Session: Steel 1


# The Details We Left Behind

***Michael D. Engelhardt***
***Dept. of Civil, Architectural and Environmental Engineering***
***University of Texas at Austin***

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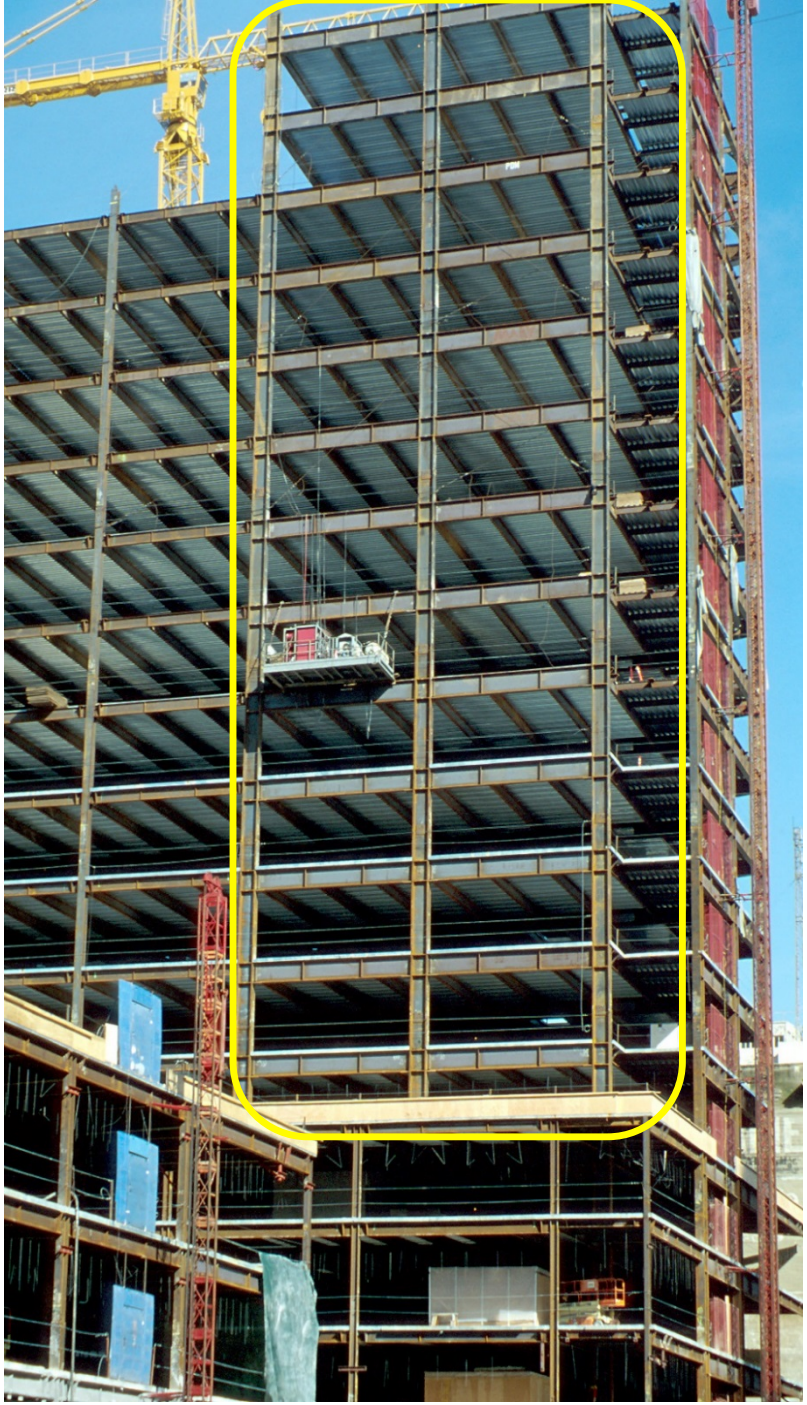
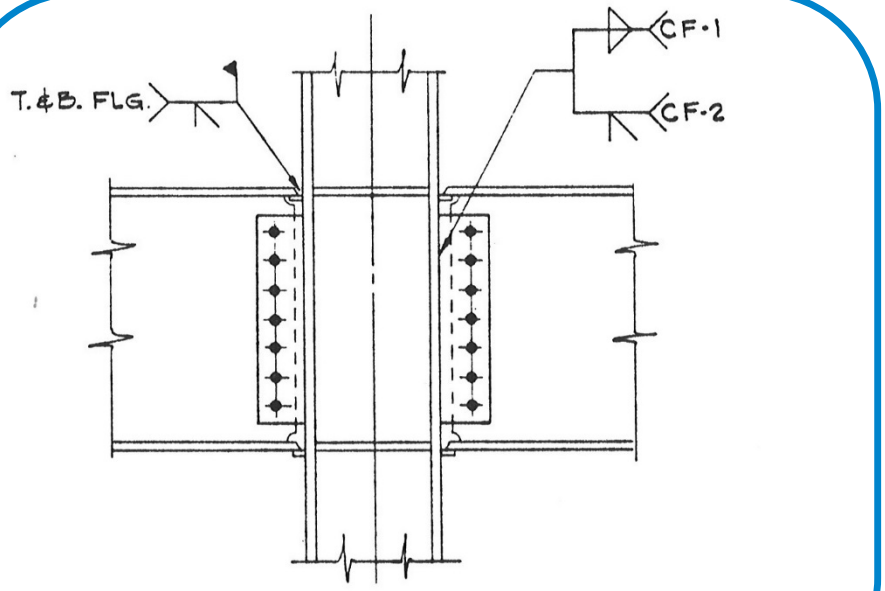
# Overview

- Review of “Pre-Northridge” steel moment connection.
- A brief history of research and code adoption.
- Examples of damage observed following Northridge Earthquake.
  - Observations

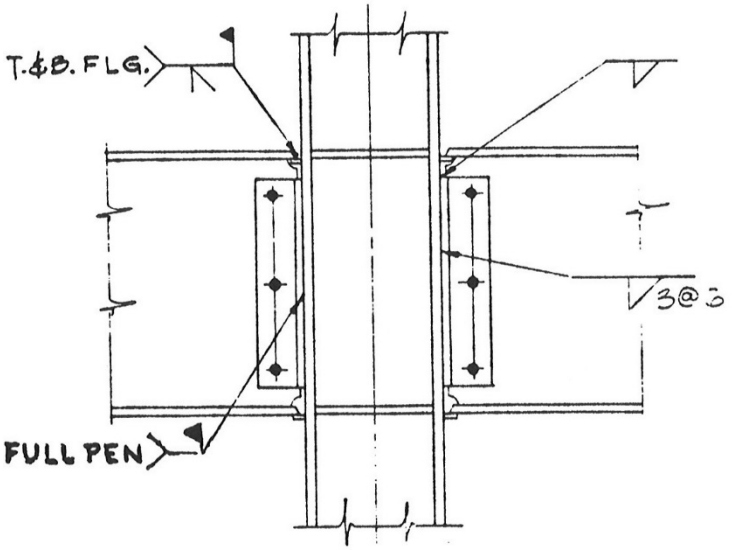


# Steel Moment Resisting Frame

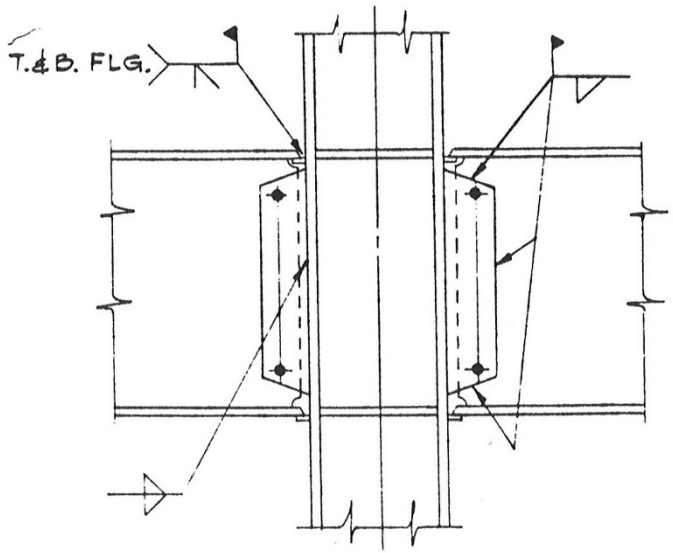
# *Pre-Northridge* Beam-to-Column Connections for Steel Moment Resisting Frames



