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STANDARDIZING SEISMIC EVALUATION OF EXISTING BUILDINGS

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SUMMARY

With the publication of ASCE 31, the American Society of Civil Engineers (ASCE) has produced a document that represents a consensus standard for the seismic evaluation of existing buildings. The evolution of ASCE 31 over many years and through several generations of guidelines is described. These past guidelines have represented a de facto standard that have been used by engineers for many years. The most recent guideline was FEMA 310, published by the Federal Emergency Management Agency, which has been required for use for federally owned and leased buildings.

The ASCE 31 standard has incorporated many recent developments in performance based design. It includes procedures for Life Safety and Immediate Occupancy Performance Levels. Definitions of seismicity are based on the most recently published seismological data for the United States and the influence of local soils conditions using modern soil factors. Additional standard building types have been included.

The basic methodology in ASCE 31 is a three tier approach for screening buildings. In the first tier, a series of checklist statements are provided for standard building types. Those buildings that do not comply with all of the checklist requirements can be further evaluated using the procedures in the second tier. Buildings not meeting the requirements for the second tier can be further evaluated using the third tier procedure. ASCE 31 also includes evaluation procedures for geotechnical and foundation hazards and nonstructural components in the building. The requirements in the evaluation vary depending on the seismicity and the seismic performance. Checklists and evaluation procedures are also provided for nonstructural components and foundations.

The appropriateness of the procedures in ASCE 31 is evaluated using example buildings. The results of these examples are described and compared to other methodologies and changes to the standard are recommended.

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INTRODUCTION

Over the last twenty years, significant effort has been made in understanding the factors that affect the seismic performance of buildings. This has resulted in changes in the procedures for designing new buildings to resist the effects of earthquakes. In addition, engineers have also realized the importance and complexity of evaluating the seismic resistance of existing buildings.

In the early 1980's, the Applied Technology Council (ATC) published one of the first set of guidelines for the seismic evaluation of existing buildings, ATC-14 by ATC [1]. This guide provided a relatively comprehensive methodology that dealt with a variety of building types. This document was later modified and was published by ATC as ATC-22 [2]. Further modifications were made, resulting in the publication by the Federal Emergency Management Agency (FEMA) of FEMA 178 [3]. This guideline has been widely used as the de facto standard methodology for evaluating the seismic resistance of existing buildings in the United States. It is also used, with some modifications, in other countries.

In the 1990's, FEMA sought to update FEMA 178 methodology in light of findings from recent earthquakes, as well as from the development of performance based design procedures. Following a multi-year effort, FEMA published a revised guideline for seismic evaluation of existing buildings, designated FEMA 310 [4] entitled *Handbook for the Seismic Evaluation of Buildings - A Prestandard*. The designation of the guide as a "prestandard" was an indication that the document was in the process of becoming a consensus standard. The American Society of Civil Engineers (ASCE), and its committee on seismic evaluation of existing buildings, was tasked with revising FEMA 310 and publishing it as a consensus standard document. ASCE, through its process, revised the document and published it as a consensus standard in 2003, entitled *Seismic Evaluation of Existing Buildings* ASCE/SEI 31-03 [5].

FEMA 310/ASCE 31 METHODOLOGY

The methodology presented in FEMA 310 for evaluating the seismic resistance of buildings consists of a three-tier approach. The first tier is the screening phase, the second tier is the evaluation phase, and the third tier is the detailed evaluation phase. These phases are described below.

Two important changes were introduced in FEMA 310 that differ substantially from FEMA 178 and its predecessors. The first is that the seismicity is based on the latest seismic hazard data, using as its basis, an earthquake with a 2 percent probability of exceedence in 50 years, whereas previous methodologies had used an earthquake with a 10 percent probability of exceedence in 50 years. The second is that the methodology allows for evaluations at Life Safety and Immediate Occupancy performance levels, whereas previous codes and guidelines considered only Life Safety performance.

Tier 1 - Screening Phase

The intent of the screening phase of FEMA 310 is to identify those buildings that appear to comply with the designated seismic performance. In the screening phase, a building structural type is designated for each building using one of 24 building types, as described in Table 1. A change in FEMA 310 compared to FEMA 178 is the addition of new building types. The design of the subject building is first evaluated in comparison to the design provisions of model building codes depending on the building structural type. If the building is known to have been designed and constructed in accordance with the designated model building code for that building type, termed the benchmark buildings, then the building is deemed to pass the structural design requirements.

