PDHonline Course C254 (15 PDH)

Slope Stability

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EXCAVATION AND BACKFILL

1. General. Excavation and backfill in the critical area of a flood control project could have a direct impact on the stability of the flood control project. Improper excavation in the levee embankment or in the critical area can create unstable slopes and slope failures, which damage the levee embankment and weaken the flood protection structure. Additional damages to the levee embankment or flood protection structure can also be caused by underseepage conditions associated with piping and heave. This removal of material from the flood control structure foundation (piping) can ultimately produce collapse of a levee embankment or floodwall. All excavation and backfill activities within the critical area are to be reviewed and approved by the COE and the local sponsor before construction begins.

2. Underseepage. Excavation stability may be influenced by underseepage. Underseepage considerations include methods of determining of the hydraulic grade line through the levee and through the foundation material, which are used for uplift calculations of proposed structures and for stability analysis for excavations and temporary flood control. Underseepage analysis should conform to the recommendations and method summarized in the topic UNDERSEEPAGE.

3. Excavation Requirements. All excavations must meet Federal, State and local criteria, COE safety manual and OSHA criteria. Supplementary requirements for the excavation and backfill in the critical area are as follows:

3.1. Excavation in levee embankments below the freeboard zone must be analyzed to determine the stability of the embankment. The analysis should include the assumptions used, basis for selection of soil parameters, and the failure surfaces and associated factors of safety. Stability of the levee embankment must be maintained at all times. Vertical or unsupported over-steepened side slopes in or through the foundation or embankment will not be permitted. Excavations within the freeboard area should be sloped no steeper than 1V on 1.5H.

3.2. Excavation adjacent to the levees within the limits of the levee-projected slopes should be sloping no steeper than 1V on 1.5H from the bottom of the excavation. Stability analysis may be required for the deep excavations or problem foundations.

3.3. Excavations beyond the projected levee slopes but still within the critical area, should meet Federal, State and local criteria, COE safety manual and OSHA criteria.

3.4. Excavation utilizing sheeting and bracing in lieu of open cut, requires a design analysis for the excavation support system. In the event that the sheeting and bracing method of excavation are used in the critical area, the sheeting and bracing must be removed as the backfill is brought up. In no event shall the bracing or sheeting be left in place permanently. Materials in areas outside of the sheeting and bracing showing evidence of distress will need to be removed, backfilled, and recompacted. The sheeting and bracing should be designed conform to requirements described in TM 5-818-1 and EM 1110-2-2504: Design of Sheet Pile Walls. Trench boxes are allowed outside the levee-projected slope only.

3.5 Dewatering: Dewatering control should conform to the topic DEWATERING.

3.6. Temporary Flood Control should conform to requirements shown in the topic INTERIM FLOOD PROTECTION AND CONTINGENCY PLAN. Stability of the temporary flood control projects, as ring levees, should conform to the topic STABILITY ANALYSIS.

3.7. Excavation in the critical area shall not be performed between flooding season of any year. The flooding season is shown in the INTERIM FLOOD PROTECTION AND CONTINGENCY PLAN. Waivers to this restriction may be obtained from the Corps of Engineers for periods not to exceed 30 days, provided antecedent conditions and potential river stages are favorable. A waiver request should include a contingency plan for high river stages. The contingency plan should conform to requirements shown in the topic INTERIM FLOOD PROTECTION AND CONTINGENCY PLAN. Any work, which potentially weakens a flood protection structure, shall be performed in an expedited manner to minimize the length of time that the structure is weakened. Complete backfill of the excavated area and bulkheading of any drainage structures or other outfalls, will be required within 24 hours if flood stages are forecast. Major excavations in or near mainstream levees are treated on a "case-by-case" basis and further restrictions may be required.

3.8. Slope stability. Slope stability considerations include the determination of appropriate soil shear strengths to perform stability analyses. Excavations into a levee embankment or berm or on channel banks must be evaluated. Slope stability analyses must conform to recommendations and methods discussed in the topic SLOPE STABILITY.

4. Backfill and compaction requirements.

4.1. Crushed rock or other pervious materials will not be permitted within the critical area. An exception can be made for pervious zones existing in the foundation.

4.2. Care shall be taken to replace the natural foundation stratification and embankment zoning. In lieu of selective stockpiling and zoned backfill, impervious materials from an approved borrow may be used.

4.3. Frozen material shall not be used nor shall any fill be placed on frozen surfaces.

4.4. No foundation or embankment backfill shall be placed in standing or running water. Should a quick condition develop, dewatering by well points or other methods, which will nullify the excess gradient, shall be used. Sump pumping will not be permitted.

4.5. Impervious materials such as silts, clays (ML, CL and CH) or semi-impervious materials placed as backfill within the levee embankment, and within the projected embankment slopes, must be placed in loose lifts thicknesses not to exceed 8 inches and compacted to a minimum 95 percent Standard Proctor density determined at optimum moisture content according to ASTM D-698. Moisture control limits are to be within -1% to +3% of optimum.

4.6 Compaction of impervious and semi-impervious materials outside the projected levee

slopes, within the critical area of the flood control project, should be compacted to a minimum of 90 percent of maximum Standard Proctor dry density determined at optimum moisture content according to ASTM D-698, unless otherwise directed. Moisture control limits are to be within -1% to +3% of optimum.

4.7 Compaction requirements of pervious materials. Pervious materials are usually defined as free-draining, cohesionless sand and/or gravel, containing less than approximately 5% passing US Standard 200 screen. Where zoning of the levee or stratification of the foundation permits the use of pervious material, it shall be placed in 6-inch layers in a manner that will prevent segregation. Compaction shall be performed to a minimum of 70% relative density according to ASTM Test D-2049.

