Preparation of Cost Analysis Based on The Study of Fresh And Hardened Properties of Self Compacting Concrete Using Recycled Bituminous Road Aggregates

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Abstract- *Self-consolidating concrete or self-compacting concrete (SCC) has high application in congested reinforcement members where good workability is required. Self-compacting concrete is normally being applied for industrial structure and high rise construction. This paper intends to evaluate the influence of different amount of recycled bituminous road aggregate (RBRA) on fresh and harden properties of SCC. Natural coarse aggregate (NCA) is partially replaced with RBRA by an amount of 0%, 20% and 40% and results were recorded. The study was conducted to find out the amount of NCA that can be replaced by RBRA and also to investigate the effect on SCC with cement and fly ash combination. The effect of RBRA on properties of SCC in fresh state was studied with slump flow test, V-funnel test, L-box test and J-ring test and properties in harden state was studied with compressive strength test. The mix design was carried out for M25 grade of concrete. Curing of concrete was done for 7 days, 28 days and 60 days. The result obtained showed that SCC can be best achieved with paste content ranging from 0.39 to 0.43. All mixes of SCC with different replacement ratio satisfied the recommended limits of SCC in fresh state. The experimental results indicates that the compressive strength is less for concrete with recycled aggregate when compared to concrete with natural aggregates. It was found that as replacement ratio of recycled aggregates increases, compressive strength also increases. The present study recommends that the SCC with volume of paste 0.41 and 20% replacement ratio is successful and can be used for construction work.*

Keywords- Natural coarse aggregates, Recycled bituminous road aggregates, Fresh properties, Harden properties.

I. INTRODUCTION

Concrete is one of the most widely used material in construction industry and is generally related with Portland cement as main ingredient. Demand for concrete in construction industry is increasing day by day and new experiments are being conducted every day in order to increase the strength and properties of concrete. Various admixtures and reinforcement are added to achieve the finished product with desired properties. The mixture of cement, sand, coarse aggregate and water is used to produce material that can be moulded into any shape. Aggregate comprises of about 65-75% of total volume in concrete. With time cement binds up all the material together and forms a hard matrix to form a stone like material. Many development have took place in the field of concrete with the passage of time out of which self-compacting concrete is the one.

SCC is a concrete with excellent segregation resistance and deformability and was first developed in japan in 1980. It can easily flow under its own weight and can completely fill up the spaces in formwork within congested reinforcement. SCC provides a high level of homogeneous mix, minimizing the void spaces and have uniform concrete strength to provide superior level of finishing and durable structure with noiseless construction. The use of SCC has gained more and wider acceptance in recent years and is being used for many different purpose which includes construction of bridges, precast bridge members, pavement repairing work etc. use of SCC increases construction speed, provide good quality concrete witout segregation and air loss, reduses energy and cost of labour and helps in minimizing environmental impacts.

In developing countries, construction activities are increasing at a very faster rate and so is the consumption of raw materials. Every year thousands of kilometres of new roads are constructed and maintenance of these old and new roads is carried out at a vast scale. Most of this pavement material is being reused to construct new roads specially top bituminous layer, but rest is discarded and is used as landfill material. Many new technologies have been developed to recycle these construction and demolished waste and bituminous pavement waste and to reduce the cost of natural aggregates. Recycling of bituminous aggregates started way back in 1915 when prices of bitumen binder increased rapidly. Many methods, strategies and technologies were employed in order to recycle the bituminous pavement and lower down the binder prices. Many practices are still in use to recycle aggregates in pavement construction and rehabilitation. Economic benefits can be achieved by replacing some percentage of fresh aggregates with recycled aggregates, resulting in lowering the overall cost of materials and project.

II. EXPERIMENTAL PROGRAMS

A. Materials

The following materials were used for experimental study :

- Ordinary Portland cement of 53 grade confirming to requirements of IS 8112 (Part II) with specific gravity of 3.1, three days compressive strength of 27 Mpa and fineness of 296 m^2/kg was used for experimental purpose.
- In order to reduce amount of cement in the mix, fly ash with specific gravity of 2.15 and fineness 370 m^2/kg was used.
- Natural crushed angular aggregates with nominal size of 20mm, confirming to requirement of IS 2386, having specific gravity of 2.7 and water absorption of 5% was used for the study.
- Zone II manufactured sand or robo sand confirming as per IS 2386 with specific gravity 2.6 and water absorption 4% was used for experiment.
- Recycled bituminous road aggregates with size between 10mm to 20mm, having specific gravity 2.4 and water absorption 8% was used as replacement for natural aggregates.
- A third generation high range poly-carboylic ether based super-plasticizer Glenium B233 was employed for experimental study.

