AISC Seismic Steel Moment Frame Provisions Then and Now
(What a Difference 20 Years Makes)

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Codes Before Northridge – ’85 UBC

- Total length of Chapter 23 Seismic Provisions in 1985 was 13 pages.
- Braced Frame connections designed for 1.25
- Ductile Moment Frames covered in one page
  - > Material definitions
  - > Full plastic beam capacity connections
    - Or ductile displacement mechanism
  - > Plastic design member sections to be used
  - > ½ page on NDE
- Those were the days!

Codes Just Before Northridge

- 1985 NEHRP and 1988 UBC incorporated ATC 3 information
  - > Major switch to Strength Based Design (‘97 UBC)
  - > “R” replaces “K” factor for system response
  - > System definitions introduced
  - > Capacity Design concepts introduced (EBF)
- First AISC Seismic Provisions in 1992 (E. Popov, Chair)

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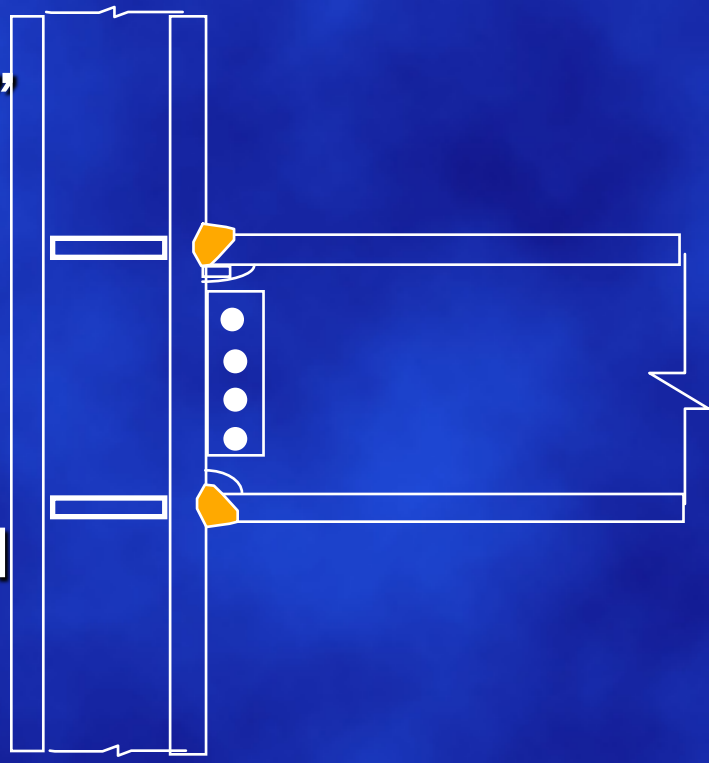
Steel Moment Frames in ’92 AISC Seismic

- 4 ½ pages total (out of 62)
- Defined “Ordinary” and “Special” Moment Frames
- Pre-qualified what came to be known as the “Pre-Northridge” Connection
  - > Had become de-facto standard after 1971 UCB Tests
  - > Other details penalized with 1.25 factor



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The "Present" – AISC 341-10

- AISC 341-10 is now included by reference in the 2012 IBC.
- 20 pages of Moment Frame Requirements
  - > AISC 341-10 is 356 pages, including Commentary
  - > AISC 358-10 (Pre-qualified connections standard) is another 157 pages
  - > AWS D1.8 (Seismic Supplement to D1.1) is another is another 111 pages
  - > Four Systems – OMF, IMF, SMF and STMF

Overall Philosophy of AISC 341

- Identify Target Yield Mechanism for Each SLRS
- Designate Deformation-Controlled Elements (Structural Fuse):
  - -Design for Reduced Seismic Forces
  - -Ductility Design Is Relatively Straightforward (Prescriptive)
- Design Remaining Elements as Force-Controlled:
  - -Design for Forces to Remain "Essentially Elastic at Capacity of Fuses
  - -Use Either "Local" or "Global" Approach
  - -Capacity Design Requires Good Judgment and Experience

