International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2015): 6.391

Impact Strength of Concrete with Nano Materials at Elevated Temperatures

Rakesh Kumar Choubey[1], Dr. B K Singh[2]

[1] Post Graduate Student, Greater Noida Institute of Technology, Knowledge Park II, Greater Noda, UP, India

[2] Professor, HOD Civil Engineering, Greater Noida Institute of Technology, Knowledge Park II, Greater Noda, UP, India

Abstract: ***Nanocomposite is a multiphase solid material where one of the phases has one, two or three dimensions of less than 100 nanometers (nm), or structures having nano-scale repeat distances between the different phases that make up the material. Nano composites are produced by adding nano-particles to a material in order to improve the properties of material.. The materials such as nano cement, nano-silica, nano flyash, nano metakaolin are being combined with cement. The use of finer particles (higher surface area) has advantages in terms of filling the cement matrix, densifying the structure, resulting in higher strength and faster chemical reactions i.e. hydration reactions. Nano-cement particles can accelerate cement hydration due to their high activity. Similarly, the incorporation of nano-particles can fill pores more effectively to enhance the overall strength and durability. Normally, the particle size ranges between 1nm to 100nm, they are generally called as nano materials. The fineness can reach up to molecular level by special processing techniques. An experimental investigation has been carried out to determine the influence of concrete with nano-particles such as (nano-cement, nano-fly ash, nano-metakaolin, & nano-silica fumes) under elevated temperature. M30, M40 and M50 grades of concrete were cast. For each of grades of concrete, 10%, 20% and 30% of cement was replaced with nano-materials. The particle size of the nano-materials was determined using a Scanning Electron Microscope (SEM). Impact strength of concrete with nano materials under various elevated temperature (250°C, 500°C, 750°C and 1000°C) were found by using Impact Testing Apparatus. Impact strength is found to be least for the concrete specimens with replacement of nano-metakaolin. It was also found that impact strength of M30 grade concrete specimens was low as compared to other grades of concrete (M40 & M50).***

Keywords: Nano Cement, Nano Silica Fumes, Nano Fly Ash, Nano Metakaolin, Elevated Temperature, Impact Energy

1. Introduction

Nano technology is an interesting but emerging field of study, which is under constant evolution offering a very wide scope of research activity. Normally, if the particle size ranges between 1nm to100nm (1), they are generally called as nano-particles or materials. The fineness can reach up to molecular level (1 nm –100 nm), by special processing techniques. As the fineness increases, the surface area increases, which increases the 'reactivity' of the material. Nano-cement was produced in a high energy ball grinding mill and was used as a partial replacement to cement. Application of nano-cement in concrete can lead to significant improvements in the strength and life of concrete. The mechanical behaviour of concrete materials depends to a great extent on structural elements and phenomena which are effective on a micro- and nanoscale. The ability to target material modification at the nano structural level promises to deliver the optimization of material behaviour and performance needed to improve significantly the mechanical performance, volume. Nano composites are produced by adding nano-particles to a material in order to improve the properties of material. Concrete is a material most widely used in construction industry. Concrete is a composite material made up of cement, sand, aggregate, water and mineral or chemical admixtures. The materials such as nano-silica, nano flyash, nano metakaolin are being combined with cement (5). There are also a limited number of investigations dealing with the manufacture of nano-cement. The use of finer particles (higher surface area) has advantages in terms of filling the cement matrix, densifying the structure, resulting in higher strength and faster chemical reactions i.e. hydration reactions. Nano-cement particles can accelerate cement hydration due to their high activity. Similarly, the incorporation of nano-particles can fill pores more effectively to enhance the overall strength and durability.

K. Ramesh, Dr. K. Arunachalam, S. Rooban Chakravarthy (April 2013). Study the Impact Resistance of the Fly ash concrete reinforced with steel fibers (2). Balakrishnaiah, Balaji.K.V.G, Srinivasa Rao.(November 2013) used materials like cement, different percentages of admixtures like fly ash, silica fume, metakaolin, finely grounded pumice(FGP), group granulated blast furnace slag(GGBS), polypropylene fibre(PP fibre), palm oil fuel ash(POFA), Portland pozzolana cement(PPC), rice husk ash(RHA), different fine and coarse aggregates, super plasticisers, retarders and the conditions included a temperature range of 28°C to 1200°C(3).

2. Materials and Experimentation

- Cement: In this experimental work OPC 43 grade with specific gravity 3.15 was used confirming to IS: 8112: 2013.
- Fine aggregates: Sand used in this experimental work was locally procured and was confirming to zone II. Specific gravity was determined to be 2.67.
- Coarse aggregates: Locally available crushed angular coarse aggregate having the maximum size of 12.5 mm were used in the present work. The specific gravity of coarse aggregate was 2.7 and bulk density 1550 Kg/m^3.
- Water: Potable tap water was used for experimental works and also for curing specimens.

- Cement Replacement: 10%, 20%, 30% replacement with nano Cement, Nano Fly ash, Nano Slica Fume, Nano Metakaolin

In this experimental work mix design is arrived at through trial and error. IS method is used as a basis to arrive at the final mix design. Concrete was designed for M30, M40 & M50 grade.

