It’s all about Academic Instruction

Can Codes and Standards Improve the Performance and Longevity of Existing Concrete Structures?

Lawrence Kahn, PhD, PE

Professor Emeritus, Georgia Institute of Technology

Member ACI 562

Based on my perspective

- As a teacher: developed Assessment-Repair-Rehabilitation sequence along with Drs. Abdul Zureick and David Scott at Georgia Tech
  (beginning late 1980's – continues today)
- As a researcher: against industry and ACI obstacles
- As a past chair of ACI 562 & current TAC Chair + ACI and IRCI committees

Education is needed

- Large segment of construction industry: > $20 billion annually
- Poor repair performance: After 10 years only 30% of repairs are OK
- Exciting area requiring maximum creativity – both office & field
- Great opportunities for your graduates
- More consulting firms require engineers to do assessment and repair activities

Where do students learn about rehabilitation?
University undergraduate and graduate programs.

- Queried ACI Faculty Network
  - 29 faculty responses from 26 universities:
    - 21 US universities including Puerto Rico,
    - 3 from Canada,
    - 1 Australia
    - 1 Italy
    - 1 Sweden

- ACI University, ICRI continuing education

Schools & Courses

Materials, Rehabilitation, Repair

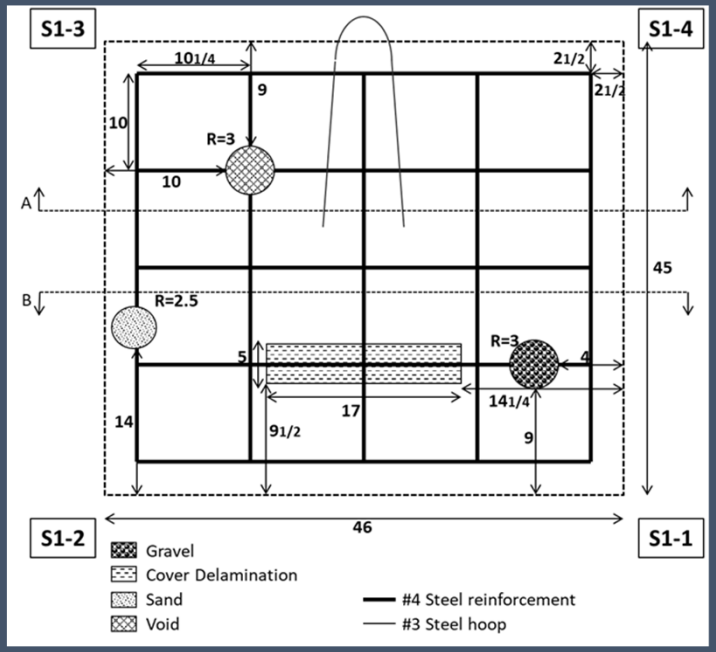
# of Courses	# of Schools	Universities
4	1	Politecnico di Milano (Italy)
3	2	Georgia Tech & U. Illinois
2	3	Pitt, Purdue NW, U. Toronto
1	15	Arkansas, Auburn, Clemson, Concordia, Florida, Kentucky, Minnesota, Nebraska, New Mexico, Ottawa, Puerto Rico, South Florida, Swinburne Tech (Australia), Texas, Victoria (Canada)
1 or 2 partial	3	U. Toronto, Virginia Tech, Louisiana at Lafayette, Lulea (Sweden)

