

**A Brief History of Pullout Testing**  
**With Particular Reference to Canada**

**By**

**Dr. John A. Bickley, P.Eng.**

**A Personal Journey**

# History

- 1930's to 1970's Applied research in Russia, USA and Canada
- Kierkegaard-Hansen establishes a straight line relationship
- Germann-Petersen designs a portable apparatus



# Correlation

- Irrespective of failure theory, pullout strength is affected by a fundamental strength parameter of concrete
- There is good correlation between pullout strength and compressive strength

# Robust Correlation

## Not affected by:

- Cementitious materials
- Water-cement ratio
- Age
- Air entrainment
- Admixtures
- Shape or size of aggregate up to 40 mm
  - Lightweight aggregate, however, produces significantly different correlation

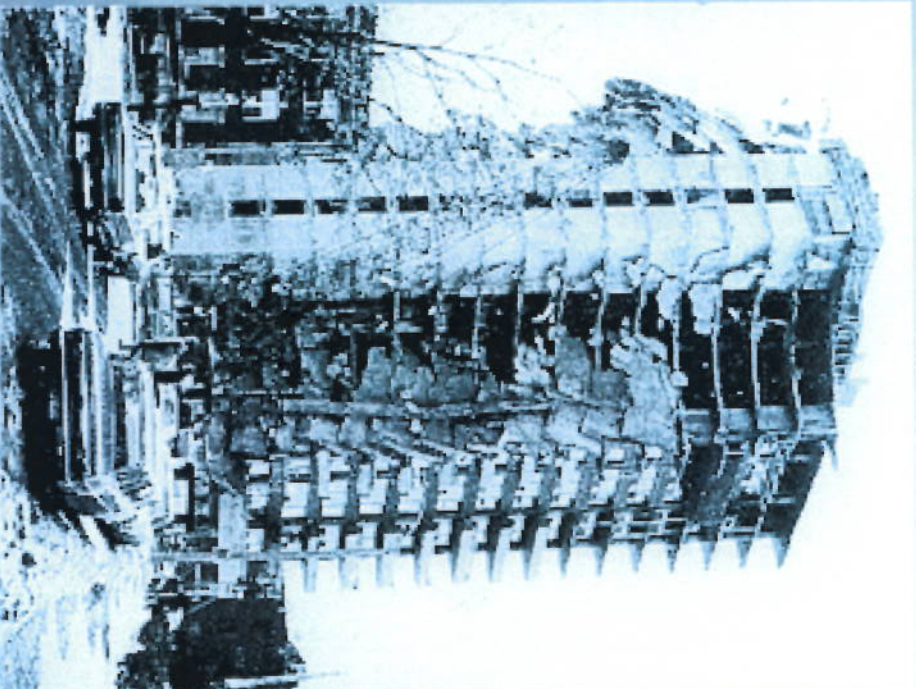


# Safety

- Early form removal generally leads to faster completion and financial savings
- Hard to sell safety
- Lok-test made safety attainable and economic



# Strength for Formwork Removal



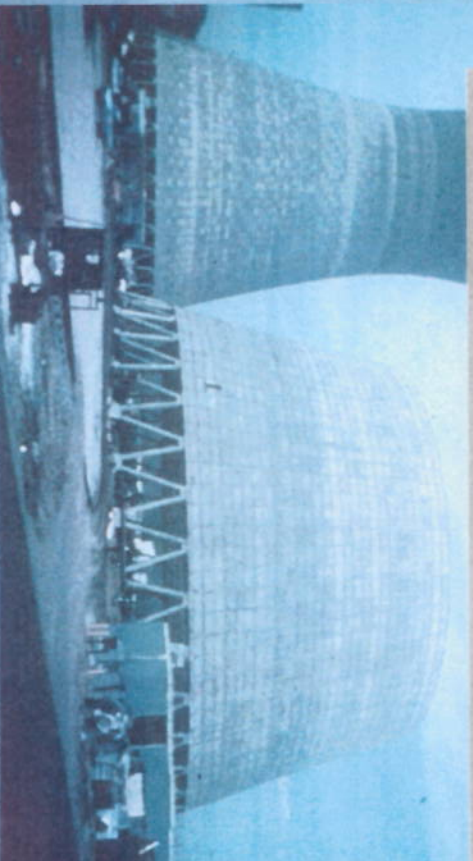
- Multi-story building collapse in Boston, USA.
- Standard cylinders tested had passed the requirement.
- Subsequent investigation showed the in-place strength to be 50% of the cylinder strength at the time of formwork removal.



