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Effect of Recycled Coarse Aggregate on Hardened Properties of Self Compating Concrete

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ABSTRACT: This paper gives you view to study the properties by using Recycled concrete aggregate as partial replacement for natural coarse aggregate on the properties of Self Compacting Concrete (SSC) in hardened state with different proportions. Compressive strength test is done for 7 and 28 days.SCC has favourable characteristics such as high fluidity, good segregation resistance and the distinctive self compactibility without any need for vibration during the placing process and so noiseless construction. The unique characteristics of SCC are a rapid rate of concrete placement with very less time. SCC offers a very high level of homogeneity; minimize the concrete void spaces and have uniform concrete strength and also provides the superior level of finishing and durability of structure. SCC also achieves same engineering properties and durability as traditional vibrated concrete. The use of SCC has gained a wider acceptance in recent years. Recycled aggregates (RA) are produced from the re-processing of mineral waste materials, with the largest source being the construction and demolition waste. In general, the quality of RA is inferior to those of natural aggregates. In experiment, three types of concrete mix were made, where the percentage of substitution of coarse aggregate by recycled aggregate was 0%, 25% and 50% is varied. Determined the influence of different proportion on the performance of concrete made with coarse recycled aggregate from stamp out concrete. The properties analysed in Hardened properties. This paper explains the utilization of Recycled concrete aggregate in properties of Self Compacting Concrete. SCC is type of concrete with very high level of homogeneity; minimize the concrete void spaces and have uniform concrete strength and also provides the superior level of finishing and durability of structure. SCC also achieves all same engineering properties and durability as the traditional vibrated concrete we use on construction. The use of SCC has gained extensive acceptance in recent years.

Keyword: Self compacting concrete (SSC), Recycled coarse aggregate (RCA), Hardened properties, Coarse Aggregate (RA), Compressive strength.

I. INTRODUCTION

Reinforced concrete is one of the most extensively used materials in different types of material. The demand increasing day by day for reinforced concrete structures in the modern society to meet the needs of new developments due to increasing population and new ambitious structural design ideas, the reinforcement in concrete structures is becoming more dense and congregate. The massive and dense reinforcement can raise problems of pouring and compacting the concrete during placing. The concrete must be able to pass the dense rebar arrangement without obstructing or segregating. The design of such type of concrete is very challenging because it have poor placement quality and the lack of good vibratory compaction can lead to the inclusion of voids and loss of long term durability of concrete structures. This has been a concern for engineers for many years due to such type of problem.

SCC has favourable characteristics such as high fluidity, good segregation resistance and the distinctive self compactability without any need for vibration during the placing process and so noiseless construction. The unique characteristics of SCC are a rapid rate of concrete placement which take very less time. SCC offers a very high level of homogeneity; minimizes the void ratio between concrete and have uniform concrete strength and also it provides the superior level of durability and finishing of structure. Self compacting concrete also achieves same type of properties and durability as traditional vibrated concrete. During the last decade, concrete technology has made an extensive use advance through the introduction of self-compacting concrete (SCC). Self-compacting or self-consolidating concrete is a new generation of high-performance concrete. Recycled aggregates (RA) are produced from the re-processing of mineral waste materials, construction and demolition waste are largest source. In general, the quality of Recycled aggregate is almost near to those of natural aggregates we use. The density of the natural aggregate is higher than recycled aggregates and natural aggregate have a lesser water absorption value compared to recycled aggregates. By proper mix design we can obtain the desired qualities for concrete made with Recycled aggregate.

1.1 Self-compacting concrete definition

The British Standard (BS EN 206-9, 2010) defines "SCC is the concrete that is able to flow and compact under its own weight, fill the formwork with its reinforcement, ducts, boxouts etc., whilst maintaining homogeneity".
Other researchers (Ozawa et al., 1989; Bartos and Marrs, 1999; Khayat, 1999) have defined SCC in almost the same terms as a highly flow-able concrete that should meet the following requirements:

- **Flow-ability**: SCC should flow under its own weight and fill all parts of formwork without any external aid Or vibration.