Table 1: Mix proportions

Particulars	M30	M40	M50
Cement (Kg/m^3)	438	492.5	562.8
Fine aggregates (Kg/m^3)	691.42	656.446	617.43
Coarse aggregates (Kg/m^3)	1093.6	1083	1063.1
Water (l)	197	197	197

Table 2: Replacement ratio of nano-materials

GRADES	M30	M40	M50
Cement content Kg/m³)	438	492.5	562.85
Nano-materials replacement of 10%(Kg/m³)	43.8	49.25	56.285
Nano-materials replacement of 20%(Kg/m³)	87.6	98.5	112.57
Nano-materials replacement of 30%(Kg/m³)	131.4	147.75	168.85

In this experimental work, concrete specimens were cast with different grades. The specimens were cast in this study consist of impact cylinders of size 150 * 64 mm.

Mixing of nano-cement can be accomplished by many methods. The mix should have a uniform dispersion of the nano-cement in order to prevent segregation during mixing. Cement with 10%, 20%, 30% replacement of nano-cement and aggregates are mixed thoroughly by using rotary mixer machine. The total nano-cement volume fraction used for casting is 10%, 20%, & 30%. Compared to conventional concrete, nano-cement concrete mixes are generally characterized by higher cement factor, higher fine aggregate content, and smaller size coarse aggregate. External vibration is preferable to prevent fiber segregation. Metal trowels, tube floats, and rotating power floats can be used to finish the surface.

Table 3: SEM results of Nano Materials

Particulars	Size of material before grinding	Size of material after grinding
Cement	10 - 45 microns (10-6 m)	10 – 118.53 nano-meters (10-9 m)
Fly Ash	45 - 100 microns (10-6 m)	1 – 175.36 nano-meters (10-9 m)
Silica Fumes	0.1 microns (10-6 m)	1 – 173.33 nano-meters (10-9 m)
Metakaolin	0.6 microns (10-6 m)	1 – 159.56 nano-meters (10-9 m)

2.1 Testing Specimens Under Elevated Temperature

An electric furnace was used to heat the specimens. The inner dimensions of the furnace are 500mmx 500mmx 500mm. The sides and top are lined with electrical heating coils embedded in refractory bricks. The control panel has a temperature controller to prevent damage to the furnace by tripping off, if the temperature inside the furnace exceeds the specified temperature. The maximum operating temperature of the furnace is 1200°C. The concrete specimens were exposed to fire inside the furnace and the furnace was heated from 27°C to 1000°C. After exposing the specimens to desired temperature and duration, the furnace was switched off and the specimens were taken out of the furnace. The specimens were naturally allowed to reach the room temperature by air cooling and water cooling. Ultimate loads of the specimens were found at 28th day for the reference and other specimens that were subjected to elevated to temperature.

After 28 days of curing the specimens taken out from the curing tank and kept out for one day to avoid moisture. Then the specimens were placed in the furnace. The specimens were heated upto a temperature of 1000°C. The specimens were naturally allowed to reach the room temperature by air cooling and water cooling.

2.2 Experimental Set Up and Testing Procedure

The size of the specimen recommended by the ACI 544.2R89 committee is 150mm in diameter and 64mm in height (4).

The equipment consists of a standard manually operated 4.4Kg compaction hammer with an 18 inch drop (457mm) a 44mm diameter hardened steel ball and a flat base plate with positioning bracket.

In addition to the above equipment, a mould to cast 150mm diameter and 64mm thick concrete specimens is needed.

The impact energy is calculated by the formula;

The impact energy is calculated by the formula;
E = W x h x n (N-m)

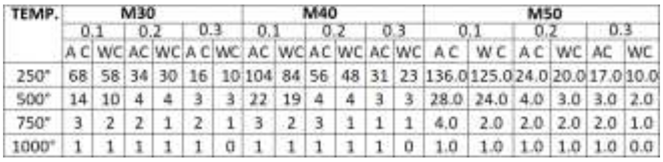
Where;
W = wt. of hammer (N).
h = height of fall (m).
n = no. of blows required for complete failure.
E2 = Energy absorption for final failure.

3. Results and Discussion

3.1 First crack

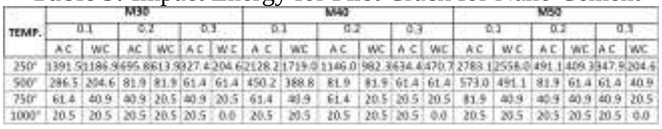
Impact strength and impact energy was evaluated at 1st crack of specimen. Results are as followed from Table 4 to Table 11.

