

Navigating the Building Code Requirements for the Seismic Rehabilitation of Schools in California

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Abstract

The Division of the State Architect (DSA) has authority for the plan review and supervision of construction for elementary and secondary schools (K-12) and community colleges in California. School Districts are continually modernizing and altering their inventory of existing school buildings to meet school demands, and in that process, there are a number of building code requirements that address triggers for a mandatory seismic rehabilitation. DSA works in partnership with school districts through a 3-step seismic rehabilitation process. The first step includes a voluntary pre-design meeting. The second step includes a pre-application design criteria and material testing program submittal for DSA approval. The third step is the preparation and submittal of rehabilitation construction documents in accordance with the DSA approved design criteria using the normal plan submittal and approval process.

This paper will discuss the building code requirements and describe the process for the seismic rehabilitation of schools in California. The paper will also describe the testing program and seismic rehabilitation design criteria for both structural and non-structural components utilizing ASCE 41 in accordance with Chapter 34 in the 2010 California Building Code.

Introduction

The Division of the State Architect (DSA) has authority for the plan review and supervision of construction for public elementary and secondary schools (K-12) and community colleges in California. This is accomplished through 4 regional offices spread across the state located in Sacramento, Oakland, Los Angeles, and San Diego, in addition, to the headquarters office located in Sacramento. Construction documents for school projects are submitted for approval to their respective region. DSA has the authority to enforce the structural, fire life safety, and access compliance provisions in California Code of Regulations, Title 24.

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demands, and in that process, there are a number of building code requirements that address triggers for a mandatory seismic rehabilitation. DSA works in partnership with school districts through a 3-step seismic rehabilitation process. When a seismic rehabilitation is not required by one of these triggers, then the school district can choose what level of voluntary seismic strengthening is desired, if any.

When a seismic rehabilitation is required, there are a number of design methods that can be chosen. Each design method is described below along with a discussion of the seismic performance goals. In addition, a data collection and material testing program is required to assess the existing conditions of the buildings. A geologic hazard report is also required to assess the any geologic site hazards.

Seismic Rehabilitation of Schools

The building code provisions governing the seismic rehabilitation of schools in California are located in the 2010 California Administrative Code (CAC), Title 24, Part 1, Sections 4-306 through 4-309 and in 2010 California Building Code (CBC), Title 24, Part 2, Sections 3401.1 and 3417 through 3423. The structural provisions in the remainder of Chapter 34 are not adopted by DSA since they are typically addressed by the CAC. It should be noted that CBC Chapter 34A is not adopted by DSA, whereas all other CBC "A" chapters are co-adopted by DSA with the Office of Statewide Health and Planning Department (OSHDP) for hospitals. CBC Chapter 34A governs existing hospital buildings and is adopted by OSHDP only.

The provisions in CAC address the administrative, processing, and triggers for seismic strengthening. While the provisions in CBC Chapter 34 address the seismic rehabilitation performance objectives, documentation of existing conditions, material testing requirements, design methodologies, peer review requirements, and outlines the evaluation and design criteria report requirements.

The CAC and CBC uses the term structural rehabilitation to refer to a complete structural evaluation and strengthening of a structure for all loading conditions, including but not

limited to seismic, wind, dead, live, and snow loading. For the purpose of this paper, the focus will be on the seismic provisions of the structural rehabilitation and not on the other loading conditions.

Structural rehabilitation projects also trigger fire life safety and access compliance upgrades. The scope of these upgrades is not discussed in this paper, but can be found in Appendix C of DSA Procedure 08-03 and in the Appendices of DSA's "Rehabilitation of Existing Non-Conforming Buildings for Public School and California Community College Use", dated November 30, 2011, both of which are available on DSA's website (www.dgs.ca.gov/dsa).

The 2010 CBC added alternate structural design provision for community colleges enacted under SB 588. These alternate provisions are described in CBC Section 1.9.2.2 and are denoted as DSA-SS/CC in the CBC. Community colleges are, by default, still regulated under the provisions applicable to public elementary and secondary schools (K-12) described in CBC Section 1.9.2.1 and are denoted by DSA-SS in the CBC. If a school district elects to use the alternate DSA-SS/CC provisions, it requires written acknowledgement by the school district at time of project submittal since some of these provisions are less stringent and can result in more structural and non-structural damage in a major earthquake.

