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COMPARISON OF SELF COMPACTING CONCRETE USING RECYCLED AGGREAGTES & NORMAL AGGREGATES

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ABSTRACT

Self- compacting concrete or self levelling concrete is a high performance concrete which flows through restricted sections under its own weight without any segregation and bleeding and does not require any external vibrator. Self-compacting concrete utilizes the waste materials like fly ash, silica fume, blast furnace slag etc. and thus helps in sustainable development. The primary aim of this research is to develop self-compacting concrete using recycled aggregates (a technology for sustainable development). Recycled aggregates were produced by hammering the concrete blocks obtained as a waste from the demolished residential building. The methodology used to obtain self-compacting concrete was same as that recommended by Okumara (2003). The research consists of: i) development of recycled aggregates from Construction & Demolition waste, ii) selecting suitable mix proportions for Self compacting concrete based on previous researches, iii) casting of concrete samples using recycled aggregates, iv) casting of concrete samples using conventional aggregates, v) comparing the fresh state and hardened state properties of concrete samples. It was observed that fresh state properties of Self compacting Concrete using recycled aggregates (SCCRA) were within the EFNARC standards and the compressive strength of SCCRA was slightly less than self-compacting concrete containing normal aggregates (SCCNA). There is significant potential for growth of recycled aggregates as an appropriate and green solution for sustainable development in construction industry

Keywords: Self-Compacting Concrete, Construction & Demolition Waste, Recycled Aggregates

I. INTRODUCTION

Self-compacting concrete or self levelling concrete is a high performance concrete which flows under its own weight through restricted sections without segregation and bleeding and does not require any external vibration for consolidation. Self-compacting concrete completely fills the formwork and achieves full compaction even in the presence of heavily congested reinforcement mesh. The process of producing self-compacting concrete is same as that of normal conventional concrete, but its production requires suitable selection of finely ground cementitious materials and aggregates along with proper water powder ratio to maintain its workability without bleeding and segregation. Proper selection of finely ground aggregates enhances the packing density of solid particles and enables the reduction of water demand. For producing self-compacting concrete incorporation of

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highly finely ground powder (fly ash, silica fume) is necessary to enhance the slump and cohesiveness. Further water reducing admixtures and viscosity modifying agents are also used in producing self-compacting concrete. The material cost of self-compacting concrete is more as compared to normal conventional concrete because of high demand of cementitious materials and chemical admixtures. The chemical admixtures named as super plasticizers or High Range Water Reducing Admixtures (HRWR) reduce the water demand and thus help to achieve the desired flow ability of concrete at minimum water content. To avoid the segregation of materials, Viscosity Modifying Agents (VMA) are also incorporated.

Recycled aggregates are the aggregates obtained from recycling of construction and demolition waste. The construction and demolition waste consists of cement concrete, bricks, cement plaster as major components while the minor component include steel components (Galvanised iron pipes/iron pipes), electrical fixtures, panels, glass etc. For producing good quality recycled aggregates cement concrete is used. The recycled aggregates obtained from cement plaster and bricks cannot be used for structural applications.

II. NEED FOR RECYCLING C AND D WASTE

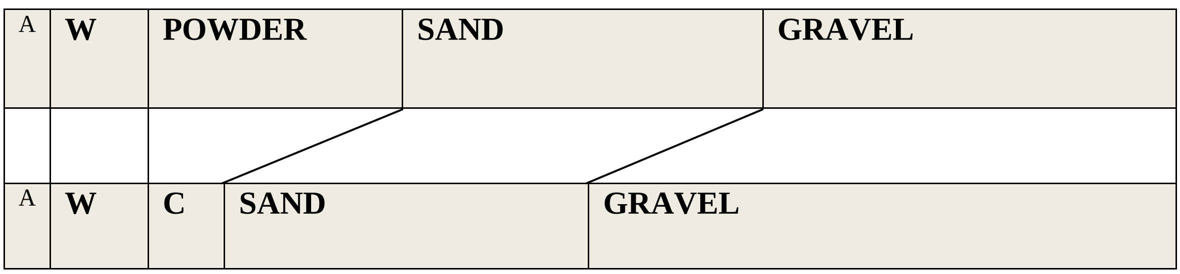
Stringent anti-pollution and environmental regulation acts have been passed by the State & Central government of India, for conservation of natural resources and dumping of demolition waste. It is estimated that construction industry in India generates about 10-12 million tonnes of waste annually (2010 reports by Indian Concrete Institute and Central Public Works Department). In recent survey, the Construction & Demolition waste generation jumped to 14.7 million tonnes, of which 50% is concrete and brick waste, which needs to be dumped somewhere. The dumping of C and D waste requires large landfills and dumping sites, but unfortunately there has been considerable decline in the availability of dumping sites in India as well as in other parts of the world. Considerable decline in the availability of good quality natural aggregate in the vicinity of construction site and easy availability of recycling technology has laid obligations on mankind to recycle the construction and demolition waste.