Table 4: No of Blow for First Crack for Nano Cement



TEMP.	M30						M40						M50					
	0.1		0.2		0.3		0.1		0.2		0.3		0.1		0.2		0.3	
	A C	WC	AC	WC	A C	WC	AC	WC	A C	WC	AC	WC	A C	W C	A C	WC	AC	WC
250°	68	58	34	30	16	10	104	84	56	48	31	23	136.0	125.0	24.0	20.0	17.0	10.0
500°	14	10	4	4	3	3	22	19	4	4	3	3	28.0	24.0	4.0	3.0	3.0	2.0
750°	3	2	2	1	2	1	3	2	3	1	1	1	4.0	2.0	2.0	2.0	2.0	1.0
1000°	1	1	1	1	1	0	1	1	1	1	1	0	1.0	1.0	1.0	1.0	1.0	0.0

Table 5: Impact Energy for First Crack for Nano Cement

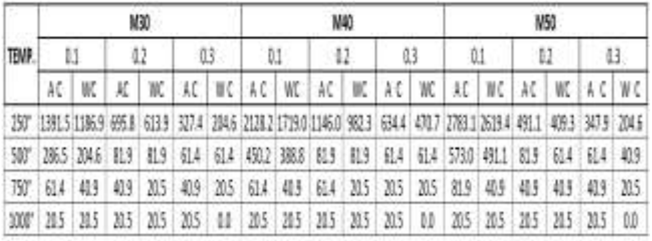


TEMP.	M30						M40						M50					
	0.1		0.2		0.3		0.1		0.2		0.3		0.1		0.2		0.3	
	A C	WC	AC	WC	A C	W C	A C	WC	A C	WC	A C	WC	A C	W C	A C	WC	A C	WC
250°	1391.5	1186.9	695.8	613.9	327.4	204.6	2128.2	1719.0	1146.0	982.3	634.4	470.7	2783.1	2558.0	491.1	409.3	347.9	204.6
500°	286.5	204.6	81.9	81.9	61.4	61.4	450.2	388.8	81.9	81.9	61.4	61.4	573.0	491.1	81.9	61.4	61.4	40.9
750°	61.4	40.9	40.9	20.5	40.9	20.5	61.4	40.9	61.4	20.5	20.5	20.5	81.9	40.9	40.9	40.9	40.9	20.5
1000°	20.5	20.5	20.5	20.5	20.5	0.0	20.5	20.5	20.5	20.5	20.5	0.0	20.5	20.5	20.5	20.5	20.5	0.0

Table 6: No of Blow for First Crack for Nano Fly Ash

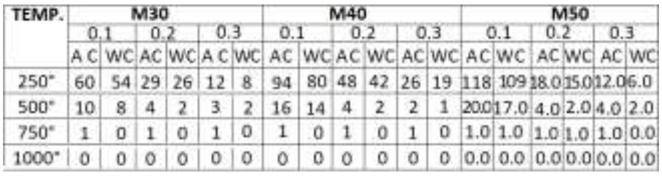
TEMP.	M30						M40						M50					
	0.1		0.2		0.3		0.1		0.2		0.3		0.1		0.2		0.3	
	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC
250°	68	58	34	30	16	10	104	84	56	48	31	23	136	128	24	20	17	10
500°	14	10	4	4	3	3	22	19	4	4	3	3	28	24	4	3	3	2
750°	3	2	2	1	2	1	3	2	3	1	1	1	4	2	2	2	2	1
1000°	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0

Table 7: Impact Energy for First Crack for Nano Fly Ash



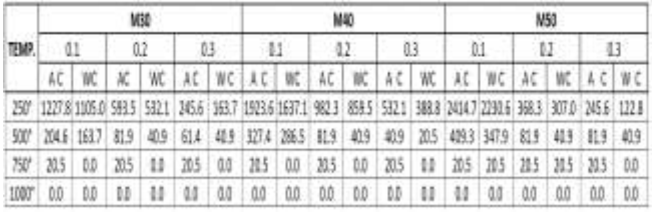
TEMP.	M30						M40						M50					
	0.1		0.2		0.3		0.1		0.2		0.3		0.1		0.2		0.3	
	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC
250°	1391.5	1186.9	695.8	613.9	327.4	204.6	2128.2	1719.0	1146.0	982.3	634.4	470.7	2783.1	2619.4	491.1	409.3	347.9	204.6
500°	286.5	204.6	81.9	81.9	61.4	61.4	450.2	388.8	81.9	81.9	61.4	61.4	573.0	491.1	81.9	61.4	61.4	40.9
750°	61.4	40.9	40.9	20.5	40.9	20.5	61.4	40.9	61.4	20.5	20.5	20.5	81.9	40.9	40.9	40.9	40.9	20.5
1000°	20.5	20.5	20.5	20.5	20.5	0.0	20.5	20.5	20.5	20.5	20.5	0.0	20.5	20.5	20.5	20.5	20.5	0.0

