Andrea Schokker is a Professor and Head of Civil Engineering at the University of Minnesota, Duluth (UMD). She is the author of The Sustainable Concrete Guide—Strategies and Examples and teaches a course in Sustainable Design and Construction. She is a former member of the ACI Board of Direction and Chair of ACI Committee 130, Sustainability of Concrete. She is a member of ACI Committees 222, Corrosion of Metals in Concrete; 224, Cracking; ACI Subcommittee 318-G, Precast and Prestressed Concrete; Joint ACI-ASCE Committee 423, Prestressed Concrete (past Chair); the Educational Activities Committee; the Membership Committee; and former Chair and member of the Student and Young Professional Activities Committee (SYPAC).

ACI
WEB SESSIONS

MORRIS SCHUPACK'S CONTRIBUTIONS TO CORROSION OF METALS IN CONCRETE

Hope and Schupack Corrosion Symposium
March 18, 2012
Dallas, Texas

Presented by Andrea Schokker, PhD, PE, LEED AP

MORRIS SCHUPACK

1990 AACI 222, Corrosion of Metals in Concrete
ACI 372, Tanks Wrapped with Wire or Strand
ACI 373, Tanks with Internal Tendons
ACI 408, Development and Splicing of Deformed Bars
ACI 423, Prestressed Concrete
ACI 440, Fiber-Reinforced Polymer Reinforcement

1990 ACI ARTHUR J. BOASE AWARD

"for pioneering work on the development of prestressed concrete and for his tireless efforts to improve the durability of structural concrete through innovative development in material technology and unselfish service with technical committees."

BACKGROUND

- Structural engineering course at Brooklyn Polytech at the age of 15
  - Combining mechanics with hands on work in steel fabrication
  - Repaired the cellar doors in the neighborhood
- College in 1939 at Brooklyn Polytech then on to George Washington University in 1940
- Also working as a civilian draftsman for the U.S. Army Corps of Engineers
- As a GI 1941 selected for a year of CE training at Ohio State University

BACKGROUND

- Sent to France as a "construction specialist" with a 50 man detachment
  - Constructing 3000 bed hospital bed laundries
  - Made staff sergeant due to what his superiors called his "superior technical savy"
- Returned to Ohio University under the G.I. bill and received his CE degree in 1947
- Designed steel bridges for D.B. Steinman, Ammann, and Whitney
- In 1951 joined Preload, Co eventually becoming Chief Engineer and VP

CONSULTING

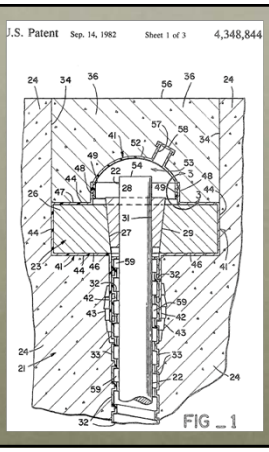
- Started his own consulting practice in 1957 specializing in prestressed concrete structures
- Has investigated over 200 prestressed steel corrosion incidents
  - ~50% ps tanks, ~40% unbonded PT
- Past Board member of ACI, PCI, and PTI
- Over 70 articles and numerous reports

PRESTRESSED TANKS

- Involved from nearly the beginning of the use in the US
- Focused on improving design, particularly on large tanks and corrosion protection
- Has investigated over 100 tanks and has published widely on the subject

ELECTRICALLY ISOLATED TENDONS

- For corrosion monitoring and protection from stray current
- 1982 Patent with art showing many potential configurations

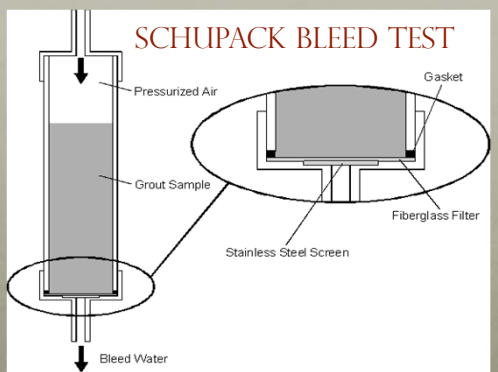


POST-TENSIONING GROUT

- Recognized the bleed problem in tall nuclear structures in the 1960's
- Series of large mockups showing bleed trails and collected water pockets
  - 150' with vertical bar tendons
  - 180' with strand tendons (54K5)

PRESSURE BLEED TEST (SCHUPACK TEST)

- Identified the strand filtering problem in 1971
- Developed bench top test to model this combination of pressure and filtering
- Produced a thixotropic, water retentive grout to combat the bleed tendency in standard grouts



SCHUPACK'S GROUTING MYTHS*

- Pressurize and lock off - with or without grout expansion - as a final grouting step to eliminate voids.
- Grout has to be visibly flowable to fill duct.
- None of the grouts can be pumped if temperature is above 80 degrees F.
- High-energy mixers alone will control bleed.
- Four-inch beaker bleed test is informative.
- Thixotropic water retentive grout needs much higher pressure to pump.
- Expansive grout is beneficial if duct is locked off under pressure.[4]
- "Topping off" vertical tendons after bleed occurs provides adequate corrosion protection.
- The ASTM flow cone test is a meaningful test method for pumpability.
- Grout strength is more important than filling the ducts and spaces between prestressing steel.

