Lessons from Northridge and SAC:

The Changes that Resulted in Research

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Changes in Codes

• **Materials Codes**
  - AISC 341
  - AISC 358
  - AWS D1.8
  - ASCE 41

• **Loadings Codes**
  - ASCE 7
  - IBC
Change 1: Set A Model

SAC Joint Venture

• A Problem-Focused, Nationwide Team Effort
• Interdisciplinary
• Practicing engineers and researchers work together
## Change 2: Mentality

### Responsibility of Weld Fracture:

<table>
<thead>
<tr>
<th>before Northridge</th>
<th>after Northridge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welder</td>
<td>Researcher</td>
</tr>
<tr>
<td></td>
<td>Designer</td>
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<tr>
<td></td>
<td>Inspector</td>
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<tr>
<td></td>
<td>Electrode Manufacturer</td>
</tr>
<tr>
<td></td>
<td>Welder</td>
</tr>
</tbody>
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Issues and Changes in Seismic Moment Connection Research and Design
Expected Seismic Demand

• Force
• Deformation
Seismic Force Demand

Steel Materials

• For seismic capacity design, stronger steel hurts!
• Capacity steel design provisions first appeared in 1988 UBC.
• Before Northridge, we naively thought A36 W-shapes still existed.
Change 3: Steel Materials

- A992 Steel Introduced
- Explicitly Considered in Design:
  - Material overstrength ($R_y$)
  - Cyclic strain hardening ($C_{pr}$)
Seismic Deformation Demand

• Before Northridge EQ.
  \[0.005K \times \left(\frac{3}{K}\right) = 1.5\% \text{ story drift}\]

  or

  \[\frac{0.04}{R_{\downarrow w}} \times \left(\frac{3R_{\downarrow w}}{8}\right) = 1.5\% \text{ story drift}\]

• After Northridge EQ.
  4\% \text{ story drift}
Test Loading Protocol Issue

- $\Delta y$ based
- Used 1 SAC Phase 1 testing
Change 4: Loading Protocol Standardization

- After Northridge EQ.
  - SAC or AISC Loading Protocol
  - Story drift based
  - Acceptance criteria established
Change 5: Specimen Scale Issue

• Before Northridge EQ.
  ♦ Small-scale models were tested
  ♦ SAC study showed size effect and welding/heat effect
• After Northridge EQ.
  ♦ Full-scale testing
  ♦ AISC 358 member size limits based on available full-scale testing
Change 6: Specimen Construction

• Before Northridge EQ.
  Little attention paid to who welded and how the welding (welding electrode, welding procedure) was done.

• After Northridge EQ.
  Always simulate field welding and document the process.
Change 7: Proprietary Connections and Alternate Systems

• Before Northridge EQ.
  No proprietary moment connections

• After Northridge EQ.
  ♦ Proprietary connections
  ♦ BRBF, SPSW, SCBF
Change 8: Steel Researchers

• Before Northridge EQ.
  Steel/concrete researcher ratio was low.

• After Northridge EQ.
  ♦ Ratio is improved, although is still low
  ♦ SAC era produced some talented younger students/researchers
  ♦ AISC follows up with Fellowship program