Table 8: No of Blow for First Crack for Nano Silica Fume



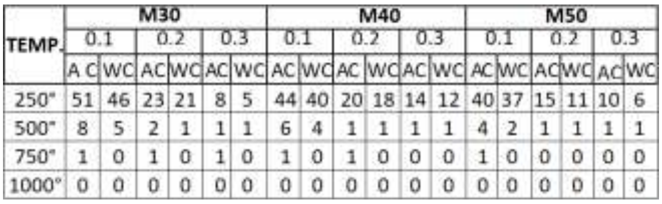
TEMP.	M30						M40						M50					
	0.1		0.2		0.3		0.1		0.2		0.3		0.1		0.2		0.3	
	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC
250°	60	54	29	26	12	8	94	80	48	42	26	19	118	109	18.0	15.0	12.0	6.0
500°	10	8	4	2	3	2	16	14	4	2	2	1	20.0	17.0	4.0	2.0	4.0	2.0
750°	1	0	1	0	1	0	1	0	1	0	1	0	1.0	1.0	1.0	1.0	1.0	0.0
1000°	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0

Table 9: Impact Energy for First Crack for Nano Silica Fume



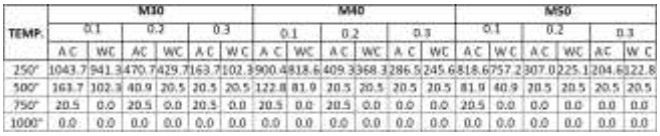
TEMP.	M30						M40						M50					
	0.1		0.2		0.3		0.1		0.2		0.3		0.1		0.2		0.3	
	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC
250°	1227.8	1105.0	593.5	532.1	245.6	163.7	1923.6	1637.1	982.3	859.5	532.1	388.8	2414.7	2230.6	368.3	307.0	245.6	122.8
500°	204.6	163.7	81.9	40.9	61.4	40.9	327.4	286.5	81.9	40.9	40.9	20.5	409.3	347.9	81.9	40.9	81.9	40.9
750°	20.5	0.0	20.5	0.0	20.5	0.0	20.5	0.0	20.5	0.0	20.5	0.0	20.5	20.5	20.5	20.5	20.5	0.0
1000°	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 10: No of Blow for First Crack for Nano Metakaolin



TEMP.	M30						M40						M50					
	0.1		0.2		0.3		0.1		0.2		0.3		0.1		0.2		0.3	
	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC
250°	51	46	23	21	8	5	44	40	20	18	14	12	40	37	15	11	10	6
500°	8	5	2	1	1	1	6	4	1	1	1	1	4	2	1	1	1	1
750°	1	0	1	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0
1000°	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 11: Impact Energy for First Crack for Nano Metakaolin

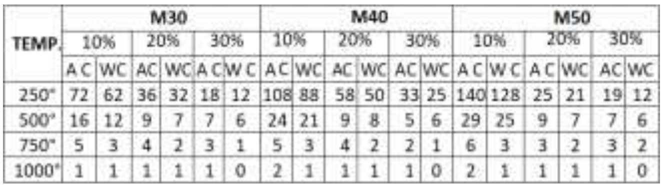


TEMP.	M30						M40						M50					
	0.1		0.2		0.3		0.1		0.2		0.3		0.1		0.2		0.3	
	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC
250°	1043.7	941.3	470.7	429.7	163.7	102.3	900.4	818.6	409.3	368.3	286.5	245.6	818.6	757.2	307.0	225.1	204.6	122.8
500°	163.7	102.3	40.9	20.5	20.5	20.5	122.8	81.9	20.5	20.5	20.5	20.5	81.9	40.9	20.5	20.5	20.5	20.5
750°	20.5	0.0	20.5	0.0	20.5	0.0	20.5	0.0	20.5	0.0	0.0	0.0	20.5	0.0	0.0	0.0	0.0	0.0
1000°	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

3.2 Final failure

Impact strength and impact energy was evaluated at final failure of specimen. Results are as followed from Table 12 to Table 19.

Table 12: No of Blow for Final failure for Nano Cement



TEMP.	M30						M40						M50					
	10%		20%		30%		10%		20%		30%		10%		20%		30%	
	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC
250°	72	62	36	32	18	12	108	88	58	50	33	25	140	128	25	21	19	12
500°	16	12	9	7	7	6	24	21	9	8	5	6	29	25	9	7	7	6
750°	5	3	4	2	3	1	5	3	4	2	2	1	6	3	3	2	3	2
1000°	1	1	1	1	1	0	2	1	1	1	1	0	2	1	1	1	1	0

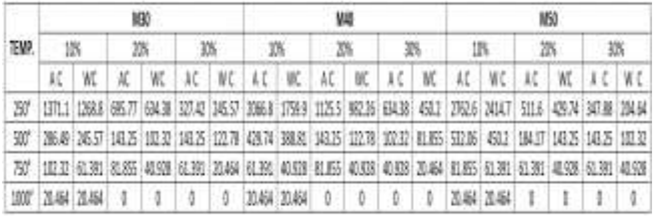
Table 13: Impact Energy for Final Failure for Nano Cement

