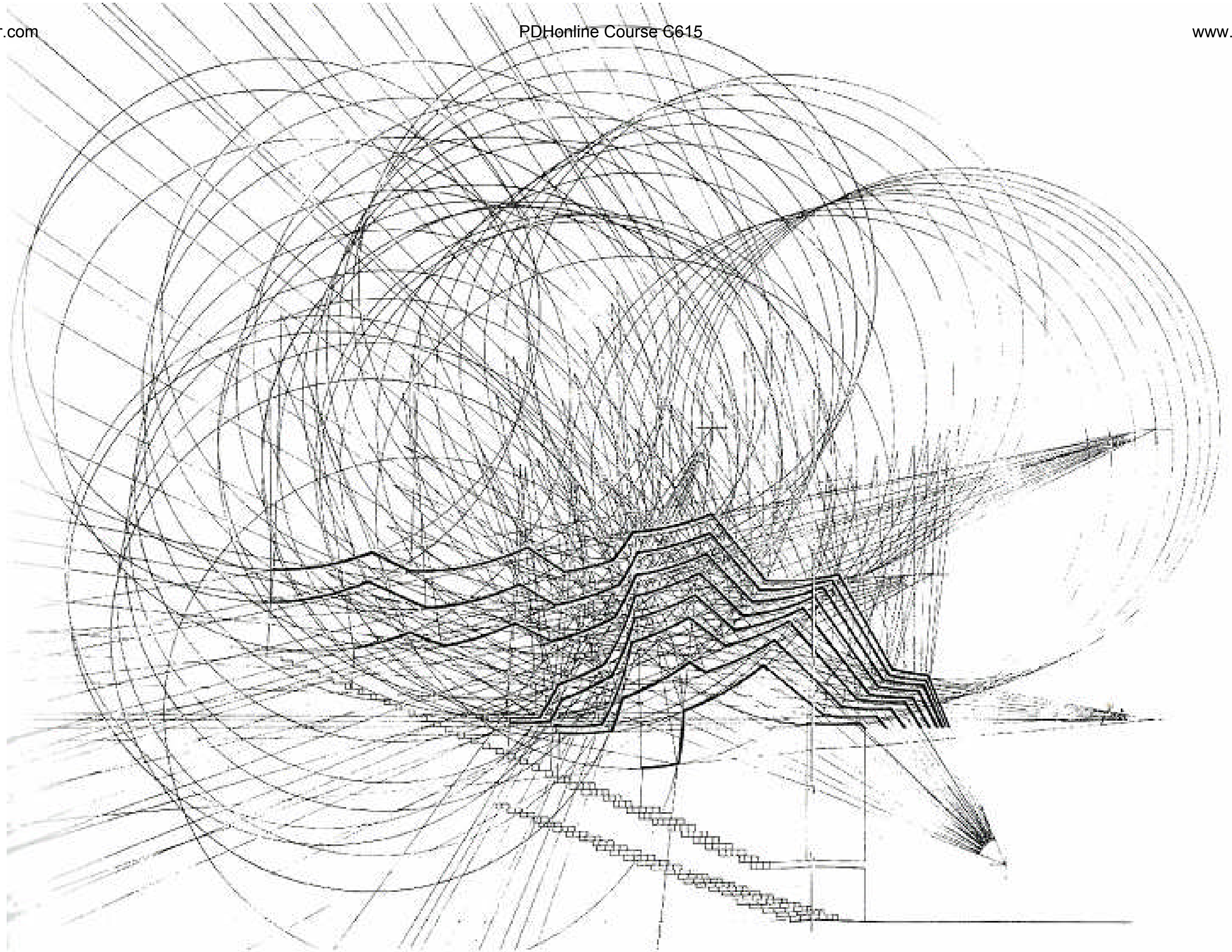




<u>Top Left</u>: **CAD image of Utzon's intended interior for the major hall**

<u>Top Right</u>: **CAD image of Utzon's intended ceiling detail for the major hall**

<u>Left</u>: **CAD image of Utzon's intended scheme for the acoustic paneling in the major hall.**

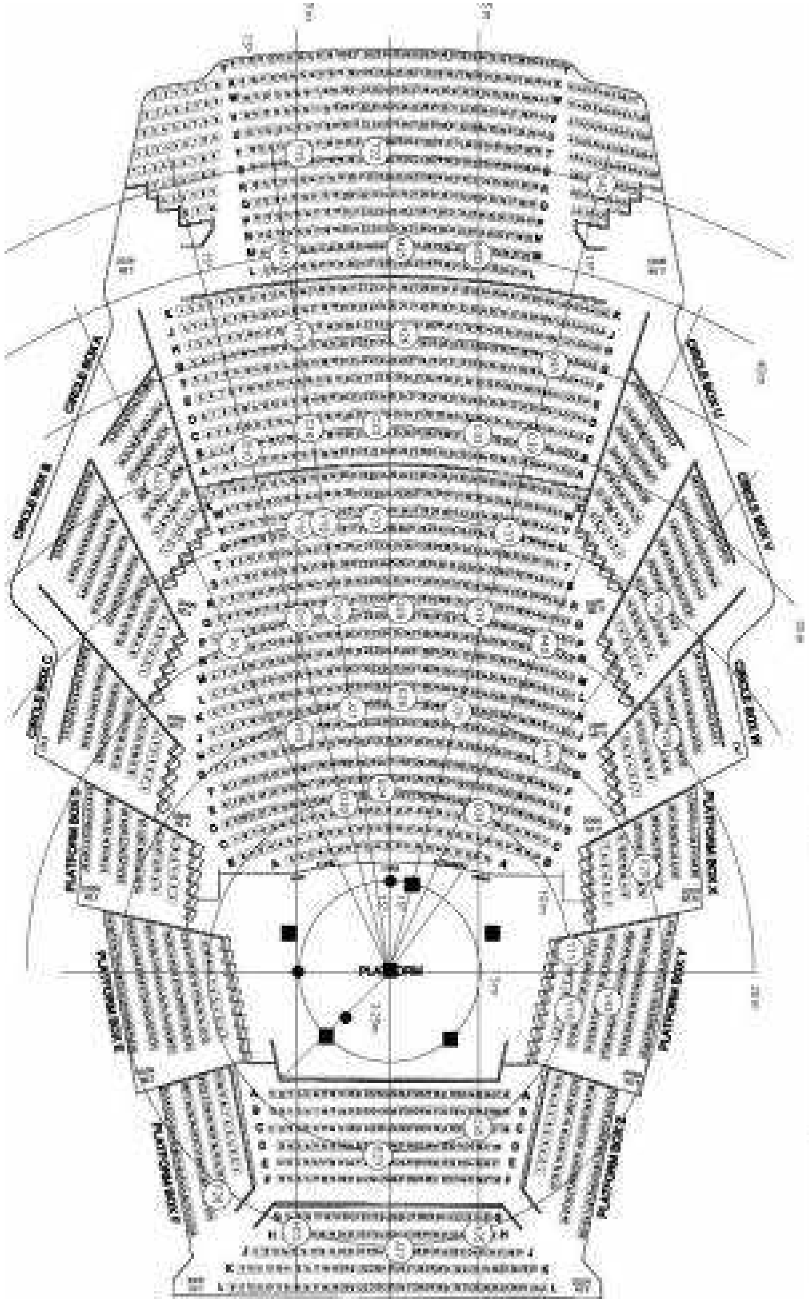


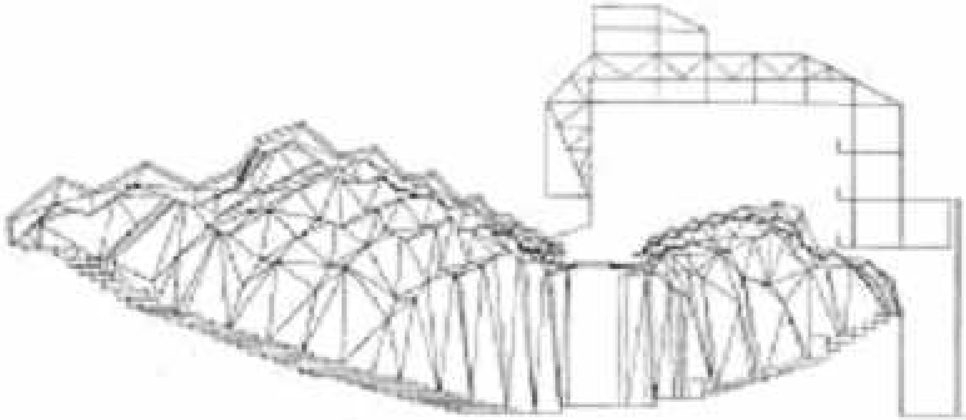
Major Hall: section demonstrating the geometrical principle (*Zodiac* No. 14, 1965)

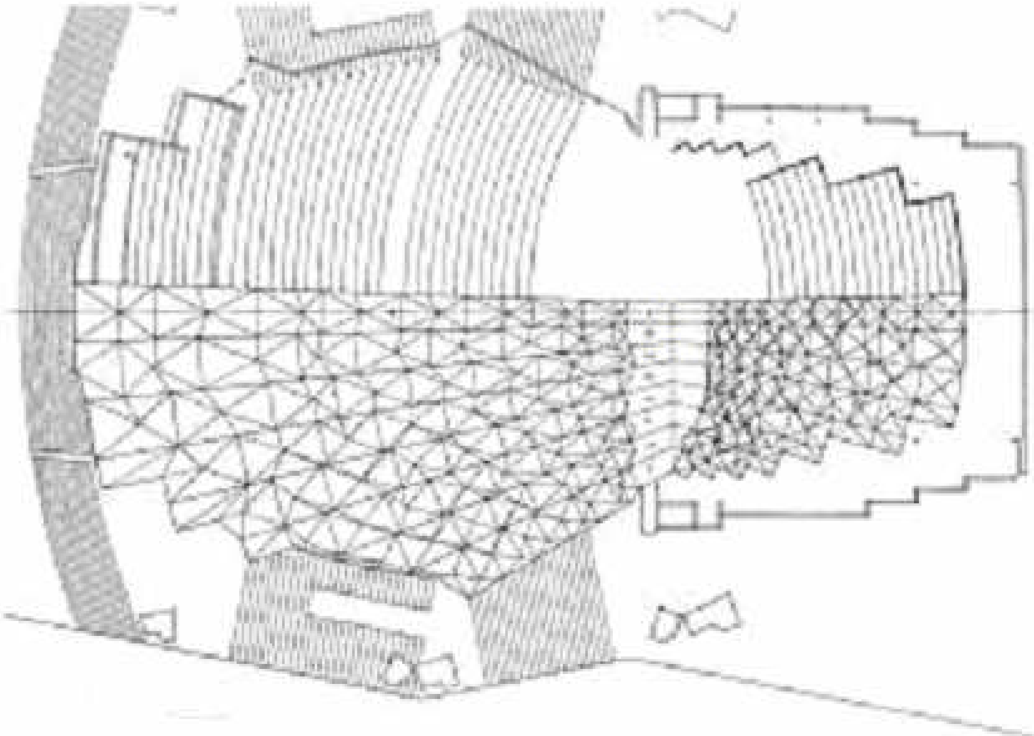
Utzon envisioned the performance hall ceilings akin to a cloud. This was to be expressed from the harbor-side (north) foyers where the waiting audience would be able to see over the banks of seating, into the gap between the top of the suspended plywood ceiling and the underside of the shell's concrete ribs. The ceiling was designed to be divisible into large, separate elements that could be constructed with services installed and finishes applied off-site then erected into position and secured. Historically, wood has been used for acoustic applications for many reasons. A wood surface does not just reflect sound, but also resonates slightly, giving it a particular "live" acoustic quality. A hard surface (such as concrete) reflects sound with a hard and sharp quality. Musicians are familiar with wood's sound characteristics since many of their instruments are made from wood so they are accustomed to the quality of the sound wood spaces create. As such, wood is well suited for the control of excessive echo and/or reverberation off of surfaces in performance and/or public spaces. A common practice is to clad walls an/or ceilings in lecture halls, performance spaces etc. with spaced wooden battens. This surface treatment breaks up the sound resulting in a reduction of echoes. Wood is a natural, variable material imparting its surface with life. However, too much variation; especially over large surfaces, is undesirable. Pale colors present a problem in achieving consistency. With darker colors, variation in tones is less noticeable.

"And I think when you look at the models of his interior you can see they have gold and red and all sorts of things. And the plywood like great waves, the beams, focus on the proscenium. And the combination of the lighting and the colours and everything else would have created I think an ambience, a magical ambience, that we can only dream of."

Elias Duek-Cohen, Author







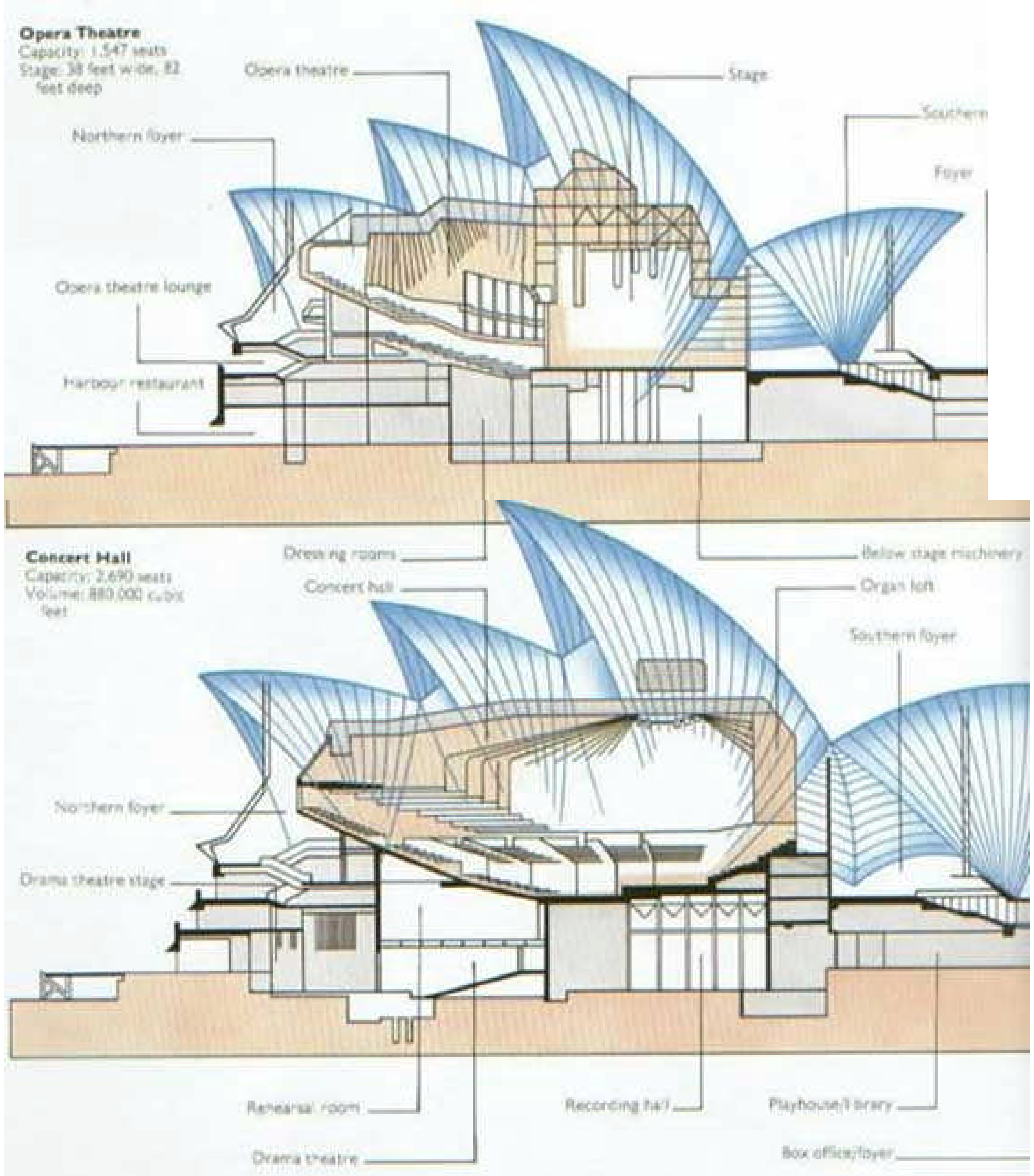
He Said, They Said

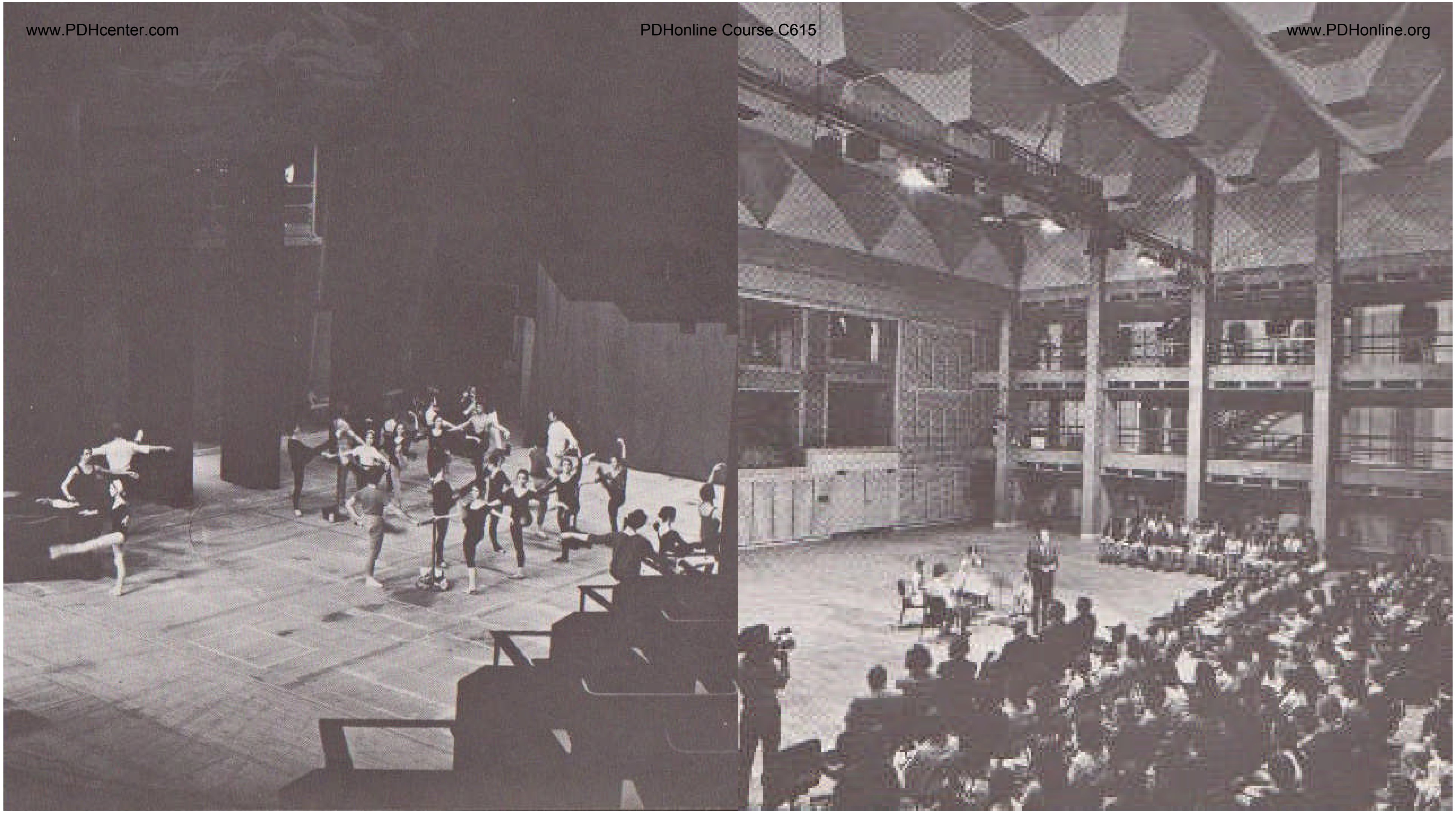
"…Even worse, one day the new architects discovered that the major hall, planned to hold 2,800 seats, in fact had room for only 1,800. Utzon's defenders claimed that the reduction in capacity had resulted from a change of mind by the opera house committee – an assertion denied by the committee. Nevertheless, the Sydney Symphony, intended to be the prime user of the house, was suddenly faced with the fact that it couldn't afford to play to such small audiences. Nor could the opera company. Then for good measure, Sydney's Chamber Orchestra group concluded that for many of its concerts maybe it couldn't profitably use the small hall meant for it in the new building either…"

***Life* Magazine, January 6th 1967**

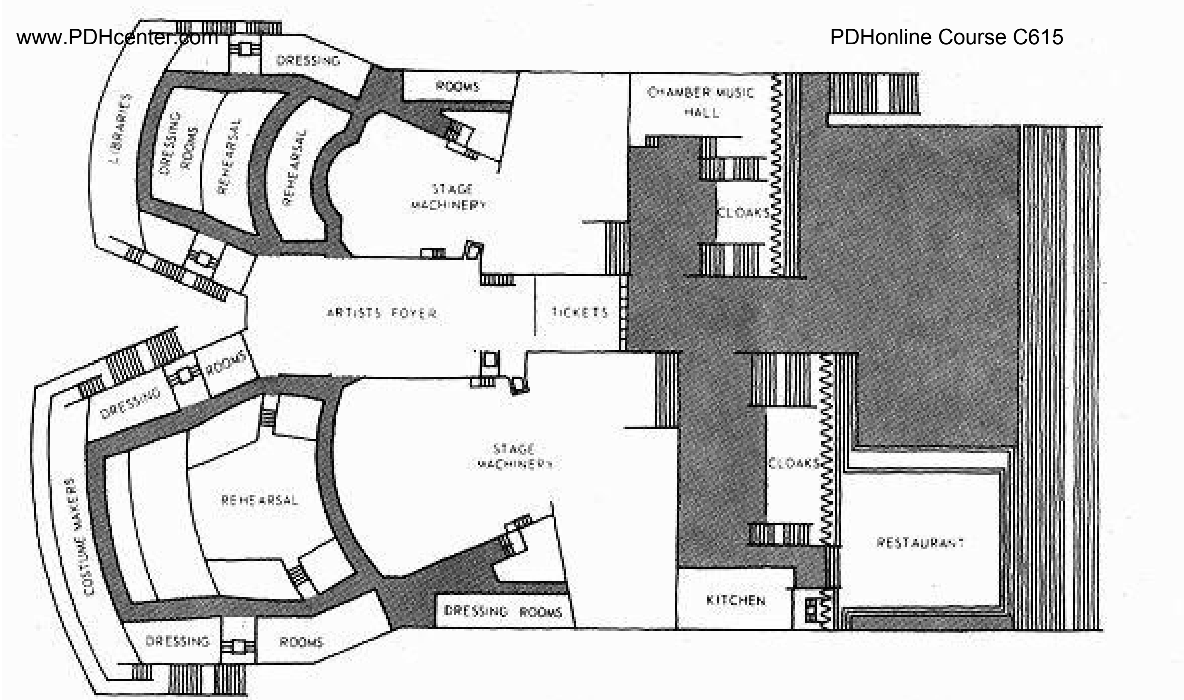
Despite the brief's requirement to design the major hall for a capacity of 2,800, Utzon informed *Professor Lothar Cremer* - his acoustical consultant, to use 2,000 in his calculations. In June 1966, ABC reiterated their requirement for seating 2,800 along with a reverberation time longer than Utzon had planned for. Also, they wanted a rehearsal room 3x the size Utzon included in his plans and a myriad of other changes the new team of Hall, Farmer and Littlemore had to satisfy. For six months they struggled with the problem and came up with the drastic solution of using the major hall for concert performances only. Now, without the need for scenery space (since there would be not operatic performances in the major hall), that freed space would be used for a rehearsal and broadcast/recording room and a small theater (for cinema and/or chamber music). The minor hall would now become the Opera Theater with a capacity of 1,500. Utzon's original design only allowed for 1,904 seats in the major hall for Opera, there would be a net gain in seating capacity all around;

