

Self Compacting Concrete (SCC) with Recycled Coarse Aggregate-A Review

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Abstract: *Self Compacting Concrete is the type of concrete which does not require vibration at the time of placing and compaction, also it is having the capacity to flow in congested reinforcement under it's own weight.^[5] The idea behind development of Self Compacting concrete is to get higher strength and to decrease the problem of compaction.^[18] Recycled aggregates have the added benefit of reducing landfill disposal, by conserving primary natural resources and reducing transportation costs, help to promote sustainable development in the protection of natural resources.^[5] The use of recycled concrete aggregates from demolition waste and rubble in combination with cementitious additions in concrete has various advantages. From various literature it has been observed that Self Compacting Concrete(SCC) with recycled aggregate meet EFNARC guidelines for fresh properties of concrete and with increase in content of recycled aggregate hardened properties like compressive strength, tensile strength and flexural strength decreases.*

Keywords: EFNARC, recycled aggregate

I. INTRODUCTION

Concrete is widely used construction material around the world. Different types of concrete have been developed to improve various properties of concrete. It has a key role to play in sustainable construction. Since it needs less efforts in it's manufacture. This facts have not only led to many inventions in the field of concrete but have also led to many studies to improve its quality, reducing the cost of implementation and make the concrete environment friendly. In case of heavy reinforcement it is very difficult to make assure that formwork gets fully filled with concrete and it is completely compacted without voids. In such circumstances compaction with manual or mechanical vibrators is quite impossible. Also methods of compaction, vibration causes delays and cost addition in the projects. This problem can be sort out with Self Compacting Concrete (SCC). Self Compacting Concrete is the type of concrete which does not require vibration at the time of placing and compaction, also it is having the capacity to flow in congested reinforcement under it's own weight.^[5] It is having the capacity to flow under it's own weight,

completely filling formwork and achieving full compaction under congested reinforcement also. SCC has characteristics like high fluidity, good resistance to segregation and typical self compatibility without vibration at the time of placing so it will result into noiseless construction.^[20] This innovation which revolutionized the construction sector in 90's by its remarkable efficiency in time and economy management is currently gaining popularity and being used in Indian market and promises to be the future of construction industry.^[2]

II. NEED FOR RECYCLED CONCRETE

Urbanization growth rate in India is very high due to industrialization.^[23] In India for the smart cities there will be the requirement of tones of raw material for the construction of buildings like hospitals, colleges, schools, residential buildings, bridges etc. By using Recycled aggregates we can lower some budget of these smart cities.^[4] Huge land, site and large amount of construction materials are required for fast infrastructure development. Better performance with longer life, less maintenance cost concrete is preferred for large construction. Environment protection is a main factor which is directly connected with the survival of the human. Different factors like natural resource protection, environmental consciousness, sustainable development play a vital role in modern requirements of construction field. Because of modernization, demolished materials are not used for any purpose, that materials are directly dumped on land. Such kind of practice affects the fertility of land.

Use of natural resources in construction affects the cost of project but for the same project if we use recycled resources it can help to decrease cost of project in some extent. As recycling process of concrete saves natural resources it is beneficial for environment also. Effective utilization of waste concrete can be obtained by recycling the waste concrete to the aggregates. For production of concrete, 70-75% aggregates are required. Out of this coarse aggregate is of 60-67% & fine aggregate is of 33-40%. There can be possibility of scarcity for normal natural aggregates in coming years so it will affect concrete construction. Waste concrete can be recycled by a very simple process as breaking, removing and crushing to desired size and quality. Recycled aggregate is not the fresh aggregate, but it is a

hydrated paste of cement which increases the porosity as compare to the porosity of the fresh aggregate. Higher water absorption aggregates occurred in the recycled aggregates because of higher porosity are the main concern to be taken care of while making the concrete using the recycled aggregates^[4]. So recycled aggregate have beneficial for reducing landfill disposal also transportation cost which helps to promote sustainable developments in the conservation of natural resources.

III. LITERATURE REVIEW

Sija K Sam, et.al (2014) studied comparison of Self compacting concrete(SCC) with conventional concrete^[20] Also in this study fly ash is also added in SCC. This is achieved by taking conventional concrete with natural aggregate and 10%,20%,30% replacement of normal aggregate with recycled aggregate. They have prepared M30 concrete grade by following the European guidelines for SCC based on 'Nan Su et al method'. They have used poly carboxylic based super plasticizer named Master Glenium SKY 8233. The investigation of fresh concrete includes Slump flow test, T-500 test, V-funnel test, L-box test and checked hardened state concrete properties by Compressive Strength test, flexural strength test, split tensile strength test and water absorption test. After performing all tests they got results as early age strength of SCC is less as compared to normal vibrated concrete. It was concluded that with additional percentage of RCA in SCC compressive strength get reduced.