B. Mix Proportion

SCC mixes can be developed with volume of paste Vp (i.e sum of volume fraction of cement, filler and water) between 0.37 to 0.43. Cement content for SCC lies between 270 kg/m^3 to 450 kg/m^3 according to IS 456 and water content of 186 l/m^3 according to IS 10262. Mix design adopted was started with fixed volume of paste ($V_p = V_{cement} + V_{filler} + V_{water}$). Three volume of paste 0.39, 0.41 and 0.43 respectively were selected to prepare the mixes. Futher water content was fixed to 185 l/m^3 for all mixes and different volume of powder ($V_{pow} = V_{cement} + V_{filler}$). For each paste volume of cement and fly ash was changed keeping water content constant to get different concrete strength. For the mix design three cement content were selected 300 kg/m^3, 375 kg/m^3 and 450 kg/m^3 respectively. The ratio of coarse aggregate and fine aggregate was kept fixed for all mixes. Total volume of concrete was taken as one unit and final volume of aggregate was calculated by deducting the volume of paste from unit volume. The replacement ratio for natural coarse aggregates was kept as 0%, 20% and 40% respectively.

C. Mixing And Curing

Proper mixing and adequate curing are most important and essential factors for achieving good SCC. Super-plasticizer also play an important role in maintaining the flow-ability of SCC mixes. Modified method of mixing was adopted in order to take maximum benefits of poly-carboxylic ether based super-plasticizers. As per modified method 80% of dosage of super-plasticizers was mixed with water to which cement and fly ash was added and was mixed thoroughly in a pan mixer of 100 litre capacity for 2 minutes. Then coarse and fine aggregate were added to the paste and thoroughly mixed for another 2 minutes. Remaining 20% super-plasticizer dosage was added in the second instalment and complete mixture was mixed thoroughly for another 2 minutes. The total mixing time of aggregates and powder was kept constant to 6 minutes. Fresh properties of SCC were examined in next 25-30 minutes and after that cubes of size 150 mm were casted for determining the harden properties of SCC. The cubes were de-moulded on the next day and were immersed in water for curing for the period of 7 days, 28 days and 60 days

D. Tests

Table 1. Test Methods

S.No	Methods	Property
1	Slump-flow by Abrams cone	Filling Ability
2	T_{50cm} slump flow	Filling Ability
3	J-ring	Passing Ability
4	V-funnel	Filling Ability
5	V-funnel at T5minutes	Segregation Resistance
6	L-Box	Passing Ability
7	Compression Strength Test	Strength Of Concrete

III. RESULT AND DISCUSSION

A. Fresh Properties

The test on fresh properties of SCC were performed in order to verify the filling ability, passing ability and segregation resistance of SCC. Slump flow test was conducted as per ASTM standards where as V-funnel and J-ring test were conducted as per EFNARC guidelines.

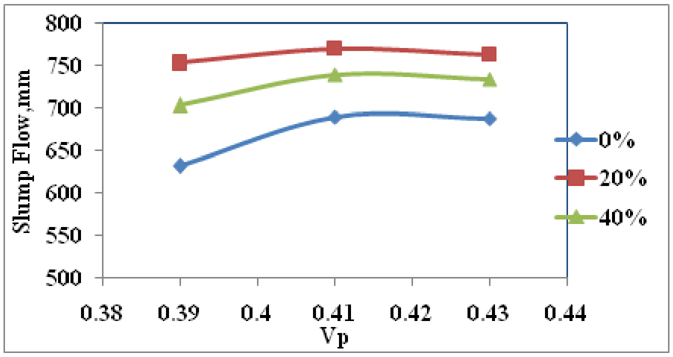

Fig. 1. Slump cone comparison of SCC with natural aggregates, 20% replaced with RBRA and 40% replaced with RBRA.

