Comparison of Strength Characteristics of Concrete Made by TSMA using Fly Ash and Nominal Concrete Made by NM Approach

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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).

1. INTRODUCTION

The manufacture and use of sustainable materials, via disposal or reuse/recycling, can be done in a way that preserves the environment, creates no ecological imbalances, has no negative effect on human health, and can be done for a long time without sacrificing productivity. The use of recycled aggregate in concrete may help to preserve the environment. By separating the mixing process into two phases, a novel concrete mixing technique was developed to improve the quality of recycled aggregate concrete.

This article presents two modified mixing techniques that differ from the two-stage mixing strategy in that they balance cement components with the amount of RA added in the second mix, which is referred as the two-stage mixing approach. Metakaolin and GGBS were also utilized to enhance concrete characteristics such as compressive strength, flexural strength, and permeability in a two-stage mixing process. After that, the results of concrete produced using the Two Stage Mixing Approach and concrete prepared with the Normal Mixing Approach were compared.

Construction is the backbone of infrastructure development. Concrete, which is an essential building element, is the world's second-most-used item after water. Natural resources, such as stone, aggregate, sand, and water, are the basic ingredients of concrete, implying that this sector degrades these environmental assets. Moreover, aggregate quarrying and transportation contribute to environmental imbalance and pollution. Since World War II, recycled aggregates (RAs) from waste (CDW) have been utilized.

High recycling rates have been reached in a number of nations, especially in Europe, including the Netherlands, Denmark, and Germany, among others. This has been aided by those countries' comparatively low natural resource reserves, which have been converted to construction materials, or by the development of strict environmental legislation. These variables have allowed RA to be used in real construction applications, albeit with significant constraints, such as in-road pavement layers, embankments, and earth-filling activities.

Limits on the replacement ratio reflect empirically established impacts of recycled aggregate on concrete in previous research projects. Indeed, the quality of the aggregates determines the primary technical issues that arise when recycled aggregates are used. The compressive strength, flexural strength, and water permeability of concrete prepared with NMA and TSMA are compared in this research. The idea of the use of recycled material in concrete is not new; worldwide research has been carried out on recycled aggregates. However, recycled aggregates in India have failed to acquire momentum in the production of high strength concrete.

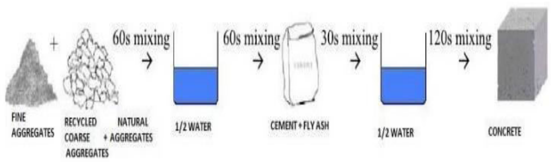
A state of large landfill areas redevelopment program in many parts of the country has cause to bring the use of recycled aggregate. The low quality of recycled aggregate has not use to low grade applications such as roadwork sub-base and pavements, while its adoption for higher-grade concrete is rare because of the lower compressive strength and higher in mechanical performance of recycled aggregate. A new method, that is the two stage mixing approach (TSMA), was publically recommends to improve the quality of recycled aggregate concrete (RAC) by splitting the mixing process into two stages.

The variation of compressive strength by experiments involves new mixing method with the two-stage mixing approach by various proportion ingredients with varying percentage of fly ash and rice husk ash and with the constant percentage of recycled coarse aggregates (RCA). Based on experimental works and results, improvements in strength to fly ash, Rice husk ash and RCA were achieved with TSMA. This can be regarded as to the porous in nature of RA and the mixing process that fills up some of pores and cracks, resulting in a denser aggregate and concrete. A good RA gives a higher strength than the normal mixing approach (NMA).

It is known that waste in India in the construction industry i.e., demolished waste is as higher as 30%. This is simple and straight forward challenge needs to be undertaken by engineers. These wastages are activities that soak up man hours, resources and materials but produce no value.

In this project, you will use those waste materials to make something fertile by manufacturing a concrete using recycled aggregate, fly ash and rice husk ash. After making concrete you will compare the compressive strength characteristics of the concrete made through NMA and TSMA. Normal mixing approach (NMA) is the layman process where all the materials are mixed in describe proportion. The problem with this approach is when concrete gets hardened some voids remains in it which acts on its strength.

In a two-stage mixing approach (TSMA) a thin layer of cement is made on the surface of RA which helps in filling voids. This results in the higher strength. In this project, you're getting to prepare two different sample of concrete using nominal mixing approach and two mixing approaches and determine compressive strength of these on day 7 and 28. These environmental issues are increasing and thoughtful sustainable approach towards our natural resources to which the recycling of the aggregates seems to be allowable cure. The comparison of compressive strength characteristics of the concrete made through NMA and TSMA. The use of recycled aggregate in concrete is not up to date, researches have been take out on recycled aggregate all over the world. Use of Recycled Aggregate in high strength concrete could not become in favour of India. There is an increases importance to stop the environmental issue in the present day world. Fly Ash is notable environmental damage and ways are being thought of to throw out them. Rice husk is actually a super pozzolonic since it is high in Silica and has about 85% to 90% Silica. A finer way of utilizing this material is to use it for making “High Performance Concrete” which gives high workability and long-term durability of the concrete.