Table 1 - ASCE 31 Standard Building Types

Building Type	Description
W1	Wood Light Frame Buildings; residential buildings 1 to 3 stories in height
W1A	Multi-story wood frame buildings with plan area greater than 3000 sq. ft.
W2	Wood Frame Commercial and Industrial Buildings
S1	Steel Moment Frame Buildings with stiff diaphragms
S1A	Steel Moment Frame Buildings with flexible diaphragms
S2	Steel Braced Frame Buildings with stiff diaphragms
S2A	Steel Braced Frame Buildings with flexible diaphragms
S3	Steel Light Frame Buildings
S4	Steel Frame Buildings with concrete shear walls
S5	Steel Frame Buildings with Infill Masonry Shear Walls and stiff diaphragms
S5A	Steel Frame Buildings with Infill Masonry Shear Walls and flexible diaphragms
C1	Concrete Moment Frame Buildings
C2	Concrete Shear Wall Buildings with stiff diaphragms
C2A	Concrete Shear Wall Buildings with flexible diaphragms
C3	Concrete Moment Frame Buildings with Infill Masonry Shear Walls and stiff diaphragms
C3A	Concrete Moment Frame Buildings with Infill Masonry Shear Walls and flexible diaphragms
PC1	Precast/Tiltup Concrete Shear Wall Buildings with flexible diaphragms
PC1A	Precast/Tiltup Concrete Shear Wall Buildings with stiff diaphragms
PC2	Precast Concrete Frame Buildings with shear walls
PC2A	Precast Concrete Frame Buildings without shear walls
RM1	Reinforced Masonry Bearing Wall Buildings with Flexible Diaphragms
RM2	Reinforced Masonry Bearing Wall Buildings with stiff diaphragms
URM	Unreinforced Masonry Bearing Wall Buildings with flexible diaphragms
URMA	Unreinforced Masonry Bearing Wall Buildings with stiff diaphragms

For the typical buildings that do not pass the benchmark building comparison, the building is then checked using a series of checklist statements for the particular building type. These statements vary depending on the building type, but include general statements regarding the overall lateral force resisting system and specific statements regarding the detailing and design of the lateral force resisting elements. Statements are provided for the structural system, the foundation and geotechnical hazards, and the nonstructural components. The applicable statements depend on both the seismicity at the building site and the performance level to which the building is being evaluated. For each building type there is a basic structural checklist and a supplemental structural checklist. The supplemental structural checklists are used where the level of seismicity for the building is high or when the building is being evaluated for Immediate Occupancy Performance Level where the level of seismicity is moderate. There is also a basic nonstructural checklist and a supplemental nonstructural checklist.

Limited structural calculations, referred to as Quick Checks, are used during this tier of the evaluation. Rough calculations are performed to estimate the seismic forces resisted by the primary lateral force resisting elements. These forces are calculated based on an unreduced earthquake base shear but resulting forces are then reduced at the element level and compared to an allowable force. The intent is that these Quick Checks can be performed with little computational effort and does not require a detailed structural analysis of the building.

If the configuration and detailing of the building is such that all of the tier 1 statements are compliant, then the building is deemed to have passed the tier 1 screening and no further evaluation would be necessary. If there are any statements that are found to be noncompliant, then an evaluation of the building using the procedures of tier 2 would be necessary. There is an option to conduct a full, tier 2 evaluation using all of the requirements for tier 2 or a limited tier 2 evaluation requiring only a check of those items found noncompliant in tier 1.

Tier 2 - Evaluation Phase

In the tier 2 evaluation, the building is analyzed using standard linear static or linear dynamic analysis procedures. The seismic forces however, are calculated as pseudo lateral forces, which are significantly larger than force levels used in typical building codes. The demands on the lateral force resisting elements are determined based on the pseudo lateral forces that are reduced at the element level by a factor related to the ductility of the element. This reduced demand is then compared to the element's capacity.

The structural analysis used in tier 2 requires the designation of the primary components of the lateral force resisting system and the secondary components. The primary components are those that are those that are typically designated as the lateral force resisting elements. The secondary components are those that exist in the building and may contribute some nominal lateral stiffness or strength but are not considered essential to the lateral load resistance. For some buildings the designation of primary and secondary elements is straightforward, but for many older structures that may not have been specifically designed for earthquakes, identifying the primary and secondary elements is more difficult.