TEMP.	M30						M40						M50					
	10%		20%		30%		10%		20%		30%		10%		20%		30%	
	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC
250°	1473.4	1268.8	736.7	654.84	368.35	245.57	2210.1	1800.8	1186.9	1023.2	675.31	511.6	2864.9	2476.1	511.6	429.74	388.81	245.57
500°	327.42	245.57	184.17	143.25	143.25	122.78	491.13	429.74	184.17	163.71	102.32	122.78	593.45	511.6	184.17	143.25	143.25	122.78
750°	102.32	61.391	81.855	40.928	61.391	20.464	102.32	61.391	81.855	40.928	40.928	20.464	122.78	61.391	61.391	40.928	61.391	40.928
1000°	20.464	20.464	20.464	20.464	20.464	0	40.928	20.464	20.464	20.464	20.464	0	40.928	20.464	20.464	20.464	20.464	0

Table 14: No of Blow for Final failure for Nano Fly ash

TEMP.	M30						M40						M50					
	10%		20%		30%		10%		20%		30%		10%		20%		30%	
	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC
250°	67	62	34	31	16	12	101	86	55	48	31	22	135	118	25	21	17	10
500°	14	12	7	5	7	6	21	19	7	6	5	4	26	22	9	7	7	5
750°	5	3	4	2	3	1	3	2	4	2	2	1	4	3	3	2	3	2
1000°	1	1	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0

Table 15: Impact Energy for Final Failure for Nano Fly ash



TEMP.	M30						M40						M50					
	10%		20%		30%		10%		20%		30%		10%		20%		30%	
	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC
250°	1371.1	1268.8	695.77	634.38	327.42	245.57	2066.8	1759.9	1125.5	982.26	634.38	450.2	2762.6	2414.7	511.6	429.74	347.88	204.64
500°	286.49	245.57	143.25	102.32	143.25	122.78	429.74	388.81	143.25	122.78	102.32	81.855	532.06	450.2	184.17	143.25	143.25	102.32
750°	102.32	61.391	81.855	40.928	61.391	20.464	61.391	40.928	81.855	40.928	40.928	20.464	81.855	61.391	61.391	40.928	61.391	40.928
1000°	20.464	20.464	0	0	0	0	20.464	20.464	0	0	0	0	20.464	20.464	0	0	0	0

Table 16: No of Blow for Final failure for Nano Slica fume

TEMP.	M30						M40						M50					
	10%		20%		30%		10%		20%		30%		10%		20%		30%	
	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC
250°	62	56	30	27	13	9	95	81	49	43	27	20	120	110	19	16	14	7
500°	11	9	5	3	4	3	17	15	5	3	3	1	21	18	5	3	5	3
750°	1	0	1	0	1	0	1	0	1	0	1	0	2	1	1	1	1	0
1000°	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

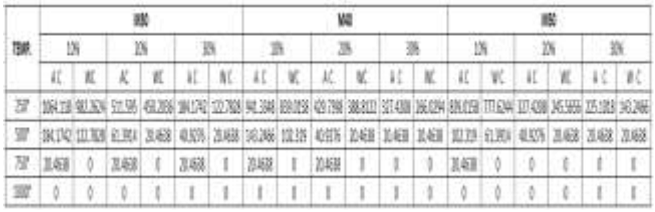
Table 17: Impact Energy for Final Failure for Nano Silica Fume

TEMP.	M30						M40						M50					
	10%		20%		30%		10%		20%		30%		10%		20%		30%	
	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC
250°	1268.8	1146	613.91	613.91	266.03	184.17	1944.1	1657.6	1002.7	879.94	552.52	409.28	2455.7	2251	388.81	327.42	286.49	143.25
500°	225.1	184.17	102.32	102.32	81.855	61.391	347.88	306.96	102.32	61.391	61.391	20.464	429.74	368.35	102.32	61.391	102.32	61.391
750°	20.464	0	20.464	20.464	20.464	0	20.464	0	20.464	0	20.464	0	40.928	20.464	20.464	20.464	20.464	0
1000°	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 18: No of Blow for Final failure for Nano Metakaolin

TEMP.	M30						M40						M50					
	10%		20%		30%		10%		20%		30%		10%		20%		30%	
	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC
250°	52	48	25	22	9	6	46	41	21	19	16	13	41	38	16	12	11	7
500°	9	6	3	1	1	1	7	5	2	1	1	1	5	3	2	1	1	1
750°	1	0	1	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0
1000°	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 19: Impact Energy for Final Failure for Nano Metakaolin



TEMP.	M30						M40						M50					
	10%		20%		30%		10%		20%		30%		10%		20%		30%	
	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC	AC	WC
250°	1064.128	982.2624	511.595	450.2036	184.1742	122.7828	941.3348	839.0158	429.7398	388.8122	327.4208	266.0294	839.0158	777.6244	327.4208	245.5656	225.1018	143.2466
500°	184.1742	122.7828	61.3914	20.4638	40.9276	20.4638	143.2466	102.319	40.9276	20.4638	20.4638	20.4638	102.319	61.3914	40.9276	20.4638	20.4638	20.4638
750°	20.4638	0	20.4638	0	20.4638	0	20.4638	0	20.4638	0	0	0	20.4638	0	0	0	0	0
1000°	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