Two stage mixing approach process

It is known that wastage in India in the construction industry is as high as 30%. This is a large, yet relatively simple and straightforward challenge needs to be tackled by engineers. These wastages are activities that absorb man hours, resources and materials but create no value. In this project, you will use those waste materials to make something productive by making a concrete using recycled aggregate and fly ash. After making concrete you will compare the compressive as well as flexural strength characteristics of the concrete made through NMA and TSMA.

Normal mixing approach (NMA) is the layman process where all the materials are mixed in defined proportion. The problem with this approach is when concrete gets hardened some void space remains inside it which affects its strength.

In a two-stage mixing approach (TSMA) a thin layer of cement slurry is created on the surface of RA which helps in feeling those void spaces. This results in the higher strength of the composite.

In this project, you are going to prepare two different sample of concrete using above two mixing approaches and determine compressive strength, the flexural strength of those on day 7 and 28.

The main objectives of the study is to reduce industrial waste, to reduce demolished construction waste, to reduce cost of material, to inspect the profitable use of modern waste as the cement replacement in construction work, to evaluate the good proportion of rice husk ash as a favourable replacement with cement incement concrete.

2. LITERATURE REVIEWS

SandeepUniyal (2014) will describe two criteria that have been used to measure the compressive and flexural strength of concrete prepared using the two-stage mixing approach (TSMA). These parametric parameters are compared to traditional concrete with a percentage of recycled coarse aggregates (RCA) and fly ash variation. The results of this study show that concrete manufactured with 25% and 50% RCA substitution and 10% fly ash addition using TSMA has higher compressive and flexural strength for both 7 and 28 day strength than the comparable nominal concrete specimen made by NMA.

Santosh Kumar and Sonu Pal (2017), focuses on the pre-soaked slurry two-stage mixing approach (PSTSMA) for getting the greatest mechanical properties. In the M40 concrete grade, recycled aggregate was employed as a 30 percent, 50 percent, and 100 percent replacement for natural aggregate. When compared to the Normal Mixing Approach, the PSTSMA approach improves the strength of recycled aggregate concrete by up to 6.35 percent at 28 days (NMA).

Dr.VanitaAggarwal (2014) did a modified mixture involving recycled coarse aggregates (RCA) and fly ash to increase the proportioning of the ingredients. Results from the experimental analysis were presented which showed changes in compressive strength. As a result of the porous nature of RA and the premixing process, TSMA has improved the strength of RAC. This can be attributed to the porous nature of RA and the fact that the aggregate and concrete were significantly denser.

GummaSoumya (2018) aims to investigate the impact of concrete by replacing cement with silica fume partially and fine aggregate with quartz sand. This is done by running the compressive strength, split tensile strength and flexural strength of M35 grade concrete. The optimum ratios of silica fume and quartz sand were found at 15% and 60%. It can be seen that the addition of 60% quartz sand and 15% silicafume increased the compressive strength by 19.16%, the split tensile strength by 7.2% from the nominal concrete, and the be flexural strength by

6.64% from the nominal concrete. Evaluation of M35 on the 28th.

3. MATERIALS AND METHODOLOGY

Cement

Rapid Hardening Cement use in this project. Rapid Hardening Cement contains the following ingredient proportions. 60% Tricalcium silicate (C3S), 15% Dicalcium silicate (C2S), 10% Tricalcium aluminate (C3A) and 8% Tetracalciumalumino ferrite of the total weight of cement. OPC contains 50% C3S of its total weight. So, it is observed that Rapid Hardening Cement contains a higher percentage of C3S than OPC. Rapid Hardening cement with 28 percent normal consistency conforming to IS: 8041- 1990 was used. The specific gravity of cement 3.15.Ordinary Portland cement, grade 53, meeting IS: 8112-1989 standards.

Fine aggregate

Locally available sand was used of maximum size 4.35 mm was used. Sand confined to zone 2 of IS: 383-1970 locally available sand.

Coarse aggregates

Aggregate is a granular substance that is used to create any construction material such as cement or mortar etc. such as sand, gravel, pulled stones, recycled concrete etc., and that is combined with other binding elements. Locally available coarse aggregate of maximum size 10.0 mm was used. Recycled Coarse Aggregates: Aggregates obtained by the demolished construction waste are known as recycled aggregates.

