


American Concrete Institute®  
Advancing concrete knowledge

**The Art of Designing Ductile Concrete in the Past 50 Years: The Impact of the PCA Book and Mete A. Sozen, Part 1**

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October 21 – 24, Toronto, ON

ACI WEB SESSIONS



**Dr. James O. Jirsa** is chairman of the Department of Civil Engineering at The University of Texas at Austin and holder of the Janet S. Cockrell Centennial Chair in Engineering. He is one of the foremost researchers in the United States in the behavior and design of reinforced concrete structures, including the anchorage and development of reinforcement, detailing, durability, and rehabilitation of structures in seismic zones. He is also one of the leading educators in earthquake engineering. Jim served on the EERI Board of Directors and is an Honorary Member and past President of the American Concrete Institute. He has given outstanding service to the earthquake engineering community as a member and chair of numerous ACI committees, including ACI 318, Structural Concrete Building Code, and ACI 369, Seismic Repair and Rehabilitation. He has engineering degrees from the Universities of Nebraska and Illinois and was on the faculty at Nebraska and Rice University before joining UT Austin in 1972.

ACI WEB SESSIONS

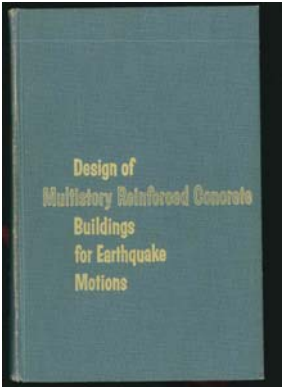
The Art of Designing Ductile Concrete in Past 50 Years:  
The Impact of the PCA Book and Mete Sozen

**Reflecting on Ductile Concrete  
A perspective from Zone 0**

James O. Jirsa  
The University of Texas at Austin

A tale of the blue books !

(1)1962



**Preface**

*“Above all it is necessary to have an understanding of the manner in which a structure absorbs the energy transmitted to it by an earthquake and the maximum amount of motion and energy the structure can sustain.”*

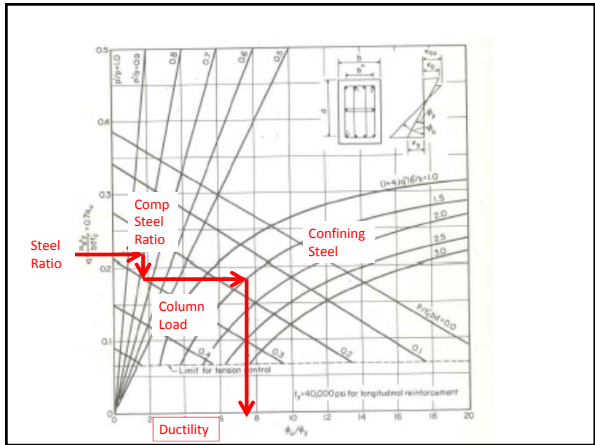
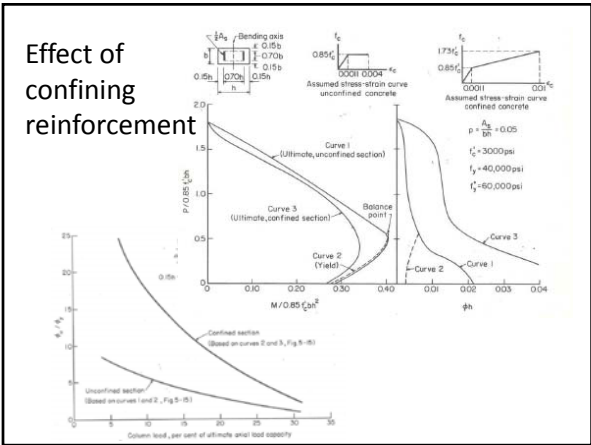
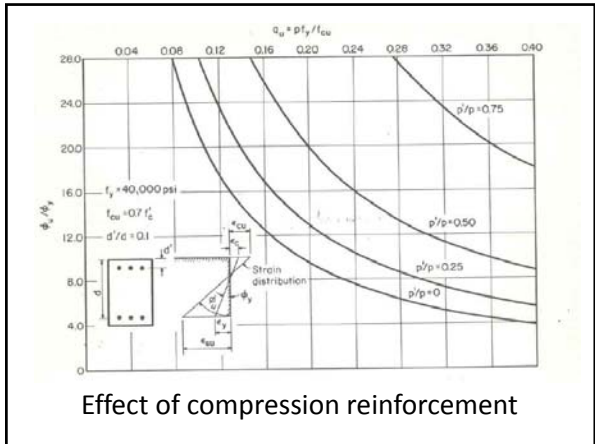
The PCA book was intended to help engineers understand and implement these concepts.