- **Passing ability**: SCC should pass through heavy reinforcing steel bars.

- **Segregation resistance:** SCC should maintain its homogeneity without any migration or separation of its large components (aggregates or/and fibres).

1.2 SCC Mix design Types

Over the last decade, extensive research has been devoted to achieve self-compactability. Three different types of mixes can be distinguished: "Powder- type" by increasing the powder content, "VMA-type" using viscosity modifying admixture (VMA) and "Combined-type" by increasing powder content and using a viscosity agent in consideration of structural conditions, constructional conditions, available material, restrictions in concrete production plant, etc.

Powder-Type SCC

Okamura and Ozawa (1995) proposed a simple mix proportioning system for SCC mix (Figure 2.7). Their main ideas were to fix the coarse aggregate content at 50% of solid volume and the fine aggregate content at 40% of mortar volume. Depending on the properties of mortar, the water to powder ratio is in the range of 0.9-1. This ratio should be carefully selected due to the high sensitivity of SCC to it. The self-compactability is achieved by adjusting the super-plasticizer dosage and the final water to powder ratio. This independent consideration of gravel and sand, results in a relatively high content of paste. The Japanese method has been adopted and used in many European countries as a starting point for the development of SCC (Brouwers and Radix, 2005).

Su and Miao (2003) then developed an alternative method, henceforth referred to as 'the Chinese method' which starts with packing all coarse and fine aggregates, and then filling of the aggregate voids with paste. This easier method can result in less paste and hence saving the most expensive constituents, namely cement and filler. With this method, concrete with normal strength is obtained, while in Japanese method a higher strength than actually required can be attained (Brouwers and Radix, 2005).

VMA-type SCC

By adding a high dosage of VMA to the mix of SCC, plastic viscosity can be controlled and increased without adding extra powder. To achieve flow-ability using this method a higher amount of super-plasticizer or higher water-powder ratio is required compared with the powder-type method.

Combined-type SCC

This type of mix was developed to improve the robustness of powder-type SCC by adding a small amount of VMA. In such mixes, the VMA content is less than that in the VMA-type SCC and the powder content and water to powder ratio are less than those in the powder-type SCC. The viscosity is provided by the VMA along with the powder. This type of SCC was reported to have high filling ability, high segregation resistance and improved robustness (Roziere et al., 207).

1.3 RECYCLED CONCRETE AGGREGATE

Recycled concrete aggregate (RCA) is a construction material, which is being used in the Canadian construction industry more frequently than it was in the past. The environmental benefits associated with RCA use, such as reduced landfilling and natural aggregate (NA) quarrying, have been identified by industry and government agencies. This has resulted in some incentives to use RCA in construction applications. Some properties of RCA are variable and as a result the material is often used as a structural fill, which is a low risk application. The use of RCA in this application is beneficial from an overall sustainability perspective but may not represent the most efficient use of the material. Efficient use of a material means getting the most benefit possible out of that material in a given application. The initial step in efficient material use is evaluatinghow a material affects its potential applications. In the use in concrete as a coarse aggregate case of RCA, this includes RCA is made up of both aggregate and cement mortar from its original application. Its make-up results in absorption capacities, which are higher than NA. Its high absorption capacity indicates that RCA can retain a relatively large proportion of water. Internal curing of concrete is the practice of intentionally entraining reservoirs of water within concrete. This water is drawn into the cement at a beneficial point in the cement hydration process. This water allows for a more complete hydration reaction, less desiccation, a less permeable concrete pore system, and less susceptibility to the negative effects of poor curing. The potential for RCA to act as an internal curing agent was evaluated in this research.

II. LITERATURE REVIEW

Grdic et al. designed three types of mixes with the incorporation of 0%, 50% and 100% of CRA. The type of cement used was CEM/II/B-M 42.5N maintaining a constant quantity of 409.6 kg/m3. The water absorption of the recycled aggregate was 5.08%, and the SP ratio was kept constant (0.7% relative to the weight of cement) and the water content was adjusted, increasing with the substitution ratio.