Metakaolin

Metakaolin is a form of kaolinite, a clay mineral, DE hydroxylated. Metakaolin is clay, which is frequently used in pottery but it is also utilized in concrete as a cement replacement. Meta-cooling has a lower particle size (1–2 m) and a greater surface area than Portland cement, but a larger particle size than SF. Metakaolin is subjected to a pozzolanic concrete reaction that refines the microstructure of the hydrated concrete paste. Compared to ordinary Portland cement, metakaolin reacts rapidly and lowers the diffusion coefficient. Research shows that SF and metakaolin have comparable effects on the chloride input resistance of the concrete. The usual metakaolin replacement levels range from 5% to 10% because to its tiny particle size and high surface area.

GGBS

Ground granulated slaughterhouses (GGBS, GGBFS) are produced from molten iron slaughter, which is then dried in water or steam and ground into a fine powder, in order to produce a glassy, granular product. GGBS includes high levels of CSH (calcium silicate hydrates), a strength boosting component to increase concrete strength, durability and aesthetics. GGBS is highly cementitious. The production of enhanced slag cement such as PBFC (Portland Blast furnace Cement) and High- Slag Furnace (HSBFC) cement with a GGBS content of 30 to 70 percent and the development of ready-mixed and site-backed durable concrete are two of GGBS's most frequent applications. Use of GGBS reduces the danger of alkali-silica reaction (ASR), improves chloride intrusion resistance, and reduces the risk of corrosion strengthening, and increases sulphate resistance and other chemical assaults.

Fly ash

Fly ash includes substantial amounts of silicon dioxide (SiO2), aluminium oxide (Al2O3) and calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata. Fly ash is used as partial replacement of cement of total cementitious material in all the cases of the experiments. The specific gravity as 2.4 and satisfying IS 3812-1999.

Water

Portable water was used for the experimentation.

Material properties obtained

Normal consistency, Initial & final setting time of Cement: Initial setting time of cement is found to be 30 min. Final setting time of cement is found to be 10 hr. Normal consistency of the given cement sample is 32%.

Pycnometer method of Fine aggregate: Specific gravity of fine aggregate is 2.6. Dessicator method of Coarse aggregate: Specific gravity of coarse aggregate is 2.8.

Impact value of Coarse aggregate: The average impact value of coarse aggregate is 17.04%.Slump test of concrete: The measured slump of Concrete is 120mm.

4. METHODOLOGY USED

NMA follows the following steps:

- First, coarse and fine aggregate are mixed.
- Second, water and cementitious materials are added and then mixed.

TSMA follows different steps:

- First, coarse and fine aggregates are mixed for 60 seconds and then half of water for the sample is added and mixed for another 60 seconds.
- Second, cementitious material is added and then mixed for 30 seconds.

Thirdly, the remaining water is added and mixed for 120 seconds.

Experimental investigation

- M-40 (0-0-100) denotes a specimen mix containing 0% Metakaolin, 0% GGBS, and 100% FA.
- M-40 (10-30-15) denotes a specimen mix containing 10% Metakaolin, 30% GGBS, and 15%RA.
- M-40 (10-30-30) denotes a specimen mix containing 10% Metakaolin, 30% GGBS, and 30%RA.
- M-40 (10-30-45) denotes a specimen mix containing 10% Metakaolin, 30% GGBS, and 45%RA.

Tests to be conducted

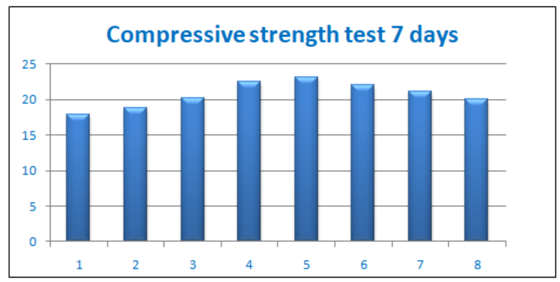
- Compressive Strength
- Split Tensile Strength Test
- Flexural Strength

5. RESULTS AND ANALYSIS

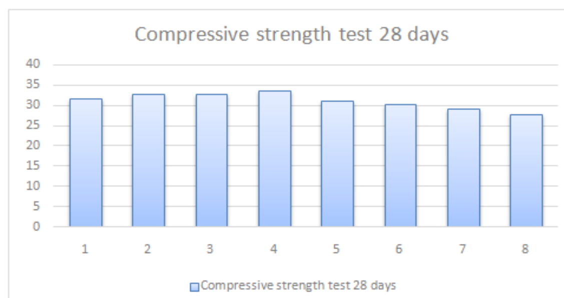
Mix ratios used:

1-0%, 2-10%, 3-20%, 4-30%, 5-40%, 6-30%, 7-40% and 8-40%.