It provided a background so that engineers knew what “questions” to ask

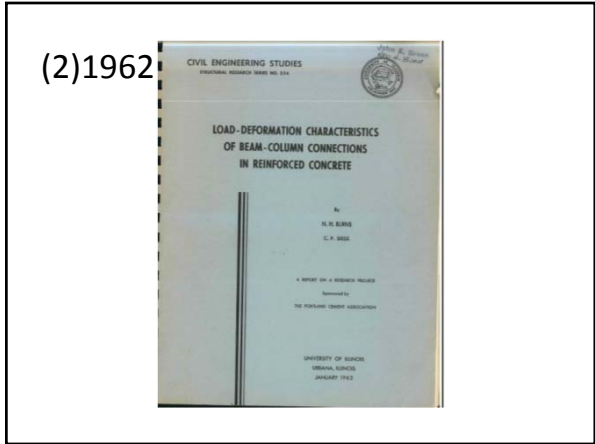
**CHAPTER 5**  
**Strength, Ductility, and Energy Absorption of Reinforced Concrete Members**

“.....to define the strength and deformation characteristics of reinforced concrete members which are important in the design of buildings to resist lateral forces.”

Computations for response were confirmed by test data.

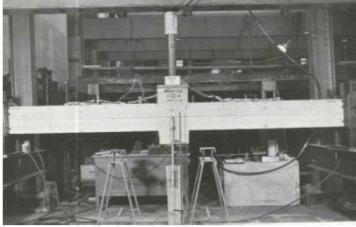


- The experimental results included in Chapter 5 of the PCA Book were from a test program conducted by Burns and Siess on--
- Bending deformation of reinforced concrete members
  - Distribution of Curvature at Ultimate
  - Measured Moment-Curvature Relationships
  - Measured Load-Deflection Relationships
  - Behavior under reversals of loading

