SEAOC Seismology and Structural Standards Committee
Position Statement – September 2001, Revised November 2004
Omega Factor Discussion

The 1997 UBC introduced the seismic force amplification factor, Ω_0, to account for structural overstrength. Structures subjected to seismic loading are likely to develop forces well in excess of the strength required of them based on seismic design loads determined utilizing the R factor. Ω_0 is intended to reflect the upper bound lateral strength of the structure and estimates the maximum forces in elements that are to remain non-yielding during the design basis ground motion. It is addressed in Section 1630.3.1

> ***1630.3.1 Determination of Ω_0.*** *For specific elements of the structure, as specifically identified in this code, the minimum design strength shall be the product of the seismic force over-strength factor Ω_0 and the design seismic forces set forth in section 1630. For both Allowable Stress Design and Strength Design, the Seismic Force Overstrength Factor Ω_0, shall be taken from Table 16-N.*

and most prominently utilized in Section 1630.1.1 Equation (30-2) $E_m = \Omega_0 E_h$., where E_h is the earthquake load due to the base shear, V, or the design seismic force, F_p (including the design seismic force on a diaphragm, F_{px}), and E_m is the estimated maximum earthquake force that can be developed in the structure.

Note that the code paragraph regarding determination of Ω_0 states that it is to be used for <u>specific elements</u> of the structure, <u>as specifically identified</u> in this code. The code identifies the use of Ω_0 generally by invoking the Special Seismic Load Combinations.

> ***1612.4 Special Seismic Load Combinations.*** *For both the Allowable Stress Design and Strength Design, the following special load combinations for seismic design shall be used as specifically required by Chapter 16, Division IV, or by Chapters 18 through 23:*
>
> $1.2D + f_1 L + 1.0E_m$ *(12-17)*
>
> $0.9D \pm 1.0E_m$ *(12-18)*

Note that the horizontal component of E_m is Ω_0 times the seismic force E (not Ω_0 E/1.4); thus if allowable stress design is being utilized and the analysis results are in terms of a reduced element seismic force E/1.4, that force must be multiplied by 1.4 to be used in this equation in order to be compared to member strength.

The Special Seismic Load Combination is specifically identified in the following locations in Chapter 16:

> ***1630.8.2 Elements Supporting Discontinuous Systems***
> ***1630.8.2.1 General*** *Where any portion of the lateral-load-resisting system is discontinuous, concrete, masonry, steel and wood elements supporting such discontinuous systems shall have the design strength to resist the combination loads resulting from the special seismic load combinations of Section 1612.4.*
>
> > ***Exceptions:*** *1. The quantity E_m in Section 1612.4 need not exceed the maximum force that can be transferred to the element by the lateral-force-resisting system.*
> > *2. Concrete slabs supporting light-frame wood shear wall systems or light-frame steel and wood structural panel shear wall systems.*

A typical and illustrative yet somewhat complex application of this provision is to a discontinuous wood shear wall over a beam. The Ω_0 factor should not be applied to the design of the shear wall nailing, the boundary member, or the hold down. The Ω_0 factor should be applied to the bending and shear design forces for the beam, connection of the beam to the column, the column and the column connection to the foundation, as noted in Section 1809.3 (see below).

Note that there is no analytic basis for Exception 2 for concrete slabs supporting light frame shear wall systems and that this exception does not exist in ASCE 7-02. SEAOC Seismology Committee concurs that this exception is not appropriate.

> ***1633.2.6 Collector Elements:*** *In addition, collector elements, splices, and their connections to resisting elements shall have the design strength to resist the combined loads resulting from the special seismic load of Section 1612.4.*
>
> > ***Exception:*** *In structures, or portions thereof, braced entirely by light-frame wood shear walls or light-frame steel and wood structural panel shear wall systems, collector elements, splices, and their connections to resisting elements need only be designed to resist forces in accordance with Formula (33-1).*

Note that collectors are also required to be provided as necessary to resist the diaphragm force, F_{px} from equation (33-1), and designed per 1633.2.6.

In addition, in Chapter 22, Division V (ASD version) the Omega factor is specifically identified in multiple locations, often with the phrase Ω_0 times the design seismic forces. Again note that design seismic forces is defined in Section 1627 as the minimum total strength design base shear, thus if a reduced ASD level base shear has been used to determine element forces then the base shear should be factored up by 1.4 prior to applying Ω_0.

As an aside, for Lateral Resistance for Steel Stud Wall Systems:

> ***2220.2 Boundary Members and Anchorage****. Boundary members and the uplift anchorage thereto shall have the strength to resist the forces determined by the load combinations in Section 2213.5.1 Column Strength Requirements.*

Thus for this type of shear wall, the boundary elements and hold downs are to be designed for the strength of the wall or Ω_0 times the design seismic forces so that shear yielding of the panel is the predominant yielding mode.

The Special Seismic Load combination is also indirectly identified in Chapter 18, Section 1809, Foundation Construction – Seismic Zones 3 and 4.

> ***1809.3 Superstructure-to-Foundation Connection.*** *The connection of superstructure elements to the foundation shall be adequate to transmit to the foundation the forces for which the elements were required to be designed.*

For instance, since Section 2213.5 Column Requirements specifically identifies the Ω_0 factor, Section 1809.3 requires the column-to-foundation connection to be designed for a load combination which includes the Ω_0 factor.

Where not specifically called out, the Special Seismic Load combination is not intended to be used, even when collectors or load transfers are involved. For example, the Standard Load combinations should be used to determine the design stress for the following provision:

> ***1921.6.2.3*** *Structural-truss elements, struts, ties and collector elements with compressive stresses exceeding .2f'$_c$ shall have special transverse reinforcement.*