A Summary of Requirements in the State of Oregon

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ABSTRACT:

With the recent global seismic activity, there is a renewed interest in the steps the State of Oregon has taken concerning the seismic design and construction of structures. The purpose of this paper is to offer a concise history of those standards that govern seismic design in the State of Oregon and provide a context for performance expectations for structures during earthquakes.

First Statewide Building Code

In 1974, a statewide building code was adopted as a means to bring the building criteria for every city and county under one all-inclusive code. The initial building code adopted was the 1973 Uniform Building Code as compiled by the International Conference of Building Officials (ICBO). The code was known as the State of Oregon Structural Specialty Code and Fire and Life Safety Code (OSSC). Under this code, the first provisions for seismic design criteria were implemented. Chapter 23, Earthquake Regulations, Section 2314 dealt with the structural design criteria for all structures. The general description stated that "every building or structure and every portion thereof shall be designed and constructed to resist stresses produced by lateral forces as provided in this section." The seismic provisions of the initial code had a formulation for creating the forces that a structure was required to be designed to resist. One of the multipliers related to the degree of risk a structure was subject to based on earthquake forces. All of Oregon was deemed to be in Seismic Risk Zone 2, which equated to the structure being subjected to moderate damage seismic event equivalent to intensity VII on the Modified Mercalli Intensity Scale (M.M.) and carried a 0.5 multiplier value in the formulation. The worst Seismic Risk Zone available was a 3, which represented an M.M. of VIII and carried a 1.0 multiplier value in the formulation. After performing the analysis for a typical wood-framed building, the overall multiplier to determine the seismic base shear would be 0.05 times the weight of the structure. The following is an abbreviated description of the 12 levels of Modified Mercalli intensity with the corresponding Richter Scale Magnitude (RM).

I. Not felt except by a very few under especially favorable conditions. RM = 3.5

II. Felt only by a few people at rest, especially on upper floors of buildings. RM = 4.2

First Statewide Building Code Continued

III. Felt quite noticeably by people indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations are similar to the passing of a truck. Duration estimated. RM = 4.3

IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, and doors disturbed; walls make cracking sound. Sensation like heavy truck striking a building. Standing motor cars rocked noticeably. RM = 4.8

V. Felt by nearly everyone; many awakened. Some dishes and windows broken. Unstable objects overturned. Pendulum clocks may stop. RM = 4.9-5.4

VI. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. RM = 5.5-6.0

VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken. RM = 6.1

VIII. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, and walls. Heavy furniture overturned. RM = 6.2

IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations. RM = 6.9

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. RM = 7.0-7.3

XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly. RM = 7.4-8.1

XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air. RM = >8.1

As was typical of one- and two-family dwellings of the time, the structures mostly constructed of wood framing and following the provisions of Chapter 25 for Wood and Chapter 29 for Foundations, the building officials did not require an engineered structure that followed the design criteria of the code. Most commercial structures were required to follow the design provisions of the code, but quite often would not be designed by engineers or architects.

Second Statewide Building Code Adoption

When the Uniform Building Code (UBC) was developed in 1976 by ICBO, a new seismic provision and formulation in Section 2312 was developed that added a new Seismic Risk Zone of 4, which addressed buildings that were being constructed near known major fault systems.

This new designation did not carry the M.M. intensity scale but did have a higher Z factor of 4 that carried a multiplier factor of 1.0. In addition, a new Seismic Importance Factor was established that gave greater design forces to essential facilities and buildings with higher risk factors, such as buildings with large occupancy loads. This, coupled with some new criteria for a site-structure resonance and another factor based on deforming characteristics of the type of structure, created a more precise loading for buildings. With the addition of these new factors, the Seismic Risk Zone for Oregon did not change but now carried a multiplier factor of 0.375. After performing the analysis for a typical wood-framed building, the overall multiplier would be 0.0525 times the weight of the structure to determine seismic base shear. The net result of the change for Oregon was about a 5 percent increase in base shear. This code was in effect from March 1978 until July 1980 as the Oregon Structural Specialty Code (OSSC). The codes were enforced in roughly the same manner as previously established in 1974.

