Variation of Compressive strength and water absorption of concrete made by Two-Stage Mixing Approach using Fly ash with the variation of percentage of Recycled Coarse Aggregates

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Abstract— Nowadays construction materials are increasingly evaluated by their ecological characteristics. Concrete recycling gains importance because it protects natural resources and eliminates the need for disposal by using the readily available concrete as an aggregate source for new concrete or other applications. The concrete in this paper is produced by utilizing alternative and recycled waste materials such as fly ash and recycled concrete aggregates to reduce energy consumption, environmental impact, and usage of natural resources. The inferior quality of recycled aggregate (RA) has restricted its use to low-grade applications such as roadwork sub-base and pavements, while its adoption for higher-grade concrete is rare because of the lower compressive strength and higher variability in mechanical performance of RA. A new concrete mixing method, two-stage mixing approach (TSMA), was advocated to improve the quality of RA concrete (RAC) by splitting the mixing process into two parts. In the current paper we will discuss two parameters on which the concrete made by TSMA has been tested for strength characteristics viz. compressive strength and flexural strength. These parametric properties are compared with the conventional concrete with the variation of percentage of recycled coarse aggregates(RCA) and fly ash.

***Keywords**: ICU, DNA, AFM*

I. INTRODUCTION

Main agenda of infrastructural development is construction. Material for the development is concrete, which can be considered as the second most highly used item in the world after water. The basic constituents of concrete are the natural resources i.e., stone, aggregate, sand and water, This suggests that this industry has degrading impacts on these environmental assets. In addition, the quarrying and transportation of aggregates further lead to ecological imbalance and pollution. Not only this, the disposal of the debris of the demolished concrete structures has also become a big problem in various cities. These environmental problems are a driving force in developing an urgent and thoughtful sustainable approach towards our natural resources to which the recycling of the aggregates seems to be a allowable remedy. The paper presents a comparison of the compressive strength and water absorption of the concrete made through NMA and TSMA. Researches have been carried out on recycled aggregate all over the world, however, use of Recycled Aggregate in high strength concrete production could not become popular in India. M C Limbachiya[3] indicating the inferiority of recycled aggregate concrete, reported that often this concrete is used in as road construction, backfill for retaining walls, low grade concrete production, drainage and brick work and block work for low cost housing.

II. LITERATURE REVIEW

Singh S.K and Sharma P.C(2007)[8], stated that the use of recycled aggregates in concrete prove to be a valuable building materials in technical, environment and economical respect. The compressive strength of recycled aggregate concrete is relatively lower up to 15% than natural aggregate concrete. There are several reliable applications for using recycled coarse aggregate in construction. However, more research and initiation of pilot project for application of RCA is needed for modifying our design codes, specifications and procedure for use of recycled aggregate concrete. The subject of use of RCA in construction works in India should be given impetus.

Tam V.W.Y et al(2005)[10], proposed the technique of modified mixing of concrete. They concluded that the higher water absorption and higher porosity results in poor quality of RAC. The weaker interfacial transition zone(ITZ) between Recycled Aggregates(RA) and cement mortar limits the application of RAC in higher grade applications. In the study, the TSMA provides strength to the weak link of RAC, which is located at the (ITZ) of the RA. In TSMA , cement slurry formed gels up with RA providing a stronger ITZ by filling up the cracks and pores within RA. Concrete made through TSMA shows improved compressive strength when tested in laboratory. This approach provides an effective method for enhancing the strength characteristics and other mechanical properties of RAC, and thus, opens a wider scope of applications.

Patil S.P et al(2013)[6], have concluded in their paper on Recycled Coarse Aggregates that the compressive strength of concrete containing 50% RCA has strength in close proximity to that of normal concrete. Tensile splitting test shows that concrete has good tensile strength when replace upto 25-50%. The strength of concrete is high during initial stages but gradually reduces during later stages. Water absorption of RCA is higher than that of natural aggregate. Thus the usage of RCA in concrete mixture is found to have strength in close proximity to that of natural aggregate and can be used effectively as a full value component of new concrete.

