International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 6, Issue 10, October 2016)

Utilizing Aggregates Having Good Thermal Stability in Concrete at Elevated Temperature

Dr. Shailesh Choudhary[1], Er. Shobit Kumar[2]

[1]*Assistant Professor, Department of Structural Engineering, J.N.V.U. Jodhpur, India*
[2]*Phd Scholar, Department of Structural Engineering, J.N.V.U. Jodhpur, India*

Abstract— **physical and chemical changes in concrete will have the effect of reducing the compressive strength of the material. In practice, the critical temperatures for significant strength reduction depend strongly on aggregate type, approximate values being: sand light-weight concrete (650°c), carbonate (660°c) and siliceous (430°c). In present work sand is replaced by crushed insulator and then its behaviour is recorded.**

Keywords— **Grinded insulator, elevated temperature, concrete**

I. Introduction

Thermal properties of concrete are more complex than for most materials because the concrete is a composite material whose constituents have different properties, its properties also depends on moisture and porosity. Exposure of concrete to elevated temperature affects its mechanical and physical properties. Elements could distort and displace and under certain conditions the concrete surfaces could spall due to the buildup of steam pressure. To dispose the waste of construction industries like broken and damaged pieces of ceramic insulators is a big challenge for the environment. In this experimental work these waste products have been used and their performance at elevated temperatures has been examined. the residual strengths of Cement Concrete cubes and weight losses were evaluated in cold state after exposing them to elevated temperature for 1, 1.5 and 2.0 hour. The cubes were heated for 200°c, 400°c, 600°c and 800°c. The effect of elevated temperature is recorded. After getting results from basic test of concrete ingredients like cement, sand, course aggregate etc. one mix was designed as per IS 10262-2009 to achieve M-20 grade of concrete. To determine the effect of elevated temperature on concrete, the ingredients were changed keeping the ratio same. The objective of this study was to provide an overview of the effects of elevated temperature on the behavior of concrete materials.

II. Experimental Program

2.1 Material Characterisation

2.1.1 Cement

Ordinary Portland cement (OPC) 43 grade conforming IS-8112-1989 manufactured by ACC Limited is used. Cement is tested as per IS codes and results are as follows:-

Table 1
Test results of Ordinary Portland cement 43 grade

(1)	Specific gravity of cement	3.14
(2)	Consistency of cement	26%
(3)	Initial setting time	40 min.
(4)	Final setting time	115 min.
(5)	Compressive strength of cement at 7 days	28.45 N/mm^2
(6)	Compressive strength of cement at 28 days	44.47 N/mm^2
(7)	Fineness of cement(90 micron sieve)	Residue 6.5%
(8)	Soundness of cement (le-chaterlier)	1 mm

2.1.2 Water

Water used for mixing and curing was clean and free from injurious amount of oils, acids, alkalis, salts, sugar, organic materials or other substances of pH 6.80 >6.0.

2.1.3 Aggregates

(A) Coarse aggregates (20 mm and 10mm size) from local quarry (Kakani) have been used.

Table 2
Sieve analysis of 10 mm size aggregate

S.No.	IS Sieve No	Weight retained(gm)	% retained	% Finer	% passing
1	40 mm	0.0	0.0	100	--
2	20mm	0.0	0.0	100	--
3	10mm	630	12.6	87.4	85-100
4	4.75mm	4822	96.44	3.56	0-20
5	Pan	5000	100.0	0.0	0-5

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 6, Issue 10, October 2016)

With the help of IS-2386(part I) 1963 aggregate was found 10 mm single size.

Table 3
Sieve analysis of 20 mm size aggregate

S.No.	IS Sieve No	Weight retained(gm)	% retained	% Finer	% passing
1	40 mm	0.0	0.0	100	100
2	20mm	743	14.86	85.14	85-100
3	10mm	4930	98.60	1.40	0-20
4	4.75mm	4995	99.90	0.10	0-5
5	Pan	5000	100.0	0.0	--

With the help of IS-2386(part I) 1963 aggregate was found 20 mm single size.

Table 4
Specific gravity and void ratio for coarse aggregate.

Type of coarse aggregate	Specific gravity	void ratio
20 mm single size.	2.64	42.82%
10 mm single size.	2.64	44.12%

(B) Fine aggregates from Local River have been used.

Table 5
Specific gravity and void ratio for fine aggregate.

	Specific gravity	void ratio
Fine aggregate	2.65	28.33%

Table 6
Sieve analysis of fine aggregate.

S.No.	Sieve No	Weight retained(gm)	% retained	% Finer	Grading Zone III
1	4.75 mm	0.0	0	100.0	90-100
2	2.36 mm	35	3.5	96.5	85-100
3	1.18 mm	178	17.8	82.2	75-100
4	600 micron	343	34.3	**65.7**	**60-79**
5	300 micron	604	60.4	39.6	12-40
6	150 micron	956	95.6	4.4	0-10
7	Pan	1000	100.0	0	

Silt contents in F.A. was 0.6%<2% and With the help of IS-2386-1963(Part I) fine aggregate was found of Zone III.

2.1.4 Crushed insulator

Insulators of high tension line were crushed up to desired size and grading.