Fermy George and Sarah Anil (2018) studied fresh and hardened state properties of Self Compacting Concrete(SCC) by following mix design grade of M30 concrete by replacing 15%,30%,45% of natural aggregate with coarse recycled aggregate and cement is also partially replaced with fly ash and Ground Granulated Blast Furnace Slag.^[5] For fresh concrete properties test such as Slump flow, T 500, V-funnel test, L-box test were conducted and reported test results as per EFNARC guidelines. Also for hardened properties Compressive, Flexural and Split Tensile strength also modulus of elasticity were found and from this test they found that Compressive, Flexural and Split Tensile strength of SCC decreases with increasing amount of Coarse Recycled Aggregate.

Prashant O Modani and Vinod M Mohitkar (2014) investigated the effect of recycled concrete aggregate in self compacting concrete(SCC) with respect to strength, permeability, chloride penetration, acid attack and alkalinity. For this study ordinary Portland Cement(OPC)(53grade) taken ,to increase powder content in concrete silica fume is partially added to cement ,fine aggregate and 12mm coarse aggregate obtained from demolished cube specimen after cube testing taken by checking the

properties of coarse aggregate as per IS383-1970, Polycarboxylic ether polymer superplasticizer of brand named Auramix 400 were used. M30 grade of concrete mix design were used as per EFNARC guidelines and replacement natural aggregate done by 0%,20%,40%,60%,80% and 100% with recycled aggregate. For fresh state properties of SCC they got satisfactory results as per EFNARC guidelines. In case of compressive and tensile strength test they got result as strength decreases with increasing percentage of recycled coarse aggregate(RCA). In case of permeability and alkalinity they were found that as water absorption and PH value increases with increase in the percentage of RCA. SCC with RCA gives good resistance to acid attack and chloride penetration.

Shahil M Bandi, et.al (2016), compared hardened and fresh properties of Self Compacting Concrete(SCC) with Recycled Coarse Aggregate(RCA). They have replaced natural aggregate with recycled aggregate in the proportion of 10%,20%,30% and 40% and Polycarboxylic ether super plasticizer under brand name master glanium SKY 8784 and also in cement 25% of fly ash were added. Result gives fresh properties of SCC as per EFNARC 2005 guidelines and Compressive and Split Tensile Strength of SCC with RCA decreases after 40% replacement of RCA.

Sherif A Khafaga (2014) reported the effect of replacement of natural coarse and fine aggregate with recycled coarse and fine aggregate. This study was conducted in Egypt. 13 concrete mixes were prepared with same mix design. One mix was with total natural aggregate and three mixes were with replacement of 25%,50% and 75% of natural fine and coarse aggregate with recycled coarse and fine aggregate. For testing fresh properties of concrete Slump Flow test, V-funnel test and J-ring test were performed. Guidelines provided EFNARC specification and Egyptian Technical Specification for Self Compacting Concrete (ETSSCC) were followed. Hardened concrete properties like Compressive, flexural and indirect tensile strength were tested. Filling ability, passing ability and segregation resistance result of fresh concrete were satisfactory. As compared to normal Self compacting concrete (SCC) compressive strength, flexural strength and indirect tensile strength values are lower in SCC with replacement of RCA. But still they achieved self compacting property of concrete.

M.Seethapathi et.al(2015)studied about the Self Compacting Concrete(SCC) by replacement of normal coarse aggregate with recycled aggregate with the proportion of 0% to 100% in the interval of 10% and replacing fine aggregate with eco sand(by product obtained from cement manufacturing process) in the same proportion of coarse aggregate. M30

grade of concrete were prepared for the tests. In this study for flow ability Slump flow test, for passing ability L box test and J ring test were performed on fresh concrete and SCC properties were satisfied up to 40% replacement of Recycled aggregate and eco sand. Also Compressive Strength, Split Tensile Strength and flexural strength were conducted on hardened concrete. After testing of hardened concrete they got result as Compressive strength of SCC value of conventional SCC got by 50% replacement of recycled aggregate and eco sand. For split tensile strength they got the result as, strength decreases with increase in the percentage of replacement materials. Also they obtained result in flexural strength testing as by 40% replacement of recycled aggregate and eco sand conventional SCC concrete strength gained. So up to 40% replacement of recycled coarse aggregate and eco sand can be done to get the result as conventional SCC.

