



Structural Steel

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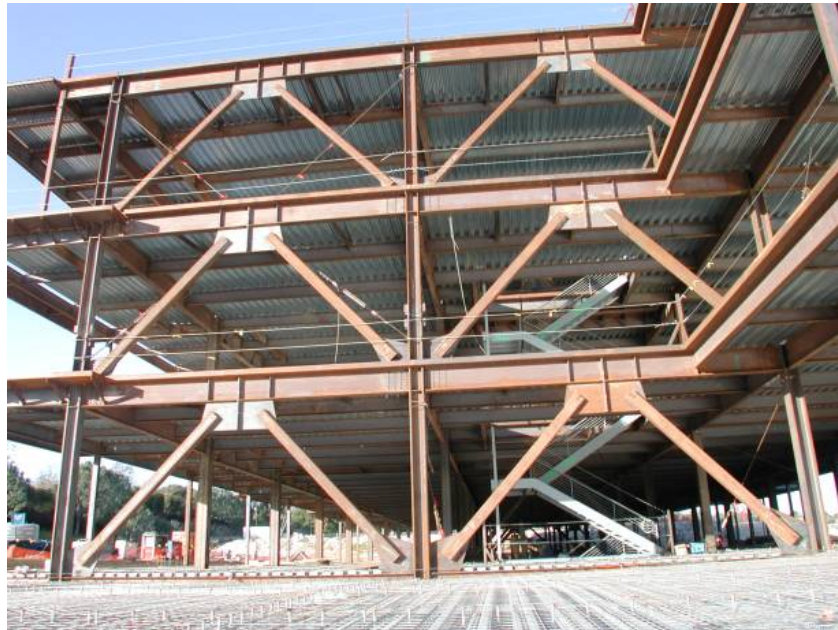
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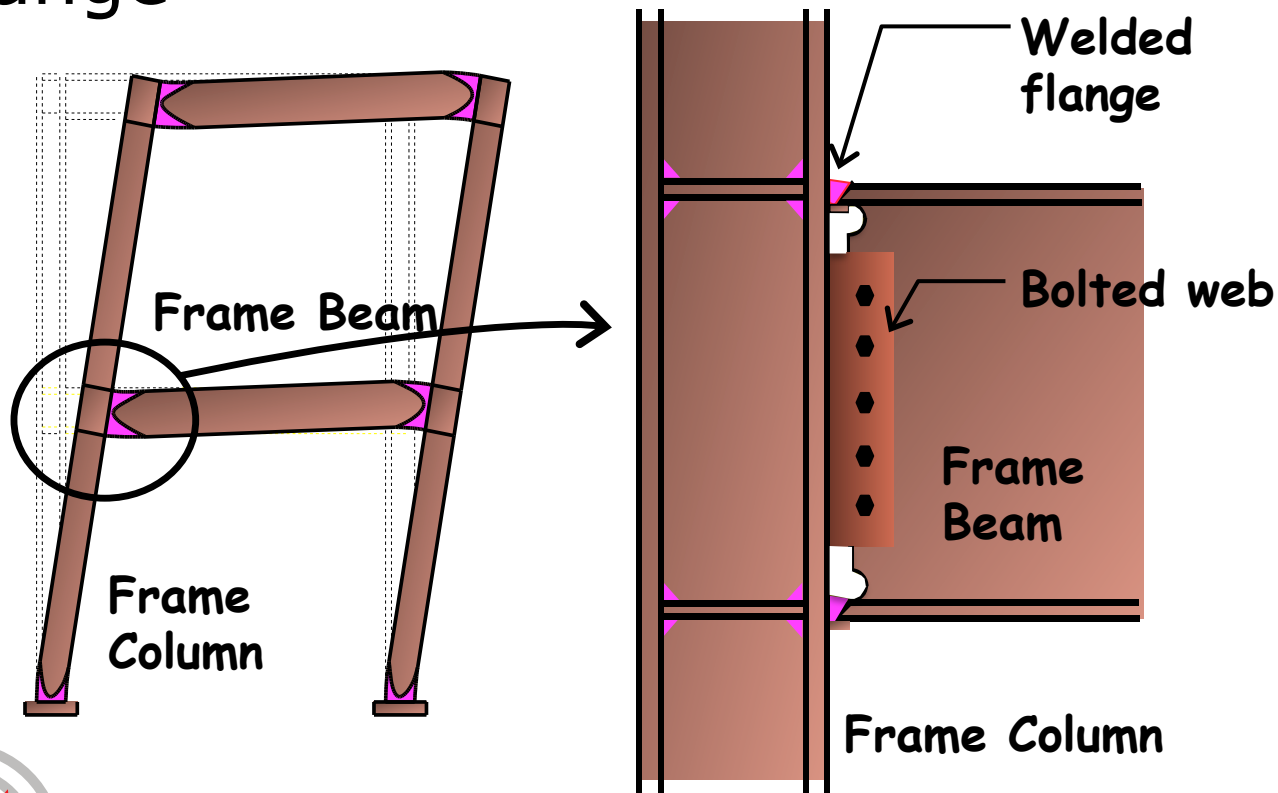
Impacts – Structural Steel