(i) Water absorption of grinded insulator = 1.2 %

Grinded insulators have been replaced with equivalent size (grading) fine aggregate by weight.

2.1.5 Chemical Admixtures

A water reducing agent and super plasticizer for promoting accelerated hardening and free flowing concrete Sikament-170 complies with IS 9103-99, also conforms to ASTM C494/C494M-99a Type –F and BS 5075 Part-3 has been used as chemical admixture.

2.2 Development Of Concrete Mixes

After getting results from basic test of concrete ingredients like cement, sand, coarse aggregate etc. one mix was designed as per IS 10262-2009 to achieve M-20 grade of concrete. To study the effect of elevated temperature on cement concrete, the ingredients altered keeping the proportion (0.45:1.0:1.393:3.17)

Water cement ratio	0.45
Cement	389 kg/m^3
Water	175 kg/m^3
Fine aggregates	542 kg/m^3
Coarse aggregates	1233kg/m^3

Mix (A-1)

Proportion of 20mm and 10mm size coarse aggregate is taken as (60%+40%) and rests were kept same.

Mix (A- 2)

Proportion of 20mm and 10mm size coarse aggregate is taken as (40%+60%) and rests were kept same.

Mix (A- 3)

Only 20mm size coarse aggregate are used and rests were kept same.

Mix (A-4)

Proportion of 20mm and 10mm size coarse aggregate is taken as (60%+40%) and 20% of fine aggregate were replaced with crushed insulator saturated surface dry condition.

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 6, Issue 10, October 2016)

Same grading of fine aggregate is maintained by using IS sieves of 2.36 mm, 1.18mm, 600 micron and 300 micron and rests were kept same.

Mix (A-5)

Proportion of 20mm and 10mm size coarse aggregate is taken as (60%+40%) and 30% of fine aggregate were replaced with crushed insulator saturated surface dry condition. Grading is maintained same of fine aggregate by using IS sieves of 2.36 mm, 1.18mm, 600 micron and 300 micron and rests were kept same.

Mix (A-6)

Proportion of 20mm and 10mm size coarse aggregate is taken as (60%+40%) and 40% of fine aggregate were replaced with crushed insulator saturated surface dry condition. Grading is maintained same of fine aggregate by using IS sieves of 2.36 mm, 1.18mm, 600 micron and 300 micron and rests were kept same.

2.3 CASTING OF CUBES

All required raw materials were populated at laboratory. Moulds for cube of 100mmx100mmx100mm were made with the help of recycled plastic of 30mm thickness to avoid any deflection during casting. Burnt oil was applied on sides of moulds for easy de-molding of cubes. Electrically operated mixer as per IS 1791:1968 and vibrator as per IS 2505:1980 were used for casting.

2.4 Curing

Each set of cubes were demoulded after 24 hrs. of casting and placed in water curing tank for 28 days. Curing of concrete was at laboratory temperature. Cubes were taken out and kept in laboratory after 28 days curing period.

2.5 Heating Of Cubes

After curing for 28 days cubes were heated in Furnace for 60 minutes, 90 minutes and 120 minutes. Temperature to which cubes were exposed was 200^{o}c, 400^{o}c, 600^{o}c and 800^{o}c. (temperature was rose according to time temperature curve). It was noted that the variation in temperature of Furnace after reaching to desired temperature was +/-(10^{o}c). Oil based furnace was used for heating the cubes. The temperature was controlled by controlling oil in the furnace and by air blower control. Cubes were placed in staggered pattern with a maximum of four rows. Diameter of this furnace was 600 mm and height was 900 mm.

2.6 Testing Of Specimens

After exposed to temperature cubes were cooled down to laboratory temperature and compressive strength was determined.

2.6.1 Compressive Strength Test

Compressive strength of cubes was determined with the help of gradual loading by a calibrated compression testing machine. Make of this compression testing machine was "BENISON, SAML DENISON & SON LTD, ENGLAND. Loading capacity of this machine was 200,000 Kgs and model no was TI B/MC.

2.6.2 Weight loss

Weight of cubes was taken before and after heating for 60 minute duration for finding loss in weight. Loss in weight of the cubes which are heated 90 and 120 minute duration could not be found due to chipping of concrete.

2.6.3 Water Absorption Test

Water absorption of cubes was done with the help of oven.

(Compressive Strength Test)

(Insulator)

(Curing of cubes)

(Crushed Insulator)

(Heating of cubes)

(Heating of cubes)

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 6, Issue 10, October 2016)

