## PDHonline Course C254 (15 PDH)

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# Slope Stability

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**2020**

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# SLOPE STABILITY

1. General. Any excavation, which alters the levee or channel bank cross-section, either temporarily or permanently, must be checked to verify slope stability. Placement of stockpiles, heavy equipment, or other surcharges may also cause channel bank instabilities and should be analyzed. Verification of slope stability involves three basic parts: 1) obtaining subsurface information, 2) determining soil shear strengths and 2) determining a potential slide failure surface which provides the minimum safety factor against failure for various river stages. EM 1110-2-1913 and EM 1110-2-1902 provide detailed guidance for preparing a slope stability analysis.

2. Subsurface Information. Subsurface information in the vicinity of the proposed work can generally be obtained from the original levee/channel construction plans. Boring logs shown in these plans may or may not be located close to the work and the engineer must determine if additional subsurface information is needed. Additional boring(s) at the site are generally beneficial. Other completed work in the nearby vicinity may also provide useful information. Soil type, thickness of each soil zone, depth to bedrock, and groundwater conditions must be known to proceed with a slope stability analysis.

3. Selection of Soil Shear Strengths. Soils in and under levees in the Kansas City District usually consist of varying mixtures of sands, silts, and clays. Shear strength of these soils is defined in terms of a friction component ($\varphi$) and a cohesion component (C). C and $\varphi$ can be determined by testing soil samples in special laboratory test apparatus or from special equipment, which can measure these parameters on site. For work in and around an existing levee, using shear strength data from the original levee construction is generally sufficient to verify slope stability. Useful information can also be obtained from correlations with simple soil properties, such as moisture contents and Atterberg limits, and from other nearby projects where soil testing was performed. Common correlations to approximate soil shear strength and other soil properties can be found in the EM=s as well as in soil mechanics textbooks. Methods to determine soil shear strength are discussed to some extent in EM 1110-2-1913 and in more detail in EM 1110-2-1902.

4. Slope Stability Analysis. Methods to perform a slope stability analysis are listed in EM 1110-2-1902. The method required by the Kansas City District is Spenser method.

4.1. Circular failure surfaces can be assumed if soil conditions are determined to be relatively homogeneous. If soil conditions are not homogeneous or if geologic anomalies exist, slope failures may occur on non-circular shear surfaces. For these conditions, non-circular failure surfaces should be analyzed. All circular as non-circular failure analyses should utilize the Spencer=s procedure. Commercially available computer programs, which offer several analysis procedures, are useful for slope stability problems.

5. Required Safety Factors. EM 1110-2-1913 indicates the required safety factors for levees. The following factors of safety are required:

| Design Condition | Minimum Factor of Safety |
|---|---|
| End of Construction | 1.30 |
| Sudden Drawdown (riverside slope only) | 1.20 (for rivers where high stages are likely to persist for long periods before drawdown)<br>1.00 (for creeks and rivers where the high stages are unlikely to persist for long periods preceding drawdown) |
| Intermediate river stage (riverside slope only) | 1.40 |
| Steady Seepage from full flood stage (landside slope) | 1.40 |

The following safety factors apply for channel slopes only:

| Design Condition | Minimum Factor of Safety |
|---|---|
| During Construction Case | 1.10 |
| End of Construction Case | 1.25 |
| Long Term (Drained) Case | 1.25 |

6. References. The following references can be used for evaluation of slope stability.

6.1. EM 1110-2-1913; Design and Construction of Levees includes the following:

a. Necessary field investigation and laboratory testing to obtain the design soil strength parameters.
b. Recommended methods for stability analysis.
c. Required factors of safety.

6.2. EM 1110-2-1902; Engineering and Design, Stability of Earth and Rockfill Dams, includes the following:

a. Basic design considerations for earthen embankments.
b. Determination of soil strength parameters.
c. Methods of stability analysis.

d. Design conditions for analysis.