SLOPE STABILITY EVALUATION AND ACCEPTANCE STANDARDS

A. PURPOSE

This Information Bulletin is to provide uniform requirements for evaluation of and standards for acceptance of stability of slopes within the City of Los Angeles. These requirements include consideration of pertinent engineering geologic and soils engineering factors of the critical field conditions that may reasonably be expected at the project location. These requirements include documentation and recommendations needed to determine if the site as proposed to be developed has an acceptable level of stability.

B. APPLICATION

A stability evaluation will be required for cut, fill and natural slopes whose gradient exceeds two horizontal to one vertical (2:1) and for all slopes that expose incompetent bedrock or unfavorable geologic structure such as unsupported bedding or that contain evidence of prior instability or landslide activity. Analysis is to include deep-seated and surficial stability evaluation under static load conditions. Where the site is within a State of California Seismic Hazard Zone requiring investigation for seismically induced landslide, or where the Department requests, a seismic slope stability analysis is required.

C. SAFETY REQUIRED

The Municipal Code specifies 1.5 as the minimum acceptable static factor of safety for cut, fill, and natural slopes.

Safety factor is defined as the quotient of the sum of forces tending to resist failure divided by the sum of forces tending to cause failure.

1. New buildings and additions to buildings may be constructed on or adjacent to a cut, fill, or natural slope provided that:
   a. The slopes have an evaluated safety factor of at least 1.5 against deep-seated static failure.
   b. The slopes ascending above proposed structures have an evaluated safety factor of at least 1.5 against surficial failure or adequately designed protective devices are recommended that will protect the construction from the hazard of mud and debris flow. When protective devices are used, the owner shall record an affidavit with the Office of the County Recorder stating that specified areas of the site may be subject to mudflow hazard and notifying future owners of their responsibility to provide maintenance of the protective devices (7014.3).
   c. The slopes have an evaluated safety factor of at least 1.0 against seismic deep-seated failure.

2. Minor additions or alterations may be made to existing structures where acceptable devices are provided to mitigate potential damage from failure of adjacent slopes and where the hazard to life or property is not increased.

D. DESIGN OF PROTECTIVE DEVICES

Protective devices shall be permanent structures designed to either isolate, contain, deflect or channelize any potential mud or debris flow. The design and construction details shall be based upon an estimate of the volume and location of containment area made by a soils engineer or engineering geologist.

The devices shall be located so that any potential surficial failure will be confined to remote or unused portions of the property at least 15 feet from all structures unless such portions are designed as permanent channels to prevent the accumulation of mud and debris. Remote or unused portions of the property shall not include accessory areas such as pools, driveways, parking or landscaped areas. Mud and debris shall not be diverted onto adjoining property.

Provision shall be made for reasonable access to all areas which may need future maintenance.

E. TYPE OF ANALYSIS

1. **Deep-Seated Stability**

   Evaluation of slopes for safety factor against deep-seated failure shall be in general conformance with the following:

   a. The potential failure surface used in the analysis shall be composed of arcs, planes or other shapes considered to yield the lowest factor of safety and to be most appropriate to the soil and geologic site conditions. For reasonably homogeneous soils, an arcuate failure surface is considered adequate. In cohesive soils, a vertical tension crack may be used to aid in defining the potential failure surface. The potential failure surface having the lowest safety factor shall be used in the analysis.

   b. Loadings to be considered are gravity loads of potential failure mass, seepage forces and external loads. The potential for hydraulic head is to be evaluated and its effects included when appropriate. Soils below the piezometric surface shall be assumed saturated.

   c. An appropriate mathematical analysis method shall be chosen for the case analyzed. Simple planar failure surfaces can be analyzed by force equilibrium methods. Bishop's Method shall only be used for circular failure surfaces. Taylor's Method shall only be used for homogeneous simple slopes.

2. **Steep Rock Slope Stability**

   Analysis of nonconforming slopes whose gradient is one horizontal to one vertical (1:1) or steeper, exposing bedrock shall include the following:

   a. Detailed mapping and description of discontinuities; such as joints, fractures, and faults, with characteristics such as orientation, spacing, presence of infilling or openness, continuity, etc.

   b. Detailed mapping and description of rock falls (fallen boulders), pop-outs, and wedge failures that may have occurred on the slope.

c. Kinematic analysis of discontinuities relative to the slope face, using stereographic methods to assess potential planar, wedge and topple type failures.

d. Slope stability analysis of the potential failures using appropriate methods for the type of failure identified from the kinematic analysis.

3. **Surficial Stability**

Evaluation of the slope surface for safety factor against surficial failure shall be based either on analysis procedures for an infinite slope with seepage parallel to the slope surface or on other methods approved by the Department. For the infinite slope analysis, the assumed depth of soil saturation shall be a minimum of three feet or the depth to firm bedrock, whichever is shallower. Soil strength characteristics used in analysis are to be obtained from representative samples of surficial soils that are tested under conditions approximating saturation.

