Bridges of the Future –
UM Quest for Sustainability

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Presentation objective

To entertain you, but leave you with a message:
***a change in the built environment needs your brain and your commitment**. It is a business opportunity and, at the same time, a legacy for the future.*

Motivation

Something is happening to our environment that has unprecedented consequences on our constructed facilities. Forget the why (may be too controversial), but we need to take action.

An article published in the Boston Globe in October 2014 titled "***For concrete, climate change may mean a shorter lifespan***" pointed out to the general public some pessimistic, but still worth noting, predictions:

Collapse of reinforced concrete structures due to steel reinforcement corrosion could be the most immediate vulnerability resulting from climate change.

Motivation (2)

California has about one year of water stored. Should we ration now?

Flooding at home. Have we had enough?

Challenges

No real gain for stakeholders (i.e., owners, developers, designers, contractors, home builders and material suppliers) for adopting innovation in the built environment.

Just the opposite for almost every other industry.

Combine the charging port with the 3.5-mm audio jack and you will make millions because we have an obsession with thinness (and does it really matter?)

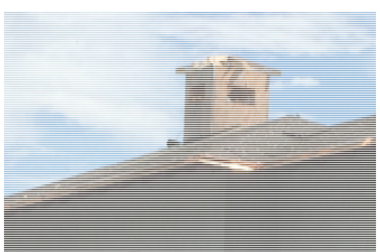
Challenges (2)

Innovation is stuck, we build like we were still in the middle ages.

Termite damage and control costs in Florida exceed $500 million annually

Challenges (3)

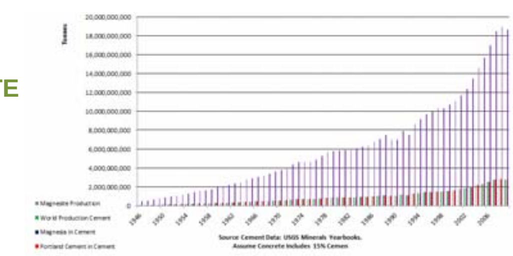
We build like if there were no tomorrow.



Chimney of multimillion home under construction in Pinecrest, FL (September 7, 2015)

Innovation I know something about

a. CONCRETE



Concrete plays a remarkable socio-economic role in the world. More than 18B tons of concrete are produced every year requiring large amounts of natural resources. Produced in almost every country because, compared to other construction materials, it is cheap and abundant.

b. WATER & AGGREGATES

Approximately 1.5 trillion liters of freshwater are used annually in concrete production for mixing, curing and equipment cleaning.

Recycled concrete aggregate (RCA) and recycled asphalt pavement (RAP) are abundant.

Worldwide, construction and demolition wastes make about 30% of total. In the US, annual construction waste ranges from 250 to 300M tons.

c. CORROSION

In coastal environments, chlorides in seawater/air cause de-passivation of the steel and consequent corrosion phenomena.

A peek under a bridge.
Keep on driving and hope…

Looks familiar? Lean over at your own risk…

c. COMPOSITE REINFORCEMENT (FRP)

To prevent risk of premature degradation non-corrosive reinforcement in the form of composites CAN BE be adopted.

Technology developed over the last two decades has made available FRPs to replace black steel reinforcement when the durability of a structure is of concern.

Samples being distributed

d. CONCRETE WITH NO CHLORIDE LIMITS

If steel corrosion were not the most compelling concern, chloride limits would not be required. Thus, concrete itself could become a more sustainable material.

Use of cements without chloride limits would give cement manufacturers the opportunity to use solid waste as kiln fuel (co-generation) as well as adding kiln dust (byproduct that currently requires disposal) back to the clinker.

Bridges of the Future – UM Quest for Sustainability

Four Examples:

- SML Lab (http://www.um-sml.com/)
- Fate Pedestrian Bridge
- Hecht Pedestrian Bridge
- SEACON: EU-funded R&D project

UNIVERSITY OF MIAMI STRUCTURES AND MATERIALS LABORATORY

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LABORATORY TESTING SERVICES

SML operates as a testing facility and has met the requirements of the International Accreditation Service (IAS) AC89 "Accreditation Criteria for Testing Laboratories", has demonstrated compliance with ANS/ISO/IEC Standard 17025:2005 "General requirements for the competence of testing and calibration laboratories" and is an accredited testing facility for the test methods listed in the approved scope of accreditation under Testing Laboratory # TL-478.