Figure 1 shows the average values of slump flow for replacement level of 0%, 20% and 40%. The graph is plotted between slump flow and volume of paste Vp. It was observed that the pattern of curve for 20% and 40% replacement is almost similar to 0% replacement curve. Slump flow is directly related to yield strength of concrete. It was observed that as the volume of paste increases yield strength decreases and higher slump flow is achieved. It means that as volume of paste increases, slump flow increases. It was also observed that there is a limit for volume of paste after which as volume of paste increases, slump flow decreases and yield strength increases. From the graph plotted it was observed that volume of paste of 0.41 is that limiting point after which slump flow decreases.

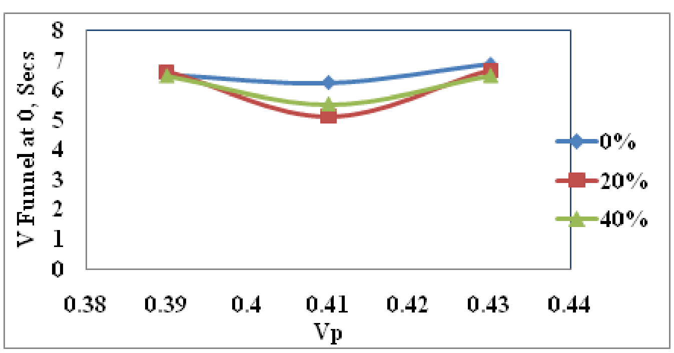

Fig. 2. V- funnel comparison of SCC with natural aggregates, 20% replaced with RBRA and 40% replaced with RBRA.

Figure 2 shows the average values of V-funnel for replacement level of 0%, 20% and 40%. The graph is plotted between V funnel values and volume of paste Vp. It was observed that the pattern of curve for 20% and 40% replacement is almost similar to 0% replacement curve. V-funnel is related to filling ability of concrete. It was observed from the experiment that as the volume of paste increases, time taken by SCC to pass through V-funnel decreases. But it was also observed that there is a limit for volume of paste after which the time for V-funnel increases. From the graph it was observed that after 0.41 volume of paste the time taken by SCC to pass through V-funnel increases.

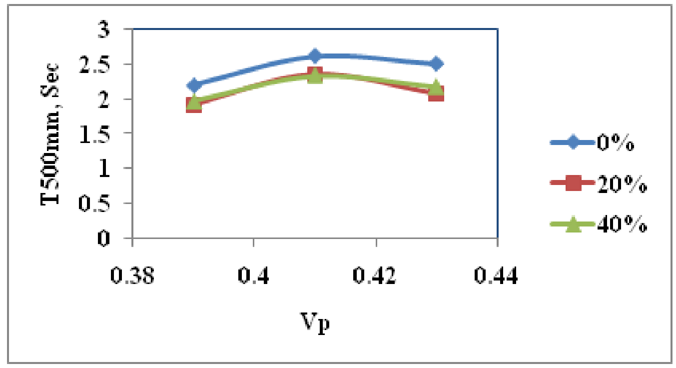

Fig. 3. T500mm comparison of SCC with natural aggregates, 20% replaced with RBRA and 40% replaced with RBRA.

Figure 3 shows the average values of T500mm values for replacement level of 0%, 20% and 40%. The graph is plotted between T500mm values and volume of paste Vp. It was observed that the pattern of curve for 20% and 40% replacement is almost similar to 0% replacement curve. It was observed from the experiment that as volume of paste increases the time taken to reach 500mm ring decreases. From the graph it was observed that only at 0.41 volume of paste the time taken for the concrete to reach 500mm ring increased. The reason for this can be increase in cohesiveness and stickiness.

B. Harden Properties

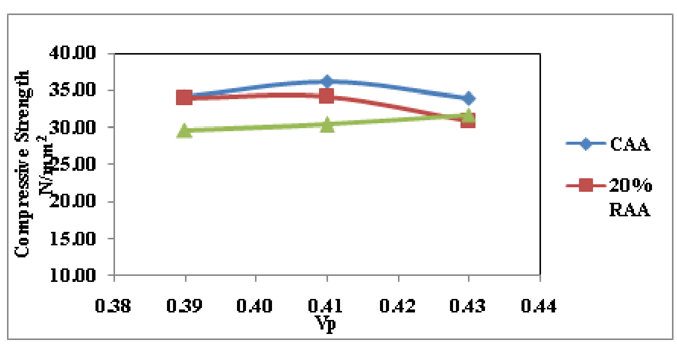

Fig 4. Shows the relation between compressive strength V/s Vp for 7 days.

