Technical Note

Occupancy Categories for Structural Mitigation of Sympathetic Faults

CHAD E. WELKE

26047 Jefferson Avenue, Suite C, Murrieta, CA 92562

INTRODUCTION

A multitude of possibilities exist when designing structures near potential surface fault rupture. The following Occupancy Category methodology could be used to supplement the existing requirements of the Alquist-Priolo Act (Hart and Bryant, 1997). The Alquist-Priolo Act currently does not allow for mitigation of any surface fault expression. For seismic design (shaking resistance), structures with different levels of importance are treated differently in the California Building Code (CBC) (California Building Standards Commission, 2007). Thus, essential facilities should be treated differently with regard to surface fault rupture by interweaving the Alquist-Priolo Act with the CBC. The main fault rupture surface(s) would continue to be avoided, as is currently required in the Alquist-Priolo Act, but with options for sympathetic faults. Sympathetic faults shall be defined herein as faults that are in close proximity to better-defined, more-established main fault rupture surface(s).

DISCUSSION

Structural mitigation options may include mat-type foundations, cantilevered foundations, grading options, etc. The primary option anticipated for structural mitigation would consist of various mat-type foundations, as a result of their tendency to slide rather than shear during horizontal surface rupture, as presented by Professor Jonathan D. Bray at the 2009 Shleman Specialty Conference (Shlemon, 2010). In order to implement structural mitigation options for sympathetic faulting, the appropriate occupancy categories determined from Table 1604.5 of the CBC (see Table 1)—along with the criteria found in Table 2—are proposed. Table 2 summarizes the proposed interweaving of the Alquist-Priolo Act with the CBC requirements recommended herein. The Structural Mitigation Minimum Nos. I through IV (mat foundations, grading, etc.) found in Table 2 would serve as predetermined minimum structural requirements. The requirements for Structural Mitigation Minimum Nos. I through IV would be determined in the future with input from engineering geologists, geotechnical engineers, and structural engineers. To a large extent, the field exploration guidelines provided in the Alquist-Priolo Act would remain the same.

A depth of 4 ft (1.2 m) was chosen in order to be near the bottom of most residual soil profiles and to help minimize exploratory fault trench depths for sympathetic faults. More importantly, should rupture occur, this depth will provide a minimum amount of earth materials with which to help absorb vertical movement before the movement reaches the surface. If during exploration the exposure is not adequate at a depth of 4 ft (1.2 m) below natural grade, then a maximum of 1 in. (2.5 cm) of dip-slip displacement per foot of depth may be used. For reasons of practicality, the horizontal component of displacement is neglected in Occupancy Categories I through III. The vertical component of displacement would be the controlling factor for life safety. These are sympathetic faults with a history of relatively low vertical displacement.

The structural mitigation options for known long–recurrence interval faults, projected to rupture at any time, or for projects with proposed cuts to finished grade may not be acceptable, depending on the limitations of the structural mitigation options themselves. When reviewing-agency or consulting engineering geologists know that their data are sparse and when their level of uncertainty about the main fault trace is high, recommendations for the standardized structural mitigation minimums could be made without the presence of sympathetic faults in combination with avoidance.

Table 1. *CBC Table 1604.5 Occupancy Category of Buildings and Other Structures.*

Occupancy Category	Nature of Occupancy
I	Buildings and other structures that represent a low hazard to human life in the event of failure, including but not limited to: • Agricultural facilities • Certain temporary facilities • Minor storage facilities
II	• Buildings and other structures, except those listed in Categories I, III, and IV
III	Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to: • Covered structures whose primary occupancy is public assembly with an occupant load greater than 300 • Buildings and other structures with elementary school, secondary school, or day-care facilities with an occupant load greater than 250 • Buildings and other structures with an occupant load greater than 500 for colleges or adult education facilities • Health care facilities with an occupant load of 50 or more resident patients, but not having surgery or emergency treatment facilities • Jails and detention facilities • Any other occupancy with an occupant load greater than 5,000 • Power-generating stations, water treatment for potable water, wastewater treatment facilities, and other public utility facilities not included in Occupancy Category IV • Buildings and other structures not included in Occupancy Category IV containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released
IV	Buildings and other structure designated as essential facilities, including but not limited to: • Hospitals and other health care facilities having surgery or emergency treatment facilities • Fire, rescue, and police stations and emergency vehicle garages • Designated earthquake, hurricane, or other emergency shelters • Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response • Power-generating stations and other public utility facilities required as emergency backup facilities for Occupancy Category IV structures • Structures containing highly toxic materials, as defined by Section 307, where the quantity of the material exceeds the maximum allowable quantities outlined in Table 307.1(2) • Aviation control towers, air traffic control centers, and emergency aircraft hangars • Buildings and other structures having critical national defense functions • Water treatment facilities required to maintain water pressure for fire suppression

