SURFACE FAULT RUPTURE HAZARD INVESTIGATIONS

This information bulletin provides a general guideline for conducting surface fault rupture hazard investigations (fault investigation) within the City of Los Angeles. Fault investigation reports submitted to the Los Angeles Department of Building and Safety (LADBS) shall be based upon sufficient geologic data to determine the location or nonexistence of active fault trace(s) on the site. In addition to this Information Bulletin, geologists conducting fault investigations should use California Geological Survey (CGS) Special Publication 42 and Note 49, which provide detailed guidelines and suggested format for fault investigations.

I. AREAS REQUIRING FAULT INVESTIGATIONS

Fault investigations are required by the City of Los Angeles for projects located within an official or preliminary Aquist-Priolo Earthquake Fault Zone (APEFZ); and/or within a City of Los Angeles Preliminary Fault Rupture Study Areas (PFRSA). The PFRSA's have been established along faults considered active within the City boundaries that the CGS has not yet zoned; including the Palos Verdes, and Santa Monica. The City's previous PFRSA for the east Hollywood/West Raymond fault has been superseded by the CGS's preliminary revised APEFZ for the Los Angeles Quadrangle issued December 15, 2016. An official APEFZ for this area is expected in March of 2017. See NavigateLA for the locations of the City PFRSA's. Projects exempted from fault investigations are discussed in P/BC 2017-44.

II. GENERAL REQUIREMENTS

Fault investigations must be conducted by a licensed California Certified Engineering Geologist or Professional Geologist who is experienced with fault investigations, at the discretion of the Grading Division of LADBS.

A. Research

A licensed professional shall conduct research as outlined below.

1. Review published literature and maps regarding regional geology, faults, and other pertinent information.
2. Search City and State records for fault investigation reports for properties in the site vicinity. The geotechnical reports may also provide useful information, including geologic units and groundwater levels.
3. View stereographic aerial photographs and/or old U.S. Geological Survey maps to evaluate geomorphic features, soil or vegetation contrasts, or lineaments suggestive of faulting.
4. Evaluate site-specific maps and plans to assess appropriate scope of the field investigation. A site visit is highly recommended prior to planning the field work.

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B. Field Investigation

An important goal of a fault investigation is to directly observe continuous strata of late Pleistocene age to rule out State defined active faults (see Special Publication 42 for further information on definitions, etc.). Direct observation by exploratory trenching is the best method of investigation. However, consultants are encouraged to discuss the proposed scope of work with the Grading Division reviewing geologist prior to conducting the field work. The reviewing geologist shall be invited to observe open trenches.

The following is an outline of various exploratory methods, associated requirements and suggested considerations:

1. **Trenches**: As stated above, trenches are the preferred method of fault exploration. Trench excavation shall be done in a safe manner. The following is required by the Department:
   a) Consulting firms conducting trench exploration are required to have their annual CalOSHA permit current. Proof of the annual permit and notification to CalOSHA of the specific project shall be on site at all times.
   b) Underground Service Alert must be notified at least 2 days prior to excavation. Consideration should also be given for the use of a private utility locator utilizing electromagnetic utility locating techniques and/or ground penetrating radar to map out the location of known or suspected utilities.
   c) Permits from the Department of Public Works are required for excavations in the public right-of-way.
   d) CalOSHA regulations regarding trench safety shall be followed, with appropriate shoring and/or benching, ladders and/or exit ramps, etc.
   e) Trenches left overnight shall be secured by locked fencing. In some cases it may be appropriate to cover the trenches with steel plates or chain link fencing for an added precaution.
   f) The Department's reviewing geologist shall be invited to observe the trench after they are secured; shored or benched; cleaned; and a string line or grid reference system is in place. A completed field log is preferred but not necessary.
   g) For major projects, invitation to CGS geologists and other paleoseismic experts to view trenches is strongly encouraged.
   h) A grading permit is required to backfill the trench with primary or secondary certified fill. Otherwise, backfill will be considered uncertified.
   i) Spoil piles should be protected from erosion during the rainy season and not encroach neighboring property.
   j) Trenches should not remove lateral support from adjoining property, buildings on or off the site, or public right-of-way.

2. **Logging:** Trench walls must be sufficiently cleaned to expose geologic features and to conduct proper logging. A leveled string line with stationing is usually required. The minimum scale for logging is 1 inch = 5 feet. All geologic features should be logged and described in

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detail. Emphasis should be placed on defining and describing contacts between recognized geologic units. Use Munsell color chart and notation to describe color. Pedologic development features should be described, if present.

3. **Transects:** Transects of borings and Cone Penetrometer Tests (CPT's): Many properties within the City of Los Angeles are occupied by structures with little room outside the building footprint. As such, there is typically not enough room to trench, especially where significant depth is required to reach Pleistocene sediments. In this case a series of borings, either down-hole logged bucket auger borings or continuous core borings should be used. The borings should be sufficient in number and spacing to allow valid correlations and interpretations. Boring depth must be sufficient to expose geologic features used to support conclusions, which usually requires two or more Pleistocene units or marker beds. Borings should be logged in detail, similar to a fault trench. Intermittently sampled geotechnical borings are not adequate for fault investigations, although they may provide supplemental information.