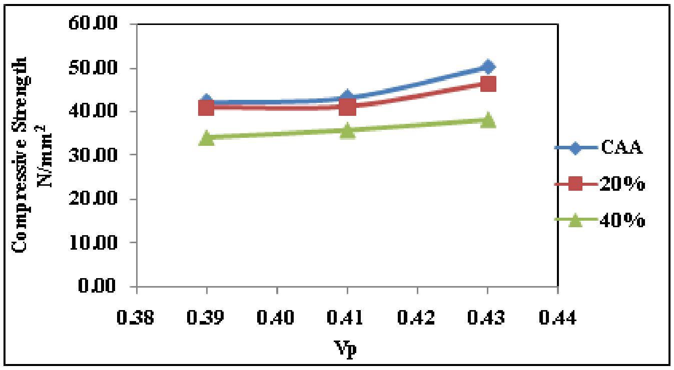

Fig 5. Shows the relation between compressive strength V/s Vp for 28 days.

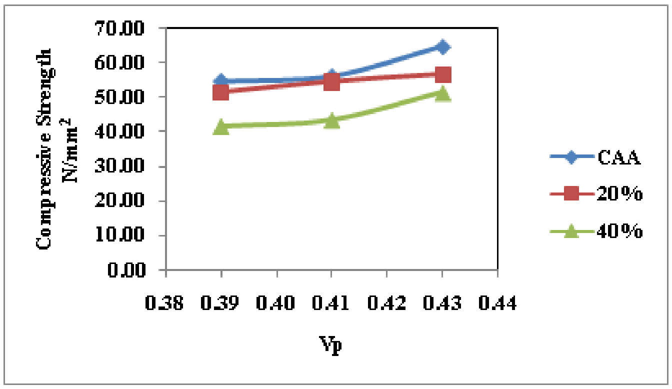

Fig 6. Shows the relation between compressive strength V/s Vp for 60 days.

Figure 4,5 and 6 shows the graph between compressive strength and volume of paste for 7 days curing, 28 days curing and 60 days curing. The pattern of the curve for all replacement ratio was almost same. From the graph plotted it was observed that as volume of paste increases, compressive strength also increases for 7 days, 28 days and 60 days. It was also observed that strength of 40% replacement ratio is less when compared to 20% and 0% replacement ratio. From the results it was indicated that 20% replacement ratio is optimal even though compressive strength of 20% replacement ratio is less when compared to 0% replacement ratio.

IV. CONCLUSION

The following conclusions can be drawn based on the results obtained from this study:

- SCC using crushed angular and manufactured aggregate can be best achieved within a paste content ranging from 0.39 to 0.43 based on absolute volume concept starting with a volume of paste.
- The mix design method based on absolute volume concept can be successfully employed for achieving SCC with crushed angular and recycled asphalt aggregate. The method is simple and reduces the number of trials.
- Talking about fresh properties all mixes satisfies the recommended limits of values for fresh properties of SCC.
- The slump flow increases with paste content, but there is a limit to the paste content; greater than that, the slump flow decreases. This limit for Vp was 0.41 for both concrete with natural aggregates and partially replaced coarse aggregates.
- V-zero funnel time and T_{50cm} shows evident that at higher cement contents the time taken to reach 500mm is less indicating that as volume of paste increases, the plastic viscosity decreases, indicating a faster flow for higher cement contents. This result was observed for both concrete with natural aggregates and partially replaced coarse aggregates.
- Higher the value of Vp, the compressive strength is also high for almost all the mixes at 7, 28 and 60 days.
- The compressive strength of SCC mixes with 40% RBRA replacement is less compared to SCC mixes with CAA and 20% RBRA. Results indicate the optimal usage of 20% RBRA in SCC mixes.
- Even though strength of SCC mix with 20% RBRA replacement is less compared to SCC mix with CAA, SCC of lower strength can be obtained which would result in economy when lower strength is sufficient.