In tier 2 evaluations, each primary and secondary component that resists earthquake forces is evaluated based on its assumed capability to respond nonlinearly. Those actions that are ductile are considered deformation-controlled and those that are brittle are considered force-controlled. Seismic forces are considered along with dead loads, live loads, and snow loads.

In addition to comparing the demands and capacities of the structural elements, there are a series of statements pertaining to the specific building type that must also be checked, similar to the tier 1 statements. Based on the responses to these statements and the demand to capacity ratios, the building is designated as either passing the tier 2 evaluation or not passing. For those buildings that do not pass the tier 2 evaluation, a further evaluation using tier 3 can be performed.

Tier 3 - Detailed Evaluation

Tier 3 evaluations are intended to provide a detailed evaluation of a building using a performance based approach. A tier 3 evaluation can be conducted for the entire building or only those components that were found to be noncompliant in tier 2. There are no detailed procedures provided for conducting the tier 3 evaluation. Reference is made to the use of procedures for design of seismic rehabilitation of buildings and for design of new buildings. When these other procedures are used, the seismic demand forces are allowed to be reduced by a factor of 0.75. Tier 3 also includes requirements for the use of linear dynamic or nonlinear static analysis for buildings with specific characteristics.

STANDARDIZATION PROCESS

The ASCE committee on seismic evaluation of existing buildings was tasked with developing the FEMA 310 document into a consensus standard. The document was submitted to the members of the committee who were each given the opportunity to vote separately for each section as either affirmative, affirmative with comments, negative, or abstained. Each negative or affirmative with comment vote was required to

include a description of the reason for the vote and a recommendation for a change to the document that would change the vote to affirmative.

The chair of the committee was responsible for reviewing and resolving the ballot comments. For negative votes, the chair could designate the comment as being editorial, persuasive, or non-persuasive. Editorial and persuasive comments resulted in revisions to the document. Comments ruled as non-persuasive require an explanation as to the reason for being non-persuasive. Once the changes were made, the changes in the document was re-balloted by the committee. The committee also voted on whether they agreed on the designation of comments ruled as non-persuasive by the chair.

Once the balloting by the committee was completed and all of the comments resolved, the document was then submitted to any interested party in the general public who could also vote on the document. Comments from the public ballot were resolved in a fashion similar to that of the committee balloting.

For a document of this size, the time required to thoroughly review and comment on the document was immense. A extended review period was provided to reviewers, however this did not provide sufficient incentive to allow all of the reviewers to comment on the document.

In the balloting process, the interest and responsiveness of the members of the committee varied. At the start of the balloting process, there were 197 members of the committee, but only 48 percent submitted a response to the first ballot. This required issuing a second ballot. At the completion of the ballot process only 98 members of the committee remained. Many of those who left the committee did so due to the mandatory requirement to be dropped from the committee for failure to return committee ballots. As a result, the comments received during balloting represented only a handful of committee members who took the time to review and comment. Negative comments were burdensome since it required the commenter to include specific suggestions for changes to the document to be considered or else the comment would be invalid.

Following the committee balloting, there was a period provided for public balloting. Any interested person was allowed to review the document and submit comments. After receiving a few comments during the first public ballot, the document was revised. The revisions were then submitted to the committee for concurrence. The document was then submitted to a second public ballot for only those items that had been changed.

TECHNICAL CHANGES

Based on the comments received during the balloting, a number of significant technical changes were made to the document. These changes generally provided additional clarification to the provisions and corrections to ambiguous or conflicting sections of the document. Many other editorial changes were also made. Some of the technical changes are described below as examples of the changes that were made.

Building Types

One of the changes made in the development of FEMA 310 was the designation of additional building types that had not been included in previous documents. One of the new building types was described as a "Northridge-style apartment building." This was defined as a multi-story, multi-unit light wood frame residence. This building type appeared to have been added to distinguish multi-story apartment buildings with parking on the first floor, similar to the Northridge Meadows Apartment building that collapsed during the 1994 Northridge Earthquake from single family houses. Although apartment buildings similar to this have a potential soft story seismic vulnerability, the definition of this new building type was not

sufficiently clear to establish it as a new building type. There was no difference in the screening or evaluation methodology between this new building type and other wood frame buildings other than a check for a soft story or weak story.