3.3 Percentage of replacement vs Impact Energy graphs at different elevated temperature

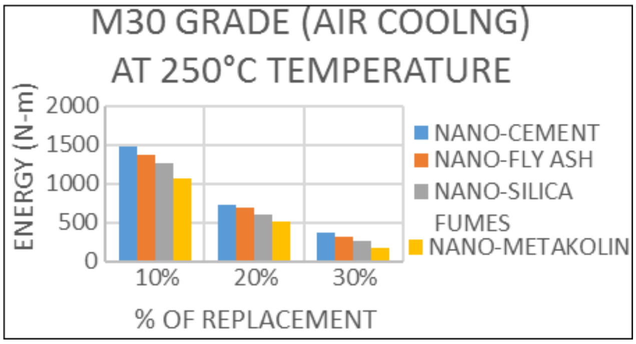


Figure 1: M30 Grade (Air Cooling) at 250°C temperature

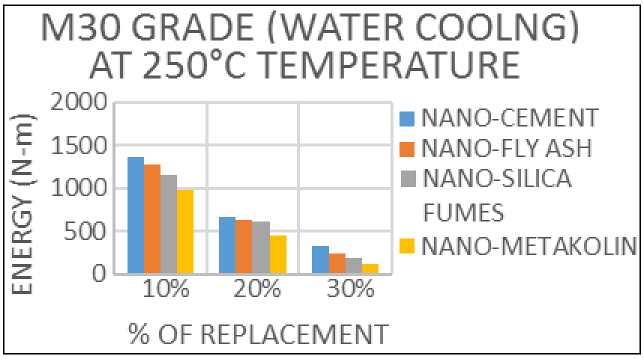


Figure 2: M30 Grade (water Cooling) at 250°C temperature

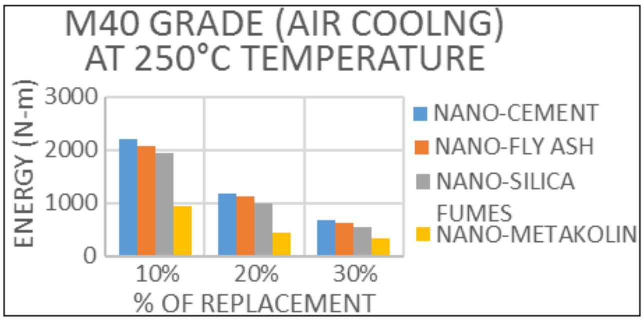


Figure 3: M40 Grade (Air Cooling) at 250°C temperature

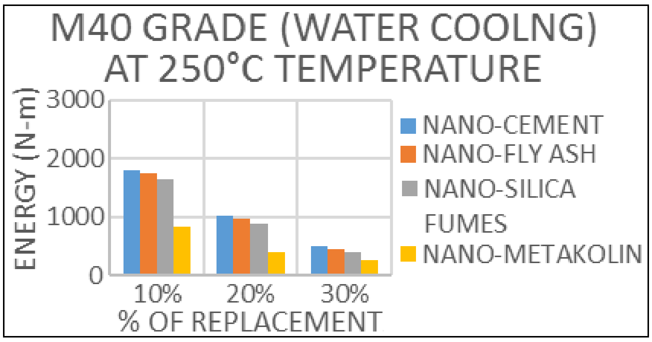


Figure 4: M40 Grade (water Cooling) at 250°C temperature

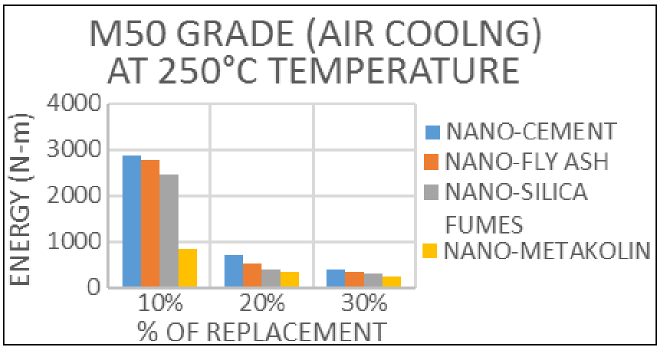


Figure 5: M50 Grade (Air Cooling) at 250°C temperature

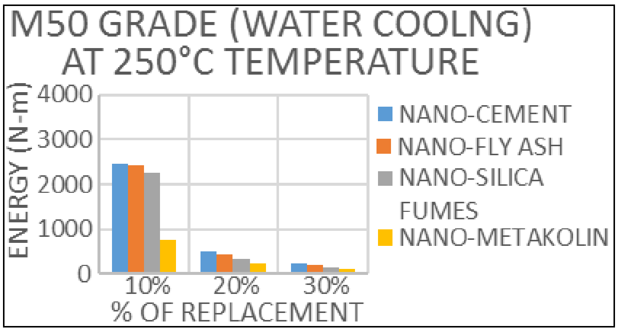


Figure 6: M50 Grade (water Cooling) at 250°C temperature

