STUDY ON SPLITTING TENSILE STRENGTH OF HYBRID LENGTH STEEL FIBER REINFORCED CONCRETE UNDER ELEVATED TEMPERATURE

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Abstract— Concrete is a composite material likely exposed to high range of temperatures during its service life. The relative properties of concrete after such an exposure are of great importance in terms of the durability of buildings. The constituents of concrete have different properties and also depends on moisture and porosity. A complete understanding of the behavior of concrete under elevated temperature after a thermal excursion is essential for reliable design evaluations and assessments. The properties of concrete changes with respect to time and the environment to which it is exposed, an assessment of the effects of concrete is also important in performing safety evaluations.

Keywords— Concrete, Temperature, Split tensile strength

INTRODUCTION

Exposure of concrete to elevated temperature affects its mechanical and physical properties. Temperature affects produce dimensional changes, loss of structural integrity, release of moisture and gases resulting from the migration of free water could adversely affect plant operations and safety. Steel fibres are relatively short and closely spaced as compared with countinuous reinforcing bars of wires. The study focuses on the effect of temperature on fiber reinforced concrete by incoperating two different length hooked steel fibers.

LITERATURE REVIEW

Balazs and Lubloy [1] investigated the properties of concrete may be considerably influenced by high temperatures. These properties are depends on the maximum temperature and the composition of the concrete. Water-cement ratio (W/C), type of cement, type of aggregate and porosity are also influenced by the temperatrure. The deterioration of concrete at high temperatures is manifested as deterioration of the material itself and the deterioration of the structural performance. *Bangi and Horiguchi* [2] investigated on effect of fibre type and geometry on maximum pore pressures in fibre-reinforced high strength concrete at elevated temperatures. Fibre type and geometry, significantly contributes towards pore pressure.

The objectives of the study are;

- Study the effect of steel fibers on compressive strength of concrete
- To predict the performance characteristics of steel fibers with different percentages (0%,0.5%,1%) on concrete with temperatures(Ambient temperature,200°C,400°C)
- To minimize the experimental procedure according to Box-Behnken Design for optimization.

MATERIALS AND METHODOLOGY

The materials selected for this experimental study includes normal natural coarse aggregate, Manufactured sand as fine aggregate, cement, superplasticizer, both end hooked steel fiber and portable drinking water. Potable clean drinking water available in the water supply system was used for casting as well as for curing of the test specimens. Hooked end Steel fibers of two different diameters 0.55mm with 35mm length and 0.75mm diameter with 60mm and aspect ratio of 63.63 and 80 were used. The manufracturer is Stewols private limited,Nagpur. The super plasticizer used was MASTER RHEOBUILD 918 a product of BASF India Pvt. Ltd, Ernakulam.

MIX-DESIGN

The mix design is carried out as per relevant Indian standard Code Specification [7]. Mix designing is carried out to arrive at the quantities required for 1 m^3 of concrete and mix designation as shown in Table I.

TABLE I. QUANTITY REQUIRED FOR 1M^3 MIX

W/C	**Proportion of Steel Fiber**	**Water (Kg)**	**Cement (Kg)**	**F_a (Kg)**	**C_a (Kg)**	**Steel Fiber (Kg)**
0.35	0	160	460	660	1240	0
	0.5	159	457	656	1233	39
	1	158	455	653	1237	78
0.4	0	160	400	700	1260	0
	0.5	159	398	696	1253	39
	1	158	396	693	124	78
0.45	0	160	360	730	1260	0
	0.5	159	358.2	726	1253	39
	1	158	356.4	722	1247	78

MATERIALS AND METHODOLOGY

- *Box -Benhken Design*

Box– Behnken designs are experimental designs for esponse Surface Methodology, devised by George E.P.Box and Donald Behnken in 1960 [8]. Response Surface Methodology (RSM) is an empirical optimization technique for evaluating the relationship between experimental outputs (or responses) and factors called x_1, x_2, and x_3. Box–Behnken is a spherical, revolving design. In this study Box-Behnken design with three variable and three-level factor to reduce the numbers of experiment adopted. Three control factors, namely, water-cement ratio, steel fiber percentage, and temperature are used in this experimental work. In the present investigation 3 set of factors are involved and hence we require a 3^3 set that is requiring 27 replications and a 3^3 full factorial design. But according to Box–Behnken designs it can be reduced to 13 sets and the design points reside in the middle of the sides and at the corner points of a cube. Figure I. Shows the model for Box–Behnken design. The model is designed using the equation:(1)

$$y = ß_0 + ß_1x_1 + ß_2x_2 + ß_3x_3 + ß_{11}x_1^2 + ß_{22}x_2^2 + ß_{33}x_3^2 + ß_{12}x_1x_2 + ß13x1x3 + ß23x2x3 \quad (1)$$

