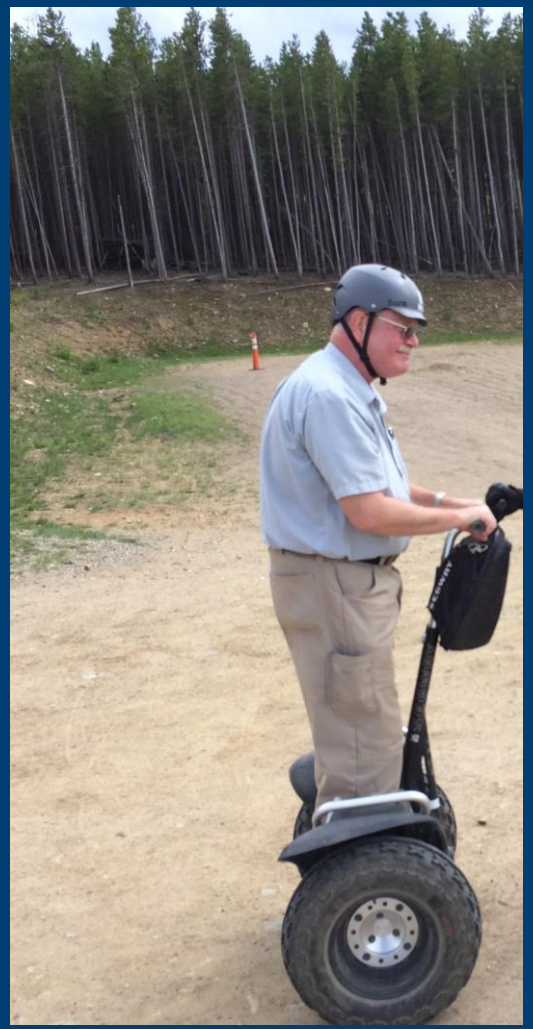
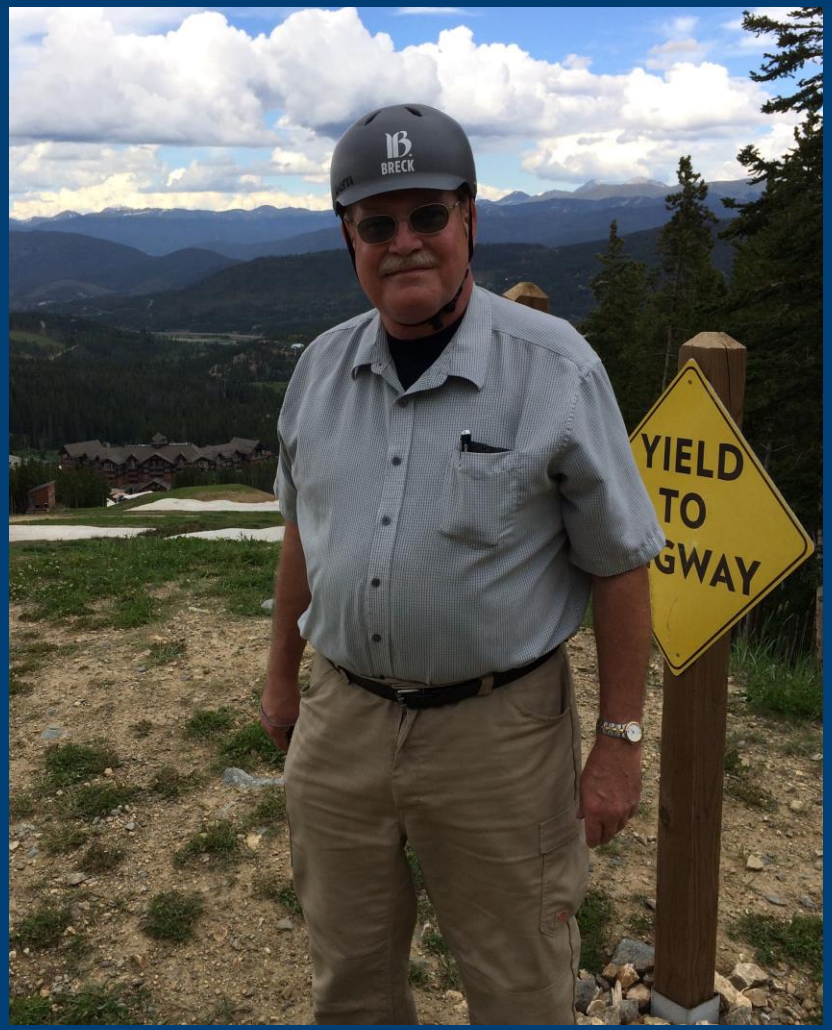
American Concrete Institute