Based on comments during the balloting process, the definition of this new building type was revised. The new definition emphasizes that the building size is the importance difference of multi-story, multi-unit residential buildings compared to single family dwellings. Large residential buildings, either apartment buildings or condominiums, are generally designed and constructed different from single family dwellings. These large buildings are more likely to have been designed by an engineer, whereas single family residence are rarely designed by and engineer and are often constructed using conventional construction provisions in the building code.

Tier 1 Height Limits

FEMA 310 included a table that listed the maximum number of stories beyond which a Tier 1 screening could not be used. The height limit depends on the building type and the performance level. In FEMA 310, there was no height limit for buildings being checked for Life Safety Performance Level except unreinforced masonry buildings with flexible diaphragms in Moderate and High seismic zones, which were required to be evaluated using the URM Special Procedure.

Based on committee input, specific height limits were included in ASCE 31 for Life Safety Performance Level for each building type in Moderate and High seismicity levels. The exception however, is unreinforced masonry buildings with flexible diaphragms, which have no height limitation in ASCE 31. Therefore, ASCE 31 allows all unreinforced masonry buildings with flexible diaphragms, including those exceeding the 6-story limit for the URM Special Procedure, to be evaluated in Tier 1, whereas FEMA 310 requires a Tier 2 evaluation for all unreinforced masonry buildings with flexible diaphragms.

Condition of Structural Elements

The structural condition of the lateral force resisting elements was included in the items to be checked for each building in FEMA 310. The required checks of the structural condition depended on the material used for the structural system. To check the condition of the structural elements, it was recognized that an examination of the building structure would be needed. The extent of investigation required to complete the evaluation was not clearly defined and was somewhat left to the judgment of the engineer. However, the specific structural condition checks were phrased such that the engineer may need to verify the condition of all of the structural elements to verify compliance.

For wood frame buildings as an example, FEMA 310 required that for Life Safety and Immediate Occupancy Performance Levels there be “no evidence of overdriven fasteners in the shear walls.” This created a potential for an exhaustive, and potentially unnecessary, investigation of the structure. In most cases, the nailing of shear wall sheathing would be covered by finishes. To verify that there would be no overdriven fasteners, the finishes would need to be removed to examine the fasteners. An extensive investigation such as this would generally not be undertaken for a routine seismic evaluation. In addition, FEMA 310 required that there be no overdriven fasteners. However, a limited number of overdriven fasteners would not necessarily prevent a shear wall from providing life safety performance.

Based on comments during the balloting process, the need for examining shear walls for overdriven nails was relaxed. The presence of anomalies in the shear wall fasteners was changed to only apply to Immediate Occupancy Performance Level. The scope of the examination was expanded to also account for other construction-related errors. It was recognized that it would be acceptable for a shear wall to have a limited amount of overdriven fasteners. It was also accepted that overdriven fasteners do not necessarily create a life safety hazard but instead are a concern for immediate occupancy performance. As a result,

inadequate or overdriven fasteners need only be checked when the building is being evaluated for immediate occupancy performance and a wall may have up to 15 percent of its fasteners installed incorrectly and still be considered as compliant for the purpose of the seismic evaluation.

For the materials in the structural system, ASCE 31 requires that there be no "signs of " deterioration. In concrete or masonry buildings in which the structural elements are generally exposed, the evaluation of the presence of deterioration may be relatively straightforward. However, for steel buildings and many wood frame buildings, it will be necessary to remove architectural finishes to evaluate the presence of deterioration. Destructive testing is specifically required for Tier 2 evaluations, but there is not guidance as to the frequency of the testing.

Flexible Diaphragm Connections

An important aspect of buildings with heavy structural walls and flexible diaphragms is the connection of the diaphragm to the walls. These connections resist the out-of-plane forces generated by the walls. The FEMA 310 tier 1 evaluation check for these connections emphasized that the wall to diaphragm connections should be stiff. The statement required that the anchorage connections "be stiff enough to prevent movement between the wall and the diaphragm." While the intent of this statement was to preclude the acceptability of flimsy or miss installed anchors, the statement as written could not adequately be used as a screening tool since there are no anchors that can always prevent relative movement between the walls and the diaphragms.