- **<u>Major Hall</u>: from 1,904 to 2,800 seats**
- **<u>Minor Hall</u>: from 1,150 to 1,500 seats**
- **<u>Small Theater</u>: from 350 to 600-700 seats**
- **<u>Net Gain</u>: from 3,554 to 6,550 seats**

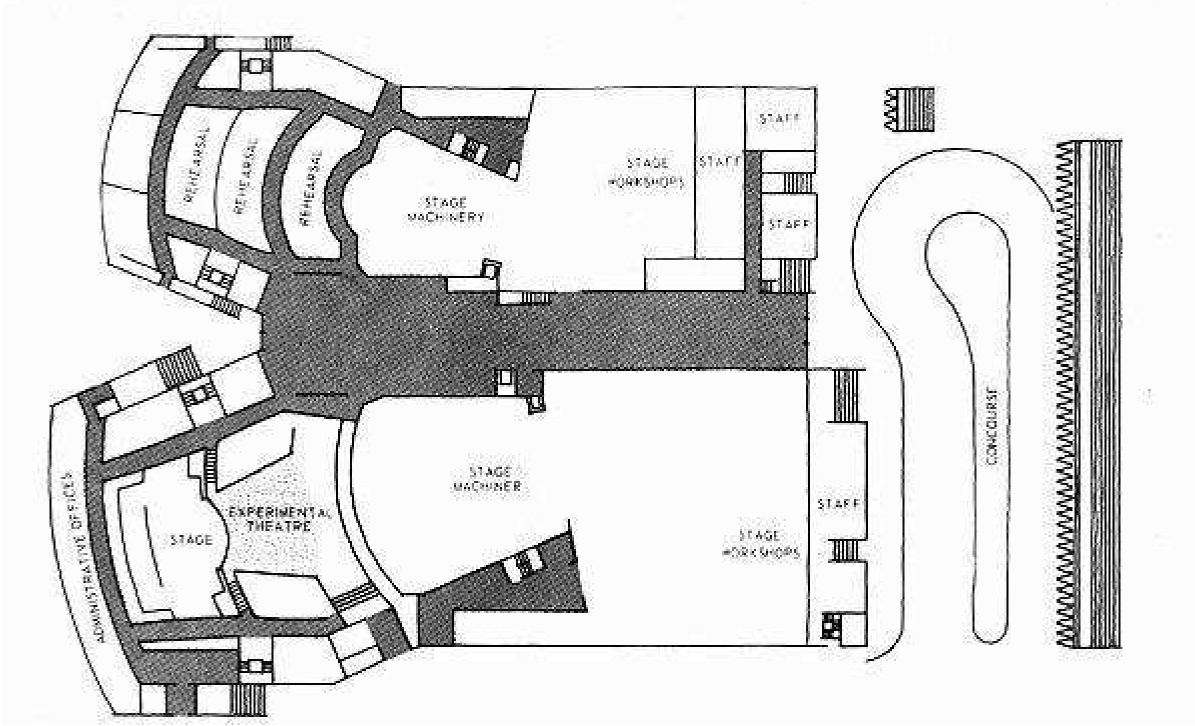

Opera Theatre
Capacity: 1,547 seats
Stage: 38 feet wide, 82 feet deep
Opera theatre
Stage
Southern
Foyer
Northern foyer
Opera theatre lounge
Harbour restaurant
Concert Hall
Capacity: 2,690 seats
Volume: 880,000 cubic feet
Dressing rooms
Below stage machinery
Concert hall
Organ loft
Southern foyer
Northern foyer
Drama theatre stage
Rehearsal room
Recording hall
Playhouse/library
Drama theatre
Box office/foyer



<u>Left</u>: Rehearsal Room, <u>Right</u>: Broadcast/Recording Room. Aside from the performance-related spaces (i.e. auditoria), the SOH complex holds many administrative offices, large and small rehearsal rooms and fifty dressing rooms. In all, there are over 900 rooms including the offices of the SOH Trust. The SOH attracts about two million visitors annually.



Lower Level



Concourse Level

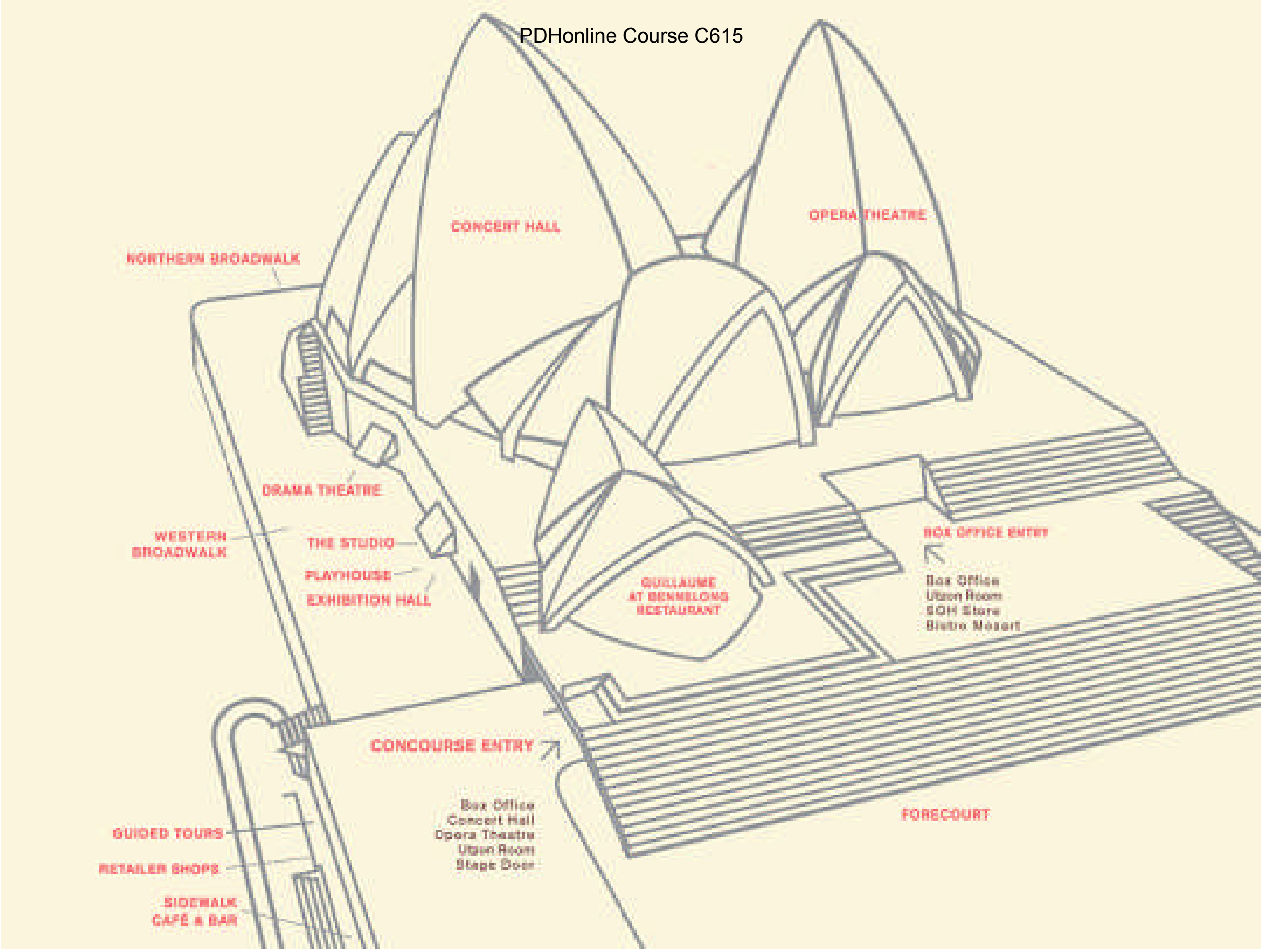
Playhouse

The SOH Trust Board Room

Concrete Camel

"…Most of the opera house's original supporters believe that everything will work out; and the opera house committee, having revised the seating capacity up to suitable levels, is still optimistic…In the meantime, work on the beautiful concrete camel goes ahead and the costs keep going up and no one can really figure out anything better to do than finish the thing and, beginning right now, grab any business that comes along. There is at least one organization whose faith in the project is unshaken, and it has made the first solid booking to use Sydney's monument to culture in October 1970: The International Dairy Congress."

***Life* Magazine, January 6th 1967**



<u>Above</u>: the entire SOH complex covers seven acres. Utzon was working with *Concrete Industries* (a subsidiary of *Monier*) to produce reconstituted granite facing with an even coloration for the Podium which would have given it the appearance of a homogenous rock. Like Symonds, they worked with Utzon under the assumption that they would get the job without competitive bidding since there was no like material.

<u>Above</u>: patrons of the SSO ascending the broad ceremonial steps (restaurant at left)
<u>Left</u>: SSO patrons ascending interior stairs

"We'll have a monument for centuries. When all these problems are resolved, everybody will be on the bandwagon."
SOHEC Chairman (ca. early 1967)

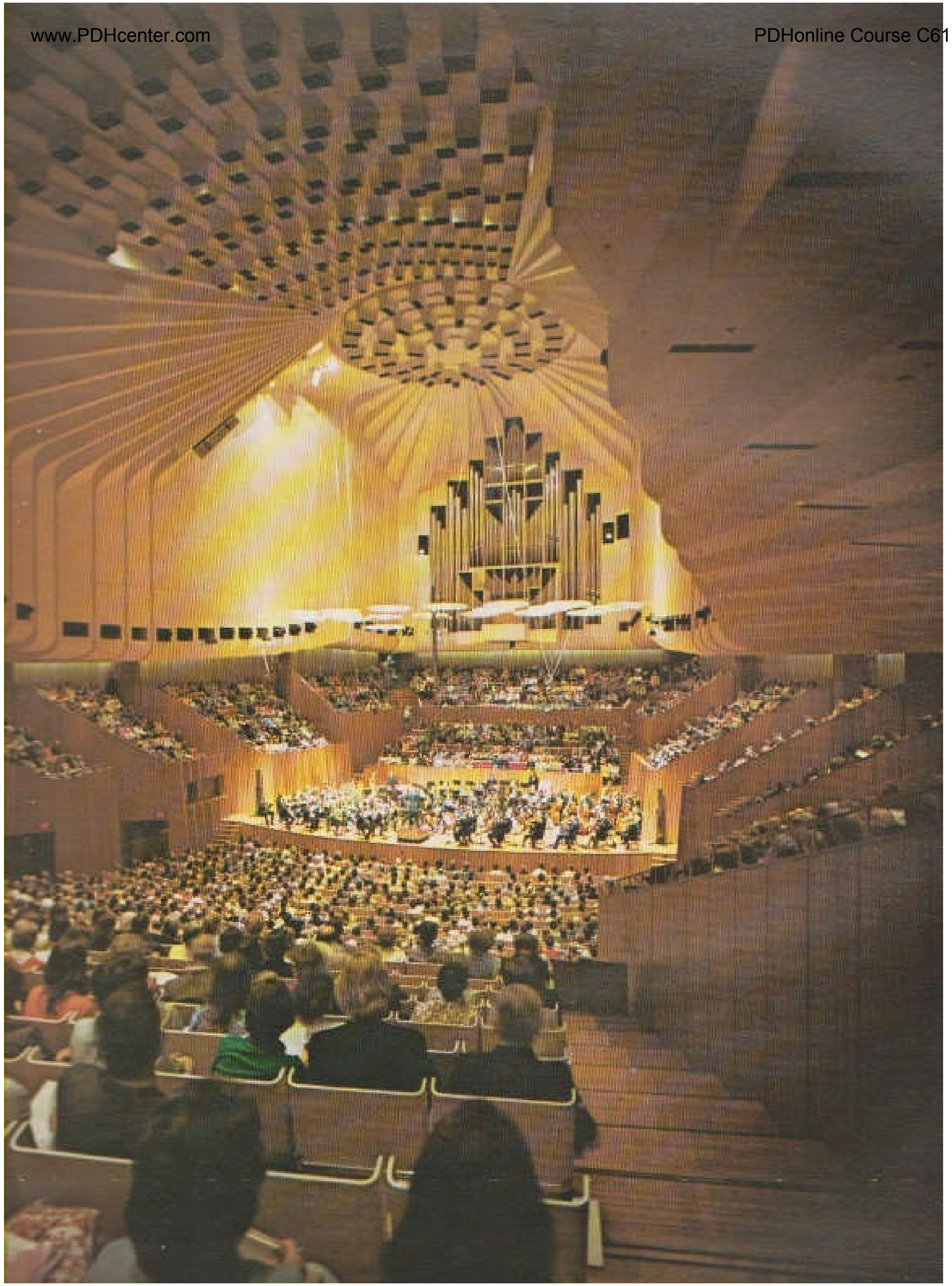
Beautiful or Not

"Beautiful or not, it was not in our language. It would have been a complete integrated project. Every part somewhere in the building would have been in family with whatever happens in another place."

Mogens Prip-Buus, Architect - Utzon's Office (1958-66)

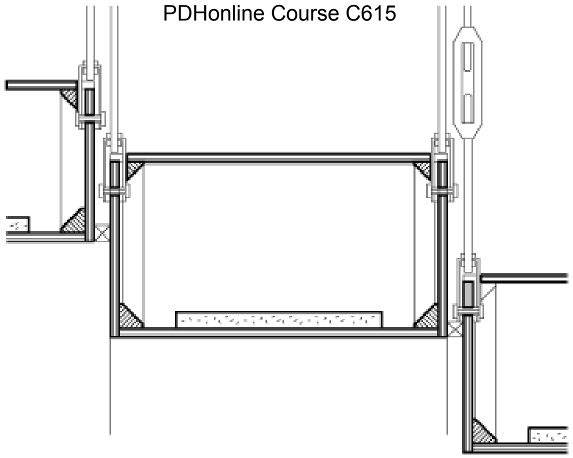
RE: Utzon was finalizing the design for the interiors of the building when he resigned in late February 1966. The partnership of Hall, Todd and Littlemore was commissioned to finish the interiors as part of Stage Three. A change in brief and a more conservative structural approach resulted in a different design than Utzon planned. However, the extensive wood interiors remained and provides an excellent example of the use of plywood and laminated hardwood in a public building.

A Wrenching Drop

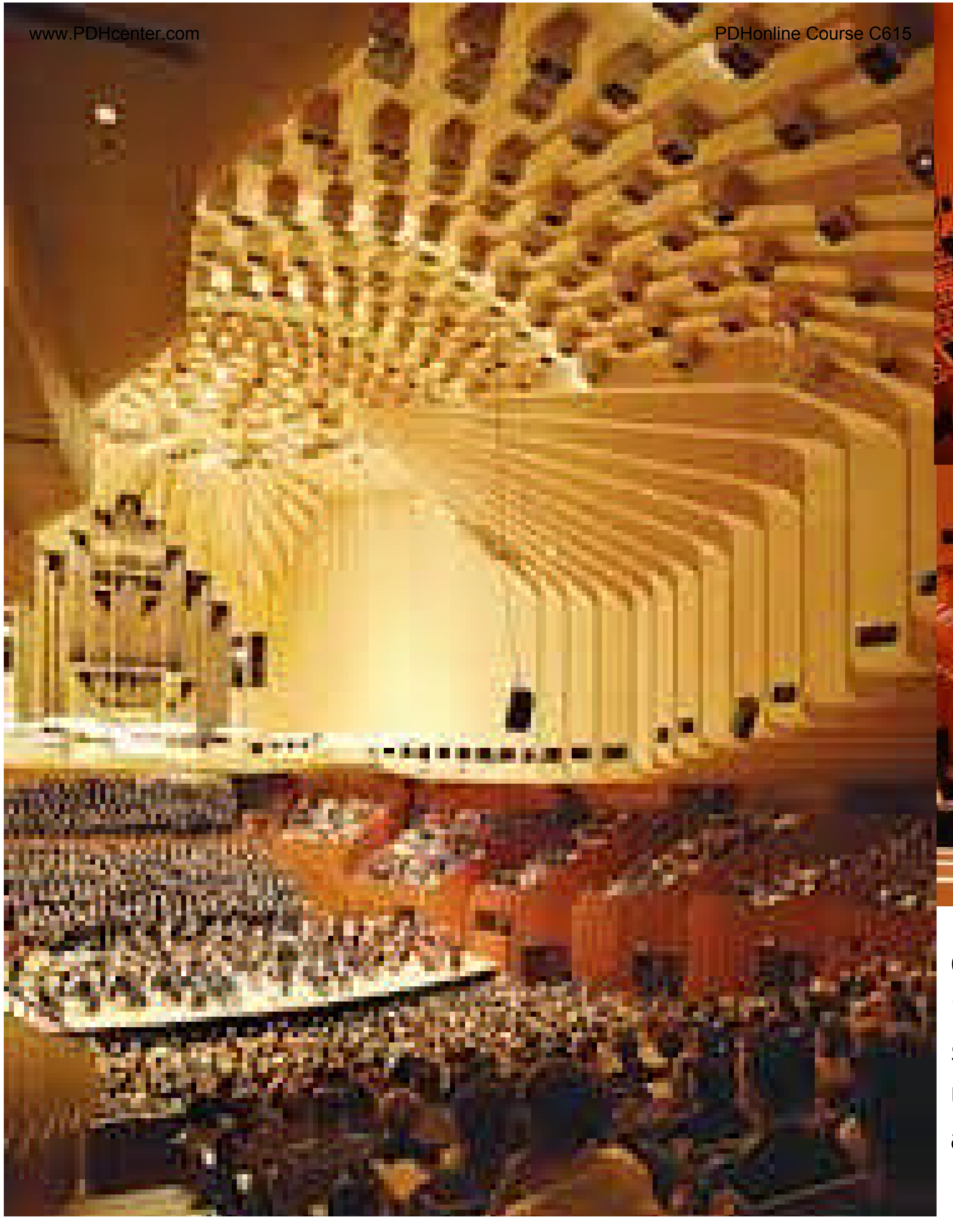


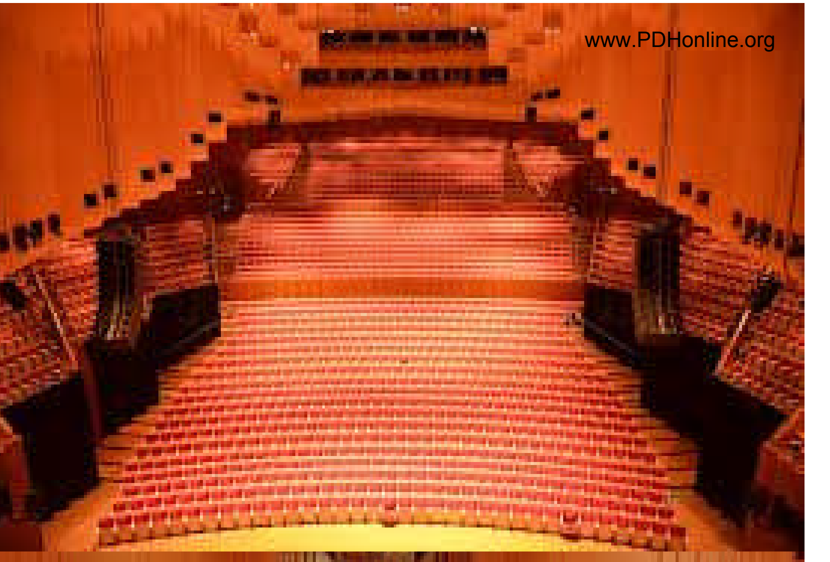
"…It would be unfair to call Hall's work on the Opera House a failure. But in aesthetic terms, the passage from Utzon's exterior to Hall's interior is a wrenching drop from poetry to grandiloquent decor. The main hall fulfills its function: its acoustics are good, and it seats 2,700 people. It lacks the frigid and pompous vulgarity of theaters like the Metropolitan Opera House at Lincoln Center or, worse still, Edward Durrell Stone's monstrous box of upholstered Mussolini at John F. Kennedy Center for the Performing Arts in Washington. But that is not saying a great deal…"