Determining the Load Capacity of a Structure When As-built Drawings are Unavailable (364.4T)

Lawrence F. Kahn

Fred Goodwin, a Friend and Outstanding ACI Colleague





- Hard at work as TAC member
- TAC sub-Chair Repair-Rehab
- 364 Rehabilitation, Chair
- 562 Repair Code, sub-Chair
- 546 Repair, member
- 563 Repair Specs, member
- Fellow
- Delmar Bloem Distinguished Service
- Jean-Claude Roumain Innovation in Concrete
- ICRI Leader + great Segway driver

Determining Load Capacity when As-built Drawings are Unavailable

Develop and implement an investigation/assessment program:

- History
- Visual inspection & physical measurements
- Material testing
- Nondestructive testing (NDT)
- Analysis & calculations
- Load tests

Rely on knowledge, experience & judgement to develop cost-effective approach to assessment and rehabilitation.

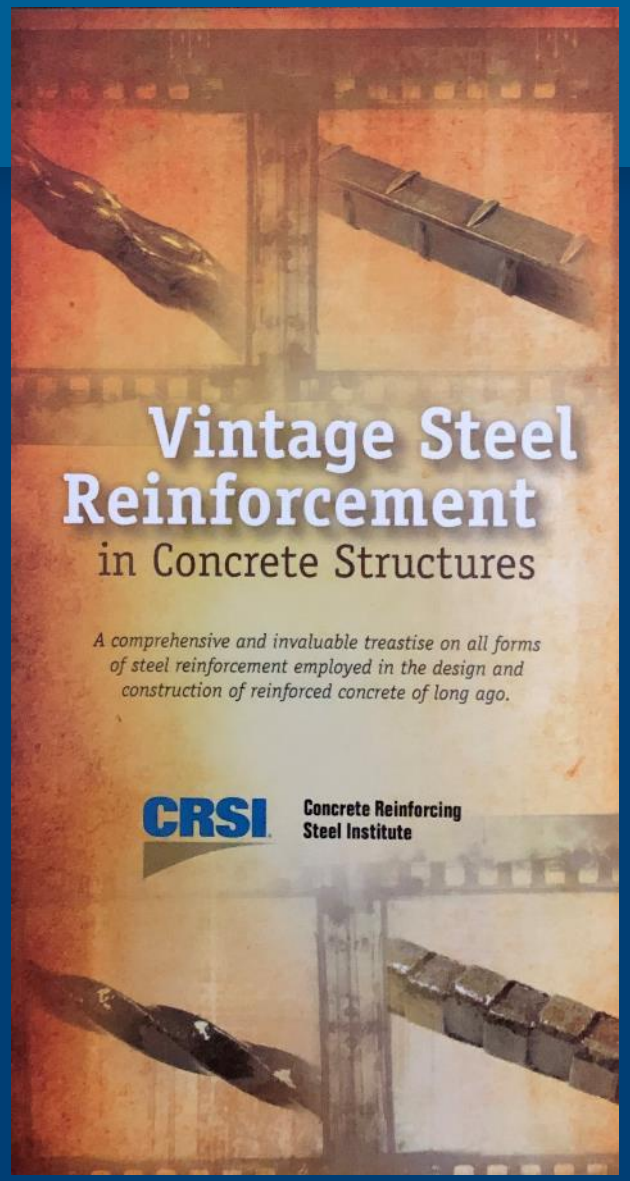
History

- Age
  - Prospective reinforcement materials
  - Construction techniques
  - Concrete quality
  - Probable foundation type
  - Deterioration mechanism e.g. carbonation
- How
  - Ask
  - Building officials, including retired ones

History

Table 6.3.2a—Default compressive strength of structural concrete (psi) [ACI 562-19]

Time frame	Footings	Beams	Slabs	Columns	Walls
1900-1919	1000	2000	1500	1500	1000
1920-1949	1500	2000	2000	2000	2000
1950-1969	2500	3000	3000	3000	2500
1970 -	3000	3000	3000	3000	3000



D.F. Meinheit & A.L. Felder, *Vintage Steel Reinforcement in Concrete Structures*, CRSI 2014

Visual Inspection & Physical Measurements (ACI 364.1R)

- Define overall structural system – vertical and lateral load resisting systems
- Slabs, beams, columns, walls, and foundations – dimensions
- Deterioration:
  - Deflections
  - Cracking
  - Spalling
  - Rust staining
  - “Soft” concrete
  - and more…..