According to Yong P.C and Teo D.C.L(2009)[12], the Recycled Aggregate Concrete(RAC) can achieve high compressive strength, split tensile strength as well as flexural strength. RAC has higher 28-day compressive strength and higher 28-day split tensile strength compared to natural concrete whereas the 28-day flexural strength of RAC is lower than that of natural concrete. Recycled Coarse

Aggregate(RCA) shows good potential as coarse aggregate for the production of new concrete.

Vyas C.M and Bhatt D.R(2013)[10] in their research on use of recycled Coarse aggregates in concrete have stated that the experimental results show that the early compressive strength of concrete made of natural coarse aggregate and recycled coarse aggregate are approximately same. As the percentage of recycled aggregate are increased then the workability decreases. The compression test result indicates an increasing trend of compressive strength in the early age of the concrete specimens with 60% recycled aggregates. The results also show that the recycled aggregate can be used in concrete with 40% replacement of natural coarse aggregate.

Marthong C and Agrawal T.P(2012)[5], have stated that the normal consistency increases with increase in the grade of cement and fly ash content. Setting time and soundness decreases with the increase in grade of cement. Use of fly ash improves the workability of concrete and workability increases with the decreases in the grade of cement. Bleeding in fly ash concrete is significantly reduced and other properties like cohesiveness, pumping characteristics and surface finish are improved. Compressive strength of concrete increases with grade of cement. As the fly ash contents increases in all grades of Ordinary Portland Cement(OPC) there is reduction in the strength of concrete. The rate of strength gain of concrete with age is almost similar in all the three grades OPC. Concrete with 20% fly ash content closer to that of ordinary concrete at the age of 90 days. In all grades OPC, fly ash concrete is more durable as compared to OPC concrete and fly ash upto 40% replacement increase with grade of cement. Shrinkage of fly ash concrete is similar to the pure cement concrete in all grades of OPC.

According to Bendapudi S.C.K and Saha P(2011)[1], a primary goal is a reduction in the use of portland cement, which is easily achieved by partially replacing it with various cementitious materials. The best known of such materials is fly ash, a residue of coal combustion, which is an excellent cementitious material. In India alone, we produce about 75 million tons of fly ash per year, the disposal of which has become a serious environmental problem. The effective utilization of fly ash in concrete making is, therefore, attracting serious considerations of concrete technologists and government departments. The new Indian Standard on concrete mix proportions (IS 10262-2009)[16] are already incorporated fly ash as a supplementary material to cement. Fly ash replacement of cement is effective for improving the resistance of concrete to sulfate attack expansion. The higher is the compressive strength of concrete, the lower is the ratio of splitting tensile strength to compressive strength. Finally, this literature search showed that the properties of concrete are enhanced when the substitution of Portland cement and aggregate was done by fly ash.

According to Yadav S R and Pathak S R(2009)[11], Aggregate in the size of 4 to 8mm is found to have the highest amount of adhered mortar, thus implying that the size of aggregates will have tremendous effect on the water absorption and strength of concrete. The changes in mechanical properties of recycled concrete aggregateare attributed to the patches of cement mortar present after crushing which increases the water absorption. depending upon the size of the aggregates and the water absorption lies between 3–10 percent while for natural aggregates the value is less than 5 percent.

According to Kenai S., Debieb F. and Azzouz L.(2005)[2],The results of their experiments indicate that it is possible to produce good quality concrete using recycled aggregates. Recycled aggregates have higher water absorption and a lower density because of the adhering old mortar. water absorption and water permeability are increased for recycled aggregate concrete, and hence the level of substitution has to be limited and precautions should be taken to avoid durability problems in some structural elements in practice.

Sharma S, Sharma S K and Chakraborty K.(2014)[7], elaborated that with increasing percentage of waste concrete aggregates, water absorption increases. This can be seen in their experimental analysis.

