C1 Comment:

ASCE Policy 360 acknowledges that “there is clear evidence of a changing climate” and states that “engineering practices and standards associated with [infrastructure exposed to effects of extreme climate and weather events] must be revised and enhanced to address climate change to ensure they continue to provide acceptably low risks of failures and to reduce vulnerability to failure in functionality, durability and safety over their service lives.” Furthermore, ASCE Code of Ethics requires its members to be committed to designing, building, operating, and maintaining climate-safe infrastructure for the 21st century and beyond. In addition, there is significant concern at the state, local, and professional levels in addressing climate change or engineering vulnerabilities related to stationarity bias and it would be helpful to acknowledge their importance. Specifically, climate change reflects non-stationarity in extreme meteorological events over long-time horizons (e.g., 30 years), which leads to underestimation of intensities associated with the design events considered in this Standard. The underestimation in turn results in designs that do not achieve the desired reliability targets of this Standard. Climate change also affects the static performance assumptions that govern soil behavior and load bearing performance, particularly in regions of permafrost that are subject to seismic loading. Such assumptions may result in designs that do not achieve the desired reliability targets of this Standard.

The ASCE Committee on Climate Intelligence in Codes and Standards (CICS) encourages enhancements to all future versions of ASCE 7 that are consistent with existing methodologies already adopted in the ASCE 7 standard to develop design intensities, and that accounts for the non-stationarity of meteorological events to achieve the desired reliability for all structures for the duration of their service life.

In the interim, CICS recommends two additions to Commentary C1 of ASCE 7-22:

C1, Page 8, Line 16

> (NOTE: This Standard assumes that the frequencies and intensities of climate and weather observed in the past adequately represent those that will occur in the future. Assumed climate and weather stationarity does not reflect changes associated with climate variability and climate change. Please see the discussion *Climate Variability and Climate Change*, at the end of this section for more information.)

C1, Page 13, Line 22

> *Climate Variability and Climate Change*
>
> The approaches currently used in this Standard to establish design loads produced by meteorological events (wind, temperature, snow, rain, tornadoes, etc.) rely on identifying design intensities with prescribed mean return periods. Intensities are obtained from probability distributions that are consistent with available historical data enriched by meteorological models. The meteorological models are used to extend the available observational record to obtain stable and reliable estimates of intensities with high return periods. Use of observational records, and meteorological models parameterized on those records, assumes the stochastic processes describing meteorological phenomena are stationary and ergodic. Longer records are thus expected to produce more accurate probability distribution estimates. In other words, the approaches currently available are subject to inherent stationarity bias.

The consensus among climate scientists is that observed increases in the concentrations of atmospheric greenhouse gases introduces nontrivial, non-stationary changes in weather and climate extremes on time scales of 30 years or longer. Stationarity and ergodicity assumptions additionally have known inaccuracies characterizing decadal and multidecadal climate variability and regional teleconnections. From a structural engineering point of view, this non-stationarity in meteorological events may lead to designs that do not achieve the desired reliability prescribed by the design codes.

Methods for quantifying the impact of climate variability or change are underway and were not evaluated in the development of this Standard. In those situations where understanding of regional processes is sufficient to quantify the impact of climate variability or climate change in parameters identified by this standard, this knowledge should be incorporated. Any quantification methods thus employed must be evaluated and documented. Additional guidance is necessary. In the interim, structural engineers, architects, and building code officials might review and apply the ASCE Manual of Practice 140: *Climate Resilient Infrastructure Adaptive Design and Risk Management* and the ASCE Manual of Practice 144: *Hazard-Resilient Infrastructure: Analysis and Design.*

Applying more robust methodologies for addressing uncertainty in future weather and climate conditions, and commensurate uncertainties in dead, soil, or earthquake loads, than called for in this Standard may be desirable in some circumstances. As discussed in ASCE Manual of Practice 140, several considerations affect how much risk to undertake in designing a system, such as the importance of the system, political and legal constraints, and the economics associated with the costs and benefits for the system. Tables C.1.3.1A and C.1.3.1B (Tables 7.3 and 7.4 from ASCE Manual of Practice 140) provide recommended levels of climate analysis as a function of design life and risk category (Table 1.5.1) and the characteristics of various levels of climate analysis.

Table C1.3.1A Recommended Level of Climate Analysis as a Function of Design Life and Risk Category

	Design Life < 30 years	Design Life > 30 years < 75 years	Design Life > 75years
Risk Category I	Climate Analysis Level I	Climate Analysis Level I	Climate Analysis Level II
Risk Category II	Climate Analysis Level I	Climate Analysis Level II	Climate Analysis Level III
Risk Category III	Climate Analysis Level I	Climate Analysis Level III	Climate Analysis Level IV
Risk Category IV	Climate Analysis Level II	Climate Analysis Level IV	Climate Analysis Level IV

Table C1.3.1B Characteristics of Various Levels of Climate Analysis

Level of Climate Analysis	**Characteristics**
Climate Analysis Level I	Use of published values of weather and climate extremes based on historical observations is appropriate
Climate Analysis Level II	Use of published values of weather and climate extremes based on historical observations and climate projections is appropriate

Climate Analysis Level III	Use of published values of weather and climate extremes based on historical observations and climate projections is appropriate, assuming independent analysis of sensitivity to uncertainly in projections is acknowledged and accounted for
Climate Analysis Level IV	Independent, transparent, and rigorous analysis of risk posed by future weather and climate extremes based on historical observations and climate projections is appropriate