V. COST ANALYSIS

Cost is one of the important factor in construction project. Reducing the cost of any project is one of the important criteria to sustain in the present competitive market. Cost analysis based on the result from the study was done by taking a duplex of 1150 sq.ft area as an example. It was studied and observed from the estimate prepared that the amount of concrete required for construction of 1150 square feet duplex was about 34.42 cubic metre or 113 cubic feet, whose costing calculated was approximately equal to 180150 rupees. Now when this normal concrete with natural aggregates and river sand was replaced with SCC with 80% natural coarse aggregates and 20% RBRA and manufactured sand the total cost of 34.42 cubic metre or 113 cubic feet concrete required for 1150 square feet duplex reduced by approximately 25000 rupees. Now when a single duplex is considered 25000 rupees does not create much difference but when a complete project or township with more than 50-80 duplexes is considered it creates a huge impact on overall project cost.

VI. ACKNOWLEDGEMENTS

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REFERENCES

[1] Hajime Okamura and M.Ouchi: "Self Compacting Concrete (invited paper)"; (Journal of Advanced Concrete Technology volume I, No1, pp. 5-15; April 2003

[2] .Mohan: " Investigation Of Self Compacting Concrete By Using Self Curing Agent" International Journal of Scientific & Engineering Research, Volume 7, Issue 4, April-2016

[3] KshamaShukla, AkanshaTiwari: "Self Compacting Concrete Mix Design for M-30" International Research Journal Of Engineering And Technology volume: 4, issue 7 July 2016.

[4] Fouad M. Khalaf and Alan S. Devenny: " Performance Of Brick Aggregate Concrete At High Temperatures" Journal Of Materials In Civil Engineering, ASCE, November/ December 2004.

[5] Zine-el-abidineTahar, Tien-Tung Ngo, El HadjKadri, Adrien Bouvet, FaridDebieb and SalimaAggoun: "Effect Of Cement And Admixtures On The Utilization Of Recycled Aggregates In Concrete" ELSEVIER, Science Direct Construction And Building Materials 149 (2017) 91-102

[6] M. Ben Aicha, Y. Burtschell, A. HafidiAlaoui, K. El Harrouni and O. Jalbaud: "Correlation Between Bleeding And Rheological Characteristics Of Self-Compacting Concrete" Journal Of Material In Civil Engineering, ASCE, ISSN 0899-1561, J. Mater. Civ. Eng.

[7] Jin Tao, Yong Yuan and Luc Taerwae: "Compressive Strength Of Self-Compacting Concrete During High Temperature Exposure" Journal Of Material In Civil Engineering, ASCE / October 2010 / 1005, J. Mater. Civ. Eng.

[8] M. Bravo, J. de. Brito, L. Evangelista, J. Pacheco: "Super-plasticizer's Efficiency On The Mechanical Properties Of Recycled Aggregates Concrete: Influence Of Recycled Aggregates Composition And Incorporation Ratio" ELSEVIER, Science Direct, Construction And Building Materials 153 (2017) 129-138.

[9] Ngoc Kien Bui, Tomoaki Satomi and Hiroshi Takahashi: "Improvement Of Mechanical Properties Of Recycled Aggregate Concrete Basing On A New Combination Method Between Recycled Aggregate And Natural Aggregate", ELSEVIER, Science Direct, Construction And Building Materials 148 (2017) 376-385.

[10] K. C. Panda and P. K. Bal: "Properties of self-compacting concrete using recycled coarse aggregate", ELSEVIER, Science Direct, Procedia Engineering 51 (2013) 159 – 164.

[11] BernardinusHerbudiman and AdhiMulyawanSaptaji: "Self-Compacting Concrete with Recycled Traditional Roof Tile Powder", ELSEVIER, Science Direct,Procedia Engineering 54 (2013) 805 – 816.

[12] Sara A. Santos, Pedro R. Da Silva and Jorge De Brito: "Mechanical Performance Evaluation of Self-Compacting Concrete with Fine and Coarse Recycled Aggregates from the Precast Industry", Science Direct, Materials 2017, 10, 904.

[13] EFNARC Guidelines.