Bending Investigation of High Capacity Reinforced Concrete Beams

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Abstract— It is known that cement possesses the property of adhesion and is a substance that can fuse with other materials to solidify and get stiffen even independently. During ancient times, the binders used were of conventional type, such as sugarcane byproduct, silica dust, residual ash, to name a few. In the present world, cement is the main folder material. Aggregate generally represents 75% to 85% of the volume of concrete and this mainly consists of fine aggregate and coarse aggregate, though it is generally considered inert filler, which has little impact on the properties of the finished concrete. The proposed work is primarily aimed at improving the strength and durability properties of cement while maintaining the ecological balance. Therefore, utilizing the fact that when factory made derivatives such as silica dust, residual ash, and furnace steel residue derivatives are being used to fabricate an exclusive mixture of concrete mixes, for the early fabrication of high-capacity concrete, the percent rate of substitution is ideal for dual and ternary mixes. In addition to binary and ternary combinations to find out the bending properties of high capacity reinforced concrete beams, it can also be used with supplied factory made derivatives. The proposed research work utilizes the aforementioned ingredients that supply methodical and monetary payback, along with enhancing the strength and durability characteristics of concrete. The results seem to be very encouraging in case of SFC1, RAC1 and SSAC1 with 4.68, 1.53 and 13.68 % outperforming the other CC blends.

Keywords: Concrete; Strength, Durability, Factory Made Derivatives

I. INTRODUCTION

Undoubtedly, concrete is chiefly used material for construction of structures across the globe for all types of frameworks and is the long lasting material due to its properties. Concrete attracts raw materials and offers numerous merits such as strength, durability, low fabrication costs and maintenance capacity, flexibility to produce the most varied shapes and structural importance devoid of being connected with metallic structures. However, the manufacture production faces mainly imperative obstacles on relation of the chief constituents of concrete. Manufacture of cement requires enormous energy that leads to the generation of huge amount of carbonic anhydride and with increase in manufacturing of cement, there is quick increase in temperature of earth (Climate Warming) which in turn causes unfavorable ecological circumstances. As a result, it is imperative to lessen the usage of cement and amplify the work to utilize alternatives, for instance, chemical additives that help in amplification of firmness and resistance with mineral compounds. The study to use construction materials based on resourceful materials is in development in the largest part of the progressing countries. The present study ensures the mixing of chemical additions or natural resource additions to cement to formulate high quality concrete.

The studies conducted in the past suggested that factory made derivatives can be used to substitute concrete materials to move forward monetary situations and lessen structure expenditure. Therefore, in the formation of concrete mix aggregate has maximum contribution of about 70% is one of the essential requirement. Sand obtained from rivers is more often used as a fine aggregate in concrete and is obtained by drawn out of sand along the bank of river. Since sand is obtained by mining process this not only impacts underground layer of water bearing porous rock, but also causes ecological tribulations. For the manufacturing of cement used in construction of various structures factory made derivatives or derived materials has been used. A number of factories fabricate fresh factory products and resultant materials. Formation of concrete from such materials when compared with the ordinary concrete has great enhancement in feasibility persistence and various mechanical properties. Various diligent researches .has been carried out in last few decades in order to look into all supplementary uses and products, such as high quality silica sand (HQSS), coal lower slag (CLS), rotary cement furnace (RCF) and residue powder wood (RPW) to make cement and flow able fill(FF). High fabrication of mineral additions and factory made derivatives, as well as ecological contamination, require fresh clarifications for supportable development.

II. RESEARCH METHODOLOGY

To accomplish the above goals, the subsequent technique is used. Factory made derivatives such as silica dust, residual ash and furnace steel residue provides an efficient way to fabricate high-quality concrete which is the function of this work. In this work the substitute material for cement fine aggregate and coarse aggregate are blended in such a way to get the best combination out of it using proportion method of combination which is as per the guidelines of IS 10262. In this work for different shapes different types of samples sizes are made, for prisms 100 mm x 100 mm x500 mm are used, for blocks 150 mm x 150mm x 150 mm are used and for cylinders 150 mm x 300 mm are used. The compressive strength, the split tensile strength and the bending strength of the concrete with substitute material are determined from the investigational check observation. Based on the compressive strength of a single collaboration mixture, the most favorable interchange intensity mixture for the concrete should be decided for additional examination. A total of 60 samples are designed to be poured for investigational testing of standard concrete and concrete substitute materials, e.g. 20 cubes for the compressive strength, 20 cylinders for the splitting tensile strength and 20 prisms for the flexural strength of concrete.

