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Experimental Study of SCM RCC Element at Higher Temperature

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Abstract — *Reinforced concrete element contains rebar in the structure to bear the forces. This allows the section o take the tensile stress by rebars in the concrete structure; however, the rebars does not interfere with the thermal expansion of the concrete, but they deboned when exposed to high temperature. Many types of SCM can be used in the design of the concrete mix to add strength to the structure while it cures. A little bit of sand stone slurry powder is used in concrete mixtures in the present study, since it has a smaller number of crystalline quartz structures so it imparts the better denser homogeneous concrete. If a crystalline aggregate is added to the mixture, the thermal expansion increases with temperature to a maximum temperature of 1000 degrees Celsius.*

Keywords- *Experiment, RCC Element, SCM-Supplementary Cementious Material, Muffle Furnace, Photos Analysis, Mix Design*

I. INTRODUCTION

Several of the characteristics dependent on the temperature of the concrete is due to the type of aggregate used and the composition of the concrete mixture. The thermal conductivity is directly related to the ambient temperature. If the heat conditions rise, the thermal conductivity of the reinforced concrete drops (Chikh, Gahmous & Benzaid, 2012). During the initial curing stage, the temperature of the concrete rises rapidly with the hydration process and can dry quickly, resulting in a thermal break (Olivova & Bilcik, 2011; Siddiqui, Alsayed & Al-Salloum, 2014). In special structures, for example, those that contain a high fuel charge or when you want to optimize the design to fire, it is possible to adopt the performance approach. In this, an analysis of the tensional state of the structure is made, including the effect of the temperature on both the concrete and the reinforcement bars and all the possible failure modes of the structure are analyzed.

II. LITERATURE REVIEW

Concrete is a material that has an excellent intrinsic behavior when exposed to high elevated temprature. It does not burn i.e. it is non-combustible and it has a high thermal conductivity which significantly flows down the spread of heat through concrete elements. However, due to heterogeneous nature of concrete, each material present in it interacts differently at elevated temperature; hence the properties of concrete as whole may change radically when exposed to Elevated temperature. The mechanical properties such as strength and modulus of elasticity are significantly reduced during these exposures. This may result into undesirable structural failures. Therefore, the properties of concrete exposed to fire are very important for determining the load carrying capacity of structural elements. Also there are changes in chemical and physical properties. The dehydration such as the release of chemically bound water from the calcium silicate hydrate (C-S-H) becomes significant above about 600º C. The dehydration of the hydrated calcium silicate and the thermal expansion of the aggregate increase internal stresses and micro-cracks are induced in the material above 300 C. Calcium hydroxide Ca(OH)2, which is one of the most important compounds in cement paste, dissociates at around 530 C resulting in the shrinkage of concrete causing cracking and crumbling. Some changes in colour may also occur during the exposure due to oxidation. The changes produced by high temperatures are more evident when the temperature exceeds 500C.

According to Al-Salloum (2007), a reinforced concrete structure is completely resistant to fire in case of high temperatures and therefore does not require major safeguards in this matter. However, faced with high temperatures, reinforced concrete undergoes important physical and chemical transformations that are sometimes irreversible, and that depends on the temperature level, the time of exposure, the type of cooling and its composition. Some years ago, the coatings of the reinforcements that were used in the traditional reinforced concrete were greater (Elsanadedy, Al-Salloum & Abbas, 2012; Ponmalar, 2012). Thus, the temperatures of the steels were lower, and the piece behaved better. Today, all structural engineering aims at increasingly lighter elements and more resistant materials are sought, which threatens stability in a fire (Quiertant & Clement, 2011; El-Din & Mohamed, 2012). The lighter the structure, the easier it is to raise its temperature and the faster it loses its mechanical properties. The type and properties of SCMs also play an important role on the properties of concrete exposed to High temperature. The strength degradations of different type of concretes with different ingredients are not same under elevated temperature because of different structure. Quartz in siliceous material polymorphically changes above 500 C with a volume expansion and consequent damage whereas limestone aggregate in concrete, $CaCO_3$ turns into CaO at 800-900 C and expands with rise in temperature.

The changes in the concrete matrix when exposed to fire calls for systematic study of characteristics of concrete exposed to high temprature as the residual properties of concrete help in determining the best rehabilitation strategy. The physico-chemical processes of concrete exposed to fire is summarized below.

