Why 0.6W?

Changes to ASCE 7-10 Wind Load Combinations and Wind Map Baffles the Building Industry *Where did the allowable stress wind load go? This article is intended to help you find it again.*

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Introduction

The ASCE 7-10 Standard for Minimum Design Loads for Buildings and Other Structures has again changed its wind maps. Unlike past wind map changes (e.g., the change from a “fastest-mile” average wind speeds to a 3-second gust wind speed basis in the 1995 edition of ASCE 7), this more recent wind map change now also impacts the way allowable stress design (ASD) wind loads are determined. ASD wind loads are used when calculating wind loads on roof coverings. The wind maps in the most recent edition of ASCE 7 represent Ultimate Design Wind speeds (Vult). Due to this change the calculated wind load, W, must be multiplied by a load factor, 0.6, to obtain an ASD wind load. Conversely, the strength design or “load and resistance factor” (LRFD) design approach now uses a wind load factor of 1.0 instead of 1.6 as in the past. In many ways, this change in format has caused the ASD format for wind design to look more like the LRFD format and vice versa. Needless to say, this format change has caused much confusion.

The changes to the ASD format for wind loads may be confusing, but the purpose for doing so does provide a better representation of variation of wind hazard (and thus design safety or probability) across the US.

Why all the confusion? Because…

Wind pressure on a building surface is determined with the following basic relationship:

W = Wind Pressure(load) = $f(V^2)^*$ = $0.00256K_zK_{zt}K_dG(V^2)$ x (net surface pressure coefficient, Cp) [Eq. 1]

' That pressure is a function of the square of the velocity of wind is a fundamental physical principle called the "Bernoulli Principle", named after Daniel Bernoulli who published it in his book Hydrodynamica in 1738. This principle is important to understanding how and why the 0.6 factor now applied to allowable stress wind loads became necessary with recent wind map changes from an ASD wind speed basis to a so-called Ultimate wind speed basis.*

If the mapped wind speed is an "allowable stress wind speed" (i.e., as maps that were published prior to ASCE 7-10)), then one simply calculates the wind load, W, and it is implicitly an allowable stress design wind load, W_{asd}, which requires no further adjustment or factoring.

For example:

> ASD wind speed from old, pre-2010 ASCE 7, V_{asd} = 90 mph
> Calculated ASD wind load = $0.00256(1)(1)(1)(1)(90\text{ mph})^2$ x (1) = 20.7 psf ←
> (all coefficients are set at a value of '1' for sake of example only)

However, the new wind maps in ASCE 7-10 are now determined for a much lower probability of exceedance or a greater mean recurrence interval. This was done so that the newer Strength Design or LRFD design format could have a factor of 1.0 applied to W rather than 1.6. Thus, a typical building site's mapped wind speed (Category II type building) is based on a 700-year return period (1/700 = 0.0014 = 0.14% probability of annual exceedance). It is known as an "ultimate" wind speed, V_{ult}. In essence, the mapped wind speeds were increased by the square root of the LRFD wind load factor of 1.6 so that the load factor in the LRFD format could be changed to 1.0 (e.g., mapped wind speeds were increased by sqrt(1.6) = 1.26), setting aside other wind map changes due to improved analysis of historic wind data and modeling of hurricane wind hazards. These adjustments are based on the relationship W = $f(V^2)$; see explanation in the note below Eq. 1.

This change to the wind speed probability basis in the wind map makes things more complicated for ASD since the result is Ultimate and not ASD. To compensate, one must either (1) adjust the ASD safety factors (which would require an enormous re-calibration effort for all material standards) or (2) adjust the calculated wind load (based on a 700-year ultimate wind speed map) back down to an allowable stress basis. The latter approach was chosen for ASCE 7-10. This was done by applying a factor to the calculated ultimate wind load, W_{ult}. This factor is determined by the square of the ratio of V_{asd}/V_{ult} which is nothing more than the inverse of the difference between the pre-ASCE 7-10 load factors for ASD and LRFD. For example, 1/1.6 = 0.625.

Essentially the same ASD wind load is achieved with use of the 0.6 ASD wind load factor in combination with the newer 700-year (Category II type building) ultimate wind speed map is demonstrated as follows for the same hypothetical building location as used in the example above:

Ultimate wind speed from ASCE 7-10:	115 mph (rounded up from 90mph x 1.26 = 113 mph)
Calculated Ultimate Wind Load (Eq.1):	33.9 psf
Factored ASD Wind Load:	0.6(33.9 psf) = 20.3 psf ←

The above two examples, using the older (pre-ASCE 7-10) and newer (ASCE 7-10) wind design provisions result in essentially the same ASD wind load when the 0.6 factor is applied as explained above.

Qualifiers are always important…

As with anything that is not an exact science and with moving targets (or shells), there are qualifications that need to be made to the simple explanation provided above. First, the 700-year wind speed mentioned above is just one of the mapped wind speed return periods in ASCE 7-10; there are others for more or less important buildings because the wind load importance factor is now represented in separate wind speed maps. Second, the above example was for an ideal condition where the wind map did not include additional changes for other reasons (e.g., improvements in wind data analysis and modeling). Third, in the 2012 *International Residential Code* the application of the ASCE 7 wind map was modified back to an ASD wind speed basis. Thus, if wind speeds are used from that map to determine a wind load, the 0.6 factor should not be additionally applied to the calculated wind load.