Seismic provisions in the Saudi building code

Authors: A. Shuraim, M. Al-Haddad, R. Al-Zaid, R. Mirza, K. Al-Sheref
Publication date: 2007

Conference: The Seventh Saudi Engineering Conference
Description: The paper describes the development of seismic provisions as presented in SBC 301 (Design Loads for Building and Structures) which is one of the six codes constituting the structural part of Saudi Building Code (SBC). IBC and ASCE-7 were chosen to be the source codes where extensive modifications have been carried out to reduce complexity and to account for differences in the seismicity level, construction materials, structural systems and quality control between USA and the Kingdom. ASCE-7 has all the seismic provisions in...

Total citations: Cited by 1
Scholar articles: Seismic provisions in the Saudi building code
Cited by 1 - Related articles - All 8 versions
SEISMIC PROVISIONS IN THE SAUDI BUILDING CODE

A. Shuraim¹, M. Al-Haddad¹, R. Al-Zaid¹, R. Mirza¹, K. Al-Sheref²

¹ King Saud University  
² Saudi Aramco  
ashuraim@gmail.com

ABSTRACT

The paper describes the development of seismic provisions as presented in SBC 301(*Design Loads for Building and Structures*) which is one of the six codes constituting the structural part of Saudi Building Code (SBC). IBC and ASCE-7 were chosen to be the source codes where extensive modifications have been carried out to reduce complexity and to account for differences in the seismicity level, construction materials, structural systems and quality control between USA and the Kingdom. ASCE-7 has all the seismic provisions in one complex chapter, covering all different topics. In SBC 301, however, seismic provisions have been reorganized and rationally presented in eight chapters to represent distinguished themes. The paper aims at providing a brief introduction of various chapters of the code related to the seismic provisions in terms of contents and basic concepts. Challenges, changes and the overall process were highlighted for the purpose of facilitating the understanding of seismic provisions and permitting successful future revisions.

KEYWORDS: building codes, structural, coding, seismic.

INTRODUCTION

The Royal directive of 2002 represents a milestone in the evolution of the Saudi Building Code on the basis of comprehensive international codes such as IBC, EC and NBC along with Arab codes and local research and studies in the kingdom. For carrying out this objective, the National Committee of the Saudi Building Code (NCSBC) was formed. The overall framework of code committees that include consultative committee (CCSBC) and eight technical committees, among them the structural technical committee (STC) and its associated workgroups are shown in Figure 1. The development of structural codes was carried over the period described by the timeline shown in Figure 2.
The general methodology adopted by NCSBC requires each of the technical committees to conduct a thorough study of: a) the Source code, relevant national studies, and Arab league sponsored codes. Based on the study, technical committees were instructed to identify chapters, sections, and items that should be removed, added, or modified. Rationale and scientific evidence for such decisions by the technical committee should be provided.

The source code mentioned in the NCSBC directive was identified as the set of codes published by The International Code Council (ICC)[1]. The ICC issues about fourteen codes, one of them is the international building code (IBC) which has been considered as the default source code, where its contents have been distributed among the various technical committees. During the evaluation stage, the STC has divided the eight chapters of IBC among themselves, and agreed on a methodology and criteria for the thorough reviewing process. The criteria are summarized as: 1) scientific basis; 2) compact not voluminous; 3) relevant to national/local issues; 4) simplified without unwarranted complexity; and 5) minimum shortcomings and deficiencies. These criteria aims at achieving the main STC objective entitled “towards rational and applicable codes”.

Seismic provisions of the source codes are very complex and play major influence on the provisions of design, construction and quality control. In the source code, the provisions are located in chapter 16 of IBC and in ASCE-7-02 [2] which is one of the standards referenced by IBC. These provisions need to be simplified, with the following considerations:

1. The seismicity of the kingdom is less severe than the seismicity of USA, for which the source code was developed. Keeping the high seismicity provisions was judged by the STC to be counterproductive for the goal of applicability because engineers and building official will be required to master these unneeded complex provisions.

2. The seismic provisions are contained in a few sections within chapter 16. These provisions have significant dependency on ASCE-7-02. Accordingly, implementing any changes may not lead to a practical Saudi code. Eventually, a decision has been made to adopt ASCE-7 as the source code for entire SBC 301.

3. ASCE-7 has all the seismic provisions in one complex chapter, covering different systems and materials and methods. The provisions also address external referenced codes and standards.