1. 30-110 C: The evaporable water and a part of the bound water escapes.
2. 110-180 C: The decomposition of gypsum starts
3. 180-350 C: The loss of bound water from the decomposition of the C-S-H and carbo-aluminate hydrates starts
4. 450-550 C: Dehydroxylation of the portlandite.
5. 700-900 C: Decarbonation of calcium carbonate.
6. Above 900 C: further decomposition of aggregates & SCMs starts and concrete is starts burning.

The effect of high temperature is more vulnerable on per-stressing steel than on rebars. At temperatures of 200-400 c, pre- stressing tendons show considerable loss of strength (>50% loss at about 400C).

III. RESEARCH METHODOLOGY & EXPERIMENTAL PROGRAM

Here, an emphasis is made to study the characterization of the basic ingredients of different material used in mortar and concrete as per the Indian standard specifications. The various tests are performed to characterize the materials to be used for the production of desired grade and type of concrete

III.I Characterization of Material Used

III.I.I Cement- Ordinary Portland cement (OPC 43 grade) Wonder Cement brand conforming to IS 8112: 1989 was used with specific gravity of 3.09, fineness of 2278 cm2/g, Normal consistency of 29 minute, Initial setting time of 80minute and final setting time of 205 minute. Compressive strength 28days (06 cubes Average) found 48.8 N/mm^2.

III.I.II Water- Potable tap water having pH of 7.4 and other tests are performed as per IS 3025: 1964.

III.I.III Aggregates- The natural river bed sand from Binawas, Jodhpur was used as fine aggregate. The coarse aggregate (from Kakani, Jodhpur) of two sizes were used.

Table 3.1 Properties of fine aggregate

SN	Property	Value obtained
1	Specific Gravity	2.5
2	Bulk Density (Kg/m^3)	1620
3	Fineness modulus	2.64
4	Water Absorption	1.9 %
5	Void Content	26.0 %
6	Gradation	Zone II as per IS: 383-1970

Table 3.2 Properties of coarse aggregate

SN	Property	for 20 mm size	for 10 mm size
1	Specific Gravity	2.66	2.66
2	Bulk Density (Kg/m3)	1620	1575
3	Fineness modulus	7.01	6.03
4	Water Absorption	1.4%	1.6%
5	Void Content	46.13 %	46.13 %
6	Gradation	20 mm Single Size	10 mm Single Size

III.I.IV Chemical Admixtures- A unique multipurpose modified plycarboxylate based superplasticiser SicaPlast 5202 NS, that is particularly suitable to provide high water reduction and improved fresh concrete characteristics is used.

III.I.V SCMs-Sand Stone Slurry (SSS) Powder - Stone, one of the most common building materials of ancient times, is a ubiquitous material. Today, different operations on stones, like-quarrying, sawing, cutting etc. are being processed by modern technologies which are improving the rate of production of stones as well as stone waste continuously. The stone waste is now-a-days a serious environment problem which is threat to modern civilization. As it is a non biodegradable material, therefore poses numerous hazards. If this stone waste is dumped on land then, it can reduce the rate of rain water percolating and deteriorate the soil fertility. Stone waste dumped in rivers, streams and seas contaminates the water and marine. Although land-filling can be an alternative to reuse stone waste but apart from this, it can also be used to make various cement composites, as one of the best solution for disposing of stone waste, due to its economical and ecological advantages.

The physico-chemical and mineralogical characterization of the sludge was carried out to identify the major components and to compare it with the typical sand used to produce concrete. The dry sludge could be used in the mix design in replacement of fine materials with sizes < 160micron. This application could conserve the natural materials and solve the environmental and economical problem caused by sludge accumulation.

Table 3.3 Physical & Chemical Properties of Sand Stone Slurry (SSS) Powder

S N	Constituents/ Properties	Percent by Weight
1	Color	LightPink
2	Texture	Powder
3	Particle Size	4.75mm-75micron
4	Fineness Modulus	1.57
5	Natural moisture absorptions	<2.4 %
6	Solubility	Insoluble
7	Densification	Lesser
8	Specific gravity	2.41
9	Bulk Density (Kg/m3)	1420
10	Loss on ignition	21.80
11	Silica (SiO2)	37.85
12	Iron Oxide (Fe2 O3)	3.10
13	Alumina (Al2 O3)	0.52
14	Calcium Oxide (CaO)	30.35
15	Magnesium Oxide (Mgo)	5.60
16	Total Sulphur (SO3)	0.16
17	Chloride (Cl)	0.003
18	Total Alkalis (N2O)	0.28