4.8 All disturbed areas shall be completely restored to the original condition. This restoration shall include but is not limited to, sodding, seeding, surfacing, slope protection, and bedding restoration.

4.9 Flowable fill used for trench backfill. If flowable fill is used for trench backfill it should conform to the following requirements:

4.9.1 Flowable fill mix:

Material	**Fill Mix (batch weights per cubic yard)**	**Remarks**
Portland Cement, Type I or II (lbs)	at least 100	ASTM C 150 meeting low alkali requirements. Alternately, Ground Granulated Blast Furnace Slag (GGBFS) cement conforming to ASTM C 989 Grade 100 or 120 is acceptable.
Fly Ash (lbs)	at least 275	ASTM C 618, Class N, C, or F. (Class C shall not be used with Missouri River Sand, or other aggregate, which exhibits alkali-aggregate reactivity potential).
Sand, SSD (lbs)	2795	ASTM C 33, concrete fine aggregate. Projects requiring 200 cubic yards or more of flowable fill shall be tested for alkali-aggregate reactivity in accordance with ASTM C 1260. Test results shall indicate measured expansion of less than 0.10% at 16 days after casting.
Total Water (lbs)	no more than 370	Potable source.
Air Entraining Agent, oz.	at least 2	ASTM C 260.
Water Reducing Admixture	As Required to produce a cohesive flowable mixture.	ASTM C 494, Type A or F. See Para. 4.9.3.

4.9.2 Flowable fill strength - The mixture shall have a compressive strength of 100 psi at 28 days age.

4.9.3 Flowable fill consistency - The fresh mixture shall not be thin and watery, but shall have a consistency similar to that of batter. It shall be tested by filling an open-ended 3-inch diameter, 6-inch high cylinder to the top with the mixture and immediately pulling the cylinder straight up. The correct consistency will produce an approximate 8-inch diameter circular-type spread with no segregation.

5. Criteria for borrow areas in the critical area of flood control projects.

5.1 Borrow from historical riverside scour holes is not recommended, since these areas generally consist of soft river sediment deposits. Also, they have probably been backfilled in previous repair efforts to provide for underseepage protection. Scour holes located close to the levee toes were typically filled with a layer of impervious fill to minimize underseepage. Both existing borrow areas and scour holes backfilled by the river should be investigated and underseepage analyses performed before being recommended for borrow sites.

5.2 Although site subsurface investigation and underseepage analysis may indicate that the borrow area does not reduce the safety factor for underseepage below minimum requirements, the minimum suggested distance for locating a borrow area from the levee toe is 100 feet both riverside and landside.

5.3 A minimum 2 foot thick impervious layer should be left on the bottom of the borrow areas in the critical areas of the flood control project, unless underseepage analysis supports a lesser thickness. Also the vertical elevation limits at the bottom of the borrow areas located along the Missouri River should stay 5 feet above the construction reference plane as required in Corps of Engineers Guidance Construction Reference Plane, dated March 1990.

6. Recommended references. The following references contain details regarding the COE requirements for excavation and backfill in levee embankments and within the critical area.

6.1 EM 1110-2-1913, DESIGN AND CONSTRUCTION OF LEVEES, includes the following:

a. Necessary subsurface investigations and laboratory testing to define the foundation of the proposed construction and adjacent levee and to obtain the geotechnical properties for underseepage and stability analyses.

b. Seepage control, including foundation underseepage and seepage through embankments

. c. The topic B “Mathematical Analysis of Underseepage and Substratum Pressure” establishes the method of underseepage analysis, the assumptions and the determination of factors involved in the analysis for different cases.

6.2 EM-1110-2-1901, SEEPAGE ANALYSIS AND CONTROL FOR DAMS, includes the following:

a. Necessary subsurface investigations for determination of soil parameters for groundwater analysis.

b. Determination of permeability of soils in the foundation.

c. Seepage principles, including seepage forces, hydraulic gradients and uplift pressure.

d. Seepage conditions in the presence of relief wells, including well design.

e. Seepage control in earth foundations adjacent to structures, and remedial seepage control.

f. Monitoring of ground water and seepage control features.

g. Seepage control using relief or dewatering wells.

6.3 EM 1110-1-1804, GEOTECHNICAL INVESTIGATIONS, includes the following:

a. Field investigation for determination of the foundation soils parameters for new construction, or temporary flood control projects (geophysical explorations, drilling methods, exploratory excavations, groundwater studies, and in situ testing).

b. Empirical correlations for determination of soil parameters.

c. Laboratory testing necessary.

d. Backfilling of boreholes and exploratory excavations.

6.4 EM 1110-2-1906, LABORATORY SOIL TESTING, describes laboratory testing procedures for obtaining the necessary soil parameters to be used in the design of flood control features.

6.5 EM 1110-1-1906, SOIL SAMPLING, describes the methods and equipment for drilling and sampling of undisturbed or disturbed soil samples from boreholes and exploratory test pits or trenches.

6.6 EM 1110-2-2504: Design of Sheet Pile Walls, includes requirements for sheeting and bracing design.

6.7 TM 5-818-4, AFM 88-5, Chap.5: BACKFILL FOR SUBSURFACE STRUCTURES describes the following.

a. Excavations for structures to accommodate backfill operations.

b. Excavation and preparation for foundation.

c. Backfill operations such as placement, instrumentation, preconstruction distress.

d. Construction control such as excavation control techniques, foundation preparation and control techniques, backfill quality control.

6.8 TM 5-818-1, AFM 88-3, Chap. 7, SOILS AND GEOLOGY PROCEDURES FOR FOUNDATION DESIGN OF BUILDINGS AND OTHER STRUCTURES (EXCEPT HYDRAULIC STRUCTURES), includes information regarding dewatering, ground water control, and excavation support systems (including sheeting and bracing).