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Comparison of Compressive Strength of Concrete Made by Two-Stage Mixing Approach(TSMA) using Fly Ash and Nominal Concrete Made by Normal Mixing Approach(NMA)

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***Abstract*— Exhaustion of landfill areas redevelopment programe in many parts of the country has prompted the use of recycled aggregate. However, 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, that is the two-stage mixing approach (TSMA), was advocated to improve the quality of RA concrete (RAC) by splitting the mixing process into two. The current paper describes the variation of compressive strength by experimental analysis involving the modified mixing method with some alteration to the two-stage mixing approach by proportioning ingredients with the percentage of recycled coarse aggregates (RCA) and fly ash. Based on experimental works and results, improvements in strength to RAC were achieved with TSMA. This can be attributable to the porous nature of RA and the premixing process that fills up some of its pores and cracks, resulting in a denser aggregate and concrete. An improved interfacial zone around RA gives a higher strength than the normal mixing approach (NMA).**

Keywords—concrete, fly ash, recycled aggregate, Two-stage mixing approach(TSMA), Normal mixing approach(NMA).

I. INTRODUCTION

Backbone of infrastructural development is construction. Material for the development is concrete, which forms the indispensable material for construction, 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, suggesting 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 due to paucity of landfill sites.

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 of the concrete made through NMA and TSMA. Concept of use of recycled aggregate in concrete is not new, 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 [10], 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

Tam V.W.Y et al(2005)[6], proposed the technique of modified mixing of concrete. The scientists concluded that the poor quality of RAC resulted from the higher water absorption, higher porosity, weaker interfacial transition zone (ITZ) between Recycled Aggregates(RA) and new cement mortar hampers the application of RAC for higher grade applications. In this study, the two-stage mixing approach is proposed to strengthen the weak link of RAC, which is located at the (ITZ) of the RA. The two-stage mixing approach gives a way for the cement slurry to gel up the RA, providing a stronger ITZ by filling up the cracks and pores within RA. From the laboratory experiments, the compressive strengths have been improved. This two-stage mixing approach can provide an effective method for enhancing the compressive strength and other mechanical performance of RAC, and thus, the approach opens up a wider scope of RAC applications.

According to Yong P.C and Teo D.C.L(2009)[9], 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.

Patil S.P et al(2013)[4], 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.

Vyas C.M and Bhatt D.R(2013)[8], 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.

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) 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.

Vyas C.M and Pitroda J.K(2013)[7], have worked on the combination of RCA and Fly Ash and have concluded that the applications of recycled coarse aggregate in the construction area are very wide. The main aim of using recycled coarse aggregate is to reduce the use of natural resources. Another improving method is using the Fly ash in the recycled coarse aggregate mixing. Application of fly ash in the recycled coarse aggregate concrete can improve the durability of the recycled coarse aggregate concrete. The use of fly ash could improve the strength characteristic of recycled coarse aggregate concrete.

Marthong C and Agrawal T.P(2012)[3], 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, M.L Gambhir[2]. 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.

III. MATERIALS USED

1.Cement

Ordinary Portland cement of 43 grade satisfying the requirements of IS: 8112-1989. The specific gravity of cement was found to be 3.005.

2.Fine aggregates

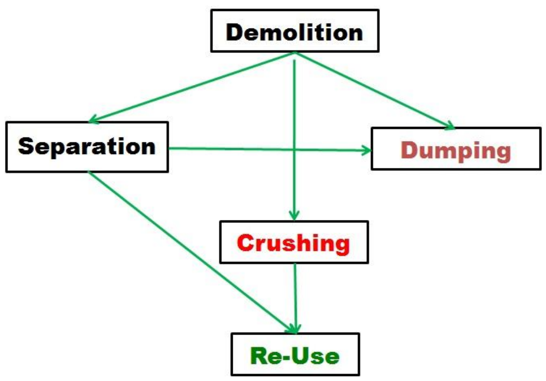
The sand generally collected from haryana. Sand is the main component grading zone-I of IS: 383-1978 was used with specific gravity of 2.62 and water absorption of 1 % at 24 hours.

3.Coarse aggregates

Mechanically crushed stone from a quarry situated in haryana with 20 mm maximum size, 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.

4.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.

5.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 .

METHODOLOGY

NMA follows the following 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 layer of cement slurry on the surface of RA which is expected to get into the porous old mortar and fill the old cracks and voids. Using recycled concrete as the base material for roadways reduces the pollution involved in trucking material.

IV. EXPERIMENTAL OBSERVATIONS

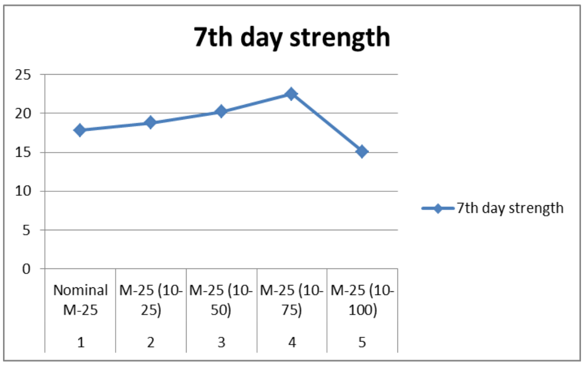
Following table shows the experimental observations of the test samples made from TSMA and nominal mix by NMA.

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

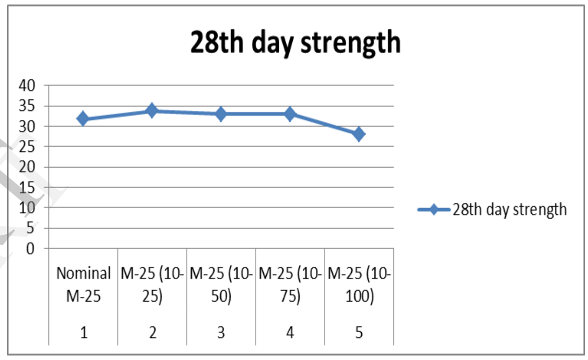
S. No.	Specimen	COMPRESSIVE STRENGTH	
		7^{th} day (MPa)	28^{th} day (MPa)
1	Nominal M-25	17.84	31.7
2	M-25(10-25)	18.81	33.77
3	M-25(10-50)	20.21	32.88
4	M-25(10-75)	22.51	32.88
5	M-25(10-100)	15.10	27.99

These observations can be depicted in graphical form as follows :

<u>Chart 1 : 7^{th} day strength</u>



<u>Chart 2 : 28^{th} day strength</u>



V. RESULSTS AND CONLUSION

RESULTS

The above experimental analysis provides us with the following results:

i) 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.

ii) 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.

iii) 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.

iv) 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.

v) 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.

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, however, 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.
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, whereas, 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.
From 28 day strength point of view, specimen M-25(10-25) shows optimum increase in strength i.e 6.52% with respect to nominal mix specimen.

CONCLUSION

Samples after casting were tested and gave the above results depicted by chart 1 and 2. The outcome of this work reveals that concrete made by replacement of 25% , 50% and 75% RCA and addition of 10% fly ash using TSMA gives more compressive strength for both 7 day and 28 day strength than the referred nominal concrete specimen made by NMA however on using 100% RCA the concrete shows decrease in compressive strength than the Nominal concrete.

Maximum 28 day strength is obtained by concrete made by using TSMA involving replacement of 25% RCA and addition of 10% fly ash. This concrete so made will be cost effective as well as strong and can be used in any constructional works in place of nominal concrete.

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IS CODES

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