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Research Paper

SYNERGISTIC EFFECTS OF NANO-SIILICA, FLY ASH, AND GGBS ON MECHANICAL AND DURABILITY PERFORMANCE OF RECYCLED AGGREGATE M30 CONCRETE

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Abstract

Concrete is widely used in construction, but its production places considerable demand on natural aggregates and ordinary Portland cement. Demolition activities also generate large quantities of concrete waste, while industrial by-products such as fly ash and ground granulated blast-furnace slag (GGBS) can be used as supplementary cementitious materials. This study investigated the combined use of fly ash, GGBS, nano-silica and recycled coarse aggregate (RCA) in M30-grade concrete. The investigation focused on their influence on workability, mechanical strength and selected durability characteristics.

Five mixtures, designated M0 to M4, were considered. M0 was the control mixture. In M1 to M4, fly ash and GGBS were each used at 2.5%, 5%, 7.5% and 10% of the reference cement mass, respectively. Nano-silica was varied at 1.5%, 3%, 4.5% and 6%, while RCA replaced 15%, 30%, 40% and 50% of natural coarse aggregate by mass. Workability was assessed using slump and compaction-factor tests. The hardened-concrete programme included compressive, split tensile and flexural strength tests at the stated curing ages. Acid, alkaline and sulphate exposure tests were also reported.

The recorded results showed a reduction in slump as the replacement levels increased, while the compaction factor rose slightly across the mixtures. The highest 28-day split tensile value in the presented table occurred in M2, whereas the highest 28-day flexural value occurred in

M3. The durability tables indicate increasing strength loss with increasing replacement level. These results show that the best-performing mixture depends on the property being considered; the available results do not establish M3 as the optimum for every property. The findings are limited to the materials, proportions and test data reported in this investigation.

KEYWORDS: *M30 concrete; recycled coarse aggregate; fly ash; GGBS; nano-silica; workability; split tensile strength; flexural strength; durability.*

1. INTRODUCTION

Concrete is one of the principal construction materials used in buildings, bridges, roads and other infrastructure. Its widespread use is

associated with its ability to be cast into different shapes, its relatively high compressive strength, the availability of its constituents and its suitability for a wide range of construction applications. Conventional concrete is generally produced using cement, fine aggregate, coarse aggregate and water, with chemical admixtures added when required to achieve the specified fresh and hardened properties.

The large-scale production and use of concrete place considerable demand on natural resources. Quarrying of natural coarse aggregate and extraction of river sand can disturb local ecosystems, while the manufacture of ordinary Portland cement (OPC) requires substantial energy and releases carbon dioxide. At the same time, demolition and renovation activities generate large quantities of concrete waste. Disposing of this material without recovery occupies landfill space and may create additional environmental burdens. These issues have encouraged the development of concrete mixtures that use recycled aggregates and supplementary cementitious materials.

Recycled coarse aggregate (RCA) is obtained by processing hardened concrete recovered from construction and demolition waste or discarded concrete specimens. After suitable crushing, removal of contaminants and grading, the recovered aggregate can be used as a partial replacement for natural coarse aggregate. Its properties are not necessarily identical to those of natural aggregate. In particular, adhered old mortar may increase porosity and water absorption and may reduce particle density. These characteristics can influence fresh-concrete workability, water demand and the strength of the hardened concrete. The performance of RCA concrete therefore depends on the quality of the recycled material, its replacement level, moisture condition and the mix-design procedure.

Fly ash and ground granulated blast-furnace slag (GGBS) are industrial by-products that can be used as supplementary cementitious materials. Fly ash is collected from the flue gases of pulverised-coal combustion systems. Depending on its source and classification, it contains silica, alumina and other oxides and can contribute to later-age cementitious reactions. GGBS is produced by rapidly cooling molten blast-furnace slag and grinding the resulting granulated material. When used with Portland cement, it can contribute to the formation of additional cementitious hydrates. Partial replacement of cement by these materials can reduce the quantity of OPC in a concrete mixture and may influence workability, strength development and durability.