Hope you will come and visit during the event of February 2

Industry Partners and Collaborators in the last 5 years

AltusGroup
American Rebar
Apollo Steel Company
Archer Western
Astaldi Construction
ATP Construction Composites s.r.l.
Baker Concrete
BP Composites Ltd.
C1 Pultrusions LLC
Citadel
Cobalt Construction Group
Composite Rebar Technologies
Composite Reinforcement Solutions
Concrete Industries, Inc.
Condotte America
Cone & Graham, Inc
Creative Pultrusions Inc.
Dextra Group, Hong Kong
Douglas Wood
DowAksa USA, LLC
Dragados USA
Fenestration Testing Laboratory, Inc.
Ferreira Construction Co
fischer (Shanghai) International Trading Co. ,Ltd.
fischerwerke (Germany)
Florida Department of Transportation
Fortress Stabilization Systems
FYFE Asia
G & P Intech S.r.l
GLF Construction Corporation
Hubbard Construction Company
Hughes Brothers
International Code Council Evaluation Service
KCI Technologies, Incorporated
Mapei
Marshall
Miller and Long DC, Inc.
Milliken
No Rust Rebar Inc.
Orion Marine Construction, Inc.
Owens Corning
Prince Contracting
Pultrall
QuakeWrap Inc
Rurdeil
SEMA Construction
Sieg & Ambachtsheer, Inc.
Sika - US
Simpson Gumpertz & Heger
Simpson Strong-Tie
Sireg S.p.A
Stressbar
Structural Group
Structural Technologies
Supermx
THiN-Wall
Titan America
Tokyorope
Wingerter
Zep Construction, Inc.
Zoltek

Fate Bridge Innovation and Monitoring

Motivation

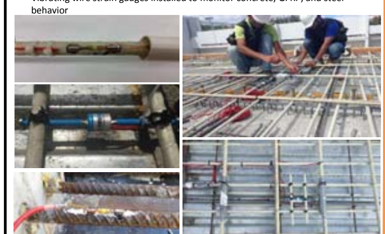
- Implementation of corrosion-resistant Glass Fiber Reinforced Polymer (GFRP) bars in place of conventional steel reinforcement
- Less labor due to GFRP light weight
- Serving as an educational test-bed by combining innovation deployment and monitoring

Concrete Test

- Concrete cylinders prepared on site during casting
- Compressive tests performed in the lab to determine concrete strength

Instrumentation

- Vibrating wire strain gauges installed to monitor concrete, GFRP, and steel behavior



Monitoring

- Data acquisition device permanently mounted under the bridge
- Trial test performed in September 2015
- Load tests scheduled for long-term monitoring under service loads

Date: July 2, 2015

Phase I (conventional): Site mobilization and pile driving

Date: July 27, 2015

Phase II (conventional): Construction of pile caps and launching of steel girders

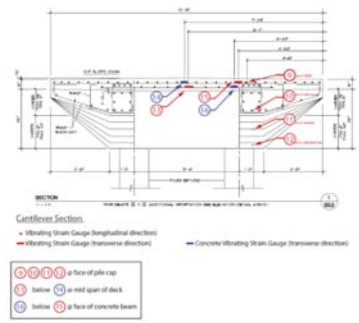
Date: August 28, 2015

Phase III: Construction of the deck reinforced with Glass FRP bars

Date: September 1, 2015

Phase IV: Final concrete pour

Date: December 30, 2015



Phase V: Bridge load testing with forklift (about 9,200 lbs.)
To be repeated at regular intervals of time

ACE Innovation Award Finalist

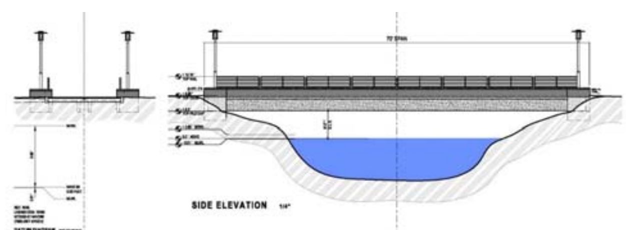
CAMX 2015 – The Composites and Advanced Materials Expo, October 26-29, 2015, Dallas, TX

https://vimeo.com/144433359

Play video

Hecht Athletics Pedestrian Bridge

First bridge in the world made of concrete without a single pound of steel: prestressed with Carbon FRP tendons and reinforced with Basalt and Glass FRP.




Date: October, 2015
Location: Coreslab, Miami

Phase I: Construction/ instrumentation of two PC Double-Tees with CFRP tendons and BFRP reinforcement

Play video

Phase I: Continued

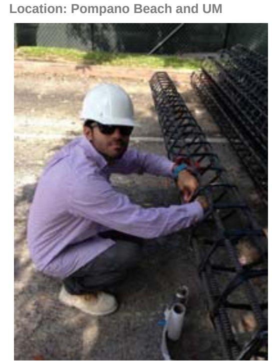
Date: October, 2015
Location: Coreslab, Miami

Date: November, 2015
Location: Coreslab, Miami


Phase II: Load testing of one Double-Tee

Play video


Date: November, 2015
Location: Pompano Beach and UM



Phase III: Fabrication of BFRP cages for auger-cast piles, delivery and instrumentation

Date: December, 2015
Location: UM

Phase IV: Construction 8 auger-cast piles with BFRP cages

Play video

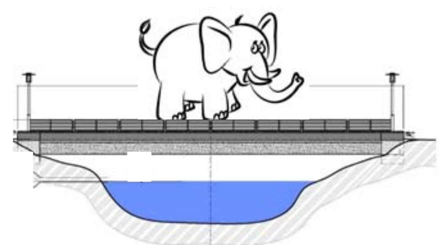
Date: December, 2015
Location: UM

Phase V: Excavation around piles and demolition of grout to expose reinforcement cage

Date: January, 2016
Location: UM

Phase VI: Placement of BFRP reinforcement for pile-caps

To be continued – we hope to have Governor and County/City elected officials for the grand opening and load test with live elephant! Join us.