4. There are a number of differences in the construction materials, systems and quality control between USA and the Kingdom. For example, wood is a major construction material in USA, especially for single dwelling units, also masonry is used extensively for low-rise buildings. Differences also occur in material properties, structural systems, and quality control in design and construction.
5. Shortcomings in codes include numerical errors, confusing statements and complex provisions that can be misinterpreted. Wrong references to sections, tables and equations can have serious implications.

In view of the above challenges, the paper presents the eight seismic chapters (9 through 16) of SBC 301 assembled, mainly, from chapter 9 and appendix A of ASCE-7-02. Substantial portions of the provisions in chapter 9 of ASCE-7-02 were discarded or simplified for being irrelevant or unwarrantedly complex for the conditions of the Kingdom (Table 2). The paper also briefly highlights some fundamental concepts of seismic provisions to permit understanding the changes that have taken place. It is believed that such documentation can play a great deal in illustrating the code provisions and in recognizing major issues that need to be taken into consideration in the future revisions and development.

Figure 1: Saudi Code Building Committees

Figure 2: Timeline of code development

Proceedings of the 7th Saudi Engineering Conference (SEC7)
BACKGROUND OF SEISMIC DESIGN

Earthquake-induced inertia forces depend on the response characteristics of the structure and the intensity of ground motion at the site. The latter depends primarily on three factors: the distance between the source and the site, the magnitude of the earthquake, and the type of soil at the site. Different individual structures shaken by the same earthquake respond differently. One important characteristic is the fundamental period of vibration of the structure. Shape or configuration is another important characteristic that affects structure response.

It is generally uneconomical and unnecessary to design a structure to respond in the elastic range to the maximum earthquake-induced inertia forces. Thus, the design seismic horizontal forces prescribed in the seismic codes (IBC 2003, ASCE-7, SBC 301), are generally less than the elastic response inertia forces induced by the design earthquake. Acceptable performance can be achieved by structures elastically designed for reduced forces, if suitable structural systems are selected, and structures are detailed with appropriate levels of ductility, regularity, and continuity [1-4]. Accordingly, structural systems are expected to undergo fairly large deformations, allowing inelastic energy dissipation, when subjected to a major earthquake. Some structural and nonstructural damage can be expected due to large deformations. Therefore, seismic provisions regulate both strength and lateral drift.

Prescribed design lateral forces are significantly reduced from those that would actually be produced by a design earthquake, if a structure responds elastically, by the response modification coefficient $R$ and the importance factor. $R$ is an empirical response reduction factor intended to account for damping, over strength and the ductility inherent in the structural system at large displacements. The importance factor, $I$, allows for a partial control on the amount of damage experienced by the structure under a design earthquake. The elastic deformations calculated under these reduced design forces are then amplified, by the deflection amplification factor ($C_d$) to estimate the expected deformations likely to be experienced in response to the design ground motion.

CHAPTER 9: SEISMIC DESIGN CRITERIA

Chapter 9 is the first chapter in SBC 301 that deals with seismic provisions and is composed of six sections, as shown in Table 1, to reflect a basic theme in the design process. The main concepts in this chapter are the design acceleration coefficients, and the Seismic Design Category. More on these two topics are given next.

Table 1: contents of chapter 9 as extracted from ASCE-7.

<table>
<thead>
<tr>
<th>ASCE-7-02 Section/subsection Title</th>
<th>SBC 301 Section/subsection Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.0 Earthquake Loads</td>
<td>Chapter 9 Seismic Design Criteria</td>
</tr>
<tr>
<td>9.1 General Provisions</td>
<td>9.1 General</td>
</tr>
<tr>
<td>9.2.1 Definitions</td>
<td>9.2 Definitions</td>
</tr>
<tr>
<td>9.2.2 Symbols</td>
<td>9.3 Symbols and Notations</td>
</tr>
<tr>
<td>9.3</td>
<td>9.4 Seismic Ground Motion Values</td>
</tr>
<tr>
<td>9.1.4 Occupancy Importance Factor</td>
<td>9.5 Occupancy Importance Factor</td>
</tr>
<tr>
<td>9.4.2 Seismic Design Category</td>
<td>9.6 Seismic Design Category</td>
</tr>
</tbody>
</table>
Design acceleration coefficients