- Unexpected Problems in Steel Seismic Systems
 - Fractures in steel moment frame beam-to-column connections
 - Fractured steel braces in braced frames



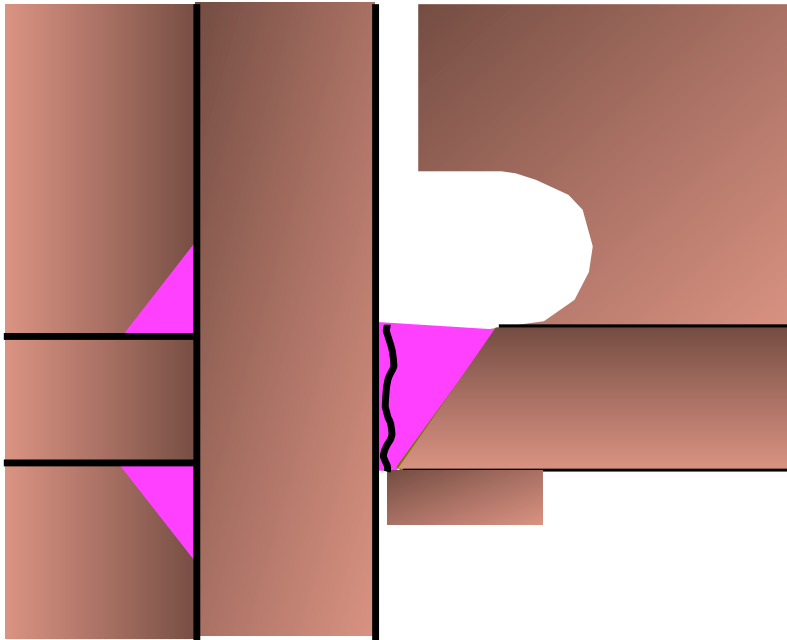
Impacts – Moment Frames

- Primary problem: brittle fractures of the weld between beam flange and column flange



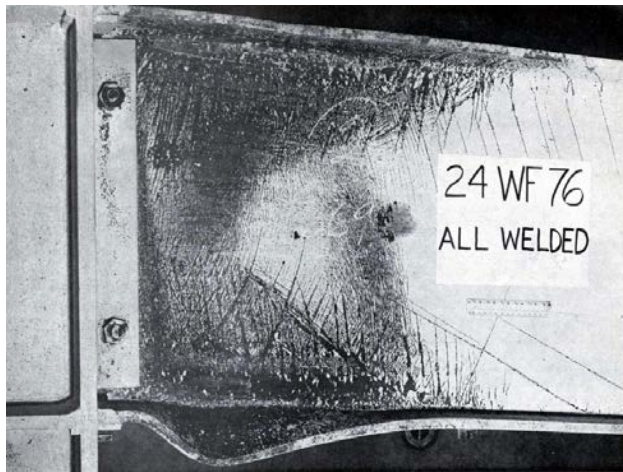
Impacts – Moment Frames

- Primary problem: brittle fractures of the weld between beam flange and column flange

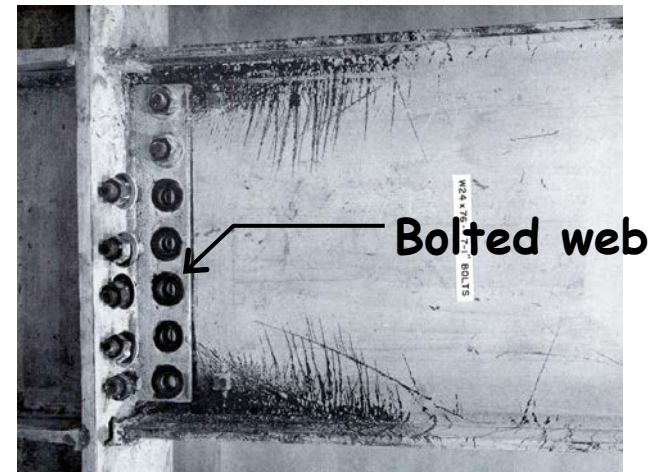


Impacts – Moment Frames

- Causes of Problems in Steel Moment Frames
 - Design Problems
 - Use of less reliable version of tested moment frame connection
 - Use of deep steel beam sections



All-welded: better performer



Bolted web: not so much

Impacts – Moment Frames

- Causes of Problems in Steel Moment Frames
 - Construction Problems
 - Weld metal with low resistance to brittle fracture
 - Welders did not follow required welding procedures