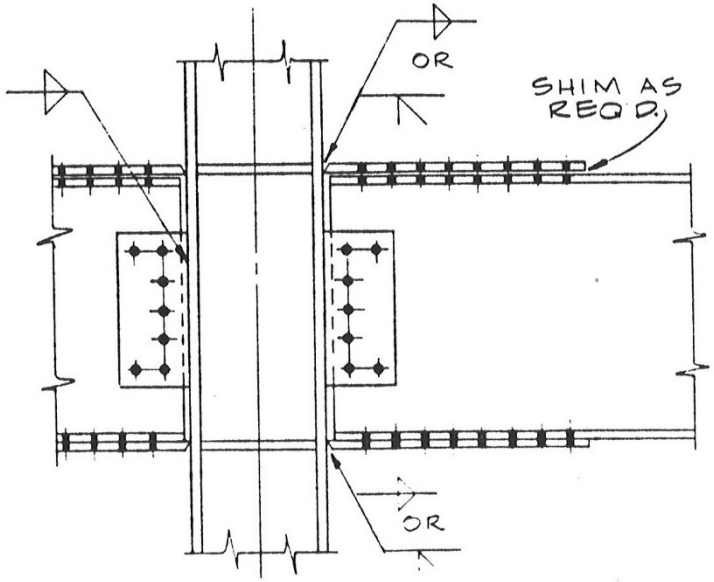

WEB BOLTED – FLANGE BUTT WELDED




WEB AND FLANGE BUTT WELDED

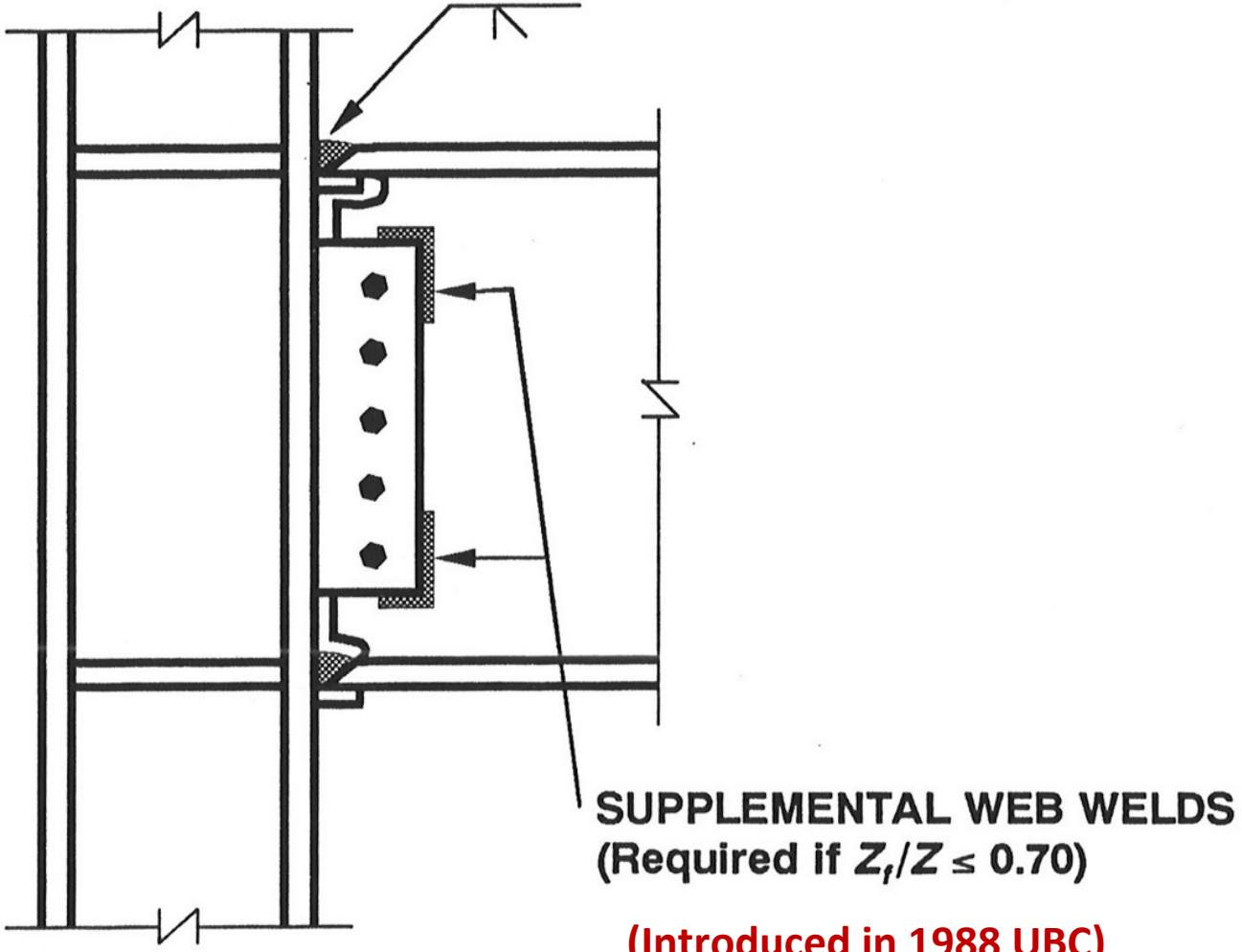



FLANGE BUTT WELDED – WEB FILLET WELDED TO TAB



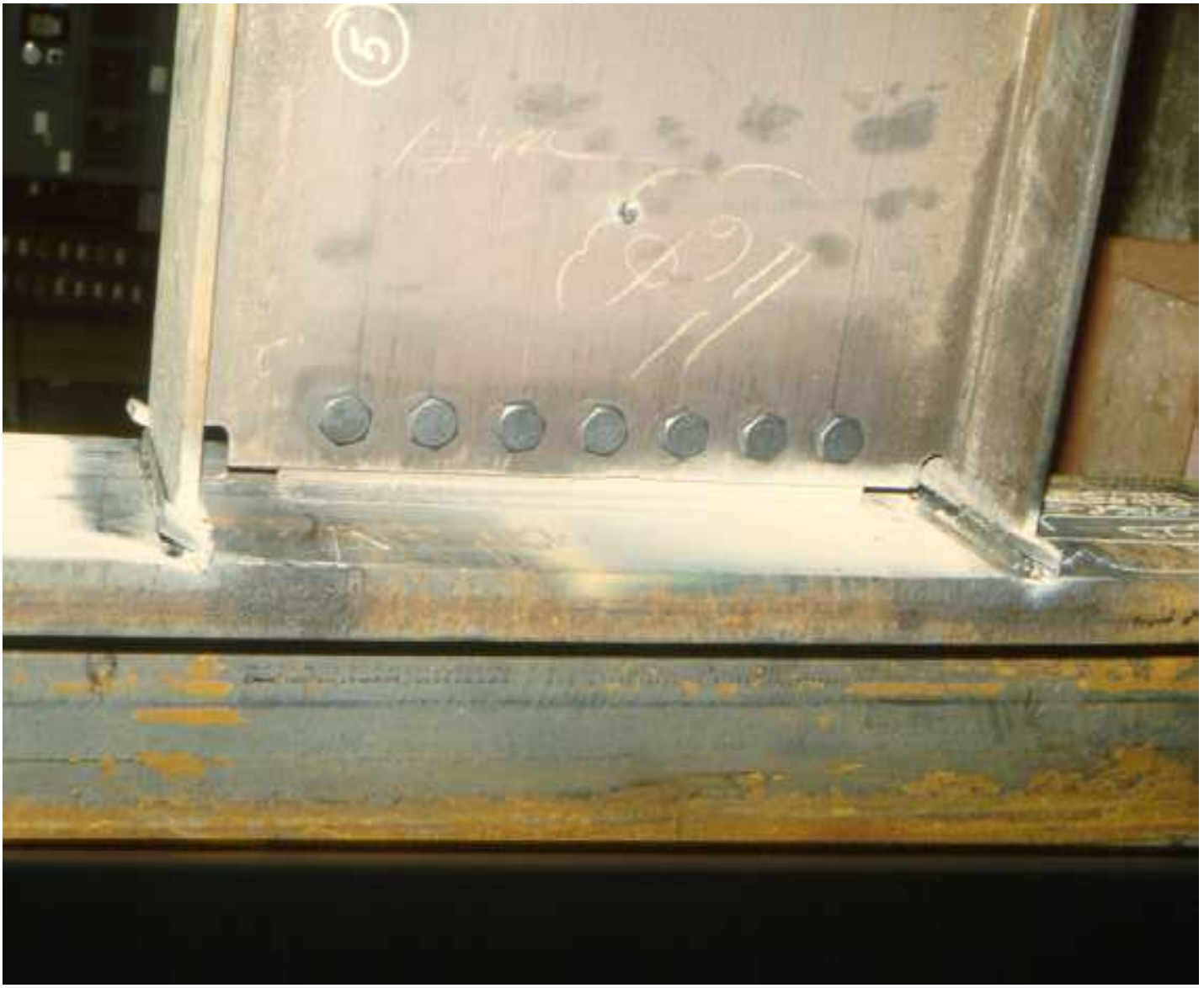

WEB AND FLANGE H.S. BOLTED WITH MOMENT PLATES

**"Steel Connections/Details and Relative Costs" 1986**




(Introduced in 1988 UBC)

# Typical Pre-Northridge Welded Flange-Bolted Web Moment Connection



# Code Provisions Prior to 1994

## 1982 UBC

"Each beam or girder moment connection to a column shall be capable of developing in the beam the full plastic capacity of the beam or girder."