The selected three dual combinations mix BASSAC, SFSSAC, SFBAC, and a ternary mixture SFBASSAC is acquires from results with a single arrangement. Factory made products when they are added as substitution for dual and ternary mixes the split tensile strength at the age of 28 days. Also with the best substitution flexural strength is found at the age of 28 days and the age of 7, 28, 56 and 90 days for compression strength. For investigational testing of ordinary concrete and HPC mixes, a total of 40 samples have to be poured, e.g. 10 cylinders for a split tensile test, 10 cubes for the compressive strength test, 10 prisms for the testing concrete flexural strength, and 10 cylinders for the modulus of elasticity.

Durability of the concrete, which is the chief measure for the concrete's life in order to get concrete which is long standing its performance, must be superior than durability. Durability test such as resistance against salt, absorption of water, resistance against acid and sulphate and various penetration tests are carried out by taking above into consideration. For trial testing of conventional concrete and HPC blends total of 40 samples were made: 30 cubes for testing of resistance against acid, salt and sulphate and 10 disc cylinders of dimensions 100mm x 50mm for testing against penetration of rapid chloride ion.

III. MATERIALS USED

Usage of high capacity concrete have grown-up significantly not only due to its vast applications but also due to its various properties like firmness, longevity, permanence and workability. To make available time after time improved performance properties for the chosen deposit of materials, uses, and contact situation is the purpose of use of high quality concrete. In High performance concrete we use factory made derivatives and additions of chemicals which is not used in ordinary concrete that is the point of elementary variation among the two. Water content and no of voids are reduced in hydrated cement paste by the use of additives while the strength and permanence are enhanced. HPC is prepared through various fundamental components like ordinary concrete, however has elevated qualitative and computable performance, creating it a latest substitute material. Turning down the water content to an extremely small intensity through a elevated amount of chemical mixtures is unwanted, and the efficiency of chemical mixtures essentially super plasticizers is unwanted. Pozzolanic material along with Factory made derivatives such as silica dust, residual ash and furnace steel waste which are used in place of concrete ingredients cement fine aggregate and coarse aggregate mingle by the process of hydrogenation in which they react. When chemical combinations with factory made derivatives when they are substituted by cement, fine aggregate and coarse aggregate are collectively used the product is high quality concrete in which workability is improved checked by slump value and other properties of strength like strength for flexure, tension, compression and modulus of elasticity of concrete. For checking the long lasting performance test performed, resistance against salt, sulfate, and acid also penetration of chloride ion and absorption of water test. Factory made derivatives when applied also improved the flexural performance of HPC beams with a variety of frameworks such as load divergence properties, energy ability, torque, flexural behavior, ductility and load elongation condition.

A. Mix Proportioning

The design of the combination is based on the recommendations of the definite volume method as per IS 10262-1982. At water cement ratios range between 0.40-0.55various blends are designed to attain a grade of M30 and their compressive strength is checked. The design of concrete mixes incorporates deciding the portions of the ingredients so that the configuration generates a composition with the aim of having definite properties in fresh and cured state. To attain the particular configuration of performance and homogeny necessities, a roughly best possible combining ratio of HPC is extremely significant. No precise guiding principles are accessible for the HPC mix portion. Based on the obtainable data the test and error method are performed to obtain the requisite combination ratios. Based on the specifications of the ordinary concrete blends is the other technique used. In order to get the requisite properties for both fresh and cured concrete to merge dissimilar concrete components the technique used is by mix proportioning. For cement, fine aggregate and coarse aggregate examination blend proportions are prepared as given in table 1 (Here, C-cement, FA-fine aggregate, CA-coarse aggregate, w/c-water-cement ratio, fck-7 days compressive strength in MPa).