Credit: C. M. Uang

It's This Simple…

Target Mechanism Plus Ductility Requirements Plus Capacity Design Requirements Equals…

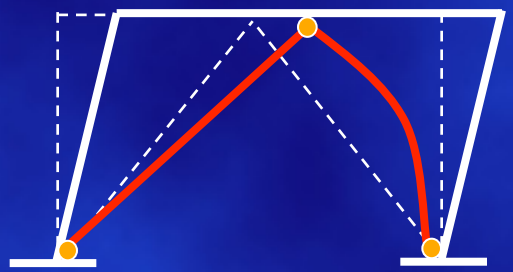
Seismic Provisions for Structural Steel Buildings

Including Supplement No. 1

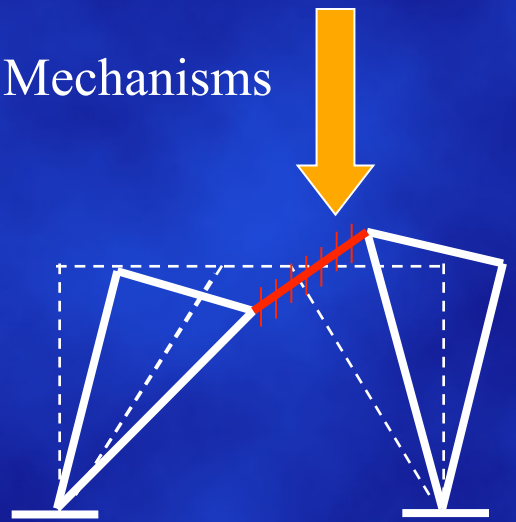
Seismic Provisions for Structural Steel Buildings dated **March 9, 2005** and Supplement No. 1 dated **November 16, 2005**

Target Yield Mechanisms

Flexural Yielding



Tensile Yielding/Buckling



Shear Yielding

SMF's - What's the Same (or Close)?

- Capacity Design of Connections to Develop Mp of beam
  - > Now we also want deformation capacity and Ry considered
- Shear Capacity of Connections to develop moment hinges
- Width-thickness requirements for both beams and columns
- Beam lateral support bracing spacing
- Beam-column connection restraint, when braced by beam or not

