Climate-Resilient Infrastructure: An ASCE Manual of Practice

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Needs and Objective

• Needs
  – Design requirements for new projects by owners
  – Sense of urgency: According to the U.S. Census Bureau*, the Value of Construction Put in Place is about $1.3 trillion (2018) per year

• Objective
  – Provides guidance for and contribute to the development or enhancement of standards
  – Introduces adaptive design and risk management at this stage when standards have not been updated to account for more severe climate or weather extremes

*Source: https://www.census.gov/construction/c30/c30index.html
Available since October 2018

Civil infrastructure systems traditionally have been designed for optimum functionality, resiliency, and safety for climate and weather extremes during their full-service life. However, climate scientists inform us that the extremes of climate and weather have altered their historical values in ways difficult to predict or project. Climate-Resilient Infrastructure: Adaptive Design and Risk Management, Manual of Practice No. 140, provides guidance for and contributes to the developing or enhancing of methods for infrastructure analysis and design in a world in which risk profiles are changing and can be projected with varying degrees of uncertainty requiring a new design philosophy to meet this challenge.

The underlying approach to this MEP is based on probabilistic methods for quantitative risk analysis, and the design framework provided focuses on identifying and analyzing low-rage, adaptive strategies to make a project more resilient.

Beginning with an overview of the driving forces and factors associated with a changing climate, important chapters in MEP 140 provide observational methods, illustrative examples, and case studies; estimation of climate exposures; very specifically related to precipitation with guidance on monitoring and assessing methods; flood design criteria and the development of project design; flood elevations; computational methods of determining flood loads; adaptive design and adaptive risk management in the context of life-cycle engineering and economics; and climate resilience technologies. MEP 140 will be of interest to engineers, researchers, planners, and other stakeholders charged with adaptive design decisions to achieve infrastructure resilience targets while minimizing life-cycle costs in a changing climate.

Climate-Resilient Infrastructure

Adaptive Design and Risk Management

Committee on Adaptation to a Changing Climate

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Hazard
Dilemmas for Engineers

- Account for future climate and weather
- Accommodate a range of future climate projections (the past doesn't represent the future)
- Estimate future extremes appropriately
- Meet project requirements by owners

**Uncertainty of a different nature**

Variability and randomness → Reliability-based or Robust design

Plus

Projections with uncertainty → Adaptive design
Offered to Engineers:
ASCE Manual of Practice (MOP) 140

• Framework of the Manual of Practice
  – Non-prescriptive
  – Quantitative: probabilistic
  – Analytic methods with native measurement units of potential losses that would support economic valuation and benefit/cost analysis
  – Adaptive solutions based on the concept of real options

• Step Towards Developing Standards
  – Development of standards could take years
  – An interim solution

Methodology (Framework)
Chapter 7. Adaptive Design and Risk Management

• Context and Objectives
• Hazard Identification and Projection
  – Uncertainty Analysis
  – Extreme Value Analysis
• Failure Probability Estimation
• Economics of climate resilience
  – Exposure and Loss Analysis
  – Economic Valuation
• Risk Quantification as Loss Exceedance Probabilities
• Development of Feasible Design Adaptations for Decision Making
  – Cost and Benefit Estimation and Analysis
  – Risk-Informed Decision Analysis
• Hazard and Risk Monitoring
  – Risk-Informed Adaptation Analysis for Actions During Life

Use of real option
Example: Adaptive Design

Designing for 2100 Sea Level

1. Lower bound sea level
2. Most probable sea level
3. Upper bound sea level
4. Sea level used in design

Aleatory and epistemic uncertainty
Select a design modification


Example: LOSSAN Adaptive Design

Los Angeles to San Diego (LOSSAN) Rail Corridor follows the sea coast and crosses low-lying areas on trestles

Uses precast piers and caps to allow insertion of additional pier segments if needed to adapt to flooding hazard

ASCE Codes & Standards: Our Institutes and Stakeholders

Credit for all remaining slides:
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Standards By Institute

TOTAL: 67

AEI CI COPRI EMI EWRI GI SEI TDI UESI

0 2 1 0 28 3 6
ASCE Policy Statement 365: International Codes and Standards

Encourages broader participation by the U.S. in development of international codes/standards while supporting, maintaining, and strengthening the existing domestic standards development system.