For the site where a structure is to be constructed, the design acceleration coefficients are to be computed after making basic decisions. First, designers need to obtain two spectral response accelerations SS and S1, corresponding to 0.2 and 1.0 second spectral response accelerations, respectively and can be obtained from maps developed for all regions of the kingdom as exemplified by Figures 1. Next, Designers also need to obtain site class which is to be determined based on the site soil properties, the site shall be classified as Site Class A, B, C, D, E or F in accordance with Chapter 14. Third, based on (SS and S1, and site Class), two coefficients, Fa and Fv are to be determined from Tables in Chapter 9. These two coefficients respectively scale the SS and S1 values determined for firm rock sites to appropriate values for other site conditions. The maximum considered earthquake spectral response accelerations adjusted for Site Class effects are designated respectively, SMS and SM1, for short period and 1 second period response. Finally, design acceleration coefficients (SDS, and SD1) are defined according to appropriate equations. The effect of soil classification on SD1 and SDS is illustrated in Figure 4, which shows how weak soils tend to magnify the design accelerations.

![Figure 3: typical contour seismic map for one of the regions in the kingdom.](image)

Seismic Design Categories

All structures shall be assigned to a Seismic Design Category based on their Occupancy Category and the design spectral response acceleration coefficients, SDS and SD1, determined in accordance with Section 9.4.4. Each building and structure shall be assigned to the most severe Seismic Design Category in accordance with Table 9.6.a or 9.6.b, irrespective of the fundamental period of vibration of the structure, T. Once the Seismic Design Category (SDC) (A to D) for the building is established, many other
requirements such as detailing, quality assurance, systems and height limitations, specialized requirements, and change of use are related to it.

Figure 4: Effects of Soil Class on spectral response acceleration

CHAPTER 10: STRUCTURAL DESIGN REQUIREMENTS FOR BUILDING STRUCTURES

Chapter 10 is composed of fourteen sections, extracted from the contents of ASCE-7-02 and extensively modified, as shown in Table 2. Modifications include section titles, adding new subsections, removing some subsections, Simplifying lengthy provisions.

Table 2: contents of chapter 10 as extracted from ASCE-7.

<table>
<thead>
<tr>
<th>ASCE 7-02</th>
<th>SBC 301</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.5 Structural Design Criteria, Analysis,</td>
<td>Ch. 10 Structural Design Requirements for</td>
</tr>
<tr>
<td>and Procedures</td>
<td>Building Structures</td>
</tr>
<tr>
<td>9.5.2 Structural Design Requirements</td>
<td>10.1 Structural Design Requirements</td>
</tr>
<tr>
<td>9.5.2.2 Basic Seismic Force-Resisting Systems</td>
<td>10.2 Structural System Selection</td>
</tr>
<tr>
<td>9.5.2.3 Structure Configuration</td>
<td>10.3 Diaphragm Flexibility, Configuration</td>
</tr>
<tr>
<td>9.5.2.7 Combination of Load Effects</td>
<td>Irregularities and Redundancy</td>
</tr>
<tr>
<td>9.5.2.5 Application of Loading</td>
<td>10.5 Direction of Loading</td>
</tr>
<tr>
<td>9.5.2.5 Analysis Procedures</td>
<td>10.6 Analysis Procedures</td>
</tr>
<tr>
<td>9.5.3 Index Force Analysis Procedure for</td>
<td>10.7 Index Force Analysis Procedure for</td>
</tr>
<tr>
<td>Seismic Design of Buildings</td>
<td>Seismic Design of Buildings</td>
</tr>
<tr>
<td>9.5.4 Simplified Analysis Procedure for</td>
<td>10.8 Simplified Analysis Procedure for</td>
</tr>
<tr>
<td>Seismic Design of Buildings</td>
<td>Seismic Design of Buildings</td>
</tr>
<tr>
<td>9.5.5 Equivalent Lateral Force Procedure</td>
<td>10.9 Equivalent Lateral Force Procedure</td>
</tr>
<tr>
<td>9.5.6 Modal Analysis Procedure</td>
<td>10.10 Modal Analysis Procedure</td>
</tr>
<tr>
<td>9.5.2.6 Design and Detailing</td>
<td>10.11 Design and Detailing Requirements</td>
</tr>
</tbody>
</table>

Proceedings of the 7th Saudi Engineering Conference (SEC7)
There are some fundamental concepts that need some brief clarifications, namely, the response modification factor, fundamental period, structure configuration, and analysis procedures.

