REPAIR OF MAJOR FAULTY CONCRETE STRUCTURES

SHARJAH RESEARCH ACADEMY, UAE

OMAINTEC Conference 2019 - by Sharjah Research Academy, UAE

OUTLINE

- Concrete Durability & Failure
- Concrete Durability & Repair
- Concrete Repair Materials
- Full-Scale Project
- Experimental Work
- Results
- Conclusion

Concrete Durability & Failure

- Concrete worldwide annual production is 4.4 billion metric tons
- Concrete production is taxing the environment
- Concrete can face many form of attacks: Chemical attack, Sulfate attack, Leaching & alkali aggregate reaction.
- Significant spending budgets are implemented for repairs and maintenance of existing concrete infrastructure
- Enhanced durability and service life of new concrete infrastructure is more economical and important for sustainability

Concrete Durability & Failure

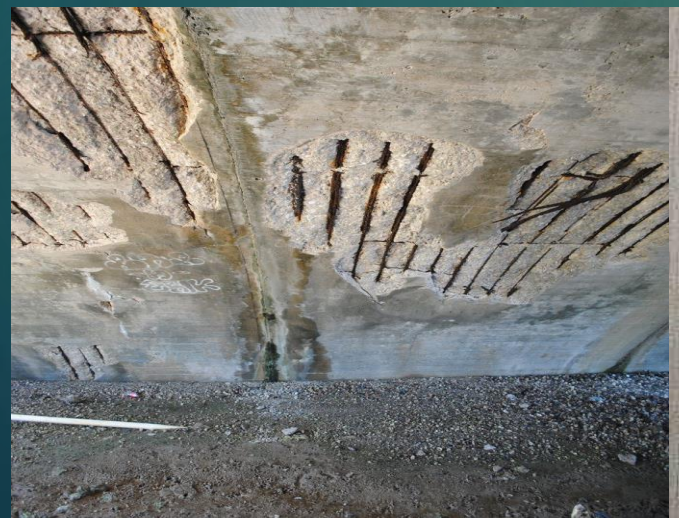
- Many concrete failures or signs of failure result from exposure to severe services or environmental conditions.
- Outright failure or collapse caused by too low strength are extremely rare

Failure Cause	Percentage
Damages due to Compounds of concrete	40%
Damages due to manufacture of concrete	22%
Damages due to structural design	12%
Damages due to excessive loads	8%
Damages due to foundations	7%
Damages due to fire, etc	4%
Damages due to collapse of structure	5%

Most common causes of failure and the percentage of its occurrence.

Concrete Durability & Repair

- Durability is gaining more importance in modern design and construction practices in Building & Repair
- Lack of durability can lead to inadequate performance of concrete and failures
- Various types of defects can be observed in hardened concrete surfaces including, cracking, crazing, blistering, delamination, dusting, curling, efflorescence, scaling and spalling

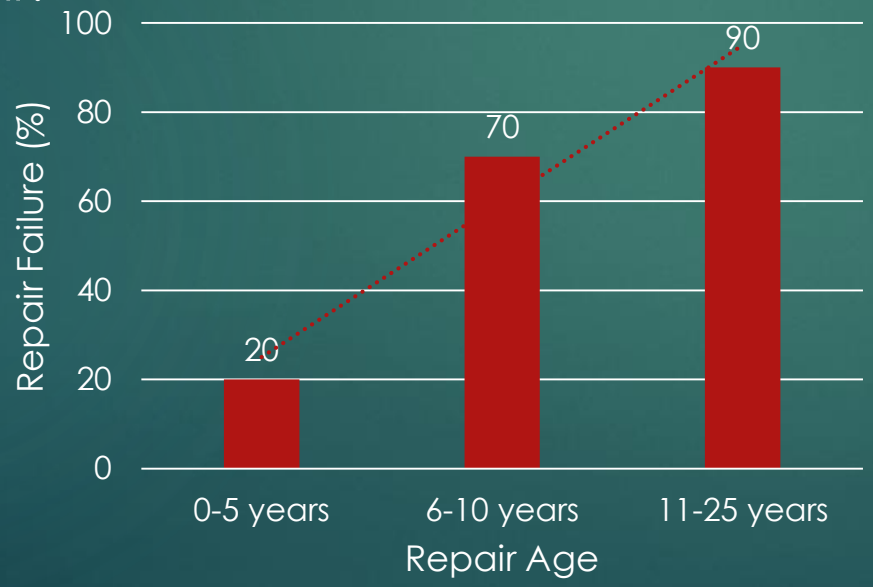


Concrete Durability & Repair

- Cracking have a variety of causes like repeated thermal cycling, accidental overloading, drying shrinkage, inadequate design or construction.
- The cause of a deficiency must be understood, to choose an appropriate repair system.