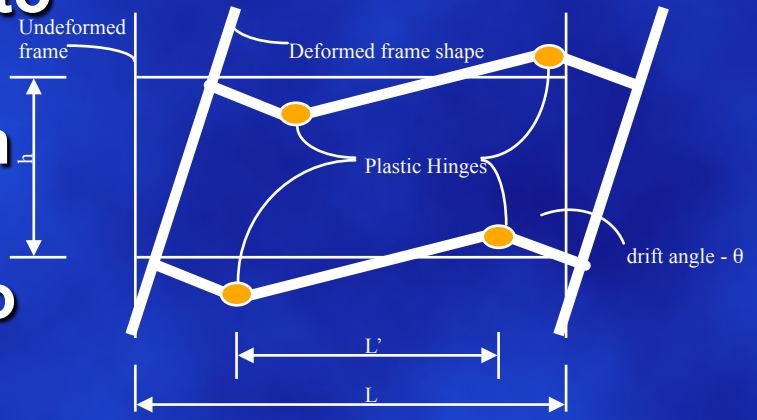


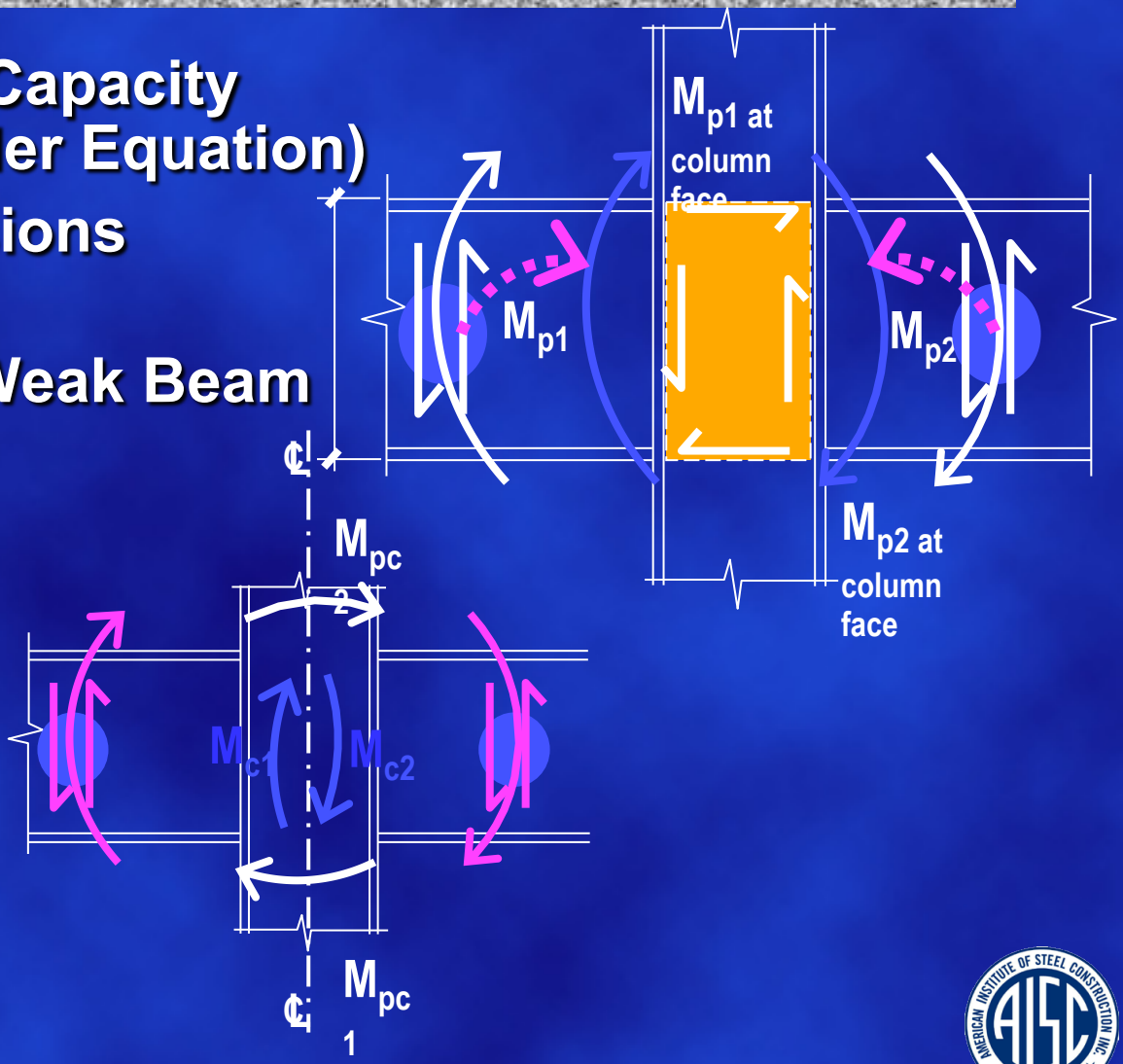
TABLE I-8-1
Limiting Width Thickness Ratios λ_{ps} for Compression Elements

	Description of Element	Width Thickness Ratio	Limiting Width-Thickness Ratios λ_{ps} (seismically compact)
Unstiffened Elements	Flanges of I-shaped rolled, hybrid or welded beams [a], [b], [f], [h]	b/t	$0.30\sqrt{E_s/F_y}$
	Flanges of I-shaped rolled, hybrid or welded columns [a], [c]	b/t	$0.30\sqrt{E_s/F_y}$
	Flanges of channels, angles and I-shaped rolled, hybrid or welded beams and braces [a], [d], [h]	b/t	$0.30\sqrt{E_s/F_y}$
	Flanges of I-shaped rolled, hybrid or welded columns [a], [e]	b/t	$0.38\sqrt{E_s/F_y}$
	Flanges of H-pile sections	b/t	$0.45\sqrt{E_s/F_y}$
	Flat bars[g]	b/t	2.5
	Legs of single angle, legs of double angle members with separators, or flanges of tees [h]	b/t	$0.30\sqrt{E_s/F_y}$
	Webs of tees [h]	d/t	$0.30\sqrt{E_s/F_y}$

SMF's- What's the Same (or Close)?