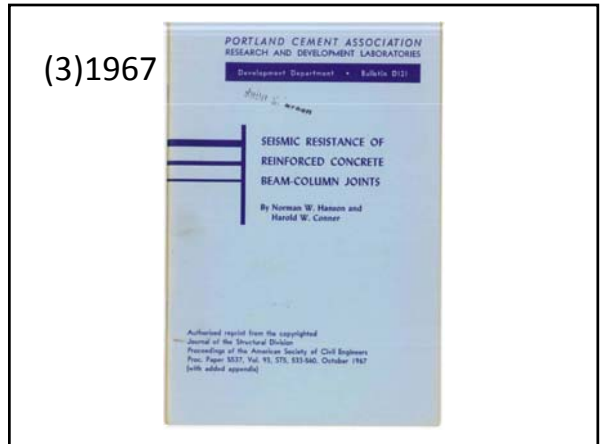
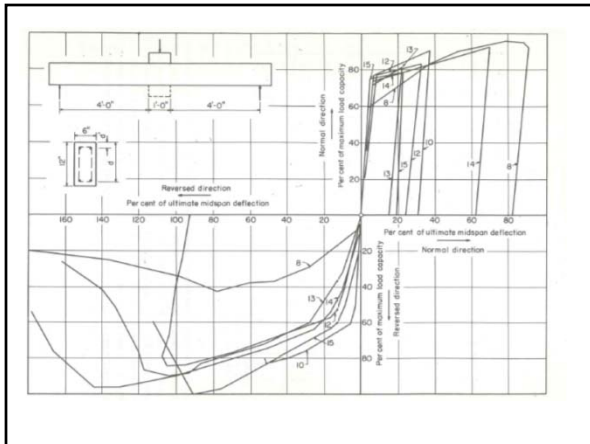
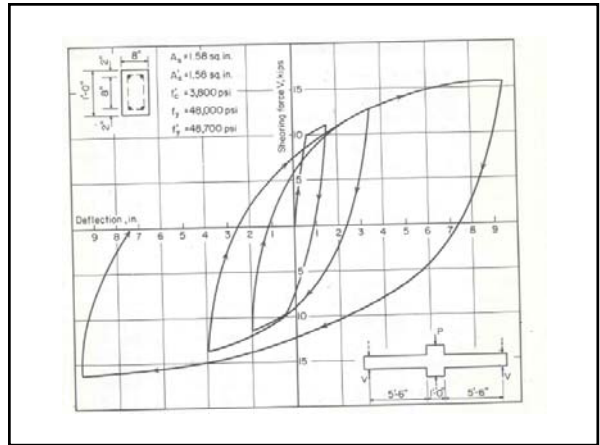
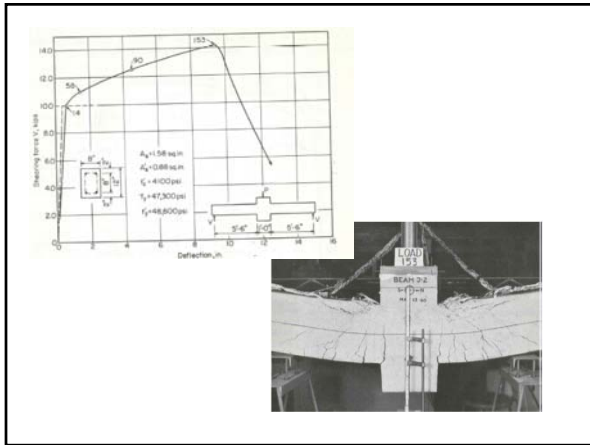
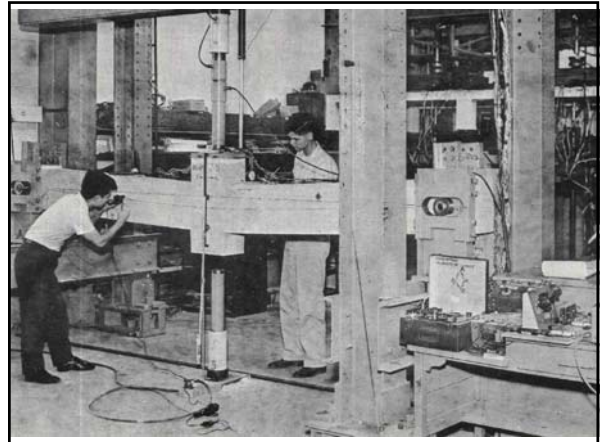