# Code Provisions Prior to 1994

## 1988 UBC

**Required Strength:** The girder to column connection shall be adequate to develop the lesser of the following:

i. The strength of the girder in flexure.
ii. The moment corresponding to development of the panel zone shear strength as determined from Formula (22-1).

# Code Provisions Prior to 1994

## 1988 UBC (cont)

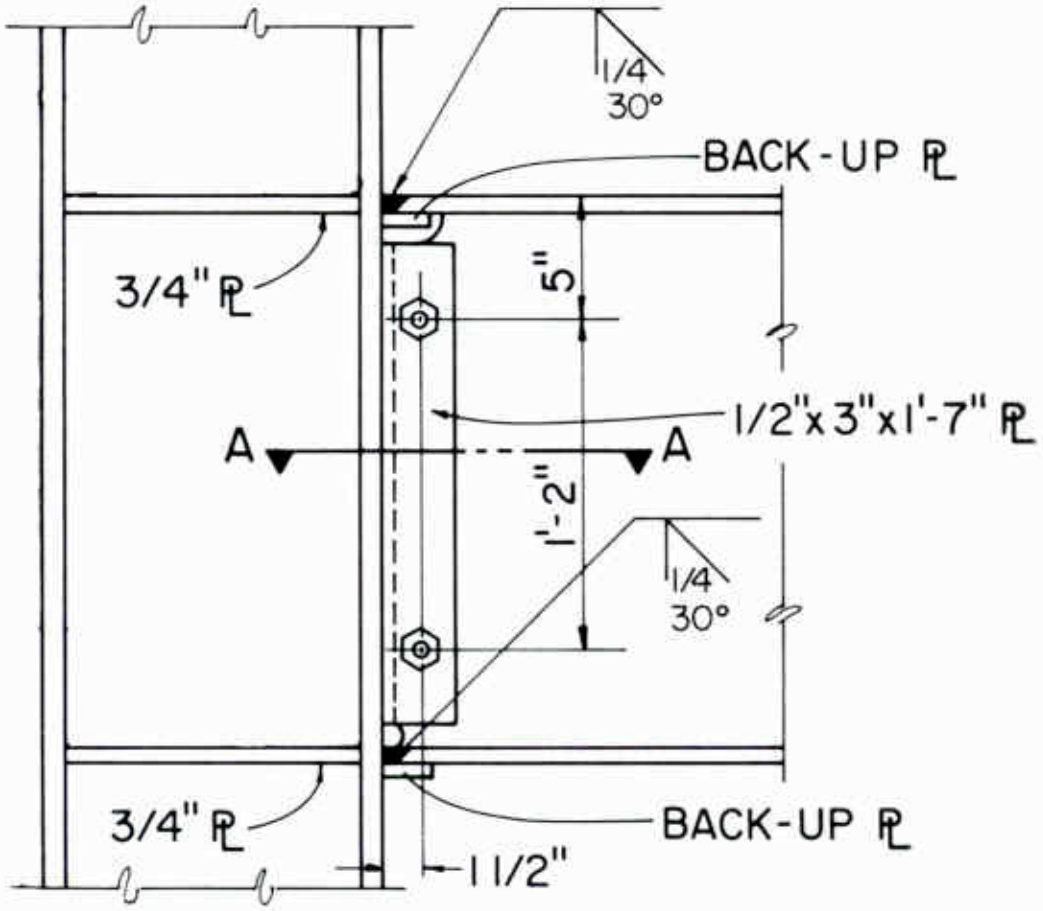
The girder to column connection may be considered adequate to develop the flexural strength of the girder if it conforms to the following:

i. The flanges have full penetration butt welds to the columns.
ii. The girder web to column connection shall be capable of resisting the girder shear determined for the combination of gravity loads and the seismic shear…..