Third and Fourth Cycles of the Statewide Building Code Adoption

The 1979 through 1985 Uniform Building Codes (1980-1986 OSSC) changed very little in the Earthquake Regulations Section 2312. Some minor modifications were added to enhance wall structure and the ability to take into account soil configurations in the structural period response but this had little affect on the typical seismic design criteria.

Fifth Generation Statewide Building Code Adoption

A significant shift occurred in the 1988 UBC (1990 OSSC) when the Seismic Risk Zone in Oregon shifted to a 2B designation and the formulation to determine base shear changed to include a more precise designation of the type of lateral force resisting system. After performing the new style analysis for a typical wood-framed building the overall multiplier would be 0.0688 times the weight of the structure to determine seismic base shear. The net result of the change for Oregon was an additional 31 percent increase in base shear. The codes were enforced in roughly the same manner as previously established even in the new seismic zone. However, if a building was located in Seismic Zone 3, then an engineering analysis was required for most nonresidential structures. There was only a small portion of the state in Seismic Zone 3. In 1990, the State of Oregon officially adopted the 1990 Edition of the One and Two Family Dwelling Specialty Code. The code was based on the Council of American Building Officials (CABO) 1989 Edition of the One and Two Family Dwelling Code. This code established the standards of how one and two family residences could be constructed independent of the 1990 OSSC. These standards were very minimal in nature and covered the lateral bracing criteria for both seismic and wind loading. Under the seismic provisions the entire state, short of a small area near the California-Nevada border, was established as

Fifth Generation Statewide Building Code Adoption Continued

being in Seismic Zone 1, which only required 1 x 4 let-in bracing at every 25 feet on center for residential structures.

Sixth Cycle of the Statewide Building Code Adoption

With the adoption of the 1991 UBC (1993 OSSC), additional significant changes occurred in the treatment of seismic loading and analysis. The counties west of the Cascade Range of mountains were designated as Seismic Zone 3 while the eastern counties remained at Seismic Zone 2B. This change increased the multiplying factor for base shear to 0.1032 times the weight of the structure for a 50 percent increase from the previous design criteria. This shift also precipitated the need to provide lateral force designs for most buildings, including residences with irregular configurations in their lateral force resisting systems. The 1993 Edition of the One and Two Family Dwelling Specialty Code was adopted based on the CABO 1992 Edition of the One and Two Family Dwelling Code. This code continued the standards of how one- and two-family residences could be constructed independent of the 1993 OSSC. These standards were slightly more involved than in the 1990 One and Two Family Dwelling Code for the lateral bracing criteria for both seismic and wind loading. Under the seismic provisions, the state was split into two seismic zones that followed the 1993 OSSC, with the exception that the easterly seismic zone was a Seismic Zone 2 instead of a 2B. Under the revised seismic zones, 1 x 4 let-in bracing at every 25 feet on center was still allowed in some conditions, but provisions for structural sheathing panels were introduced for bracing in two- and three-story applications.

A New Look in the Seventh Cycle of the Statewide Building Code Adoption

When the 1994 UBC (1996 OSSC) was developed, the codes took on another new look with the structural design provisions moving to Chapter 16 and the engineering requirements being placed into a second book. The design formulations and minimum code values were centralized and summarized in greater detail giving newer and in most cases more stringent requirements. The seismic base-shear formulation remained the same as the previous code, but the tables delineating Occupancy Categories and the Seismic Importance Factors were enhanced to provide more intense design values for the higher risk and important or essential facilities. The overall seismic design values for loading did not increase for the typical building under this code adoption. The 1993 Edition of the One and Two Family Dwelling Specialty Code was adopted as the 1995 Edition of the One and Two Family Dwelling Specialty Code so no changes were made from the previous code cycle. In 1996, the code cycle was brought back up to the adoption of the current version of the CABO One and Two Family Dwelling Code. The 1996 Edition of the One and Two Family Dwelling Specialty Code was adopted based on the CABO 1995 Edition of the One and Two Family Dwelling Code. The bracing criteria changed very little in this code revision, but provisions were made to allow for an alternate brace wall, which accommodated a narrower braced panel.

