P *CODE DEVELOPMENT FOR STATE BUILDINGS*
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ticipation Comments for the Notice Dated November 16, 2009 Written comments are to be sent to the Building Standards Commission

Written Comments Deadline December 9, 2009

December 8, 2009

Emailed to: cbsc@dgs.ca.gov, dave.walls@dgs.ca.gov

From: Charles C. Thiel Jr., Ph.D., Chai

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% 480 Arlington Avenue, Berkeley, CA 94707

We do not agree with the Agency proposed modifications as submitted on **Section 3415.4 and request that these modifications be disapproved and the original text be restored.**

CODE DEVELOPMENT FOR STATE BUILDINGS

1. Recommendation for disapproval of proposed modifications of Section 3415.4

The Code Development for State Buildings Group (Code Group) recommends that the proposed modifications of Section 3415.4.1 contained in the 15-day Express Terms for Proposed Building Standards of the California Building Standards Commission not be accepted. We believe that they are inappropriate and recommend that they not be accepted.

The proposed text of the modified provision was developed by the Code Group over the period of the last year. The Code Group is comprised of state agencies that oversee construction of buildings including the Judicial Council, University of California, California State University, California Community Colleges, Department of General Services (DSA, RESD), Transportation, Corrections and Rehabilitation, Water Resources, representatives from policy groups such as the Seismic Safety Commission and the Division of the State Architect, and the interested technical professionals from the Structural Engineers Association of California.

2. Basis for recommendation

We understand that only one response was received on this matter and that it was from the State Geologist. His proposed deletions were published for public comment. The Code Group became aware of these proposed changes only this last week and has not participated in the evaluation of them. The State Geologist recommended the elimination of references to active faulting in Section 3415.4 so as to read (red indicates changes, strike through are deletions):

> ***3415.4.1 Site hazard study.*** *If a portion of the foundation is within a zone of potential ~~active faulting,~~ earthquake-induced landsliding, or liquefaction susceptibility, as published by the California Geological Survey, then a site hazard study shall establish that the structure can sustain the effects of liquefaction, or landslide, ~~or fault displacement~~ corresponding to the Level 2 performance criteria of Table 3415.5. ~~Fault displacement demands shall be permitted to be taken as the median horizontal and vertical displacements corresponding to or having the same annual probability of exceedance as the hazard specified with the Level 2 performance criteria of Table 3415.5.~~*
>
> ~~***Exception:*** *Fault displacement need not be considered when no portion of the foundation is with 50 feet of a splay of an active fault.*~~
>
> This is the text currently open for Public Comment.

The Code Group developed the original submission which this modification is proposed to modify and takes exception to the proposed change, see Section 3 below). The Code Group requests that The Building Standards Commission not accept this proposed modification. Our reasons are that the arguments made for the action by the State Geologist for these changes are not based upon facts. We shall establish this in the following discussion. The State Geologist's first point was:

> *All references to fault displacement should be deleted. The language as currently written does* not adequately acknowledge that *the Alquist-Priolo Act prohibits* substantial improvements *to existing structures that lie across the trace of an active fault (see Public Resource Code, Sections 2621-2630). Therefore, the surface fault rupture aspect of the proposal* ***does not meet criteria 1*** *of Health & Safety Code Section 18930.*

In fact, as noted in the submission to the BSC, the Alquist-Priolo practices were referenced, see Section 3 below. Indeed the reasoning of the Group was that the Alquist-Priolo (AP) requirements by statute do not apply to state agencies. If reference to the AP could easily be accommodated by inserting a reference to it. We would be happy to revise the text to acknowledge the Alquist-Priolo Act in the text of Section 3415, but would suggest that it may be more appropriate to reference the Seismic Hazards Mapping Act of 1990, in that way also bringing into consideration other seismic hazards of liquefaction, land sliding and other earthquake-caused site hazards.

Therefore, we do not conclude that conclusive basis in his first observation for rejection based on the Health and Safety Code.

The State Geologists second reason was

> *Furthermore, we are unaware of any accepted means of designing structures to accommodate fault displacement, which might range in magnitude from a few inches up to 30 feet laterally or 15 feet vertically on certain faults in California. Both ASCE 7-10, Section 11.8.1, and California Administrative Code (Title 24, Part 1), Chapter 6, Section 9.3.3, assume there is no reasonable means to design for surface fault rupture, and we are unaware of any published standards to support the proposed concept of designing for surface fault rupture. In addition, the hazard level specified seems inappropriate, because fault displacement on any particular fault segment is both less likely and less well understood than strong ground shaking. Therefore, the surface fault rupture aspect of the proposal* ***does not meet criteria 7B*** *of Health & Safety Code 18930..*

A first point, the object of the Code Group is not to suggest that the fault rupture can be altered, since this is clearly not feasible. The object is to assess the performance of a modified structure to safely withstand the applied forces or displacements when such a rupture occurs within its foundations.