Concrete Durability & Repair

- Failure and deficiency in concrete performance require strong repairing systems
- Durability of materials incorporated into a repair shall be considered for individual repairs, the overall durability of the repaired structure, and the interaction of the repair system with the structure.
- Even if the proper material is selected, timing is key for the success of the repair.



The earlier the repair the better its performance

Concrete Repair Materials

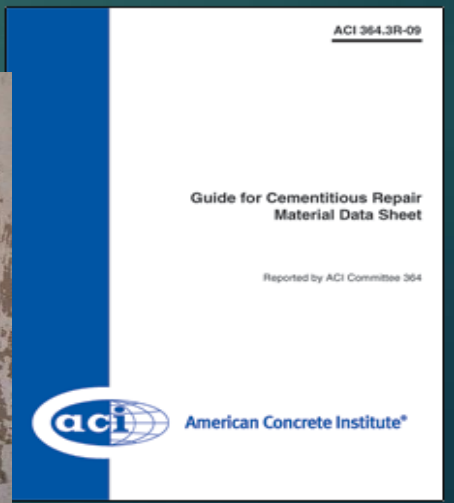
- It is vital that repair materials selected for the repair of concrete structures to be durable and suitable for the purpose it is selected for.
- Repair materials and methods shall be selected that are intended to be compatible with the structure, and are durable within the service environment.
- ACI 364.3R Guide for Cementitious Repair Material Data Sheet ACI 437R— Strength Evaluation of Existing Concrete Buildings
- General consideration:

Environmental Conditions

Curing Requirements

Physical Properties Adhesion

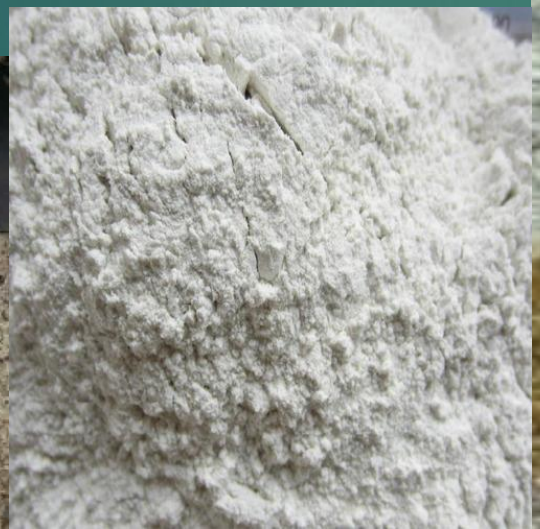
Thermal Movement



Concrete Repair Materials

1) Resin mortars:

- Mortars used for rapid and high strength concrete repairs
- To resist a wide range of aggressive chemicals and having the ability to cure under environmental condition.
- Two types either pre-mixed polymeric or site mixed slurry grout



Concrete Repair Materials

2)Epoxy mortars:

- A polymer-based bonding paste used as an adhesive and paste for structural repair.
- The paste is a mixture of materials such as epoxy resins, solvent, binder, mineral fillers.
- It can also be used to fill gaps, cracks and vents in driveways, patios and plazas.
- In a well formulated epoxy mortar the shrinkage can be as low as 20 micro strains.

Concrete Repair Materials

3)Bonding coats:

- Based on polymer and can act as a defense against corrosion and other forms of damage
- Beneficial in repair works because it can make strong bonds between layers which guarantee a powerful adhesion
- Based on a number of different polymer chemistries—acrylic, polyvinyl acetate (PVA), vinyl acetate/ethylene (VAE), styrene butadiene (SBR), or various copolymers—they are all defined by ASTM C1059 as either Type I or Type II

Research project

- A full-scale project between Sharjah Research Academy (SRA), University of Sharjah (UOS), and Arab Center for Engineering Studies (ACES) is intended to find durable repair mixes to resist damage from various environmental conditions
- This paper presents part of Phase I of an enlarged study that aims on choosing durable repair mixes.

