An Emphasis of Geopolymer Concrete with Single Activator and Conventional Concrete with Recycled Aggregate and Data Analyzing using Artificial Neural Network

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ABSTRACT

The emphasis of concrete in the advancement of construction industry is essential. Due to the rapid increase in the development of infrastructure, there is a considerable demand for the construction materials. The construction materials drained gradually due to continue use in construction and there is a degree for the advancement of these development materials. Therefore, in this context, a rapid increase in the price of conventional construction materials and various governments have put restrictions on fine aggregates. In this circumstance, the investigation attempted to determine the appropriateness of the substitute materials in concrete development because these materials are easily available at very low cost as compared to conventional fine and coarse aggregates. The effect of recycled aggregates on the strength of conventional concrete and Geo-polymer concrete was studied. The natural aggregates are replaced by the crushed aggregates of intervals of 10%, 20%, 30%, 40%, and 50% in both geo-polymer and conventional concrete. The different strengths of 20MPa, 40MPa, and 60MPa were studied in this research work. The conventional concrete cubes were cured in normal water and geopolymer concrete cubes cured in ambient room temperature. The coarse aggregates used were of size 20mm and 10mm sieved and the recycled aggregates contains a cement mortar attached to it. The outcomes show that a slight decline in the strength of conventional concrete and high strength found with 30% substitution of coarse aggregate and eventually the prediction of data was analyzed using Artificial Neural Network.

Keywords: Geopolymer concrete, Fly Ash, GGBS, Compressive Strength, Geo-activator and Artificial Neural Network