The alternate community college provisions are intended to align the community college structural provisions to those applicable to the California State University and University of California buildings, while maintaining the same level of seismic safety as it relates to occupant safety, but may experience more damage. For the seismic rehabilitation of existing school buildings, these alternate provisions are located in CBC Chapter 34 adjacent to the other public school provisions and are denoted as "community college".

Seismic Rehabilitation Triggers

School buildings are required to be structurally rehabilitated when any of the following conditions occur:

1. Existing nonconforming building is converted for use as a school building, per CAC Section 4-307.
2. Alterations to an existing school building where any of the following occur, per CAC Section 4-309(c):
 - a. The cost of alteration exceeds 50% of the replacement value of the existing building.
 - b. Increase the effective seismic weight or wind force in any story by more than 10 percent.

- c. Decrease the design capacity of any existing structural component by more than 5 percent, unless the component has the capacity to resist the retrofit design forces.

3. Alteration to an existing school building where a change of occupancy results in a structure being reclassified to a higher occupancy category.

Existing nonconforming buildings refers to any building that has not been certified by DSA as a school building. These buildings are generally constructed under the local building department's jurisdiction for another use and may have been purchased by the school district to be converted to school use. These buildings are governed by CAC Section 4-307 and require structural rehabilitation. These buildings also require mechanical, electrical, and plumbing (MEP) upgrades in addition to the fire life safety and access compliance upgrades noted earlier and the scope of these upgrades can be found in the Appendices of DSA's "Rehabilitation of Existing Non-Conforming Buildings for Public School and California Community College Use", dated November 30, 2011.

The structural rehabilitation of existing school buildings is mandatory when they are altered such that the scope of the project exceeds certain thresholds, as defined in CAC, Section 4-309(c). If not exceeded, then no structural rehabilitation is required and it is at the discretion of the school districts to perform voluntary seismic strengthening, which is addressed later in the paper. As indicated in 4-309(c)(1), when evaluating the 50% cost threshold, the cost of maintenance work, air-conditioning equipment, insulation materials costs, and structural rehabilitation costs need not be included.

The structural rehabilitation requirements for change of occupancy are located in CBC Section 3408, however, this section is not adopted by DSA. However, the building code requirements for public school buildings should not be less restrictive than that required for other buildings, therefore, DSA enforces the structural provisions in CBC Section 3408. Amendment being proposed in the 2013 CBC will correct this issue.

Submittal Process

The submittal process for seismic rehabilitation projects is a 3-step process, which is slightly different than new construction submittals at DSA.

Step 1: Pre-Design Meeting (optional) – The design team and school district meet with DSA to have a preliminary meeting to discuss the project and go through key structural, fire life safety, and access compliance issues. This step usually occurs during the design development stage of the project where the structural engineer has already done a preliminary analysis to have a sense of the scope of the seismic rehabilitation. This step is not mandatory.

Step 2: Rehabilitation Pre-Application – In accordance with CAC Section 4-306 or 4-307, a pre-application for the seismic rehabilitation project shall be submitted to DSA. This submittal includes a completed pre-application form DSA-1.REH, a retainer fee of \$2,000 in accordance with CAC Section 4-326, and an Evaluation and Design Criteria Report in accordance with CBC Section 3423.1. DSA assigns a REH pre-application number to track the submittal and Report. This REH number is not the same as the project application number used for construction document submittal which is assigned in Step 3.

The Evaluation and Design Criteria Report (EDCR) describes the building's structural and nonstructural systems, potential deficiencies, proposed methodologies for the evaluation and design, and the acceptance criteria used. The EDCR also identifies geological hazards, outlines the material testing and condition assessment program, includes existing construction documents, and addresses fire life safety, access compliance, and MEP (as applicable) deficiencies. DSA reviews the EDCR and once approved, DSA will stamp and sign it. Additional fees may be required if the review exceeds the retainer fee.

The EDCR is then used as the basis by the design team to complete the analysis, design, and material testing. It is the intent that the material testing and condition assessment occurs between approval of the EDCR and submittal of the project application in Step 3 so that the findings of the investigation are incorporated into the

design. Alternative timelines for the investigations must be approved as part of the EDCR.

