Purpose

- Recommended alternative to the prescriptive procedures for seismic design of buildings contained in *ASCE 7* and the *International Building Code (IBC)*.

- Intended for use by structural engineers and building officials engaged in the seismic design and review of individual tall buildings.
The new breed of tall buildings

- Designed without dual moment-resisting frames
- Justified using nonlinear analyses and “performance-based” procedures adapted from ASCE 41
The Source
The Approach

- Design per the building code with a few exceptions
  - Exceed height limits for structural systems
  - Use different R values
  - Neglect redundancy requirements

- Develop nonlinear analytical model
  - MCE (2%-50 year) shaking
  - Conservative values on acceptable parameters

- Rigorous Peer Review
Purpose

- Suggest improved design criteria that will ensure safe and usable tall buildings following future earthquakes based on:
  - Recent design experience
  - State-of-art research
Development Team

Research
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Scope -

- Design of tall buildings:
  - Fundamental periods $>> 1$ second
  - Significant mass participation and response in higher modes
  - Slender aspect ratio
    - Large portion of drift due to flexural behavior as opposed to shear behavior
Performance Intent

- Similar to that historically contained in SEAOC Blue Book & ASCE-7 for Ordinary Occupancies
  - Small risk of collapse (perhaps 10%) in MCE shaking
  - Limited risk (50%) of loss of cladding in MCE shaking
  - Negligible risk to life for design shaking
  - Negligible risk of occupancy loss for Service level shaking

- Other Objectives
  - Possible
  - Need to modify these criteria on project-specific basis
Design Criteria

- Formal written criteria required
  - Building description
  - Codes and standards
  - Performance Objectives
  - Gravity Loading
  - Seismic Hazards
  - Wind Loading
  - Load Combinations
  - Materials
  - Analysis Procedures
  - Acceptance Criteria
Seismic Input

- Two Event Levels
  - Service level
    - Elastic response spectrum - required
    - Response history analysis - alternate

- Maximum Considered level
  - Nonlinear response history
Preliminary Design

- Configuration Issues
- Structural Performance Heirarchy (capacity-design)
- Wind
- Higher Mode Effects
- Diaphragms
- Nonparticipating elements
- Foundations
Service Level Design

- 50% - 30 years (43 year return)
- Elastic analysis – 2.5% damping
- Maximum DCRs 150% of expected strength
- Story drift limited to 0.005
Maximum Considered Level

- 3-D nonlinear response history analysis
- Ground motion input at structure base
- SSI Permitted

Desired

Typical

Optional
Maximum Considered Level

- Modeling must consider degradation effects
- Global acceptance criteria
  - Transient drift
    - <3 % mean
    - <4.5% any run
  - Residual drift
    - <0.01 mean
    - <0.015 any run
Maximum Considered Level

- Component Acceptance
- Ductile actions
  - Response within validity limits of hysteretic model
- Brittle actions
  - Inconsequential failure
    \[ \bar{Q} \leq Q_{n,e} \]
  - Significant consequence
    \[ Q_u \leq \phi Q_{n,e} \]
    \[ Q_u = 1.5 \bar{Q}; \quad \bar{Q} + 1.3\sigma \geq 1.2 \bar{Q} \]
Peer Review

- Qualifications
- Responsibilities
- Documents to be reviewed
- Stages of Review
- Resolution of concerns
Summary

- Successful multi-disciplinary effort
  - Geotechnical engineers & Seismologists
  - Structural engineers
  - Building Officials
- Project has had positive impact on the design of real structures
- Has also affected design practice internationally