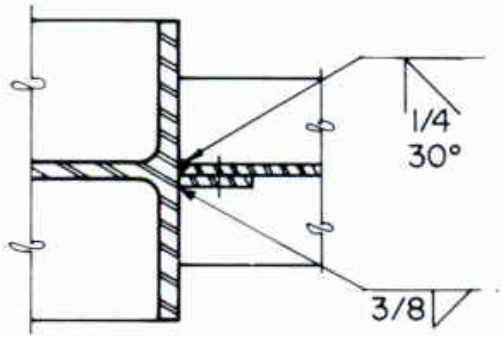
# Research and Testing Prior to 1994

"Cyclic Loading of Full-Size Steel Connections"
E.P. Popov and R.M. Stephen
AISI Bulletin 21, 1972

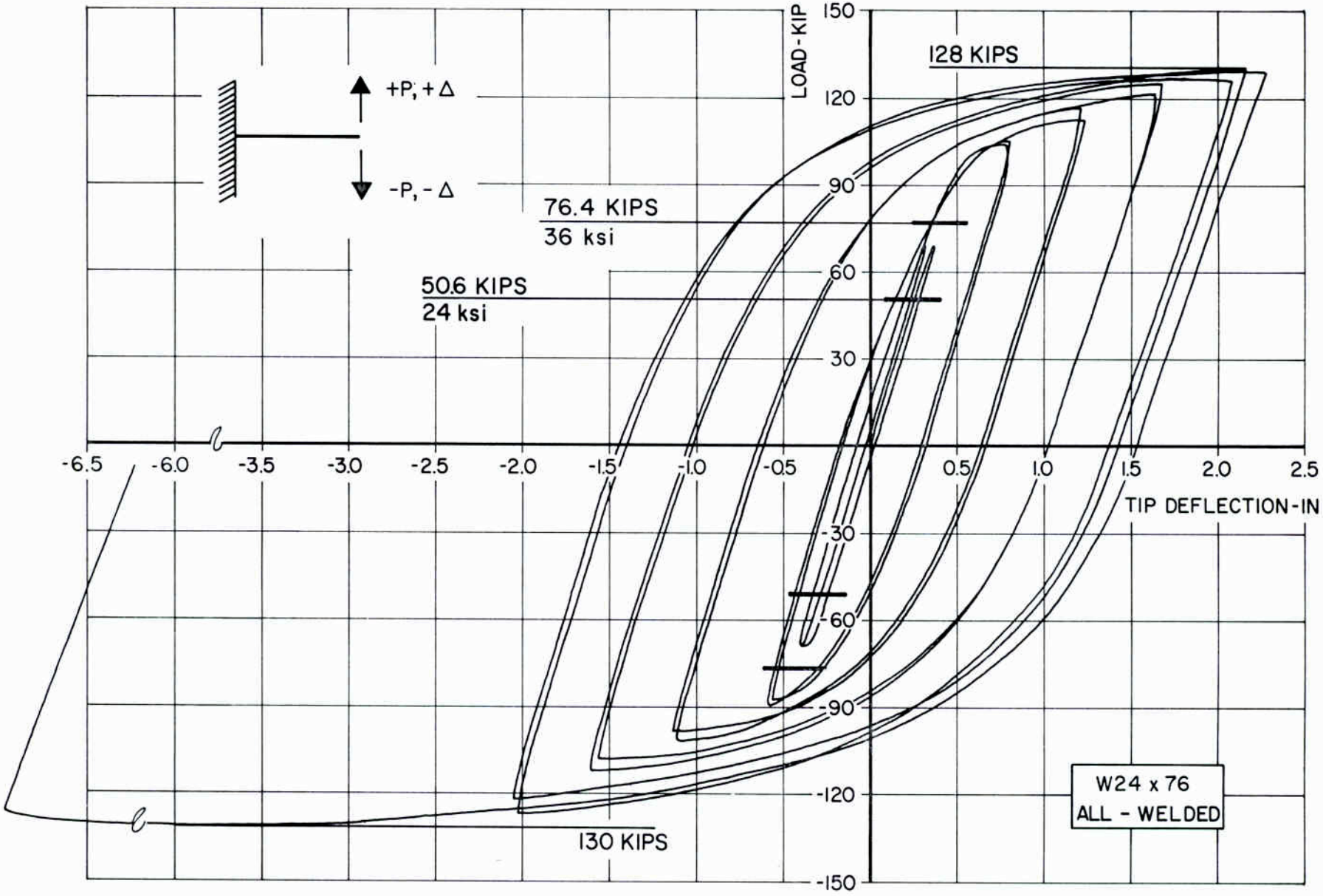
- Tests conducted at UC Berkeley ~1970
- Tests on W18x50 and W24x76 beams
- Tests compared all-welded connections with welded flange-bolted web connections