SEACON

Infravation
An Infrastructure Innovation Programme

SEACON: Sustainable concrete using seawater, salt-contaminated aggregate and non-corrosive reinforcement

13/11/2015 SEACON 33

Consortium

Infravation
An Infrastructure Innovation Programme

Partners

- University of Miami (UM)
- ATP srl (ATP)
- Politecnico di Milano (POLIMI)
- Owens Corning (OC)
- Buzzi Unicem (BUZZI)
- Acciaierie Valbruna (AV)

Collaborators

- Florida DOT (FDOT)
- Pavimental (PV)
- Titan America (TT)

13/11/2015 SEACON 34

Goal of SEACON

Infravation
An Infrastructure Innovation Programme

The safe utilization of seawater and salt-contaminated aggregates (natural or recycled) for a sustainable concrete production when combined with non-corrosive reinforcement

13/11/2015 SEACON 35

Objectives

Infravation
An Infrastructure Innovation Programme

- Make it clear that chlorides are harmful for steel reinforcement, but they do not damage the concrete's characteristics (i.e., workability, strength development, durability)
- Assess through LCA and LCC durability performances and economical impact resulting from use of chloride contaminated aggregates, high chloride content cement and seawater on structural concrete
- Demonstrate technology by means of two real-size field prototypes in two countries (Italy and Florida, USA)

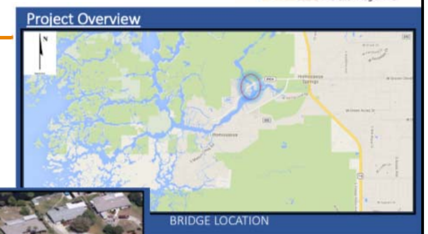
13/11/2015 SEACON 36

WP4- Demo in **Citrus County, Florida**

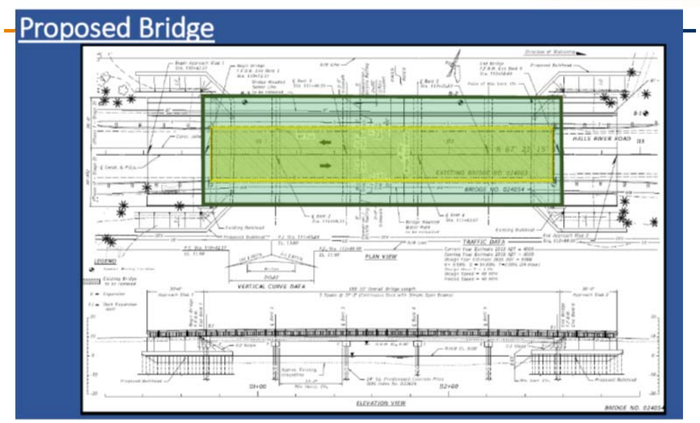
Replace functionally obsolete Halls River Bridge to increase capacity and improve safety.

New bridge total length is **56.5** m consisting of five **11.3** m simply supported spans (two 3.6-m traffic lanes with 2.4 m outside shoulders, 1.5-m wide sidewalk with standard traffic barrier and bridge pedestrian/bicycle railing on each side).

Halls River Bridge Replacement



Halls River Bridge Replacement

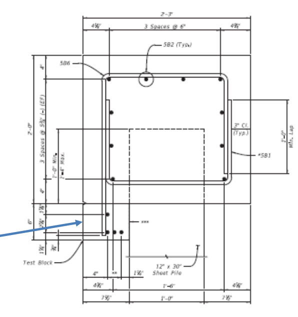


Halls River Bridge Replacement

Super- and sub-structure classified as extremely aggressive due to chloride concentrations in water and close proximity of superstructure to water.

Non-corrosive bars and stirrups address long-term durability of cast-in-place concrete bulkhead caps, pile caps, wing-walls, back-walls, deck and approach slabs.

Provisions being made for collection of samples from the bulkhead cap over time as shown in figure.



CONCLUSIONS

The challenges of addressing sustainability of the built environment have to be met by the public and our best minds. This is not a problem of the construction industry alone.

There are significant business opportunities (with unprecedented societal implications) available in transforming some of the materials, processes and technologies adopted in construction.

UM is playing an active role in many aspects related to sustainability via its Green U initiative. Among them, is the deployment of more durable and economical systems for construction.

ACKNOWLEDGEMENTS

R&D work at UM is made possible as a result of support from many sources including:

- The National Science Foundation (NSF) via the Industry/University Center for Integration of Composites into Infrastructure (CICI).
- The US DOT via the University Transportation Center RE-CAST
- Affiliated Corporations

THANK YOU

Questions?