

# **CEMENT REDUCTION IN CONCRETE**

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LECTURE 2011, ENVIRONMENTALLY SUSTAINABLE CONSTRUCTION – MITIGATION OF AND ADAPTATION TO CLIMATE CHANGE

THE MAKING OF CONCRETE, ONE OF THE MOST USED CONSTRUCTION MATERIALS, IS INEXTRICABLY TIED TO THE MAKING OF PORTLAND CEMENT. IT HAS BEEN ESTIMATED THAT THE MANUFACTURE OF EACH TONNE OF PORTLAND CEMENT TYPICALLY PRODUCES A TONNE OF CO<sub>2</sub>, AND THAT CEMENT MANUFACTURE ACCOUNTS FOR AN ESTIMATED 5-6% OF TOTAL MAN-MADE CO<sub>2</sub> EMISSIONS WORLDWIDE. FROM AN ENVIRONMENTALLY RESPONSIBLE PERSPECTIVE, THE FOLLOWING SUGGESTS ITSELF: WE SHOULD ATTEMPT TO REDUCE THE CEMENT CONTENT IN CONCRETE, BEING CAREFUL TO MAINTAIN SATISFACTORY SHORT-TERM AS WELL AS LONG-TERM PERFORMANCE OF BUILT CONCRETE STRUCTURES.

THE PAPER PRESENTS A NUMBER OF POSSIBLE APPROACHES TOWARDS ACHIEVING THIS OBJECTIVE, WHICH INCLUDE THE FOLLOWING:

(I) CEMENT SUBSTITUTION BY USING SUPPLEMENTARY CEMENTITIOUS MATERIALS (“CEMENT REPLACERS”) SUCH AS POZZOLANS, GGBS, PFA, AND CONDENSED SILICA FUME (MICROSILICA) TO REDUCE THE NET AMOUNT OF MANUFACTURED PORTLAND CEMENT IN THE CONCRETE FOR PARTICULAR PERFORMANCE REQUIREMENTS;

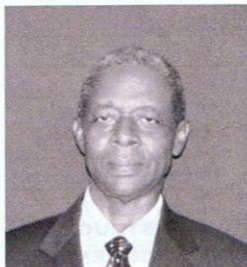
(II) REDUCTION OF CEMENT BY THE USE OF WATER REDUCERS (PLASTICIZERS AND SUPERPLASTICIZERS); BY REDUCING THE AMOUNT OF WATER NEEDED IN CONCRETE TO SATISFY CONSTRUCTION REQUIREMENTS (PRIMARILY WORKABILITY), THE AMOUNT OF CEMENT CAN BE PROPORTIONALLY REDUCED. THIS IS ALLOWABLE AS LONG AS THERE REMAINS ENOUGH CEMENT PASTE VOLUME TO FORM SUFFICIENT MORTAR (WITH THE FINE AGGREGATE) SO AS TO ADEQUATELY SURROUND AND COVER THE COARSE AGGREGATE, THUS MAKING A PRACTICAL, USABLE CONCRETE;

(III) THE USE OF ROLLER-COMPACTED AND ZERO-SLUMP (BUT PLASTICIZED) CONCRETE FOR PAVEMENTS AND THEIR APPURTENANCES TO ALLOW VERY LOW CONSTRUCTION-WATER REQUIREMENTS (AND THEREFORE VERY LOW CEMENT REQUIREMENTS);

(IV) REDUCTION OF STRUCTURAL-CONCRETE REQUIREMENTS IN LARGE CONSTRUCTIONS NEEDING MASS (SUCH AS COUNTERWEIGHTS, CERTAIN SEA-DEFENCE STRUCTURES, LOCKS FOR WATERWAYS/NAVIGATION SYSTEMS, DAMS OF MODEST DIMENSIONS), BY THE USE OF HYBRIDIZATION/COMPOSITE DESIGN AND CONSTRUCTION. ONE EXAMPLE OF THIS COULD BE CELLULAR OR VOIDED CONSTRUCTIONS WHERE STRUCTURAL HONEYCOMBS WOULD BE FILLED WITH CONTROLLED-STRENGTH CONCRETE INFILL OF CONSIDERABLY REDUCED STRENGTH, ONLY SLIGHTLY REDUCED DENSITY, AND CONSIDERABLY REDUCED CEMENT CONTENT.

(V) REDUCTION OF THE ZONES OF RELATIVELY UNSTRESSED CONCRETE IN STRUCTURES, USING APPROACHES TO STRUCTURAL DESIGN THAT ARE ALREADY WELL ESTABLISHED AND READILY AVAILABLE, SUCH AS COMPOSITE SLABS, THE USE OF WAFFLE FLOORS, SHELL OR OTHER SHAPE-DEPENDENT STRUCTURES, ETC. THOUGH THIS OPTION IS STRICTLY SPEAKING OUTSIDE OF THE TOPIC, IT IS MENTIONED BECAUSE OF ITS OBVIOUS RELEVANCE TO THE OBJECTIVE OF USING LESS CEMENT TO BUILD A PURPOSE-SUITABLE AND COST-EFFECTIVE STRUCTURE.

IN ADDITION TO BEING ENVIRONMENTALLY RESPONSIBLE, CAREFUL AND WELL-INFORMED DESIGN AND CONSTRUCTION PLANNING (INCLUDING COMPETENT MATERIALS SELECTION AND SPECIFICATION) HAS THE POTENTIAL TO YIELD BOTH (A) CAPITAL-COST SAVINGS, AND (B) LIFE-CYCLE COST SAVINGS, TO FUTURE PROJECTS.