Step 3: Project Application – The project is submitted to DSA for approval of the construction documents for the seismic rehabilitation using the plan and specification submittal process used for new construction and alteration projects in accordance with CAC Article 3. This is the same process used on all DSA projects and is not described herein. During this step, the DSA plan reviews will use the EDCR approved in Step 2 as the basis for the design and they will review the material testing data outlined in the report.

Seismic Rehabilitation Objective

When a seismic rehabilitation is required by the one of the triggers indicated above, the objective of the seismic rehabilitation is that the rehabilitated building to have equivalent structural performance to that of a new school building constructed in accordance with the CBC. The scope of the rehabilitation addresses not only the structural components of the building, but also the non-structural components. The seismic rehabilitation shall be in accordance with one of the following three design methods which are outlined in CBC Sections 3417-3423.

1. ASCE 41-06 “Seismic Evaluation of Existing Buildings” in accordance with CBC Section 3417.5.
2. CBC using the design and detailing provisions required for new school buildings with applicable DSA amendments (e.g. A-chapters) in accordance with CBC Section 3417.7 and Table 3417.5 footnote 2.
3. For non-conforming buildings converted to school use, CBC Section 3419.1 Exception allows buildings constructed to the requirements of the 1998 CBC or newer, as adopted by the governing jurisdiction, to use that code as the as design basis.

Historical school buildings undergoing a seismic rehabilitation may not utilize less stringent design criteria than those contained in the 3 methods indicated above in accordance with the California Historical Building Code (CHBC), Title 24, Part 8, Section 8-702.1

Design method 1 uses the systematic rehabilitation objective of ASCE 41 which consists of a two-tiered seismic evaluation procedure and uses the performance criteria given in CBC Table 3417.5. For public schools, the performance criteria in this table uses an Enhanced Rehabilitation Objective in accordance with ASCE 41 Section 1.4.2, which results in

higher performance criteria than that required for the Basic Safety Objective (BSO) outlined in ASCE 41 Section 1.4.1. The BSO is intended to represent the earthquake risk to life safety traditionally considered acceptable for normal occupancy structures.

CBC Table 3417.5 contains entries for both “public schools” and “community college” buildings. “Public schools” includes all school buildings under the jurisdiction of DSA, including public elementary and secondary schools (K-12) and, by default, community colleges. “Community college” is for school districts electing to use the alternate building standards enacted under SB 588 and requires written acknowledgement by the school district to use these provisions as discussed previously.

To illustrate and compare the performance criteria between those for public schools, community colleges (CC) and the BSO in ASCE 41, Tables 1 and 2 were created by extracting the structural and non-structural performance levels, respectively, from CBC Table 3417.5 and combining it with the associated damage states of ASCE 41. The ASCE 41 approach requires the building to be evaluated for two different earthquake ground motions: 1) ‘level 1’ earthquake similar to that used to design new buildings, and 2) a larger ‘level 2’ ground motion. Tables 1 and 2 are split into two sub-tables for each of these two ground motions.

Only the Occupancy Category II and III buildings are illustrated in Tables 1 and 2 since they represent a vast

majority of school building. Footnote 1 in CBC Table 3417.5 indicated how to interpolate acceptance criteria for the intermediate damage state values for S-2 and S-4 in ASCE 41, since they are not explicitly tabulated in ASCE 41. It should be noted that the BSE-R ground motion, defined in CBC Section 3418, is smaller than the BSE-1 ground motion.

The entries in the Table 1 illustrate that the structural seismic performance criteria for DSA public schools is higher than the BSO in ASCE 41 and should generally result in less structural damage during a major earthquake. The structural seismic performance criteria of the DSA alternate community college provisions is about the same as the BSO in ASCE 41 and should result in similar structural performance.

The entries in the Table 2 illustrate that the non-structural seismic performance criteria for DSA public schools is also higher than the BSO in ASCE 41 and should generally result in less non-structural damage during a major earthquake. Conversely, the non-structural seismic performance criteria of the DSA alternate community college provisions is less than the BSO in ASCE 41 since it utilizes a smaller ground motion (BSE-R) to evaluate a higher damage state for non-structural components, which may result in more non-structural damage during a major earthquake.