***Time* magazine,**
October 8th 1973

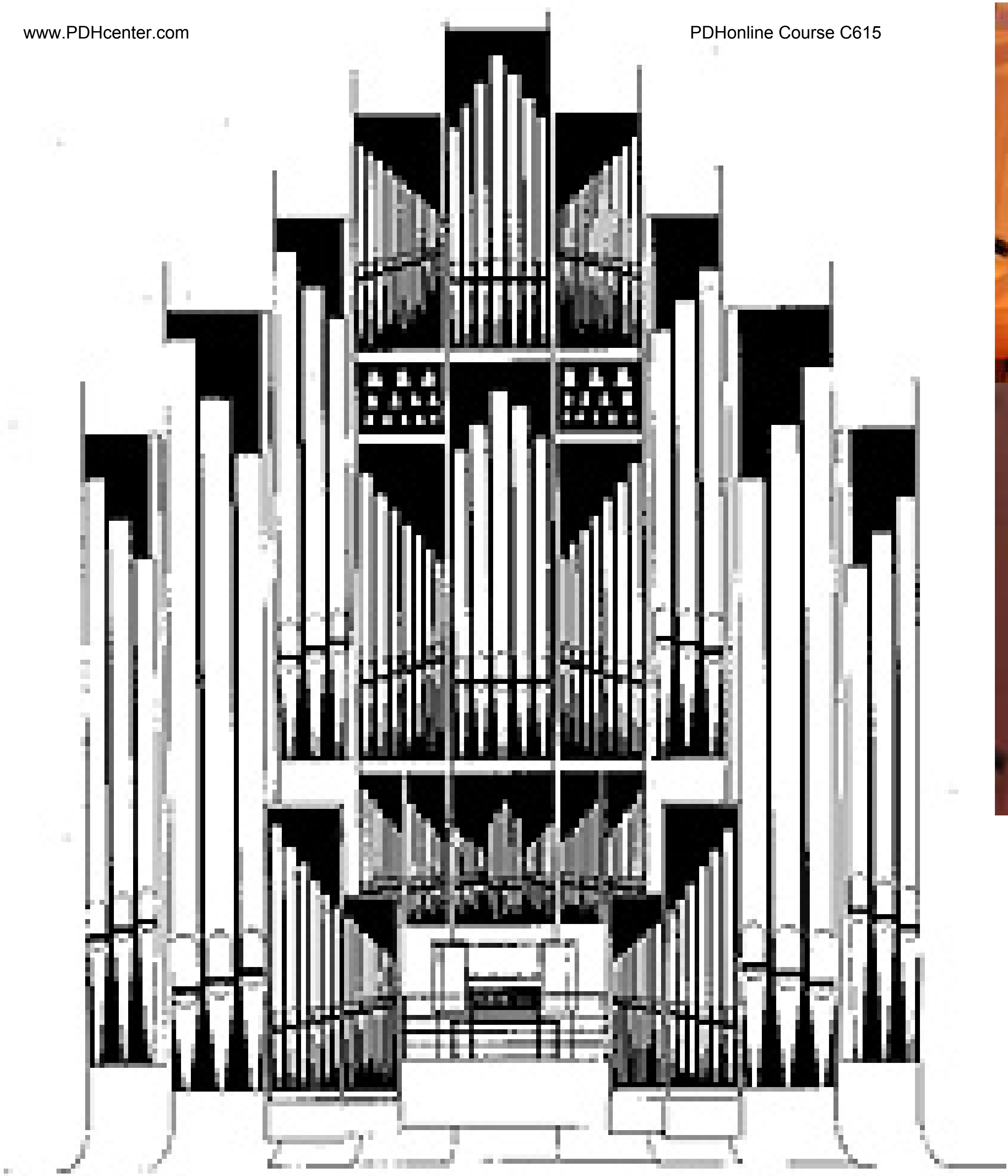


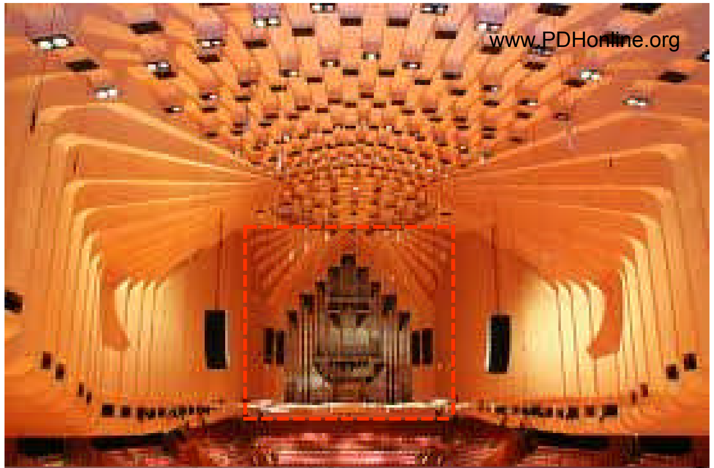
Both the Concert Hall and Opera Theater ceilings are constructed of *White Birch* plywood panels backed with acoustic plasterboard and suspended from steel *purlins*. The purlins in turn are suspended from arched steel trusses in between the shells and the ceiling. With the trusses picking up all the loads of the ceiling and distributing them to the side of the shells, the ceiling itself no longer has any structural elements like the plywood beams in Utzon's scheme. A crown of plywood dominates the ceiling of the Concert Hall (over the stage). Radiating out from this are a series of ribs that cascade down to their junction with the walls. The ceiling's complex geometry created many problems during its fabrication. The crown consisted of eighty separate sections of plywood; all of which had to be assembled to an accuracy of 0.8mm. To cut arcs with that kind of precision, long swinging arms were developed to carry the plywood accurately through band saws. At various points, curved cuts had to be made into already curved pieces of plywood. A computer was used to generate the dimensions for such cuts; a novel approach to solving the problem at the time.



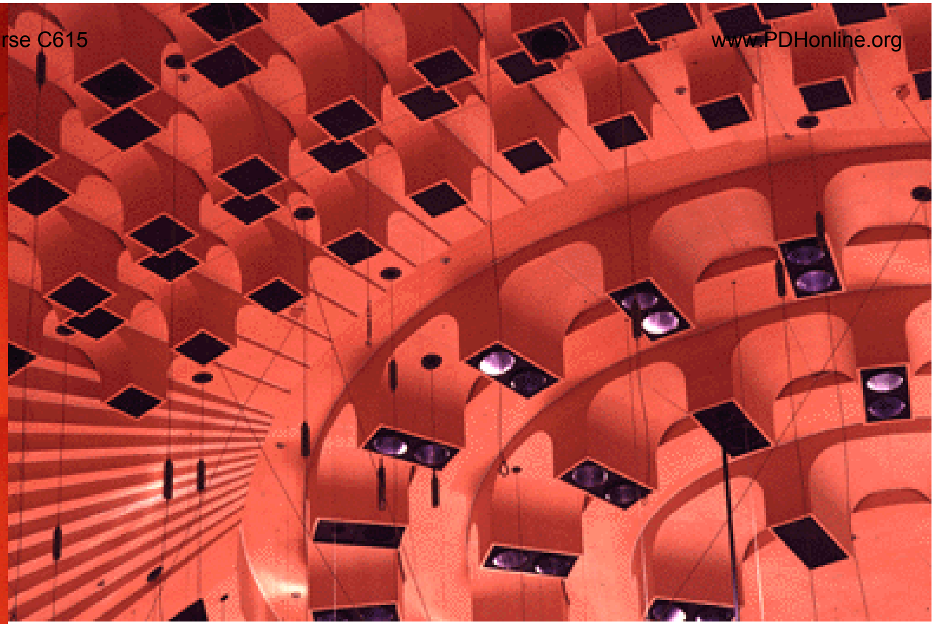


Concert Hall Interior views. The two performance halls (and other public spaces) are lined with panels made up of spaced Brush Box battens over a sound absorbing mat.





SOH's Grand Organ is the largest mechanical action organ in the world with over 10,500 pipes. It was completed on May 30th 1979.



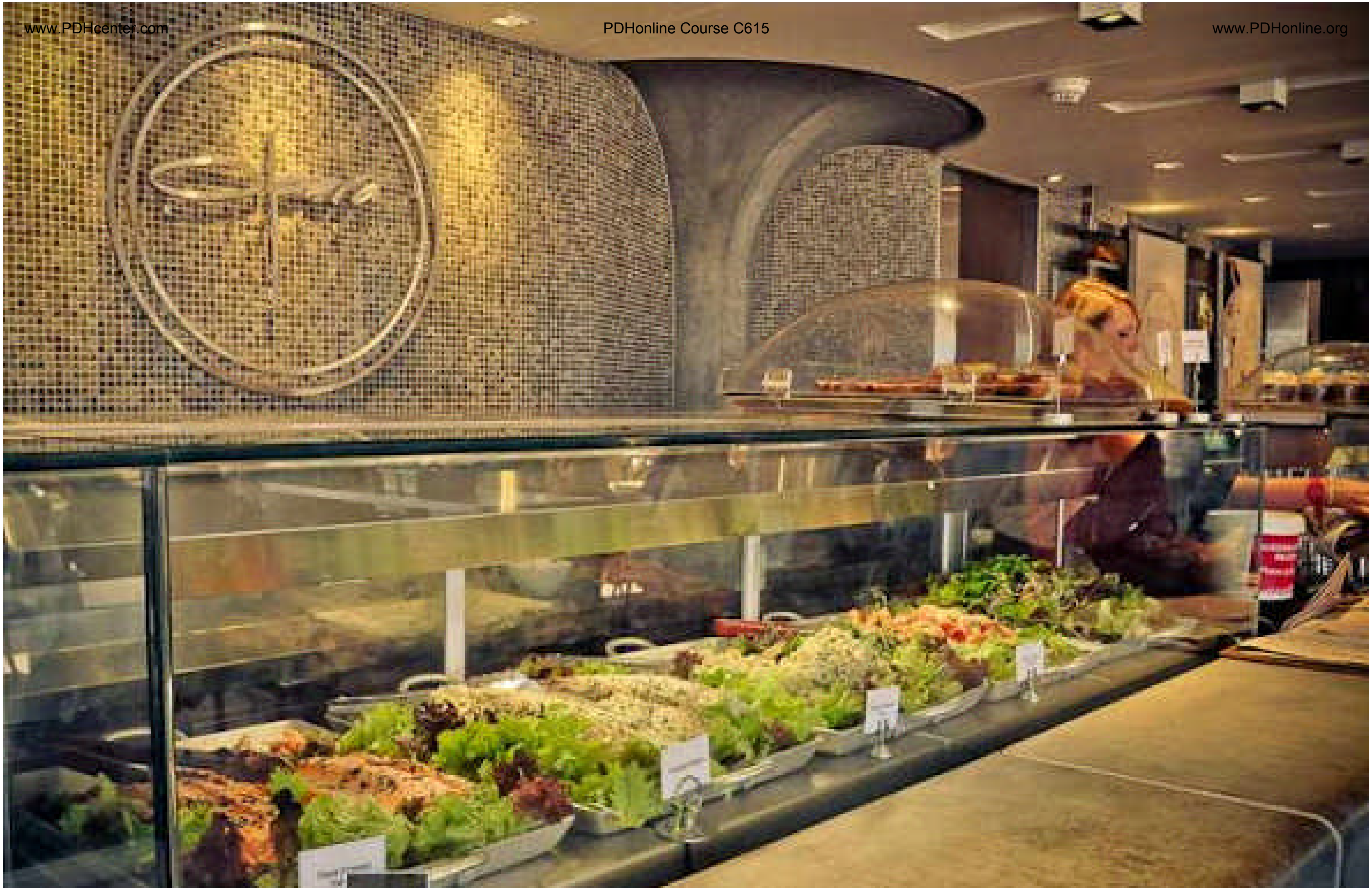
<u>Left</u>: detail of Concert Hall ceiling

<u>Above</u>: detail of the crown ceiling over the stage of the Concert Hall. The crown measures 40-feet in diameter and is suspended 80-feet above the stage and includes many integral light sources.

A consortium was formed consisting of *Philips of Holland* (Australian) and the *General Electric Company of Britain* to design, manufacture and supply both the interior and exterior lighting in all areas (except the stages). Known as *G.E.C. – Philips Opera House Lighting Company Ltd*., the project proved to be the largest and most complex ever undertaken in Australia up to that time. SOH featured an elaborate system of concealed lighting. The lighting plan's strategy was to light the approach areas in a very "low key." As patron's progressed towards the halls, the lighting intensity would 'build-up" highlighting features of "particular interest" and reaching a crescendo of light intensity in the auditoria. At night, the roof shells are softly floodlit accentuating the creamy-white coloration of the roof tiles. Around the Broadwalks, large glass spheres (on Bronze columns) give off a warm yellow glow reminiscent of gaslight. The wide treads of the Podium's ceremonial steps are lit by lamps recessed in the handrails and by the soft floodlighting reflecting off the shells. Careful consideration was also made so as not to impair the magnificent views through the glass end/side-walls from internal (artificial) light sources.

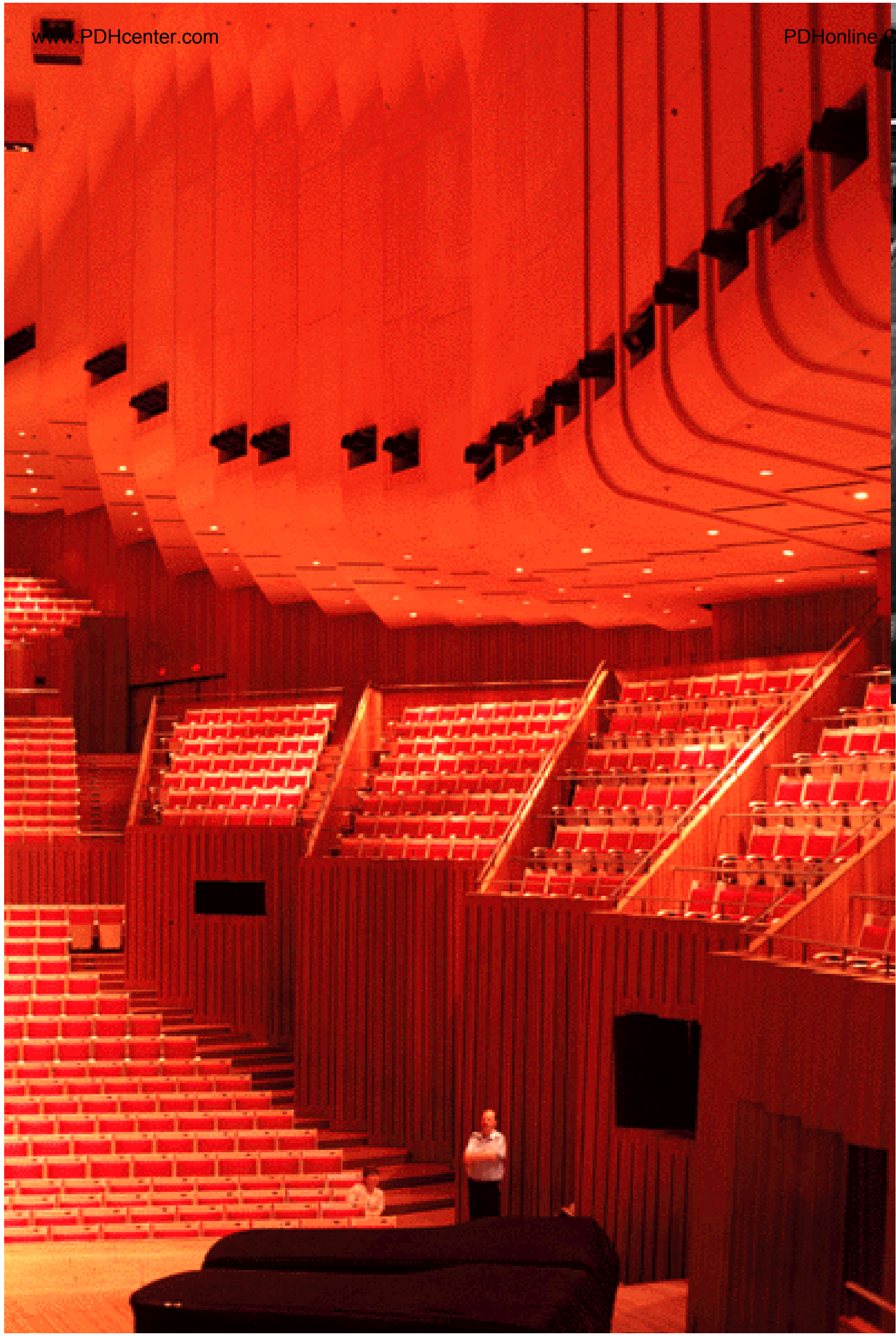
Closed circuit television was included in all three theaters (Concert, Opera and Drama) for the benefit of patrons arriving late (they must wait in the lounges until the end of an act before being admitted so as not to interrupt the performance). An internal communications system (including 350 extensions) allows two-way communication between levels, rooms and halls. In the major and minor halls, electronic translators (in five languages) provides instant translation, very similar to the translation system in the U.N. headquarters in New York City. In the Drama Theater, Cinema and Recital Room, three language translations were available. Some staging equipment was made in Australia, but most was fabricated by *Waagner Biro A.G*. of Vienna, Austria. The stage equipment arrived on-time but the shells were not ready to receive them thus they required expensive air-conditioned storage to prevent corrosion. Inevitably, the local media made much of this as another example of SOH wastefulness. An HVAC plant costing $A3.5 million allows for eight air changes per hour in the theaters and, in the kitchen, every two minutes. Two restaurants provide fine dining before and/or after a performance and for SOH visitors. On the Quay (west) side of the Podium, the main restaurant (originally known as "Bennelong Restaurant") is independent of the rest of the superstructure and includes three levels; upper and lower for meals and the main level includes a bar. Below the minor hall (overlooking the harbor) was the self-service *Harbour Restaurant* seating 150 (under cover) and up to 300 in the open. The foyers of the major and minor halls as well as the Music Room and Exhibition Hall included buffets serving food and beverages.


Restaurant
Concert Hall
Opera Theater

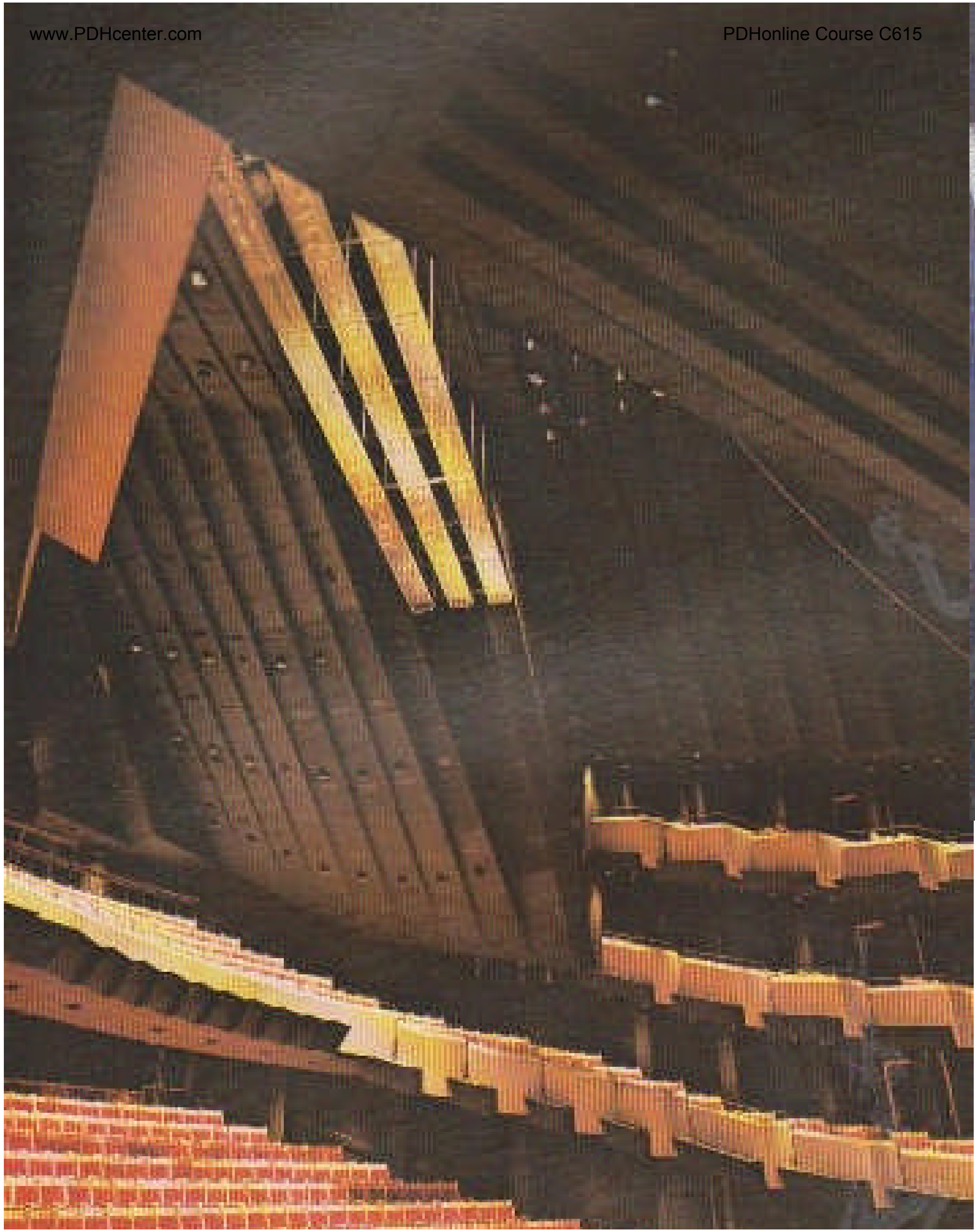


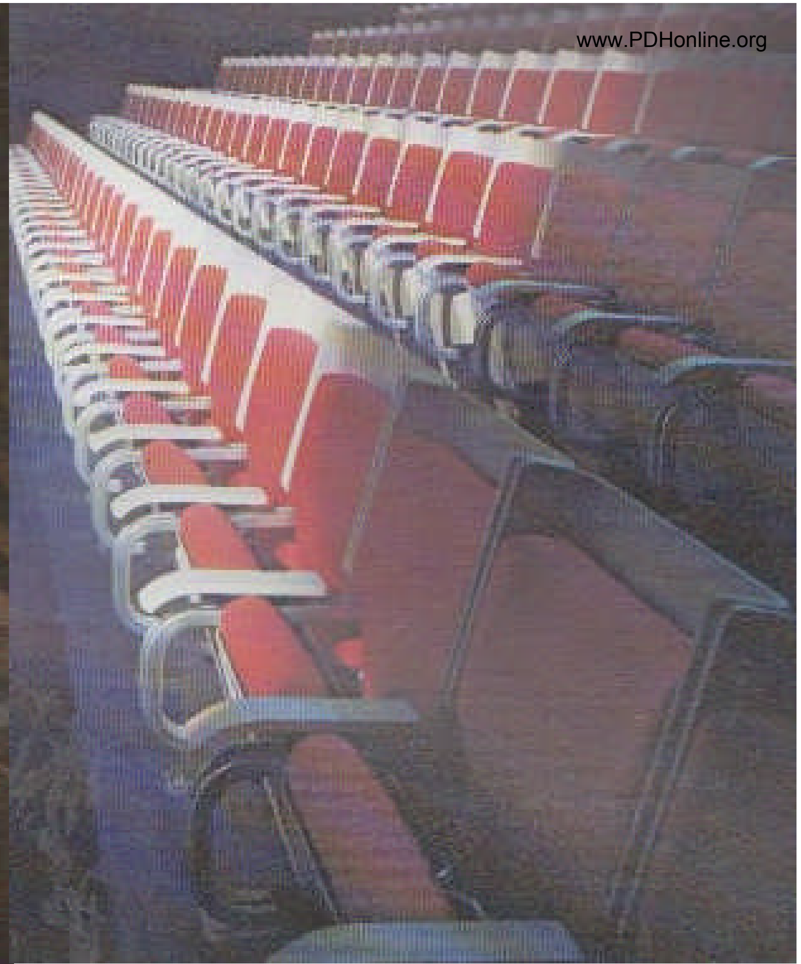
<u>Above</u>: the *Opera Kitchen* is located on the lower level of the SOH (next to *Opera Bar*) just below the Concourse

Opera Bar



<u>Left</u>: Concert Hall (as-built) showing Brush Box acoustic paneling and the multiple curves of the plywood ceiling
<u>Above</u>: Brush Box seating being installed

