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Performance Study of Steel Fibre Reinforced Artificial Sand Concrete

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Summary

In India, conventional concrete is produced by using natural sand from river bed as fine aggregate. Dwindling sand resources poses the environmental problem and hence government restrictions on sand quarrying resulted in scarcity and significant increase in its cost. This paper presents the performance study of artificial sand as fine aggregate for concrete by comparing its basic mechanical properties with that of conventional concrete. Three matrices with compressive strength 20, 30 and 40 MPa were designed and reinforced with crimpled steel fibers at dosage rate of volume fraction 0, 0.5, 1.0 and 1.5 percent. Sufficient numbers of specimens were prepared, cured and tested for compressive strength, flexural strength and split tensile strength at 7 and 28 days curing. The experimental results encourage the full replacement of natural sand by artificial sand. The promotional use of artificial sand will conserve the natural resources for the sustainable development of the concrete in construction industry.

Keywords: Natural sand, Artificial sand, Super plasticizer, Steel fibers, Compressive strength, Flexural strength, Split tensile strength.

1. Introduction

The large variation in the strength of concrete is due to variation in the strength of aggregates used. There is scarcity of natural sand due to heavy demand in growing construction activities which forces to find the suitable substitute. The cheapest and the easiest way of getting substitute for natural sand is by crushing natural stone to get artificial sand of desired size and grade which would be free from all impurities. For the purpose of experimentation concrete mixes are designed for M20, M30 and M40 grades by 100% replacement of natural sand to artificial sand. Compressive, split and flexural tests are conducted to study the strength of concrete using artificial sand and the results are compared with that of natural sand concrete. The artificial sand concrete is reinforced with crimpled steel fibres at the dosage rate of volume fraction 0%, 0.5%, 1.0% and 1.5% and its mechanical properties namely cube compressive strength, flexural strength and split tensile strength are presented in the paper. Empirical relationships were developed based on regression analysis of the test data with an expectation that these models would be helpful in assessing the strength properties of SFRCAS based on the matrix strength and fiber reinforcing index, RI.

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2. Strength Prediction Models

The mechanical strength properties of Steel Fibre Reinforced Artificial Sand Concrete with (SFRASC) are closely related to fibre parameters, matrix strength and their interaction. The improvement in mechanical properties of SFRASC is expressed as function of reinforcing index RI ($RI = V_f L_f / \Phi_f$). The proposed strength models for strength properties are presented in table 1.

Table 1 - Proposed Strength Models for SFRASC

S. N.	Strength Property	Predicted Model
01	Cube compressive strength	$f_{cuF} = f_{cu} + 0.045(f_{cu})\ RI + 1.16\ RI$
02	Flexural strength	$f_{flF} = 0.91(f_{cu})^{0.5} + 0.32(f_{cu})^{0.5}\ RI + 1.125\ RI$
03	Split tensile strength	$f_{spF} = 0.70(f_{cu})^{0.5} + 0.315(f_{cu})^{0.5}\ RI + 0.06\ RI$

3. Results and Discussion

It is observed that there is marginal increase in the compressive strength of M20, M30 and M40 grade concrete at 7 days and 28 days. The increase in strength varies in the range of 4% to 7%. The percentage increase in flexural strength of artificial sand concrete over the natural sand concrete is in the tune of 12% to 17%. The increase in split tensile strength varies in the range of 12% to 17%.

The addition of steel fibers increased strength of concrete. The average increase in compressive strength of SFRASC due to addition of steel fiber (V_f = 1.5%) was found to be 6.22%, 5.92% and 5.60% for M20, M30 and M40 concrete respectively. The maximum value of standard deviation in the test results was found to be 2.6%. The flexural strength of SFRASC also increased. At volume of steel fibers V_f = 1.5%, the increase in strength was found to be 48.65%, 45.00% and 44.00% for M20, M30 and M40 concrete respectively. The average increase in split tensile strength of SFRASC due to addition of steel fiber (V_f = 1.5%) was found to be 38.39%, 37.63% and 37.40% for M20, M30 and M40 concrete respectively.

4. Comparison of Predicted and Experimental Results

The predicted values of above strength properties of SFRASC have been compared with the experimental results of the present study. The ratio of experimental values to the predicted values by the proposed models is almost unity.

5. Conclusions

It is observed from the above results that there is consistent increase in the strength of plain concrete when natural sand is fully replaced by artificial sand. The increase in compressive stress is marginal as compared to flexural and split tensile strength. Similar trend is observed when the artificial sand concrete is reinforced with steel fibres. It is seen that as the reinforcing index go on increasing, the strength of SFRASC also go on increasing. The sharp edges of the particles in artificial sand provide better bond with cement than the rounded particles of natural sand resulting in higher strength. But considering the workability and balling effect of the fibres, the maximum volume fraction of fibre is restricted to 1.5%. To get the design degree of workability, essentially super plasticizer was used. The excessive bleeding of concrete is reduced by using artificial sand. The cost of artificial sand is in the range of 40% to 70% to that of natural sand and considering cost of screening, washing and wastage due to oversize particles of natural sand, the artificial sand concrete will be about 15% to 25% cheaper than that of natural sand concrete. The test results obtained from well planed and carefully performed experimental programme encourages the full replacement of natural sand by artificial sand considering the technical, environmental and commercial factors.