

Effect of Flyash on Recycle Coarse Aggregate Concrete

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Abstract

The rapid growth in construction and depleting natural resources demands the recycling and reusing technology to be adopted in construction field. The recycle coarse aggregate is one of the approaches towards this need. If the recycled coarse aggregate are used in conventional construction work it would saves the cost of materials. In this experimental study the natural coarse aggregate is replaced with recycled coarse aggregate at different percentage and the mechanical strength of concrete is tested. In addition the flyash is introduced as replacement of Cement to improve the quality of concrete. The mix designing is done for water cement ratios 0.38. Cylinders and cubes are casted using virgin coarse aggregate and replacing virgin aggregate with 20%, 30%, 40%, 50% and 100% recycle coarse aggregate, total sixteen batches are made. Obtained results are than used for Multi Linear Regression to establish an empirical relationship between the strength of concrete and with percentage of recycle aggregate, with percentage of fly ash and with age of concrete. Results shows that recycle aggregate up to 40% can be used with 10% flyash for making concrete.

Keywords: Recycling, flyash, bonding, compressives strength, split tensile strength, regression analysis.

1. Introduction

The Recycling System for concrete being heightened in recent days due to the rapid economic growth is leading to urbanization and industrialization generating waste

which is adversely effecting the environment. To address the problem of waste management in the country the Ministry of Environment and forests, Government of India constituted a committee to evolve a road map for the management of waste in India and to suggest a policy and strategy for achieving the same.¹ Construction materials are increasingly judged by their ecological characteristics. Recycling of demolished concrete is gaining 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.² The demand of concrete expected to grow to approximately 18 billion tons a year by 2050, which means in future we need approximately 14.4 billion tones of natural aggregate for concreting. [P.K. Mehta and P.J.M. Monteiro, Concrete: Microstructure, Properties, and Materials]. Management of waste in an environmentally sustainable manner is a challenging task. It involves reusing and recycling of all types of waste ranging from domestic constructional waste to industrial constructional waste. Technologies have to be developed for tackling Waste Management and promoting its reuse, recycling and waste to energy operation.¹ The aim of this research is to assess the feasibility of inclusion of flyash (as replacement of Cement) for RCA based concrete to improve its quality and secondly, to evaluate the effect of various percentage flyash, RCA, on compressive strength and split tensile strength of concrete. Recycling of concrete is a relatively simple process. It involves breaking, removing, and crushing existing concrete into a material with a specified size and quality.²The quality of concrete with RCA is very dependent on the quality of the recycled material used. In the process of manufacturing such recycled aggregate, the manufacturing cost and amount of CO₂ emissions is likely to rise sharply, consequently limiting the extent to which recycled aggregate concrete is used³.

Recycled-aggregate concrete (RAC) for structural use can be prepared by completely substituting natural aggregate⁴, in order to achieve the same strength class as the reference concrete, manufactured by using only natural aggregates. It is useful to prove that to manufacture structural concrete by partly substituting natural with recycled aggregates by up to 30% percent is indeed feasible⁵. Moreover, high-volume fly ash recycled aggregate concrete (HVFA-RAC) can be manufactured with a water to cement ratio of 0.60, by simultaneously adding to the mixture as much fly-ash as cement, and substituting the fine aggregate fraction.⁶ In India very less progress in research on the reuse and recycling of construction and demolition waste has been made. This is due to the lack of awareness and knowledge about this technology. In India, 2009 Delhi government have initiated a program to manage the construction and demolition waste.

2. Experimental Programme

2.1 Material Used

Cement: Portland pozzolana cement conforming to IS 1489 (Part-1).

Fly ash: It is obtained from Koradi Thermal Power Station at Nagpur, India.

Fine Aggregate: Locally available Natural sand of zone-II as per IS 383:1970.

Coarse Aggregate: Machine crushed stone obtained from quarry as a coarse aggregate.

Recycle Aggregate: It is obtained from demolition of concrete cubes at the concrete testing laboratory.