Beyond Policy
Benefit to Profession:
Prestige for ASCE
Revenue

Arguments For and Against

FOR

• Elevate practice to minimum level
• Basis for performance evaluation
• Defense in a liability claim

AGAINST

• Can limit judgment
• Cannot anticipate all site variables
• Can be used against the engineer in a liability claim
Attributes of a Standard

- **Prescribed rules**, conditions, or requirements institutionalizing **practices and procedures**

- **Regulated use in building codes** only when developed in accordance with definitive **rules of procedure and consensus**

- Refers to the **process** by which the document was developed implying the use of a format, documented process to **achieve consensus**

Hierarchy of Documents

1. **Standard**
2. **Manual of Practice**
3. **Committee Report**
4. **Journal Article**
5. **Published Article**
Types of Standards

**Mandatory**
- Prescriptive, Performance-based language
- Standard test methods
- Standard specifications
- Standard material properties
- Design or construction standards that establish minimum requirements

**Non-Mandatory**
- Permissive language
- Consensus practice - provides recommendations
- Consensus guidelines - offers a series of options, suggestions, methods, or instructions but not a specific course of action

Fundamental Principles of Consensus Standards Development

- **Open** to participation by everyone
- **Balanced** - Not dominated by any group
- **Agreement** clearly defined
- System accords due **process** to participants
- Includes a way for **appeals** to be heard
Establishing a Standardization Activity

1. Proposal
   → Distribute Proposal Within ASCE
   → Institute Board Approval
   → C&S Committee (CSC) Approval
   → Existing or New Committee
   → Submit Report to Codes and Standards (C&S) Staff
   → Assemble Resolution Report
   → Notification to ANSI (PINS Form)
   → Develop Standard

Arriving at a Standard

2. Draft Document OR Existing Std + Proposed Changes
   → Ballot Proposals To Committee
   → Resolve Comments And Negatives
   → Substantive Changes
   → Public Comment
   → CSC Approval
   → Council ExCom Approval
   → CSC Approval
   → Publication
Fundamental Principles of Consensus Standards Development

- Codes and Standards Committee (CSC) is part of the Committee on Technical Advancement (CTA)
- Currently Twelve Members as follows:
  - 10 Institute representatives (from 7 of the 9 institutes 1-CI/1-COPRI/2-EWRI/1-GI/4-SEI/1-TDI/1-UESI that have standards)
  - 2 Regional Governors
  - 2 Liaisons from CTA
  - Nominal 3-year terms
- Update and Interpret governing documents of ASCE Standards Program
- Vote on issues concerning committee balance, standard development, publication, policy and ethics
- Maintain ASCE’s ANSI accreditation

Standards Resource Material

- ASCE Rules for Standards Committees
- ASCE Standards Writing Manual
- Editor’s Guide for Standards
- ANSI Essential Requirements
Time to Complete Standards

- There is no average time to create/revise a standard.
- For example, ASCE 7 (Structural Loads) is on a 6-year revision cycle.
- FCAPS (Fiber Composites And Polymers Standards) is a new standard under development that’s been in development for about 6 years with another 1 to 2 years to get to completion.
- On the other hand, the new standard on permeable interlocking went from start to publication in about 4 to 5 years.

ASCE Standards and Adaptation to a Changing Climate: Immediate Needs

Source: MOP 140

*Groups are as follows:

I. Change in loading
II. Change in surface hydrology (including flood extent or frequency, or inundation owing to SLR)
III. Change in groundwater table height (including that owing to SLR)
IV. Changes in temperature

Thank you