W24 x 76 WELDED
JOINT DETAIL

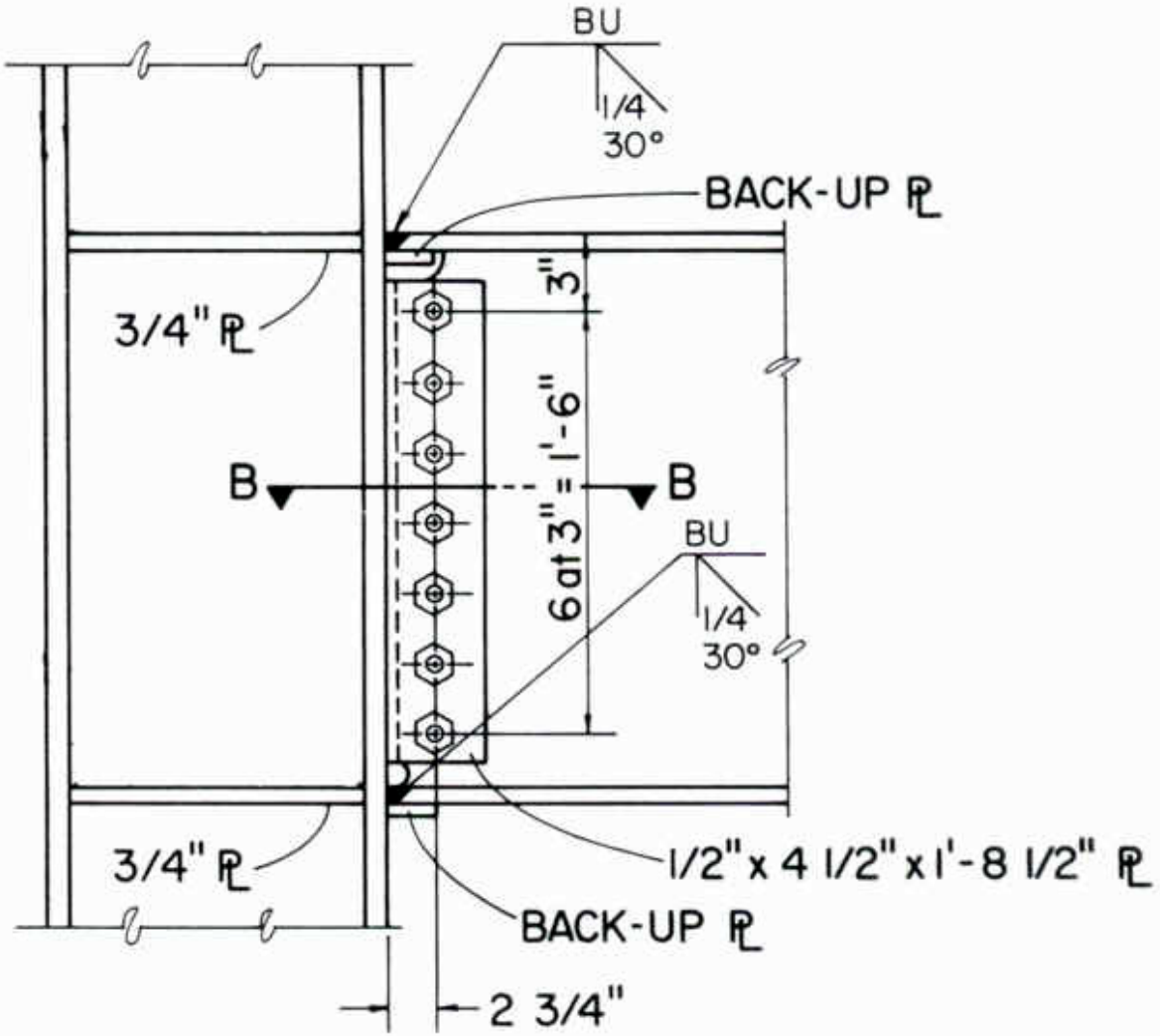



SECTION A-A

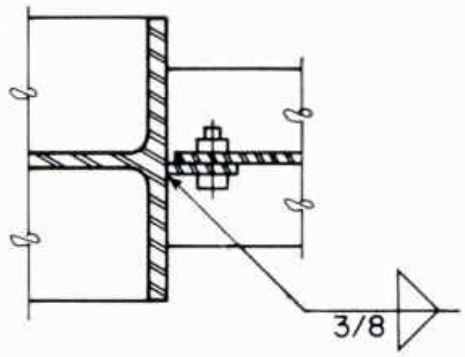



**All-Welded Detail**

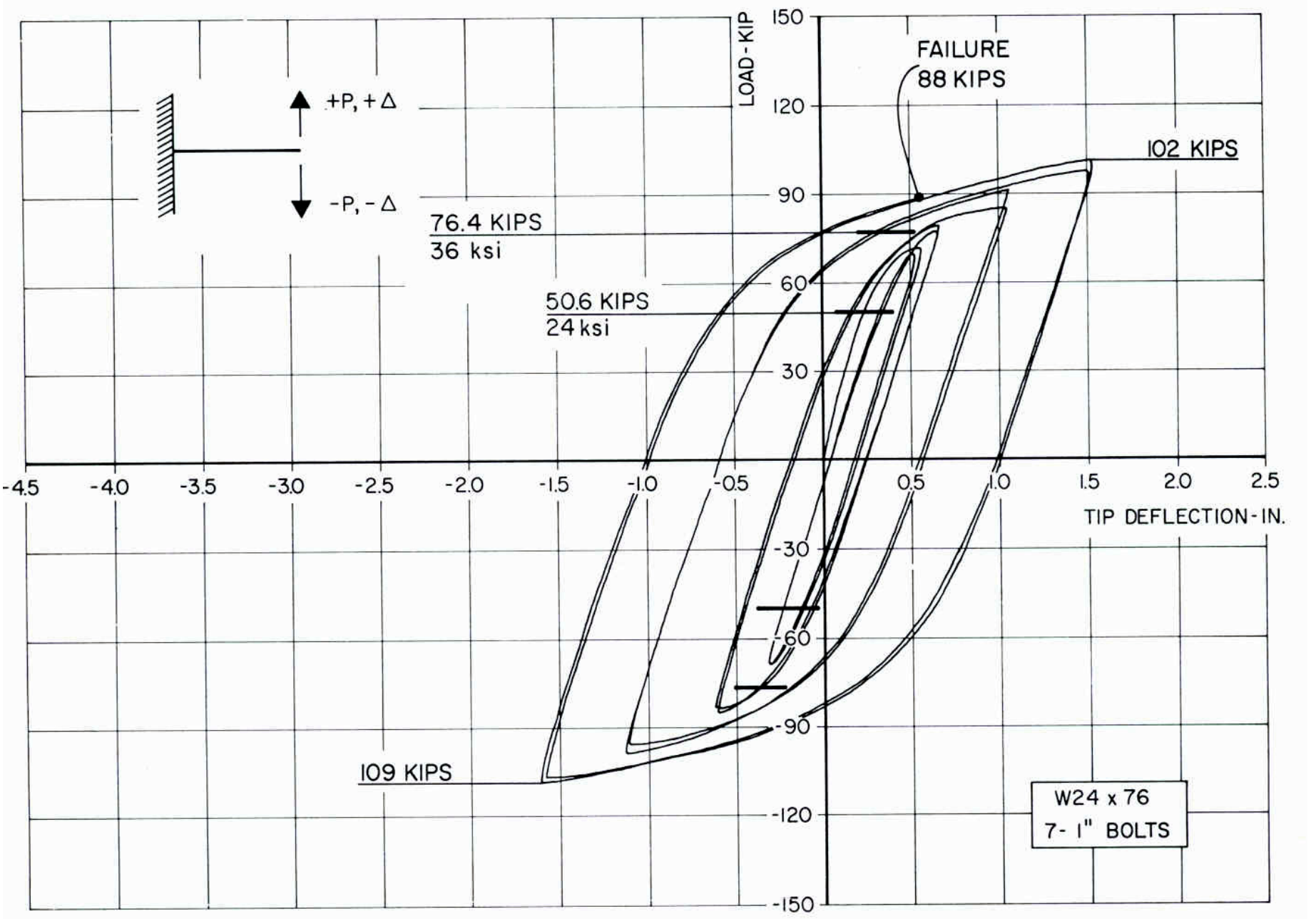

24 WF 76
ALL WELDED



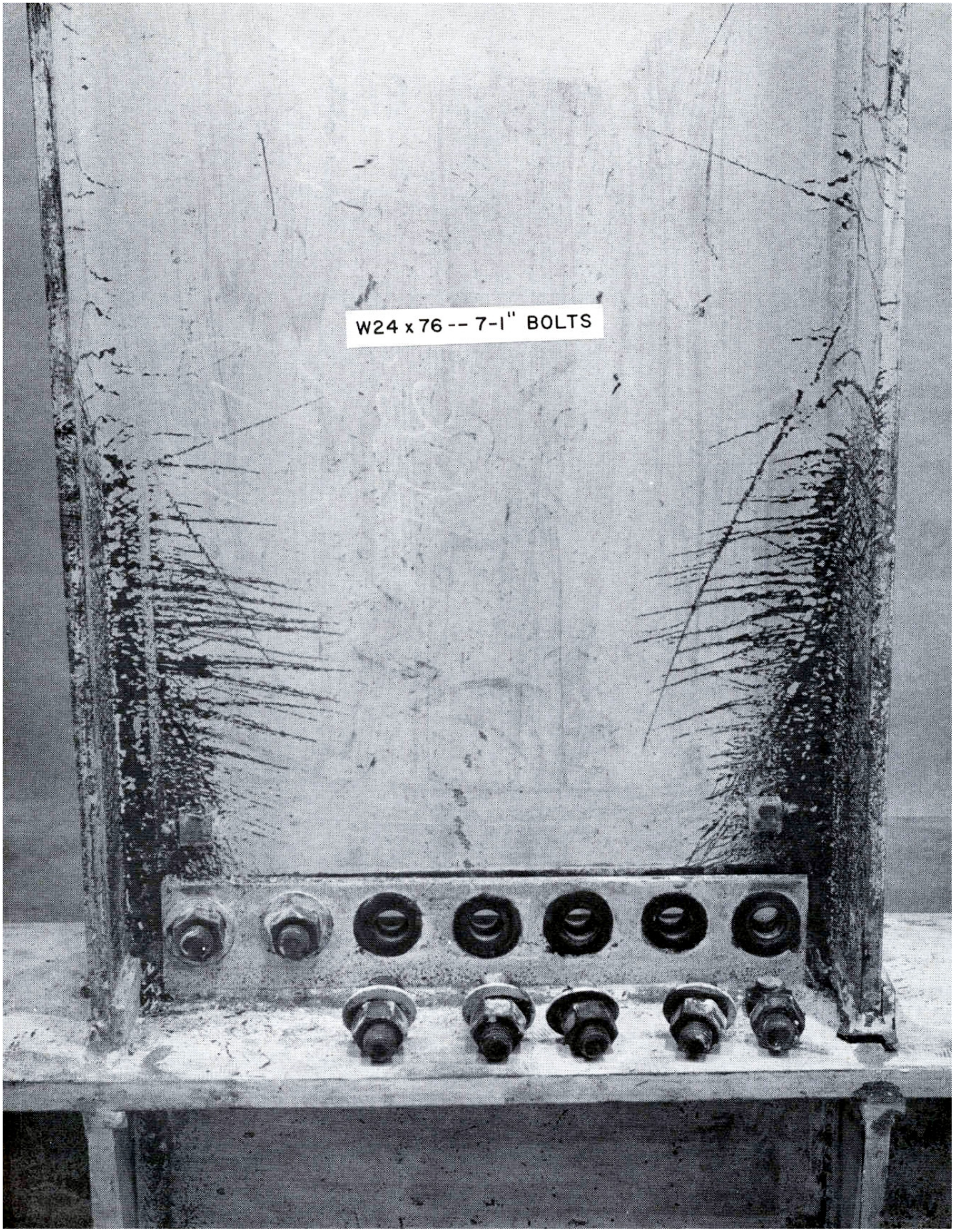

W24 x 76 BOLTED
JOINT DETAIL




SECTION B-B