1. INTRODUCTION

The reused coarse aggregate acquired by dismantled concrete were utilized for concrete production. Four distinctive reused total aggregates were delivered; made with 0%, 25%, 50%, and 100%, respectively [1]. The blend extents of the four concretes were structured to accomplish a similar compressive strength. The shape and surface of the aggregates can likewise influence the functionality of the concrete [2]. Crushed concrete as partial replacement accomplishes a high level of reused coarse aggregate without followed by mortar. Concrete made with 100% of coarse reused aggregate requires high measures of cement to accomplish a high compressive strength and subsequently is not a monetary recommendation as it is not practical. Concrete made with 100% of reused coarse total has...
20 to 25% less pressure quality than traditional cement at 28 days, with a similar viable w/c proportion and concrete amount. [3], learned about certain boundaries like compressive strength, ultrasonic velocity, shrinkage, water absorption tests. The outcomes demonstrated a diminishing compressive strength towards the significant level of the reused aggregate substance that is because of the low quality of the followed mortar. It was seen from the analysis that reused total cement was "good" as per UPV measurable values.[4] considered the mechanical properties, durability studies, and the basic presentation of reused aggregates for around 10 years (1996-2011). He discussed the acquired outcomes and the consequences of ordinary cement. The perceptions uncovered that the aggregate of – concrete grid interfacial zone of reused aggregate composed of free and permeable hydrate. Regarding the toughness properties, the carbonation and chloride resistance were lower when contrasted and the ordinary cement. For the components, for example, shrinkage and creep, indicated increased for the conventional concrete. [5] Consider the designing and strength properties of fly ash based geopolymer reused aggregate concrete and the outcomes were introduced in this paper. The increase of reused coarse aggregate (RCA) recovered from construction and demolition(C&D) indicated promising capacity in development industry as an option in contrast to regular aggregates. It monitors gigantic amounts of common assets and decreases the space required for the landfill removal of C&D squanders. In this examination and augmentation of 25% halfway substitutions by weight of characteristic aggregates with reused aggregates in geopolymer concrete, up to 100% substitutions were considered. The new and mechanical properties of all the over four concrete blends have been researched. The results showed that the functionality of geopolymer solid reduction than normal concrete and it took over 24 hours to set. Geo polymer-based reused aggregate concrete shows preferable quality and solidness execution over standard reused total cement. [6]. The product not just gives general capacity to strength examination and improvement alongside an intelligent easy-to-use interface, yet additionally incorporates one of a kind highlights, for example, artificial neural network modelling, network & multithreaded computing, and user-accessible programming modules. Visual Gene Developer is helpful for the two analysts who need to rapidly examine and improve strength, and the individuals who are keen on creating and testing new calculations in bioinformatics. [7] Presents an investigation of the impact of reused aggregate on the strength and durability properties of fly ash-based geo polymer concrete. Geo-polymer concrete examples were set up from high calcium fly ash, sodium silicate and sodium hydroxide arrangement, fine aggregate from river sand, and two types of coarse aggregate, and the results demonstrated that reused aggregate can be utilized as a coarse aggregate in high calcium fly ash geo-polymer cement with the 7-day compressive strength of 30.6–38.4 MPa which were marginally lower than those of high calcium fly ash geopolymer concrete with demolished limestone. [8] tested the consequences of reused concrete aggregate and the results are contrasted and the characteristic RCA. The fine aggregate utilized in the concrete is both recycled and conventional aggregate. The outcomes shows the compressive, tensile, and flexural strength of reused aggregate are normal from 85% to 95% of the characteristic aggregate. [9] Artificial neural systems (ANNs) are generally considered as software that can assist with examining cause-impact connections in complex frameworks inside a major information structure. In this circumstance, a specific neural system apparatus, which can deal with little datasets of exploratory or observational information is shown that can help in distinguishing the principal causal elements prompting changes in some factors. Clear details of ANN are provided, its applications to specific study are discussed. There is an extensive use of concrete. Thus, the consumption of natural sand is also very high globally. Generally, in developing countries, the demand for natural sand is comparatively very high to satisfy the rapid growth in infrastructure, whereas, in the same situation, India being a developing country is lacking better quality natural sand. Mainly in India, depletion of the deposits of natural sand causes a serious threat to the society and the environment. As the extraction of natural sand from the riverbeds goes on increasing, it creates many problems. Some of
the problems include loss of vegetation on the riverbanks, loosing water, retaining sand strata, causing landslides due to the deepening of the river courses. This also affects the aquatic life and the agriculture as the level of the underground water is lowered largely. In the earlier decades, the cost of construction used to be relatively high due to the variable cost of the natural sand that is used as a fine aggregate in concrete. Considering this situation, a research has been initiated to find out an alternative substance to the natural sand, which is comparatively less expensive and available easily. In extension to this, the data prediction using Artificial Neural Network(ANN) is also studied. Data analysis and data prediction is a game changer in this modern world where ample work is needed to be done in a short time. Based on the previous statistics and data available, we can generate the new data of our needs. Which saves time, energy, and cost. Based on the algorithm of ANN, we can predict the data and compare the experimental values and analytical values. Moreover, single activator in geopolymer mortar is a highly effective, innovative and environmentally friendly material that could affect strength of geopolymer mortar compared to alkaline activator [10]. The Molarity increases the amount of sodium hydroxide increases and resulted increase in strength of mortar. Few specimens were casted with 1:3 proportion using single activator and combined solution (Mix of sodium hydroxide and sodium silicate solution of ratio 2.5 with 8 Molarity) and tested compressive strength after 1, 3, 7 and 28 days under ambient curing. Besides, UPV test is done for the specimens and compared. The test results displayed that a single solution cube specimens produced better early strength properties compared to other specimens. Since there are lack of literature on the topic, less study are discussed in this paper

2. EXPERIMENTAL PROGRAMME

Materials Used in the Investigation

Fly ash: Fly ash is a byproduct of coal obtained from the La Mangada Thermal Power Plant (NTPC). In this experiment, we use class F fly ash as the source material.

GGBS: The crushed blast furnace slag is a byproduct of the steel processing plant that replaces the cement obtained from Toshali Cement Pvt. Ltd Bayyavaram, India.

Fine aggregate (stone dust): The fine aggregate used in this investigation is stone dust which is grey in colour, with a specific gravity of 2.6 conforming to IS 2386 (part-3)-1963. Water absorption for stone dust is 0.6% conforming to IS 2386 (part-3)-1963.