It is true that ASCE/SEI 7-10 does not set specific design standards for consideration of faulting displacement values for new buildings. However, it is noted that ASCE 7-10, in Sections 1.3.3. 1.3.4, requires provisions for self-straining forces resulting from possible displacements that are not the result of specified loads. Fault displacement is one of these self-training conditions and is thereby covered. Therefore, ASCE requires design for new buildings to <u>be demonstrated to be safe in these conditions</u>. A difficulty is that these procedures do not specify the specific design displacements and other conditions that must be accommodated. Thus it is open to interpretation what displacements need to

be considered in design. The Code Group's proposal removes this uncertainty by specifying a minimum standard in the CBC for state-owned buildings.

There is worldwide evidence that on many occasions where a fault rupture has occurred through a building's foundation, where the foundation was adequate, the building remained safe. The State Geologist may wish to discuss with his predecessor James Davis his observations of building performance in the recent 2006 Turkey earthquake where fault ruptures passed through building foundations and did not cause collapse or life-threatening damage tot he buildings. This has been observed throughout the world. When the building and foundation is appropriately designed, then a building can be reasonably expected to accommodate the displacements and resulting loads, both vertically and horizontally. Whether, in any particular case, it is economic to do so is another matter.

Now to the issue of whether there are standards for existing buildings and whether there is evidence that standards exist to develop with such designs. Chapter 3415 through 3420 are the regulatory standards for state-owned buildings. These requirements do not apply to private sector buildings, but only to state-owned buildings. The only exception is that for DSA regulated buildings they use some of the technical provisions, but retain through Part 1 the CGS requirements for site conditions, which include faulting and site performance issues under CGS control. (See Section 5 for more discussion.)

The structural requirements referenced in Sections 3415-3420 are contained in ASCE/SEI 41, as discussed in Section 5 below. ASCE/SEI 41 Chapter 4 specifically addresses faulting hazards and sets requirements for the designer to accommodate the hazard. A session of the conference is dedicated to this issue. So there is no doubt that the structural engineering community has addressed the technical issues to assess the possibility of fault rupture within the foundations of existing buildings. It could be argued that there is no specific value specified for such design, but this is also true for other aspects of design for self-straining conditions.

Now to the derivative question if reputable structural engineers accept such a proposition as to retrofit structures astride faults. The Code Group had the participation from Kevin Moore, Ian Williams, Ryan Kersting, Colin Blaney, Doug Hohbach and David Bonowitz, all Structural Engineers and designees of their respective SEOAC technical committees in the development of our code proposals. SEAOC is the Structural Engineers Association of California. The intention of this participation was to assure professional council in development. Mr. Moore commented that:

> *One example project that could have benefitted from such a change is the Memorial Stadium project. UC Berkeley is intending to execute the seismic retrofit of Memorial Stadium, which straddles the Hayward Fault. Not only has this retrofit project been studied and accepted by extremely bright and capable Geotechnical and Structural Engineers, the project is considered a true success and advance in earthquake engineering and is being presented at the December ATC/SEI conference. I assume that the general SEAOC membership appreciates*

such a creative and important engineering solution for a storied institution. Abandonment or full replacement were possible options, but for many people untenable.

For these several reasons, we conclude that the assertion that there is no basis for considering faulting in design is not consistent with the facts either of regulation or of engineering.

The balance of the comment assets that the *"hazard level specified seems inappropriate, because fault displacement on any particular fault segment is both less likely and less well understood than strong ground shaking."* The hazard level is set by the original proposal at exactly the same probability of exceedance level as it is for ground motion for the collapse level for ground motion evaluation (for new buildings BSE-2, and for existing buildings Level 2, which is either 2% or 5% probability of exceedance in 50 years). For an existing building, the requirement is, in lay terms, that building collapse be avoided. Now since we know that building collapse does not necessarily follow from fault movement within a foundation, should the hazard posed by building collapse under faulting be less likely than that the building collapse under applied ground motions? If the argument of the State Geologist is that faulting is a more serious hazard than ground motions, then we would like to know on what basis this is true.