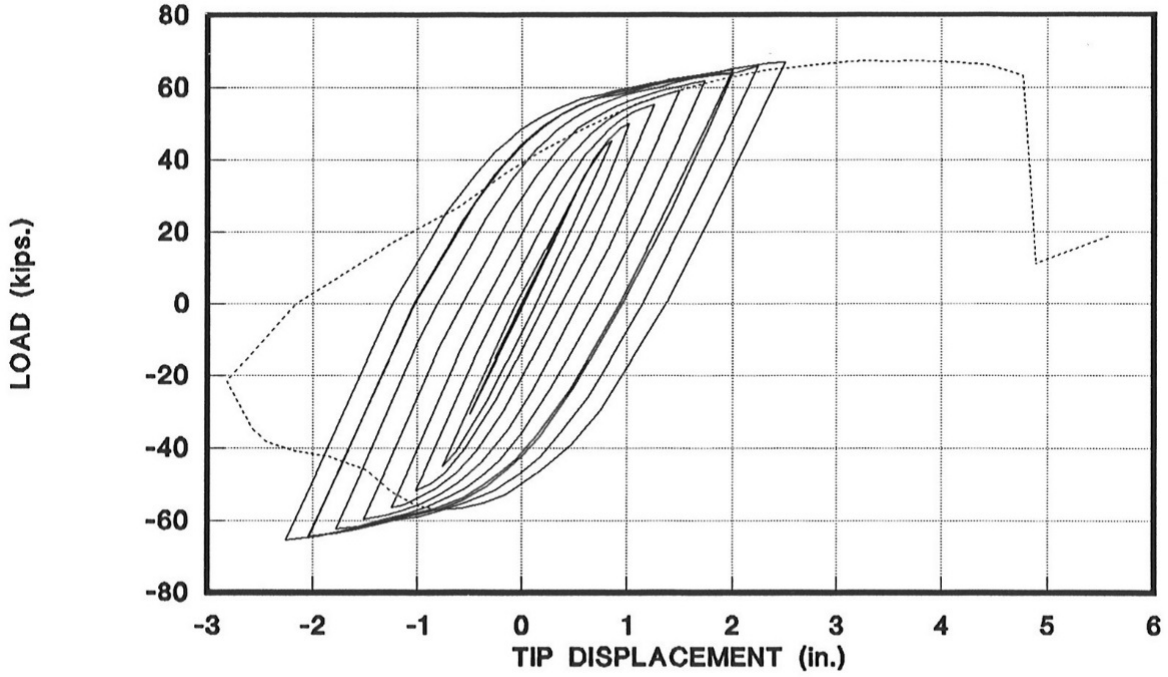


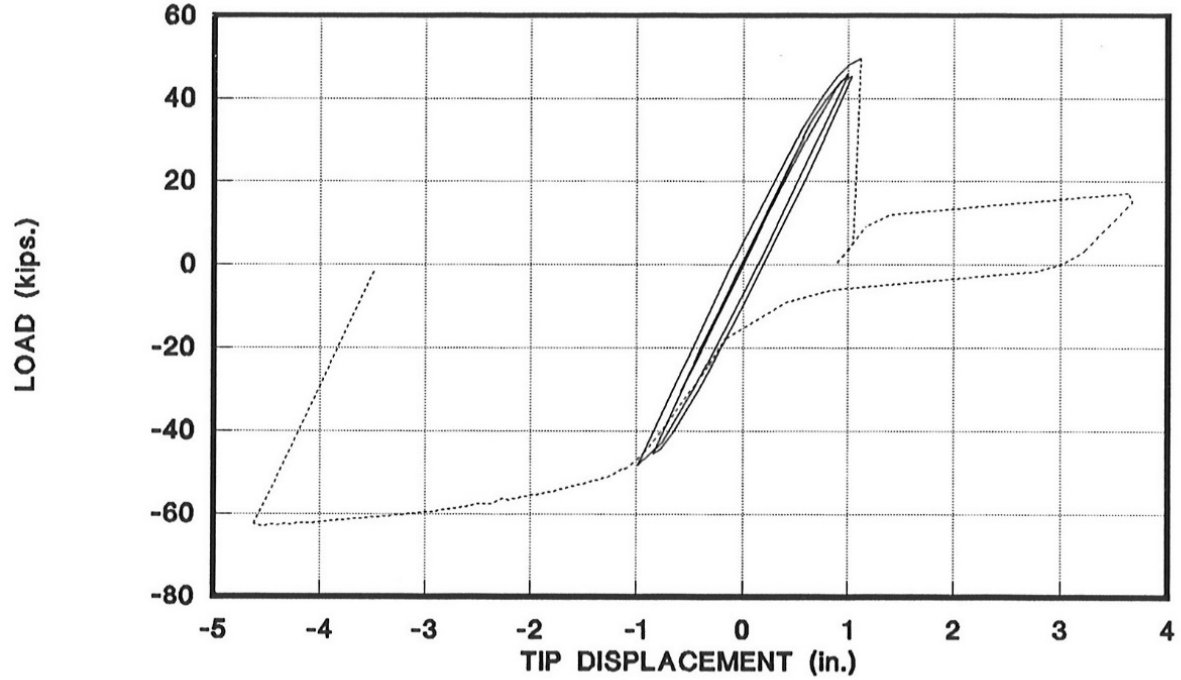

**Welded Flange – Bolted Web Detail**


W24 x 76 -- 7-1" BOLTS

# Research and Testing Prior to 1994

**Subsequent test programs…**


LOAD (kips.)
80
60
40
20
0
-20
-40
-60
-80
-3
-2
-1
0
1
2
3
4
5
6
TIP DISPLACEMENT (in.)