Nano-silica is an ultrafine form of silicon dioxide. Its small particle size and high specific surface area can contribute to particle packing and pozzolanic reactions in cement-based materials. When properly dispersed and proportioned, nano-silica may refine the cementitious matrix. However, its high surface area can also increase water and admixture demand. The effect of nano-silica is therefore dependent on its dosage, dispersion method, compatibility with the superplasticizer and the overall binder composition.

The combined use of RCA, fly ash, GGBS and nano-silica offers an approach to investigate resource efficiency in concrete. The recycled aggregate component addresses the reuse of concrete waste, while the supplementary cementitious materials reduce the amount of OPC required. The performance of such a mixture must be evaluated experimentally because the effects of the materials may interact. A mixture that contains a higher proportion of recycled aggregate or binder replacement does not automatically provide better strength or durability.

2. MATERIALS USED FOR THE STUDY

For this experimental study initially we have collect the necessary materials to make concrete the details of materials collection and specification are discussed in the below

2.1 Cement

Ordinary Portland cement of 53 grade was utilized in this experimentation adjusting to I.S. – 12269-1987. For the current examination I was gathered ultra tech cement of 53 grade from local area Hyderabad. The

example cement bag utilized in this investigation is appeared in the below figure 1



Figure 1: Ultra Tech OPC 53 Grade cement Bag

2.2 Recycled Coarse Aggregate

The original report describes RCA produced by breaking tested concrete specimens of M20, M25 and M30 grades. The specimens were first reduced to smaller pieces and then manually crushed to obtain aggregate of the required size. For the revised work, the recycled material should be cleaned to remove soil, wood, plaster and other contaminants, crushed, sieved and separated into the required size fractions.

2.3 Fly ash

Fly ash is a finely divided by-product collected from the flue gases of pulverised-coal combustion in thermal power plants. It commonly contains silica and alumina, with composition depending on the source of coal and combustion process. In blended concrete, fly ash can contribute to later-age cementitious reactions and can influence workability, heat development and permeability.



Fly ash

2.4 GGBS

GGBS is produced by rapidly quenching molten blast-furnace slag, followed by drying and grinding the granulated material. When used with Portland cement, it contributes to the formation of additional cementitious hydrates. Its influence on strength development and durability depends on its fineness, chemical composition, replacement level and curing conditions. The GGBS used in the study should be characterized and its source documented. It is incorporated as a partial replacement for cement by mass.



GGBS

2.5 Fine Aggregates

Locally open sand zone II with specific gravity 2.65, water absorption 2% and fineness modulus 2.92, changing as per I.S. – 383-1970. It is the aggregate the a lot of which passes 4.75 mm IS sifter and contains basically such an unprecedented proportion of coarser as is allowed by detail.



Figure 2: Fine aggregates

2.6 Coarse Aggregates

Coarse aggregates are those stones which are held on IS4.75 strainer number squashed stone mix of 20mm size is incorporated from near to quarry. Aggregates of length more critical than 20mm size are secluded by using sieving. The underneath figure shows the example of Coarse totals which are utilized in this investigation.



Figure 3: Coarse aggregates

2.7 Mix Design And Trials Used For The Study

The mix design used for this study is M30 grade concrete having mix ratio 1:1.86:2.89 at w/c of 0.50 as per the materials properties.

3. METHODOLOGY

In order to test the strength and durability of concrete using recycled coarse aggregates, fly ash and GGBS for M30 grade concrete we need to cast the cubes, cylinders and prism specimens for compressive strength, split tensile strength, flexural strength and durability of various curing periods. Along with those strength tests workability is also studied for various trial mixes. For this project the following methodology is used

3.1 Batching

Batching is the process of taking the quantity of materials required for the project. Generally measuring the material quantity is done by two methods one is weight batching, second is volume batching. In the present study I was taken weight batching to measure the materials quantity.