- Panel Zone Shear Capacity Equation (Krawinkler Equation)
  - > Many other versions considered
- Strong-Column – Weak Beam Concept

$$\frac{\Sigma M^*_{pc}}{\Sigma M^*_{pb}} \geq 1.0$$



SMF's - What's Different?

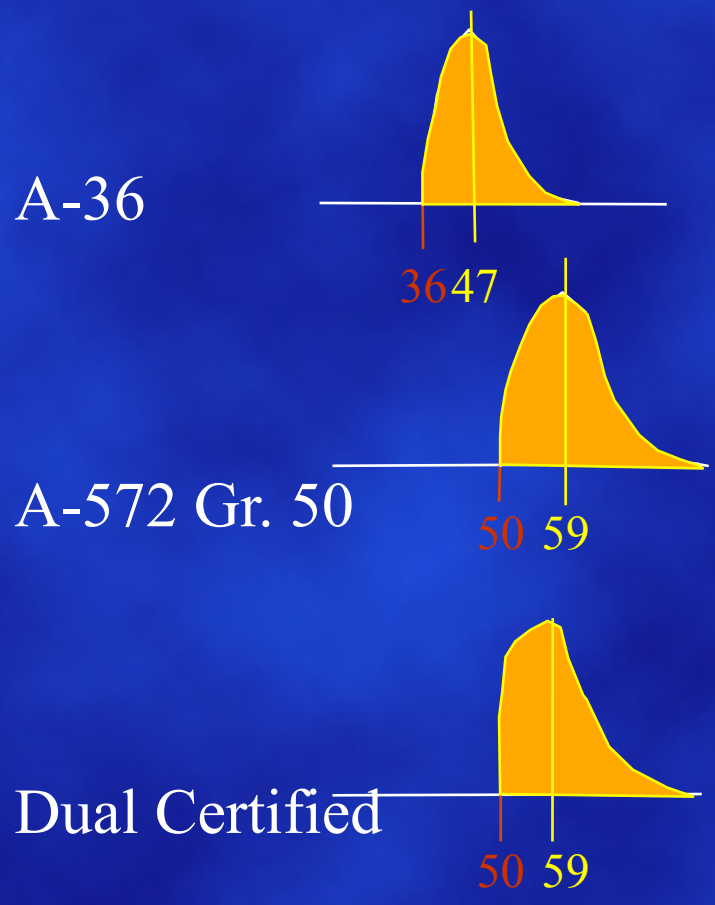
- *Everything Else!!!!!*

Project Documentation Requirements

- From Nothing to Section that Define Expectations for:
  - > Design drawings and specifications
  - > Shop Drawings
  - > Erection Drawings
- Includes lists of information to be provided such as SLRS designation, connection detailing, welding requirements, protected zones, etc.