Table 2. *Sympathetic Faulting Requirements for Structural Mitigation Options.*

Occupancy Category	Sympathetic Faulting Requirements[1]	Structural Mitigation Minimum Requirements
I	If sympathetic faulting has been determined to be inactive within the last 1,000 years, then Structural Mitigation Minimum No. I is an alternative to avoidance.	Structural Mitigation Minimum No. I (to be determined)
II	If sympathetic faulting has been determined to be inactive within the last 2,000 years, then Structural Mitigation Minimum No. II is an alternative to avoidance.	Structural Mitigation Minimum No. II (to be determined)
III	If sympathetic faulting has been determined to be inactive within the last 5,000 years, then Structural Mitigation Minimum No. III is an alternative to avoidance.	Structural Mitigation Minimum No. III (to be determined)
IV	If sympathetic faulting has been determined to be inactive within the last 8,000 years, then Structural Mitigation Minimum No. IV is an alternative to avoidance. Three-dimensional trenching is required for determining if sympathetic faulting is present. For unfavorable geologic strata, alternative sympathetic faulting analysis methods may be allowed under the jurisdiction of the reviewing agency.	Structural Mitigation Minimum No. IV (to be determined)

[1]Sympathetic faulting shall have no more than 4 in. (10.2 cm) of dip-slip displacement at a depth of 4 ft (1.2 m) below natural ground surface per event and, in the case of Occupancy Category IV, a 12-in. (30.5-cm) strike-slip displacement. If the controlling dip-slip displacement at a depth of 4 ft (1.2 m) below natural ground is not readily available as a result of poor exposures or other practical limitations then a maximum of 1 in. (2.5 cm) of dip-slip displacement per foot of depth may be used.

CONCLUSIONS

The Alquist-Priolo Act would continue to function in much the same way, with the exception noted for sympathetic faulting. Sympathetic faulting beyond the main fault rupture surface(s), as determined by a certified engineering geologist, may be structurally mitigated when the applicable occupancy category requirements have been incorporated. This methodology for supplementing the Alquist-Priolo Act would facilitate providing a level of risk that is more in line with the seismic design portion of the CBC. The level of risk associated with surface faulting should be somewhat proportional to the significantly reduced ground acceleration design parameters for structures currently implemented in the CBC. The risk to the public would be reduced through the provision of more-appropriate and, thus, safer structural foundation designs within the Alquist-Priolo zones. Data can be sparse, misleading, or absent for the main fault surface(s), and as a result the structurally mitigated foundations will provide a second line of defense for the main fault surface(s) avoidance zone when misinterpreted projections of the main fault rupture beyond the avoidance zone. Additionally, recommendations for the standardized structural mitigation minimums could be made without the presence of sympathetic faults in combination with avoidance. These guidelines incorporate elements of the 2007 CBC and could easily be incorporated into the CBC/International Building Code.

REFERENCES

California Building Standards Commission, 2007, *2007 California Building Code, California Code of Regulations*: Title 24, Part 2, Vol. 2 of 2, Based on 2006 International Building Code, 7 p.

Hart, Earl W. and Bryant, William A., 1997, *Fault Rupture Hazard Zones in California*: California Division of Mines and Geology Special Publication 42, revised 2003.

Shlemon, R. J., 2010, A proposed mid-Holocene age definition for hazardous faults in California. In Cato, K. D. (Editor), AEG Shlemon Specialty Conference, Investigation, Risk Analysis, and Mitigation of Surface Faulting: *Environmental Engineering Geoscience*, Vol. 16, No. 1, p. 55.