SELF CONSOLIDATING CONCRETE PREPARED WITH RECYCLED CONCRETE AGGREGATE AND RECYCLED ASPHALT PAVEMENT

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OVERVIEW

Introduction
Objective
Experimental Program
Testing Procedures
Results and Discussions
Conclusions
INTRODUCTION

- Self-Consolidating Concrete — fresh concrete that can flow around reinforcement and consolidate within formwork under its own weight without vibration and that exhibits no defect due to segregation or bleeding.

- It was developed to avoid problems such as honeycombing and segregation due to the incapacity to pour concrete in congested reinforced concrete elements and lack of skilled labors needed to achieve adequate compaction required for concrete durability.

- SCC needs to possess three basic characteristics: high deformability, restrained flowability and high resistance to segregation.
INTRODUCTION

Constituents of SCC:

• Cement
• Aggregate (NCA, FAG, RCA, RAP)
• Water
• Chemical Admixtures (i.e. Superplasticizers, and Viscosity Modifying Agents (VMA)).
• Supplementary Cementitious Materials (i.e. Fly Ash, GGBFS, Silica Fume, etc.)
OVERVIEW

Introduction
Objective
Experimental Program
Testing Procedures
Results and Discussions
Conclusions
OBJECTIVE

To study the effect of replacing the natural coarse aggregate (NCA) by recycled concrete aggregate (RCA) and recycled asphalt pavement (RAP) with different percentages and the partial replacement of cement by high volume SCMs on the fresh, mechanical and durability characteristics of SCC.
CONCRETE MIXES

- 100% NCA, 0% RCARAP
- 75% NCA, 25% RCARAP
- 50% NCA, 50% RCARAP
- 25% NCA, 75% RCARAP

EXPERIMENTAL PROGRAM
- 100% CEMENT, 0% FLY-ASH AND SLAG
- 30% CEMENT, 70% FLY-ASH
- 30% CEMENT, 70% SLAG
- 50% CEMENT, 50% FLY-ASH AND SLAG

- FRESH (SLUMP FLOW, T50, J-RING, SIT)
- COMPRESSIVE TEST AT 3, 14 AND 28 DAYS
- SPLIT TENSILE TEST AT 28 DAYS
OVERVIEW

Introduction
Objective
Experimental Program
Testing Procedures
Results
Summary and Conclusion
EXPERIMENTAL PROGRAM

• Number of Concrete Mixtures = 16
• Water-Cement Ratio (w/c ratio) = 0.4 (constant)
• Coarse Aggregate/Fine Aggregate ratio = 1.02 (constant)
• Crushed Limestone Aggregate (max size of 19 mm)
• RCA (Building Demolition Waste) + RAP
• Well graded local sand
• Type I Portland Cement
• Ground granulated blast furnace slag (S)
• Class C fly-ash (FA)
• Polycarboxylic based High-Range Water Reducing Admixture (HRWRA)
### AGGREGATE GRADATION

![Aggregate Gradation Graph](image)

#### FINE AGGREGATE

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## MIXTURES PROPORTIONS

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<th>% RCA &amp; RAP</th>
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</table>
OVERVIEW

Introduction
Objective
Experimental Program
Testing Procedures
Results and Discussions
Conclusions
TESTING PROCEDURES - FRESH PROPERTIES

SLUMP FLOW AND T50 TESTS:

Slump flow test aims at investigating the filling ability of SCC.
It measures two parameters: flow spread and flow time T50.

Accordance to (ASTM C 1611/ C 1611M-09b, (2009))
TESTING PROCEDURES - FRESH PROPERTIES

SLUMP FLOW WITH J-RING

• The J-ring test aims at investigating both the filling ability and the passing ability of SCC.

• It can also be used to investigate the resistance of SCC to segregation by comparing test results from two different portions of sample.
TESTING PROCEDURES – FRESH PROPERTIES

SEGREGATION INDEX TEST

SCC sample patty left after testing the slump is inspected for visible signs of segregation. A rating from 0 to 3 is assigned based on appearance:

- 0 showing no signs of segregation.
- 1 showing some bleeding water on the surface.
- 2 showing slight mortar halo (<10 MM) and noticeable bleeding.
- 3 showing clear segregation and well-defined mortar halo (> 10 MM) with aggregate accumulation at the center.
COMPRESSIVE STRENGTH TEST

- 100 x 200 mm concrete cylinders at 3, 14, and 28 days were tested.
- The compressive strength testing was performed in accordance with ASTM C 39-11.
- The average compressive strengths of three cylinders were used at each test age to find the final measurement.
- A compression machine with a capacity of 1800 kN was used.
TESTING PROCEDURES - HARDENED PROPERTIES

SPLIT TENSILE STRENGTH TEST

• The specimens were moist cured for 28 days prior to testing.
• Load was applied continuously at a loading rate of 100 to 200 psi/min (689 to 1380 kPa/min)
TESTING PROCEDURES – DURABILITY CHARACTERISTICS