For existing buildings faulting is a serious issue. The California Building Code for state-owned buildings has established the return period for earthquake ground motions of 975 years for the performance level of collapse prevention for most buildings, except for Group Occupancy IV, where it is 2,475. This has been the standard contained in the Building Code since the 1998 edition, and is the standard of the current edition. There are no proposals to change it in the current revisions. It is certainly true that fault displacement at a particular site is less likely than ground motions, since the ground motions can be generated by many faults, but the ground displacement at the site by only one. The development of probabilistic ground motions at a site from many sources of earthquakes is well established. Similar procedures are available for fault displacement at a specific site on a specific fault. It is certainly true that there is uncertainty in the specification of the parameters for such an analysis. But no more so than for the seismic parameters of the site fault and the others for determination of the ground motions. Support of the requirement that fault rupture requires longer return periods is not supported, but asserted. In fact, such probabilistic assessments are completed with large bounds on the parameters and the procedures acknowledge the different results that can occur with weightings for their likelihood. The result is that the more uncertain the parameters, the higher the specified design parameters.

In reality, for many of the most hazardous buildings (for example, unreinforced masonry), any fault movement over a few inches through the foundation will lead to failure of the building, and it will be determined that the building does not meet the S-5 performance criterion set in Table 3415.5. For some other types of buildings, say those with large concrete mat foundations supported on granular soils, it may be that the building's foundations are so strong compared to the loads applied by the deforming supporting soils, as to

allow meters of displacement without adverse impacts. It requires engineering analysis to determine whether the consequences of fault movement in the foundation lead to unacceptable performance of the building. And this analysis depends on setting the values of displacement that are to be assessed. Without the original proposed modification (specifying equal return period for both ground motion and fault displacement),this was left unspecified, and the default value of the largest possible displacement may be used with the possible result of either a prohibitive retrofit cost or vacating the building.

Now to a principal issue for State Buildings. The requirements of the Alquist-Priolo legislation as reported by Special Publication 42 of the California Geological Survey states:

> *Under the Act, the State Geologist … is required to delineate "Earthquake Fault Zones" (EFZs) along known active faults in California. Cities and counties affected by the zones must regulate certain development "projects" within the zones. They must withhold development permits for sites within the zones until geologic investigations demonstrate that the sites are not threatened by surface displacement from future faulting. [CGS, SP-42, page 1]*

This is widely interpreted by state agencies as not applying specifically to them since the language is specific to *Cities and Counties*. State Agencies do not issue *development permits* as part of the construction programs, and indeed do not issue building permits for their own work and no other state agency has such responsibility. To the extent that State Agencies comply with the AP requirements, it is their decision and not a requirement of the State Building Code.

Without a specification of the degree of hazard (return period) associated with a fault movement in the foundations, then the basis for decision is likely to be "any movement is unacceptable." This was not acceptable to the Code Group, and therefore we recommended that the seismic safety requirements for existing buildings for fault displacements be the same as those for ground motions.

Without a standard for the evaluation of the faulting hazard, then a response could vary from do nothing to demolish the building as unsafe. Is this reasonable? We think not. If the fault shows signs of recurrent fault ruptures that could damage the building on a 10,000-year return period, should the building be demolished? We think not. So where is the compromise? We believe using the same standard for life-safety of occupants for all earthquake loadings to a structure is the correct conclusion, and this is what was proposed originally.

As a supplementary point, liquefaction, landsliding, and other seismic hazards referenced in the proposed modification were not proposed for removal, and the uncertainties of their occurrence not used as a justification for their removal. They pose significant damageability possibility to a building that are every bit as uncertain as fault displacements or occurrence at a specified location. If the argument is accepted for faulting to be deleted, then the same argument leads to the conclusion that the section should be deleted. The Code Group accepts neither of these propositions as responsible.

Therefore, we conclude that the State Geologists has not in fact presented a conclusive basis in his second observation for rejection based on the Health and Safety Code.

3. Argument provided to the BSC in support of the original proposed changes

The proposed new sections in Chapters 16 and 18 cover new state-owned structures. Currently, there is no codified prohibition against building across a fault (unless the local jurisdiction has established its own regulations). ASCE 7 Section 11.8 addresses geological hazards and investigations. It prohibits construction of new buildings for faulting hazards in Seismic Design Categories E and F only. It requires investigations for Categories C or higher, but is mute on what constitutes an evaluation basis, or what the design requirements to accommodate the hazard are. For state buildings, this is a flaw because there is no planning agency to enforce the requirements.