Structural Seismic Performance Criteria - Level 1 Earthquake - Occupancy Category II, III					
Building Regulatory Agency	Immediate Occupancy	Damage Control	Life Safety	Life Safety Range	Collapse Prevention
	S-1	S-2	S-3	S-4	S-5
	Increasing Damage →				
DSA – Public Schools		BSE-1			
DSA - CC			BSE-R		
ASCE 41 BSO			BSE-1		

Structural Seismic Performance Criteria - Level 2 Earthquake - Occupancy Category II, III					
Building Regulatory Agency	Immediate Occupancy	Damage Control	Life Safety	Life Safety Range	Collapse Prevention
	S-1	S-2	S-3	S-4	S-5
	Increasing Damage →				
DSA – Public Schools				BSE-2	
DSA - CC					BSE-2
ASCE 41 BSO					BSE-2

Table 1: Structural Seismic Rehabilitation Objectives

Non-Structural Seismic Performance Criteria - Level 1 Earthquake - Occupancy Category II, III					
Building Regulatory Agency	Operational	Immediate Occupancy	Life Safety	Hazards Reduced	Not Considered
	N-A	N-B	N-C	N-D	N-E
Increasing Damage →					
DSA – Public Schools			BSE-1		
DSA - CC				BSE-R	
ASCE 41 BSO			BSE-1		

Non-Structural Seismic Performance Criteria - Level 2 Earthquake - Occupancy Category II, III					
Building Regulatory Agency	Operational	Immediate Occupancy	Life Safety	Hazards Reduced	Not Considered
	N-A	N-B	N-C	N-D	N-E
Increasing Damage →					
DSA – Public Schools				BSE-2	
DSA - CC					No Check
ASCE 41 BSO					No Check

Table 2: Non-Structural Seismic Rehabilitation Objectives

When using the ASCE 41 analysis method, an independent peer review may be required in accordance with CBC Section 3422. An independent peer review is required when design “Method B” is utilized, as defined in CBC Section 3421, but may be waived if DSA has qualified staff available to perform the review per CBC Section 3421.2. “Method B” is generally used for complex analysis, irregular structures, tall buildings, energy dissipation systems, and Occupancy Category IV structures. The selection criteria for design “Method A” and “Method B” are indicated in CBC Section 3419.7.

Design method 2 allows the rehabilitation of existing school buildings to use the same design and detailing methodology as that used for new buildings. However, the detailing requirements are often difficult to comply with on older structures, so this method is seldom utilized.

Design method 3 allows public schools and community colleges to purchase newer non-school buildings (e.g. commercial building) designed to the 1998 CBC or newer, as adopted by the local building jurisdiction, and convert them to school use by analyzing them to that same code they were originally designed to and forego the DSA amendments. In the 2013 CBC, it is being proposed to raise the benchmark code year from 1998 CBC to 2007 CBC due to the significant developments in the buildings code during this era related to the seismic ground motions used in buildings design, the effects of irregularities and redundancy in building design, and changes to the design coefficients and factors used for the design of seismic force-resisting systems of buildings.

Data Collection and Testing

The existing building conditions need to be determined in accordance with CBC Section 3419.2, which includes gathering existing construction documents, documenting as-built conditions, performing a condition assessment, and determining material properties.

The CBC data collection and material testing requirements tie in directly with ASCE 41 Table 2-1. For public schools, the “Comprehensive” level of data collection is required per ASCE 41 Section 2.2.6.3 and CBC Section 3419.2(2). For community college buildings that have been approved and the construction was certified by DSA, then the “Usual” level of data collection is required per ASCE 41 Section 2.2.6.2 and CBC Section 3419.2(3). For community college buildings that have not been approved by DSA and the construction was not certified by DSA, then the “Comprehensive” level of data collection is required per ASCE 41 Section 2.2.6.3 and CBC Section 3419.2(4). The “Usual” level of data collection results in less material testing, and it is recognized above that for community colleges that had DSA construction oversight, there is a reduction from “Comprehensive” level down to “Usual” level. In 2013 CBC, a similar reduction is being proposed for public schools.

Existing construction documents should be obtained through the school districts archives and should contain the DSA approval stamp of the original construction. If records are not available locally, DSA has archives in Sacramento that can be

retrieved for a small fee and often include original calculations, specification, material test reports, and approved construction plans. Existing material testing reports may be used to reduce the number of material testing samples required.