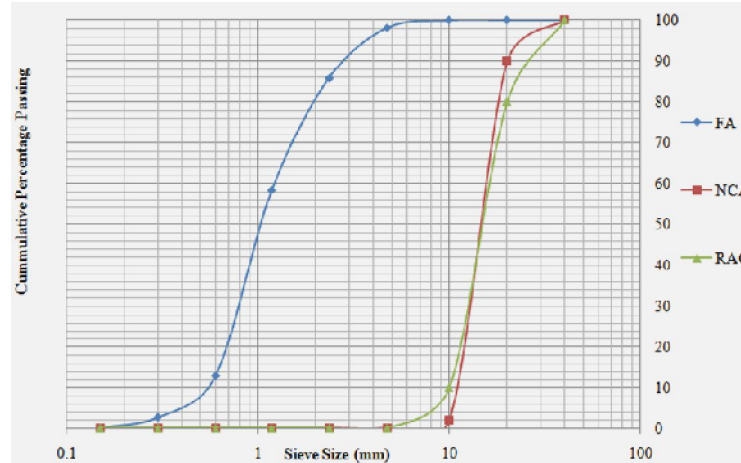


Figure 1: Grade Curve.

2.2 Methodology

IS: 10262:2003 is used for mix designing and 0.38 water cement ratio is taken. The recycle coarse aggregate is added in 0%, 20%, 30%, 40%, 50% and 100% with the mix. Again, cement is replaced with flyash in 10 and 20 percent respectively. Mould sizing 150mm by 150mm by 150mm were used for compression test and cylinder of 150mm dia. 300mm long is used for splitting tensile test. After casting, the cubes are cured at ambient temperature for 7 days, 28 days and 90 days respectively. The test procedure is according to the method mentioned in IS: 516:1989. The obtained experimental values are then used to do regression analysis by using Multi-linear regression. After the analysis of practically obtained results the relationship between various parameter of concrete mix and strength is obtained. The selected parameters are percentage of flyash, percentage of recycles aggregate, age of concrete.

2.3 Experimental Results

2.3.1 Compressive Strength results

The experimental results obtained after the curing of 7 days, 28 days and 90 days are shown below in the graph. The figure no. 2 shows the experimental results obtained from the compressive test of the mix batch without flyash. From the obtained result the compressive strength of concrete cube made with natural coarse aggregate after 28 days of curing is 44.88 N/mm^2 . Now, when the recycle coarse aggregate replaces the natural aggregate percentage this strength goes on reducing. The reason between this may be the poor bond between recycle aggregate and cement matrix.

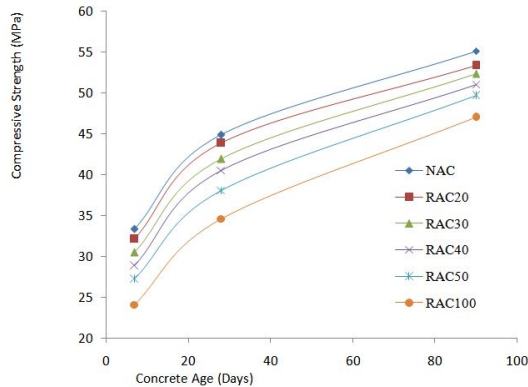


Figure 2: Compressive Strength Vs Age for 0% flyash.

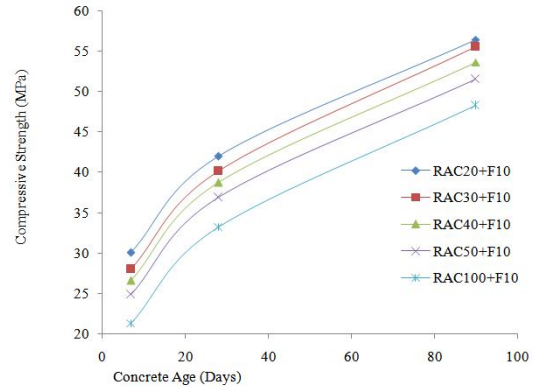


Figure 3: Compressive Strength Vs Age for 10% flyash.