As a result of comments received regarding this ambiguity, the statements provided in ASCE 31 for checking wall to diaphragm connections was revised. In the revised statement the anchors are required to be stiff enough to allow no more than 1/8 inch (3 mm) of movement prior to engaging the anchor. While this revision eliminates the unachievable requirement of completely preventing movement, the revised statement still lacks two important considerations. There is no specific requirement as to the amount of lateral force that should be applied to the anchor. Also, there is no check of the anchor for strength or stiffness since the criteria only applies to the movement prior to engaging the anchor.

Nonstructural Elements

The FEMA 310 tier 1 evaluation procedure includes two sets of statements for checking nonstructural components: a basic nonstructural checklist and a supplemental nonstructural checklist. The basic nonstructural checklist includes statements that apply to many architectural elements and a few mechanical elements. The supplemental nonstructural checklist includes statements for additional mechanical and electrical elements, including elevators, as well as more stringent statements for architectural elements. The supplemental nonstructural checklist is specified to be used where the building is being checked for Immediate Occupancy Performance and is in an area where the level of seismicity is moderate or high.

In ASCE 31, an intermediate nonstructural checklist was added which is to be used when the building is being checked for Life Safety performance with high seismicity or is being checked for immediate Occupancy with moderate seismicity. Some checklist items that had been in the basic nonstructural checklist in FEMA 310 were moved to the intermediate checklist in ASCE 31 and some of the supplement nonstructural checklist statements were moved to the intermediate checklist. Bracing of suspended acoustic ceiling systems was required in the basic nonstructural checklist in FEMA 310, but in ASCE 31 was required in the intermediate nonstructural checklist so that it would be a concern for life safety performance for high seismicity levels and for immediate occupancy performance for moderate and high seismicity levels.

EVALUATION EXAMPLES

Two example buildings are presented to demonstrate the use of the ASCE 31 procedure. A general description of the building is included along with some of the key assumptions needed for carrying out the evaluation. The significant results from the evaluation are also presented.

Example 1

The first example building is a typical, two-story, single family house constructed with conventional wood frame construction. The exterior walls of the house and the cripple wall are sheathed with cement plaster (stucco). The building has a garage door opening on the first floor. A floor plan of the building is depicted schematically in Figure 1. The building is assumed to be located in an area where the seismicity is considered high and is being checked for Life Safety performance. Therefore, in the tier 1 screening, the basic and supplemental checklists are applied.