III. MECHANISM FOR ACHIEVING SELF-COMPACTING CONCRETE

The mechanism how to achieve self-compacting concrete has been well explained by Okumara (2003). As per Okumara self compactibility can be achieved by:

i) Limiting the coarse aggregate content and size
ii) Low water powder ratio
iii) Use of super plasticizers

Self-compacting concrete



Conventional Concrete

Figure1: Comparison of Mix Proportioning Between SCC & NC

The paper presents experimental program and shows the effect of recycled aggregates on the fresh and hardened properties of self-compacting concrete.

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IV. MATERIALS

Ordinary Portland Cement of 43 grade was used to carry out the research work. Some of the selected properties of cement are presented in Table 1.Tape water was used for all mixtures. The pH of water was found out to be 6.5. Natural river sand of zone II was used as fine aggregate.The recycled aggregates were produced by hammering/jaw crushing the concrete blocks obtained as a demolished waste from residential building. The maximum size of aggregates was limited to 12.5 mm. Master Genelium 8362 was used as high range water reducing admixture.

Table 1: Specification of Cement

Property	Range of Values
Normal consistency	33%
Initial setting time	30 minutes
Final setting time	5.5 hours
Specific gravity	3.65

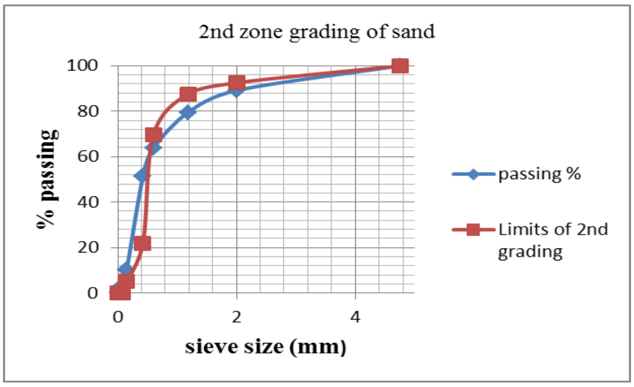


Figure: 2 Grading of Sand

V. MIX PROPORTIONS & SPECIMEN PREPARATION

For experimental work eight mixes of concrete were made. The proportions of the concreting materials have been fixed keeping in the view the rational mix design proposed by Okumara (2003) that is limiting the coarse aggregate content and using low water powder ratio. The coarse aggregate content was fixed to be less than 50 percent. The water powder ratio to be used for first mix was kept 0.60 with super plasticizer dosage of 0.15% of powder content. Two separate mixes with same proportions were made but in one recycled aggregates were used while in other crushed stone aggregates were used. Similarly other mixes were prepared at varying water power ratios and super plasticizer dosage, using recycled and crushed stone aggregates separately. The detail of the mix design is shown in Table 2.

Table: 2 Detail of Mix Design

	MIX	C Kg/m^3	S Kg/m^3	C.A (kg/m^3) 4.75-10 mm	10 mm	12.5 mm	Fly Ash Kg/m^3	S.F Kg/m^3	w/p	S.P (%)
1	SSC1RA	485	970	223.1	167.3	167.3	145.5	-	0.6	.15
2	SCC2FA	485	970	223.1	167.3	167.3	145.5	-	0.6	.15
3	SCC3RA	485	970	223.1	167.3	167.3	145.5	-	0.52	.18
4	SCC4FA	485	970	223.1	167.3	167.3	145.5	-	0.52	.18
5	SCC5RA	485	970	223.1	167.3	167.3	-	72.7	0.44	1.8
6	SCC6FA	485	970	223.1	167.3	167.3	-	72.7	0.44	1.8
7	SCC7RA	485	970	223.1	167.3	167.3	-	72.7	0.35	1.8
8	SCC8FA	485	970	223.1	167.3	167.3	-	72.7	0.35	1.8

C: Cement, S: Sand, C.A Recycled Coarse Aggregate, S.F: Silica Fume, S.P Superplasticizer.