Coarse aggregate: Natural granite aggregate having specific gravity of 2.8 and water absorption of 0.1% conforming IS 2386 (part 3). Recycled aggregate demolished from buildings having specific gravity of 2.19 and water absorption of 0.2% conforming IS 2386 (part 3). Aggregate passing through 12mm IS sieve and retained on 10mm IS sieve is taken in the entire investigation as shown in Table 1.

| TESTS                  | RECYCLED AGGREGATE | NATURAL AGGREGATE |
|------------------------|--------------------|-------------------|
| Specific Gravity       | 2.35               | 2.73              |
| Water Absorption (%)   | 2.89               | 2.19              |
Geo activator: In this experiment, only a single alkaline liquid was used, namely, geo activator replacing alkaline activator (Mix of sodium hydroxide and sodium silicate). Geo activator Solutions of silica modulus SiO₂:Na₂O (Mₛ) =2.92:1 with 28.98% SiO₂; 9.92% Na₂O by weight, which was produced from KIRAN GLOBAL Ltd, Chennai India.

Super plasticizer: To improve the workability of fresh concrete naphthalene based superplasticizer was added to the mixture.

Mix Proportions

Different grades of concrete of MIX (A)20MPa, MIX(B)40MPa, and MIX(C)60MPa were performed with replacement of coarse aggregate with crushed aggregate of 0%, 10%, 20%, 30% 40% and 50% as shown in Table 2 and Table 3

Table 2: Mix proportions of Conventional Concrete

| Mix     | Cement (kg/m³) | Coarse aggregate (kg/m³) | Fine aggregate (kg/m³) | Water (kg/m³) |
|---------|----------------|--------------------------|------------------------|---------------|
| Mix A (20MPa) | 396            | 1216                     | 608                    | 198           |
| Mix B (40 MPa) | 450            | 1380                     | 428                    | 180           |
| Mix C (60 MPa) | 687            | 866                      | 474                    | 170           |

Table 3: Mix proportions of Geo-polymer Concrete

| Grade    | Fly ash (kg/m³) | GGBS (kg/m³) | Coarse aggregate (kg/m³) | Fine aggregate (kg/m³) | Geo activator (kg/m³) |
|----------|-----------------|--------------|--------------------------|------------------------|-----------------------|
| Mix A (20MPa) | 396             | 0            | 1216                     | 608                    | 198                   |
| Mix B (40 MPa) | 315             | 135          | 1280                     | 528                    | 180                   |
| Mix C (60 MPa) | 412             | 275          | 474                      | 966                    | 170                   |

3. RESULTS AND DISCUSSIONS

Figure 1 shows the compressive strength of recycled aggregate concrete for 7 and 28 days. The aggregate was replaced up to 50% at an interval of 10%. From figure 1, it can be observed that the compressive strength was decreased with increase in the replacement levels of coarse aggregate. The maximum compressive strength was observed at 0% replacement level at was 28.51 MPa after 28 days, whereas for 50% replacement level of coarse aggregate it was observed as 22.31 MPa. The compressive strength decrement was maximum observed at 30% replacement of coarse aggregate.
Figure 1: Compressive strength of conventional concrete cubes of Mix (A) 20 MPa

Figure 2 shows the compressive strength of conventional concrete of 40MPa for replacement of RCA from 10% - 50% at the intervals of 10. For the age of 7 days and 28 days. We can see from the result the RCA shows good compressive strength for 40MPa in 10% and 20% replacement of CA and after then the strength decreases slightly when we increase RCA dosage. The replacement of RCA in concrete will decrease the compressive strength. On this context, the compressive strength for 0% replacement of RCA was 47.39 MPa and for 50% replacement was 41.31MPa

Figure 2: Compressive strength of conventional concrete Mix (B) 40MPa
Figure 3 shows the compressive strength of conventional concrete of 60MPa for replacement of RCA from 10% to 50% at the intervals of 10 at the age of 7 days and 28 days. We can see from the result, the RCA shows good compressive strength for grade 40 MPa in 10% and 20% replacement of CA and after then the strength decreases slightly when we increase RCA dosage. The replacement of RCA in concrete will decrease the compressive strength. On this context, the compressive strength for 0% replacement of RCA was 65.13MPa and for 50% replacement was 59.78MPa.

