R. Doug Hooton: A Legacy of Support for Use of Slag cement

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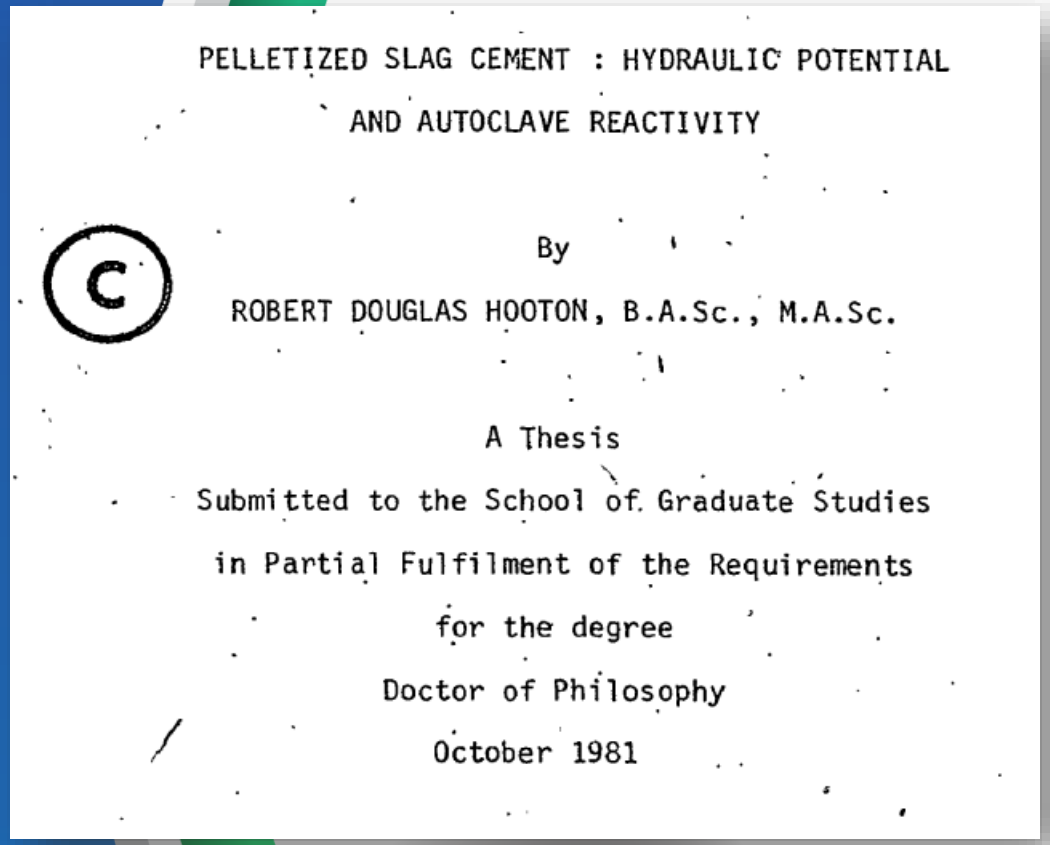
R. Doug Hooton

- PhD from University of Toronto – 1981
- Research Engineer at Ontario Hydro – 1981-1986
- Professor – University of Toronto – 1986 – 2021
- Professor – University of Toronto – 2021 – Now
- Principal – Concrete Durability Associates – 2019 - Now

PhD Thesis



PELLETIZED SLAG CEMENT : HYDRAULIC POTENTIAL
AND AUTOCLAVE REACTIVITY

By

ROBERT DOUGLAS HOOTON, B.A.Sc., M.A.Sc.

A Thesis
Submitted to the School of Graduate Studies
in Partial Fulfilment of the Requirements
for the degree
Doctor of Philosophy
October 1981

- "Pelletized Slag Cement: Hydraulic Potential and Autoclave Reactivity" (1981)
  - Development of a test method to quantify the degree of vitrification achieved in BF slag; and evaluation of test methods for potential use in commercial quality control.
  - The study of the incorporation of slag cement in autoclaved binders having a wide range of compositions in the ternary system containing slag, portland cement and grbund quartz (silica flour)
  - The effects of variations in the physical, and chemi cal properties of slag cement on autoclave reactivity.