Geologic Hazard Reports

Geologic hazard reports are required for all seismic rehabilitation projects to document the geologic site hazards and determine the site specific ground motions per CBC Section 3419.3. All geologic hazard reports are submitted directly to California Geologic Survey (CGS) for review prior to project submittal to DSA, noted in Step 3 above. DSA approval of the seismic rehabilitation construction documents will not occur until CGS approval has been obtained. DSA IR A-4 provides general submittal, requirements, and approval information for geologic hazard reports. On seismic rehabilitation projects, all geologic site hazards are required to be mitigated, either through ground improvements, structural strengthening, or other means. Buildings that require seismic rehabilitation that are located within 50 feet of the trace of an active fault cannot be seismically rehabilitated per CAC 4-317(e), rather they need to be moved or replaced.

Voluntary Seismic Strengthening of Schools

When a seismic rehabilitation is not required by the one of the triggers indicated above, then the school district and design team can choose what level, if any, of voluntary seismic strengthening is desired, provided the provisions in CAC Section 4-309(d) are complied with. The building is required to be a certified school building, meaning its construction was certified by DSA. The scope of the voluntary seismic strengthening should not result in an increase in mass or decrease in design capacity beyond the triggers discussed above, otherwise a mandatory seismic rehabilitation will be required. When evaluating the cost trigger of 50% of the replacement value of the existing building, the cost of the voluntary seismic strengthening need not be included.

CAC Section 4-309(d) references CBC Sections 3417.11 and 3419.12, which require that voluntary seismic strengthening be designed to meet an approved seismic performance criteria and the following:

- The structural capacity of existing components is not reduced,
- That existing structural components are not loaded beyond their capacity,
- New components are detailed as for new construction,

- New or relocated nonstructural components are detailed and connected as required for new construction,
- A dangerous condition is not created, as defined in CBC Section 3402.

The essence of this section is that the voluntary seismic strengthening should not make the building worse.

Voluntary seismic strengthening projects do not require the 3-step submittal process as indicated above for seismic rehabilitation projects. The project may be submitted directly to DSA as part of the normal project application process. The plans and specification must clearly indicate the scope of modifications and the acceptance criteria for the design in accordance with CBC Section 3419.12.2. DSA will perform the plan and specification review based on this acceptance criteria, and the DSA approval letter will state as such.

Geologic hazard reports are not required for voluntary seismic strengthening projects unless the strengthening includes new deep foundation elements, new foundation elements not deformationally compatible with the existing foundation elements, or results in bearing pressures greater than those in an existing report, per DSA IR A-4 Section 2.5.2.

Seismic Safety Inventory and Funding

AB 300 (1999) resulted in a seismic safety inventory of existing public school buildings (K-12) that included pre 1976 CBC non-wood framed buildings. More information on this bill can be found on the DSA AB 300 website (www.dgs.ca.gov/dsa/aboutus/ab300.aspx). School districts may update information in the inventory for their buildings by completing form DSA-300.

Proposition 1D (2006) provided \$199.5 million of State matching funds for seismic mitigation of certain school building (K-12) types that can be demonstrated to pose an unacceptable risk of injury to its occupants due to ground motions. More information on the procedure for those seeking funding through this program can be found on the DSA publications website under DSA Procedure 08-03 (www.dgs.ca.gov/dsa/resources/pubs.aspx).

Conclusions

The building code requirements for the seismic rehabilitation of school buildings are spread over several parts of Title 24, CAC and CBC, and navigating all the applicable provisions can be complex. Fortunately the CAC provisions and CBC provisions have pointers to cross reference and direct users to the applicable building code provisions.

As school districts modernize and update their building inventory, they need to consider useful life of each building considering the age and maintenance of the building. It may be more economical to replace an aging structure than to perform a major renovation and seismic rehabilitation, or perhaps it is more economical to perform a minor renovation and perform a voluntary seismic strengthening to increase the usefulness of the building for a shorter period of time. In any case, this paper provides a roadmap to navigate the building code requirements so school districts and their design teams can understand the implications and costs of their decisions when perform such life cycle analysis.

References

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