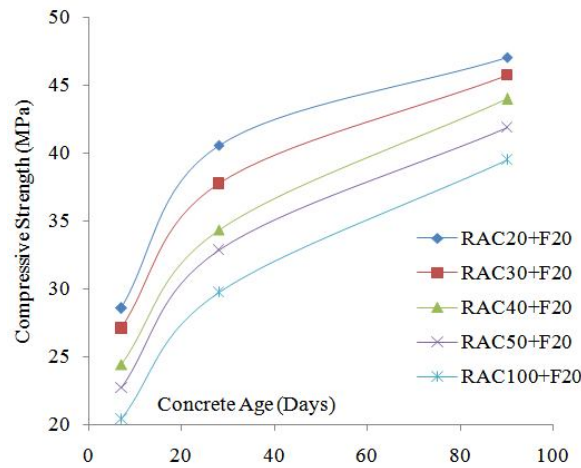


Figure 4: Compressive Strength Vs Age for 20% flyash

The figure 3 shows the increase in the strength of concrete consist of RCA and flyash in 10%, with the curing age. It can be clearly seen after comparing two figures 2 and 3 the strength after 90 days curing for RAC100+F10 is more than RAC100. This may be due to the bonding between the old mortar on the surface of Recycle coarse aggregate and flyash.

However in the figure 4 when we see at the strength of concrete RAC100 +F20 at the end of 90 days of curing, it is less than the RAC100 + F20. This may be due to the excess flyash which cause the improper bonding of aggregate and matrix.

2.3.2 Split Tensile Strength results

The split tensile strength also shows the similar pattern of results as the compressive strength results are showing in graph. The tensile strength results are shown in the Figure 5, 6 and 7 respectively.

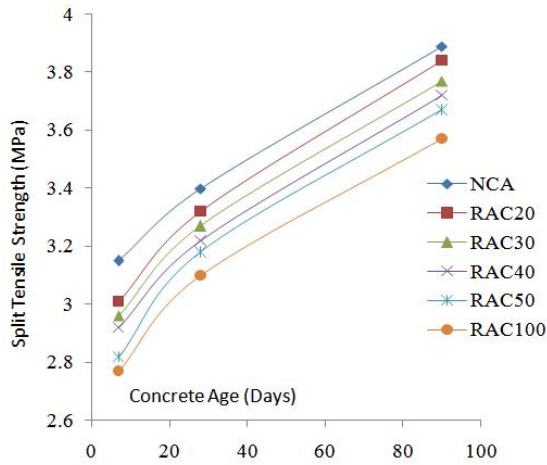


Figure 5: Split tensile Strength Vs Age for 0% flyash.

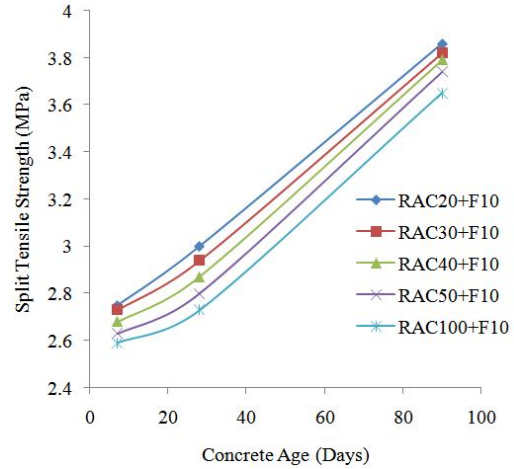


Figure 6: Split tensile Strength Vs Age for 10% flyash.