VI. TEST METHODS

The entire experimental work was divided into three parts:

i) Tests on recycled aggregates

ii) Fresh state properties

iii) Hardened state properties

6.1 TESTS ON RECYCLED AGGREGATES

The recycled aggregates obtained from the 35 year old residential building were tested for various properties. The test results are tabulated in the Table 3.

Table 3: Specification of Recycled Aggregates

Property	Range of values
Specific gravity	2.62
Water absorption	5.35%
Crushing strength	27.85%

6.2 FRESH STATE AND HARDENED STATE PROPERTIES

To check the flowing ability and passing ability of self-compacting concrete, various tests were performed in its fresh state. The fresh state tests include slump flow test, T_{50cm} flow test, L-box test.Later compressive strength test was performed on the hardened concrete cubes after 7 days and 28 days. The fresh state test results, hardened state test results of self-compacting concrete using recycled aggregates and normal aggregates are tabulated in Table 4 and Table 5 respectively. It was found that the fresh state properties were within the acceptability criteria laid by EFNARC.

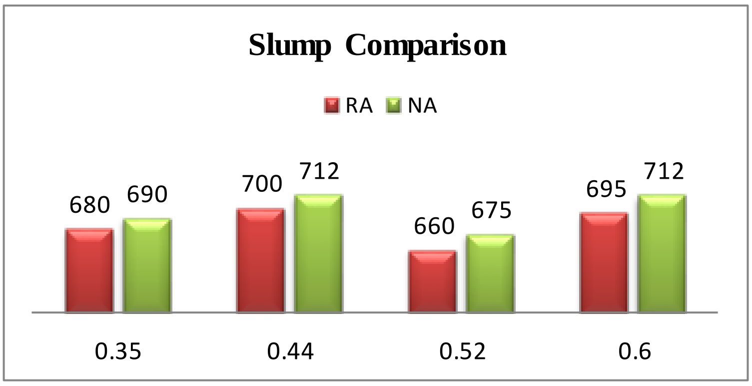
Table: 4 Results of SCC Using Recycled Aggregates

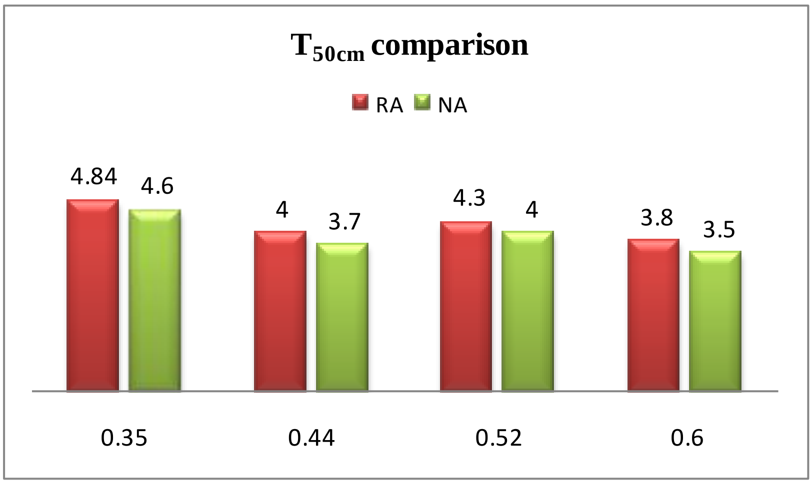
Sr. No	Mix	Slump (mm)	T_{50cm} (Sec)	H2/H1	Avg. Strength @7days (N/mm^2)	Avg. Strength @28days (N/mm^2)
01	SCC1RA	695	3.8	0.87	13.8	19.8
02	SCC3RA	660	4.3	0.85	18.8	28.8
03	SCC5RA	700	4	0.85	31.11	37.33
04	SCC7RA	680	4.84	0.83	40.88	53.99