Research project

Phase I

Preliminary analysis of the existing mixes and durability tests

Phase II

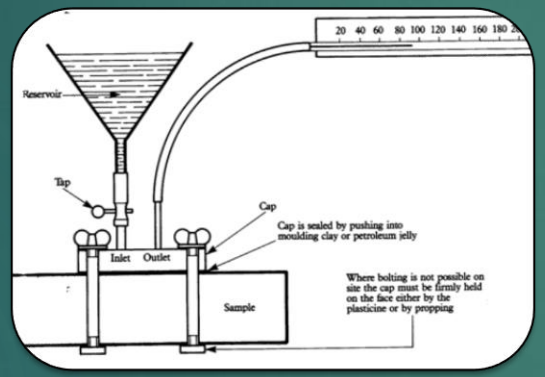
Developing new durable mixes and long-term testing

Outcome

Set of guidelines/standards will be issued to help organizations that deal with concrete to select the best durable concrete mixes in UAE

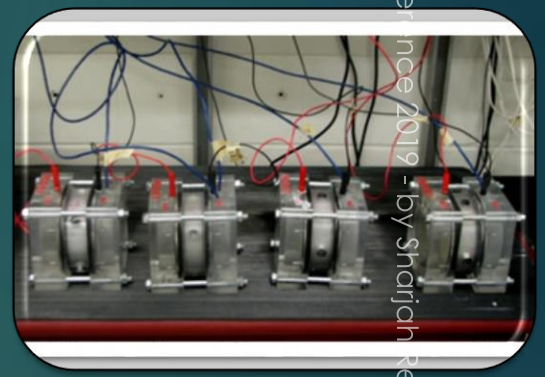
Research project
Phase 1

Concrete Water Absorption Test



Concrete Initial Surface Absorption (ISAT) Test

Concrete Permeability Test



Concrete Rapid Chloride Permeability (RCP) Test

Experimental Work

- **Materials**
- Concrete mixtures: Type I cement, C40,20 & C45,20 (ASTM C150)
- Aggregates: Locally available crushed aggregate, dune and crushed sand (RAK) from local source (ASTM C33)
- Admixtures: GGBS & MS (ASTM C 260 & C494)

Admixtures	Description	Application
GGBS	Ground Granulated Blast Furnace Slag	greatly enhanced chemical resistance particularly to chlorides and sulfates and are especially advantageous in a marine environment, resistance to Alkali Silica Reaction (ASR) is also enhanced.
MS	Micro silica	Reduces thermal cracking caused by the heat of cement hydration and can improve durability to attack by sulphate and acidic waters

Admixtures

Concrete mix	Description
C40/20	Concrete grade or strength is equal to 40 N/mm^2 at 28 days
C45/20	Concrete grade or strength is equal to 45 N/mm^2 at 28 days

Concrete Mixes before Adding Admixtures

Experimental Work

Mixes	Concrete Strength (N/mm2)	GGBS (%)	MS (kg/m3)
MIX G: C 45/20 (OPC+70% GGBS)	45	70	22.50
MIX A: C 40/20 (OPC+50% GGBS)	40	50	12.90
MIX F: C 45/20 (OPC+50% GGBS)	45	50	21.50
MIX H: C 45/20 (OPC+50% GGBS)	45	50	0.00
MIX C: C 40/20 (OPC+50% GGBS)	40	50	0.00

Concrete Mixes after adding the Mixtures

Experimental Work

- Water Absorption (WA) test according to: BS 1881: Part 122:2011
- Obtaining a core of 75 ± 3 mm. from each sample
- Water absorption assessed by measuring weight increase due to immersion in water