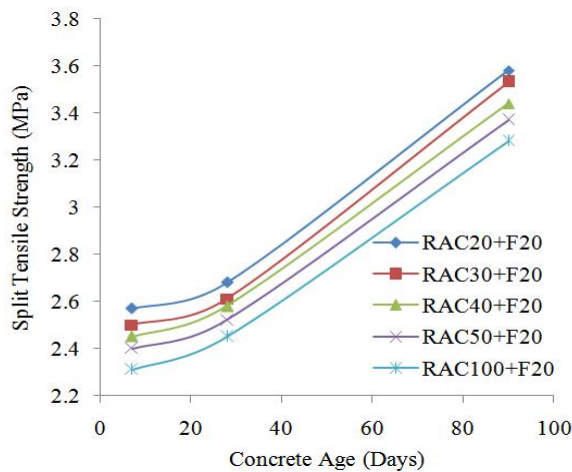


Figure 7: Split tensile Strength Vs Age for 20% flyash.

2.4 Modeling Analysis

In this section the experimentally obtained values are used for multi linear regression to obtain an empirical relationship between the strength of concrete and other independent parameters.

2.4.1. Empirical formula for Compressive Strength.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

$$Y = 34.46 - 0.098 * X_1 - 0.254 * X_2 + 0.252 * X_3$$

Where Y indicates the predicted compressive strength of concrete, in N/mm²

X₁ indicates the percentage of recycle coarse aggregate,

X₂ indicates the percentage of flyash,

X₃ indicates the Age of curing in days, respectively

2.4.2. Empirical formula for Split Tensile Strength.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

$$Y = 2.961 - 0.003 * X_1 - 0.023 * X_2 + 0.0116 * X_3$$

Where Y indicates the predicted split tensile strength of concrete, in N/mm²

X₁ indicates the percentage of recycle coarse aggregate,

X₂ indicates the percentage of flyash,

X₃ indicates the Age of curing in days, respectively

2.4.3 Graphical comparison

In the figure 8 and 9 the experimental value and predicted values are compared to each other.

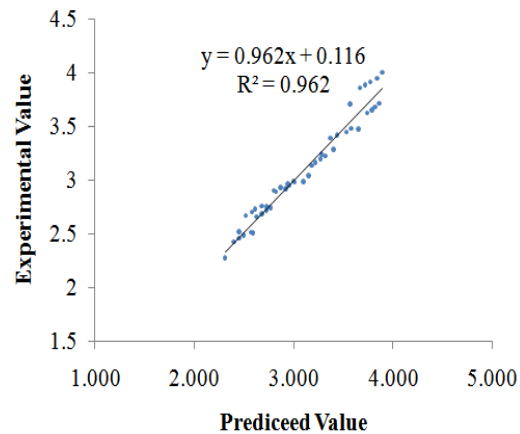
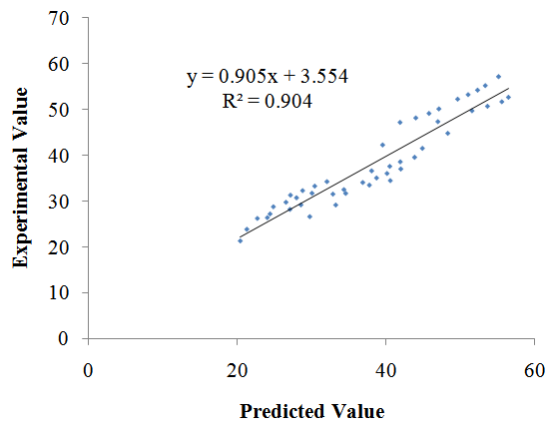


Figure 8: Predicted Value Vs Experimental Value for compression.

Figure 9: Predicted Value Vs Experimental Value for Split Tensile.

Now, the R² value greater than 75% which can be accepted for the prediction of strength of concrete under above specific experimental study.

3. Conclusions

From the study following conclusion are made:

1. The strength of concrete decrease with increase in the percentage of recycle aggregate, this may be due to the loose mortar around the recycle aggregate which do not allow the proper bonding between the cement paste and aggregate.
2. RAC based concrete with 10% flyash gives higher compressive strength than normal RAC based concrete in 90 days. This may due to bonding between the old mortar and flyash.
3. From the study it can be concluded that the Natural aggregate can be replaced by recycle aggregate up-to 40% with 10% flyash.

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