**Response Modification Factor**

If a structure responds elastically to ground motion during a severe earthquake, the maximum response accelerations may be several times the maximum ground acceleration. The role of the response reduction factor is to reduce the elastic response depending on the frame type, material, and detailing requirements. Table 10.1 of SBC 301 stipulates $R$ coefficients for different types of building systems using several different structural materials. The values in this table have been modified by the committee in order to account for variations in material properties and quality control. For a lightly damped building structure of brittle material that would be unable to tolerate any appreciable deformation beyond the elastic range, the factor $R$ would be close to 1. At the other extreme, a heavily damped building structure with a very ductile structural system would be able to withstand deformations considerably in excess of initial yield and would, therefore, justify the assignment of a larger response reduction factor $R$. Figure 5 shows illustration of the role of $R$ values on the response in terms of spectral response acceleration.

**Fundamental Period**

One important building characteristic is the fundamental period of vibration of the building (measured in seconds). The fundamental period of a building depends in a complex way on the stiffness of the structural system, its mass, and its total height. Seismic waves with periods similar to that of the building will cause resonance, and amplify the intensity of earthquake forces the building must resist. In general, a large portion of the earthquake energy is contained in short-period waves. Therefore, short-period buildings with stiff structural systems are designed for larger forces than long period, flexible, buildings. It is preferable that this be determined using modal analysis methods and the principals of structural mechanics. However, methods of structural mechanics cannot be employed to calculate the vibration period before a building has been designed.

**Structure Configuration**

The configuration of a structure can significantly affect its performance during a strong earthquake that produces the ground motion contemplated in the *SBC 301*. Configuration can be divided into two aspects, plan configuration and vertical configuration. The seismic provisions were basically derived for buildings having regular configurations.
In a regular structure, inelastic demands produced by strong ground shaking tend to be well distributed throughout the structure, resulting in a dispersion of energy dissipation and damage. However, in irregular structures, inelastic behavior can concentrate in the zone of irregularity, resulting in rapid failure of structural elements in these areas. In addition, some irregularities introduce unanticipated stresses into the structure which designers frequently overlook when detailing the structural system.

![Figure 5: Effects of response modification factor.](image)

**Analysis Procedures**

Analysis procedures are selected based on Seismic Design Category and they achieve calculating the total base shear and its distribution over the structure. Chapter 10 gives details of four basic procedures and lists additional procedures that can be used. The basic procedures are: Index method, Simplified method, Equivalent Lateral Force Procedure, and Modal Analysis Procedure.

**CHAPTER 11: MATERIAL SPECIFIC SEISMIC DESIGN**

Chapter 11 is composed of four short sections, extracted from the contents of ASCE-7-02 as shown in Table 3, each section refers to a material code. For example, section 11.2 entitled “concrete structures” refers to SBC 304 for detailed provisions for concrete members to comply with selected frame type (special, intermediate or ordinary). The chapter is entitled “Material Specific Seismic Design and Detailing Requirements” to reflect the content properly.

**Table 3: contents of chapter 11 as extracted from ASCE-7.**

<table>
<thead>
<tr>
<th>ASCE 7-02</th>
<th>Ch. 11</th>
<th>Material Specific Seismic Design and Detailing Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.8 Steel</td>
<td>11.1</td>
<td>Steel</td>
</tr>
<tr>
<td>9.9 Structural Concrete</td>
<td>11.2</td>
<td>Structural Concrete</td>
</tr>
<tr>
<td>9.10 Composite Structures</td>
<td>11.3</td>
<td>Composite Structures</td>
</tr>
<tr>
<td>9.11 Masonry</td>
<td>11.4</td>
<td>Masonry</td>
</tr>
</tbody>
</table>

Proceedings of the 7th Saudi Engineering Conference (SEC7)
CHAPTER 12: NON-STRUCTURAL COMPONENTS

Chapter 12 is composed of three sections (Table 4) that establish minimum design criteria for architectural, mechanical, electrical, and non-structural systems, components, and elements permanently attached to structures including supporting structures and attachments. The design criteria establish minimum equivalent static force levels and relative displacement demands for the design of components and their attachments to the structure, recognizing ground motion and structural amplification, component toughness and weight, and performance expectations. For design purpose, components shall be considered to have the same Seismic Design Category as that of the structure that they occupy or to which they are attached unless otherwise stated by the provisions.