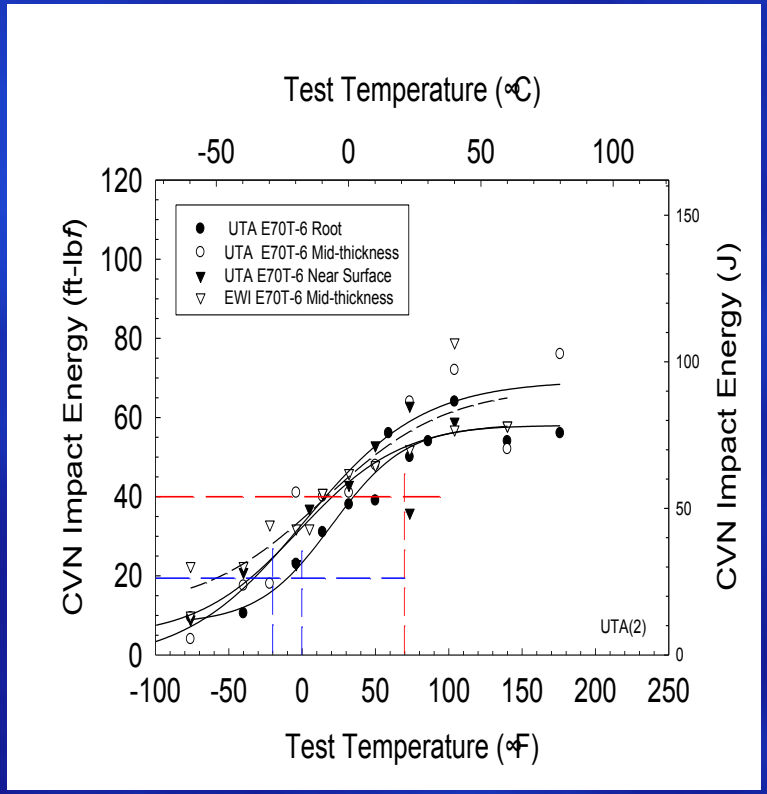
Material Specifications

- From A36 and Dual Certified A572 Grade 50 to A992
  - > Specified Maximum Yield and Y/T ratios
- Expected Yield Strength and Expected Tensile Strength (R_y and R_t) Defined to Assist in Comparison of Members Strengths
  - > To help ensure intended yield mechanisms



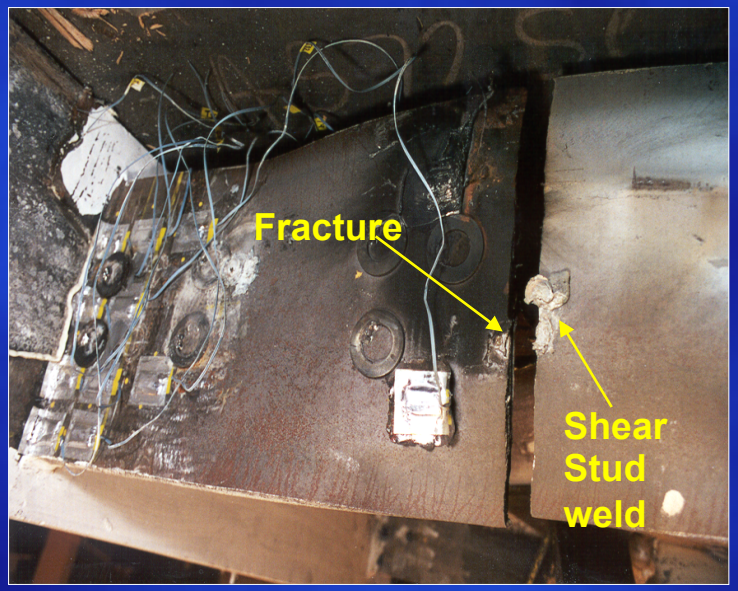
Connections - Welded Joints (All New)