For concrete grade of M30, the compressive strength at dissimilar w / c ratios of 0.45 and 0.55 was inspected. The test compositions were based on the pertinence of the cone slump values between 55 and 75 mm. The average of 4 cubes was cast to find compressive strength for incoming mixing ratios. Lastly, mixture third was chosen for its better workability and compressive strength compared to other combining distributions. The ultimate combination distribution was 1: 1.51: 3.23 with a w / c ratio of 0.55.

Mix No.	C (kg/m^3)	FA (kg/m^3)	CA (kg/m^3)	Water (lit)	W/C	Water reduced	SP (ml)	Slump (mm)	Fck (MPa)
1	480	620	1122	189.58	0.40	-	30	0	15.60
2	425	641	1145	189.58	0.45	-	35	20	18.10
3	430	636	1179	171.40	0.40	10%	30	53	14.40
4	383	645	1205	171.40	0.45	10%	40	63	19.45
5	384	672	1225	151.26	0.40	20%	35	55	13.85
6	340	679.40	1250.6	151.26	0.55	20%	25	58	20.30

Table 1: Trial Mixes for Conventional Concrete

IV. Experimental Implementation

A. Preparation of Test Specimen For Single Combination

Each of the test samples such as cubes, cylinders and prisms of standard dimensions are molded with steel molds. Lubricant was applied to the mold prior to the samples were poured. The constituents in concrete are appropriately blended, positioned and well packed down and cured for 24 hours in water. Total 30 samples are intended for investigational check of CCs Substitute concrete materials, such as 10 cubes are molded to find compressive strength, 10 cylinders slide for split wire strength, and 10 prisms are molded for bending strength.

S. No.	Mix	C (kg/m^3)	FA (kg/m^3)	CA (kg/m^3)	SF (kg/m^3)	BA (kg/m^3)	SSA (kg/m^3)
1	CC	380	650	1220	0	0	0
2	SFC 1	365.85	650	1220	20.15	0	0
3	SFC 2	342.70	650	1220	35.30	0	0
4	SFC 3	322.55	650	1220	58.45	0	0
5	SFC 4	306.40	650	1220	77.60	0	0
6	RAC 1	380	582.50	1220	0	66.5	0
7	RAC 2	380	520	1220	0	151	0
8	RAC 3	380	459.50	1220	0	195.50	0
9	RAC 4	380	390	1220	0	252	0
10	RAC 5	380	325.5	1220	0	325.50	0
11	SSAC1	380	650	1060	0	0	125
12	SSAC2	380	650	980	0	0	245
13	SSAC3	380	650	860	0	0	365
14	SSAC4	380	650	740	0	0	485
15	SSAC5	380	650	620	0	0	610

Table 2: Trial Mixes for Replacement Material Concrete

Mix	W/C	Water (lit)	SP (ml)	Slump (mm)
CC	0.55	175.50	45	55
SFC1	0.55	165.70	30	60
SFC2	0.55	150.10	40	65
SFC3	0.55	146.50	45	60
SFC4	0.55	134.80	45	55
RAC1	0.55	178.50	30	60
RAC2	0.55	178.50	35	62
RAC3	0.55	178.50	45	65
RAC4	0.55	178.50	40	65
RAC5	0.55	178.50	45	65
SSAC1	0.55	178.50	25	60
SSAC2	0.55	178.50	30	62
SSAC3	0.55	178.50	40	65
SSAC4	0.55	178.50	45	65
SSAC5	0.55	178.50	55	60