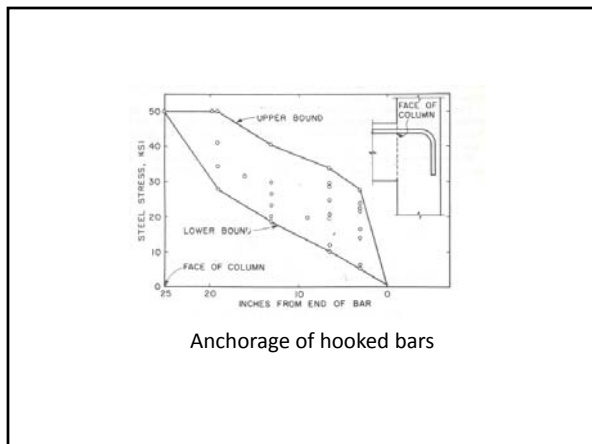
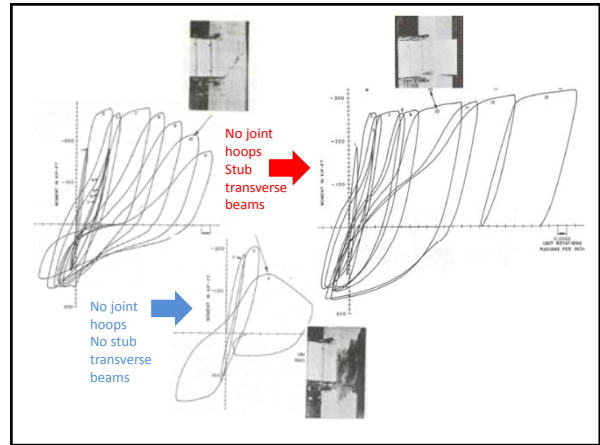
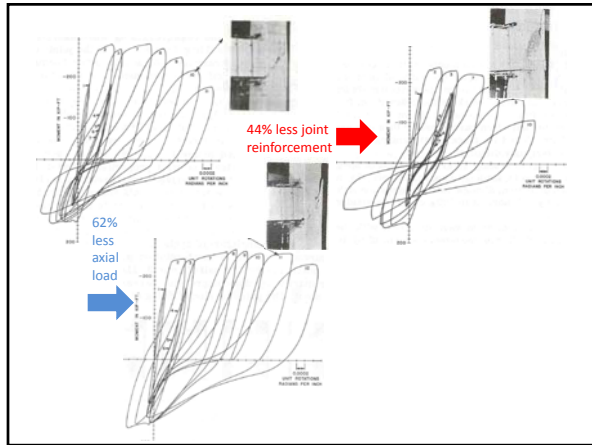
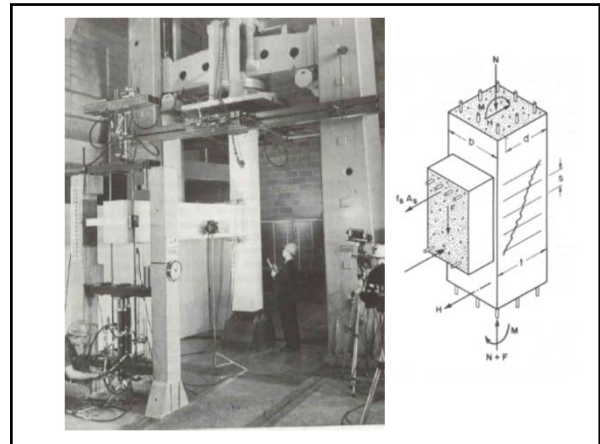
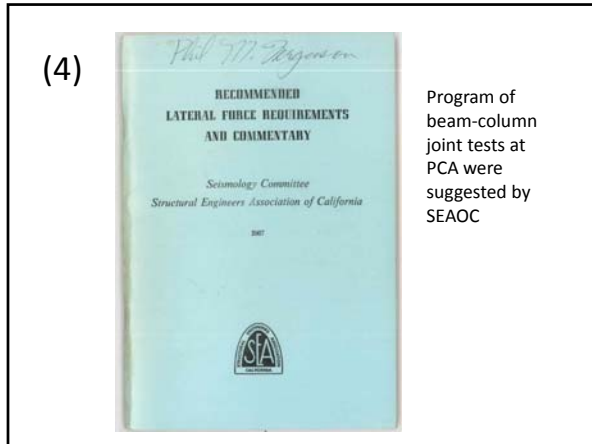
### Objective

"...to establish load-deformation relationships for the beam-to-column connections of reinforced concrete frames."



The test program was the first step in extending what was known about section strength to frame strength and deformation characteristics.





July 1976

**Recommendations for Design of Beam-Column Joints in Monolithic Reinforced Concrete Structures**

Reported by ACI-ASCE Committee 352

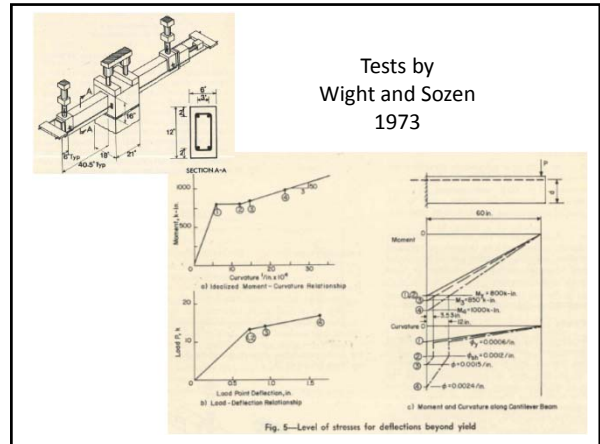
JAMES C. JIRSA, Chairman      NORMAN W. HANSON, Secretary

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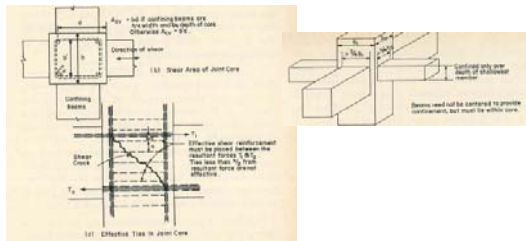
Mete Sozen chaired ACI/ASCE 352 when it was organized in 1966