LOAD (kips.)
60
40
20
0
-20
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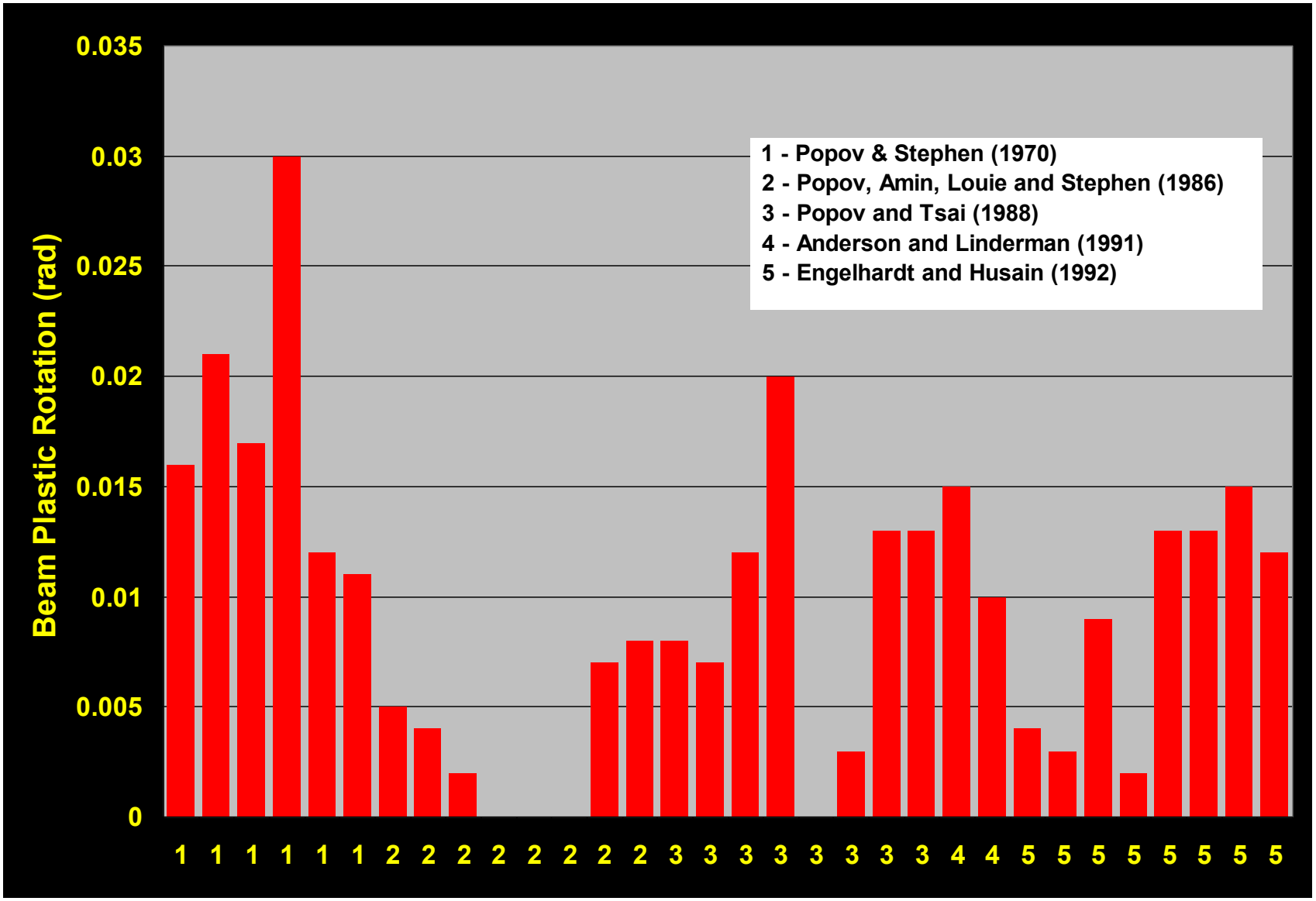
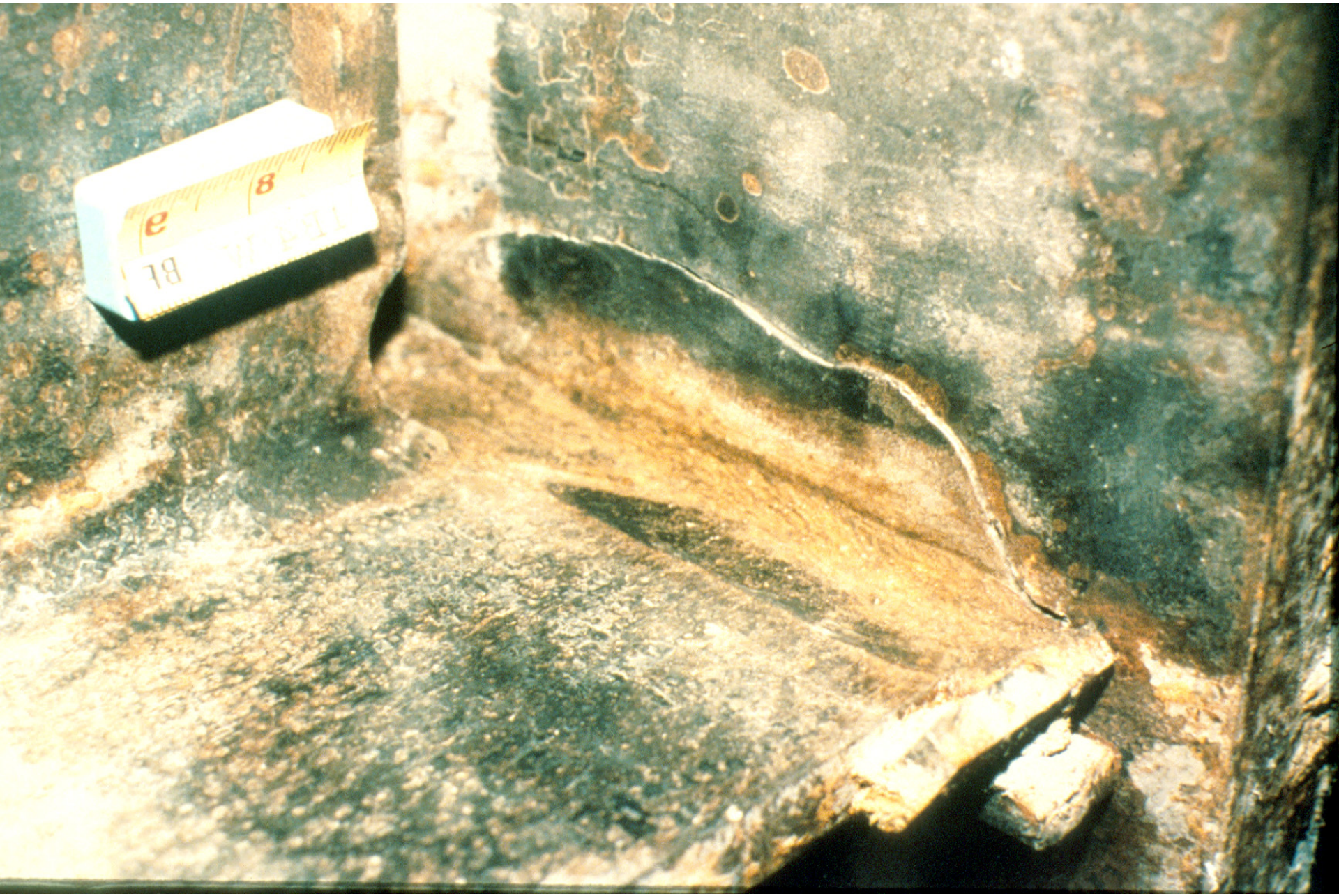
-60
-80
-5
-4
-3
-2
-1
0
1
2
3
4
TIP DISPLACEMENT (in.)