Table 3: W/C Ratio, Water, SP and Slump for HPC Trial Mixes

B. Test Results for Tensile Strength

After the attainment of 28 days curing of beams the tension stress on blends SFC, RAC and SSAC were calculated. The cylinders were examined for tensile stresses and the mean consequences were acquired. In case of ordinary concrete the tensile strength of cylindrical units is 2.99MPa when they are compared with the blends 1st, 2nd, 3rd and 4th sample of SFC tensile strength for cylindrical units obtained is 3.58MPa, 3.66MPa, 3.11MPa and 2.45MPa respectively. All SFC blends have a higher tensile strength contrasted to CC, but the elevated value enhances with 5% compensate. In case of ordinary concrete the tensile strength obtained is 2.99MPa when they are compared with the 1st ,2nd ,3rd and 4th sample of RA the tensile stresses in concrete with residual ash was achieved amid 3.78MPa, 3.88MPa, 3.44MPa, 2.45MPa and 2.22MPa respectively. As compared to ordinary concrete the tensile strength enlarged appreciably at 5%, 10% and 20% when substitution of fine aggregate with RA takes place. For ordinary concrete the tensile strength is 2.99MPa when compared to the tensile strength of blend SSAC values of 3.55MPa, 3.77MPa, 3.41MPa, 2.44MPa and 2.41MPa were observed. At the level of 5% and 10% substitution there is enhancement in the tensile strength when compared with the ordinary concrete. Blend with percentage 5% SFC, 20% RAC and 20% SSAC shows the maximum quantity of tensile stress when are obtained from results.

C. Test Results for Flexural Strength

On curing the blend of SFC, RAC and SSAC for a period of 28 days the flexural strength of the concrete blend was determined. For conventional concrete the flexural strength value is 7.11MPa,when it is compared with the flexural strength of the blend 1st , 2nd , 3rd , and 4th of the SFC the flexural strength of the prisms determined were approx. 9.05MPa, 8.62MPa, 7.11MPa and 6.68MPa respectively. On comparing with the conventional concrete the strength the strength of the blend SF which replaces cement is 5% and 10% appreciably better.

In case of conventional concrete the value of flexural strength is 7.11MPa when compared to the flexural strength of residual ash were between 8.94MPa, 8.05MPa, 6.46MPa, 6.03MPa and 5.82MPa, respectively. On comparing with the conventional concrete the bending strength increased significantly at 10% and 20% when substitution of fine aggregate is done by residual ash. In case of cement concrete the flexural strength is 7.11MPa when it is compared with the furnace steel waste aggregate concrete blend, the flexural strength in the range of 8.67MPa, 8.48MPa, 7.11MPa, 6.90MPa and 6.25MPa was observed. Flexural strength of SSAC at substitution level of 10% and 20% compared to CC there improvement in flexural strength. From the total results for the blends, the derivatives with 5% of SFC, 10% of SSAC, 10% of BAC shows the highest proportion of flexural strength. In case of blends

SSAC SAC and RAC the outcomes of various test carried for strength in compression ,strength in bending and split tensile strength were represented in the form of table 4 which is shown below.

S. No.	Code Mix	Compression strength in MPa	Split tensile strength in MPa	Bending strength in MPa
1	CC	34.21	2.99	7.11
2	SFC1	36.15	3.58	9.05
3	SFC2	33.33	3.66	8.62
4	SFC3	31.48	3.11	7.11
5	SFC4	30.95	2.45	6.68
6	RAC1	34.92	3.78	8.94
7	RAC2	32.41	3.45	8.05
8	RAC3	33.14	3.48	6.46
9	RAC4	32.34	2.15	6.03
10	RAC5	28.51	2.23	5.82
11	SSAC1	40.22	3.77	8.67
12	SSAC2	37.45	3.51	8.48
13	SSAC3	36.76	3.38	7.11
14	SSAC4	33.95	2.43	6.90
15	SSAC5	32.39	2.28	6.25

Table 4: Mechanical Properties of SFC, RAC and SSAC

D. Test Results on Salt Resistance

The loss of mass in percentage and loss of strength in percentage of various concrete blends are represented in the table 5.6 which are the outcomes of the resistance of salt examination. In terms of loss of mass in proportions of all blends the consequence of factory made derivatives on the resistance of salt of various concrete blends were uttered.

The weight drop fraction obtained were 8.11%, 2.04%, 3.38%, 1.53% and 6.69% for combinations of CC, SFRAC, SFSSAC, RASSAC and SFRASSAC, correspondingly. . The normal drop of weight for all combinations was stuck between 1.53% and 6.69% for CC. Thus, it was noticed from the trial outcome that the blends of all the combinations managed to be streaked by salt, particularly in the blend. RASSAC 1.53% had a little proportion of loss of weight. Consequently, HPC blends carrying RASSAC manifested a advanced hindrance to the attack of salt. This was due to the condensed particle dimension and the combination of the bits with high-quality firmness. All drops in weight values were lesser for CC and a extremely little loss in weight value was stated in the RASSAC mix of 1%. Consequently, the HPC combinations SFSSAC showed a superior resistance of 3.38% beside attack of salt with a proportion drop of weight.