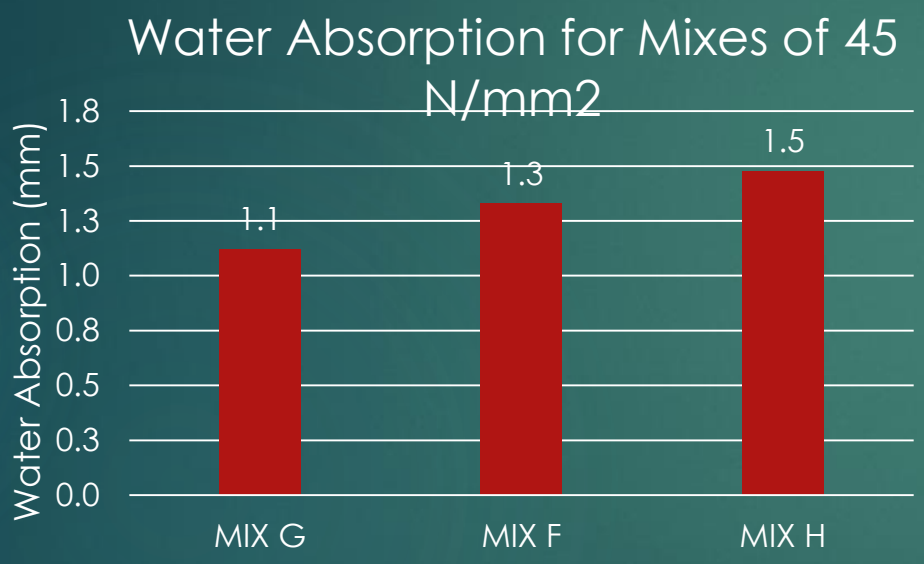
Results

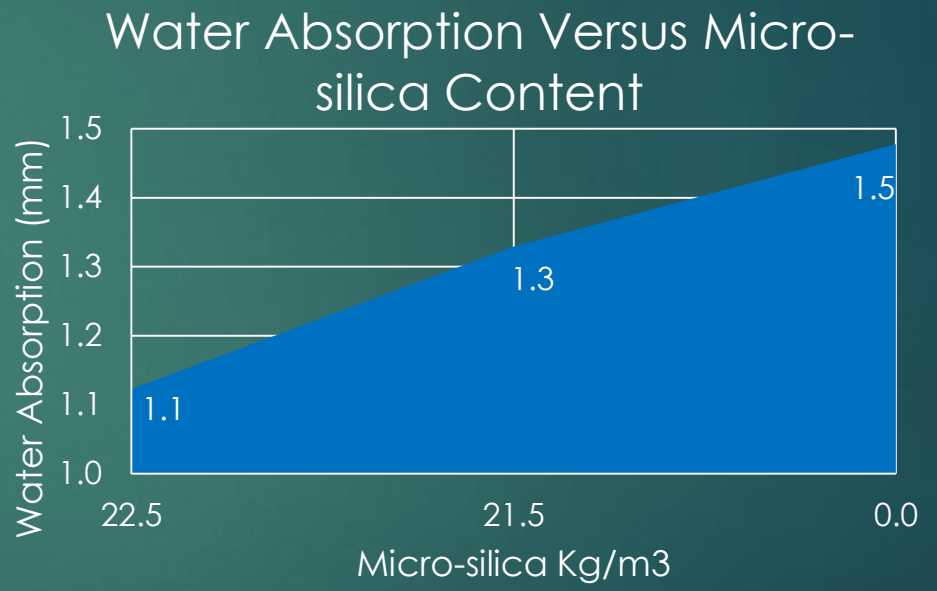
- Results of 45/20 Concrete
- High micro silica content is attributed with reduction in decreased water absorption.
- Even at the samples treated with the same GGBS%, the sample with higher micro silica content had lower water absorption.

Mixes	Concrete Strength (N/mm^2)	GGBS (%)	MS (kg/m^3)	Water Absorption (mm)
MIX G: C 45/20 (OPC+70% GGBS)	45	70	22.5	1.12
MIX F: C 45/20 (OPC+50% GGBS)	45	50	21.5	1.33
MIX H: C 45/20 (OPC+50% GGBS)	45	50	0	1.48