## Willow Island, W. Va., USA Cooling Tower Collapse, April 1978

- Failure due to insufficient strength to support next “lift”
  - 51 deaths

LOK-TEST is now used to estimate in-place strength before moving to next lift



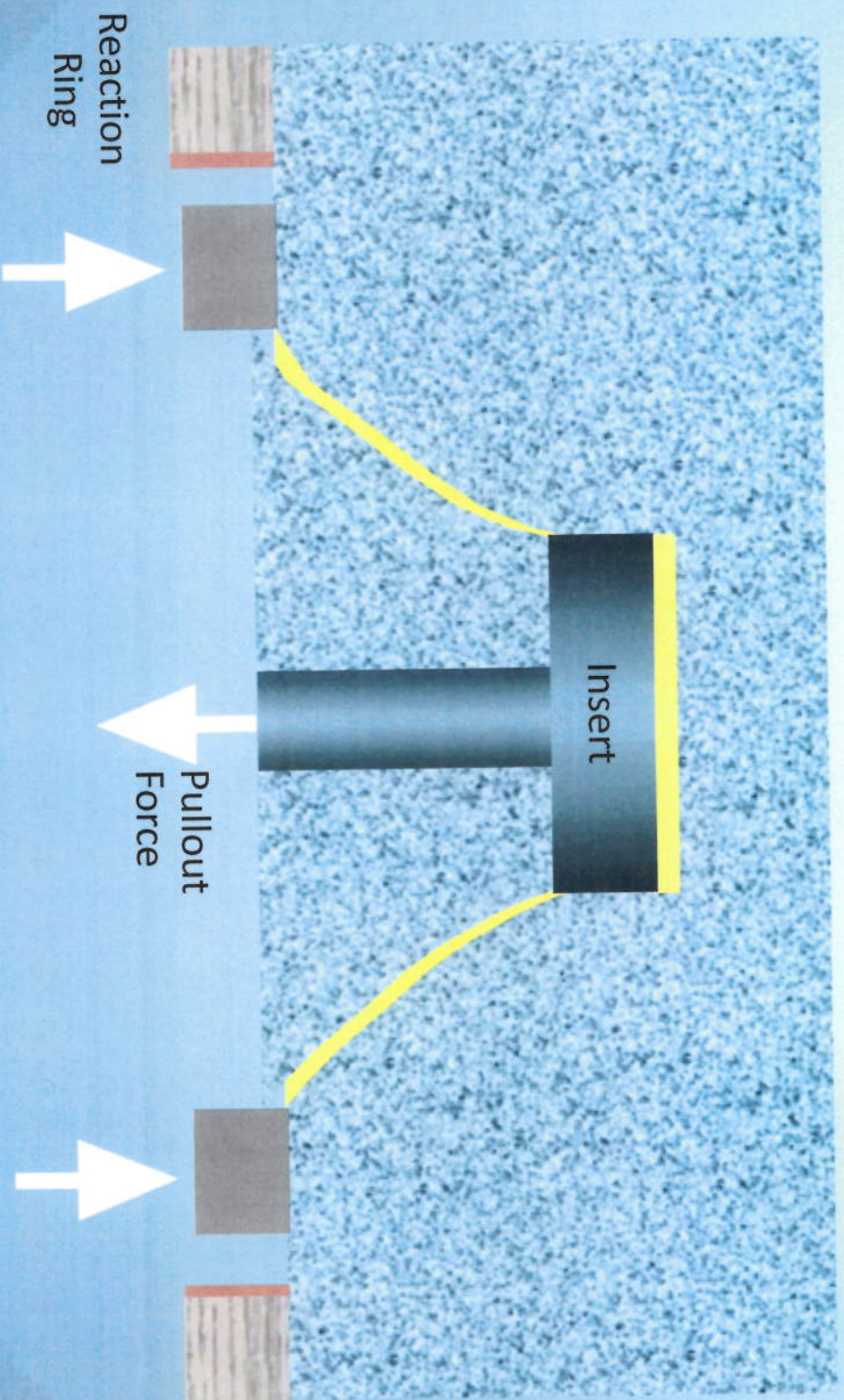


## ENTER LOK-TEST

- Portable
- Well designed and easy to use
- Multiple inserts allow accurate determination of compressive strength
- ASTM C-900-78T was first standard