UNRESTRAINED SHRINKAGE TEST

• A 76.2 x 76.2 x 254 mm SCC prism was used from each mixture in measuring the unrestrained (free) shrinkage.
• A Comparator device with a digital gauge was used to measure the unrestrained shrinkage.
• The prisms were moist-cured at room temperature (first 7 days) and air-cured up to 90 days.
OVERVIEW

Introduction
Objective
Experimental Program
Testing Procedures
Results and Discussions
Summary and Conclusion
RESULTS AND DISCUSSIONS

EFFECT OF RCARAP ON THE FRESH PROPERTIES

• Fly ash and slag increase the workability of concrete for all mixtures including those incorporating RCA and RAP.
• All mixtures achieved the minimum requirements for self-consolidating concrete.
### FRESH PROPERTIES

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RESULTS AND DISCUSSIONS

EFFECT OF RCARAP ON THE COMPRESSION STRENGTH

• The compressive strength decreases as the RCA and RAP content increases.

• The compressive strength of control mixtures decreased, by 14%, 23%, and 33% for mixtures with 25%, 50%, and 75% RCA and RAP, respectively.
RESULTS AND DISCUSSIONS

Compressive Strength (Mpa)

- 3 Days
- 14 Days
- 28 Days

Mixes 1 to 16

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IDOT REQUIREMENTS FOR COMPRESSIVE STRENGTH

Illinois Department of Transportation (IDOT) 14-days compressive strength requirements:

- Minimum 14-days compressive strength for concrete used in bridge superstructures is 27.5 MPa.
- Minimum 14-days compressive strength for concrete used in pavements is 24.0 MPa.
- Minimum 14-days compressive strength for concrete used in pavement and bridge patching applications is 22.1 MPa.
IDOT REQUIREMENTS FOR COMPRESSIVE STRENGTH

Compressive Strength (14 Days)
RESULTS AND DISCUSSIONS

EFFECT OF HIGH CONTENT OF SCMs ON THE COMpressive STRENGTH

• Mixtures with FA have the most reduction in strength and the mixtures with both FA and S showed intermediate strength between FA only and S only mixtures after 14 and 28 days.

• The use of high volume SCMs decreases the compressive strength compared to their control mixtures.
RESULTS AND DISCUSSIONS

EFFECT OF RCARAP CONTENT ON THE TENSILE STRENGTH

• As the RCA and RAP content increased from 0 to 75%; the split tensile strength of all mixtures decreased accordingly.

• The maximum tensile strength recorded was 6.2 MPa (899 psi) which corresponds to the control mixture (Mix1) of 100% cement and 0% RCA and RAP, while the minimum recorded was 2.91 MPa (422 psi) which corresponds to (Mix 14) of 70% FA and 75% RCA and RAP.
RESULTS AND DISCUSSIONS

Split Tensile Strength

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[28 Days]
RESULTS AND DISCUSSIONS

UNRESTRAINED SHRINKAGE

• Small shrinkage strains during the first 7 days.

• Drastic jump in its magnitude was observed following the 7th day as the specimens were exposed to normal room temperature.

• Almost linear change in the magnitude of its values until it was almost constant after 90 days.
OVERVIEW

Introduction
Objective
Experimental Program
Testing Procedures
Results and discussions
Conclusions
CONCLUSIONS

COMPRESSIVE STRENGTH TEST

• The compressive strength for the control mixture with 100% cement incorporating 0, 25, 50, and 75% of RCA and RAP at 28-days has increased by 19, 25, 23, and 24.5%, respectively, more than that at 14-days.

• Replacing NCA by 75% RCMAR decreases the compressive strength at 28-days by 69.5%, 60.9%, 64.5%, and 56.8% (Mix 13,14,15,16) compared to mixes with 100% NCA including those with no FA (Mix 1), 70% FA (Mix 2), 70% S (Mix 3), and 25% FA and 25% S (Mix 4), respectively.
CONCLUSIONS

SPLIT TENSILE STRENGTH TEST

• The mixtures with cement replaced by 70% S has more tensile strength than mixtures with 70% FA only and 25% FA and 25% S.

• The tensile strength is significantly higher for mixes (1-4), which correspond to 100% NCA in comparison with those having 25%, 50%, and 75% RCARAP replacement.

✦ Replacing the NCA by RCARAP decreases the compressive and tensile strength of all mixtures.
CONCLUSIONS

UNRESTRAINED SHRINKAGE

- Replacing NCA by RCARAP has resulted in the increase of unrestrained shrinkage.
- The use of SCMs such as FA and S has resulted in the decrease of unrestrained shrinkage.
- The use of 100% Portland cement results in the increase of unrestrained shrinkage.
THANK YOU!!!

QUESTIONS??