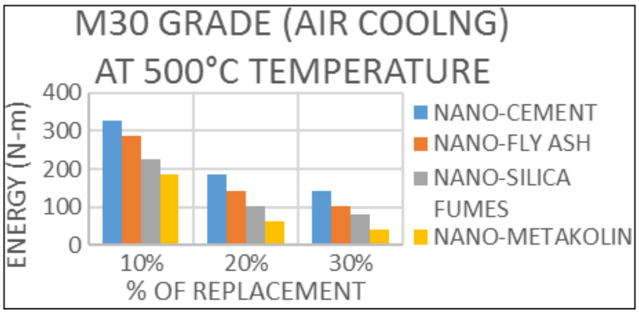


Figure 7: M30 Grade (Air Cooling) at 500°C temperature

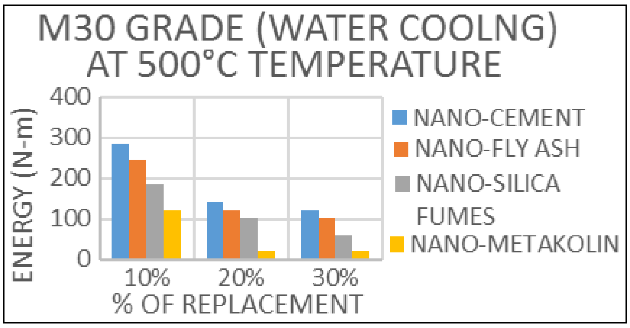


Figure 8: M30 Grade (water Cooling) at 500°C temperature

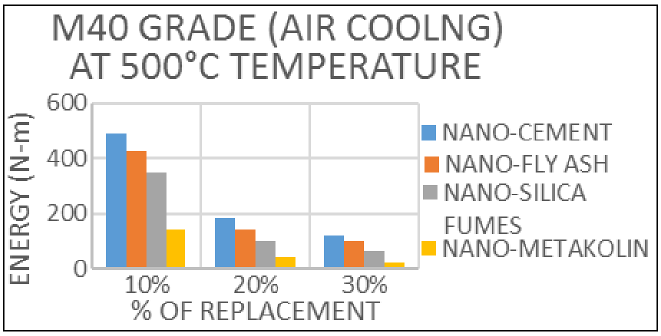


Figure 9: M40 Grade (Air Cooling) at 500°C temperature

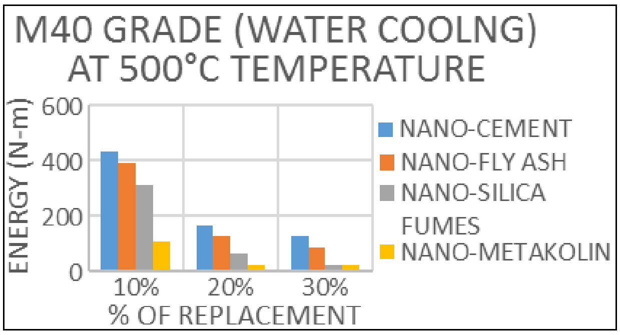


Figure 10: M40 Grade (water Cooling) at 500°C temperature

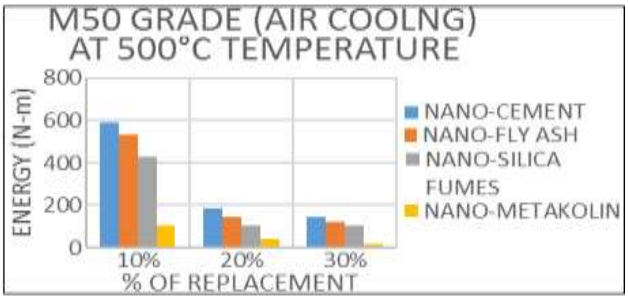


Figure 11: M50 Grade (Air Cooling) at 500°C temperature

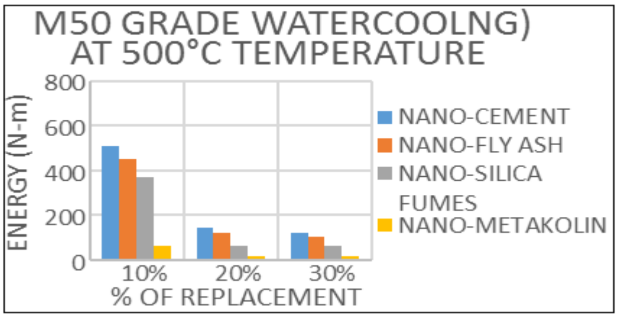


Figure 12: M50 Grade (water Cooling) at 500°C temperature

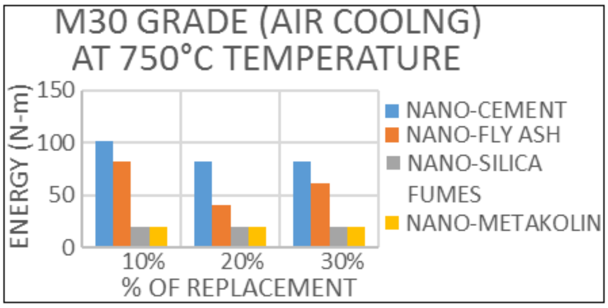


Figure 13: M30 Grade (Air Cooling) at 750°C temperature