Kumar Satish et.al (2017), studied flow ability and strength properties of fly ash induced self compacting concrete with varying percentage replacement of recycled coarse aggregate with natural coarse aggregate. For getting required flow ability they used high range water reducing agent (HRWR) with or without viscosity modifying agent. The results of are as per EFNARC 2005 guidelines. Also compressive strength of concrete are lower as compared to normal SCC. Also minimal reduction of tensile strength also observed in fly ash induced SCC with RCA.

Rafiya Majeed Khan et.al(2015), studied about fresh and hardened properties of Self Compacting Concrete using recycled aggregate with respect to self compacting concrete with normal aggregate. Slump flow, L box test, t50cm test comparison done for fresh properties of concrete and they got results as slump flow value is less because of higher water absorption of recycled aggregate. L box test values are almost same by using recycled aggregate with respect to normal aggregate. Also for hardened concrete compressive strength was tested and obtained result as there is decrease in compressive strength of Self compacting concrete with recycled aggregate about 15-20% compared to SCC with normal aggregate. The reason behind decreasing compressive strength is higher crushing value of recycled aggregate.

K.C.Panda, P K Bal (2013), studied effect of various amount of recycled coarse aggregate (RCA) which are collected from demolished building of about 25 years old on the properties of self compacting concrete (SCC) and compared results with normal vibrated concrete (NVC) which contains 100% natural coarse aggregate. As like other research fresh state of concrete tests were performed by slump flow, V funnel and L box test and hardened properties of concrete like compressive strength, flexural strength

and split tensile strength are examined. M25 grade of concrete mix were used. They concluded with the research that with the increase in percentage of recycled aggregate, strength gets decreases. Also the compressive, flexural and split tensile strength of SCC with 100% normal aggregate is less than NVC with 100% natural aggregate.

Purva P Awari(2017), studied effect of recycled aggregate on self compacting concrete. The research concluded that up to 25% replacement of recycled coarse aggregate is satisfactory to use.

Kamal M M, et.al(2013) examined properties of SCC with recycled aggregate with respect to time. Here in this research crushed red brick and crushed ceramic separately taken as recycled aggregate. Also effect of re tempering process on the compressive strength were determined and research concluded that RSCC mixes with crushed ceramic fulfill the requirement of SCC more than RSCC mixes with crushed red brick. Also in re tempering process the compressive strength of RSCC is slightly higher than the compressive strength after mixing. Research shows that cost of crushed ceramic mixes also decreases as the percentage of crushed ceramic increases and cost of crushed red brick mixes increases with increase in percentage of crushed red brick with respect to control mix.

C. Sumanth Reddy et.al (2013), studied mechanical and durability properties of concrete. For that three different grades of concrete M30, M50 and M70 were made with recycled aggregate in the replacement percentage of 0%, 25%, 50% and 100%. Compressive strength, acid resistance and water sorption test were carried out. Results suggest that with recycled aggregate performance of concrete decreases with increase in the grade of concrete. Also research suggests that it is safer to replace 25% of aggregate with recycled concrete aggregate.

Suhaib Mushtaq (2018) studied fresh and hardened properties of concrete with partial replacement of coarse aggregate in the percentage of 25%, 35%, 45%, 55% and fine aggregate by 10% with addition of steel fibers 0.75% by weight of cementitious material. M30 grade of concrete were used. Research shows that slump flow value decreased with increase in percentage of replacement of cement with glass powder and V funnel time increases with increase in the percentage of replacement of glass powder. With obtained values of slump flow, V funnel and L box research has been concluded that there is decrease in the deformation of mix also relative flow time and thereby higher viscosity. For hardened properties of concrete research suggested that the optimum replacement of aggregates by recycled aggregate with addition of steel fibers is 10% for fine aggregate and

35% for coarse aggregate for self compacting concrete.

Ajit V, Praveen Mathew (2015), studied fresh and hardened properties of self compacting concrete with replacement of normal aggregate with recycled coarse aggregate in the percentage 0%,50%,70% and 100%.Also the effect of polypropylene fibres were examined. As like other research for determining fresh properties of concrete ,Slump flow, V funnel and L box test were carried out and result obtained satisfies the EFNARC guidelines. Loss of strength is also very less and there is no change in fresh and hardened properties of self compacting concrete with addition of polypropylene fibres.