4. Seismic Stability

a. Ground motions used to evaluate slope stability shall be obtained based on methods prescribed in the 2017 LABC. Ground shaking hazard maps found in previous Seismic Hazard Zone Reports released before 2008 shall no longer be used to estimate ground shaking.

b. For the peak ground acceleration (PGA) corresponding to two-thirds of the PGAM (Maximum Considered Earthquake-Geometric Mean, MCEG adjusted for site effects ASCE 7-10 Eq. 11.8-1), the seismic coefficient, keq (Special Publication 117A, 2008 "Guidelines for Evaluating and Mitigating Seismic Hazards in California", Page 29), shall be derived based on a displacement of 5 cm where potential failure planes intersect buildings, otherwise a maximum displacement of 15 cm may be assumed. A minimum safety factor of 1.0 is required. The predominant earthquake magnitude and distance to the seismic source may be obtained from the USGS Interactive Deaggregation web site: https://geohazards.usgs.gov/deaggint/2008/. A 10% probability of exceedance in 50 years (475-year return period) may be used (either modal or mean pair of values may be used).

c. For sites consisting of soils that are liquefiable under the PGAM slope deformations shall be determined using the seismic coefficient, Keq, corresponding to the PGAM. The predominant earthquake magnitude and distance to the seismic source may be obtained from the USGS Interactive Deaggregation web site: https://geohazards.usgs.gov/deaggint/2008/. A 2% probability of exceedance in 50 years (2475-year return period) shall be used (either modal or mean pair of values may be used). Deformations of any foundations located near the slope shall be such that the foundations of the buildings or other structures do not lose their ability to carry gravity loads and that collapse of the building or other structures is prevented.

d. Requirements in item “c” above shall not apply to buildings and other structures that fall under Risk Category IV per Table 1604.5. They shall be evaluated based on a project-specific basis using the appropriate performance requirements.

F. MATERIAL PROPERTIES

The soil engineer shall use sound judgment in the selection of appropriate samples and in the determination of shear strength characteristics befitting the present and anticipated future slope conditions. To best accomplish this phase of the analysis, the project engineering geologist shall advise the soil engineer on pertinent geologic conditions and materials observed during the site investigation. The following guidelines are provided for evaluating soil properties:

1. Soil properties, including unit weight and shear strength parameters (cohesion and friction angle), shall be based on field and laboratory tests. Tests shall be made on an appropriate number of samples removed from test pits that represent the material in a particular slope. At least one test shall be made on the weakest plane or material in the area under test and shall be made in the direction of anticipated slippage.
2. Testing of earth materials shall be performed by an approved soil testing laboratory in accordance with Section 98.0503 of the Code.
3. Shear strength parameters used in stability evaluations may be based upon peak test values where appropriate. Parameters not exceeding residual test values shall be used for previous landslides, along bedrock bedding planes, highly distorted bedrock, over-consolidated fissured clays and for organic topsoil zone under fill.
4. Prior to shear tests, samples are to be soaked to approximate a saturated moisture content. Saturated shear tests shall be performed with the samples inundated in water during testing. Shearing strain rates/conditions are to be consistent with the material types and drainage conditions used in analyses.
5. An arbitrary residual angle of shearing resistance of six degrees and cohesion of 75 pounds per square foot may be used to represent the strength on shale bedding and in landslide debris in lieu of parameters determined by laboratory testing.
6. Analysis of failures of existing slopes that are similar to the slope under consideration in terms of location, configuration, height, geology and materials may be used to establish shear strength parameters.
7. Soil strength characteristics of off-site slope materials may be based upon tests of similar materials or nearby properties when both the engineering geologist and the soil engineer demonstrate a basis for assuming that the off-site materials possess strength characteristics equivalent to the material tested.

G. CONTENTS OF REPORTS

A Geotechnical Report shall be submitted to the Department which complies with applicable portions of the standard guidelines adopted as California Division of Mines and Geology Notes Number 44 and the following items:

1. Recommendations for site development that will provide at least the level of stability specified in Section C of this Bulletin.
2. An assessment of potential geotechnical hazards affecting the site.
3. A statement regarding location of potential ground water that may develop within the slope during and/or after major storm seasons and measures needed for ongoing stability.
4. Description of exploration performed as required by Information Bulletin No. P/BC 2017-068 entitled, "Rules and Regulations for Hillside Exploratory Work."

5. A plot plan and a topographical plan showing locations of test pits and the areas they are assumed to represent.
6. A complete description of the shear test procedures and test specimens.
7. Shear strength plots that include the identification of sample tested, whether values reflect peak or residual strengths, shearing strain rate, moisture content at time of testing, and approximate degree of saturation.
8. Comment on sample selection and a stated opinion that the samples tested represent the weakest material profile along with the potential failure path.
9. Calculations and failure surface cross sections used in stability evaluations.
10. General comments as to the stability of slopes from the effects of earthquakes concerning ground rupture, landslides and differential movement.
11. Detailed log of earth materials observed in test hole borings and test trenches to include characteristics such as bedding attitudes, joint spacing, fault zones, location of bentonite beds, etc.
12. Recommended drainage devices, including sub-drain systems below fills and behind stabilization structures.