The compression intensity of CC, SFRAC, SFSSAC, RASSAC and SFRASSAC was deliberated prior to and subsequent to dipping. Following dipping in 3% NaCl mixture for one month, the compression intensity of CC, SFBAC, SFSSAC, .RASSAC and SFRASSAC were determined at 8.88%, 5.73%, 4.52%, 4.77% and 4.77% in that order. The test outcome illustrated that the SFBAC blend had a advanced value of 5.97% loss in strength and the consequences of weight and intensity drop compared to ordinary concrete, as shown in figures 1 and 2.

S. No.	Mix Name	Weight of the cube (kg)		Compressive strength (MPa)		Loss in percentage (%)	
		Before	After	Before	After	Mass loss	Strength Loss
1	CC	8.858	8.118	30.16	28.43	8.41	8.88
2	SFRAC	8.828	8.659	31.99	30.08	1.91	5.97
3	SFSSAC	8.859	8.359	37.59	35.89	5.64	4.52
4	RASSAC	8.456	8.341	36.68	34.93	1.35	4.77
5	SFRASSAC	8.945	8.429	28.48	27.12	5.76	4.77

Table 5: Results of Salt Resistance Test for HPC Mixes

Fig. 1: Percentage of Mass Loss on Salt Resistance Test

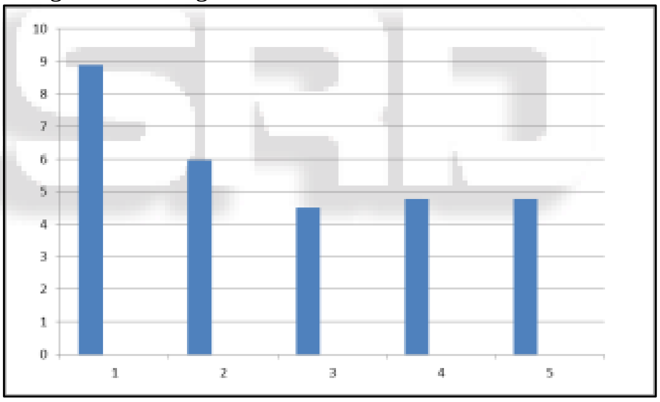

Fig. 2: Percentage of Strength Loss on Salt Resistance Test

The consequences illustrated that it had a blend of SFSSAC, RASSAC, and SFRASSAC reasonable proportion of compression intensity and condensed rate of worsening of Concrete bare to attack of salt. The drop of intensity in the combination RASSAC and SFRASSAC reached a lesser value, namely 4.77%, due to the occurrence of all three factory made derivatives.

V. DISCUSSION

As compared to the cement concrete 1st sample of the blend which is formed by the addition of substitute silica fume achieved a higher compressive strength of 36.15MPa at the age of 28 days, which was 5.67% enhanced. On comparison to the cement concrete the compressive strength of 1st specimen of RAC is 2.07% enhanced which in the numerical value after the age of 28 days is 34.92MPa. When compared with the cement concrete the compressive strength of 1t sample of SSAC is 17.27% enhanced which in the numerical value at the age of 28 days is 40.02MPa.