Heavier Loading Under the Eighth Cycle of the Statewide Building Code

Effective Oct. 1, 1998, the 1998 OSSC (1997 UBC) was adopted. This code cycle revised the seismic zone mapping along the southern Oregon coast, which was upgraded to Seismic Zone 4, the rest of the state remained at their previous zones. The formulation for determining seismic base shear was revised with factors that took into account location to known seismic faults and soils conditions at the site. With the seismic zone upgrade accompanied by the revision in the seismic base-shear formulation, in conjunction with the near source factor, could mean an increase of greater than 94 percent for the base shear in structures located along the southern Oregon coast. The base shear for a typical wood-framed structure in Seismic Zone 3 experienced an increase of 59 percent. From the initial adoption of the first building code in 1974, this base-shear multiplier value represented an increase of 328 percent in seismic loading. All of the above revisions were based upon the changes that were made to the model code, the Uniform Building Code, and, which in turn, were based on the latest research and studies conducted by USGS through their agency NEHRP.

As part of the revisions in the 1998 OSSC, criteria that established conventional light-framed construction was introduced, if buildings were constructed under this criterion, they could avoid an engineered analysis for the structure. The CABO 1998 Edition of the One and Two Family Dwelling Code was adopted as the 2000 Edition of the One and Two Family Dwelling Specialty Code. This code revision had more defined criteria for conventional construction and bracing criteria for residential buildings. The criteria established eight methods of bracing, when and where the bracing could be used, and minimum criteria for percentages of bracing along wall lines.

The 1998 OSSC remained in force with a variety of amendments for roughly a six-year period; very few seismic related revisions were made in his period. In the late 1990s, the three governing code agencies throughout the United States combined to create one uniform code group known as the International Code Council, also known as ICC. This process was brought to fruition with printing of the International Building Code and the International Residential Code. The overall concept was to formulate a uniform code that could be used by all cities and counties in the United States, creating a common platform for construction standards. These standards incorporated most of the design and construction provisions utilized in the three previously sanctioned code groups with the idea of taking the choice parts of each set of codes for the best available fire and life safety regulations. In 2003, Oregon adopted the 2000 International Residential Code as the 2003 Edition of the Oregon One and Two Family Dwelling Specialty Code. Under this new code, the various bracing criteria were greatly enhanced utilizing new provisions for Seismic Design Categories based on site class for seismic response and occurrence factors. More substantial bracing requirements were outlined in script, via tables, and in detailing that started to bring residential type buildings closer to the requirements of engineered design.

New Model Code in the Ninth Cycle of the Statewide Building Code

In 2004, the State of Oregon made the move from the Uniform Building Code to the International Building Code (IBC) and adopted the 2003 International Building Code as amended to be the 2004 Oregon Structural Specialty Code. The IBC upgraded its design

New Model Code in the Ninth Cycle of the Statewide Building Code Continued

parameters by requiring the design to a 2,500-year return period earthquake versus a 500-year return period of an earthquake in the previous edition of the UBC codes. This change incorporated a substantial shift in earthquake regulations and how the seismic base shear was determined. The new formulation took into account very specific site characteristics insofar that the specific latitude and longitude in conjunction with the United States Geological Survey (USGS) soils/ground response information could be utilized. This technology allowed the use of spectral response acceleration for short and one-second periods along with soil definitions that took into account shear waves, penetration resistance, and shear strength of the soils. In addition, the Seismic Use Group was established that was a modification of the previous Seismic Importance Factor. The types of structural systems were expanded considerably and, when used with the revised base-shear formulation, gave very site-specific seismic loading. The net result of the new technology and more precise method of loading determination predicated an overall lowering of the seismic base-shear forces. A typical wood framed structure depending on location could have a base-shear multiplier of 0.113 after performing all of the formulation calculations. Conceivably, this could be a reduction in seismic force of 68 percent from the previous code. The 2003 International Residential Code was modified and adopted as the 2005 Oregon Residential Specialty Code. The primary changes in this code from the previous residential code dealt with brace-wall provisions as they related to multi-family dwellings and their interconnection of structures. This was an Oregon amendment and was geared towards construction based on Appendix AN for Low-Rise Multi-family Dwelling Construction.