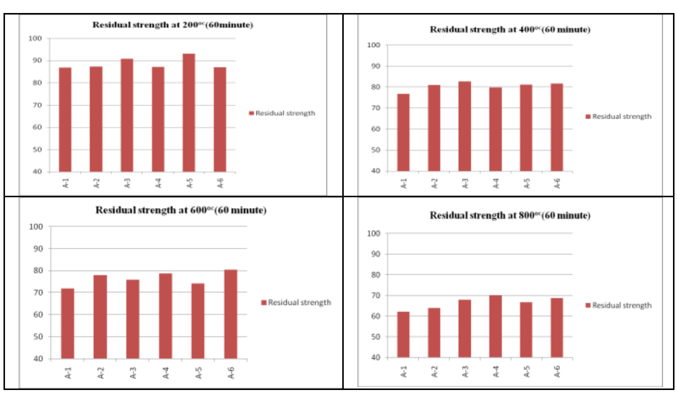
III. RESULTS

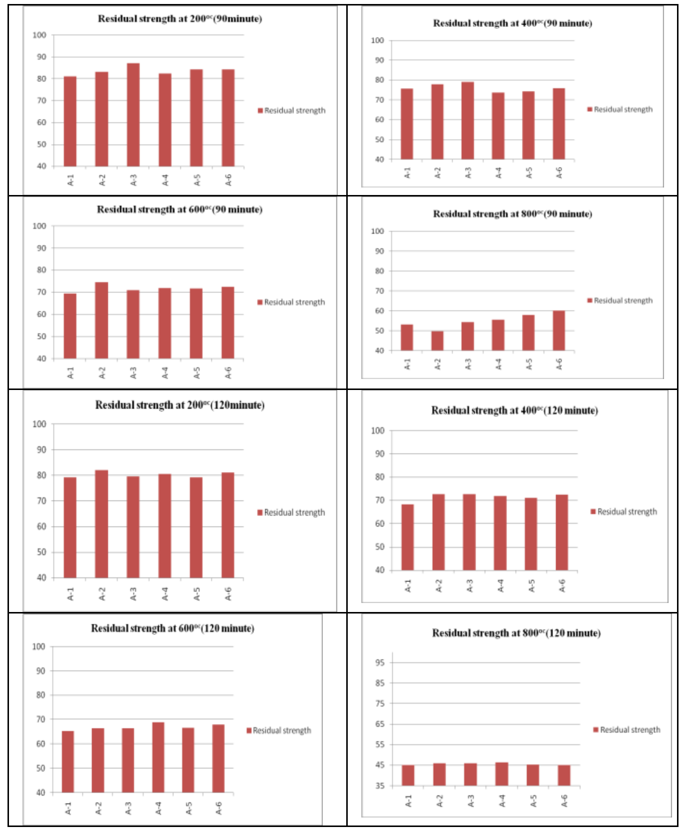
Into this study concrete cubes were than exposed to elevated temperature of 200^0c, 400^0c, 600^0c and 800^0c for 60, 90 and 120 minute heating duration. The results from this study are:

- Effect of aggregate size was found at elevated temperature. Mix having coarse aggregate only of 20 mm size perform better than mix having graded 20 mm and 10 mm size coarse aggregate. Residual strength was almost same for graded coarse aggregate for temperature 200^0c to 800^0c for 60 minute heating duration. Residual strength decreases as heating duration increases.
- Mix casted with crushed insulator replaced 30% with fine aggregate perform better at 200^0c. For the temperature range of 400^0c to 800^0c there was no major effect of percentage of crushed insulator used. Crushed insulator reduces the effect of size of coarse aggregate and gave better results with graded coarse aggregate. Its better performance than normal mix with increase heating duration was found.

With respect to material selection, the performance of the concrete materials can be improved by following ways:

1. Minimizing the moisture content through aggregate gradation, placement techniques, or use of extended-range water-reducing agents.
2. Utilizing aggregates having good thermal stability and low thermal expansion characteristics such as crushed brick or crushed insulator materials; and
3. Another possible approach is to design the concrete mix for higher strength so that any losses in properties resulting from long-term thermal exposure will still provide adequate design (safety) margins.





REFERENCES

[1] Troxell, G. E., (1968) "Composition and Properties of Concrete", 2nd Ed., McGraw-Hill, New York.

[2] Harmathy, T. Z., (1970) "Thermal Properties of Concrete at Elevated Temperatures," Journal of Materials 5, 47–74.

[3] Neville, A. M., (1970) "Properties of Concrete", Pitman, London.

[4] Waubke, N. V. (1973) "On One Physical Aspect of Strength Loss of Portland Cement Concretes at Temperatures up to 1000^oc", Technical University Braunschweig, Germany.

[5] Harmathy, T. Z., Allen, L. W. (1973) "Thermal Properties of Selected Masonry Unit Concretes", American Concrete Institute 70, 132–142.

[6] "Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens", (1975) Part 14 of Annual Book of ASTM Standards, ANSI/ASTM C78-75, American Society for Testing and Materials, West Conshockon, Pennsylvania.

[7] Quon, D. H. H., (1980) "Phase Changes in Concrete Exposed to Sustained High Temperatures", Division Report MRP/MSL 80-111(TR), Mineral Sciences Laboratories, CAANMET, Ottawa, Canada.

[8] Schneider, U., Diererichs, C., Ehm, C., (1981) "Effect of Temperature on Steel and Concrete for PCRV's", Nuclear Engineering and Design.

[9] Khoury, G. A., Granger, B. N., Sullivan, P. J. E., (1985) "Transient Thermal Strain of Concrete: Literature Review, Conditions within Specimen and Behaviour of Individual Constituents", Magazine of Concrete Research.