## BIO

DR. ROBIN OSBORNE (PH.D. CIVIL ENGINEERING) WAS BORN IN ROSEAU, DOMINICA, DID HIS B.SC. AND PH.D. IN CIVIL ENGINEERING AT UWI ST. AUGUSTINE, WHERE HE WAS ALSO A MEMBER OF ACADEMIC STAFF OF THE FACULTY OF ENGINEERING FOR 28 YEARS, ENDING IN 2005. HE WAS DEPUTY DEAN (RESEARCH AND POSTGRADUATE) OF THAT FACULTY FOR THE PERIOD 1994-1998.

DURING 2008-2011 HE WAS ASSOCIATE PROFESSOR, VICE DEAN, AND PROGRAMME DIRECTOR, M.Sc.(BUILT ENVIRONMENT) WITHIN THE FACULTY OF THE BUILT ENVIRONMENT, UNIVERSITY OF TECHNOLOGY, JAMAICA.

HE HAS BEEN A CONSULTANT TO THE TCL GROUP OF COMPANIES FOR APPROXIMATELY 30 YEARS, AND HAS TAUGHT ON A NUMBER OF COMPANY-SPONSORED TRAINING SESSIONS THROUGHOUT THE COMMONWEALTH CARIBBEAN, INCLUDING BELIZE AND GUYANA. MORE OF THESE ARE PLANNED FOR DELIVERY IN LATE 2011.

HE HAS ALSO BEEN AN INVITED CONSULTANT ON A NUMBER OF MAJOR ENGINEERING AND CONSTRUCTION PROJECTS IN THE CARIBBEAN, OF WHICH THE FOLLOWING ARE A SELECTION:

- (I) INDEPENDENT REVIEWER IN 2002 ON CONSTRUCTION QUALITY, GRENADA NATIONAL STADIUM (20,000 SEATING); SUBMITTED AN ADVERSE REPORT; STADIUM SUBSEQUENTLY SUFFERED MAJOR COLLAPSE UNDER HURRICANE LOADING.
- (II) CONCRETE CONSULTANT TO READYMIX (WEST INDIES) LTD ON ATLANTIC LNG TRAIN 3 IN POINT FORTIN (PROJECT COST APPROX. US\$ 1,000MILLION, >200,000 TONNES OF CONCRETE, 2002);
- (III) CONCRETE CONSULTANT TO (A) NORTHERN CONSTRUCTION LTD., TRINIDAD, ON PIARCO INTERNATIONAL AIRPORT RE-DEVELOPMENT (FAILURES OF PRESTRESSED CONCRETE PILES DURING DRIVING), ALSO TO (B) READYMIX (W.I.) LTD RE: DESIGN AND TESTING OF THE MIX, AND SUPERVISION OF INITIAL PLACEMENTS OF APPROX. 70,000 TONNES OF AIRCRAFT-PARKING CONCRETE, 2000-2001);
- (IV) CONSULTANT ON THE REMEDIATION OF CONSTRUCTION PROBLEMS, VARIOUS PHASES OF PLANT EXPANSIONS, TCL CLAXTON BAY, AND CARIB CEMENT IN JAMAICA;
- (V) CONSULTANT TO CEP (TRINIDAD & TOBAGO) LTD. (MIX DESIGN, CONSTRUCTION PLANNING, AND THERMAL MONITORING FOR CENTRAL SERVICES PILE CAP, A SINGLE CONCRETE PLACEMENT OF ABOUT 2400 TONNES OF CONCRETE, APPROX. 3.0M THICK), NICHOLAS TOWER, PORT OF SPAIN, 2001;
- (VI) CONSULTANT TO READYMIX (W.I.) LTD., UNIT TRUST BUILDING CONSTRUCTION PROJECT, PORT OF SPAIN (SUPPLEMENTAL WET CURING FOR CONCRETE SHEAR WALLS WITHIN EARTHQUAKE-RESISTING STRUCTURAL STEEL FRAME, WHICH INITIALLY ACHIEVED LOW CONCRETE STRENGTHS);
- (VII) CONSULTANT TO NIPDEC (THE NATIONAL INSURANCE PROPERTY DEVELOPMENT Co. LTD. ON COMPLETION OF BORDELAIS CORRECTIONAL FACILITIES, ST.LUCIA; ADVICE RELATING TO SECURITY/BREACHABILITY RISKS IN ALLEGEDLY DEFICIENT CONCRETE-BLOCK-WALLED HOLDING AREAS FOR HIGH-RISK INMATES, 2002;
- (VIII) CONSULTANT TO CEP (BARBADOS) LTD., EASTERN CARIBBEAN CENTRAL BANK HEADQUARTERS BUILDING, BASSETERRE, ST.KITTS; ADVICE ON SELECTION AND TESTING OF LOCAL AGGREGATES FOR CONCRETE, 1992.

A REGULAR PRESENTER AT CARIBBEAN CONFERENCES ON CONCRETE AND RELATED ISSUES, DR. OSBORNE PRESENTED IN 2010 AT THE CARIB CEMENT/JIE ANNUAL CONCRETE CONFERENCE 2010 AND THE I.STRUCT.E. CONFERENCE ON BRIDGES IN THE CARIBBEAN, BOTH IN KINGSTON, JAMAICA.