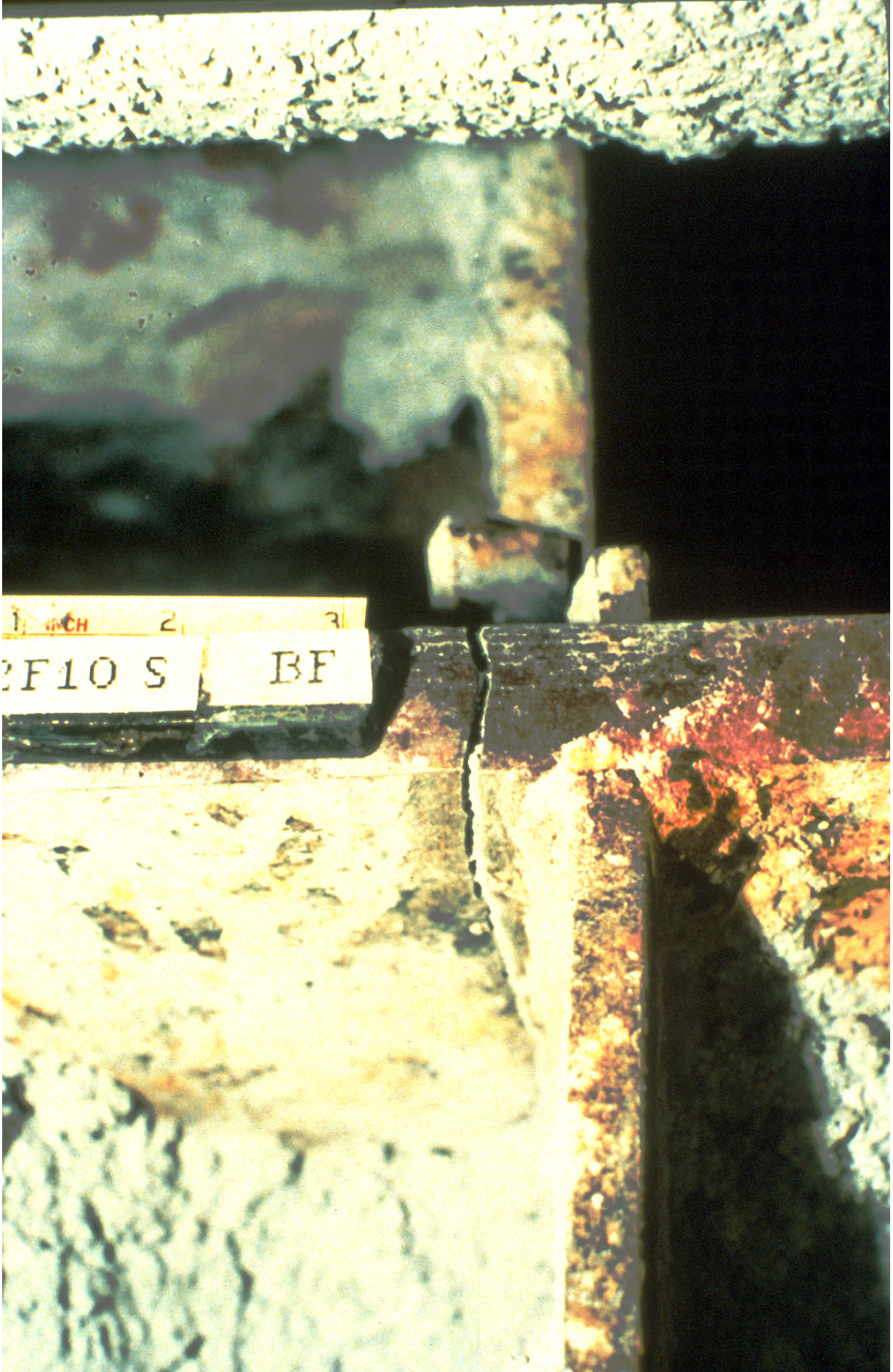
# *Tests on Large-Scale Welded Flange - Bolted Web Connections 1970-1992*



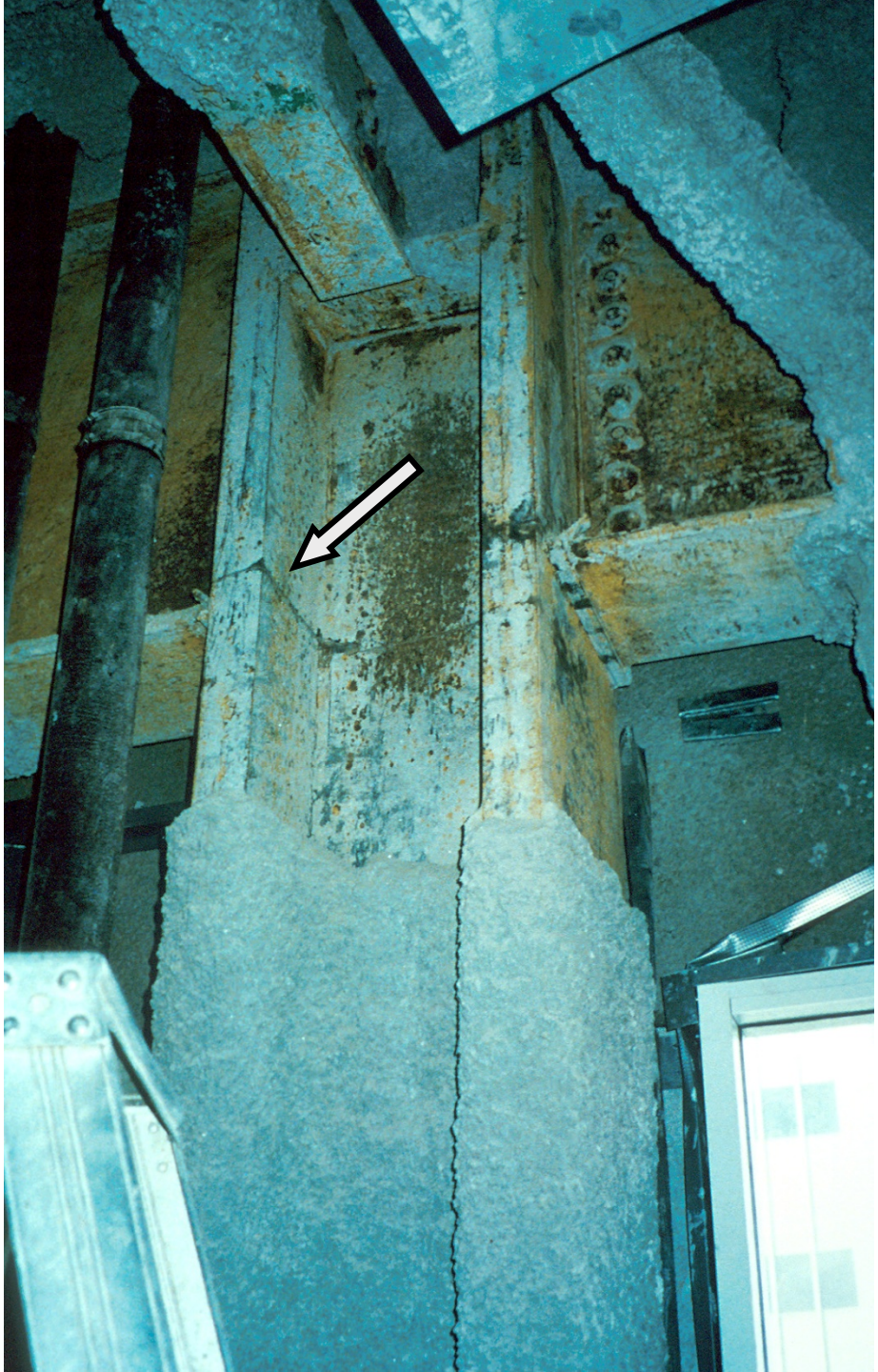
# Damage to Steel Moment Connections in the 1994 Northridge Earthquake


1M3 E BF




1 INCH 2 3
2F10 S
BF


PL-6L-N-BF



# Factors Contributing to Moment Connection Damage in Northridge

- Welding
- Design
- Materials

# Observations

- No steel moment frame buildings collapsed – no loss of life.

- Response to damage - SAC and other research efforts:
  highly effective collaboration between profession, industry, academia, and government.

# Observations

- Northridge moment connection damage ultimately led to a much better understanding of seismic response of steel structures.