4. **Cone Penetrometer Testing (CPT):** CPTs can be used to supplement boring transects. They should not be used as the only method of exploration. Continuously cored borings are required to identify and correlate units indicated in CPT soundings.

5. **Data Point Spacing:** For boring/CPT transects, the exploration points should be sufficiently spaced to adequately identify continuous beds (marker beds) of Pleistocene age. While the spacing of the initial exploration may be relatively wide, 25 to even 50 feet apart, depending on the depositional environment, the geologist should plan on additional borings and/or CPTs after the initial exploration where continuous bedding is not clear. Thus, exploration should typically have at least two stages. Discussing the results of the initial exploration with the reviewing City geologist is encouraged and preferable relative to submitting a report that is not supported by sufficient exploration.

6. **Orientation of Exploration:** Trenches and transects should be oriented perpendicular to the regional trend(s) of faulting.

7. **Data Point Location:** Trench terminations, boring, CPT and fault locations should be surveyed by a licensed surveyor.

8. **Groundwater:** If groundwater is encountered in borings, measure the static depth, which usually requires waiting some of time after drilling. However, be careful when groundwater is perched. In that case, the saturated limits may only be able to be determined during drilling.

9. **Geophysical methods:** High resolution seismic reflection, ground penetrating radar, residual gravity and other geophysical surveys may be used as indirect methods to target subsurface exploration or supplement subsurface exploration. However, geophysical methods should **not** be considered as an alternative to subsurface exploration.

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C. Age-Dating Techniques

Determining the age of geologic units is critically important in assessing the age of fault activity. The following methods may be used for age-dating.

1. **Radiocarbon (^{14}C) dating:** This isotopic method produces a numerical-age and has optimum resolution in the age range of interest for evaluating active faulting. However, this method depends on the availability and preservation of carbon. It is also subject to errors due to contamination. In general, true detrital carbon is the optimal sample. Bulk samples are likely subject to contamination from organic compounds in groundwater, especially if there is little original carbon in the soil. Testing bulk soil samples with little organic content is not encouraged by the Department. Laboratory documentation should be included in a report that contains radiocarbon dates. A color photograph of the tested sample is also encouraged.
2. **Thermoluminescence (TL) and Optical Stimulated Luminescence (OSL) dating:** TL/OSL dating is a relatively new method of dating late Quaternary sediments. Laboratory documentation should be included in a report that contains TL or OSL dates.
3. **Soil-Profile Development:** The relative age of soils are commonly determined by the degree of soil development. Ages are estimated based on comparisons with other published and dated soil profiles, such as using the Soil Development Index discussed in Harden (1982). All geologists conducting fault investigations within the City should be familiar with the basic principles of soil development, as well as Quaternary climatic cycles upon which chronostratigraphic units are commonly correlated. The glacial and interglacial periods designated by Marine Isotope Stages (MIS), or also referred to as Oxygen Isotope Stages (OIS), is a common reference for delineating chronostratigraphy. Detailed soil profiles should be described using standard procedures and terms such as those provided in the Field Book for Describing and Sampling Soils (available from the National Soil Survey Center's website). In addition, there are experts in this field that should be subcontracted if the project geologist is not experienced and confident to provide adequate descriptions and age estimates.

D. Report Contents

Once the field exploration and geologic analysis are completed, the geologist should carefully assess whether there is enough data to provide definite conclusions and recommendations. Geologic consultants should advise their clients that it is common for additional exploration to be required if data from the initial phase is inconclusive. If there is doubt, the geologist may discuss the results with the Department's geologic reviewer before submitting a report.

The contents of a typical Fault-Rupture Hazard Report are outlined below:

1. **Introduction**
   a. Purpose of investigation
   b. Description of site location, size, configuration and existing conditions
   c. Description of proposed project

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2. **Scope of Investigation**

Describe the methods and procedures used to evaluate the fault rupture hazards at the site.

3 **Geologic Setting**

Describe the major geomorphic and geologic features in the area of the site based on published or unpublished literature, maps and reports from nearby sites. The discussion should include the following:

a. Geomorphic and physiographic features of the site area

b. Geologic/stratigraphic units and geochronology

c. Geologic structure

d. Groundwater

e. Geologic history

4. **Site Specific Geology**

Describe the geomorphology and geology of the site based on the data obtained from the field exploration and data analysis. The discussion should include the following:

a. Stratigraphy and Geochronology: Describe the stratigraphic and pedological units. Describe contacts, unconformities, sedimentary environment, and other relationships of the geologic units.

b. Geologic Structure: Describe the attitudes of bedding, fractures, joints, faults, etc. Provide details on the fault features (e.g. gouge, breccia, continuity, flower structures, slickensides, etc.). Discuss folding and warping, if present.

c. Fault Characteristics: Discuss relative displacement of units across faults and include continuity of the thickness of geologic units across faults. Discuss the latest age of unfaulted sediment. Describe the width of fault/deformation zones. If possible, describe features that indicate multiple events and earthquake history.