*From 2004 paper in Concrete International

SCHUPACK'S SUGGESTED RESEARCH AREAS*

- Are vents necessary for shallow drapes if a properly designed thixotropic grout is used?
- Is a low viscosity water retentive grout flowing downhill on tendon drapes more likely to entrap air than a more viscous water retentive grout?
- Can grouts with expansion overcome loss of grout volume due to air loss and consequent grout flow after grouting is completed?
- Is the requirement to meet the chloride permeability test really applicable to a PT cement grout?
- If a proper thixotropic water retentive grout is used and proper venting of duct is provided, does vacuum grouting minimize voids?
- Are duct vents required if vacuum grouting is used?
- Does locking off the tendon duct and then pressurizing provide any benefits to PT grouting? Can a reproducible test for grout induced corrosion that is representative of practice be developed?

*From 2004 paper in Concrete International

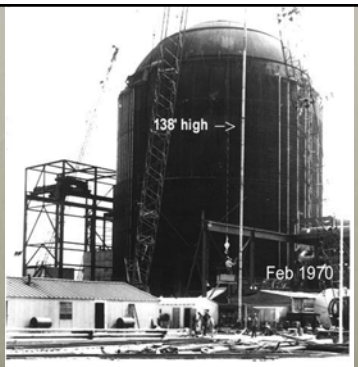


Fig. 5: Vertical grouting test of 6 - 1 3/8" (35 mm) high strength bars in a 138' (42 m) high - 5" (127 mm) I.D. schedule 40 pipe set up against the containment vessel.

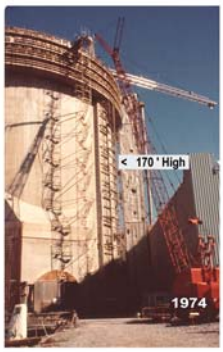


Fig. 6: Vertical grouting test of 54 - 1/2" (12.7 mm) strands in a 170' (52 m) - 5" (127 mm) I.D. schedule 80 pipe, grout water retentive - no bleed water voids.

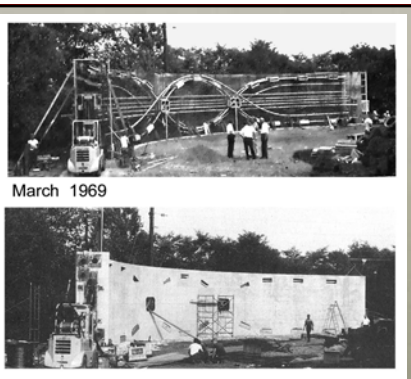


Fig. 4: Groutability and reproductibility of filling ducts in a full-size quarter segment of a nuclear containment vessel at the equipment lock. Top photo shows tendon layout prior to placing concrete.

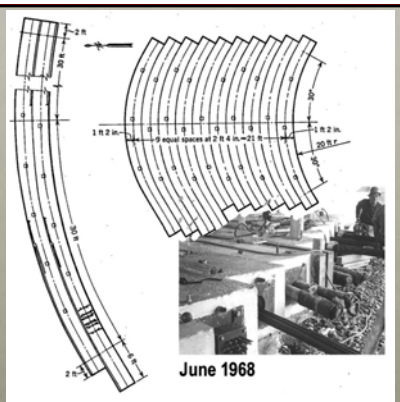


Fig. 3: Full-size tests of groutability of large capacity strand tendons, curved beam tests.

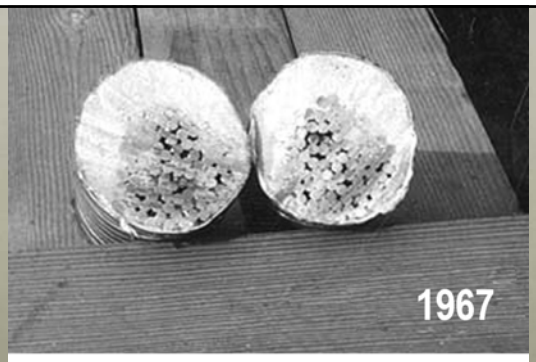


Fig 2: Voids in 90 -1/4" (6.4 mm) wire tensioned tendon on 20' (6.1 m) R

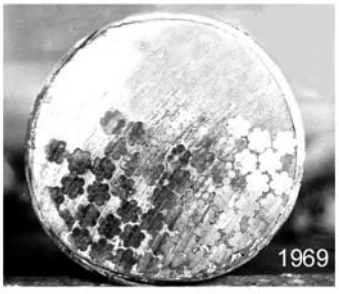


Fig. 7: Tendon slice - 54 - 1/2" (12.7 mm) stressed strands on a 20' (6.1 m) R showing excellent penetration of grout using a thixotropic water retentive grout.

MEETING MORRIS SCHUPACK

- Spring ACI Convention, 1998, Houston, Texas
  - Research in progress session (my first ACI convention)
  - "High Performance Grout Development for Corrosion Protection of Post-Tensioning Tendons"