Figure 3: Compressive strength of conventional concrete cubes of Mix(C) 60Mpa

Figure 4 shows the compressive strength of geopolymer concrete of 20MPa for replacement of RCA from 10% to 50% at the intervals of 10 at the age of 7 days and 28 days. The replacement of RCA in concrete will decrease the compressive strength. On this context, the compressive strength for 0% replacement of RCA was 27.65MPa and for 50% replacement was 23.46MPa.
Figure 4: Compressive strength of geopolymer concrete cubes of Mix A (20 MPa)

Figure 5 shows the compressive strength of geopolymer concrete of 40MPa for replacement of RCA from 10%-50% at the intervals of 10 at the age of 7 and 28 days. The replacement of RCA in concrete will decrease the compressive strength. On this context, the compressive strength for 0% replacement of RCA was 48.4MPa and for 50% replacement was 44.13MPa

Figure 5: Compressive strength of geopolymer concrete cubes of 40 MPa

Figure 6 Shows the compressive strength of geopolymer concrete of 60MPa for replacement of RCA from 10%-50% at the intervals of 10 at the age of 7 and 28 days. The replacement of RCA in concrete
will decrease the compressive strength. On this context, the compressive strength for 0% replacement of RCA was 66.83 MPa and for 50% replacement was 61.50 MPa.

Figure 6: Compressive strength of geopolymer concrete cubes of 60 MPa

Results for data prediction using ANN

The above results obtained in experimental work for conventional concrete and geopolymer concrete were taken as input data for training in Artificial Neural Network for the grades of 20 MPa, 40 MPa, and 60 MPa and the data is predicted for the same grades for replacement of RCA from 0% - 50% at the interval of 10%. Table 4 shows the composition of materials used and the data is normalized to be less than 1.

Table 4: Maximum and Minimum range of total values

| Mixes | Fly ash | GGBFS | Fine aggregate | Coarse aggregate | Alkaline solution | Recycled Coarse aggregate | Compressive strength (MPa) |
|-------|---------|--------|----------------|-------------------|-------------------|---------------------------|---------------------------|
| MIX 1 | 366     | 0      | 608            | 1094              | 198               | 121.6                     | 28.32                     |
| MIX 2 | 366     | 0      | 608            | 972               | 198               | 243                       | 27.21                     |
| MIX 3 | 366     | 0      | 608            | 852               | 198               | 364                       | 26                        |
| 30%   | ---     | ---    | ---            | ---               | ---               | ---                       | ---                       |
| 40%   | ---     | ---    | ---            | ---               | ---               | ---                       | ---                       |
| 50%   | ---     | ---    | ---            | ---               | ---               | ---                       | ---                       |
| MIX 61| 377     | 250    | 574            | 817               | 170               | 349                       | 65.23                     |
| MIX 62| 377     | 250    | 574            | 700               | 170               | 466                       | 63.21                     |
| MIX 63| 377     | 250    | 574            | 583               | 170               | 583                       | 61.21                     |
The Figures 7, 8, and 9 shows the comparative difference between data predicted for strengths of 20MPa, 40MPa, and 60MPa by training data of grades 20MPa, 40MPa, and 60MPa. Fig 1 shows the regression curve for training data set, Fig 4.8.2 shows the regression curve for prediction data set. With the values replacement of 0% to 50% of RCA. The obtained R² value for training and prediction data set should be 0.99 and 0.98.
CONCLUSIONS

• In conventional concrete, the acceptable strength of RCA is found up to 30% replacement in all the mixes.

• In geopolymer Concrete, the early strength within 7 days is observed to be of desired strength due to high calcium content in GGBS used.

• Based on the research result for Conventional concrete, the decrease in compressive strength with 10% replacement of RCA is 1-2% and with 50% of RCA, the decrease is 18-20% and for Geo-Polymer concrete. The decrease in compressive strength with 10% replacement of RCA is 1-2% and with 50% of RCA, the decrease is 12-16%.

• By this, we can conclude that the use of RCA in concrete can be replaced up to 30%, which showed minimum fluctuations, and further increase will decrease the strength.

• The data prediction using Artificial Neural Network by Visual Gene Developer shown good results and the regression analysis shows very less error. We can save the time by using ANN rather than working on trial mixes which consumes cost and time.

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