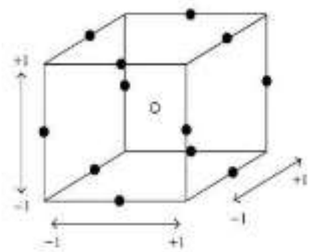

Figure I.
Box Behnken Design For Three Factors

TEST ON FRESH PROPERTIES OF CONCRETE – SLUMP TEST

It is used to study the workability of prepared concrete during the progress of work and to check the uniformity of concrete. The details of mixes corresponds to slump are shown in Table II.

TABLE II.
DETAILS OF MIXES CORRESPONDS TO SLUMP

Mix Designation	**W/C ratio**	**Superplastizer (% of cement)**	**Slump Obtained (mm)**
R0.35	0.35	0.5	66
R0.4	0.4	0.5	80
R0.45	0.45	0.5	95

HEATING OF THE SPECIMENS

The study includes the effect of temperature on the concrete. The specimens were heated in the electric oven. After attaining desired temperature, one hour is provided to the specimen to maintained in that level for reaching steady state condition. After that the oven was swithched off and allow the specimen to cool off. It is observed that the mass of the specimen decreases after subjected to temperature and the loss in concrete mass is considerably less in steel fiber reinforced specimen compared to the control mix specimen.

RESULT ANALYSIS BY BOX-BEHNKEN DESIGN USING REGRESSION TECHNIQUE

Experiments were performed using the Box–Behnken experimental design. Box–Behnken experimental design is a type of response surface methodology. Response surface methodology is an empirical optimization technique for evaluating the relationship between the experimental outputs and factors called x_1, x_2, and x_3. For obtaining the results for Box-Behnken design, analysis of variance has been calculated to analyze the accessibility of the model and was carried in Microsoft Office Excel 2007.

Box–Behnken Regression was done and the values were compared with the obtained value. The coefficient of determination (R^2) is defined as the ratio of the explained. variation to the total variation, and is a measure of the degree of fit. A good model fit should yield an $R^2$of at least 0.8. The coefficient of determination (R^2) is defined as the ratio of the explained variation to the total variation. The test result of the experimental specimen and by using Box–Behnken design as shown in the Table. III

Table.III

BOX–BEHNKEN DESIGN RESULTS

Designation	Temperature (°C)	Steel fiber (%)	Predicted Compressive Strength (N/mm^2)	Predicted Split Tensile Strength (N/mm^2)
$R_{0.35}$ S_0 T_{200}	200	0	45.05	3.09
$R_{0.35}$ $S_{0.5}$ T_0	27	0.5	53.01	4.87
$R_{0.35}$ $S_{0.5}$ T_{400}	400	0.5	49.92	3.53
$R_{0.35}$ $S_{1.0}$ T_{200}	200	1	54.60	5.29
$R_{0.4}$ S_0 T_0	27	0	38.60	3.12
$R_{0.4}$ S_0 T_{400}	400	0	34.44	2.07
$R_{0.4}$ $S_{0.5}$ T_{200}	200	0.5	41.20	3.40
$R_{0.4}$ $S_{1.0}$ T_{400}	400	1	44.40	4.14
$R_{0.4}$ $S_{1.0}$ T_0	27	1	45.64	5.05
$R_{0.45}$ $S_{1.0}$ T_{200}	200	1	43.74	4.30
$R_{0.45}$ $S_{0.5}$ T_0	27	0.5	42.93	3.74
$R_{0.45}$ $S_{0.5}$ T_{400}	400	0.5	40.62	3.13
$R_{0.45}$ S_0 T_{200}	200	0	36.49	2.50

Box-Behnken design was successfully adopted and the experiments were designed choosing the input parameters for the levels selected. Response surface methodology using Box-Behnken design proved very effective and time saving model for studying the influence of process parameters on response factor by significantly reducing the number of experiments and hence facilitating the optimum conditions. The predicted values and experimental values are approximately same and hence the model is fit. The conclusions obtained from the test results are:

- The split tensile strength increases with the increase in the % of steel fibers.
- As temperature increases the strength decreases in the case of 0% steel fiber mixes.
- As in the case of 1% steel fiber the tensile strength is very much higher compared to the control mix specimen

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