Construction – Reinforcement Layout

Reinforcement size, position (cover, “d”…), layout required for calcs.

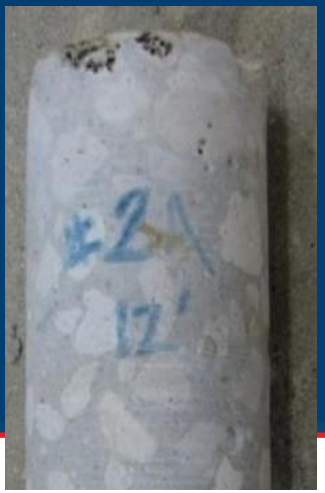
- Nondestructive testing (NDT) requires validation (ACI 228.2R)
- Pachometers: ≤ 2 in.; 2 in. to 4 in.; > 4 in. Congested reinforcement
- Ground-penetrating radar (GPR)
- Remove cover to validate measurements

Sometimes, bar placement is obvious

Material Testing

- Concrete Strength
  - Cores (ACI 214R, 214.4R, and ASTM C42)
  - Rebound hammer and probe penetration tests
- Reinforcement Strength
  - Sampling (ASTM 370, ASTM E122)
  - In-place hardness and metallurgical filing analysis
- Concrete Quality
  - Petrographic analysis

Reliability – Confidence Level – Statistics (ACI 214, ACI 562 ASTM)



Default Steel Material Properties (ACI 562-19 Sec 6.2.3)

Table 6.3.2c—Default tensile and yield strength properties for various ASTM specifications and periods

			Structural†	Intermediate†	Hard †			
		Grade	33	40	50	60	65	70
		Minimum yield, psi	33,000	40,000	50,000	60,000	65,000	70,000
ASTM Designation	Steel type	Year range	55,000	70,000	80,000	90,000	75,000	80,000
A15	Billet	1911-1966	X	X	X	—	—	
A16	Rail§	1913-1966	—	—	X	—	—	
A61	Rail	1963-1966	—	—	—	X	—	
A160	Axle	1936-1964	X	X	X	—	—	
A160	Axle	1965-1966	X	X	X	X	—	
A185	WWF	1936-present	—	—	—	—	X	
A408	Billet	1957-1966	X	X	X	—	—	
A431	Billet	1959-1966	—	—	—	—	—	

			Structural†	Intermediate†	Hard †				
		Grade	33	40	50	60	65	70	75
		Minimum yield, psi	33,000	40,000	50,000	60,000	65,000	70,000	75,000
ASTM Designation	Steel type	Year range	55,000	70,000	80,000	90,000	75,000	80,000	100,000
A432	Billet	1959-1966	—	—	—	X	—		—
A497	WWF	1964-present	—	—	—	—	—	X	—
A615	Billet	1968-1972	—	X	—		—	—	X
A615	Billet	1974-1986	—	X	—	X	—		—
A615	Billet	1987-present	—	X	—	X	—		X
A616-96‖	Rail	1968-present	—	—	—	X	—		—
A617	Axle	1968-present	—	X	—	—	—		—
A706#	Low-alloy	1974-present	—	—	—	X	—	X	—
A955	Stainless	1996-present	—	X	—	X	—		X

Foundation

- Increased vertical loads; new seismic or wind requirements
- May need a geotechnical consultant to determine foundation system
- History - Adjacent structures - Ask
- Expose foundation to determine deterioration and probable type, shallow or deep
- Coring, cone penetrometer, NDT, dynamic probes, and other techniques
- Original soil tests and those for adjacent structures