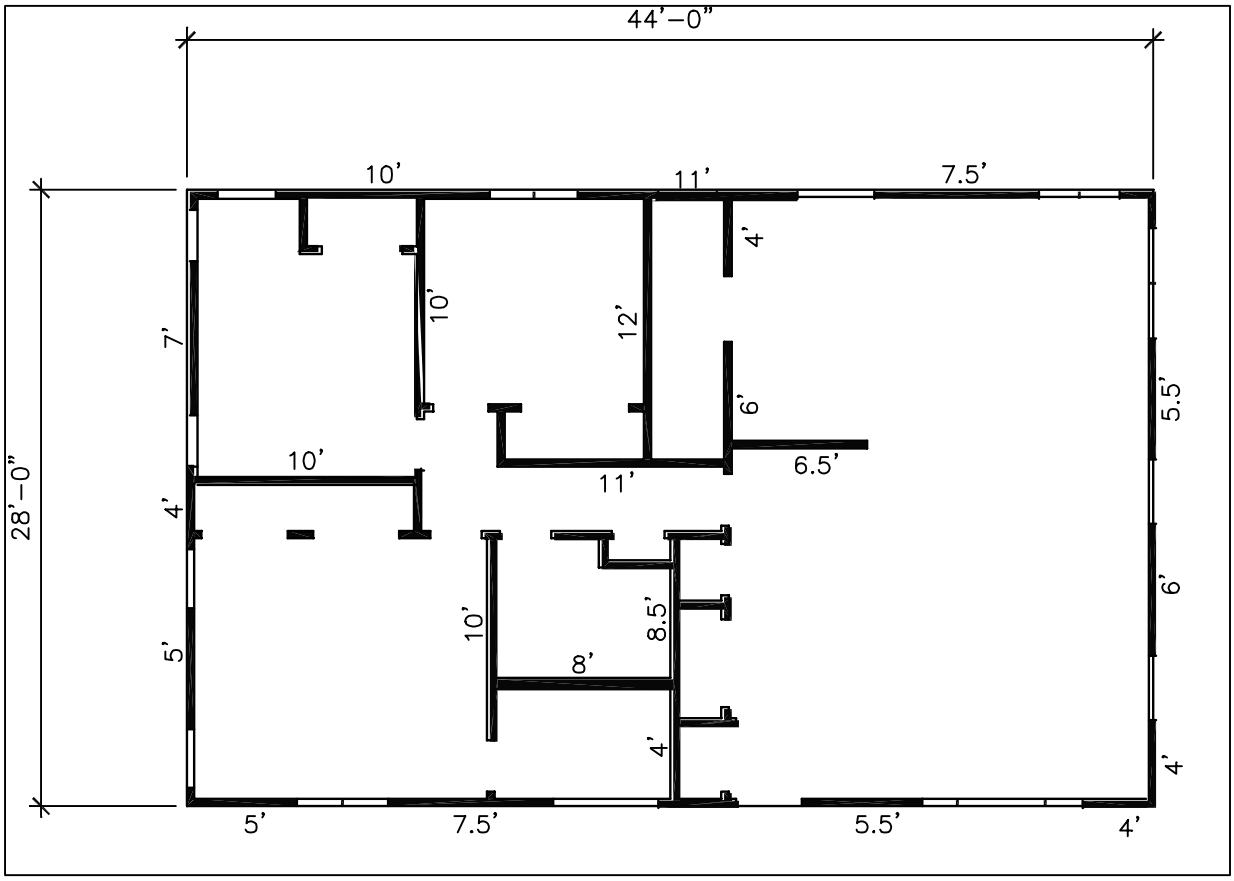

Figure 1- First Plan for Example Building 1

For the seismic evaluation of this building, it is assumed that the lateral force resisting system uses the exterior stucco walls and some of the interior gypsum wallboard walls. The building is classified as a W1, Wood light frame. Since this building relies on gypsum wallboard interior walls and exterior walls with stucco as the lateral force resisting system, this building would be judged as noncompliant with the tier 1 screening. In addition, the shear stress check indicates that the stress in the stucco and gypsum board shear walls exceeds the allowable stresses provided for the tier 1. In the tier 1 shear stress check, the stresses in the shear walls in the governing direction were 1024 pounds per foot of wall (plf) (14.9 kN/m), which is then divided by a reduction factor, m, equal to 4 for wood frame walls to get a demand load of 256 plf.

The allowable shear stress for gypsum board and stucco walls is 100 pounds per foot (1.5 kN/m). Due to these three noncompliant statements, a tier 2 evaluation would be needed to check the forces on the shear walls. All other applicable checklist statements are found to be compliant.

In the tier 2 evaluation, the seismic demands are calculated and the loads are distributed to the lateral force resisting elements. These lateral loads are reduced by the appropriate m-factors and compared with the expected strengths for gypsum wallboard and stucco shear walls. The expected strengths are taken as the allowable stress values from the 1997 Uniform Building Code (UBC) and increased by a factor of 2, as specified in ASCE 31. Comparing the demands to the expected capacities indicates that the ground floor shear walls are overstressed. In addition, the analysis of the walls for overturning indicates that all the walls would require hold-down anchors.

For comparison, the building was evaluated using the force level and allowable stresses provided in the 1994 edition of the UBC. The 1994 UBC would specify a base shear coefficient of 0.133, which leads to a value of 98 pounds per foot (1.4 kN/m) average shear stress in the walls compared to an allowable shear stress of 100 pounds per foot (1.5 kN/m) for both the gypsum wallboard and stucco walls. In this analysis, only those walls that are less than or equal to 6 feet (1.83 m) long would require hold-down anchors.

Example 2

The second example is a 3-story office building constructed with steel braced frames as the lateral force resisting system in each direction. The building is rectangular in plan and the braced frames are located around the perimeter of the building and along two column lines in the transverse direction. The floors are constructed with concrete filled metal deck and the exterior has a glass curtainwall cladding system. In both directions, the number of braced bays decreases up the height of the building, from twelve bays for the lower two stories and 8 bays at the top two stories. Elevations of the typical longitudinal and transverse moment frames are shown in Figure 2. The building is considered to be in an area of moderate seismicity and will be checked for life safety performance so the tier 1 evaluation will require the basic structural checklist and the basic nonstructural checklist.