Impacts – Moment Frames

- Causes of Problems in Steel Moment Frames
 - Inspection Problems
 - Over-reliance on after-the-fact inspection methods
 - Lack of diligence on the part of some inspectors



Impacts – Moment Frames

- Solutions to Problems in Steel Moment Frames
 - Development of moment frame connection designs based on thorough research
 - FEMA-sponsored SAC Joint Venture
 - AISC Connection Pre-Qualification Panel



Impacts – Moment Frames

- Solutions to Problems in Steel Moment Frames
 - Use of steel and welding materials with improved seismic characteristics



Impacts – Moment Frames

- Solutions to Problems in Steel Moment Frames
 - Improved Inspection Practices
 - Increased reliance on visual inspection
 - Availability of standardized inspection requirements in building codes
 - Improved certification programs (e.g., ICC-ES, AISC)

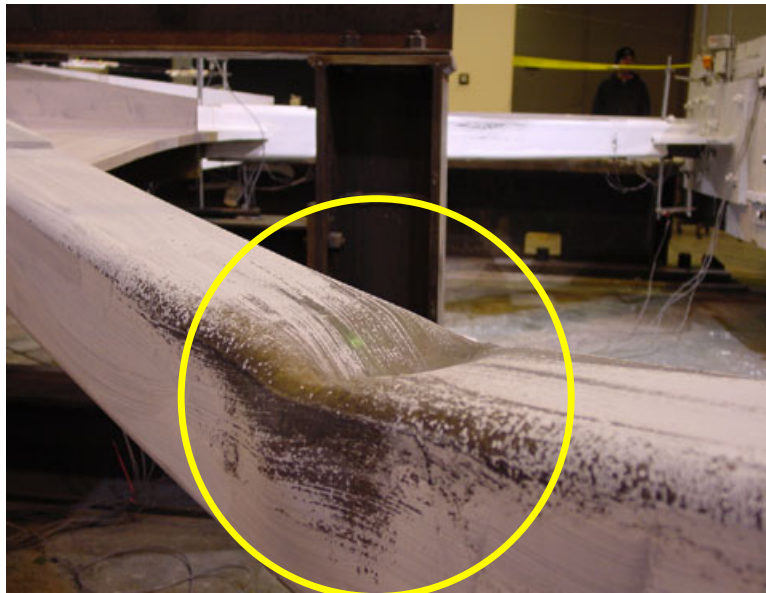
Impacts – Braced Frames

- Primary problem: fractured braces



Impacts – Braced Frames

- Causes of Problems in Steel Braced Frames
 - Use of braces with excessively thin walls



Impacts – Braced Frames

- Causes of Problems in Steel Braced Frames
 - Overcutting slots in braces required for fit-up



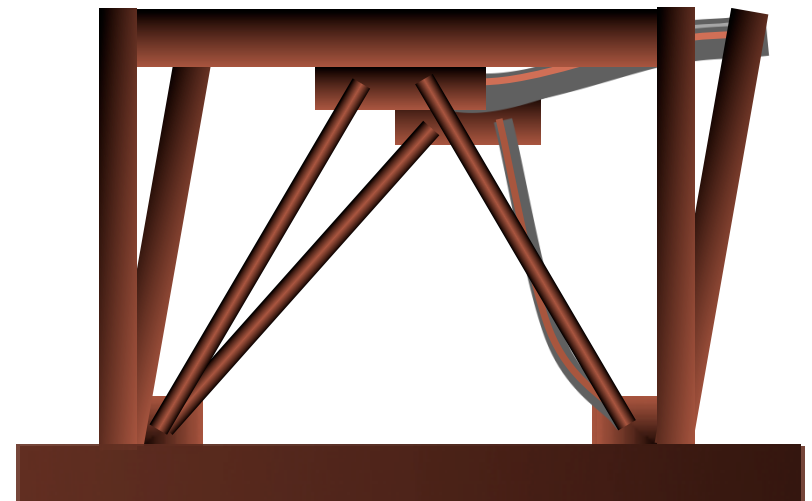
Impacts – Braced Frames

- Solutions to Problems in Steel Braced Frames
 - Specification of minimum ratio for wall thickness to brace width
 - Explicit consideration of impact of slots in braces



Impacts – Braced Frames

- Solutions to Problems in Steel Braced Frames
 - Requirement that connections develop strength of brace
 - Revised analytical methods to account for brace buckling



Recommendation - Practice

- Waiver of steel inspection requirements for seismic force resisting systems now permitted in 2012 *International Building Code* (2013 *California Building Code*)

Recommendations - Research

- Improve understanding of seismic behavior correlation between individual components and actual structures
- Improve understanding of tall steel buildings and steel buildings with heavily loaded columns during earthquakes
- Improve understanding of multi-tier braced frame behavior
- Develop reliable seismic performance standards for steel structures