Safiuddin et al.designed five types of mixes with substitutions of 0%, 30%, 50%, 70% and 100% of CNA with CRA. They employed CEM Type I, with a weight per m3 of 342 kg/m3. The W/C ratio and the content of SP are constant in all the mixes, 0.60W/C and 1.50% respectively. The water absorption of the recycled aggregate used was 1.32%.

Tuyan et al. Design four types of mixes with substitutions of 0%, 20%, 40% and 60% of CAN with CRA. The cement was class C with a content of 315 kg/m3. The W/C ratios are used, 0.43, 0.48 and 0.53. The SP content was adjusted in relation to the percentage of replacement from 0.95% to 1.97% of the cement weight. The water absorption of the recycled aggregate was 4.80%.

Modani et al. studied six types of mixes with substitutions of 0%, 20%, 40%, 60%, 80% and 100% employing a Grade 53 cement with 348 kg/m3. The W/C ratio was 0.53. The SP was adjusted in relation to the replacement ratio from 1.3% to 1.58% of the cement weight. The water absorption of the recycled aggregate used was 5.64%.

Pereira de Oliveira et al. designed four types of mixes with substitutions of 0%, 20%, 40% and 100% of CNA with CRA employing two types of recycled aggregates, using CEM I 42.5-R at 284.9 kg/m3. The W/C ratio was 0.56 and 0.57. The SP was adjusted in relation to the replacement ratio from 1.19% to 2.10% of the cement weight. The water absorption of the two used recycled aggregates was 4.10% and 4.05%.

Khayat, 1999 – Main quality of self compacting concrete is Stability and flow-ability are. That we can achieve by limiting the coarse aggregate content, the reducing water-powder ratio and maximum aggregate size together with using super-plasticizers (SP) (Okamura et al., 1998). At the time transportation and placement of SCC the increased flow-ability may cause bleeding and segregation which can be overcome by enhancing the viscosity of concrete mix, this is usually supplied by using a high volume fraction of paste, by limiting the maximum aggregate size or by using viscosity modifying admixtures (VMA).

Lewis et al., 2003; Domone and Illston, 2010 - The most common recycled concrete material used are ground granulated blast furnace (GGBS), micro-silica or silica fume (SF) and pulverised fuel ash or fly ash (FA). All CRMs have common features like; their particle size is smaller or the same as Portland cement particle and they become involved in the hydration reactions mainly because their ability to exhibit pozzolanic behaviour. By themselves, pozzolans which contain silica (SiO2) in a reactive form, have little or no cementitious value. However, in a finely divided form and in the presence of moisture they will chemically react with calcium hydroxide at ordinary temperatures to form cementitious compounds.

Uysal and Sumer, 2011; Boukendakdjia et al., 2012; Dinakar et al., 2013 - Ground granulated blast-furnace slag is a by-product from the blast-furnaces used to make iron. It has been used in many countries around the world by achieving many technical benefits in construction industries.

Russel, 1997 - Adding Ground granulated blast furnace to self-compacting concrete offers many advantages related to increasing its workability, compactibility and retaining it for a longer time, while protecting cement against both sulphate and chloride attack. Because GGBS has 10% lower density than Portland cement, replacing an equal mass of cement by GGBS will result in a larger paste volume, which substantially increases the flow-ability and segregation resistance.

Oner and Akyuz, 2007 - In their experiments on 32 different mixtures of SCC containing ground granulated blast furnace, indicated that increase in GGBS content, decreases water-to-binder ratio for the same workability and thus GGBS has a positive effect on the workability. They proved further that the strength gain is better when we use more steady concrete than GGBS made with only cement with the same binder content. Although it give lower strength at starting but as we increases curing period, the strength increase was higher for the GGBS concretes. The reason is that the slow pozzolanic reaction and that the formation of calcium hydroxide requires time.