When compared with the cement concrete the 1st sample of SFC was 31.40% enhanced which in the numerical value is 3.64MPa.on comparison to the cement concrete the 1st sample of RAC obtain a enhancement in the tensile strength of 37.18% which in the numerical value after the age of 28 days is 3.80MPa. On comparison with the cement concrete the 1stsamle of the SSAC obtain higher tensile strength of 40.07% which in the numerical terms after the age of 28 days is 3.88MPa. When compared to cement concrete the 1st sample of SFC achieved a higher bending strength 27.28% which in numerical value at the age of 28 days is 9.05MPa. When compared to cement concrete the 1st sample of RAC achieved a bending strength 25.73% enhancement which in the numerical value at the age of 28 days is 8.94MPa. On comparing with the cement concrete the 1st sample of SSAC blend achieved an enhancement in the bending strength of 21.94% which in the numerical value at the age of 28 days is 8.67MPa. In case of other blends of silica dust there is maximum drop in the compression strength which is 8.16% in the 4th sample of SFC, there is a maximum drop of 6.43% in the bending strength in the 4th sample of SFC, there is a maximum drop of 20.93% in the split tensile strength in the 4th sample of SFC blend. In case of other blends of residual ash concrete the maximum drop in compression strength obtained is 15.46% in the 5th sample of RAC, the maximum drop in the bending strength obtained is 22.16% in the 5th sample of RAC and the maximum drop obtained is 13.71% and 14.07% in the split tensile strength obtained is in the 4th and 5th sample of RAC. In case of the other blends of furnace steel waste aggregate the maximum drop in the compression strength is 5.28% and 9.77% in the 4th and 5th sample of the blend, the maximum drop is 2.95% and 12.09% in the 4th and 5th blend of SSAC and the maximum drop in the split tensile strength is 15.88% and 20.93% in the 4th and 5th blend of SSAC. In comparison with the ordinary concrete and other blends percentage the maximum strength obtained in blends in percentage was 5% of SF, 10% of RA and 10% of SSA from the optimal displacement of the results are represented.

VI. CONCLUSIONS AND FUTURE SCOPE

The proposed work has utilized the factory made ingredients that leads to methodical and monetary benefits, along with enhancing the strength and durability characteristics of concrete. It is concluded that:

1) When the component of concrete, cement is substituted by the silica dust by 10% of its volume the compression strength is increased by 5.67% when compared with the cement concrete on curing for 28 days, in terms of the numerical value the average compression strength is 36.15MPa. On comparing with cement concrete there is increase in the compression strength of 2.07% when the substitution of fine aggregate by residual ash takes place by 10 % of its volume, the average compression strength in numerical value is 34.92MPa. Similarly, on comparison with cement concrete there is increase in the compression strength of 17.27% when coarse aggregate is replaced by the furnace steel waste aggregates by 10% of its volume, and the average numerical value of compression strength is 40.12MPa
2) There is an increase of 21.43.9% and 23.9% in the bending and tensile strength respectively for SFC blends. The enhancement of strength is up to an amount of 10% only in case of SF blends this there is lessening in the strength if the amount goes beyond 10%. When compared to cement concrete the percentage increase of 27.10%, and 20.46% in the tensile and bending strength occurred for the blend of RAC. Similarly on comparison with the cement concrete the percentage increase of 28.6% and 17.99% occurs in the tensile and bending strength respectively for SSAC blend.
3) From the outcomes of distinct blends the best probable substitution fraction was found for dual and ternary blends .For all blends of CC, SFRAC, SFSSAC, RASSAC and SFRASSAC the increase in the rate of compression strength enhanced at the age of 90 days of curing when they are cured for 7, 28, 56, 90 days, the percentage increase in compression strength at the age of 28 days are 57.16%, 94.74%, 67.03%, 54.08% and 79.07% for CC, SFRAC ,SFSSAC, RASSAC and SFRASSAC , on the average the values are 47.40MPa, 62.30MPa, 62.79MPa, 56.52MPa and 51MPa. When the reaction in the factory made derivatives takes place by the pozzolanic action augment in the strength takes place in concrete.
4) For the split tensile strength, it was found that the blend of SFSSAC amplified on standard by 3.898 MPa as a highest fraction, which in contrast with CC corresponds to an enhance of roughly 40.72%. It was noticed that the rate at which the bending strength amplified had a greatest strength in the combination of SFSSAC averaging 8.15 MPa, which had amplified by roughly 14.62% compared to CC. The highest elastic modulus was obtained in the blend from SFSSAC and was 11.63% elevated than for CC.

In order to reveal what can be done in the future, then fibers could be added to enhance the strength of concrete. In high performance concrete for their better performance factory made derivatives of silica dust, residual ash and furnace steel waste aggregates were added which is considered as a limitation of this. Also by the addition of fibers in high strength and high performance concrete this current work is considered to be valid.

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