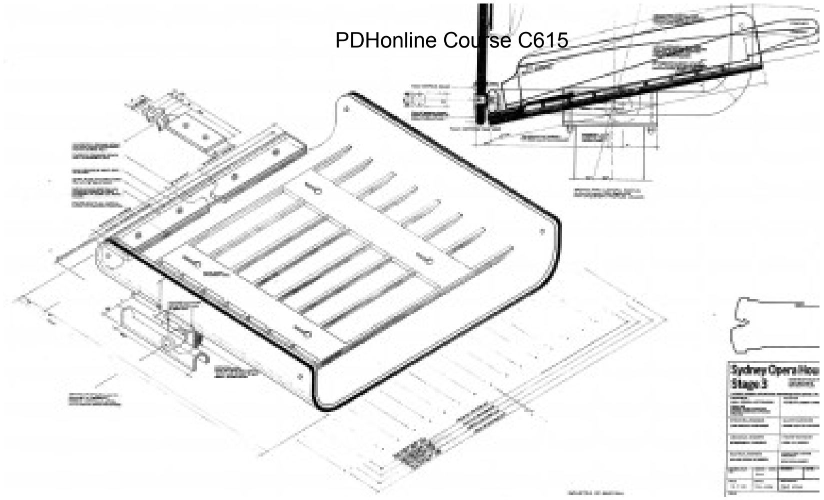




<u>Left</u>: vaulted ceiling of the major hall
<u>Above</u>: row upon row of vermillion red leather tiered seats and blue carpeting in the major hall

Best Seat in the Opera House

From the outset, the auditoria seating presented its own unique challenges. The chairs had to be comfortable (for a range of body types), provide good sightlines and adequate row spacing, have a silent tilt mechanism and be acoustically compatible with the interiors. Above all, from *Peter Hall's* perspective, all 2,800 seats for the Concert Hall had to be purpose-designed as an integral component of the auditoria aesthetics. During his first three-month study trip (in mid-1966), Hall not only sketched and recorded styles and dimensions of seating in the many auditoria he visited in Europe, North America and Japan, he even measured his seat on a flight from Boston to New York. Upon returning to Sydney, Hall approached *Davis Hughes* asking for additional funding to research and develop chair prototypes. The government insisted that readily-available proprietary seating was perfectly adequate, but Hall persisted and eventually prevailed. Preoccupied with other areas of the building, in late 1967 Hall delegated much of the responsibility for the development of the seating to interior designer *Diana Luxton.*



<u>Above</u>: working drawing by *Diana Luxton* for *Auditoria Seating Detail* (1970). **While Utzon had selected the materials to be used in the auditorium seating; plywood, steel and foam rubber, he had not left any drawings. One of Luxton's first tasks was to develop a range of alternative seating schemes. In April 1968, she produced three designs in formed plywood with options for either platform-pedestal or riser-bracketed steel supports and varying arm and backrest configurations. Not optional was the acoustic requirement of a minimum of four inches of exposed plywood above the back upholstery cushion (to minimize the difference between the sound absorption of an occupied and unoccupied seat). Functional, smart and modern (but not very ergonomic), Luxton's design schemes were referred to by her (in a contemporary newspaper interview) as: "progressive, especially for Australia." Modern too was the adventurous choice of bright "magenta purple" wool for the Concert Hall seating upholstery. While the chairs were to evolve through several design phases over the next two years, the typically late 1960s choice of color was to remain and is still in use today.**

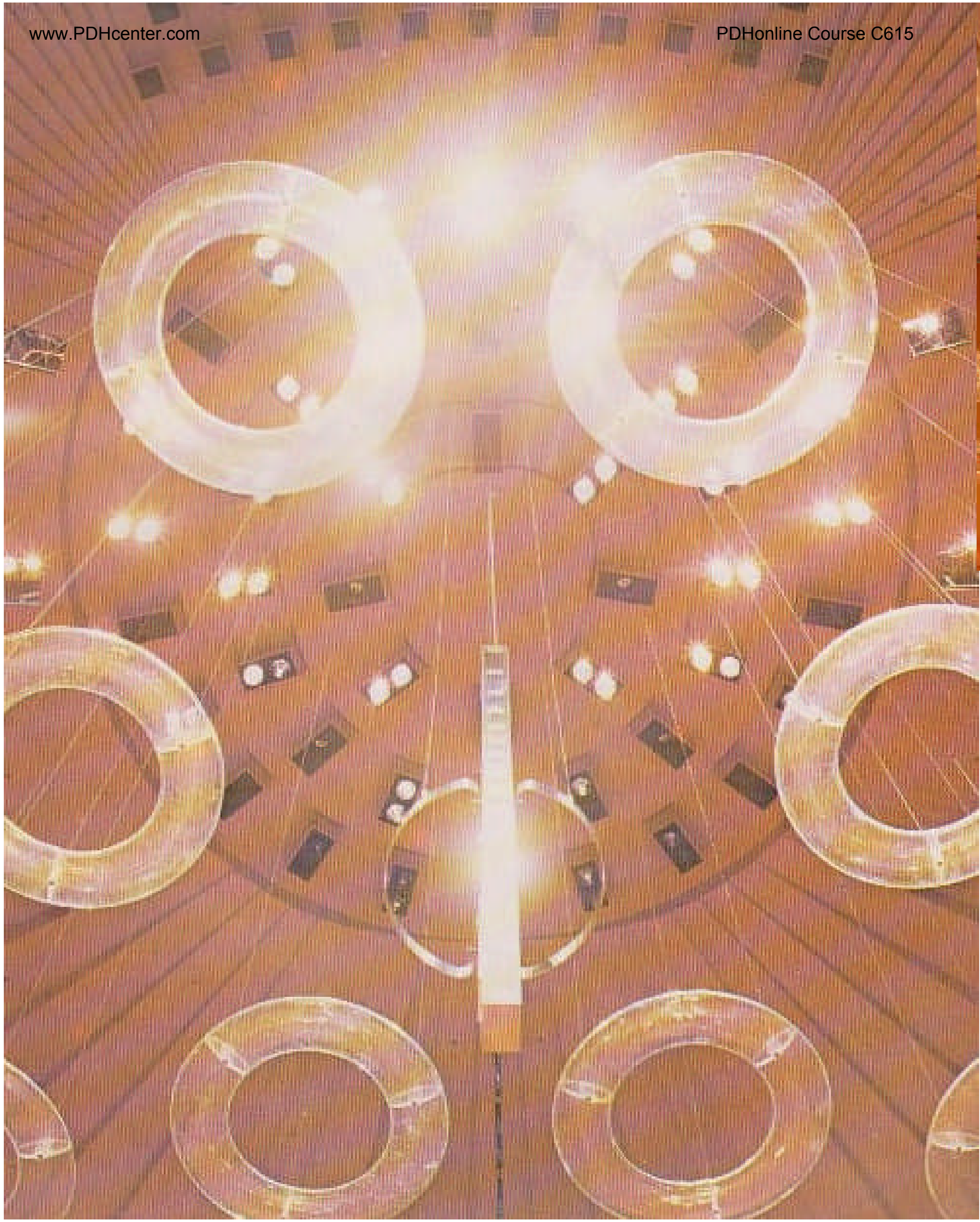
With the design of the seating underway. the choice of manufacturer to produce models and prototypes and develop the all-important tilt mechanism remained a significant decision. Skeptical that Australian manufacturers had the necessary skills and/or experience, Hall began working with the *Canadian Seating Company* in Toronto. Alarmed at the company's expenditure estimates and frustrated by their inconsistent communication during 1969, Hall turned to a Sydney company: *Coordinated Design & Supply*. It proved to be a productive collaboration through the testing of several prototypes to the manufacture of components for 4,981 chairs required for the four SOH theatres. The final design; with its Australian White Birch plywood seat and back curved around upholstered polyurethane-foam cushions, was reminiscent of the classic *Charles Eames* lounge chair and ottoman of 1956. When their cost ($A1.2 million) was announced to the media in early 1971, there was a predictable public outcry. the chairs were launched to much fanfare in late 1971. When installation in the auditoria was complete (just over a year later) the arrangement of the seating in continuous arcs of "continental" aisle-free rows was both visually effective and spatially efficient. Refurbished in the 1990s, the auditoria seats continue to look stylish and their hydraulic tilt mechanisms still function well.

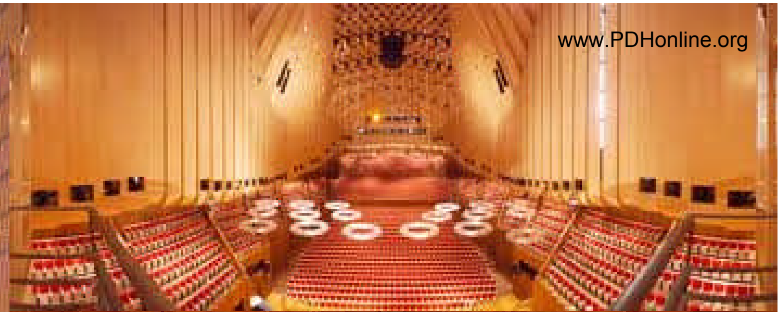
<u>Left</u>: media launch of the auditoria chair (December 1971). One useful design feature rarely used by audiences is the 'perching' edge created when the seats are upright. Intended to provide more comfortable access along seating rows, the feature was a response to the space constraints imposed by the seating requirements. Despite these constraints, Hall and his team did manage to achieve row to row distances equivalent to those of the "spacious" Boeing seats Hall so diligently measured.

Underfoot

To ensure the carpeting would maintain its appearance under heavy wear, Australian wools were mixed with British wools in a blend similar to the weave for the carpet used for Queen Elizabeth II's Coronation in 1953. Australian wools are too fine and soft to standup to the type of wear expected thus the hybrid blend using British crossbred and mountain sheep ensured both beauty and wear-resistance.

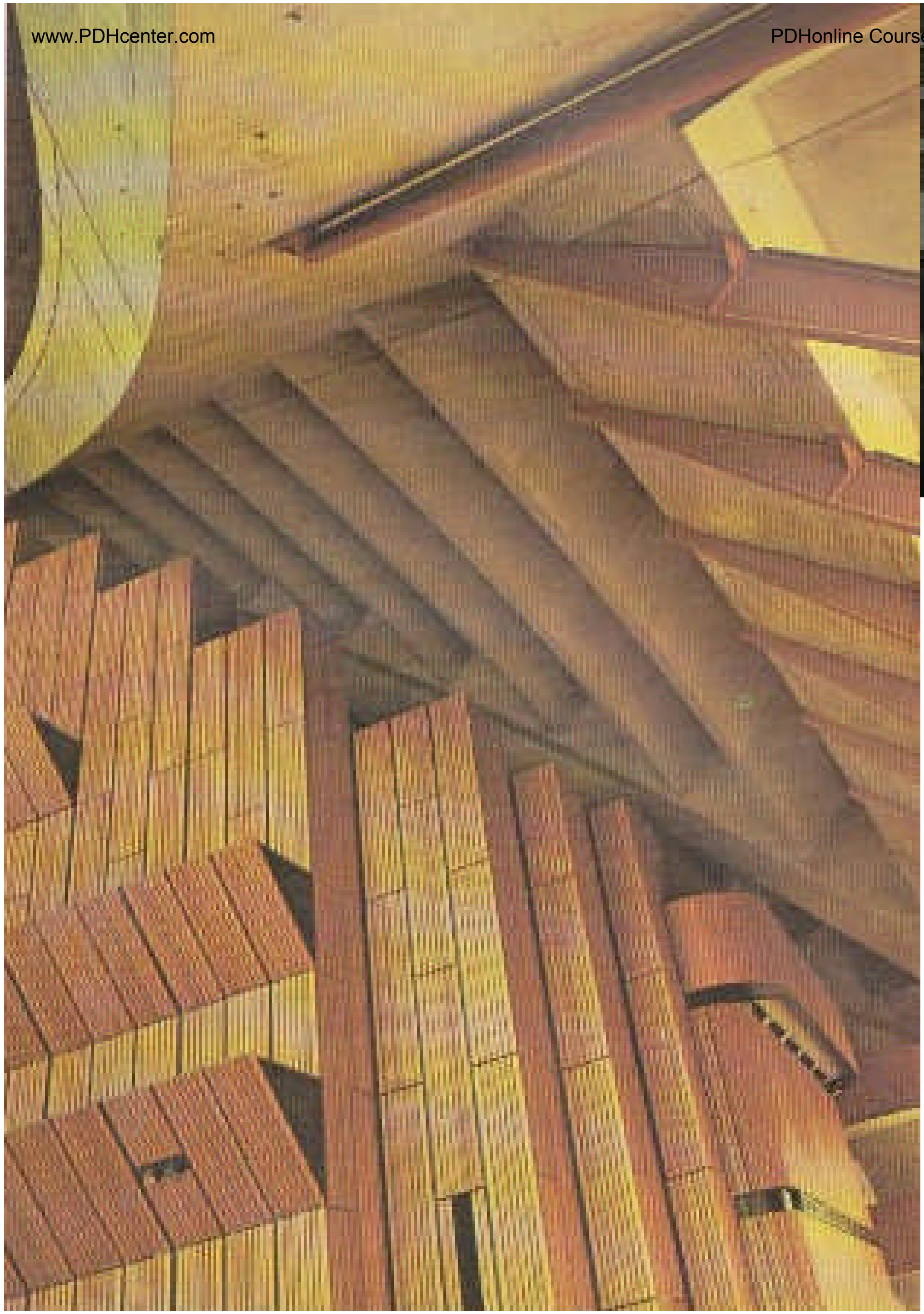
Doughnuts

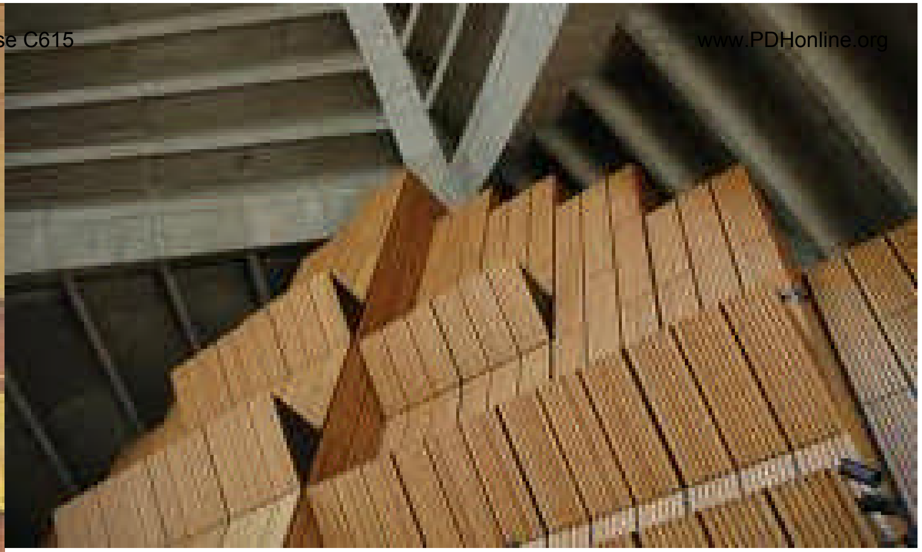




Adjustable acoustical "clouds" suspended above the Concert Hall platform. The Concert Hall has a very high roof, leading to a lack of early reflections on-stage. *Perspex* rings ("acoustic clouds") hanging over the stage were added shortly before the opening of SOH in an unsuccessful attempt to address the problem. The main hall was attuned to the sound frequency of operatic singing, with a reverberation time of 1.4s.

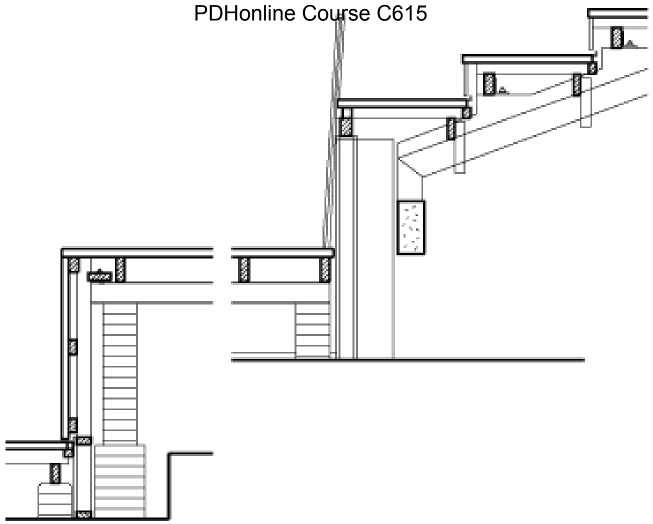
Visually Meaningless Joinery





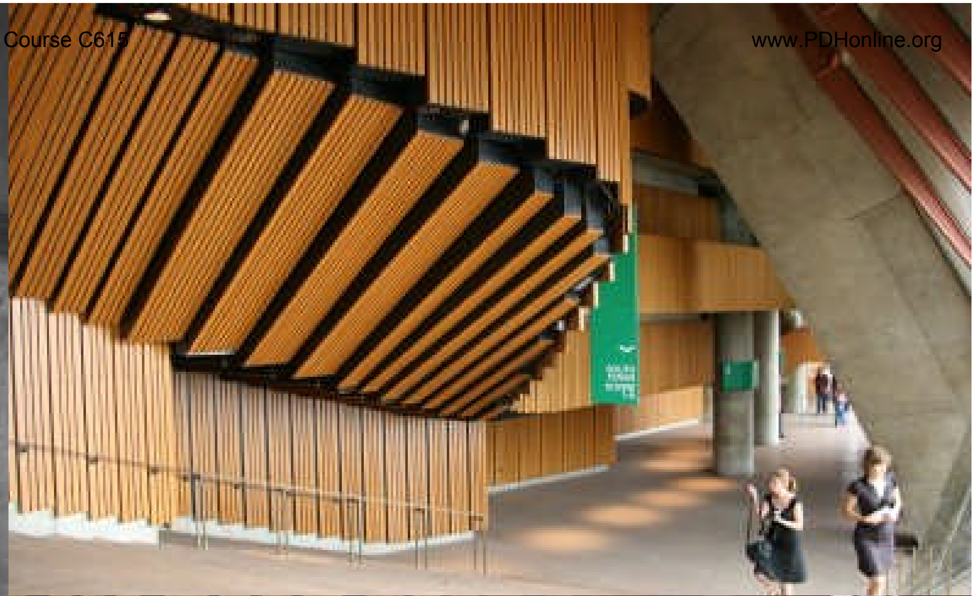
The design, with its pleats of white birch, hanging plastic doughnuts and faired-in lights is weirdly Art Deco: it could be the set for a lavish Buck Rogers movie from the '30s…The huge tapestry curtains woven at Aubusson to designs by Australian artist John Coburn are soggy pastiches of Matisse's paper cut-outs. In the foyers, no effort to mask and confuse the nobly strict curves of the roof ribs has been spared: one is met by a jumble of well-made but visually meaningless joinery, as if some gnome from the stingyback forests had gone berserk promoting the rarer Australian hardwoods…"

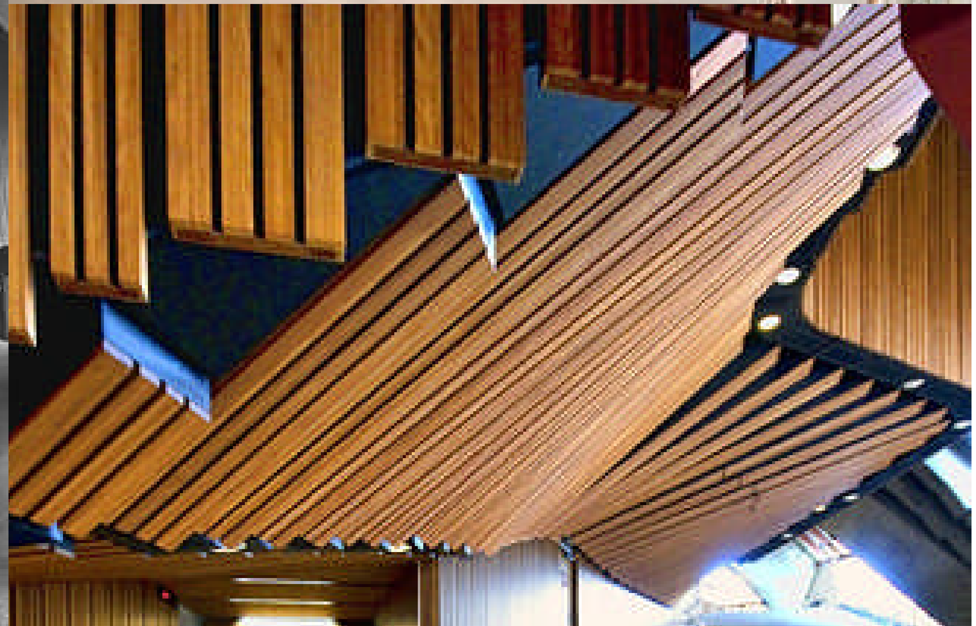
Time **magazine, October 8th 1973**



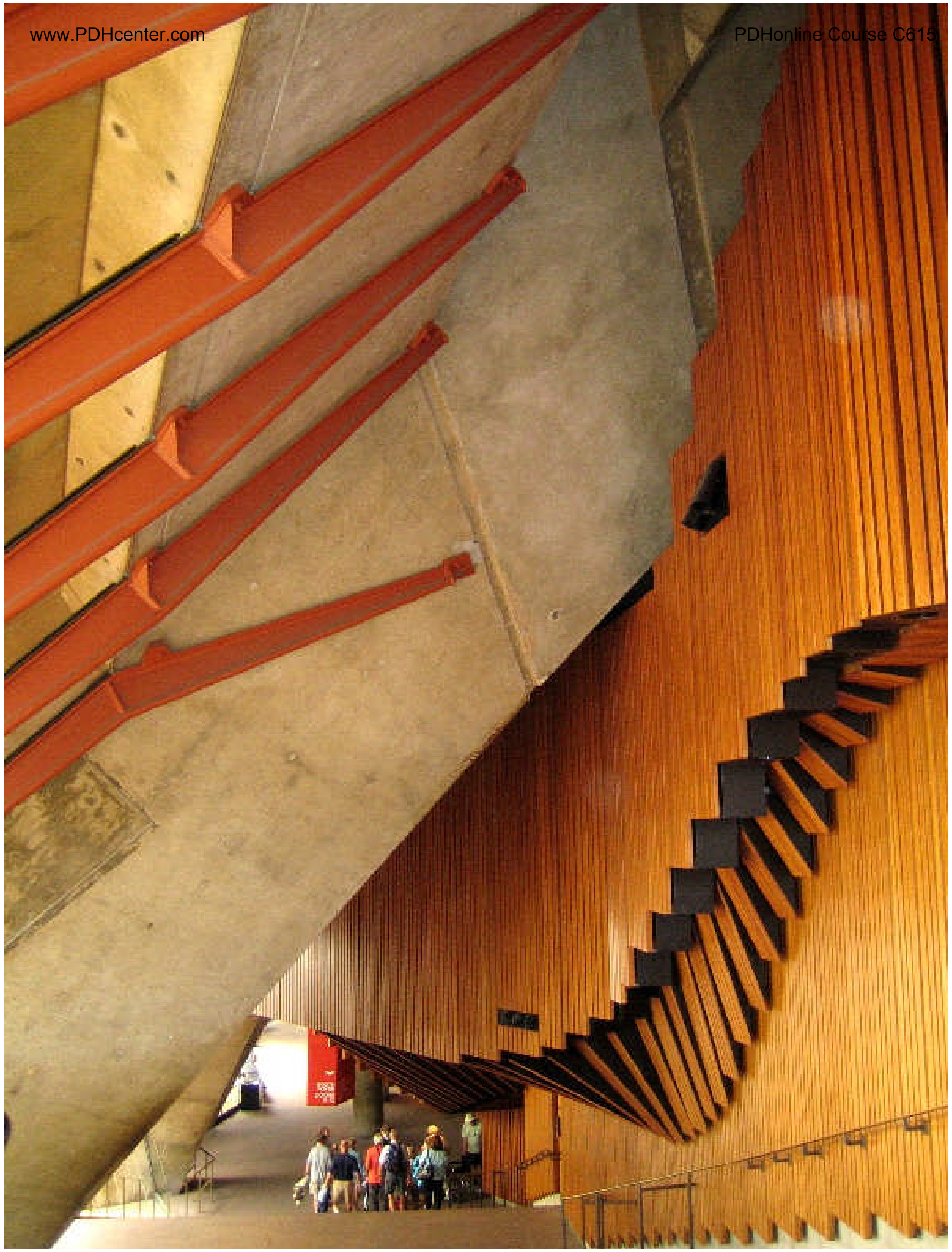
Following Utzon's lead, the new architects chose wood as the main material for the interiors. For the wood finishes to the floors and walls, Hall faithfully followed Utzon's scheme. However, for the ceiling of the performance halls (though still using plywood), the design took on a significantly different path. Throughout the interiors, prefabricated panels of laminated *Brush Box* were used for flooring, stair treads and risers and wall panels. An extremely hard and dense wood species native to Australia, Brush Box was chosen for its warm, rich color and grain pattern, acoustic performance and high durability. Made up of 38mm wide kiln-dried strips of wood glue-laminated together, each panel used in the SOH was around 1200mm wide and varied in length depending on application. The flooring and tread panels were 51mm thick and fastened to timber joists. The wall panels were 19mm thick and fastened to steel channels. Smaller panels of laminated Brush Box were also used for balustrades, parapets, and handrails.