According to Malešev M., Radonjanin V. and Marinković S.(2010)[4], the water absorption of concrete depends on the quantity of recycled aggregate. The amount of absorbed water is proportionally increased with increasing recycled aggregate content. Water absorption depends on the porosity of cement matrix in the new concrete and porosity of cement matrix of the recycled concrete: if recycled aggregate is produced from low porosity waste concrete, water absorption of the new concrete depends on the achieved structure of the new cement matrix.

III. METHODOLOGY

A. Cement

Ordinary Portland cement of 43 grade satisfying the requirements of IS:8112-1989[14]. The specific gravity of cement was 3.005.

B. Fine aggregates

The sand generally collected from haryana. Sand is the main component of grading zone-I of IS: 383-1978[13] was used having specific gravity of 2.62 and water absorption of 1 % at 24 hours.

C. Coarse aggregates

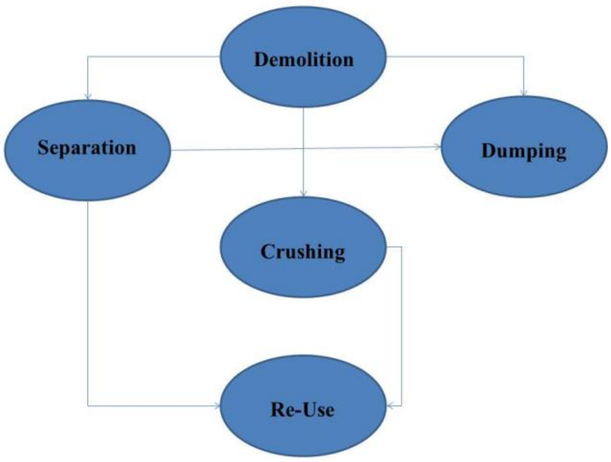
Mechanically crushed stone from a quarry situated in haryana with maximum size as 20 mm, satisfying to IS: 383-1978 was used. The specific gravity was found to be 2.63 and water absorption is 0.5 % at 24 hours.

D. Recycled coarse aggregates

Aggregates obtained by the processing of construction and demolition waste are known as recycled aggregates. Process of recycling is shown as follows RCA for the experimental analysis was procured from the C & D waste plant in Delhi which is in collaboration with Municipal Corporation Of Delhi.

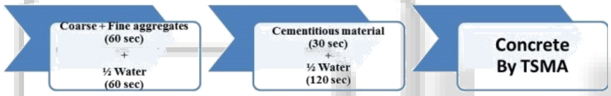
E. Fly Ash:

Fly ash is used as partial replacement of cement which replaces 10% of total cementitious material in all the cases of the experiments. Class F fly ash is used from haryana having specific gravity as 2.4 and satisfying IS 3812-1999[15].



IV. Methodology

NMA follows certain steps. First, coarse and fine aggregate are mixed. Second, water and cementitious materials are added and mixed. However, TSMA follows different steps. First, coarse and fine aggregates are mixed for 60 seconds and then half of water for the specimen is added and mixed for another 60 seconds. Second, cementitious material is added and mixed for 30 seconds. Thirdly, the rest of water is added and mixed for 120 seconds.



The specific procedure of TSMA creates a thin film of cement slurry on the surface of RA which is expected fill the old cracks and voids. Pollution involved in trucking material can be reduced by using recycled concrete as the base material for roadways.

V. Experimental Observations

Following table shows the experimental observations of the test samples made from TSMA and nominal mix by NMA.

(1) M-25(10-25) denotes the specimen mix having 10% fly ash and 25% RCA content.
(2) M-25(10-50) denotes the specimen mix having 10% fly ash and 50% RCA content.
(3) M-25(10-25) denotes the specimen mix having 10% fly ash and 75% RCA content.
(4) M-25(10-25) denotes the specimen mix having 10% fly ash and 100% RCA content.