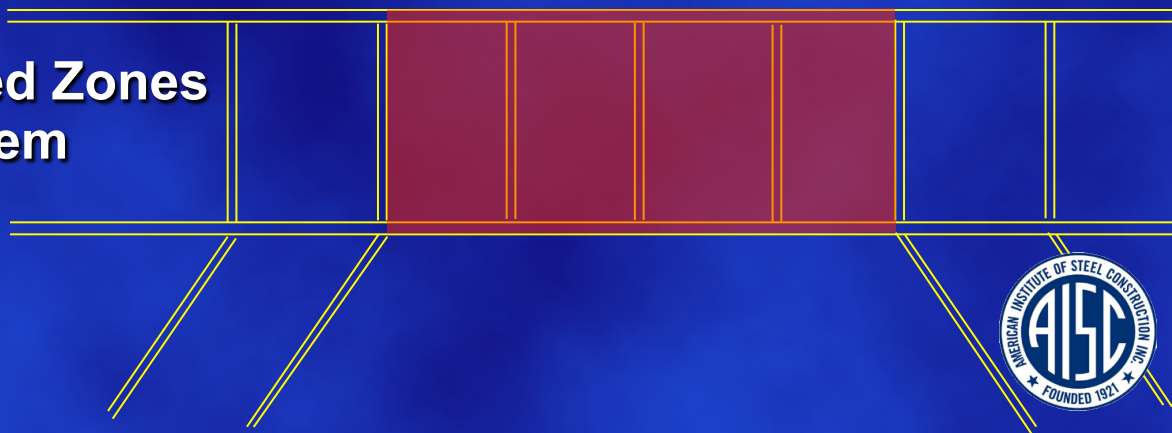
- Filler metal CVN 20 ft.-lbs. @ -0° F for all welds in the seismic load resisting system (SLRS)
- Two level toughness required for designated Demand Critical Welds in SMF, IMF and OMF
  - > based on FEMA recommendations
  - > Consistent with previous testing
  - > AWS D1.8 provides requirements for qualification
- WPS required / Approved by EOR
- Continuity plate welding and detailing specified



Welded Joints – All New (cont.)

- Defines term "Protected Zone" where special care is required
  - > Eliminates welding and other attachments in plastic hinge zones (shear studs, e.g.). Spot welds acceptable
    - OK outside hinge zones, but need to verify net section strength
  - > Discontinuities caused by welding or other construction operations must be repaired.
  - > Locations of Protected Zones defined for each system





Special Moment Frames (SMF)

- Connection designs based on cyclic test results to 0.04 radians by three methods
  - > Provide test requirements from either project specific or "public" tests
  - > Establish for "pre-qualification" of desired connection per rules specified
  - > Connections designed in accordance with AISC 358 standard
    - Ron Hamburger will cover this in upcoming talk

(N) AISC Moment Connection Prequalification Standard

- Official title: "*Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications*"
  - > Developed by separate ANSI standards development committee (Ron Hamburger, Chair)
- Allows engineers to submit moment frame designs without producing connection test results
  - > First edition focuses on RBS and End Plate connections
    - *(2010) More connections included (WUF-W, e.g.)*
- Adopted by AISC Seismic

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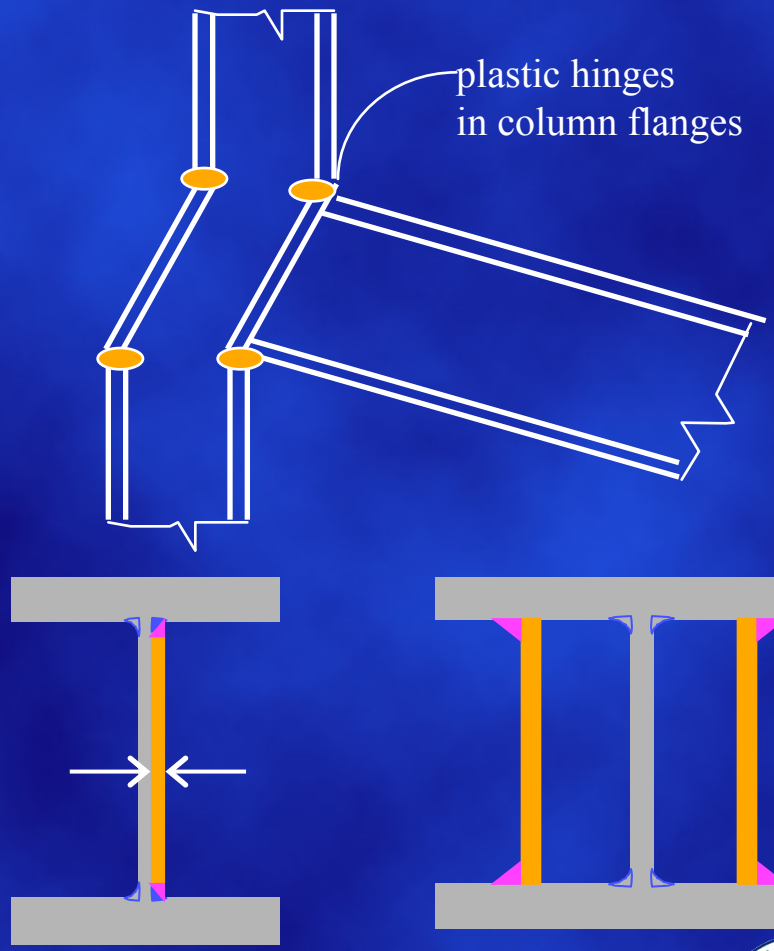
SMF (Cont.)