### ACI 352 Recommendations in 1976

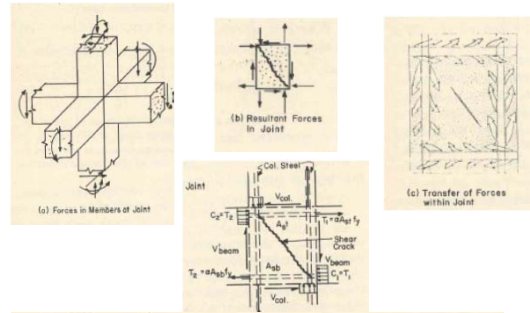
- Classified joints
- Design considerations
  - Forces
  - Critical Sections
- Joint requirements
  - Shear strength
  - Flexure of beams and columns
  - Anchorage
- Areas of needed research
- Design Examples



4.2.3.5 The value of  $v_u - v_c$  shall not exceed  $15\sqrt{f'_c}$  and in no case shall  $v_u$  be greater than  $20\sqrt{f'_c}$ .

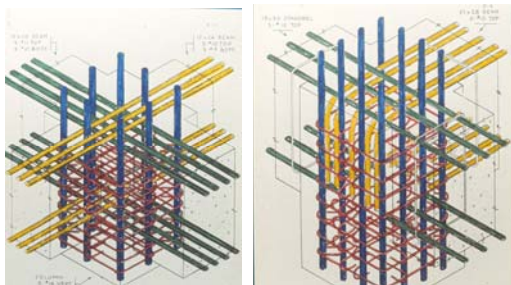


### Shear in Joints



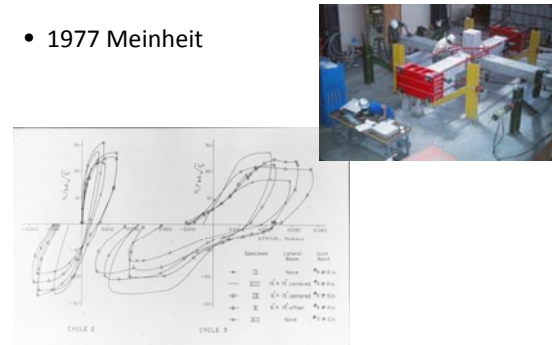
$$M_{col}^i + M_{col}^b \geq \alpha f_y (A_{st} d_R + A_{sb} d_L) - V_{col} h_j$$

### Design Examples



### Beam Column Joint Test Program at Texas

- 1977 Meinheit



- 1983 Leon (Interior and exterior Joints, some with slabs, bidirectional loading)
- 1984 Joglekar (US/Japan Large Scale Test Program)
- 1988 Guimaraes (Biaxial loading and high-strength materials)



### US/Japan Program 1980's

- 7-story RC structure with shear wall tests in Japan
- Component tests and small-scale tests in Japan and US



### Beam-Column Joint Design Requirements

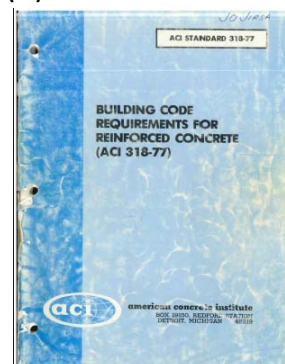
- US—ACI 352
- Japan—Architectural Institute of Japan
- New Zealand—NZ Standards

Considerable disagreement on—

- role of transverse steel
- shear capacity of concrete in joint
- minimum detailing requirements.

Many workshops and conferences were held that included researchers and designers from US, Japan, New Zealand, China, and Canada but differences were never completely resolved.

(5)1977



First version of ACI 318 that included provisions design of reinforced concrete in seismic zones.

Mete Sozen chaired the group that developed the provisions.

### Mete Sozen

- Influenced virtually all aspects of design of concrete structures in seismic zones
- Influenced a large number of researchers all over the world
- Taught us to ask the right questions
- But a sentence in the Preface to the Blume, Newmark, Corning book is still true

*"It is an art as well as a science, and requires experience and judgment on the part of the engineer, as well as a sensitivity to the true nature of the problem...."*

From the Preface to