Siddique and Khan, 2011 - Silica fume performs roles in concrete for two purpose, for Pore-size refinement and matrix densification: The presence of silica fume in the Portland cement concrete mixes causes considerable reduction in the volume of large pores at all ages. It basically acts as filler due to its fineness and because of which it fits into the spaces between grains.

Duval and Kadri, 1998 - The influence of micro-silica on the workability and compressive strength of concretes. He was found that if micro-silica increased the compressive strength at most by 25%, but the workability of concretes was best when its content was between 4%
And 8%. However, Duval and Kadri (1998) found out that if micro-silica exceeds 15% of the cementitious material, both compressive and tensile strengths are reduced.

III. MATERIALS AND EXPERIMENT

3.1 Materials

Cement: 53 grade Ultratech cement is used for all proportions SSC mixes. Specific gravity for cement is 3.12. Fineness modulus is 1%.

Fine Aggregate (FA): From IS sieve 4.74 passed is used. It is obtained from locally existing river sand, Specific gravity 2.54, Fineness modulus is 2.405, and water absorption is 0.806%.

Coarse Aggregate (CA): Coarse aggregate of 12.5mm down size is used. Specific gravity 2.75, Fineness modulus 7.84, water absorption 0.65%.

Recycled coarse aggregate (RCA): Construction dumped material at site is used. RCA is also 12.5mm down size is used. Specific gravity 2.56, Fineness modulus 8.09, water absorption 0.8%.

Superplasticizer (S.P): polycorboxylate based supeplasticizer is used. Quantity is 2% of cement material.

Viscosity modifying agent (VMA):VMA is added in a small dose of 0.3 per cent by weight of the binder content.

Fly ash: Specific gravity 2.1.

3.2 Mix design

Nan Su is the name of a scientist who initially introduced the mix design on SSC, based on that I collected the all required materials for experimental work and tested accordingly with many trial. Tests are conducted on fresh properties of SSC Slump flow, J-ring, V-funnel, L-box. Water cement ratio is 0.55. SSC is design for M25.

Table – 1: Mix proportions

Volume ratio of fine aggregate to total aggregate is 54%.

	Cement (kg)	FA (Kg)	CA (Kg)	RCA (Kg)	Flyash (Kg)	Water (Kg)	S.P.	VMA
RC0	300	895.1	604.6	-	167.5	240.4	9.35	0.72

RC25	300	895.1	453.45	151.15	167.5	240.4	9.35	0.72
RC50	300	895.1	302.3	302.3	167.5	240.4	9.35	0.72

3.3 Experiment

Density

The measurement of the density of the hardened concrete at the time of testing was performed in order to gauge the in-batch variability of the concrete. Outliers in density may be related to improper casting and could represent reason to disregard certain results.

All samples were cast in accordance with the procedures outlined in CSA A23.2-9C, and therefore each sample was a cylinder in shape. Prior to performing each hardened concrete testing procedure, the volume and mass of each sample were measured and recorded in order to calculate density. The volume was calculated based on measurements of sample dimensions taken using digital callipers.

Compressive Strength

Compressive strength of each sample was performed in accordance with CSA A23.2-9C (CSA, 2009). After casting and curing, each specimen had its bearing faces smoothed using a mechanical grinding machine. Following grinding, the dimensions of each cube (width and height) were measured and recorded. These measurements were used to calculate the actual area of the compression face of the concrete as well as to ensure that the cylinder adhered to the height-to-diameter ratio required for this test. No samples were found to have a ratio lower than 1.8:1 and therefore no corrections were necessary.

Those specimens that were moist cured prior to testing were maintained in this moisture condition until testing was performed.

Testing was performed on the compressive strength testing machine, which is shown in Figure 1. The machine consisted of a lower bearing block that moved vertically to impart load on the specimen, and an upper bearing block, which was spherically seated to allow for rotations to engage the entire surface of the specimen. The upper bearing block was attached to a digital load cell, which recorded the compressive load being applied to the sample.

