GROUND FAILURE/LIQUEFACTION

This guideline addresses the general engineering geology review of developments in areas that have been designated to have a potential for liquefaction and associated lateral spreading. The Los Angeles County Building Code, State of California Seismic Hazard Mapping Act (SHMA), DMG Special Publication SP117, California Seismic Hazard Mapping Regulations ("Article 10") and Recommended Procedures for Implementation of DMG Special Publication 117 prepared by the Southern California Earthquake Center were utilized in developing this guideline.

The State Mining and Geology Board recommends that "engineering geologists and civil engineers conduct the assessment of the surface and subsurface geological/geotechnical conditions at the site, including off-site conditions, to identify potential hazards to the project. It is appropriate for the civil engineer to design and recommend mitigation measures. It is also appropriate for both the engineering geologists and civil engineers to be involved in the implementation of the mitigation measures – engineering geologists to confirm the geological conditions and civil engineers to oversee the implementation of the approved mitigation measures."

An engineering geology and/or soils engineering report that addresses the potential for liquefaction and associated settlement and lateral spreading is generally required. The report(s) must minimally include and consider the following:

a) A description of the proposed project's location, topographic relief, drainage, subsurface geologic conditions, and proposed grading.

b) A site plan of the subject site showing the locations of all test pits, borings, penetration test locations, and soil or rock samples obtained.

c) Local and regional geologic maps showing bedrock, alluvium, colluvium, soil material, faults, shears, joint systems, lithologic contacts, seeps or springs, and other pertinent geologic and soil features existing on and adjacent to the project site.

d) Logs of borings, test pits, or other subsurface data obtained. SP117 states (chapter 6) that "In general, liquefaction hazards are most severe in the upper 50 feet of the surface, but on a slope near a free face or where deep foundations go beyond that depth, liquefaction potential should be considered at greater depths." Therefore, a minimum depth of 50 feet below the existing ground surface should be investigated for liquefaction unless geologic conditions preclude the potential for liquefaction occurring at such depths.

e) Geologic cross sections depicting geologic structure, stratigraphy, and subsurface water conditions, supported by boring and/or trench logs at appropriate locations.

f) The groundwater level to be used in the liquefaction analysis. SP117 requires that the analysis of hydrologic conditions consider the current, historical, and potential future depth to subsurface water. The historic high groundwater level should be used in the liquefaction analysis unless information obtained indicates that an alternate level is appropriate.

g) Description of seismic setting, historical seismicity and methods and/or sources used to determine earthquake ground-motion parameters used in the liquefaction analysis. For high occupancy structures it is common practice to use a deterministic seismic hazard analysis with a median-plus-one-standard-deviation (84th percentile) in developing ground motion estimates. The consulting engineering geologist must provide ground motion parameters using either the deterministic or the probabilistic method as follows:

h) Liquefaction analysis

<u>Probabilistic:</u>

Earthquake magnitudes and associated peak ground accelerations (PGA) based upon simple prescribed parameter values (SPPV) generated by the Department of Conservation may be used. These maps are included in the Seismic Hazard Evaluation Reports issued by DMG. PGA is dependent on site conditions and several maps have been prepared to accommodate these differences. Refer to SP117 for further details.

In-lieu of utilizing SPPV, a site-specific probabilistic seismic hazard analysis may be performed, and can supersede the SPPV values of PGA. Earthquake magnitudes must be based upon the current California Geological Survey Fault Model (fault catalog) along with the associated PGA utilizing recently published attenuation equations. The probabilistic seismic hazard analysis must utilize a hazard level of at least 10 percent probability of exceedance in 50 years. All input and output data files (Dat, Out, Raw) associated with the computer program (e.g. FRISKSP) must accompany the geotechnical report as hard copies.

Any modifications to the program, standard user-selected input parameters, or the current California Geological Survey and Geology Fault Model, must be justified. It is important that the difference in duration of various earthquake magnitudes be accounted for when performing liquefaction analysis. Therefore, magnitude weighting must be performed per Idriss (1985)*. Magnitude Weighting Factors used in FRISKSP should be equivalent to the inverse of the Magnitude Scaling Factors used in the engineering analysis for liquefaction. Attenuation equations and values must reflect the use of current literature and

site conditions. Attenuation relations produced by Campbell (1997), Joyner & Boore (1997), and Sadigh, et al. (1997) are acceptable** using the standard deviation on the attenuation functions. The geotechnical consultants must conduct the analysis utilizing all three of the above attenuation relations and then submit a discussion and conclusions justifying the seismic parameters utilized in the liquefaction analysis. The geotechnical consultants must justify all input parameters and certify the integrity of the data and program utilized in generating magnitudes and peak ground accelerations.

-OR-

Deterministic:

Earthquake magnitudes based upon the current California Geological Survey Fault Catalog may be used along with associated PGA determined utilizing published attenuation equations. Attenuation equations and values must reflect the use of current literature and site conditions. Attenuation relations produced by Campbell (1997), Joyner & Boore (1997), and Sadigh, et al. (1997) are acceptable**. The geotechnical consultants should utilize the average ground motion obtained from the three attenuation relations in the liquefaction analysis. Again, for high occupancy structures, it is common practice to use a deterministic seismic hazard analysis with a median-plus-one-standard-deviation (84th percentile) in developing ground motion estimates.

NOTE: The results of the submitted site-specific seismic hazard analyses will be reviewed by utilizing a probabilistic seismic hazard analysis (PSHA); a hazard level of 10 percent probability of exceedance in 50 years; the current California Geological Survey Fault Catalog; the most updated version of FRISKSP by Thomas F. Blake; attenuation relations produced by Campbell (1997), Joyner & Boore (1997), and Sadigh, et al. (1997); and standard user-selected input parameters unless otherwise justified by the geotechnical consultants. Seismic parameters recommended by the geotechnical consultants are acceptable if they are greater than or equal to values obtained using these criteria.

i) Consideration of the geologic factors that may control or affect the severity of potential hazards (e.g., site-specific response characteristics due to amplification of soft soils, deep sedimentary basins, topography, near-source affects, etc.)

j) The engineering geology report must comply with and contain a finding in accordance with Sections 110 and 111 of the Los Angeles County Building Code.

k) Discussion of proposed mitigation measures, if any, necessary to reduce potential damage caused by liquefaction.

l) Consideration of general guidelines of the DMG “Notes 42, 44, and 48."

For "projects" governed under the State of California Seismic Hazard Mapping Act and Article 10 (Section 3724):

a) The required report(s) shall be prepared by a certified engineering geologist and/or registered civil engineer, having competence in the field of seismic hazard evaluation and mitigation.

b) The required report(s) shall be reviewed by a certified engineering geologist and/or registered civil engineer, having competence in the field of seismic hazard evaluation and mitigation.

c) A copy of all geotechnical reports must be sent to the State Geologist within 30 days of plan approval.

References:

* Idriss, I. M. (1985), “Evaluating Seismic Risk in Engineering Practice,” Eleventh International Conference on Soil Mechanics and Foundation Engineering, vol. 1, pp. 255-320.

** As used by DMG OFR 96-08 / USGS OFR 96-706