Principles of Forensic Structural Engineering

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Overview

- Definition of Forensic Engineering
- Methodology for Forensic Investigations
- Case Studies of Structural Failures
- How Forensic Engineering Information Is Used In Litigation
- Questions / Discussion
Definition

forensic

adjective | fo-ren-sic | \ˈfə-ˈren(t)-sik, -ˈren-zık\

Popularity: Top 20% of words

Definition of FORENSIC

1 : belonging to, used in, or suitable to courts of judicature or to public discussion and debate <a lawyer’s forensic skills>

2 : argumentative, rhetorical <forensic eloquence>

3 : relating to or dealing with the application of scientific knowledge to legal problems <forensic medicine> <forensic science> <forensic pathologist> <forensic experts>

(Source: www.merriam-webster.com)
Who Needs This Service

• Attorneys
• Insurance Carriers
  – Property
  – Liability
• Building Owners
Typical Issues

• Collapse/Failure Analysis
• Construction Defects
  – Construction Documents
  – Building Code Requirements
  – Industry Standards
• Design Errors
  – Standard of Care
• Storm/Fire Damage Assessment
Historic Failures

• Hyatt Regency Walkway Collapse

(Source: Pfrang and Marshall, 1982)
Historic Failures

• Ronan Point Apartments

(Source: The Daily Telegraph, 1968)
Historic Failures

• Hartford Civic Center

(Source: Connecticut Historical Society)
Methodology for Investigation

- Visual Inspection
- Remote Visual Inspection
- Destructive Evaluation
- Load Testing and Instrumentation
- Non-Destructive Testing
- Material Testing
- Document Review
- Structural Analysis
- Report Preparation
Visual Inspection

- Always the first step of an investigation
- Take all steps necessary to prevent spoliation of evidence
- For collapse investigations, use the final location of failed members to provide evidence of the sequence of events
- You can’t take too many photos
Visual Inspection
Remote Visual Inspection

- **Borescope**
  - Rigid or flexible
  - Good of looking inside walls
- **Sewer cameras**
  - Readily available
- **Unmanned flying vehicle**
  - Drones can be useful, but legal issues currently make it very difficult
Remote Visual Inspection
Remote Visual Inspection
Destructive Evaluation

• Attempt to determine how components of the building were constructed
• All interested parties need to be present during destructive evaluation
• Beneficial to develop a protocol to establish how the destructive evaluation will be performed
• Document any evidence retained and maintain a “Chain of Custody” log
Destructive Evaluation
Destructive Evaluation
Destructive Evaluation
Destructive Evaluation
Load Testing and Instrumentation

- ASTM E196 – Standard Practice for Gravity Load Testing of Floors and Low Slope Roofs
- ACI 318 Chapter 20 – Strength Evaluation of Existing Structures
- ACI 437.2 – Code Requirements for Load Testing of Existing Concrete Structures
Load Testing and Instrumentation

• Due to high cost, usually a “last resort” to evaluate structure
• Must determine how to safely apply load
  – Hydraulic jacks, water, air bags, etc.
• Must consider how to maintain stability of structure if failure occurs
• Strain gages, extensometers, LVDT’s, accelerometers, pressure gages, load cells, etc.
Non-Destructive Testing

- Pachometers
Non-Destructive Testing

• Ground Penetrating Radar
Non-Destructive Testing

• Schmidt Hammer

(Photo courtesy of Proceq)
Non-Destructive Testing

• Ultrasonic Pulse Velocity

(Photo courtesy of Proceq)
Non-Destructive Testing

- Thermal Imaging
Non-Destructive Testing

- Thermal Imaging
Non-Destructive Testing

- Thermal Imaging
Non-Destructive Testing

- Thermal Imaging
Non-Destructive Testing

• 3D High-Density Scanning
  – Method to accurately document the configuration of an accident scene
  – Point cloud create using laser scanner
  – Allows for the development of computer model of the scene
Non-Destructive Testing

- 3D High-Density Laser Scanning
Material Testing

• Determine actual material properties as opposed to design properties
• More realistic results if actual material properties are known
  – Compressive strength
  – Tensile Strength
• Petrographic Analysis
• Metallurgical Analysis
Material Testing
Material Testing

• Petrographic Analysis
  – Microscopic Analysis of Concrete
Material Testing

• Metallurgical Analysis
Document Review

- Construction Documents
- Maintenance Records
- Reports By Other Experts
- Complaint Filed with a Court
- Includes Interviewing People Involved
Structural Analysis

- 3D Computer Modelling
  - Finite Element Analysis
- More realistic results if actual material properties are known
- Different approach if trying to provide analysis for failure rather than investigating a code compliance issue
Report Preparation

• Know your audience
• Use photographs or sketches effectively
• Be concise
• Present opinions in an organized fashion
• Can be written in first person
• List references or information used to develop opinions
Report Preparation

• Typical Report Sections
  – Background Information
    • Include the applicable Building Code
  – Documents Reviewed
  – Observations
  – Discussion
  – Conclusions
  – Recommendations
How Forensic Information Is Used In Litigation

• Examining the Nature of Post-Failure Disputes
• Presenting Forensic Engineering Information as an Expert Witness
Examining the Nature of Post-Failure Disputes

• Putting Parties on Notice
  – All parties must be given the opportunity to perform their own cause and origin investigation at the same time

• Filing of the Complaint
  – Lawsuit is filed
  – Notifies defendant of action and opportunity to defend
  – Lawyers work with Experts to respond
Examining the Nature of Post-Failure Disputes

• Discovery
  – Cause and origin investigations by all parties at the same time
  – Various technique by attorney to reveal details of the claim
  – Interrogatories
  – Depositions of parties and experts
    • Experts questioned about details in written report
Examining the Nature of Post-Failure Disputes

- Mediation/Arbitration
  - Alternate dispute resolution
- Trial
  - Rules of Evidence dictates evidence that will be admissible at trial
Presenting Forensic Engineering Information as an Expert Witness

• Expert Qualifications
  – Daubert Standard
  – “Junk Science”
  – Established Rule 702
Presenting Forensic Engineering Information as an Expert Witness

• Expert Qualifications
  – Rule 702
    • RULE 702. TESTIMONY BY EXPERT WITNESSES
    • A witness who is qualified as an expert by knowledge, skill, experience, training, or education may testify in the form of an opinion or otherwise if:
      • (a) The expert’s scientific, technical, or other specialized knowledge will help the trier of fact to understand the evidence or to determine a fact in issue;
      • (b) The testimony is based on sufficient facts or data;
      • (c) The testimony is the product of reliable principles and methods; and
      • (d) The expert has reliably applied the principles and methods to the facts of the case.
Presenting Forensic Engineering Information as an Expert Witness

• Deposition Testimony
  – Used to determine the qualifications and opinions of the experts
  – Occurs during the Discovery phase
  – Testimony is given under oath

• Trial Testimony
  – Expert does not have Attorney/Client privilege
Questions/Discussion