Results

- Results of 45/20 Concrete





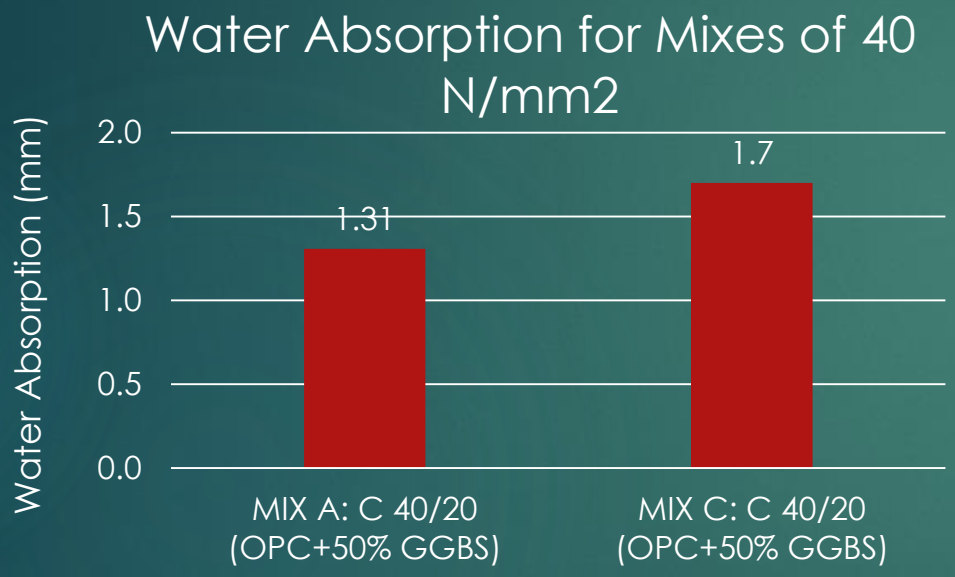
Results

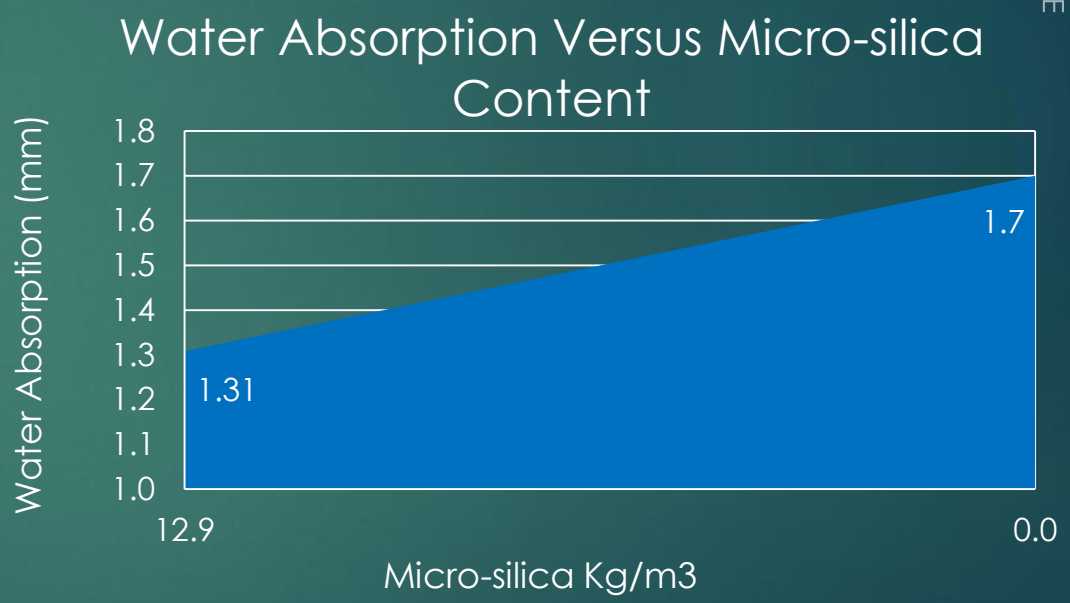
- Results of 40/20 Concrete
- Same observation for 40/20 concrete
- Addition of micro silica significantly reduce water absorption even at the same amount of GGBS

Mixes	Concrete Strength (N/mm^2)	GGBS (%)	MS (kg/m^3)	Water Absorption (mm)
MIX A: C 40/20 (OPC+50% GGBS)	40	50	12.9	1.31
MIX C: C 40/20 (OPC+50% GGBS)	40	50	0	1.70

Results

- Results of 45/20 Concrete





Conclusion

- Enhancement of concrete performance and reduction of its impact on the environment is the greatest innovation in cement industry.
- Both goals can be achieved by enhancing concrete durability.
- Minimum water absorption leads to enhanced concrete durability
- Using Micro silica admixture in concrete mix significantly reduce water absorption
- Such enhanced concrete mixes can be used in repairing deteriorated concrete structures at a large scale.

Thank You ♥
Any Questions?

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