The loading rate of the sample was maintained between 0.15 MPa/s and 0.35 MPa/s. Once the sample was observed to fail, the maximum load resisted by the sample (in kN) was recorded. This value was used with the measured diameter to calculate the maximum compressive strength of the specimen.

The failure type for each specimen was recorded, and a visual assessment was performed in order to gauge whether the failure plain within the concrete passed largely through the aggregate or the cement matrix.

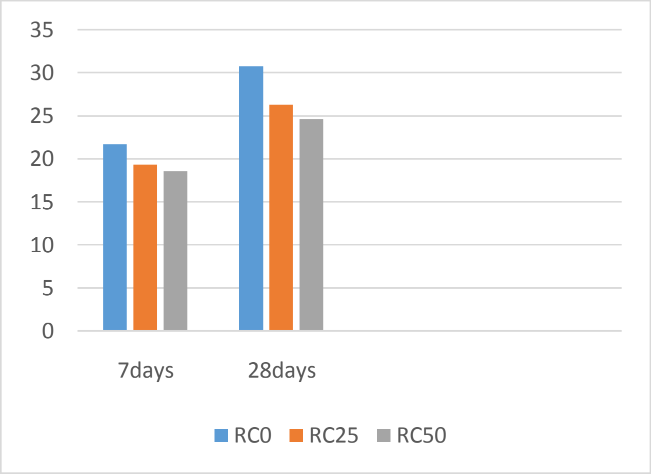
Three specimens for each mixture/age/curing condition were tested and the average of the three results was used as the compressive strength.

Fig-1: Compressive strength testing machine

IV. RESULT

Mixture designation	Average compressive strength	
	7days (Mpa)	28days (Mpa)
RC0	21.64	30.72
RC25	19.32	26.23
RC50	18.51	24.62

Chart-1: Compressive strength



V. CONCLUSIONS

To embark onto an innovative idea can be costly, sluggish and carry a high risk. There-fore, new environmental legislation could also be devised to support companies which are investing in recycled concrete. As seen above, EU policies already strongly encourage the reuse of waste materials to reduce environmental impacts. What is needed now is to find practical ways of turning this idea into reality. To achieve that, there is a need to continuously adapt regulations into facilitating the processes of turning waste material back into an applicable product.In the future, it would be worthwhile to perform Life Cycle Assessments on RA with a view to establish if the use of RA provides a more sustainable approach to concrete production. Recycling per se cannot be taken as the ultimate solution. There must be enough legitimate evidence that prove and ensure that incorporating waste into concrete actually contributes to environmental protection and is economically viable. For example, it may not be sustainable to collect, treat and transport RA from long distances to the end use site if there are aggregates available nearby.

As per above study following are the conclusion-

1.The strength investigation shows that, in all the mixes compressive and tensile strength has inverse relationship with percentage of recycled coarse aggregate. This is a consequence of adhered mortar attached to recycle aggregate contributing for weaker interfacial transition zone.

2. It was observed that the mixes containing recycled aggregate gains quick early strength due to presence of partially hydrated cement adhered to aggregate which accelerates the hydration process.

3. All the mixes having recycled aggregates have higher permeability values, which is a consequence of high initial water absorption of RCA.

4. Concrete mixes up to 40% RCA have shown good resistance to acid attack and chloride
Penetration.

5.It is possible to attain an SCC with recycled aggregates. SCC was produced with this C&DW as aggregate within the proportions recommended by EHE-08 of 20% substitution and above 50% and 100% with minimal loss in the properties. The SP content needs to be increased as RCA content increases, so CC concrete contains 0.8% of the weight cement, Mix 20 contains 1%, Mix 50 contains 1.2%, and Mix 100 contains 1.35%.

6. There is a significant potential for growth of recycled aggregate as an appropriate and green solution for sustainable development in construction industry.

7. Self compacting concrete made with recycled aggregates have achieved the target strength in all the mixes and also satisfied the fresh state properties required for SCC as per EFNARC specification.

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