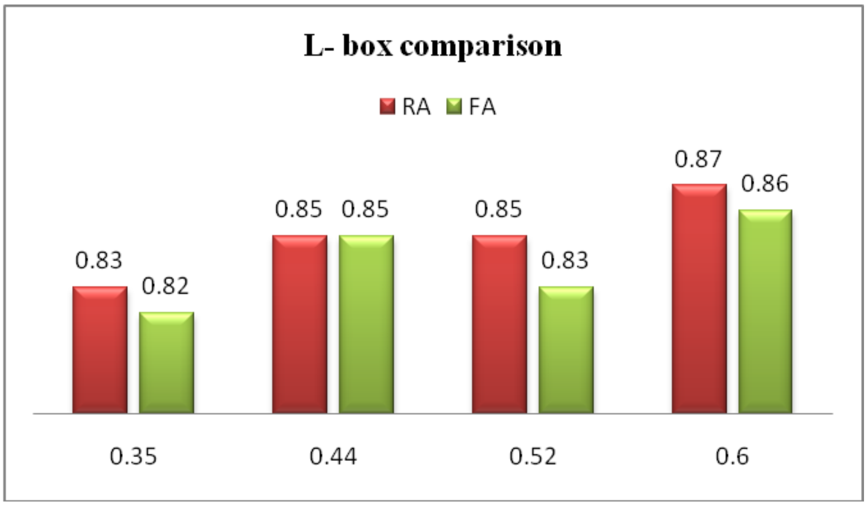
Table: 5 Results of SCC Using Fresh Aggregates

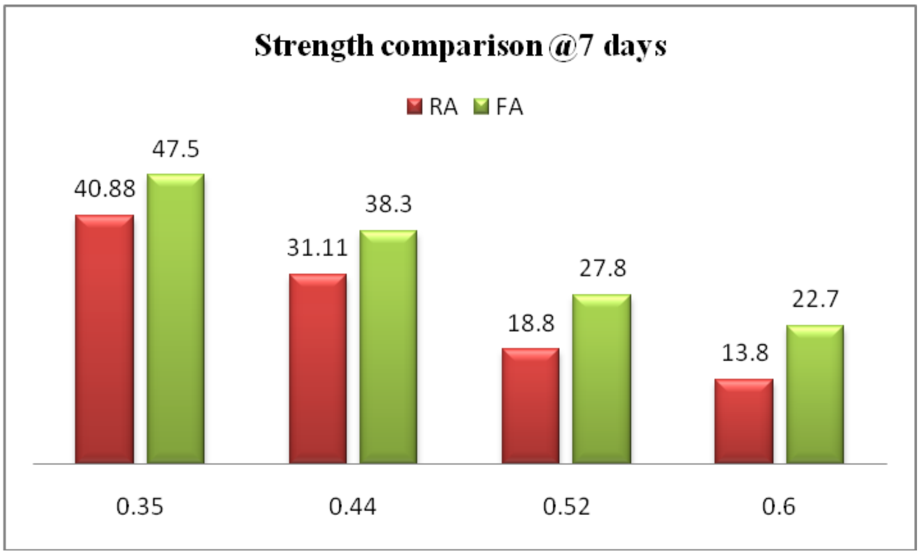
Sr. No	Mix	Slump (mm)	T_{50cm} (Sec)	H_2/H_1	Avg. Strength @7days (N/mm^2)	Avg. Strength @28days (N/mm^2)
01	SCC2FA	712	3.5	0.87	22.7	28.8
02	SCC4FA	675	4	0.83	27.8	33.7
03	SCC6FA	712	3.7	.85	38.3	41.5
04	SCC8FA	690	4.6	.82	47.5	61.8