Compressive strength

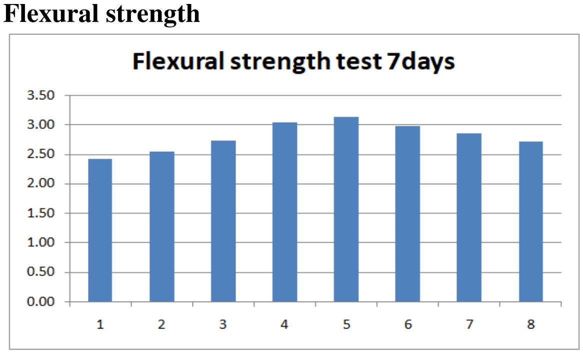


Compressive strength test 7 days value for TSMA using Fly ash and nominal concrete

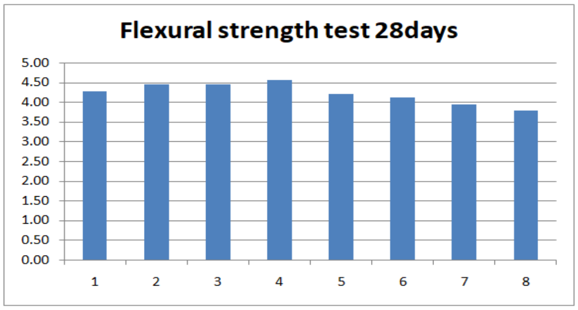


Compressive strength test 28 days value for TSMA using Fly ash and nominal concrete

Flexural strength

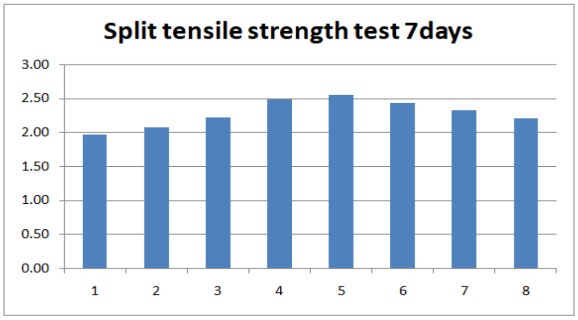


Flexural strength test 7 days value for TSMA using Fly ash and nominal concrete

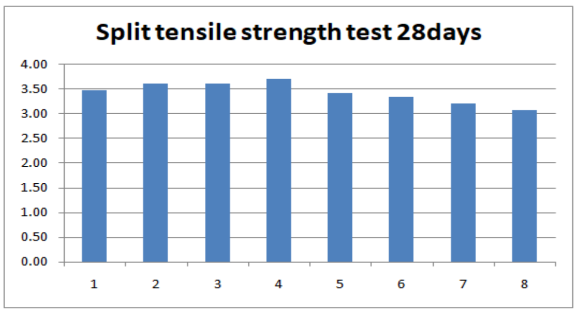


Flexural strength test28 days value for TSMA using Fly ash and nominal concrete

Split tensile strength



Split strength test 7 days value for TSMA using Fly ash and nominal concrete



Split strength test28 days value for TSMA using Fly ash and nominal concrete

6. CONCLUSIONS

1. After casting, samples were examined, yielding the aforementioned results, which are represented by TABLES and CHARTS. The results of this study show that the compressive strength, Flexure strength and water permeability of concrete produced with 15 percent, 30% and 45 percent RA replacement and addition of 10 percent Metakaolin, and of 30 percent GGBS TSMA are higher for 7 days and 28 days than the same nominal concrete specimen produced by NMA.

2. Compared to a mixing specimen, the specimen mix M-40 (10-30-15) showed an 8,31% increase in compressive strength for 7 days and a 7,03% increase in strength for 28 days. However, specimen mix M-40 (10-30-30) showed a 19,42% increase in strength of compression for 7 days and an increase of 16,06% in strength for 28 days. The compression specimen mix M-40 (10-30-45) shows an increase of 15.35% in compression strength of seven days and an increase of 15.35% in compressive strength of 28 days.

3. In 28 days, specimens M40 (10-30-15), M40 (10-30-30), and M40 (10-30-45) showed 8.85 percent, 23.02 percent, and 19.42 percent increase in flexural strength, respectively.

4. Water permeability specimen M40 (10-30-15), M40 (10-30-30) and M40 (10- 30-45) shows 10%, 25% and 35% decrease in water permeability in 28 days. Concrete built using TSMA, which includes the substitution of 30% RA and the addition of 10% Metakaolin and 30% GGBS, achieves the highest 28-day strength.

5. This concrete will be both cost effective and sturdy, and it can be adopted in place of nominal concrete in any construction project.

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