Scope of Research

- Concrete durability and service life
- Physical, chemical and mineralogical properties of portland cements, SCMs, admixtures
- Structures and Bridges
- Waste Materials Utilization
- Alkali aggregate reactions
- Sulfate resistance
- De-icer salt scaling resistance
- Properties of ancient concrete materials
- Performance standards and specifications for concrete

Honors

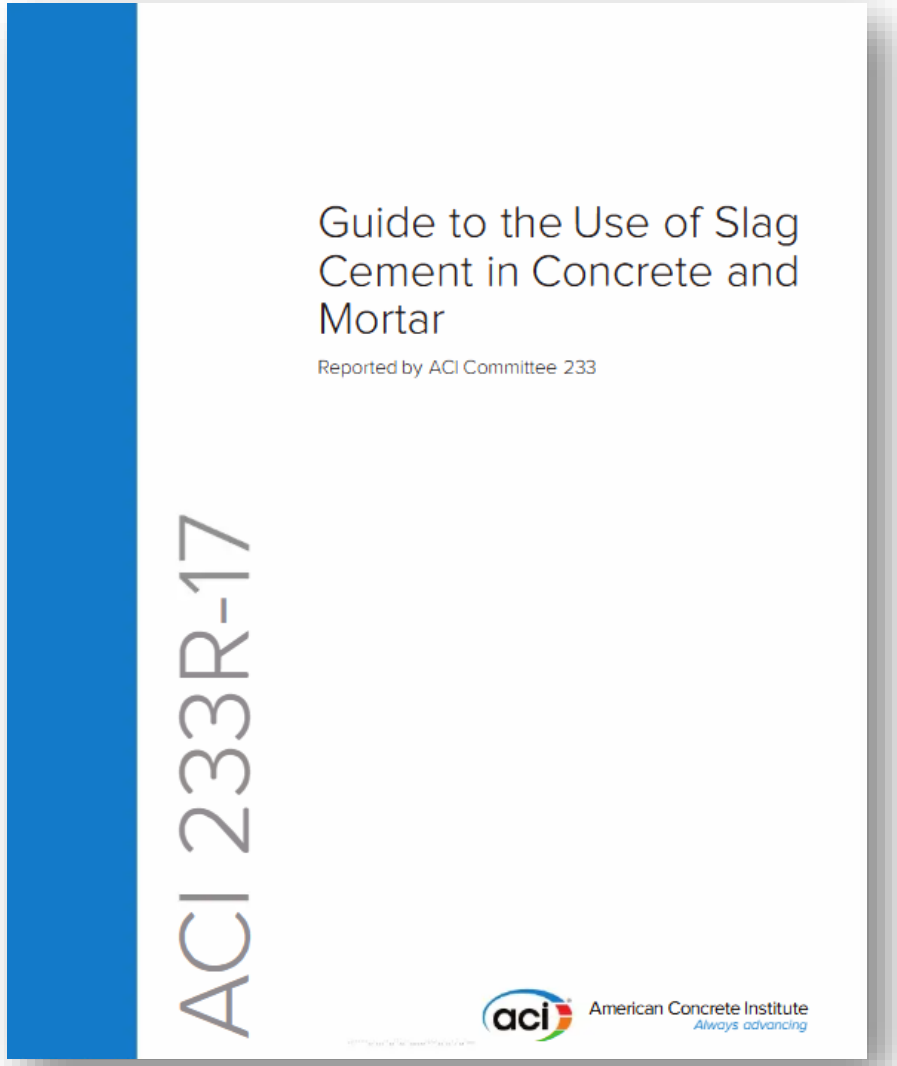
- Bryant Mather Award, ASTM, 2022
- Honorary Member, RILEM, 2022
- Honorary Member, ACI, 2018
- Research Chair in Concrete Durability and Sustainability, Natural Sciences and Engineering Research Council of Canada; Cement Association of Canada , 2010

Doug's Work with Slag Cement

- 42 out of 226 items in his Scholarly and Creative Works
- First cited work: "Glass Content Determination and Strength Development Predictions for Vitrified Blast Furnace Slag"
  - R. Doug Hooton and John J. Emery
  - ACI SP-79 (1983): Fly Ash, Silica Fume, Slag and Other Mineral By-Products in Concrete
  - Established that XRD was the most reliable method to determine degree of vitrification
  - Established that the strength of slag/portland mortars was related to:
    - Chemical composition
    - Fineness
    - Degree of vitrification

Doug and ACI 233 – Slag Cement in Concrete

- Current chair of ACI 233 Slag Cement in Concrete
- Longstanding member of committee
- 16 References with Doug as lead or co-author



Slag Characteristics

- “Pelletized Slag Cement: Autoclave Reactivity,”
  - Hooton, R. D., and Emery, J. J. (1980)
  - 7th International Congress on the Chemistry of Cement
  - Confirmed that because of the complexity of the reacting system the best way to evaluate slag cement performance is through direct testing of workability, strength characteristics, and durability