Table 4: contents of chapter 12 as extracted from ASCE-7.

<table>
<thead>
<tr>
<th>ASCE 7-02</th>
<th>SBC 301</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.6 Architectural, Mechanical, and Electrical Components and Systems</td>
<td>Ch.12 Seismic Design Requirements For Non-Structural Components</td>
</tr>
<tr>
<td>9.6.1 General</td>
<td>12.1 General</td>
</tr>
<tr>
<td>9.6.2 Architectural Component Design</td>
<td>12.2 Architectural Component Design</td>
</tr>
<tr>
<td>9.6.3 Mechanical and Electrical Component Design</td>
<td>12.3 Mechanical and Electrical Component Design</td>
</tr>
</tbody>
</table>

CHAPTER 13: NON BUILDING STRUCTURES

Chapter 13 is composed of seven sections, extracted from the contents of ASCE-7-02 as shown in Table 5. Modifications include section titles, adding new subsections, removing some subsections, Simplifying lengthy provisions. Nonbuilding structures include all self-supporting structures that carry gravity loads and that may be required to resist the effects of earthquake, with the exception of building structures specifically excluded in Section 9.1.2, and other nonbuilding structures where specific seismic provisions have yet to be developed in Chapter 13. Nonbuilding structures supported by the earth or supported by other structures shall be designed and detailed to resist the minimum lateral forces specified in this chapter.

Table 5: contents of chapter 13 as extracted from ASCE-7.

<table>
<thead>
<tr>
<th>ASCE 7-02</th>
<th>SBC 301</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.14 Nonbuilding Structures</td>
<td>Ch. 13 Seismic Design Requirements for Non Building Structures</td>
</tr>
<tr>
<td>9.14.1 General</td>
<td>13.1 General</td>
</tr>
<tr>
<td>9.14.4 Nonbuilding Structures Supported by Other Structures</td>
<td>13.3 Nonbuilding Structures Supported by Other Structures</td>
</tr>
<tr>
<td>9.14.5 Structural Design Requirements</td>
<td>13.4 Structural Design Requirements</td>
</tr>
<tr>
<td>9.14.6 Nonbuilding Structures Similar to Buildings</td>
<td>13.5 Nonbuilding Structures Similar to Buildings</td>
</tr>
<tr>
<td>9.14.7 Nonbuilding Structures Not Similar to Buildings</td>
<td>13.6 General Requirements for Nonbuilding Structures Not Similar to Buildings</td>
</tr>
<tr>
<td>9.14.7.3 Tanks and Vessels</td>
<td>13.7 Tanks and Vessels</td>
</tr>
</tbody>
</table>

Proceedings of the 7th Saudi Engineering Conference (SEC7)
CHAPTER 14: SITE CLASSIFICATION

Chapter 14 is composed of four sections, extracted from the contents of ASCE-7-02, covering site classification procedure for seismic design. This chapter is referenced by chapter 9 in order to determine site class (A to F), based on specific soil test criteria.

CHAPTERS 15 AND 16: QUALITY AND EXISTING BUILDINGS

Chapter 15 is composed of six sections that address quality assurance. All of the relevant sections of Appendix A have been moved to this Chapter. Chapter 16 addresses briefly provisions related to existing buildings for the cases of additions, change of use or multiple uses.

CONCLUDING REMARKS

The Royal directive of 2002 represents a milestone in the evolution of the Saudi Building Code on the basis of comprehensive international codes. The paper has introduced various chapters of the code related to the seismic provisions in terms of contents and basic concepts. Challenges, changes and the overall process were highlighted. The single complex chapter of ASCE-7 that covers various topics was converted into eight chapters representing different systems and materials. Buildings, nonbuildings, and nonstructural components were separated in different chapters. Soil classification provisions have been allocated a separate chapter to be accessible to geotechnical engineer. Existing building provisions were separated from new building provisions. The paper also briefly highlights some fundamental concepts of seismic provisions to permit understanding the changes that have taken place.

Many lessons have been learned from the foregoing experience, where international codes and regulations are utilized for developing national codes and standards. Through proper criteria and thorough knowledge of both the international codes and local conditions, developers can identify differences and shortcomings and propose solutions. Documenting the experience can play a great deal in illustrating the code provisions and in recognizing major issues that need to be taken into consideration in the future revisions.