Table 3.4 Sieve analysis of Sand Stone Slurry Powder

SN	IS Sieve Size	Cumulative weight	Cumulative weight	Zone II
1	4.75 mm	0.0	100.0	90-100
2	2.36 mm	0.0	100.0	75-100
3	1.18 mm	0.0	100.0	55-90
4	600 micron	0.0	100.0	35-59
5	300 micron	0.0	100.0	8-30
6	150 micron	57.4	42.6	1-10
7	75 micron	60.2	39.8	
8	Pan	39.8		

IV. EXPERIMENTAL RESULTS & DISCUSSION

IV.I Fresh& Harden Concrete Results-

Design Mix of M-25 as per IS 10262 and SP (23)-1982 and IS 456-2000, based on target mean strength of concrete and for a tolerance factor of 1.65 as specified in IS 456-2000 and the standard deviation 5.0 N/mm2 (as given in table 1, IS-10262).

(i) Target mean strength of concrete:

Ftms = 25+5*1.65

Ftms = 33.25 N/mm2

(ii) Selected W/C ratio for the desired target mean strength = 0.45

(iii) Thus the proposed mix for the grade M-25 is by weight

Water		Cement		Fine Aggregate		Coarse Aggregate
0.45	:	1	:	1.57	:	3.21

Sand Stone Slurry Powder Replacement 5%, 7%, 10% of cement.

0.75% Admixture (Plastisizer) by weight of cement

(For coarse aggregate mix proportion as 60% for 20 mm size aggregate and 40% for 10 mm size aggregate)

Table 3.5 Results of SSS based M-25 Grade Concrete

MIX	Mix Proposed (M-25)	SSS Replacement	Slump	7 Days Comp Strength (N/mm2) (Average of 3 cubes)	Modulus of Elasticity (N/mm2) by IS 456 - 2000
M-25-1	0.45 : 1 : 1.57 : 3.21	0%	70mm	26.54 N/mm^2	29593.07
M-25-2	0.45 : 1 : 1.57 : 3.21	5%	68mm	26.94 N/mm^2	29593.87
M-25-3	0.45 : 1 : 1.57 : 3.21	7%	65mm	27.84 N/mm^2	29594.46
M-25-4	0.45 : 1 : 1.57 : 3.21	10%	64mm	29.44 N/mm^2	29595.37

IV.I Water Absorptions & Photographic Analysis of Samples at High Elevated Temperature-

Table 3.6 Test results of water absorption at 100 degree Temperature

MIX	Actual weight	Weight after drying (Wd)	Weight after water soaking	Absorption (%)
M-25-1	8734	8557	8823	3.0
M-25-2	8754	8687	8958	3.1
M-25-3	8618	8601	8946	4.0
M-25-4	8727	8745	9105	4.1

Table 3.7 Test results of water absorption at 250 degree Temperature

MIX	Actual weight	Weight after drying (Wd)	Weight after water soaking	Absorption (%)
M-25-1	8739	8467	8823	4.1
M-25-2	8757	8589	8958	4.2
M-25-3	8615	8512	8946	5.0
M-25-4	8721	8601	9105	5.8

Table 3.8 Test results of water absorption at 500 degree Temperature

MIX	Actual weight	Weight after drying (Wd)	Weight after water soaking	Absorption (%)
M-25-1	8733	8407	8823	4.8
M-25-2	8744	8433	8921	5.6
M-25-3	8638	8432	8911	5.6
M-25-4	8717	8515	9021	5.8

Table 3.9 Test results of Compressive Strength

MIX	Temperature 27° C	Temperature 100° C	Temperature 250° C	Temperature 500°
M-25-1	34.67	33.42	24.87	14.02
M-25-2	35.54	34.37	25.57	14.42
M-25-3	36.12	35.00	26.04	14.69
M-25-4	38.76	37.64	28.00	15.79

V. CONCLUSION

The physicochemical changes in the concrete after exposed to high temperature analyzed and found that as the temperature raises water loss and absorption increases as the % content of sand stone slurry powder increases. At higher temperature the loss of water and absorption increases. SSS Contented concrete exhibits better durability parameters and comparatively higher compressive strength. Modulus of elasticity also increases with content of slurry powder.

Fig

Fig-1-6 Furnace, Samples at 100/250/500C, Failure pattern and change in color.

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