5. **Conclusions**

a. Provide a specific professional opinion regarding the existence or absence of active, potentially active or inactive faults on the site, per State definitions.

b. Provide an assessment of the probability of minor off-fault ground rupture in areas in close proximity to fault traces.

6. **Recommendations**

a. If an active fault is located on or adjacent to the site, recommend an appropriate structural setback zone (see III and IV).

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b. If appropriate, reduced structural setbacks where the possibility of minor off-fault rupture may exist, reinforced foundations can be considered. Provide an estimate of the anticipated horizontal and vertical offsets.

7. **References**

Cite all pertinent published and unpublished literature, reports, documents, maps, aerial photographs, or other information used in support of the investigations, conclusions and professional opinions.

8. **Illustrations**

a. Index or Location Map – Show the site on a USGS 7.5 minute quadrangle map. If in or near an A-P Zone, use the A-P map as a base.

b. Local Fault Map – Show the site on a map with previously mapped fault locations.

c. Geomorphic Map – Show the site on the old (>1930's) USGS topographic map with the prominent geomorphic features labeled, such as alluvial fans, major drainages, uplifted terraces or slopes, possible scarps, flood plains, etc.

d. Geologic Map – Include a detailed site geologic map with immediate vicinity. This map should be at a regular engineering scale, no smaller than 1" = 40'. Include the following:

- All geologic contacts, including buried contacts. Query marks can be used where uncertain. If a thin layer of artificial fill covers the site, it need not be included on the map.
- All geologic structures, including faults, shear zones, and folds. Show attitudes for all bedding and structural features.
- All exploration; trenches, test pits, borings and CPTs. Significant locations, such as active faults, trench limits, borings and CPTs should be surveyed.
- Static groundwater depths with date of reading.
- Locations of Geologic Cross Sections
- Setback zones and buildable areas if needed.

e. Geologic Cross Sections/Transects – In general, include geologic features described above. Include horizontal and vertical scales (these should generally be the same). Show the orientation of the cross section and any intersections with other cross sections. Label all prominent marker beds and paleosols. Indicate the distance and boring or CPT is projected to the cross section. For the PDF version of the report, allow the layers of the drawing to be turned off so that just the raw CPT data can be seen (i.e. tip resistance and/or sleeve friction).

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f. Graphic Logs of Exploratory Excavations – For all exploration logs, include date of exploration and indicate the identity of the logger.
   - Trench Logs – Trenches should be logged in detailed at a minimum scale of 1” = 5’. The logs should not be generalized or diagrammatic and should include vertical and horizontal scale (no vertical exaggeration). The bearing of each linear trench or linear trench segment should be indicated. A legend of symbols and detailed description of the recognized units should be presented on each log sheet. Show the entire trench profile. Benches, slopes and shoring should be indicated, but should not obscure geologic details represented on the log. Emphasis should be placed on defining and describing contacts and intervening units. Include bedding and fault attitudes. Show and describe sedimentary structures and paleosols. Include chronostratigraphic data if possible. Show locations of radiocarbon samples.
   - Continuous Core Borings – Include a detailed graphic log and/or photograph of the retrieved core. Include core runs and percent recovery. Indicate prominent marker beds and paleosols, groundwater depth, etc.
   - CPTs – High quality color prints of the CPT logs should be provided as well as the numerical data.

g. Photographs – It is commonly appropriate to include color photographs of trenches, transect locations, etc.

III. SETBACK REQUIREMENTS

Building setbacks from active fault traces are key recommendations provided in fault investigations. The default building setback from an active fault is 50 feet. Reduced setbacks can be considered if the location, trend and nature of a particular fault trace are accurately established by several data points.

Where exploration does not extend 50 feet beyond a property line within a fault investigation zone, an active trace at the property line must be considered present and require a setback. Data from adjacent or nearby sites can be used to possibly reduce a property line setback. Setbacks and buildable areas shall be clearly shown on the geologic map/site plan, and included in the report.

Special/reinforced foundations may be used to mitigate minor ground displacements that could occur near a more significant fault trace. If special foundations are used, the report shall show a special foundation area on the geologic map/site plan.

The amount of anticipated horizontal and vertical offset shall be provided in the report to provide design criteria to the structural engineer.

IV. REQUIREMENTS FOR SINGLE-FAMILY RESIDENCES

The City requires investigations for single-family residences, even if an existing residence is to be replaced. See Information Bulletin P/BC 2017-44 for exemptions. Consultants are encouraged to call the Grading Division’s reviewing geologists if considering reducing a fault investigation scope. The requirement to explore 50 feet beyond the property does not apply for single-family residences.

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