- Panel Zone Design
  - > Intended to share yielding with beam
- Doubler plate configurations may be adjusted to avoid “k” area
- Continuity plates to match tested configurations



SMF (Cont.)

- Lateral Bracing of Beams
  - > Nominal bracing required along length for both strength and stiffness based on main spec. equations
  - > Bracing at hinges (6%) required as well
    - But, not IN hinge zones!

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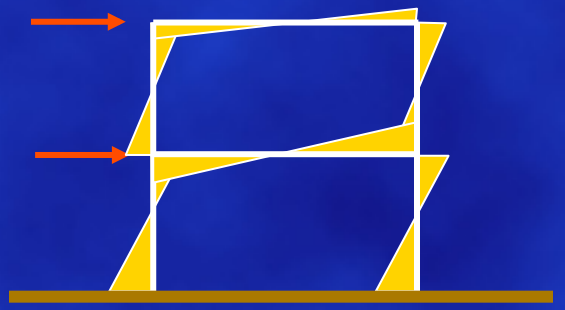
SMF Column Splices/Bases

- Column splices pushed to CJP
- Requirements for shear strength check of non-frame columns in all systems.
- *Beveled transitions required in CJP splices and removal of weld tabs (but not backing) per D1.8 specified*
  - > *Column base weld backing reqt's also defined*
- *Column base design forces defined*



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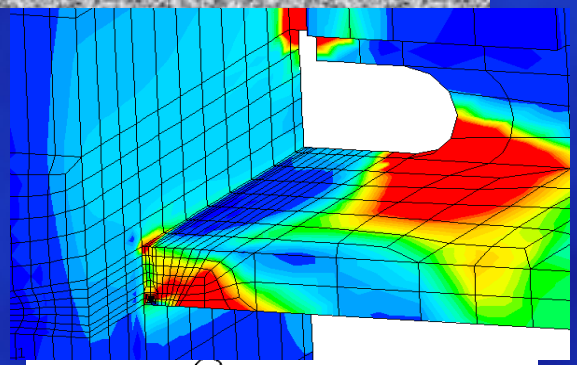
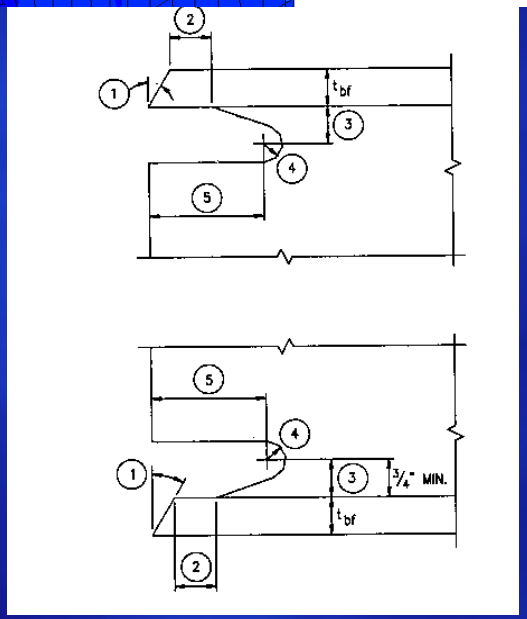
IMF/OMF Requirements

- Intermediate (IMF) provisions similar to SMF
  - > Tested capacity to 0.02 radians, beam shear, etc.
  - > Other requirements (SCWB, panel zone, b/t, etc.) not as restrictive as SMF.
  - > *DC welds at splices*
- Ordinary (OMF) provisions
  - > Allows calculation only, but for strength above 1.1 R_y M_p
  - > Specific welding and detailing requirements (access holes, e.g.)