S. No.	Specimen	COMPRESSIVE STRENGTH	
		7th day (MPa)	28th day (MPa)
1	Nominal M-25	17.84	31.7
2	M-25(10-25)	18.81	33.77
3	M-25(10-50)	20.21	32.88
4	M-25(10-75)	22.51	32.88
5	M-25(10-100)	15.10	27.99

Table 1: Compressive strength

These observations can be depicted in graphical form as follows :

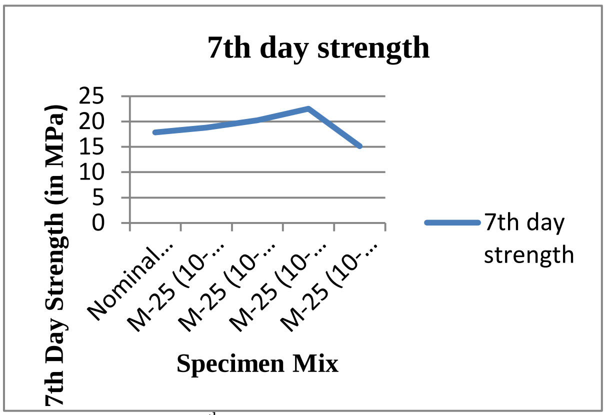


Chart 1: 7th day Compressive strength

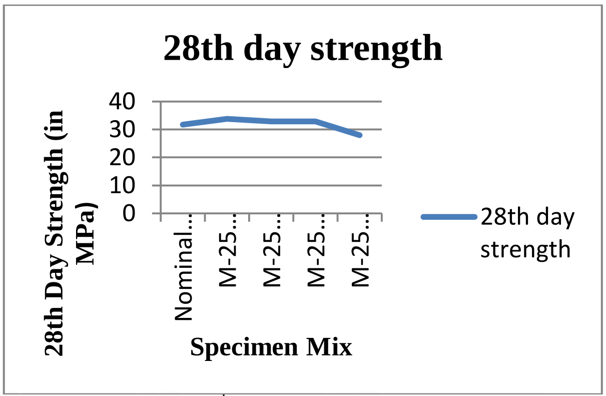
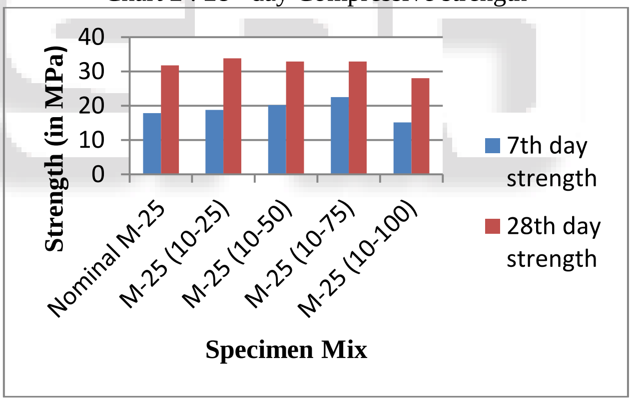


Chart 2 : 28th day Compressive strength



Graph : Compressive strength(both 7 and 28 day)

S. No.	Specimen	Water Absorption (in %)
1	Nominal M-25	2.82
2	M-25 (10-25)	3.01
3	M-25 (10-50)	3.41
4	M-25 (10-75)	3.89
5	M-25 (10-100)	4.81

Table 2

These observations can be depicted in graphical form as follows :