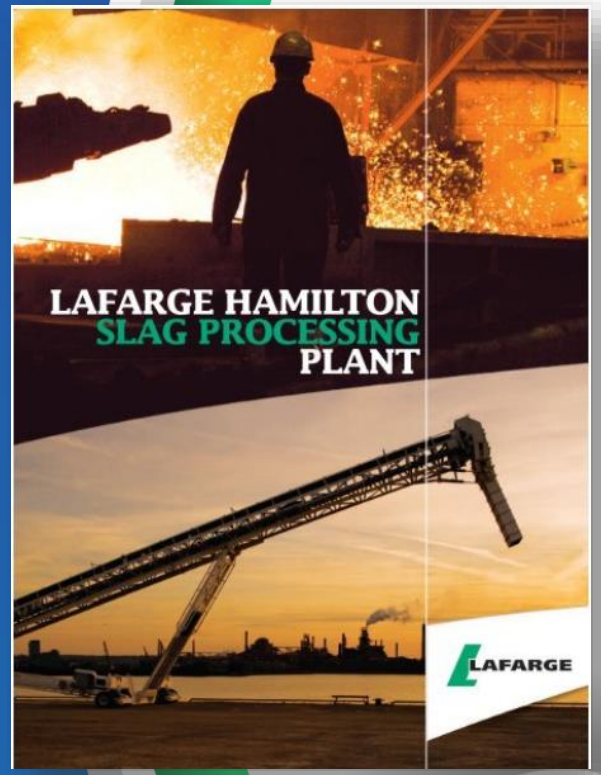
Sulfate Resistance

- "Sulfate Resistance of a Canadian Slag Cement"
  - Hooton, R. D., and Emery, J. J. (1990)
  - ACI Materials Journal
  - Over 1000 cylinders were cast from eight concrete mixes made with normal, moderate, and sulfate-resisting cements, and 45, 65, and 72 percent slag replacement.
  - Concluded that 50% slag replacement for portland provided better performance than high sulfate-resistance cement alone (regardless of C_3A content of the cement used with the slag)

Ternary Mixtures in High-Strength Structural Concrete

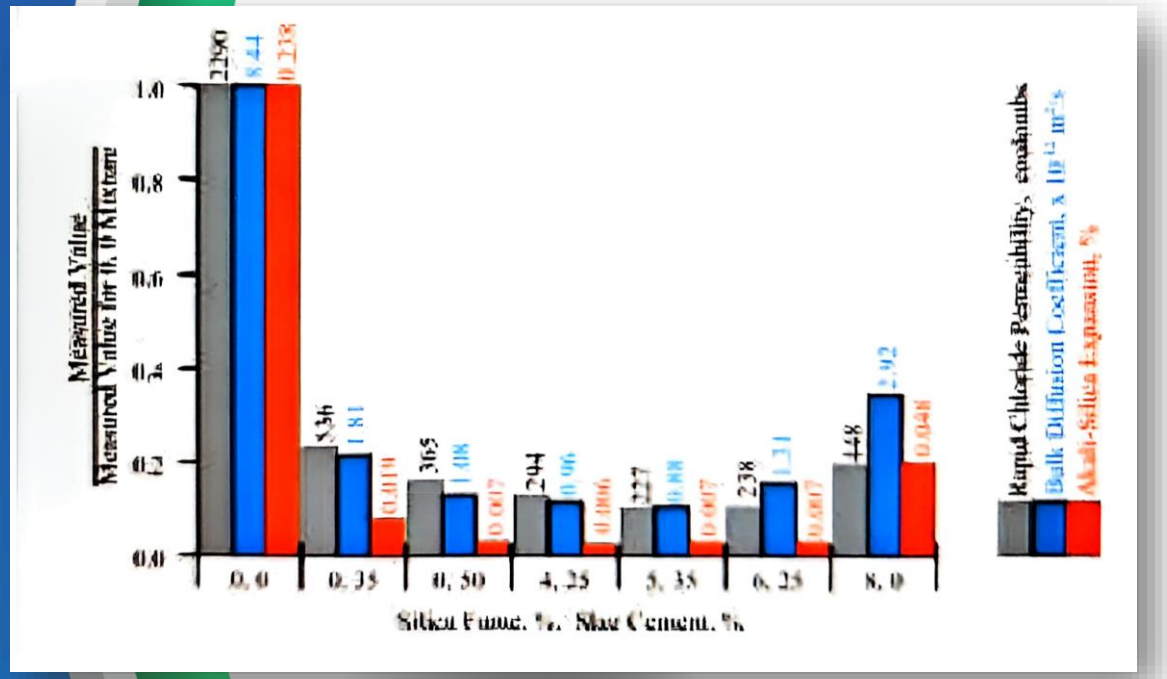
- “Some characteristics of high-strength structural concrete” (1991, 1994)
  - J. A. Bickley, J. Ryell, C. Rogers, and R. D. Hooton
  - Canadian Journal of Civil Engineering
  - 68-storey Scotia Plaza
  - Ternary mixture with 28% slag cement, 7.5% silica fume and portland cement
  - Demonstrated high-strength, high durability for high-rise structural applications – 7 years of tests
  - Testing to demonstrate no strength regression in silica fume concrete mixtures