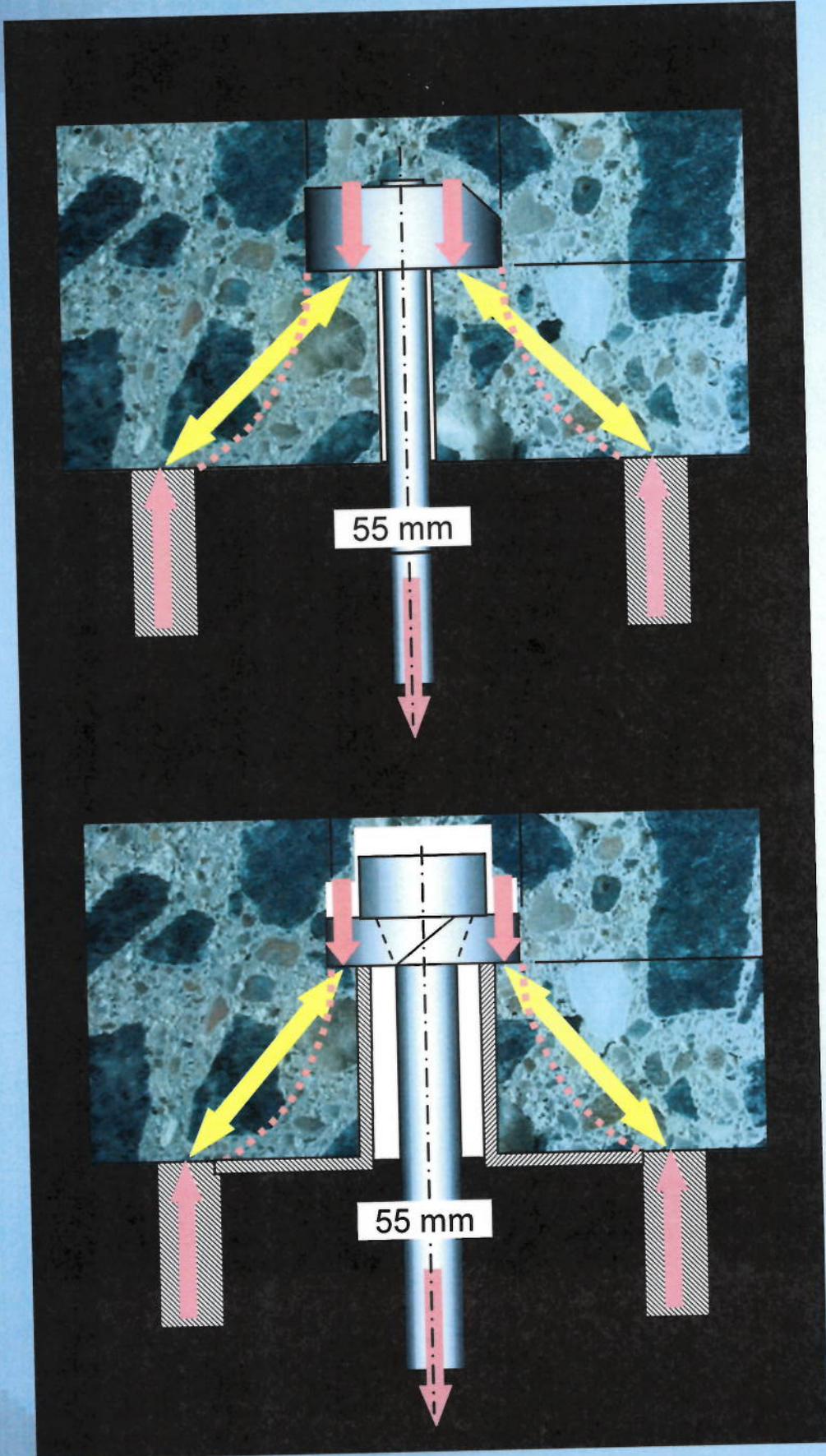


# CIP-Pullout Test





# LOK-TEST & CAPO-TEST





# Pullout Test



Pull Machine

COMA Meter



Conical Fragment



- Remove backing plate
- Attach loading system
- Apply load
- Measure pullout strength

Pressure  
gauge





# Pullout Test

## ASTM C 900

Measure force to pullout an insert anchored in concrete.

- Cast-in-place (CIP): LOK-Test
- Post-installed (PI): CAPO-Test



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## Canadian Standard CSA A23.1

- In-place strength required to remove forms, apply prestressing or post-tensioning, terminate curing and remove reshores
- Core tests or pullout tests allowed



# Concrete Optimisation

- On most projects the acceleration of the construction results in significant financial savings
- Optimisation assesses all the factors involved in acceleration and assesses the extra costs or savings



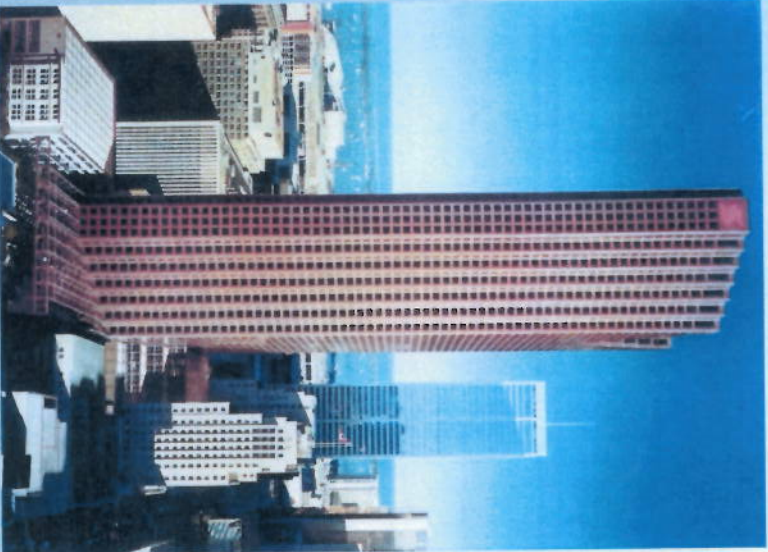
## ACCEPTANCE BY IN-PLACE TESTS

- City of Toronto accepted concrete on 2 major projects based on pullout tests
- Test results confirmed that acceptance by this approach was reliable



# Scotia Plaza

- SAFE and EARLY stripping of forms using LOK-TEST for estimating in-place strength has been done in North America on about 300 major structures
- Earnings due to speeding up construction schedule reported to be about 0.2 to 1.5 M Dollars



Scotia Plaza – Toronto,  
Canada.

*Source: Bickley, J.A.: "How to Build Faster for Less – The Role of In-Place Testing in Fast Track Construction", ACI, Spring Convention, San Francisco, 1994*



## Scotia Plaza

- Self climbing form system supported on concrete columns and spandrel beams at ages as short as 11 hours
- Maturity meters predicted adequate strength
- Pullout tests confirmed strength



## Performance Specifications

- Performance specifications will be the next generation norm
- Where acceptance of a structure is by in-place tests, early confirmation by pullouts as identity tests is an option



# Resolute

- Remote from testing laboratories (Near Magnetic North Pole)
- Supply only by air except for one ship a year
- Confirmation of adequate early strength doubled column foundation production and halved project length



## Summary

- Lok-Test is a quick, simple, reliable and economic way of determining in-situ compressive strength
- It allows acceleration of construction without compromising safety