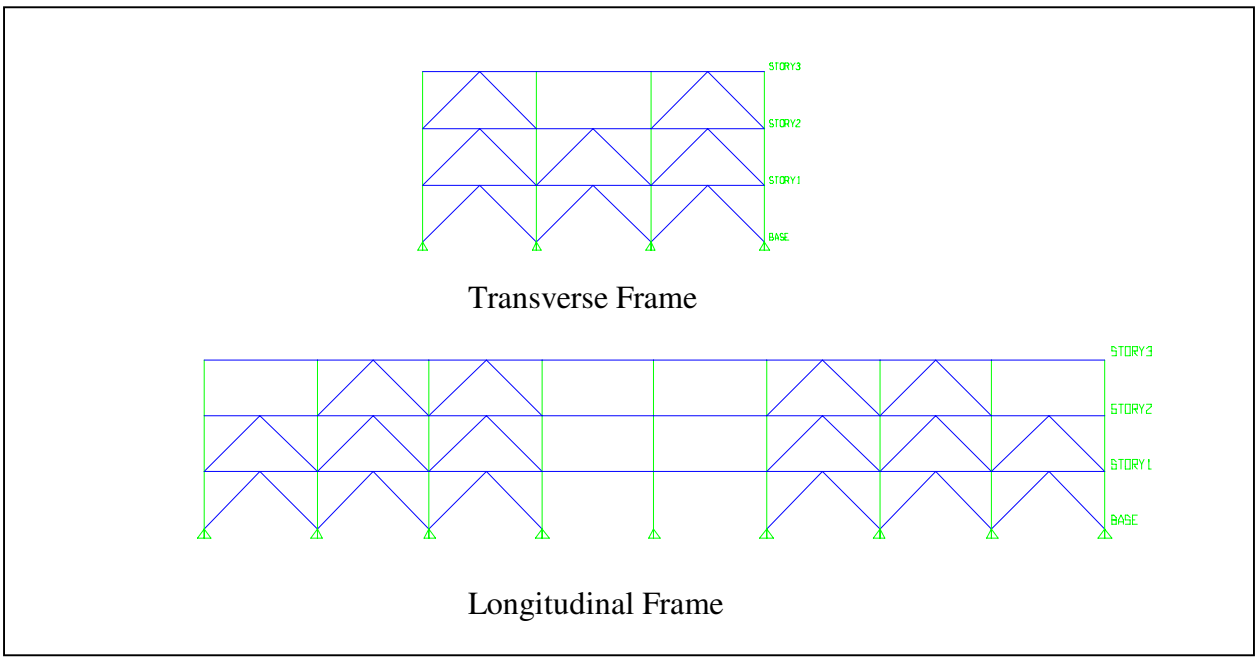

Figure 2 - Typical Frame Elevations for Example Building 2

The building as described is considered to be Type S2, Steel braced frame with stiff diaphragm. In the tier 1 screening, the building needs to be checked for the presence of either a weak story or a soft story using the criteria provided. The method required to check the strength criterion, that the strength of "any story" is not less than 80 percent of "an adjacent story," is not well explained. Considering that the tier 1 evaluation is called "screening" and not an evaluation, it is assumed that extensive calculations are not required. Using a simplified approximation of the strength and stiffness of a story as the flexural strength and stiffness of the braces, the building is found to have both a weak story and a soft story since the strength and stiffness of the third floor is only about 67 percent of the strength and stiffness of the story below. Also, because the length of the braced frames changed by 33 percent at the third floor, the building also is noncompliant for the geometry statement that requires no more than a 30 percent change in the horizontal dimension in adjacent floors. All of the other structural checklist statements for tier 1 were found to be compliant.

A tier 2 evaluation was conducted to assess the strength and stiffness of the braced frames. In this evaluation, a detailed analysis model of the building is required including all of the primary components of the lateral force resisting system. Because of the apparent stiffness and strength irregularity, a linear dynamic analysis of the building would be needed. This evaluation also requires that the top story of the building, where the lateral force resisting system changes dimension, is required to resist one-half of the required pseudo lateral force. The analysis indicates that the top story does not comply and a tier 3 detailed evaluation would be needed.