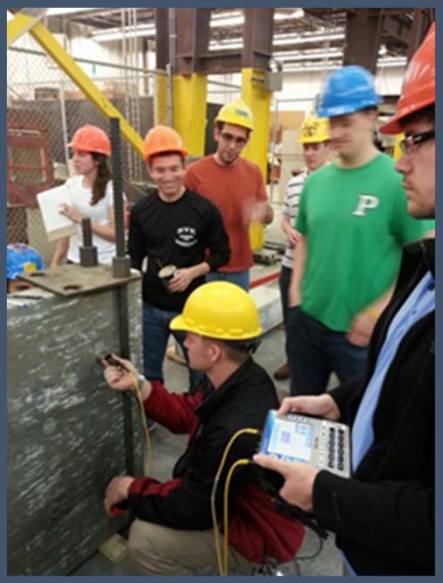
Topics

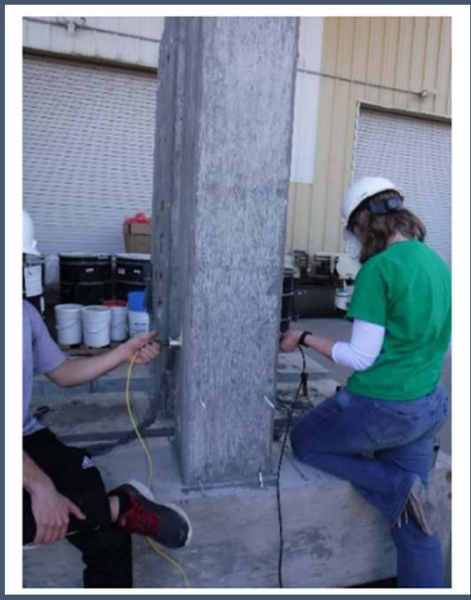
Assessment	Rehabilitation	Repair Design and Construction
Condition Assessment: Documentation, Field Investigation, Reports	Decision Criteria for Evaluation/Repair/Rehabilitation	Summary of repair construction
Deterioration Mechanisms in Concrete	Forensic Engineering - Failures	Composite behavior of existing and repair materials
Corrosion of Reinforcing Steel	Structural Strengthening Systems	FRP Design & Construction: external and internal
Destructive Methods & Petrography	Codes for Existing Structures	Prestressing: External and internal
Nondestructive Evaluation Techniques		Surface Preparation Prior to Repair
Infrared Thermography		Selection of Repair Materials
Stress Waves: Sounding, resonant frequency, ultrsonic pulse		Epoxy Injection
Magnetic/electrical methods: Half-cell, Polarization, Radar		Concrete overlays
Sensors for Structures		Shotcrete Repair
		Shoring & Inspection
		Maintenance

Lab Experiences

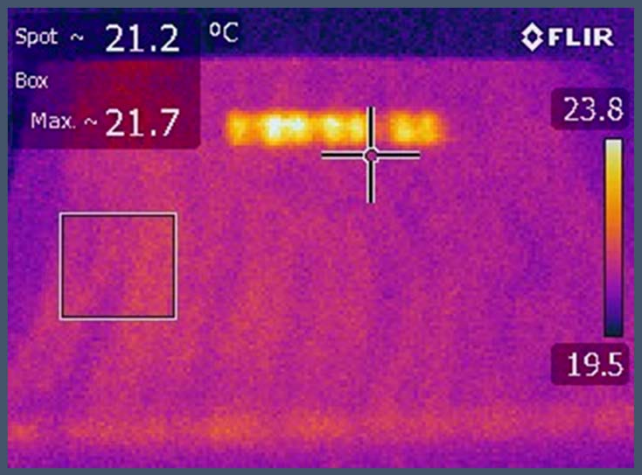
Slabs With Defects/Voids







Ultrasonic Pulse Velocity (UPV)



Infrared Thermography

From Prof. David Scott
Georgia Tech CEE 6538

References for classes – most used by 26 schools

Concrete Repair Manual, 4th Edition, ACI, 2013 (also 3rd edition)

Emmons, Peter H., *Handbook Concrete Repair and Maintenance Illustrated*. R.S. Means Company, Inc., Kingston, MA., 1993.

ACI 562-16 *Code Requirements for Assessment, Repair, and Rehabilitation of Existing Concrete Structures and Commentary*

ACI/ICRI *Guide to the Code for Assessment, Repair, and Rehabilitation of Existing Concrete Structures (562MAN-16)*

ACI 440.2R-17: *Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures*

ACI 546R-14 *Guide to Concrete Repair*

Questions & Discussion

Further References

Condition Assessment:
ACI 364.1R-07: Guide for Evaluation of Concrete Structures before Rehabilitation
ACI 437.2-13: Code Requirements for Load Testing of Existing Concrete Structures and Commentary

ACI 437.1R-07: Load Tests of Concrete Structures: Methods, Magnitude, Protocols, and Acceptance Criteria

Nondestructive Evaluation Techniques: ACI 228.2R-04, ICRI 210.4

core sampling and evaluation ACI 214.4, ASTM C823, ASTM C42

Materials: ACI 201.1-08, ACI 224.1-07, Ch 1-2, CSTR 54, Ch 3, CSTR 22
Corrosion: ACI 222-01, BRE Digest 434
Surface Preparation: ACI 546-04, Ch 2, ICRI 310.1-08, ICRI 310.3-04, ACI 364.6 T-02, ACI 364.7 T-02, ACI 364.8 T-02

Material Selection: ACI 546-04, Ch 3, ACI 546.3-06, ICRI 320.2-09

Repair Installation Techniques: ICRI 320.1-96, ACI E706, ACI 503.7-07, ACI 325.13-06

Shotcrete: ACI 506-2-95
Structural Strengthening: ACI 546-04, Ch 5, ICRI 330.1-06
Prestressing: ACI 423.4R-14 Report on Corrosion and Repair of Unbonded Single-Strand Tendons,
FRP Design:
440.2R-17: Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures
440.3R-12: Guide Test Methods for Fiber-Reinforced Polymer Composites for Reinforcing or Strengthening Concrete and Masonry Structures
Zureick, Abdul-Hamid; Ellingwood, B. R.; Nowak, Andrzej,; Mertz, Dennis, R.; Triantafillou, Thanasis C.(2010) Guide Specifications for the Design of Bonded FRP Systems for Repair and Strengthening of Concrete Bridge Elements, NCHRP Report 655,
ICRI 330.2–16 Guide Specifications for Externally Bonded FRP Fabric Systems for Strengthening Concrete Structure