Topics

- Design of the D Street portal ceiling
- Tunnel inspections
- National standards for tunnel finish designs
Project Oversight

Federal Highway Administration

MassHighway Mass. Turnpike Authority

Design and Construction

Bechtel/Parsons Brinckerhoff (B/PB)

Gannett Fleming, Inc.

Conam Inspection, Inc.

Modern Continental Construction, Inc.

Epoxy

Sika Corporation

Powers Fasteners, Inc.

Newman Renner Colony, Inc.
Design Loads

• Anchor designed for 2,600 pounds
• Finite element analysis
  – Model anchor loads
  – Determine structural redundancy
  – Examine different “hanger-out” scenarios
Design Loads

- Powers Fasteners anchoring system
- Average expected load capacity of 25,400 pounds
- Safety factor of 4
- Allowable load of 6,350 pounds
- Anchor design load of 2,600 pounds
Finite Element Analysis

- One hanger removed, loads remained below 6,350 pounds
- Two or more hangers removed, loads remained below 25,400 pounds
Responsibility of Consultant

- Gannett Fleming
  - Develop detailed design
  - Review submittals and prepare responses
- Affixed engineer’s professional seal
- Evaluation of each component of the ceiling system
Anchor Specification

- Failed to account that adhesives creep
- Adhesive anchors in pure tension was an atypical application
- Adhesives have different properties
Anchor Specification

• No specification regarding long-term properties
• No requirement for testing for long-term performance
• No consideration of service life
• No provision for periodic inspection
Anchor Approval

- Opportunity to address creep in the approval process
- Contractor’s proposed anchoring system
  - Draft version of ICBO Report ER-4514
  - Fast Set epoxy approved for short-term loads only
- Gannett Fleming authorized work to proceed
Preaccident Anchor Failures

• Opportunities to determine poor long-term characteristics of the adhesive
• First opportunity in HOV tunnel (September 1999)
• Suspected improper anchor installation
• Powers evaluated the anchor installation (October 1999)
Preaccident Anchor Failures

- Remove and replace all failed anchors
- Proof test to higher load of 6,350 pounds
- Higher load would not identify poor long-term load characteristics
- Anchor performance should have been monitored
Preaccident Anchor Failures

• Additional opportunity in eastbound I-90 connector tunnel (late 2001)
• Remedy developed was ineffective
• Considered the continuing failures as isolated instances
Preaccident Anchor Failures

- Problem attributed to installation, including overtorquing the nuts
- Tests showed overtorquing did not reduce load capacity
- Powers did not recommend to continue to monitor the anchor performance
Summary

- B/PB and Modern Continental should have instituted a program to monitor anchor performance
- Powers response to the anchor displacements was deficient