Foyer space wood (timber) paneling





“Top-Hinged” wood paneling in corridors and stairs



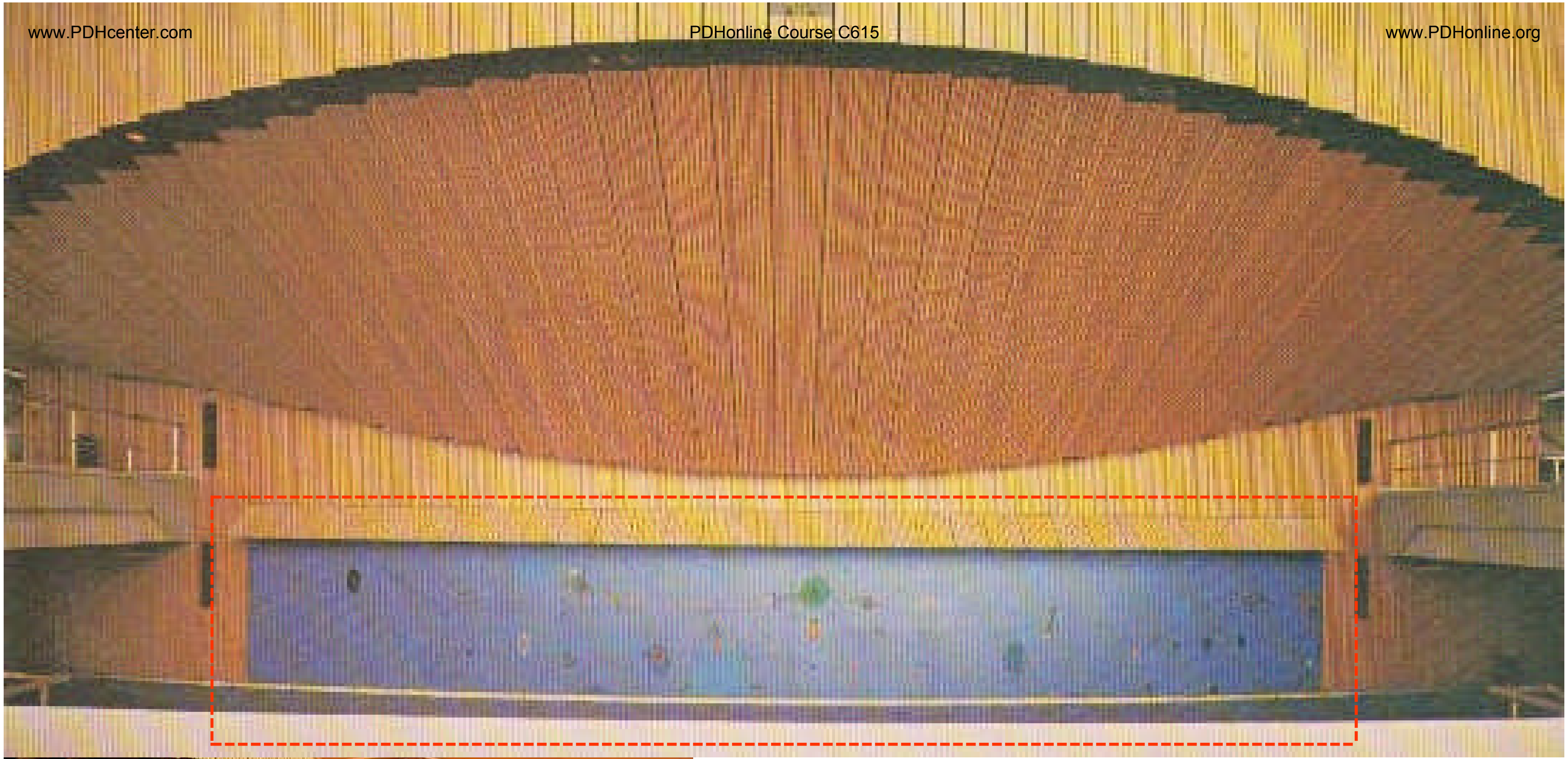
Hall and his partners set up a very rigid quality control system originating from where the lumber was milled. The White Birch plywood used for the Concert Hall ceiling was graded against control samples three times;

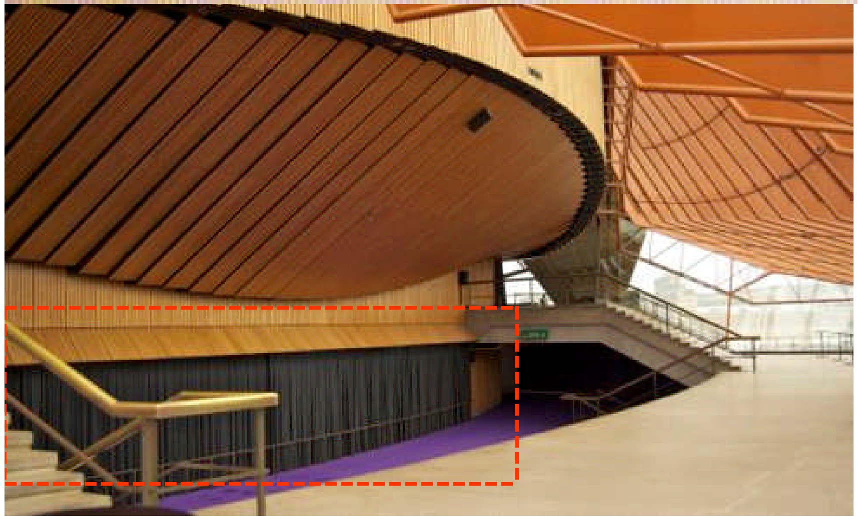
1) when it was cut at the mill;

2) as it was received at the plywood plant;

3) when the laid-up sheets were received on-site for fabrication

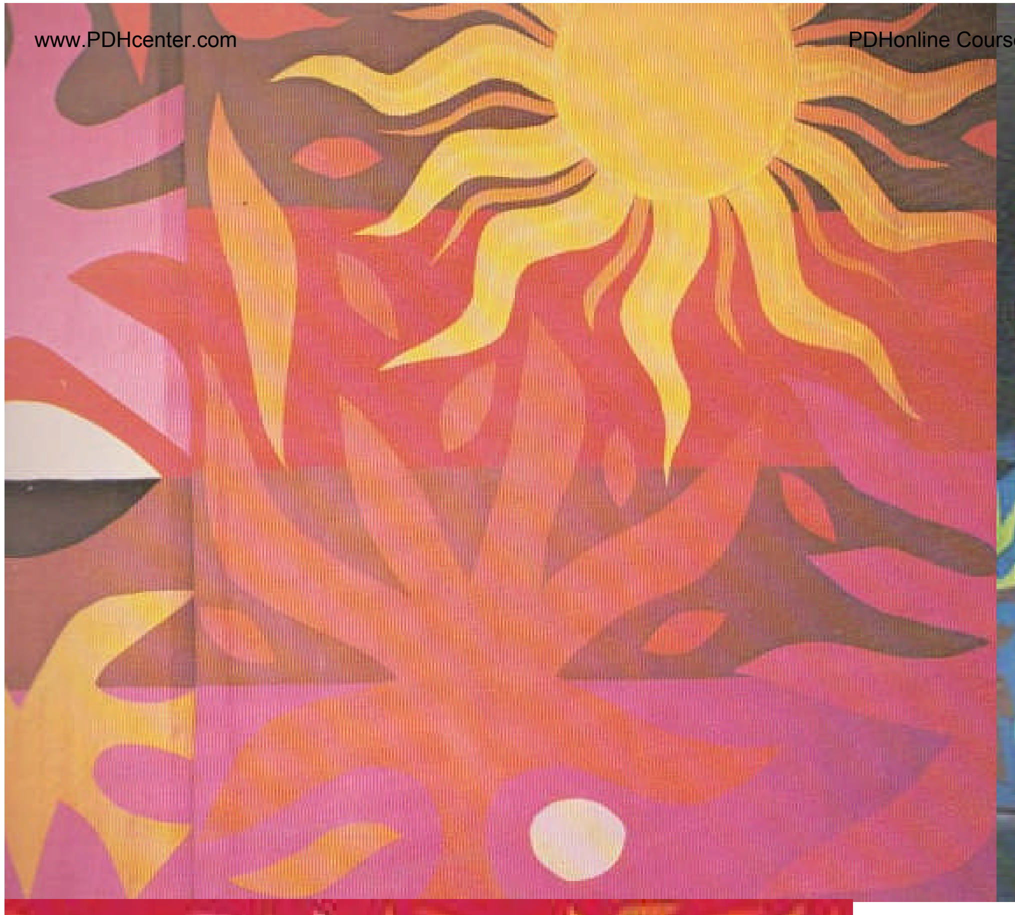
Any veneers differing in tone from the control samples were rejected. To ensure matching grain in adjacent panels, each veneer was tagged as it was cut so that it could be laid-out in sequence on the finished ceiling. Similarly, the Brush Box used was color-graded after milling to eliminate overly dark and/or light colored strips.

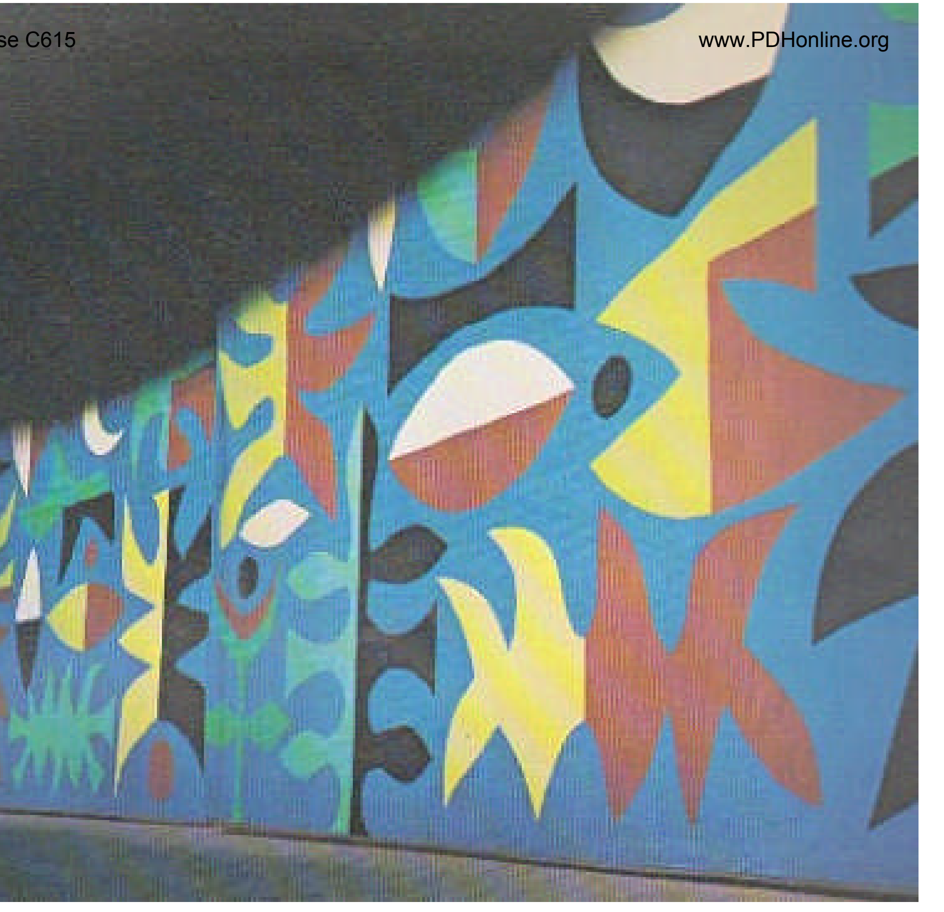




Artist *John Olsen's* mural entitled: *Five Bells*, measuring 10-feet high by 70-feet long dominates the Concert Hall foyer. It represents a nocturnal study of Sydney Harbor.

Soggy Pastiches





<u>Top Left</u>: The Opera Theater's "Curtain of the Sun" (27-feet high by 52-feet wide covering 1,404 square-feet)
<u>Top Right</u>: "The Curtain of the Moon" (within the Drama Theater) measuring 17-feet high by 64-feet wide
<u>Left</u>: Curtain of the Sun color screen print by *John Coburn* (1925-2006)

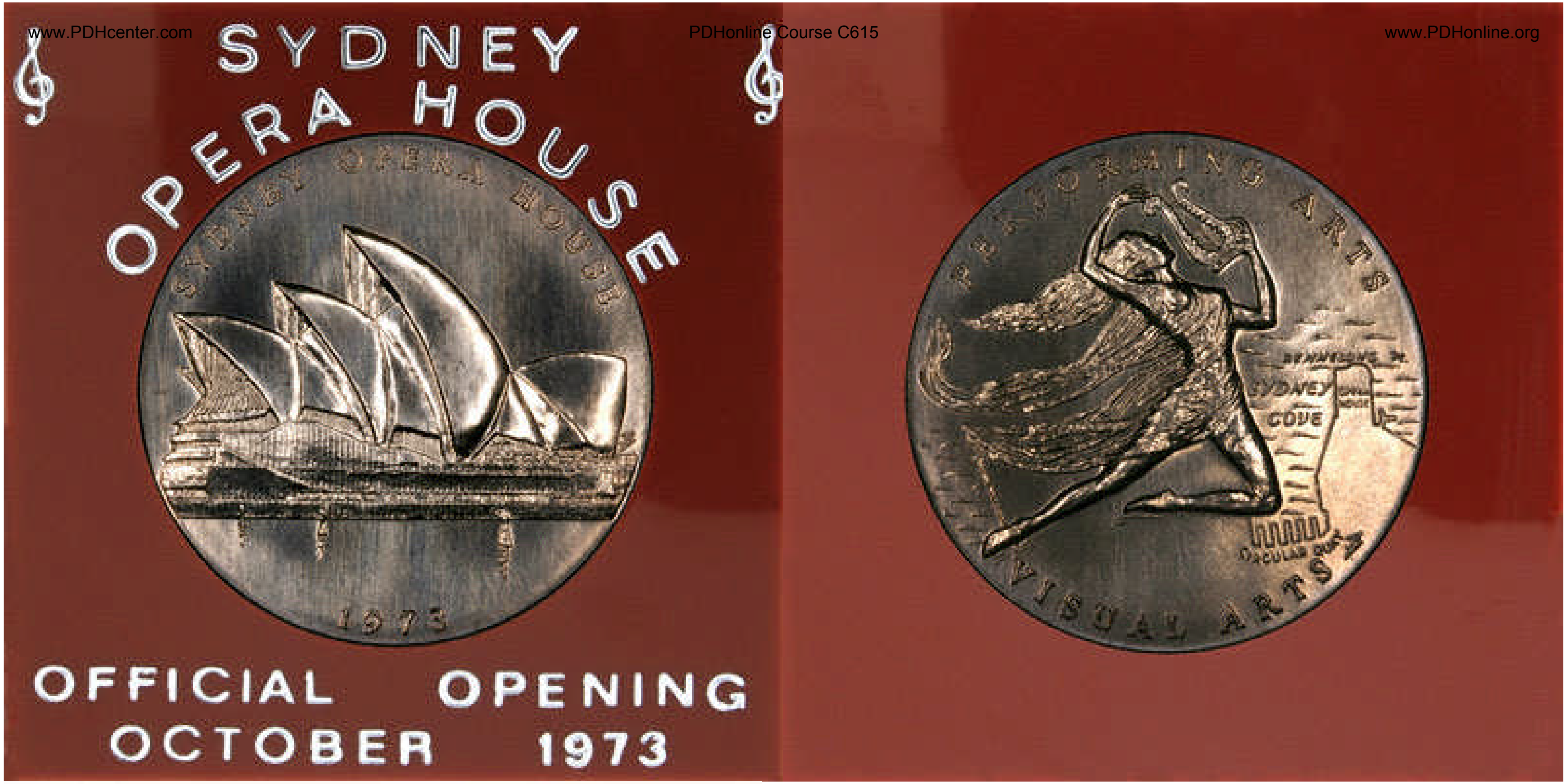
Queensland artist *John Coburn* created the multi-colored, abstract designs of *The Curtain of the Sun.* The very delicate and intricate tapestry work was done by the firm of *Pinton Feres* in a small medieval French village near *Aubusson*. All the wools and cottons used were of Australian origin.

Watershed Moment (?)

"…Still, there it is, opened last week with a production of Prokofiev's War and Peace, and ready now for its ceremonial visit by Queen Elizabeth II – an Opera House that marks a watershed in Australian cultural history, if not (as was hoped) in that of world architecture."
Time **magazine, October 8th 1973**

<u>Left</u>: poster designed by *John Coburn* celebrating the opening of the SOH on October 20th 1973. *Jorn Utzon* was invited to the opening day celebration (he declined the invitation) and his name was never mentioned during the formal ceremonies.

<u>Left</u>: *HRH Queen Elizabeth II* opening the Sydney Opera House on October 20th 1973
<u>Above</u>: festivities and fireworks celebrating the grand opening of the SOH



<u>Top</u>: Obverse (left) and Reverse (right) of 1973 SOH Official Opening Medallion (in Presentation Case)
<u>Left</u>: Obverse/Reverse of Medal commemorating the opening of SOH, NSW, Australia, 1973

"I am Bennelong…and the spirit and the spirit of my people lives"

Ben Blakeney, Aboriginal Actor

RE: appearing high atop the Concert Hall roof shell, the actor proclaimed these words as part of the opening day festivities. *Queen Elizabeth II* had compared SOH to the great pyramids at *Giza* in Egypt, with the difference being SOH was infused with life. Harbor celebrations, aerial displays and fireworks at night rounded out the celebration. The Queen and *Prince Philip* attended the SSO concert performed that night in the SOH.

Queen Elizabeth II **meets the artists who performed** ***Beethoven's Ninth Symphony*** **while attending the SOH's official (evening) opening performance (on 10/20/73)**

Left: View from the Stage of the SOH (1973). The first public concert was held in Concert Hall on September 29th 1973 with *Birgit Nilsson* singing Wagner accompanied by the *Sydney Symphony Orchestra* under conductor *Charles Mackerras*. The first public performance given in the Opera Theater occurred on September 28th 1973; a production of Prokofiev's *War and Peace* by the *Australian Opera Company*. To test the Concert Hall's acoustics, on December 17th 1972 the SSO gave a performance (conducted by *Sir Bernard Heinze*) to a capacity audience of 2K workmen and other invited guests. To test reverberation time, as the audience remained silent six blank shots were fired from a pistol. The result was the predicted 2.0s reverberation time.

Giant of a Man

On November 9th 1960 - more than a thirteen years before it was officially dedicated, the SOH had hosted its very first performance. Internationally renowned star *Paul Robeson*, in the midst of what turned out to be his final concert tour (Australia and New Zealand), sang to the SOH construction workers during their lunch break.

"…This giant of a man…After he finished singing, the men climbed down from the scaffolding, gathered around him and presented him with a hard hat bearing his name. One of the men took off a work glove and asked Paul to sign it. The idea caught on and the men lined up. Paul stayed until he had signed a glove for each one of them."