Newly developed codes should go through a process of quality assurances in a systematic manner, through monitored usage and parametric studies by qualified engineers in order to detect any inconsistency and bring the remarks to the technical committees to take proper actions. Furthermore, external referenced codes and standards should be made available in a proper form. Finally, successful implementation of the code requires education and training of engineers to digest codes provisions and intents as well as proper administrative and inspection schemes.

ACKNOWLEDGEMENT

The authors would like to thank the NCSBC, particularly its former chairman Dr. Khalid Al-Khalaf and its current chairman Engr. Mohammed Al-Nagadi, and the chairman of the consultative committee Engr. Ali Al-Zaid Without their
encouragements, supports and appreciations our work may not have been accomplished. Special thanks to all STC members and workgroup members for their excellent work and sincere efforts.

REFERENCES


Table 6: Structural Technical Committee (STC) and SBC 301 members.

<table>
<thead>
<tr>
<th>Work</th>
<th>STC</th>
<th>Additional tasks (Structural codes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SBC 301</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M</td>
</tr>
</tbody>
</table>

Abbreviations: (M) member, (CH): workgroup chairman, King Saud University (KSU), King Fahd University of Petroleum and Minerals (KFUPM); Ministry of Municipal and Rural Affairs (MMRA,: Royal commission for Jubail and Yanbu (RCJ &Y); Rashid Geotechnical and Material Engineers (RG&ME); Ministry of Interior – Directorate of Civil Defense (MOI-DCD); Saline Water Conversion Corporation (SWCC).
Table 7: Examples of provisions that have been removed from source code.

<table>
<thead>
<tr>
<th>9.1.2.4.1New Buildings</th>
<th>9.5.8.4 Design Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.1.2.5 Alternate Materials and Methods of Construction</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.1.3 Seismic Use Groups</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.1.3.1 High Hazard Exposure Structures</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.1.3.1.1Seismic Use Group III Structure Protected Access</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.1.3.1.2 Seismic Use Group III Function</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.4.1.3 Site-Specific Procedure for Determining Ground Motion Accelerations</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.4.1.3.1Probabilistic Maximum Considered Earthquake</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.4.1.3.2Deterministic Limit on Maximum Considered Earthquake Ground Motion</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.4.1.3.3Deterministic Maximum Considered Earthquake Ground Motion</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.4.1.3.4Site-Specific Design Ground Motion</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.4.1.3.5Design Acceleration Parameters</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.4.2.2 Site Limitation for Seismic Design Categories E and F</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.7.1 Modeling</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.7.2 Ground Motion</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.7.2.1Two-Dimensional Analysis</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.7.2.2Three-Dimensional Analysis</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.7.3 Response Parameters</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.8.1 Modeling</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.8.2 Ground Motion and Other Loading</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.8.3 Response Parameters</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.8.3.1Member Strength</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.8.3.2Member Deformation</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.8.3.3Interstory Drift</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.8.4 Design Review</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.9.1 General</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.9.2 Equivalent Lateral Force Procedure</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.9.2.1Effective Building Period</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.9.2.1.1Effective Building Period</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.9.2.2Effective Damping</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.9.2.3Other Effects</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.9.3Modal Analysis Procedure</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.9.3.1Modal Base Shears</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.9.3.2Other Modal Effects</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.5.9.3.3Design Values</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.13.4.7.2 Structural Elements Above the Isolation System</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.13.4.7.3Scaling of Results</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.13.4.7.4Drift Limits</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.13.5Lateral Load on Elements of Structures and Nonstructural Components Supported by Buildings</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.13.5.1Plan or Vertical Irregularities</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.13.5.2Wood</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.13.5.2.1Components at or Above the Isolation Interface</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.13.5.2.2Components Crossing the Isolation Interface</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.13.5.2.3Components Below the Isolation Interface</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.13.6Detailed System Requirements</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.13.6.1General</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.13.6.2Isolation System</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.13.6.2.1Environmental Conditions</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.13.6.2.2Wind Forces</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.13.6.2.3Fire Resistance</td>
<td>9.5.8.4 Design Review</td>
</tr>
<tr>
<td>9.13.6.2.4Lateral Restoring Force</td>
<td>9.5.8.4 Design Review</td>
</tr>
</tbody>
</table>

Proceedings of the 7th Saudi Engineering Conference (SEC7)