Seismic Provisions in the Tenth Cycle of the Statewide Building Code

In 2007, the model code, the 2006 International Building Code was adopted with modifications as the 2007 Oregon Structural Specialty Code (OSSC). The most significant change in this code was the referencing of the major code groups as part of the OSSC in an attempt to reduce repetition and inconsistency. ASCE 7-05 was referenced as the code for developing seismic forces for building design. This was not a big shift because ASCE 7-05, in conjunction with NEHRP seismic provisions, were already the basis for design in the previous code. No major change in seismic base-shear design values resulted from the adoption of the 2007 OSSC. The 2006 International Residential Code was adopted with amendments as the 2008 Oregon Residential Specialty Code. The 2008 ORSC followed the previous codes, but provided additional bracing criteria and detailing in an attempt to provide broader application of alternate brace walls in construction of the structures. More detailing was provided to show how the roof structure and foundation structures needed to be constructed in order to provide better ties to the brace wall lines.

Substantial Change in the Eleventh Cycle of the Statewide Building Code

Keeping in line with the previous code adoption processes, the 2009 IBC was adopted as the 2010 Oregon Structural Specialty Code. The basic code, as it relates to earthquake design, carried forward from the previous code cycle with very little change. The provisions for Conventional Light-Framed Construction in Chapter 23 titled “Wood” had very few revisions and still provided a prescriptive approach to the design of wood-

Substantial Change in the Eleventh Cycle of the Statewide Building Code Cont.

framed building without the need for engineered design. The adoption of the 2011 Oregon Residential Specialty Code brings a fairly substantial revision to the bracing criteria of the code. The new provisions in the wall-framing chapter outline in detail how compliance will be gained for lateral bracing in the various seismic zones within the state. This approach was taken to provide a more engineered design approach for creating a minimum standard to safeguard against major failures and loss of life in a major seismic event.

Summary of Earthquake Design for Structures

Over the years, the design of structures to prevent loss of life and limit structural damage has improved dramatically in an effort to help safeguard the citizens of Oregon. While the seismic base-shear multiplier was reduced from the 1998 OSSC criteria, the technology has increased tremendously and has been reflected by the reduction in the design parameters for current structures. This does not mean the safety has been reduced; since the first adoption of the 1974 OSSC, structural safety has increased more than 225 percent based on the minimum loading criteria base-shear factors. This has been due to hard work by architects, engineers, geologists, code officials, legislators, and a myriad of other concerned and interested individuals.

The Structural Engineers Association (SEA) *Recommended Lateral Force Requirements and Commentary* includes a general set of performance statements to qualify the nature of expected damage from an earthquake as follows:

- Resist a minor level of earthquake ground motion without damage
- Resist a moderate level of earthquake ground motion without structural damage, but possibly experience some nonstructural damage.
- Resist a major level of earthquake ground motion having an intensity equal to the strongest either experienced or forecast for the building site without collapse, but possibly with some structural as well as nonstructural damage.

The net effect of the building code evolution through the years is that the state of Oregon has substantially safer buildings being constructed now than before the initial adoption of the State Building Code. The most recent codes that have been adopted provide minimum standards for use in building design to maintain public safety in the extreme ground shaking likely to occur during an earthquake. Requirements are primarily geared towards the safeguard against major failures and loss of life, not limit damage, maintain function, or provide for easy repair. Buildings housing essential facilities will be afforded a greater level of protection due to expending the additional money required to bring the facilities to a higher level of structural stability. The overall ability of a structure to resist an earthquake ground-motion event will depend on many factors, the location to the epicenter of the earthquake, the type and location of the fault, the type of soil structure the building is sited on along with the type and quality of construction for the building.