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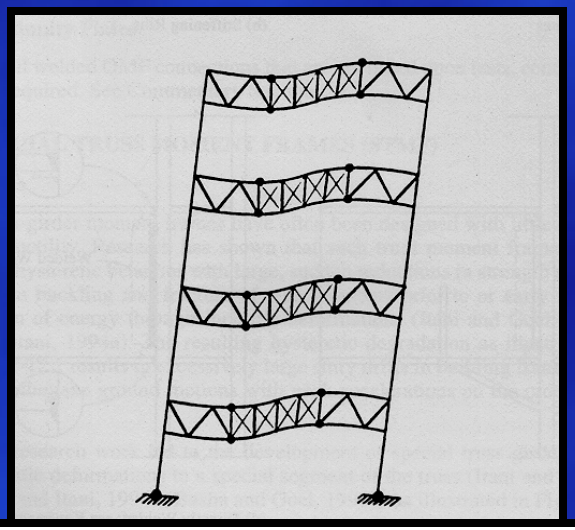
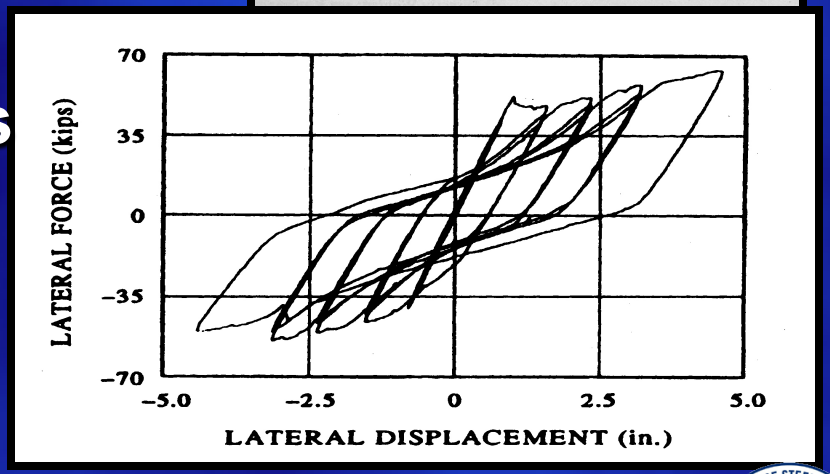
STMF

- Concept Similar to EBF's
- Ductile Special Segment (SS)
- Other Parts of the Truss Remain Elastic
- Both Cross-braced and Vierendeel configurations
- Span limited to 65 feet
- Depth limited to 6 feet





QC and QA

- Detailed set of provisions in AISC 341 and AWS D1.8
- QA plan required in conjunction with IBC Chapter 17. Covers both QA and QC.
- Documentation requirements listed
- Visual Inspection Points and Frequency Defined
  - > For before, during and after welding or bolting by both QA and QC. Shown in tabular format
    - Observe/Perform/Document vs. Periodic/Continuous
- NDT locations and requirements specified. Both UT and Magnetic Particle incorporated. All results documented.
- Defines requirements for welders and inspectors

AISC Documents Related to Seismic Design

- 2010 AISC Seismic Provisions (ANSI/AISC 341)
  - > Available via download.
- 2010 AISC Moment Connection Prequalification Standard (ANSI/AISC 358).
  - > Available via download.
- 2010 AISC Specification for Structural Steel Buildings (ANSI/AISC 360)
  - > Available via download.
- 2010 AISC Seismic Design Manual
  - > Available for purchase.

Concluding Comments

- Unprecedented changes started by Northridge EQ
- Unified Process for Steel Seismic Provision Development
  - > "Single Point of Responsibility" eliminates duplicative effort and minor differences that result in major confusion
- Hopefully, MUCH better performance will result!!!
- But, I can almost guarantee we'll never be done…

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