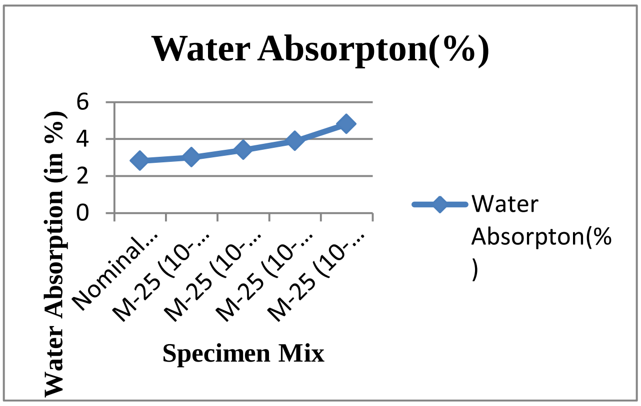


Chart 3 : Water Absorption

VI. RESULTS AND DISCUSSIONS

A. Results

The above experimental analysis provides us with the following results:

(1) The compressive strength of M-25 grade nominal concrete made by NMA gives 7 day and 28 day strengths as 17.84 MPa and 31.7 MPa respectively and water absorption as 2.82%.
(2) Using TSMA, addition of 10% fly ash, the specimen made by 25% RCA gives 7 day and 28 day strengths as 18.81 MPa and 33.77 MPa respectively and water absorption as 3.01%.
(3) Using TSMA, addition of 10% fly ash, the specimen made by 50% RCA gives 7 day and 28 day strengths as 20.21 MPa and 32.88 MPa respectively and water absorption as 3.41%.
(4) Using TSMA, addition of 10% fly ash, the specimen made by 75% RCA gives 7 day and 28 day strengths as 22.51 MPa and 32.88 MPa respectively and water absorption as 3.89%.
(5) Using TSMA, addition of 10% fly ash, the specimen made by 100% RCA gives 7 day and 28 day strengths as 17.10 MPa and 27.99 MPa respectively and water absorption as 4.81%.

B. Discussion

The specimen mix M-25(10-25) shows an increase of 5.46% in 7 day compressive strength and 6.52% in 28 day strength along with the increase in water absorption by 6.73%, whereas, specimen mix M-25(10-50) shows an increase of 13.32% in 7 day compressive strength and 3.72% in 28 day strength with respect to nominal mix specimen along with the increase in water absorption by 20.92%.

The specimen mix M-25(10-75) shows an increase of 26.17% in 7 day compressive strength and 3.72% in 28 day strength along with the increase in water absorption by 37.94%, however, specimen mix M-25(10-100) shows decrease of 15.10% in 7 day compressive strength and 11.70% in 28 day strength with respect to nominal mix specimen along with the increase in water absorption by 70.56%.

From 28 day strength point of view, specimen M-25(10-25) shows optimum increase in 28th day compressive strength i.e 6.52% and the minimum water absorption observed is of the nominal mix specimen however the specimens M-25(10-25), M-25(10-50), M-25(10-75) and M-25(10-100) show allowable rate of water absorption.

VII. CONCLUSION

Following can be concluded from the experimental analysis that concrete made by replacement of 25% and 50% RCA and addition of 10% fly ash using TSMA gives more compressive strength for both 7 day and 28 day strength along with the increase in the water absorption by 6.73% and 20.92% respectively than the referred nominal concrete specimen made by NMA.

However on replacement of 75% and 100% RCA and addition of 10% fly ash using TSMA, the concrete shows decrease in compressive strength than the Nominal concrete along with the increase in water absorption by 37.94% and 70.56% respectively than the referred nominal mix specimen made by NMA.

Maximum 28 day strength is obtained by concrete made by using TSMA involving replacement of 25% RCA and addition of 10% fly ash. Out of all the other mixes containing RCA, this concrete so made will provide low cost of construction, strength as well as durable as it it shows the least value of water absorption as compared to the other mix specimens containing RCA due to which it can be used in any constructional works in place of nominal concrete.

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A. IS CODES :

[13] IS: 383-1978 Specification for coarse and fine aggregate from natural sources of concrete.
[14] IS: 8112-1989 43 grade Ordinary Portland Cement-Specifications.
[15] IS: 3812-1999 Specification for Fly ash to use as pozzolana and admixture.
[16] IS: 10262-2009 Concrete mix proportioning-guidelines(First Revision).