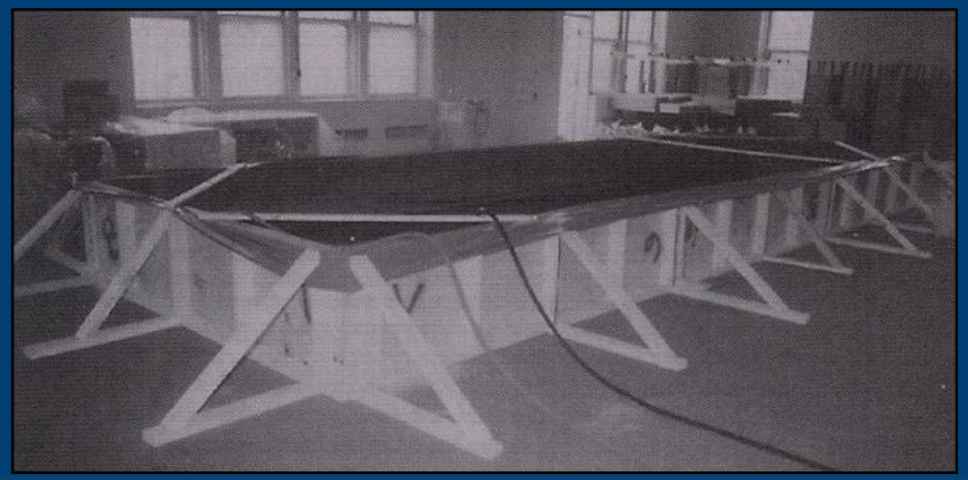
Analysis & Calculations

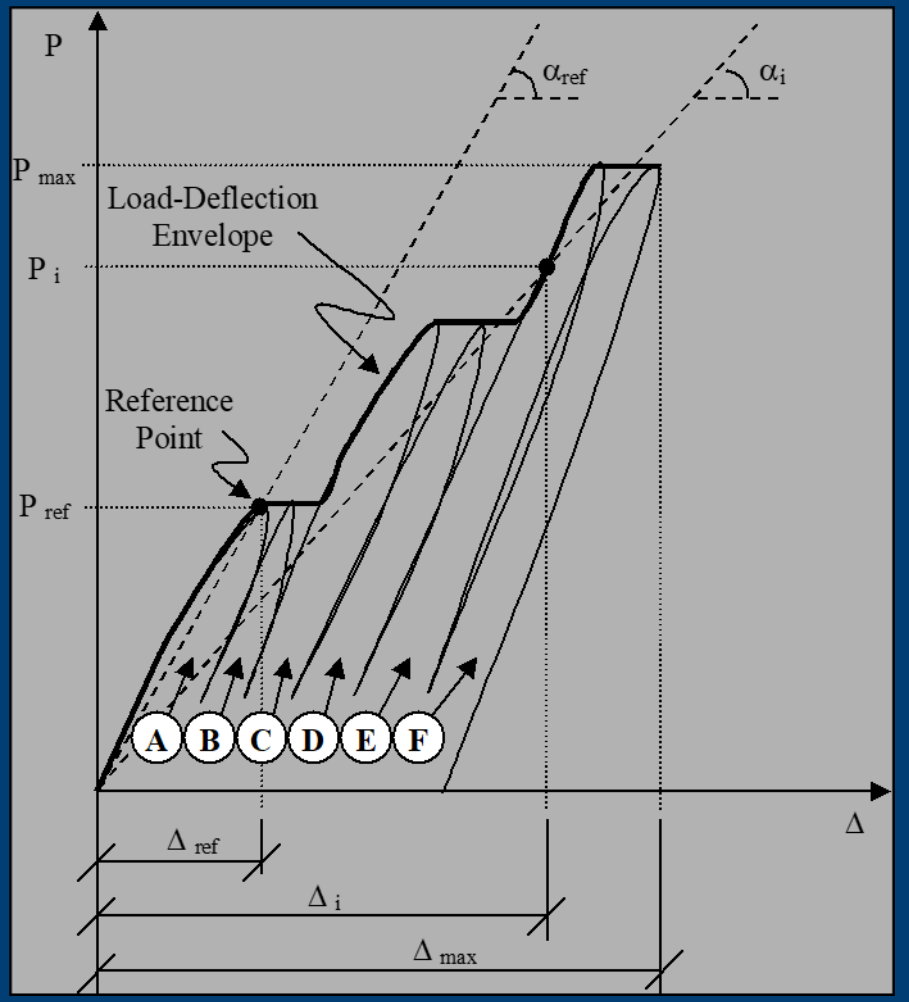
- Know span length L plus b, h, d, f_{yeq}, f_{ceq}, & connectivity
- Loads from original building code, or current, & ASCE 41
- Analyze: simplified, 2D frame, 3D, Non-linear, FEA
- Conclusion? Load Capacity

    Does it work? Do you need more data, higher strengths?

Load Testing

- Often more cost effective
- Best for gravity loads and evaluation of flexural elements
- ACI 562-19 Sec. 6.8
- ACI 437.2-13 *Code Requirements for Load Testing of Existing Concrete Structures and Commentary*
- ACI PRC 437-19: *Strength Evaluation of Existing Concrete Buildings*
- Suggest consulting with engineers who have experience in load testing





Photos by Carl J. “Chuck” Larosche, P.E., Chair ACI 562, Past Chair ACI 437

Conclusion

You now have evaluated the load capacity without original drawings!

Questions & Comments

Thank you

For the most up-to-date information please visit the American Concrete Institute at:
www.concrete.org