Alfred Rankin, SOH construction worker

RE: recalling the memorable events of November 9th 1960

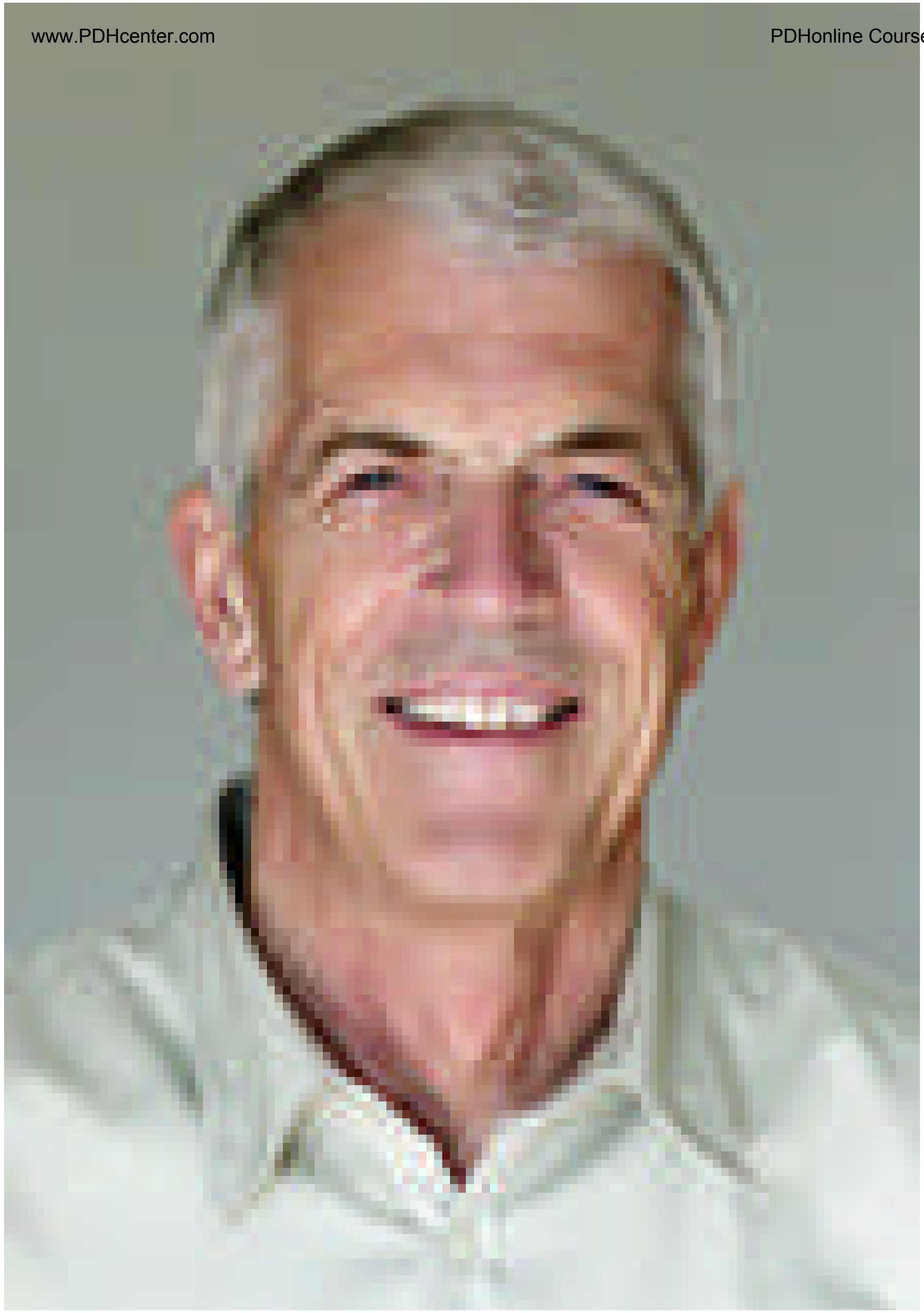
SOH (from *Farm Cove*) February 1973

Part 12

Making Things Right

Venue Improvement Plan

As the millennium approached, conservation and continuity of the SOH were the foremost considerations of *The Sydney Opera House Trust* and the government of NSW. Thus, on October 25th 1998, Premier Robert Carr (former Minister of Art) wrote to Jorn Utzon (right) asking the aging architect to consider establishing a set of design principles that could be used to continue his vision of SOH for generations to come. These principles would be employed as a guide for future architects and designers to maintain and renew the building in perpetuity. Utzon agreed. Thirty-three years had passed since Utzon left Australia and the tumultuous events of of February 1966 were long behind him, Jorn Utzon once again signed a contract with the government of NSW concerning his creation; SOH. Seeing no need to physically return to Australia, Utzon set about updating aspects of the building with the help of his architect son Jan (left). At the same time, prominent Sydney architect *Richard Johnson* was hired to develop a *Venue Improvement Plan* with the Utzons.



Jan Utzon **was born in 1944 and grew up surrounded by his father's love of nature and architecture. He studied architecture in Sydney and Copenhagen, having graduated in the spring of 1970, he became a registered, practicing architect in Denmark. After graduation, he worked in various offices in Denmark and with his father on** ***Bagsvaerd Church*** **in Copenhagen and the** ***National Assembly*** **(Parliament) project in Kuwait. In 1974, Jan was working with "Architects of Hawaii" and became a registered architect there. Starting in 1976, Jan contributed to various works with his father in;** ***Denmark, Portugal, Germany, Sweden, USA, China, Zimbabwe, Malawi, Angola, South Africa, Mozambique, Mexico*** **and** ***Australia*****. Since 1998, he has been working in conjunction with** ***Richard Johnson*** **on the** ***Venue Improvement Plan.***

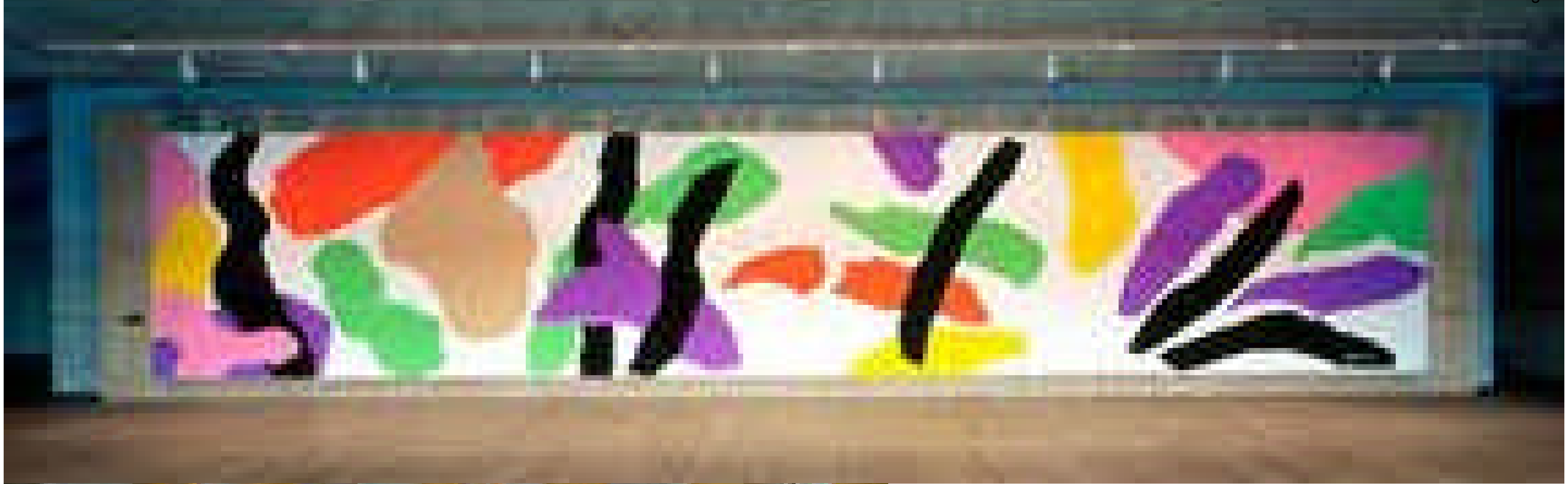
"…But when you grow up in such an environment you hardly recognize the situation as a special one. And it was not until we approached Sydney that I began to realize that my childhood environment was unique. From then on our lives were filled with a succession of wonderful experiences only temporarily to be interrupted by the unfortunate termination of my father's work in Sydney. It is therefore a great joy for my father to have been asked back to Sydney to act as a consulting architect in the planning of the future of the Sydney Opera House…"

Jan Utzon, Architect

RE: excerpt from the acceptance speech he gave on his father's behalf at the formal ceremony for *Jorn Utzon's* as Laureate of the 2003 *Pritzker Architecture Prize*

Design Principles

In 2002, the Venue Improvement Plan's "Design Principles" were published and the government of NSW Premier *Robert Carr* committed $A69 million to the refurbishment plan. This included the creation of the first interior space fully realized to *Jorn Utzon's* specifications, the "Utzon Room." The room celebrates the form of the Concourse beams which define the ceiling, and its southern wall is glass (overlooking the harbor). The north wall (inspired by the music of *Bach* and *Raphael's* painting: *Procession to Cavalry*) is dominated by a tapestry designed by Utzon. These elements of the Utzon Room (above) characterize three ideas which, though fundamental to Utzon's architectural vision for SOH, had been compromised in its realization: 1) *Honesty of Form,* 2) *The Harbor,* 3) *Procession.* The artist, designer, philosopher and architect embodied in the soul of Jorn Utzon are well represented in the Utzon Room.



<u>Above & Left</u>: "Tribute to CPE Bach" – a 2.67 x 14.02 meter woolen tapestry designed by *Jorn Utzon* (woven by the *Australian Tapestry Workshop* and supervised by Utzon's daughter *Lin*)

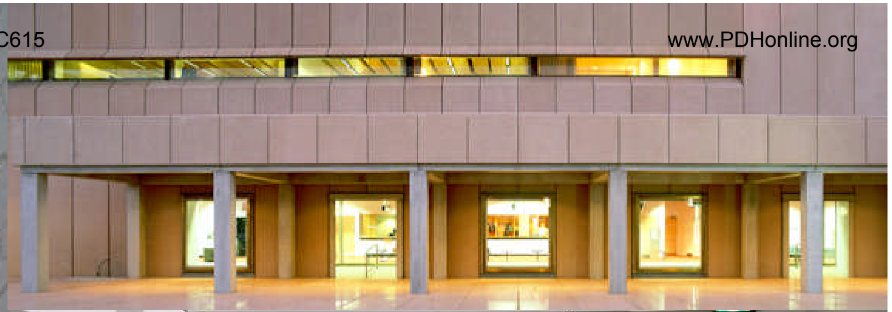
The Western Colonnade


In 2006, the *Western Colonnade* along the west (Harbor Bridge) side of SOH was completed. This was the first external change to the building since opening in October 1973. Forty-five meters long by five meters wide, the Colonnade provides an entrance for patrons of *The Studio, Playhouse* and *Drama Theater*, opening their foyers to the beautiful views of Sydney Harbor. Nine openings were created; six new large deep set windows and three doors. With over fifty percent of the façade becoming glass, these foyers are now flooded with natural light and for the first time, patrons can enjoy harbor, bridge and city views. The Colonnade was opened by *Queen Elizabeth II* on March 13th 2006 in an event that finally gave recognition to the SOH's visionary architect: *Jorn Utzon*.

"…the international symbol of the nation itself – a building to which visitors return gratefully, again and again, for renewed joy and inspiration"

Queen Elizabeth II

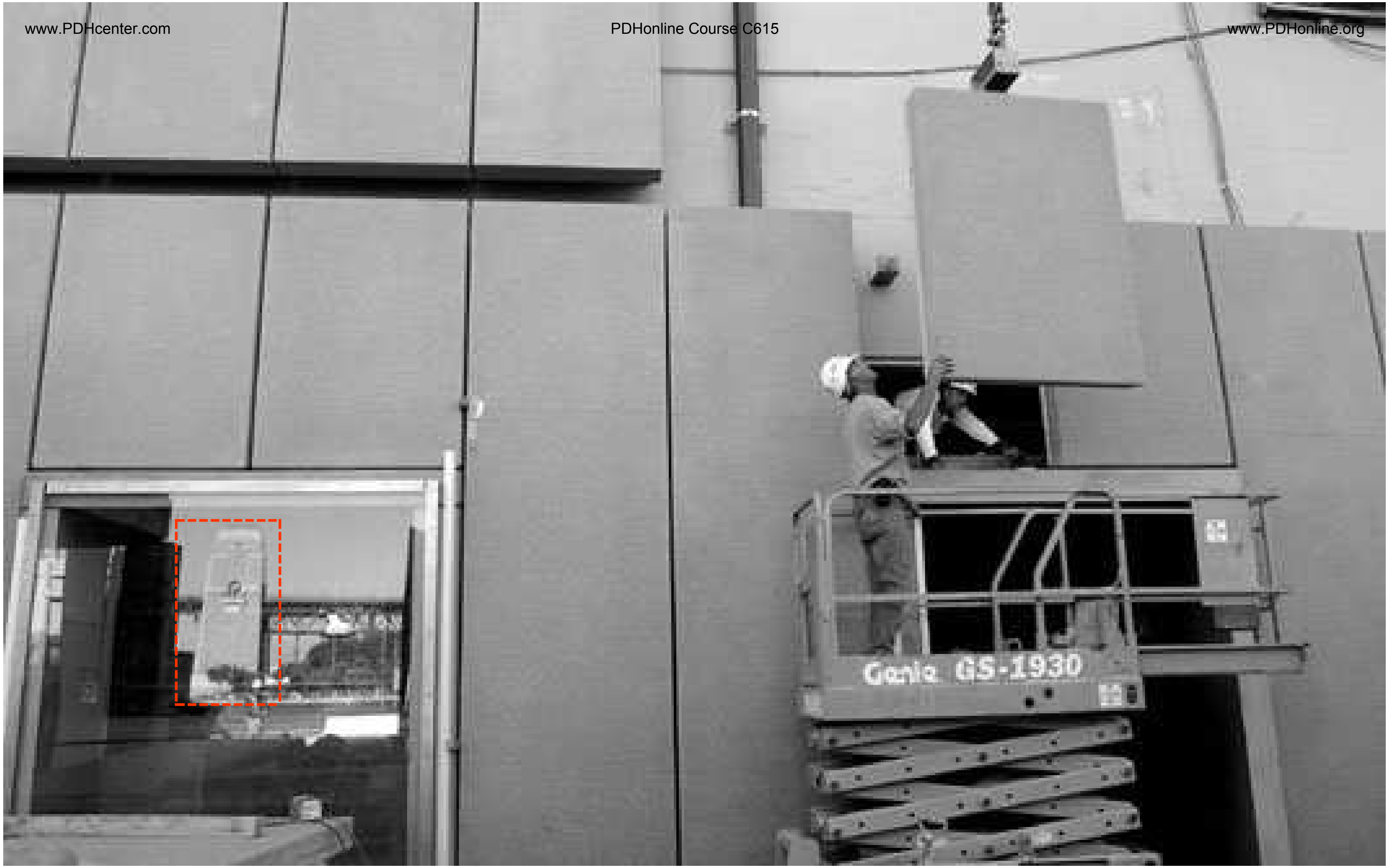
RE: excerpt from her opening day speech for SOH's new *Western Colonnade* (March 13th 2006)



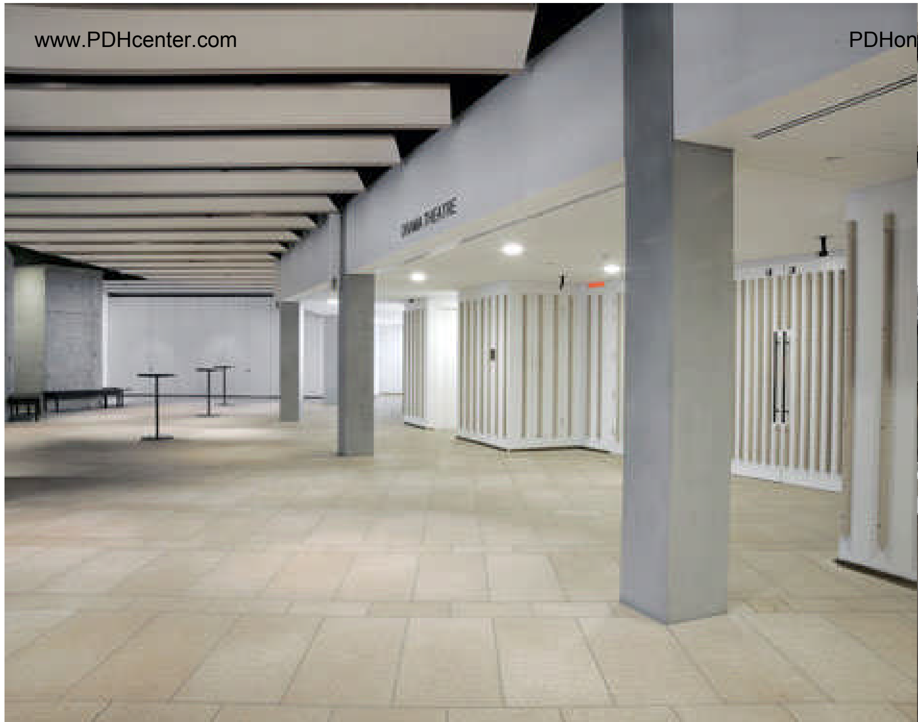
"The craftsmanship of the Colonnade and niches is absolutely first class and certainly up to the standard expected in Sydney Opera House."

Jorn Utzon, Architect (2006)

RE: the Western Colonnade transformed the foyers into a stylish and functional space providing patrons with additional amenities including new ticketing, toilet and cloaking facilities. Also, a new public elevator and a pair of escalators (a first for SOH) have improved accessibility tremendously.



Wall panel for the Western Colonnade being set in place (right) while the new window reflects the *Pylon* of *Sydney Harbor Bridge* (left)



"The recent modifications to the Opera House and the improved accessibility are all part of the natural changes to the building that will ensure its usefulness and enhance its architecture and its value as an iconic building in Sydney."

Jan Utzon, Architect

"Balancing the future functionality of Sydney Opera House with improvements to the architectural expression and impact of the building, is one of our key challenges. Jorn Utzon and his team have applied their creative genius to many of the problems and delivered solutions that will transform the visitor experience whilst respecting the architectural integrity and legacy of this incredible building."

Richard Evans, SOH CEO

The Great Dane

In 2003, Utzon was awarded the Pritzker Prize, the world's most prestigious architectural award. The judges recognised Sydney Opera House as: *"a masterpiece – Jorn Utzon's masterpiece."* Four years later (in 2007), *World Heritage Listing* was awarded to SOH. Jorn Utzon died on November 29th 2008 at the age of ninety. An unlikely series of events led to the creation of one of the greatest buildings of the twentieth century; a building which, through a union of geometry and ancient ideal, is a shrine to the performing arts and evokes a time when the Australian nation began to assert – apart from mother England, its own cultural identity.

"Jorn Utzon has designed a remarkably beautiful building in Australia that has become a national symbol to the rest of the world. In addition, in a most distinguished career, he has designed several other significant works, including housing complexes, a church, residences, and other commercial buildings. We are delighted that the jury has seen fit to recognize this great talent as we celebrate our first quarter of a century."

Thomas J. Pritzker, President of *The Hyatt Foundation*

RE: 2003 Pritzker Architecture Prize Laureate *Jorn Utzon*

"Jorn Utzon created one of the great iconic buildings of the twentieth century, an image of great beauty known throughout the world. In addition to this masterpiece, he has worked throughout his life fastidiously, brilliantly, quietly and with never a false or jarring note. He is therefore a most distinguished recipient of the Pritzker Prize."

Lord Rothschild, Pritzker Prize Jury Chairman

"Utzon has always been ahead of his time. He rightly joins the handful of Modernists who have shaped the past century with buildings of timeless and enduring quality."

Bill Lacy, Architect - Executive Director of the Pritzker Prize

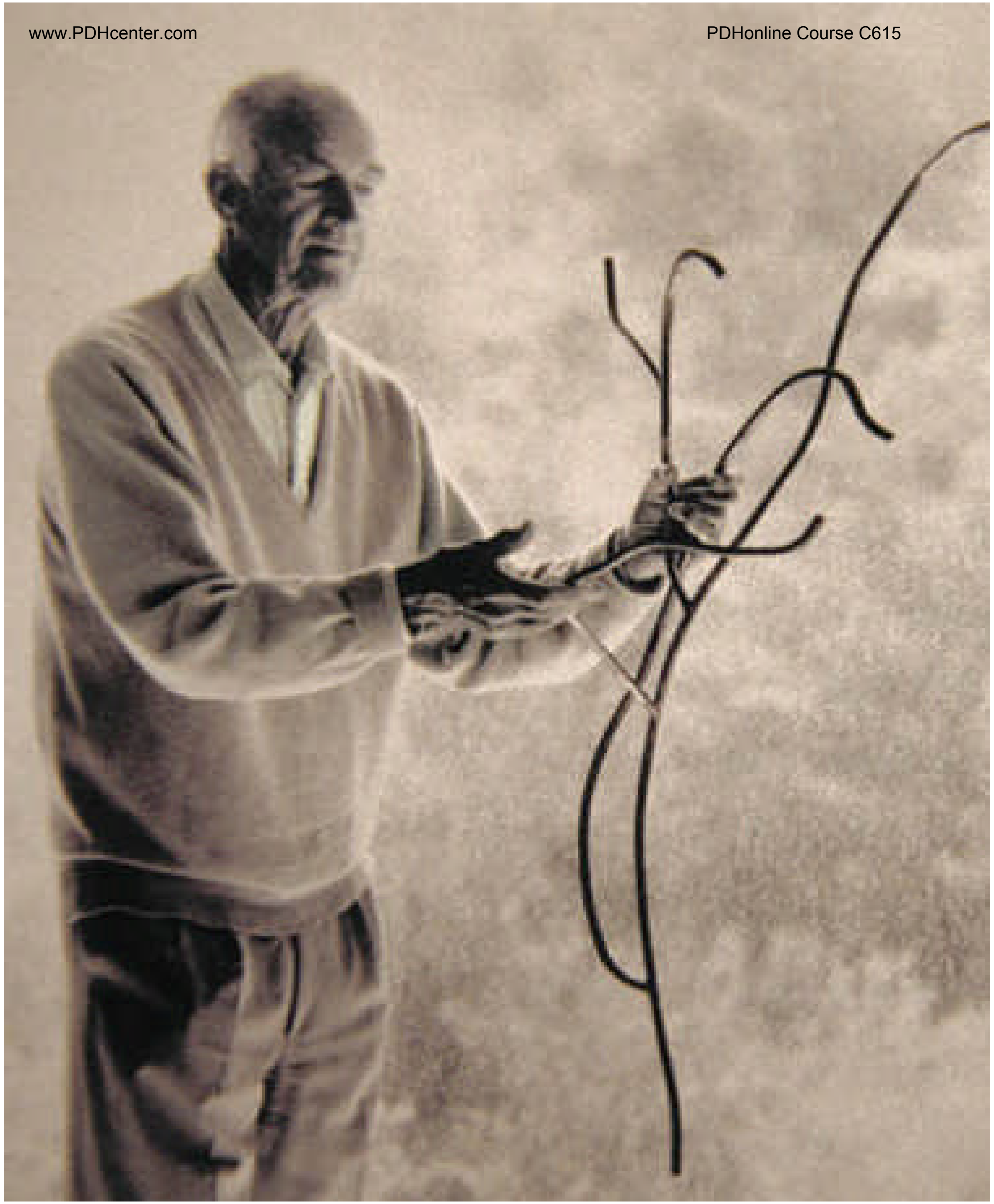
"Singular is an attribute that embodies the life and work of Jorn Utzon. The unique resolve and erudition of this architect's few but compelling works have captured the imagination of architects and the public alike ever since his brilliant debut in the international scene almost fifty years ago."