3.2 Mixing Of The Concrete

After measuring the materials quantity I mixed the materials as per the trails. Firstly we have to mix coarse aggregates, fine aggregates and other materials for some time to get uniform mix after that add the mixture again mix for some more time to get same mix throughout the material. Now add the water as per the calculations from the mix design to make freshly prepared concrete for M30 grade concrete.

3.3 Casting Of Specimens

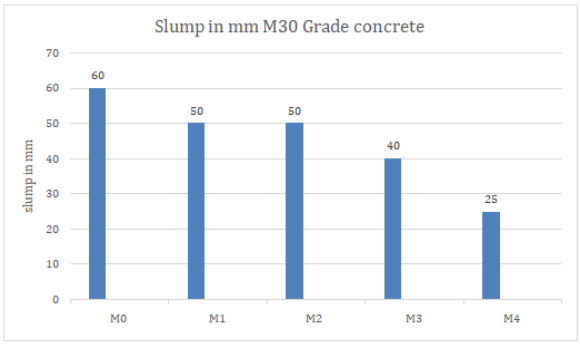
After mixing the concrete materials we have to cast the specimens like cubes, cylinders, prisms to check the strength and durability. The compressive strength, split tensile strength and flexural strength at 7days, 14 days and 28 days, 56days, 90 days and 180 days curing period along with these strength we have to cast 18 cubes for the durability of concrete for these five trial mixes.

3.4 Curing Of The Specimens

In case of compressive strength, split tensile and flexural strength studies we have to cure the specimens for 7 days, 14 days and 28 days 56days, 90 days and 180 days of curing periods with all five trial mixes. While in case of durability we have to cure the specimens to at least for acid attack and alkaline attack tests.