Canadian Use of Slag Cement in Concrete



- “Canadian use of ground granulated blast-furnace slag as a supplementary cementing material for enhanced performance of concrete” (2000)
  - Hooton, R.D.
  - Paper documenting use of slag cement—since Lafarge/Hamilton slag cement grinding facility established in 1976
  - Cited benefits in workability, strength enhancement, ASR improvement, sulfate resistance, and heat reduction; as well as whiteness for architectural applications.
  - Noted that slag has become the predominant SCM in Ontario

Durability of Ternary Concrete with Slag and Silica Fume



- "Durability of Ternary Blend Concrete with Silica Fume and Blast-Furnace Slag: Laboratory and Outdoor Exposure Site Studies" (2002)
  - Bleszynski, R.; Hooton, R. D.; Thomas, M. D. A.; and Rogers, C. A.
  - ACI Materials Journal
  - Showed how ternary mixtures with slag cement and silica fume significantly improved RCP and ASR resistance
  - Large-scale cast-in-place slabs, and simultaneous lab speciments
  - Salt scaling study, also.

Delayed Ettringite Formation

- “The Effect of Pozzolans and Slag on the Expansion of Mortars Cured at Elevated Temperature - Part II, Microstructural and Microchemical Investigations,”
  - Ramlochan, T.; Thomas, M. D. A.; and Hooton, R. D. (2004)
  - Concluded that a sufficient amount of slag cement (or metakolin, or appropriate fly ash) could prevent ettringite formation (DEF) in heat-cured mortars.

Use in Mine Tailing Stabilization

- “Microstructural and Chemical Investigations of
- Cemented Paste Backfills,”
  - Ramlochan, T.; Grabinsky, M. W.; and Hooton, R. D. (2004)
  - Documented the use of slag cement in a 90% slag/10% portland mixture for mine tailings at the Kidd Mine in Northern Ontario

Deicer Salt Scaling Resistance

- “Long-Term Scaling Performance of Concretes Containing Supplementary Cementing Materials” (2007)
  - Boyd, A. J., and Hooton, R. D.
  - Reported 12 years of field performance (from 1994) on 6 slag and fly ash SCM mixtures
  - 25-50% slag, 15% C Fly Ash, and 25/10% slag ash ternary mixture
  - Cured and tested specimens with ASTM C672 resulted in far more severe scaling than lab specimens allowed to cure for 4 months (which correlated with field slabs).

Deicer Salt Scaling Resistance (con’t)

- “Deicing Salt Scaling Resistance of Concrete Incorporating Supplementary Cementing Materials: Laboratory and Field Test Data” (2008)
  - Bouzoubaa, N., Bilodeau, A., Fournier, B., Hooton, R. D., Gagne´, R.; and Jolin, M.
  - 7 mixtures with SCMs: Compared ASTM C672 with BNQ Test (Province of Quebec Salt Scaling Standard)
  - Showed severity of ASTM C672 for SCM mixtures, and adequacey of BNQ test, comparing 4 years of field and lab results

Drying Shrinkage

- “The Effect of Ground Granulated Blast Furnace Slag on the Drying Shrinkage of Concrete—A Critical Review of the Literature”
  - Hooton, R. D.; Stanish, K.; Angel, J. P.; and Prusinski, J.(2009)
  - ACI Special Publication
  - Established that the only parameter of a slag mixture design that had a significant influence on the drying shrinkage was the total aggregate volume.
  - The level of slag replacement and the w/cm of the concrete mixture were not found to affect the relative drying shrinkage
  - Also, whether slag added at a ready-mix facility, or as a blended cement did not influence results.

ASR Mitigation

- “20-Year Field Evaluation of Alkali-Silica Reaction Mitigation,”
  - Hooton, R. D.; Rogers, C. A.; MacDonald, C. A.; and Ramlochan, T., (2013)
  - ACI Materials Journal
  - Reported 20-year performance of ASR field exposure samples placed in Kingston, ON in 1991.
  - Established the efficacy of various levels of slag and other SCMs in mitigating ASR.
  - Three concretes showed no evidence of cracking: Two with 50% slag replacement, and a ternary mixture with 25% slag and 3.8% slilica fume.
  - Low-alkali cement mixtures cracked after 12 years

Doug and the SCA

- Instrumental in educating numerous concrete industry decisionmakers in slag cement through SCA seminars
- SCA/Industry research:
  - Deicer salt scaling
    - Deicer Scaling Resistance of Concrete Pavements, Bridge Decks, and Other Structures Containing Slag Cement
    - Phase 1: Site Selection and Analysis of Field Cores
    - Phase 2: Evaluation of Different Laboratory Scaling Test Methods
  - Shrinkage
    - The Effect of Ground Granulated Blast Furnace Slag on the Drying Shrinkage of Concrete—A Critical Review of the Literature