Moslem Mohammadi Jatani, Ali Delnavaz(2017), studied fresh and hardened properties of Self Compacting concrete with percentage replacement of 0%,25%,50%,75% and 100% of normal aggregate with recycled aggregate. As like other research test of fresh properties of SCC such as slump flow, T50 test, V funnel, L box and J ring tests were carried out and results were obtained in accordance with EFNARC guidelines and for hardened properties like compressive strength, electrical resistance capillary water absorption and water penetration under pressure investigated. Result obtained as electrical strength decreases by increasing amount of recycled aggregate. Also with the increasing amount of recycled aggregate increases compressive strength decreases and permeability increases.

Ravi Shanker Yadav, Juned Ahmad (2015), investigated durability and workability characteristics of Self compacting concrete made by regular materials and addition of demolished concrete as partial replacement of coarse aggregate in the percentage replacement of 5%,10%,15% and 20% and to enhance the property of Self compacting Concrete made by demolish concrete glass fiber is added in the replacement of cement with percentage replacement of 0.15%,0.20% and 0.30%.After mixing the value of J ring, V funnel and V funnel at T5 min test were performed to determine passing ability, filling ability and segregation resistance respectively. Hardened properties like flexural strength and compressive strength were determined. The best result obtained in compressive strength with 10% replacement of demolish concrete and 0.20% replacement cement with glass fiber.

Said Kenai, Amina Debbin, Belkacem Menadi, El-Hadj Kadri (2014), studied effect of substitution of natural aggregate with recycled aggregate in the percentage of 50% and 100% on fresh properties of SCC which is made with 15% natural pozzolana. Fresh properties of SCC were determined by using Slump flow, V funnel, L box and U box test. Test results satisfies the EFNARC guidelines. The effect of addition of

pozzolana on both SCC with natural aggregate and recycled aggregate were same. By substituting 15% pozzolana in the replacement of cement causes decrease in workability. The plastic viscosity of SCC mixture decreases with increasing substitution level of natural aggregate with recycled aggregate. Pozzolana improves water retention and gives more homogenous concrete. The passing ability of recycled aggregate by L box test is better than natural aggregate.

Hamed Ahmadi Moghadam, Omolbanin Arasteh Khoshbin(2012), studied fresh properties of SCC such as Slump flow, J-ring, V-funnel L box and hardened properties of Self Compacting Concrete such as compressive strength, tensile strength for 3,7,14,28 ,90 days specimen and modulus of elasticity for 28 days specimen were determined. Also to find out proper w/c ratio different mix designs with different w/c ratios of 0.4,0.45,0.5,0.55,0.6 were casted. At fine aggregate to coarse aggregate ratio 1.13. Fresh properties result were satisfactory. But with decrease in w/c ratio up to 0.45 compressive strength, tensile strength and modulus of elasticity improved. The research concluded that for water cement ratio less than 0.45 and greater than 0.55 are not satisfactory for SCC mix designs.

Prashant O Modani, Vinod M Mohitkar (2015), studied about fresh and mechanical properties of Self Compacting Concrete with the use of coarse recycled aggregate. Fresh properties were tested by slump flow test, t50 slump flow, L box test and V funnel test and for checking mechanical properties, compressive strength, split tensile strength, flexural strength were tested. The result obtained from slump flow ranks all the design mixtures in the SF1 and SF2 class as per EFNARC guidelines. T50 slump flow result came under the class VS2 as per EFNARC and V funnel results came under the class VF1 which is an indication of good filling ability in congested reinforcement. Also L box test results meet the criterion of EFNARC and ranked under PA2 class which is suitable for densely reinforced structures. M40 grade of concrete were prepared with recycled aggregate replacement in the percentage of 0%,20%,40%,60%,80%,100%. The inverse relation were obtained in compressive strength, split tensile strength and flexural strength results as percentage of RCA increased strength get decreased.

IV. CONCLUSION

It has been seen from various research that Self Compacting Concrete (SCC) by using recycled aggregate achieves workability requirements as per EFNARC guidelines. The results obtained from various studies apparently indicate that Compressive , Flexural and Split tensile strength decrease with increasing amount of recycled aggregate. Also with the decrease in w/c ratio up to 0.45, the test results of compressive strength, tensile strength and modulus of

elasticity are found to be satisfactory. It is also reported that electrical resistance of specimens decrease with increasing amount of recycled aggregate.

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