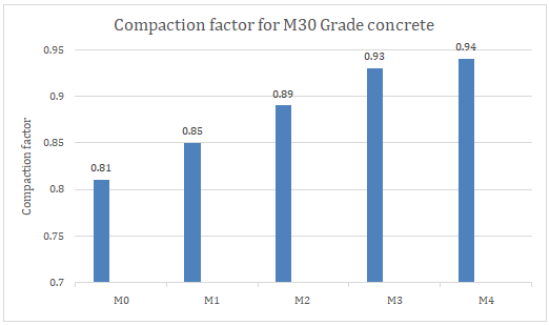
4. RESULTS AND ANA ANALYSIS

Slump cone test



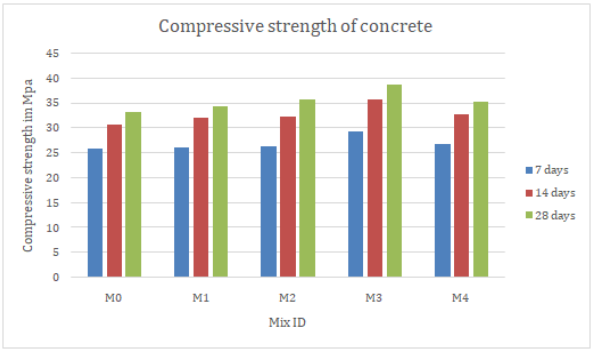
Comparison of slump cone values

Compaction factor



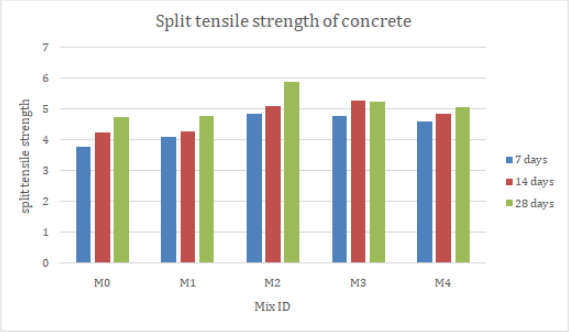
Comparison of compaction factor values

Compressive strength



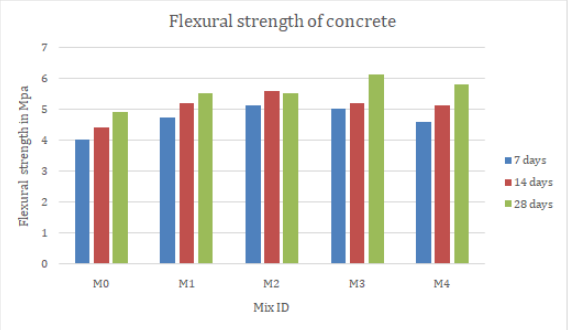
Comparison of compressive strength

Split tensile strength



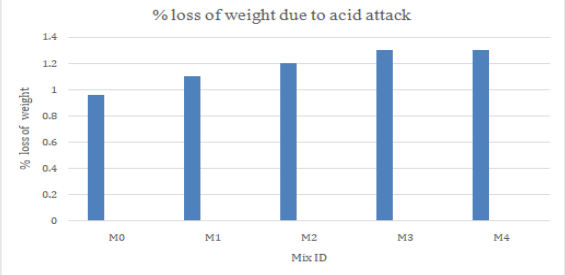
Comparison of split tensile strength

Flexural strength

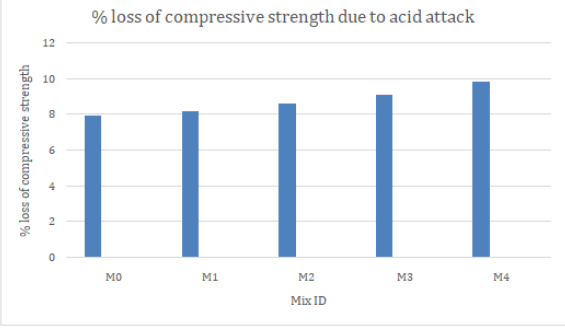


Comparison of flexural tensile strength

Acid resistance study



Comparison of Percentage loss of weight



Comparison of Percentage loss of strength

5. CONCLUSIONS

The conclusions below are limited to the numerical results currently presented in Chapter V. They should be checked against the original laboratory register before final submission.

1. The recorded slump decreased from 60 mm for M0 to 25 mm for M4. This indicates a reduction in measured workability as the combined replacement levels increased. The compaction factor increased from 0.81 to 0.94 across M0–M4; this trend should be interpreted together with the slump results and the test procedure.

2. The report does not include a complete compressive-strength table for M0–M4 at 7, 14 and 28 days. The 28-day values appearing in the chemical-exposure tables show M2 at approximately 40.40–40.41 MPa, M3 at 39.12–39.13 MPa and M4 at approximately 38.15–38.16 MPa. These values do not establish M3 as the compressive-strength optimum. The original cube failure loads and individual readings should be used to prepare the full strength table.

3. For 28-day split tensile strength, M2 recorded the highest value in the presented table (5.88 MPa). M3 recorded 5.24 MPa and M4 recorded 5.04 MPa. Therefore, the available split tensile results do not identify M3 as the optimum; they show a peak at M2 followed by a reduction.

4. For 28-day flexural strength, M3 recorded the highest value (6.11 MPa), followed by M4 (5.79 MPa), M1 (5.51 MPa), M2 (5.50 MPa) and M0 (4.90 MPa). Within the reported flexural results, M3 is the best-performing mixture at 28 days, while M4 shows a slight reduction.

5. The chemical-exposure tables show increasing percentage compressive-strength loss from M0 towards M4 for the reported acid, alkaline and sulphate exposures. M2 generally retains higher post-exposure compressive strength

than M3 and M4. The M3 acid/alkaline mass record changes from 2,294 g to 2,363 g, which is a 3.01% mass gain rather than a loss; this unusual result should be rechecked against the weighing record and surface-drying procedure.

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