Performance-Based Design Today
John Hooper, Magnusson Klemencic Associates

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Projects Utilizing PBD

- Existing Building Retrofits
- New Buildings
  - Validating Code Performance
    - e.g., confirming an Essential Facility meets I.O. performance
  - Alternative Code Equivalent Designs
    - Building does not conform to one or more requirements
      - Height limit
  - Alternative to Capacity Design Requirements
    - Determination of Maximum Forces for Design
      - Columns, beams, foundations, diaphragms, etc.
The PBD Process

1. Select Performance Objectives
2. Perform Preliminary Design
3. Assess Performance Capability
4. Acceptable?
   - Yes
   - No: Revise Design
Performance Objectives

- Earthquake Hazard
  - EQ ground shaking

- Acceptable Performance Level
  - Maximum acceptable damage given shaking occurs
Standard Performance Levels

- **Operational**
- **Immediate Occupancy**
- **Life Safety**
- **Collapse Prevention**
Existing Building Retrofit Approach
New Building Approach—Code Equivalency
Performance Level for Tall Buildings:

Operational

Immediate Occupancy

Life Safety

Collapse Prevention
New Building Approach—Code Equivalency

- Work with the Jurisdiction to determine the Peer Review Process
- Develop a Basis of Design
  - Specify code exceptions
  - Structural design approach
    - SLE, DE and MCE modeling and acceptance criteria
  - Site specific ground motions
    - Target spectra
    - Selecting and scaling of ground motions
- Work with the Peer Review Team until all comments have been resolved
New Building Approach—Code Equivalency
New Building Approach—Code Equivalency
New Building Approach—Code Equivalency

Core Wall Overturning Moment, X-Dir
Case: Envelope, 3.5 sec

Core Wall Overturning Moment, Y-Dir
Case: Envelope, 3.5 sec
New Building Approach—Code Equivalency
New Building Approach—Code Equivalency

Strain Gauge Tensile Strain
Case: Envelope, 0.8 sec

Tension Rupture
Strain Limit = 0.050

Key Plan

Ground Level (LOT)
Top of Mat Foundation

Strain (in/in)
New Building Approach—Code Equivalency
New Building Approach—Code Equivalency
(2) The required strength of columns need not exceed the lesser of the following:

(a) The forces corresponding to the resistance of the foundation to overturning uplift

(b) Forces as determined from nonlinear analysis as defined in Section C3

C3. NONLINEAR ANALYSIS

When nonlinear analysis is used to satisfy the requirements of these Provisions, it shall be performed in accordance with Chapter 16 of ASCE/SEI 7.
New Building Approach—Capacity Design
Performance Level of SF MOMA:

Operational | Immediate Occupancy | Life Safety | Collapse Prevention
New Building Approach—Capacity Design
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New Building Approach—Capacity Design

Existing Mat Slab  New Mat Slab

1"

SERVICE LOAD DEFLECTION
New Building Approach—Capacity Design

Existing Mat Slab  New Mat Slab

SEISMIC LOAD DEFLECTION

1"
New Building Approach—Capacity Design
New Building Approach—Capacity Design
New Building Approach—Capacity Design
New Building Approach—Capacity Design

![Graph showing SFMoMA Floor Displacements-Controlling Direction](chart.png)
New Building Approach—Capacity Design

SRSS of X and Y Residual Drift

- h/1717
- h/590
- 0.48%
Thank You!
What does the Code Allow?

IBC Section 104.11: The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved.
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