The proposed new sections for Chapter 34 cover existing buildings for which seismic evaluation is triggered by one of the conditions in section 3415.3.1. Currently, CBC Chapter 34 (except for OSHPD) does not limit work on existing buildings close to active faults. There is a requirement for geotechnical studies for Seismic Design Category D-F, but no other restrictions.

Under the Alquist-Priolo act, the California Geological Survey maintains maps of areas where active faults and site hazards must be investigated. The basic rule is that new construction must stay at least 50 feet (25 feet in certain cases) from the closest splay of an active fault. The A-P act is normally applied to new construction (but not to most residential buildings). In addition, local jurisdictions, including Los Angeles County, have designated other faults as subject to the AP requirements. Similar requirements are made by the Seismic Hazards act of 1992 to perform liquefaction hazard studies for buildings located in liquefaction susceptible zones as determined by the CGS.

Several state agencies have existing buildings that cross active faults or are in liquefaction zones. For consistency, the regulations and practices that address these conditions should be codified. If code provisions are placed in Part 1, then the requirements may be overlooked; if in Part 2, designers and Building Officials will be certain to see them.

There is an issue of the safety implications of earthquake-induced site failure that can be argued to be separate from that of the safety of the building to earthquake vibrations (ground motions). When the supporting site materials are ruptured, and displace significantly, there is a concern with whether the building can accommodate these displacements that is technically different from assessing the structure’s ability to withstand transient earthquake ground motions. The same considerations apply to site differential settlement that is beyond the normal accommodate of the site’s supporting soil to the newly applied gravity load form the building. The Code Group considered the question of whether these hazards are of such significance that they should trigger investigation for state buildings under Chapter 34 even when the work to be completed is minor and below the 25% threshold. The conclusion was that an assessment is warranted when there is possibility of fault motions within the plan of the structure, that is, the structure is astride the fault, and differential settlement of the supporting materials from land

sliding or liquefaction that are earthquake-induced and well beyond the normally encountered settlement under gravity loads.

Under current regulations the enforcement of these actions for private buildings is delegated to the local governmental agency with planning and code enforcement authorities. The Group finds it imperative that there be no ambiguity in the necessity for state agencies to consider faulting and site failure in its structural planning and design efforts. One of the issues in such evaluations is to make sure that very low probability or impact site issues do not preclude use of the site or existing buildings. Therefore, the proposed modifications include criteria for evaluating whether a hazard is significant or not, and allows for reasonable accommodations.

Within CBC Chapter 16 for new buildings, is interesting to note that there is not a prohibition of constructing across a fault if a community chooses to so authorize by issuance of planning and building permits. ASCE 7 Section 11.8, referenced as the requirements for structural design and analysis in Chapter 16, addresses geological hazards and investigations. It prohibits construction of new buildings for faulting hazards in seismic performance categories E and F only. It requires investigations for Categories C or higher, but is mute on what constitutes an evaluation basis, or what the design requirements to accommodate the hazard are. For state buildings, this is a fatal flaw for the same reason as for existing buildings, there is no planning agency to enforce the requirements.

In considering these issues, the Group assessed that the most serious problems and possible safety issues are posed by existing buildings, particularly those constructed before the AP requirements for avoidance of faults. Therefore, the first focus is on existing state buildings, that is Chapter 3415. The requirements for new construction also warrant concern, because there are no mechanisms in chapters 16 or 18 to limit state agencies from constructing buildings in high hazard locations, similar to those that limit local government from doing so. There are common requirements for geotechnical studies to identify faulting issues, both by code and norms of professional practice. But here is no requirement to implement them. We propose to modify Chapters 16 and 18 to make this clear and to provide for what is evaluated in the main as common practice among state agencies.

It is recommended by all the participants of the *Code Development for State Buildings Group* that these modifications be implemented to provide the users of state buildings reasonable assurance that the likelihood of extreme danger and damaging state buildings due to faulting within the foundations of the building, or significant failure of the supporting soils due to earthquake occurrences does not occur.

4. Applicable standards for new state-owned buildings:

ASCE /SEI 7 is the reference standard for new construction in CBC Chapter 16 that applies to new buildings. While ASCE-10 is not available in a published form yet, ASCE /SEI 7-05. It is expected based upon the balloted items approved for the revised version that the sections below will not be materially changed in the new edition.