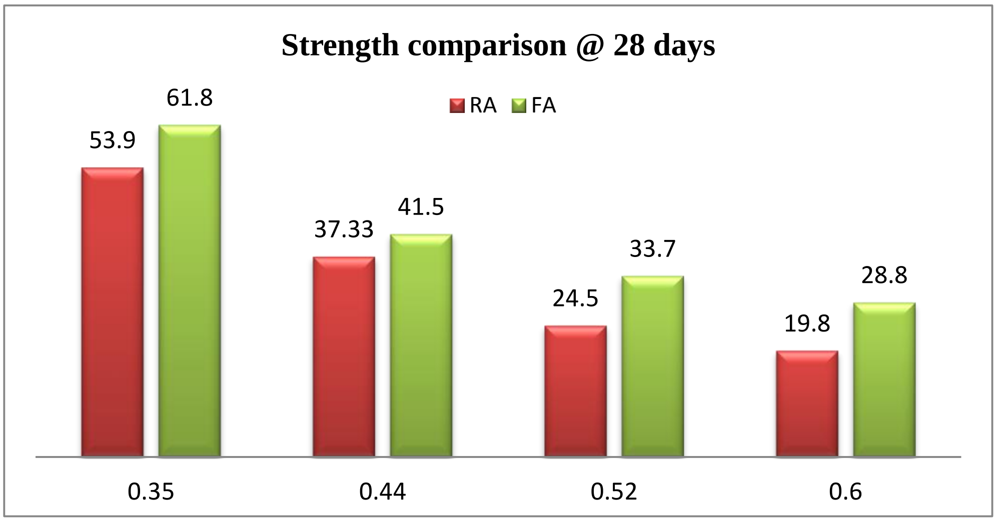
VIII. COMPARISON OF RESULTS











FA/NA: Normal or Fresh Aggregate, RA: Recycled Aggregates.

VIII. DISCUSSION OF RESULTS

7.1 Slump Flow and T_{50cm}Time

The slump flow of SCCRA (self-compacting concrete containing recycled aggregates) was less than that of SCCNA (self- compacting concrete containing normal aggregates) because of higher water absorption of recycled aggregates. Experimentally it was found that water absorption of recycled aggregates was 5.35%, while that for normal aggregates the water absorption was found out to be 0.77%. The increase in water absorption of recycled aggregates occurs due to coating of cement mortar over the aggregate particles.

7.2 L-Box Value

The L box value of SCCRA was almost same as that of SCCNA having same mix proportions. This is preferably because of nearly same specific gravity, same coarse aggregate content and same size of aggregate particles. The specific gravity of Normal aggregates is slightly higher than that of recycled aggregates.

7.3 Compressive Strength Results

The compressive strength of each mix increased with the decrease in water powder ratio. This validates Abram's law. Further the compressive strength of SCCRA corresponding to compressive strength of SCCNA was found lower by 15-20%. This is preferably because of higher crushing value of recycled aggregates. Experimentally it was found that crushing Value of recycled aggregates used for the project was 27.87% in contrast to the crushing value of normal aggregates, which was found out to be 22.8%.For 30% replacement of fly ash with 15% silica fume, and by reducing the water content from 0.5 to 0.42, there was sharp increase in the compressive strength. As per research work conducted by Heba (2011), the compressive strength of concrete increases by 12% if 15% of the cement is replaced by fly ash instead of 30% fly ash replacement. As per the research work conducted by Aggarwal (2008), the compressive strength of the SCC mixes increased from 25 Mpa to 31.54 Mpa, by reducing the water content from 0.41 to 0.40.

VIII. CONCLUSION

The slump flow and T_{50cm} of all the mixes was between (650 mm to 850 mm) and 3-5 seconds respectively, hence all mixes conforms to the criteria laid by EFNARC (2002). However for a particular Water powder ratio the slump flow for SCCRA was lesser than the slump flow for SCCNA. This is because of the higher water absorption of recycled aggregates.The L- box value or the blocking ratio for all the mixes was between (0.8 to 1.0), hence all the mixes conform to the criteria laid by EFNARC.The compressive strength of SCCRA (self-compacting concrete with recycled aggregates) was lower than SCCNA (self-compacting concrete with normal conventional aggregates) by 15-20%. This is mainly because of higher crushing value of Recycled aggregates. The compressive strength of the mixes was higher for 15% replacement of cement with silica fume instead for 30% replacement of cement with fly ash. This conforms to research work done by Heba (2011). The compressive strength of all the mixes increased with the reduction in water powder ratio and thus validates Abram's law and the research done by Aggarwal (2008).There is significant potential for growth of recycled aggregates as an appropriate and green solution for sustainable development in construction industry.

IX. FUTURE SCOPE

Already a rational mix design and an appropriate acceptance testing method at job site have been established for self-compacting concrete, thus the main obstacle for its wide has been solved. The next task is to promote rapid diffusion of the techniques for the production of self-compacting concrete. Self-compacting concrete should be

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treated as standard concrete not special concrete. Rational training and qualification systems for engineers should be established, for the production of self-compacting concrete. Awareness should me made among engineers and general public to recycle the C & D waste. Recycling of Construction and demolition waste must be made mandatory and recycling plants should be established in every part of the country. There should be ISO certification for every recycling plant.

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