In evaluating the noncompliant exterior glazing, the tier 2 evaluation requires that the glazing be evaluated to accommodate the calculated drifts. This analysis indicates that the size of the joints between glazing panels and the connections attaching the glazing to the frame are expected to accommodate the calculated drifts. Therefore, the glazing is compliant.

Discussion

In the first example, the building had a considerable number of walls that would provide shear resistance. The wall layout and length of the walls would generally be considered adequate for residential construction using conventional construction provisions. Historically, buildings of this type have performed relatively well in earthquakes unless significant design or construction defects exist. The provisions of both the tier 1 and tier 2 evaluations indicate that the building is potentially deficient. This result indicates that the acceptability criteria may need to be re-evaluated.

In the second example, the lateral force resisting system for the building reduces in size in the upper stories of the building. This is a relatively common design practice. In this evaluation, the change in the lateral force resisting system is identified by the procedure as a potential issue. The basis for this concern, as stated in the commentary, was the performance of mid-rise buildings in recent earthquakes, specifically the Kobe earthquake. In this example, the concern for a mid-height collapse does not appear to be justified since the building does not qualify as a mid-rise building. In addition, the procedure specified for evaluating this condition appears to be overly conservative.

CONCLUSIONS

Over the last twenty years there has been an ongoing effort to prepare guidance to engineers for the seismic evaluation of existing buildings. The intent of this effort is to identify those items that are considered to have the most significant effect on the seismic performance of buildings. The development

of the seismic evaluation guidance led to the publication of ASCE 31 as the first consensus standard for evaluating the seismic performance of existing buildings.

ASCE 31 differs from its predecessor documents in several significant aspects.

- First, the document allows for the evaluation of buildings for one of two performance levels, Life Safety and Immediate Occupancy. While the ability to evaluate a building for immediate occupancy performance seems useful, it is doubtful that there is sufficient data available to guarantee that buildings meeting the ASCE 31 criteria will actually achieve the desired performance.
- Second, the force levels used in the evaluation are pseudo lateral forces that are intended to assess the actual displacements to be experienced by the building due to the design earthquake. These forces are reduced at the component level to account for ductility and overstrength rather than reducing the applied seismic force. Although there appears to be some basis for these force levels and force reduction factors, the values do not appear to provide results that are consistent with current design practice.
- Third, ASCE 31 is written as a standard using mandatory language. This takes away some of the ability of the evaluating engineer to exercise judgment regarding critical aspects of a building's seismic performance. On the other hand, the issue of testing of structural materials provides little guidance for engineers, but this may have a detrimental consequence of increasing the engineer's liability if the testing was not sufficient to identify all of the potential deficiencies.

The development of ASCE 31 from the previous document revealed an important consideration regarding the process of developing a document as a consensus standard. In theory, the process can bring together a wide variety of views and experience so that the document can synthesize the collective experience of the standards committee. In practice however, relatively few individuals take the time to review and objectively comment on the provisions. As a result, the document reflects only the views of those who are motivated enough to take the time to provide input. The balloting process also places a burden on the reviewers to provide specific suggestions for changes to the document for a comment to be considered valid. This can be a disincentive to reviewers providing comments.

While the concept of developing a standard document for seismic evaluation of building is desirable, in practice a standard is difficult to develop. At present, seismic evaluation of existing buildings is somewhat of an art, as well as a science. Engineers experienced in seismic evaluations develop their own methodology and also tend to concentrate their efforts toward those items that are of particular concern. When required to use a standard document, many engineers may feel constrained from using their judgment. For unusual conditions that may not have been considered in the development of the standard, the procedures may not adequately address some potential problems that an experienced engineer could identify. Occasionally however, the use of a standard evaluation procedure may identify potential areas of concern that could be overlooked. The use of this document should not be considered a substitute for good structural engineering judgment.

As the ASCE standard is used, engineers will identify issues with the provisions of the document. In addition, research and experience should lead to suggestions for changes in the document. As with other documents, the results obtained are subject to errors due to inconsistencies within the document and errors in interpretation. Until the document is thoroughly used and evaluated, the results of seismic evaluations based on this document are likely to be incorrect if this standard is not used with great care and based on sound engineering judgment.

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