ASCE references earthquake faulting in Sections 1.3.3 and 1.3.4, and 11.8:

1.3 Basic Requirements

1.3.3 Self Straining Forces*. Provision shall be made for anticipated self-straining forces arising from differential settlements of foundations and from restrained dimensional changes due to temperature, moisture, shrinkage, creep and similar effects.*

1.3.4 Analysis*. Load effects on individual structural members shall be determined by methods of structural analysis that take into account equilibrium general stability, geometric compatibility, and both short- and long-term material properties. Members that tend to accumulate residual deformations under repeated service loads shall have included in their analysis the added eccentricities expected to occur during their service life.*

11.8 Geologic and Geotechnical Hazards

11.8.1 Site Limitation for Seismic Design Categories E and F. *A structure assigned to Seismic Design Category E and F shall not be located where there is a known potential for an active fault to cause rupture of the ground surface at the structure.*

11.8.2 Geotechnical Investigation Report for Seismic Design Categories C through F*. … An investigation shall be conducted and … including evaluation of … surface displacement due to faulting or lateral spreading.*

*1****1.8.3 Additional Geotechnical Investigation Reporting Requirements for Seismic Design Categories D through F****. The geotechnical investigation report … shall include:*

3. Assessment of potential consequences of liquefaction and soil strength loss, including estimation of the differential settlement lateral movement, lateral loads on foundations, reduction in foundation soil-bearing capacity, increases in lateral pressures on retaining walls, and flotation of buried structures.

4. Discussion of mitigation measures such as, but not limited to, ground stabilization, selection of appropriate foundation types and depths, selection of appropriate structural systems to accommodate anticipated displacements and forces, or any combination of these and how they shall be considered in the design of the structure.

ASCE/SEI 7-05 regulations clearly establish that for new buildings the requirements of clearly identifying the potential for, and design accommodation of fault displacements, as well as other soil movements, on the seismic performance of new buildings. This is not a blanket prohibition except for Seismic Design Category E and F buildings. Without going into the specifics of assignment of Design Categories, most State-owned buildings not used for essential services, are assigned to Category D or lower. Therefore, neither ASCE/SEI 7 nor the CBC restrict construction of new state-owned buildings across faults, but allow it provided that the design accommodates the hazard.

5. Applicable standards for existing state-owned buildings:

Chapter 34 of the California Building Code provides regulations for the modification of existing buildings. Section 3415 through 3421 provide the specific requirements for state-owned buildings. These section reference ASCE/SEI 41-06 as the reference standard. While ASCE/SEI 41-10 is not available in a published form yet, it is expected based upon the balloted items approved for the revised version that the sections below will not be materially changed in the new edition.

ASCE/SEI 41-06 Section 1.3 .1

> *1.3.1 Initial Considerations. The design professional shall review initial consideration with the authority having jurisdiction to determine any restrictions exist on the design of rehabilitation measure. Initial considerations shall include structural characteristics of the building, seismic hazards including geological site hazards know to be present, …*

This is further developed in Section 4.2.2.1 that specifically references fault rupture:

> *4.2.2 Seismic Geologic Hazards. Seismic rehabilitation shall include an assessment of earthquake-induced hazards at the site due to fault rupture, liquefaction,, differential compaction, landsliding, and an assessment of the earthquake-induced flooding or inundation in accordance with Sections 4.2.2.1 through 4.2.2.5.*
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> ***4.2.2.1 Fault Rupture**. A geologic fault shall be defined as a plane o zone along which earth materials on opposite sides have moved differentially in response to tectonic forces.*
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> *Geological site information shall be obtained to determine if an active fault is present under the building foundation, If a fault is present the following information shall be obtained: (listing of fault parameters omitted)*
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> ***C4.2.2.1 Fault Rupt**ure. Buildings found to straddle active faults should be assessed to determine if rehabilitation is warranted, possibly to reduce the collapse potential of the structure given the likely amount and direction of fault displacement. (N.B. The preface C means this is commentary.)*
>
> *4.3 Mitigation of Seismic-Geologic Site Hazards. Mitigation of seismic-geologic hazards identified in Section 4.2 shall be accomplished through modification of the structure, foundation, or soil conditions, or by other means approved by the authority having jurisdiction. The structure, foundation, and soil for the rehabilitated structure shall meet the acceptance criteria for the appropriate chapters of this standard for the selected Rehabilitation Objective.*

The Code Development for State Buildings Group assessed this allowance in light of the Legislative History of the Alquist-Priolo Act (and subsequent

modifications to include other earthquake-induced site failure mechanisms) as not acceptable from a policy point of view and proposed the modifications to Chapter 16 (New Buildings), Chapter 18 (Soils and Foundations) and Chapter 34 (Existing Buildings) that would apply to state-owned buildings to be constructed or modified.