Carlos Jimenez, Professor of Architecture and Pritzker Prize Juror

"Paradoxically, while the act of awarding in 2003 the Pritzker Prize to Jorn Utzon may be perceived as long overdue, it comes at such a particular moment in the development of architecture as to be timely and exemplary. In the current frenzy of unbound personal expressionism and blind subordination to attention-grabbing production techniques, his explorations remind us that both 'expression and technique' are servants and secondary to more profound and foundational architectural ideas. His work shows us that the marvelous and seemingly 'impossible' in architecture depend still on genial minds and able hands."

Jorge Silvetti, Chairman of the Department of Architecture, Graduate School of Design at Harvard University and Pritzker Juror

The Future of Architecture



"This is indeed a wonderful day. I am deeply grateful and happy for the recognition of my work I have received the Pritzker Prize. The prize means so much to me because the group of architects who received the Pritzker Prize before me are all architects I admire very much, and whose works are so important for the future of architecture…"

Jorn Utzon, Architect

RE: excerpt from his personal thanks read aloud by his son *Jan* at the formal ceremony which was held at *The Royal Academy of Fine Arts of San Fernando*, Madrid, Spain on May 20th 2003

"Sydney Opera House is a great architectural work of the 20th century. It represents multiple strands of creativity, both in architectural form and structural design, a great urban sculpture carefully set in a remarkable waterscape and a world famous iconic building."

UNESCO

RE: SOH's World Heritage Listing

Universal Presence

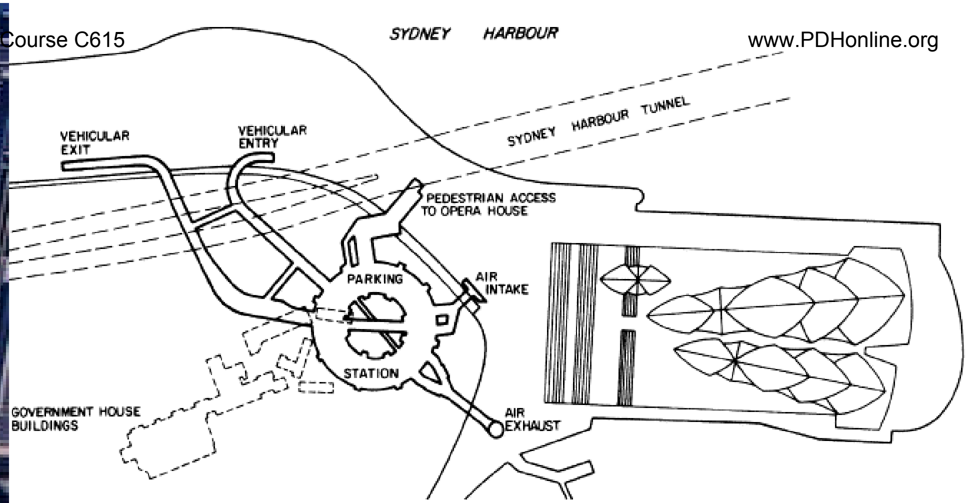
"The groundbreaking Danish architect had constructed something well ahead of its time, far ahead of available technology and he persevered through extraordinary malicious publicity and negative criticism to build a building that changed the image of an entire country. It is the first time in our lifetime that an epic piece of architecture gained such universal presence."

Frank Gehry, Architect

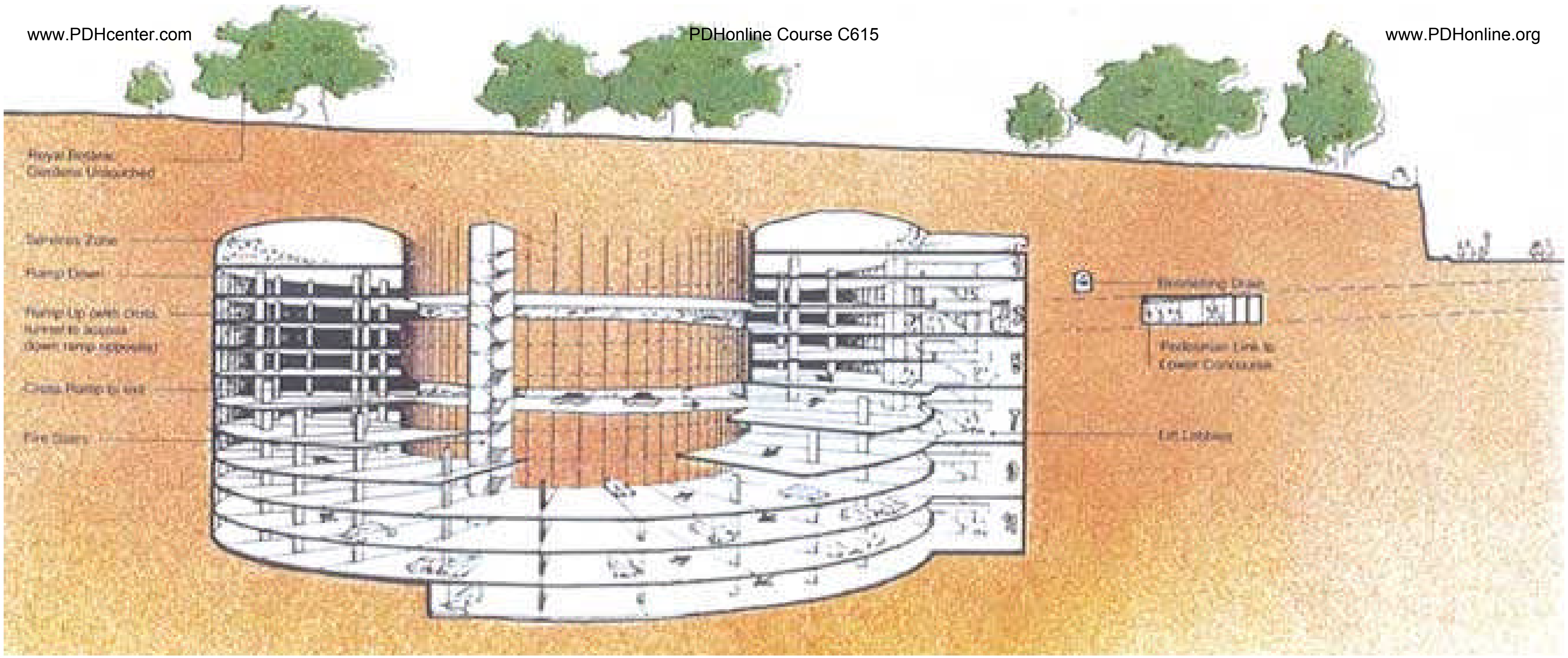
Part 13

Liebestraum

Green Banned



A competition was held to find the best design for the “missing” SOH Car Park that had to be built underground, under the adjacent *Royal Botanical Gardens* on Bennelong Point. An early proposal for a Car Park in the adjacent parkland was “green banned” by the *Builders Labourers Federation* because excavation work would have destroyed several very old *Moreton Bay* fig trees. The competition was won by a car park operating company rather than a civil engineering firm. They considered a double-helix design as the most efficient method of entry and/or exit while providing the greatest number of car parking spaces.



The underground Car Park (capacity 1,100) for the SOH is unique in size and shape. It was the world's first helical underground parking garage and makes the claim of being the widest shallow-cover rock cavern in the world. Designed as a doughnut-shaped cavern, it has a span of up to 19m; an outer radius of 75m; and a twelve-story high free-standing double-helix internal concrete ramp structure that operates on a one-way only traffic flow. Cars travel down the ramp to park diagonally into the parking space and continue going down to exit on the double-helix up ramp. Cross passages through the center core of the doughnut provide a cross cut to the exit ramp rather than having to travel the full twelve stories to the bottom to link with the reverse helix ramp.

Tunneling engineers designed the excavation in Sydney's *Hawkesbury Sandstone*. The vault was the key feature of the cavern. It has a span of between 17.5m and 19m and is beneath 7m and 8m of variably weathered sandstone cover. It is not supported with a formed concrete arch but, rather, has internal reinforcement comprising about 2,000 tensioned *MaCalloy Bar Anchors* up to 7.5m long and non-tensioned galvanized dowels (up to 4.5m long). Excavation of the cavern (and associated tunnels) involved removing approximately 130K-cm3 of sandstone. Work began in late 1990 and was completed in April 1992.

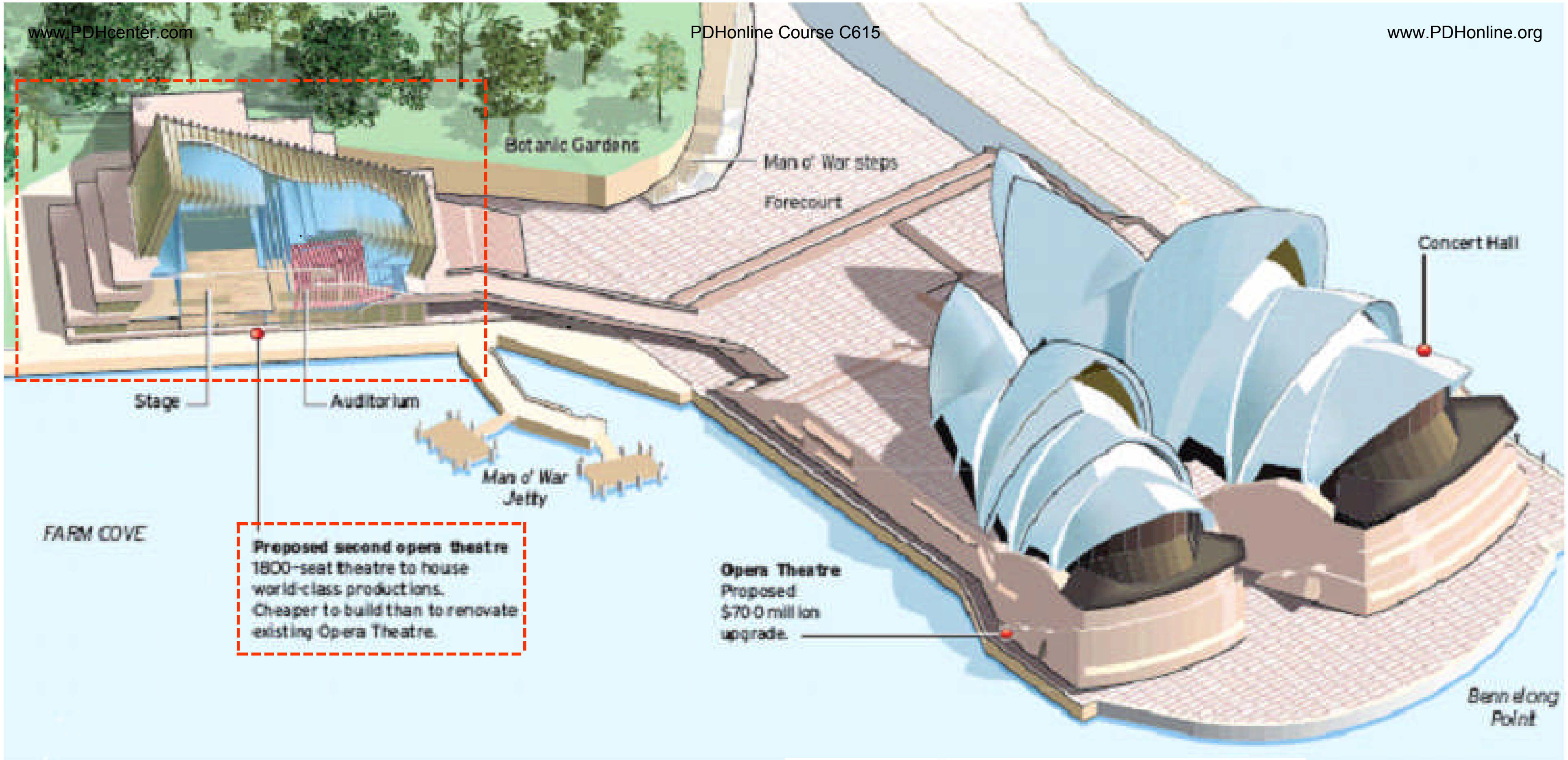
The twelve-story concrete double-helix structure was completed in September 1992 and the Car Park was officially opened on March 17th 1993 by Mr. *John Fahey*, Premier of NSW; six months ahead of schedule and at a cost of about $A40 million. while, the concrete helix ramp structure inside the cavern is freestanding, the walls of the excavated rock cannot be seen. It was thought that SOH would not be comfortable seeing the rock-face of the walls as excavated and so walls were provided on the inside and outside of the ramp/s.

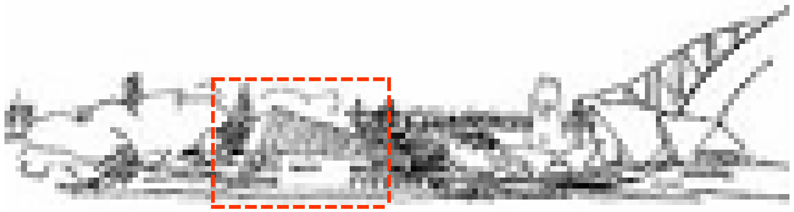
Second Opera House (?)

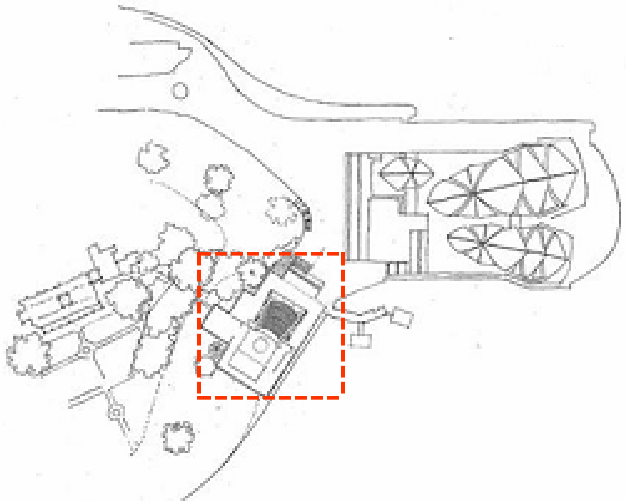
"Inclusion of Sydney Opera House on the World Heritage List confirms the very special significance it has for all people, wherever they live. The Trust and staff feel very profoundly that we are the custodians of one of the world's most important buildings, and that we are entrusted with a treasure of international significance on behalf of this generation and generations to come."

Kim Williams, Chair of Sydney Opera House Trust (2007)

The SOH did not meet its original competition requirement for a 2,800-seat Opera Hall. Rather, it got a 1,500-seat hall instead which, in world opera terms, is considered inadequate and uneconomical and remains a constant source of controversy. On June 28th 2007, SOH was made a *UNESCO World Heritage Site*. As such, the present SOH complex - including the area of the Opera House and its immediate surroundings - cannot be changed in any significant way, inside or out, without formal review/approval. Inevitably, a proposal to build a second opera hall on the site was/is controversial.


Botanic Gardens
Man o' War steps
Forecourt
Concert Hall
Stage
Auditorium
Man o' War
Jetty
FARM COVE
Proposed second opera theatre
1800-seat theatre to house
world-class productions.
Cheaper to build than to renovate
existing Opera Theatre.
Opera Theatre
Proposed
$70.0 million
upgrade.
Bennelong
Point





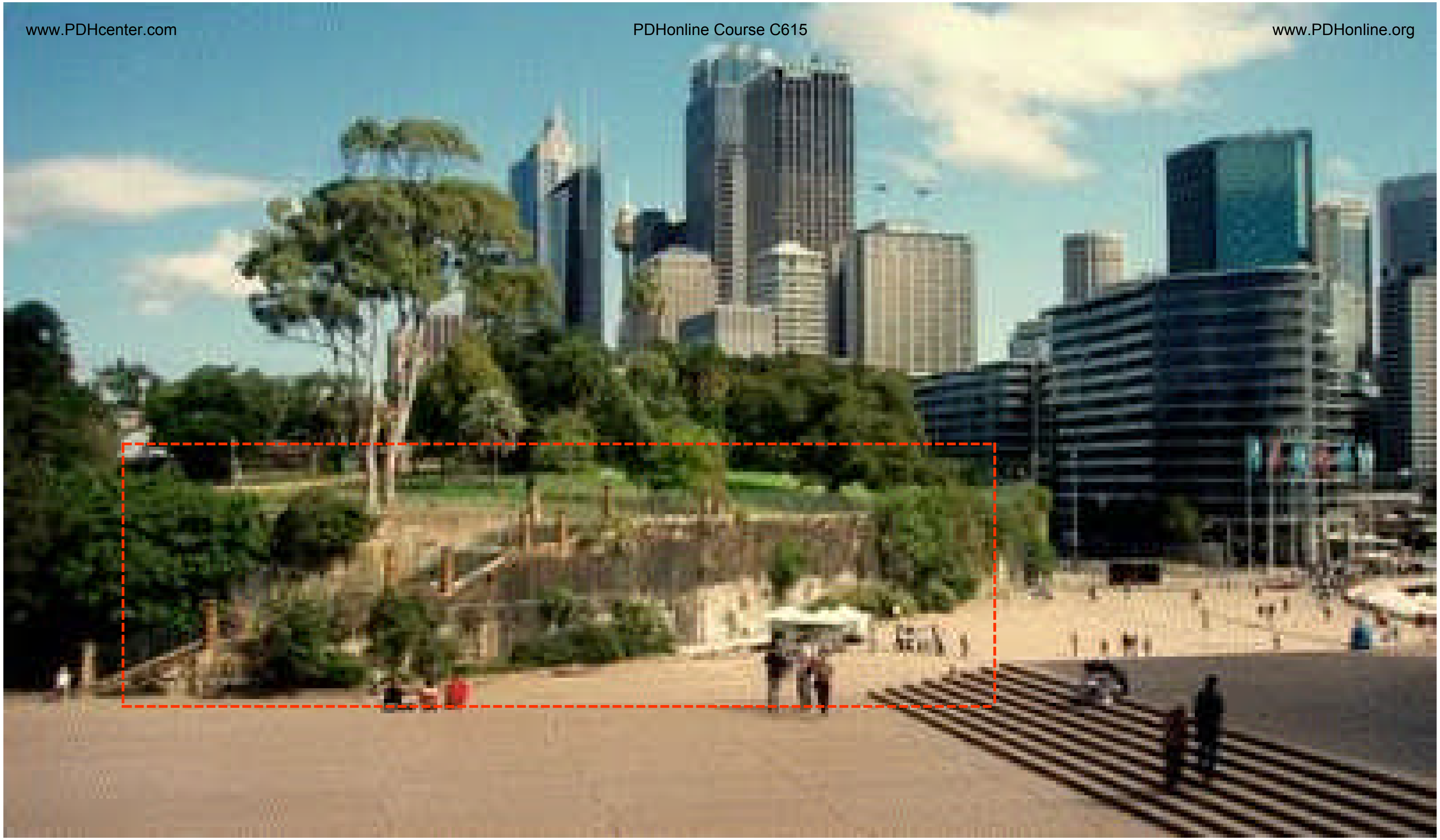
Down Under

Sydney is the result of the geological phenomena of the *Sydney Sandstone Basin*, the very reason for Sydney Harbor and most of the unique features of Sydney itself and its surrounding areas. Therefore, the natural Sydney sandstone could, itself, provide adequate space for a new opera hall if built within the sandstone bluff to the south of SOH below the Botanical Gardens.

The natural sandstone bluff could/would act as the new opera hall's entrance and it would be unique for being as *inconspicuous* as the SOH is for being *conspicuous*. The SOH precinct and the *Royal Botanical Gardens* would not be compromised in any way. As well, an additional entrance could be provided from the Botanical Gardens itself.

An additional underground car park could be created to handle the increased volume of vehicles the second opera hall would attract (the adjacent Quay has the greatest concentration of public transportation access in all of Sydney including three rail links, bus and ferry service). A major advantage of this plan is the cost and relative ease of construction. The SOH Car Park provides an excellent example of how cost-effective and efficient excavating Sydney sandstone can be. One of the significant additional costs of SOH was soundproofing of the structure from the external noises of the harbor. Being underground, noise isolation is inherent thus there would be no additional cost. Also, the air conditioning requirement/s would be much less considering the reduced heat-load from having no exposure to the hot Australian sun. The volume of the underground opera house Car Park was 140K cubic-meters. The new opera hall would be no more than 100K cubic-meters. A fine example of underground architecture using native Sydney sandstone can be found 200-meters up *Macquarie Street - The Sydney Conservatory of Music.*


wes Point
Dawes Point
Park
Sydney Cove
Opera House
Cambell's
Storehouses
To Harbour Bridge
Lower Fort St
The Rocks
Sydney Cove
Terminal
Sydney Information
Centre
Argyle
Stores
Argyle Cut
Cadman's
Cottage
Argyle St
Bradfield Highway
Hickson Rd
Kent St
Observatory
Harbour Bridge
Pylon Lookout
Entrance
Circular Quay
Government House
Museum of
Contemporary
Art
Farm
Susannah
Place
Cahill Expressway
Justice and
Police Museum
Loftus St
Customs
House
Conservatorium
of Music
Museum
of Sydney
Grosvenor St
Bridge St
Royal Botanic Gardens



The excavated area needed for a 4K-seat opera hall would be about 90K cubic-meters. Allowing an additional 40K cubic-meters for other excavated areas (i.e. entrance/exit, storage pits etc.) gives a total of approximately 130K cubic-meters of excavation.

A Music Cultural Precinct

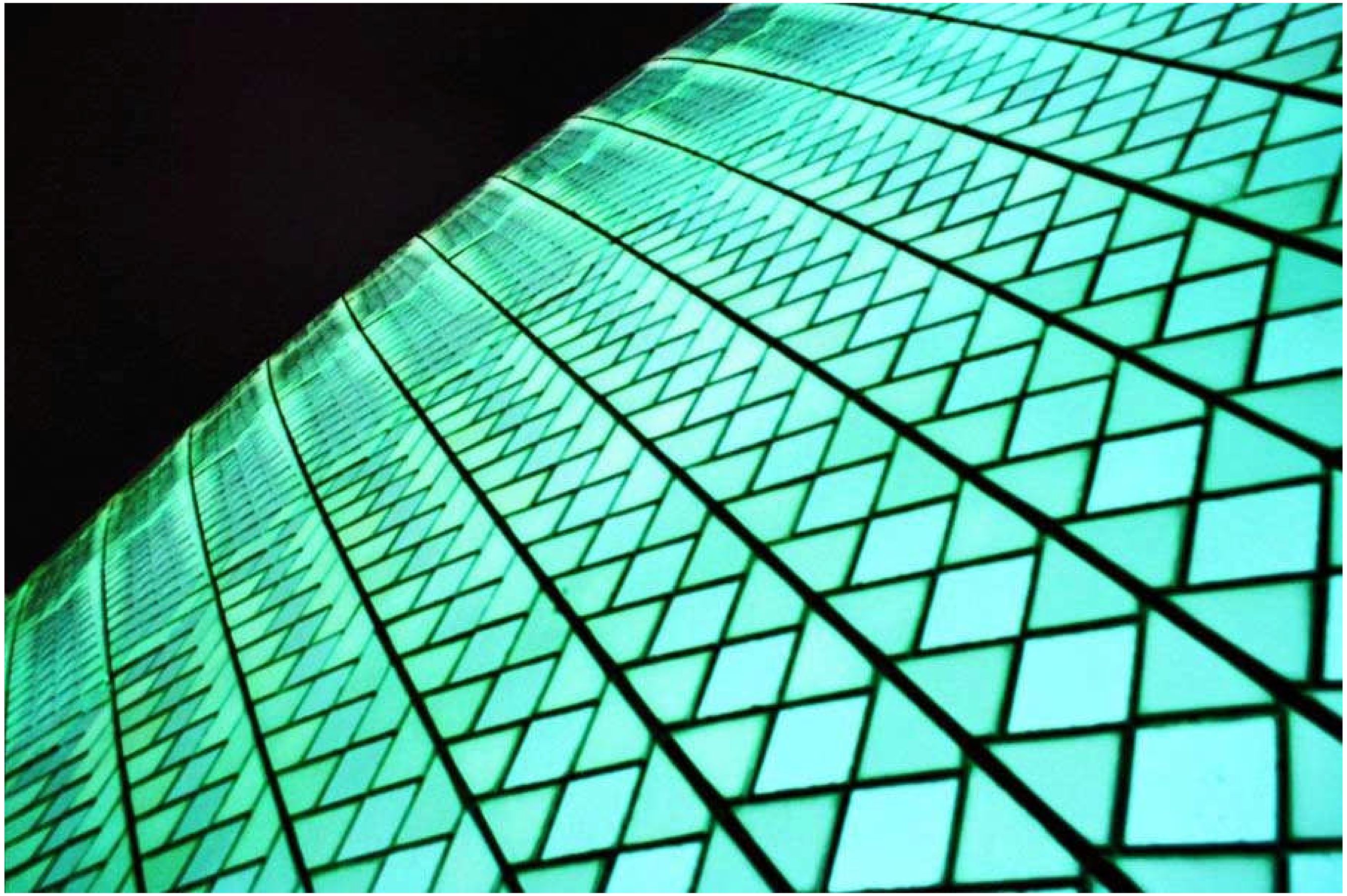
The existing SOH, particularly the opera hall with its seating for only 1,500 requires a great injection of public monies each year just to keep it afloat. A 4K-seat opera hall would resolve this situation plus provide far less expensive seating to a greater range of audiences. A "Music Cultural Precinct" featuring the architectural theme of native Sydney sandstone would carry over from the nearby *Conservatorium of Music* raising the stature of Sydney on the international music scene. NSW State lotteries were originally introduced to raise funds for "just and special causes." Over the years, this changed to be a general means of raising revenue. Another special *Opera House Lottery* could provide the necessary funding for a second opera hall, just as it did for the original complex.

Part 14

Colors of the Night

Vivid Sydney

For two weeks (at the end of May/beginning of June), an annual event known as *Vivid Sydney,* consisting of light sculptures around *Circular Quay* and throughout "The Rocks" takes place attracting large crowds of both Sydneysiders and tourists alike. The highlight event is the "Lighting of the Sails" - the projection of intricate, colorful and beautiful designs on the SOH's majestic shells.




URBANSCREEN

SOH lit up in pink for *Breast Cancer Awareness*

The SOH illuminated with red lights for *Remembrance Day*

SOH lit up by the laser technology of *Laservision Macro-Media* (in 1994) to celebrate Sydney winning the hosting of the 2000 Olympic Games.

Part 15

Legacy

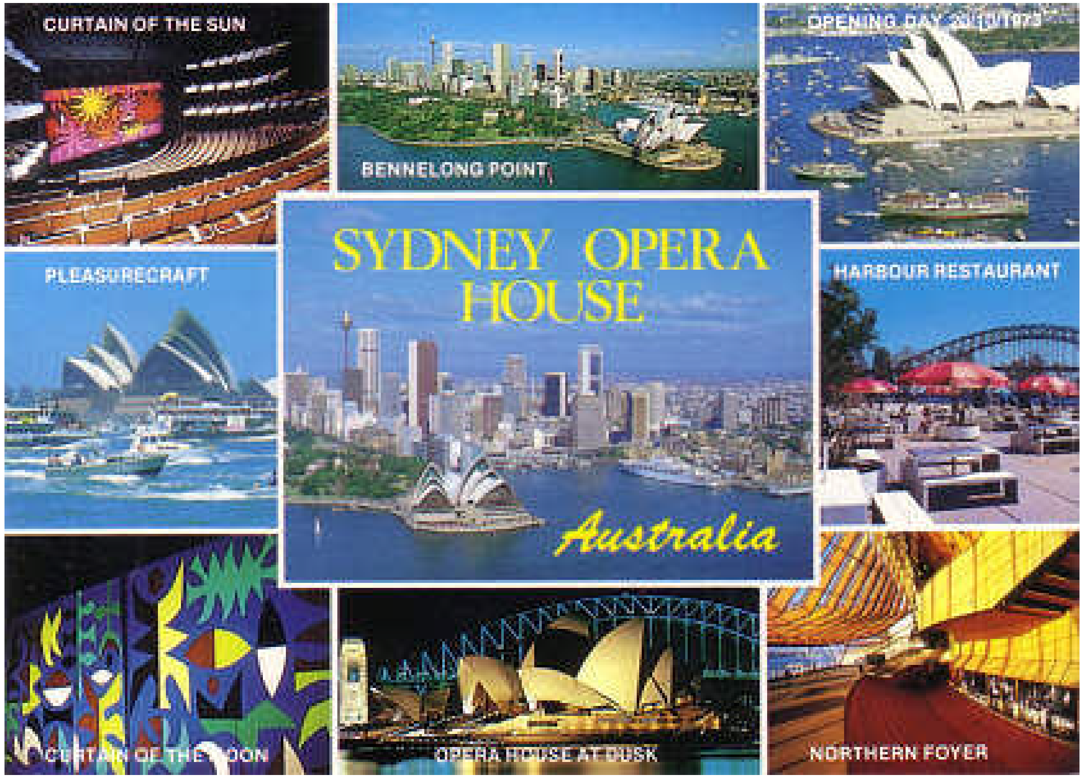
Culture

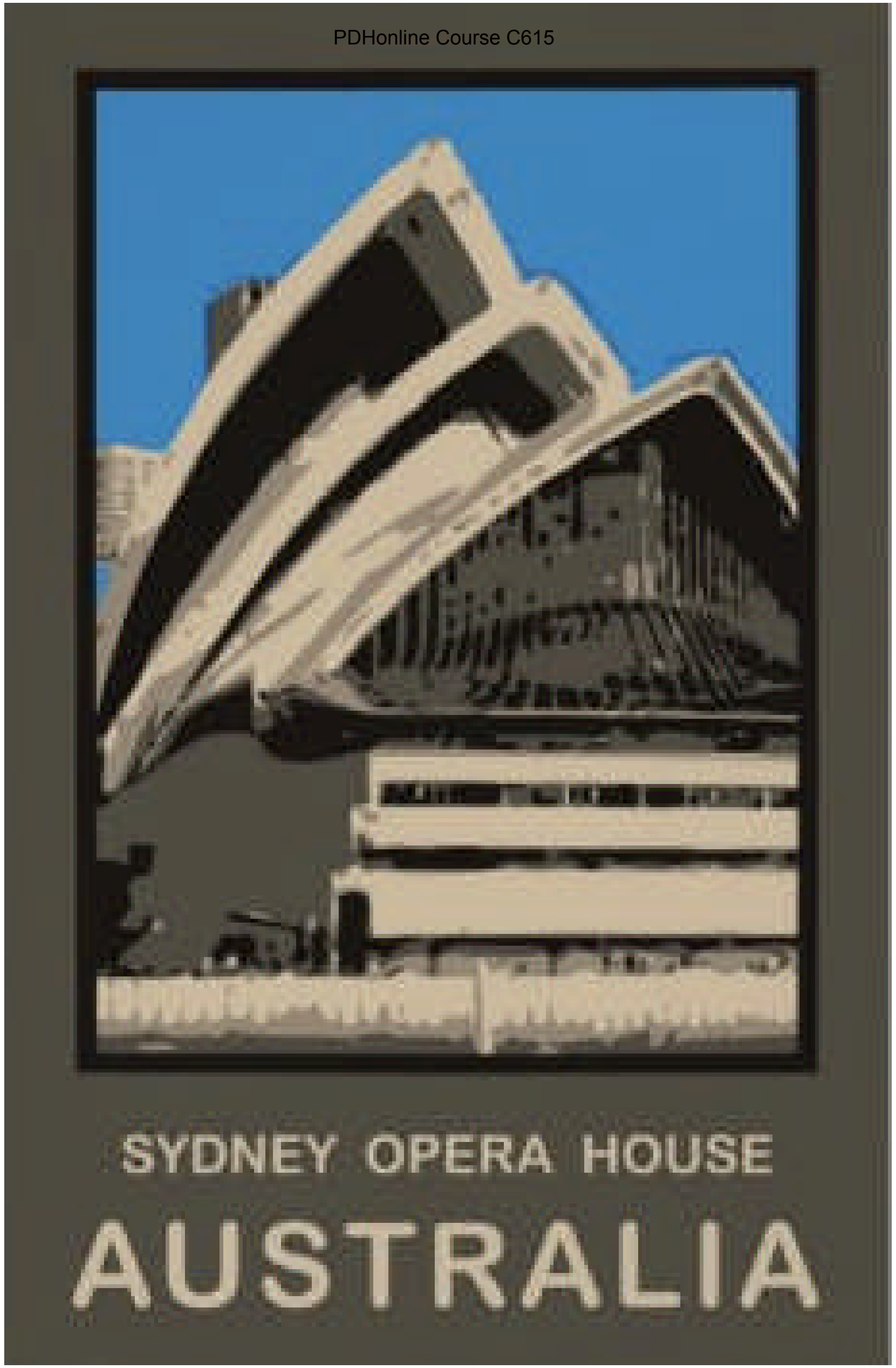

PAPUA NEW GUINEA
INDEPENDENCE 1975
AUSTRALIA
18
AUSTRALIA UK JOINT ISSUE
$1
International POST
AUSTRALIA
$1


Sydney Opera House
$1
AUSTRALIA
Sydney Opera House
$1
AUSTRALIA
Sydney Opera House
$1
AUSTRALIA
Sydney Opera House
$1
AUSTRALIA


Post Office Souvenir Cover
Sydney Opera House
Official Opening
by Her Majesty
Queen Elizabeth II
October 20, 1973
7
SYDNEY
2 0 OCT 1973
OLYMPICS OPENING DAY
15 SEPTEMBER 2000 · SYDNEY
50c
AUSTRALIA


SYDNEY
Australia


CURTAIN OF THE SUN
BENNELONG POINT
SYDNEY OPERA HOUSE
Australia
PLEASURECRAFT
HARBOUR RESTAURANT
OPERA HOUSE AT DUSK
NORTHERN FOYER


SYDNEY OPERA HOUSE
AUSTRALIA


SYDNEY
AUSTRALIA


THE SYDNEY OPERA HOUSE IS TEN
20 OCTOBER 1983

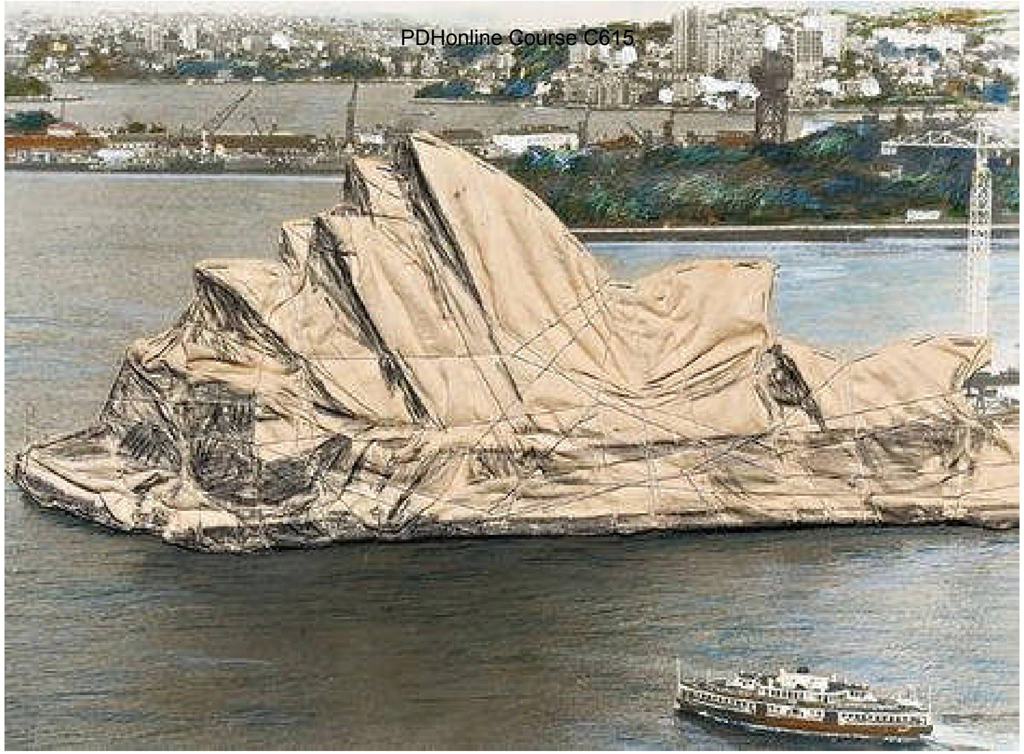
Making a Statement

Digital photo manipulation of the SOH that found its way into email in-boxes around the world following England's victory over Australia in the 2003 *Rugby World Cup*.

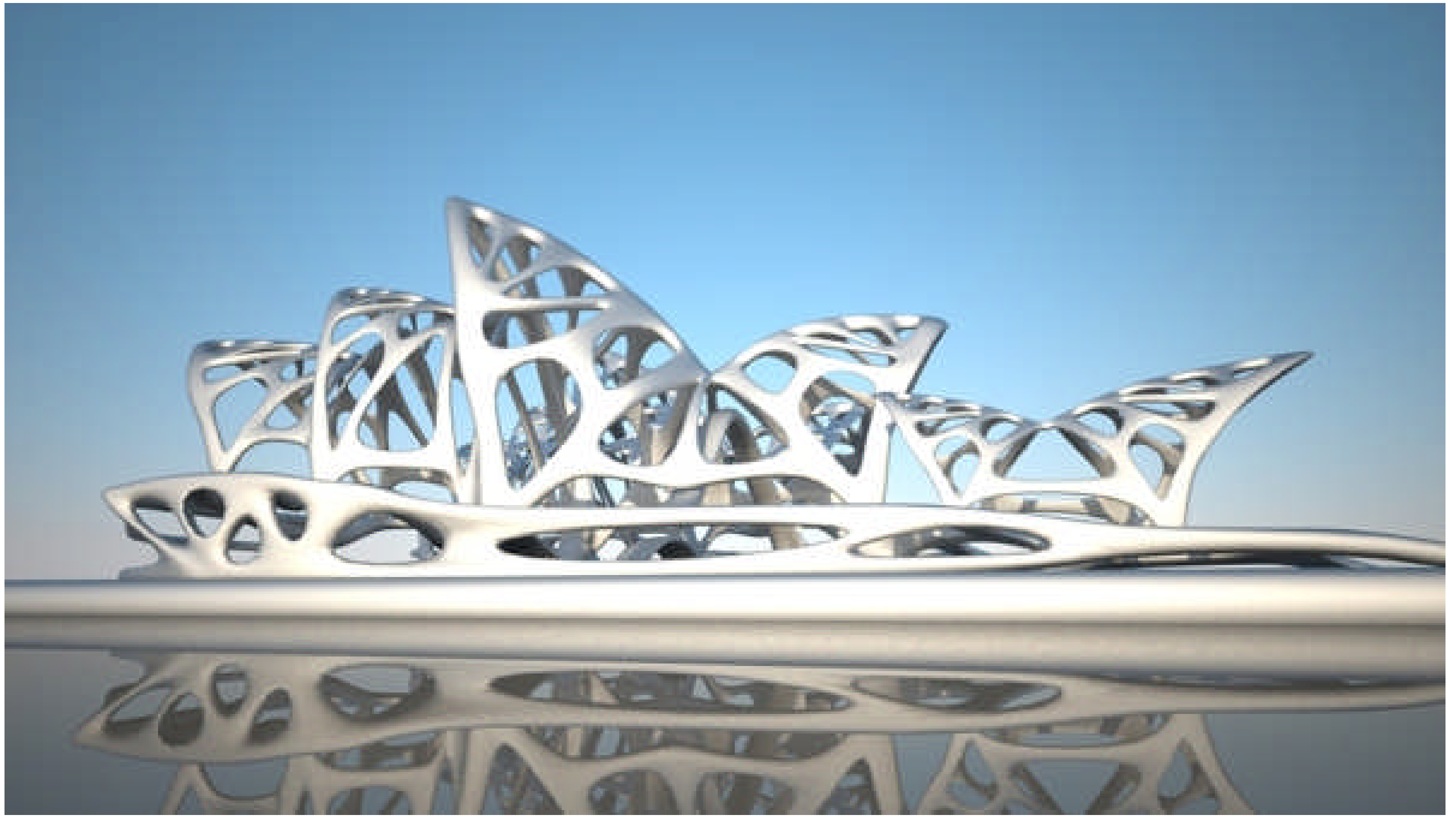
"We have come to the centre of Sydney to send a clear message to Harvey Norman that profiting from the destruction of our spectacular forests is absolutely unacceptable…Our internationally iconic Aussie forests are still being destroyed by industrial logging operations. We are taking peaceful action from the top of another great Aussie icon to tell Harvey Norman that selling Aussie forest destruction is no way to do business."

Ula Majewski, Spokesperson for *The Last Stand*

Anti-Iraq war slogan "NO WAR" painted on the western face (near ridge) of shell A2 (in 2003) by British astronomer *Will Saunders* and NSW central coast environmental lobbyist *David Burgess*.



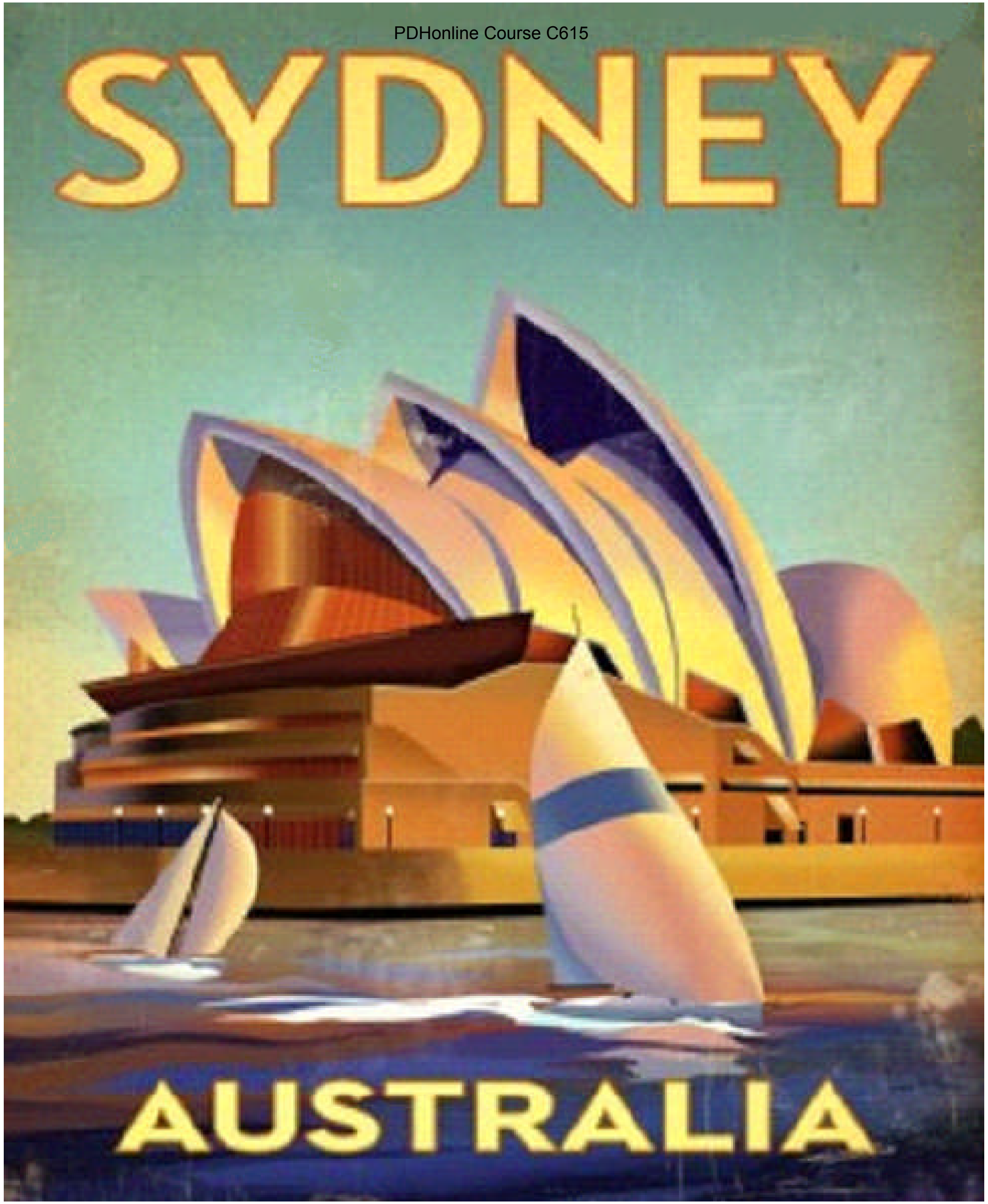
Artists *Christo* and *Jeanne-Claude* visited Sydney in 1969 to wrap the Little Bay coastline in fabric, but Christo conceived another plan for Sydney while there. He created a multimedia sketch and model of a cloth-wrapped SOH. He never carried out the project (SOH was not complete when the pair were first in town) but the concept diagram; *Wrapped Sydney Opera House*, caught the art world's (and Sydney's) attention. To make the image, Christo tied and stapled a piece of cloth to a poster of SOH. He also made a sketch with written suggestions about possible materials (woven polypropylene and concrete blocks) and scribbled a rough plan over an aerial image of Sydney Harbor.



A Living Thing

"I have made a sculpture…you will never be finished with it – when you pass around it or see it against the sky…something new goes on all the time…together with the sun, the light and the clouds, it makes a living thing."

Jorn Utzon, Architect


SYDNEY
AUSTRALIA