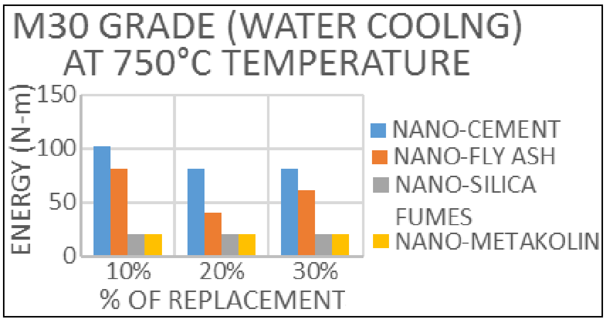


Figure 14: M30 Grade (water Cooling) at 750°C temperature

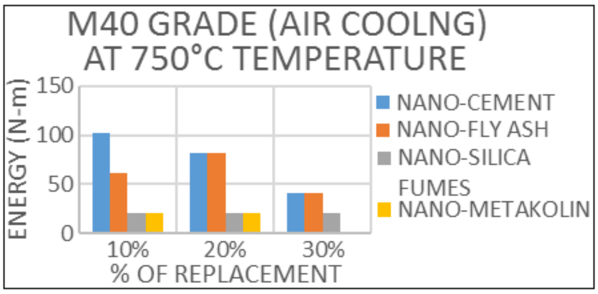


Figure 15: M40 Grade (Air Cooling) at 750°C temperature

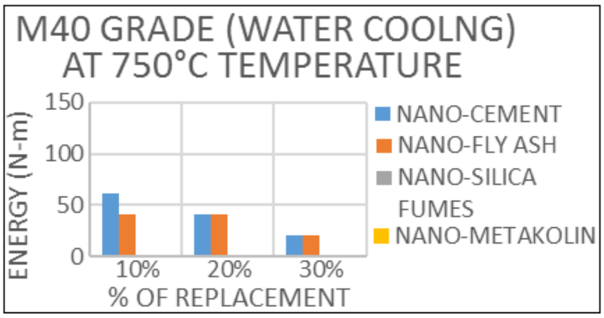


Figure 16: M40 Grade (water Cooling) at 750°C temperature

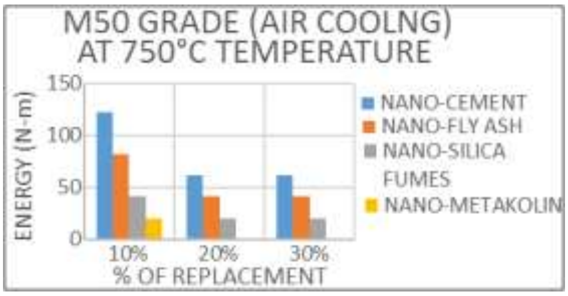


Figure 17: M50 Grade (Air Cooling) at 750°C temperature

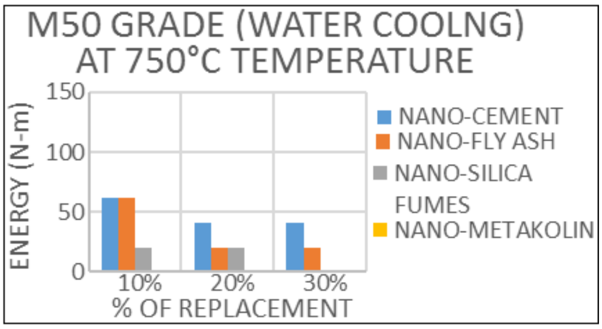


Figure 18: M50 Grade (water Cooling) at 750°C temperature

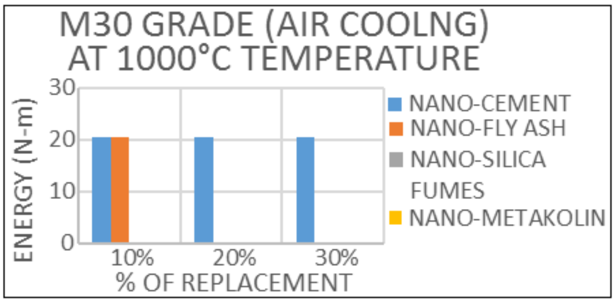


Figure 19: M30 Grade (Air Cooling) at 1000°C temperature

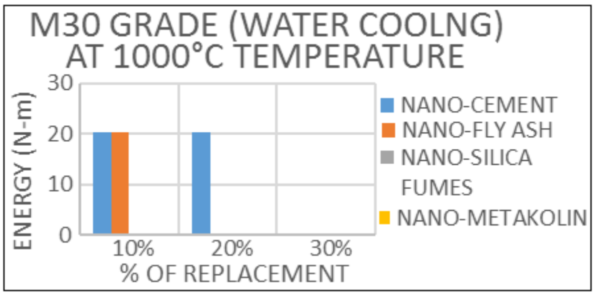


Figure 20: M30 Grade (water Cooling) at 1000°C temperature

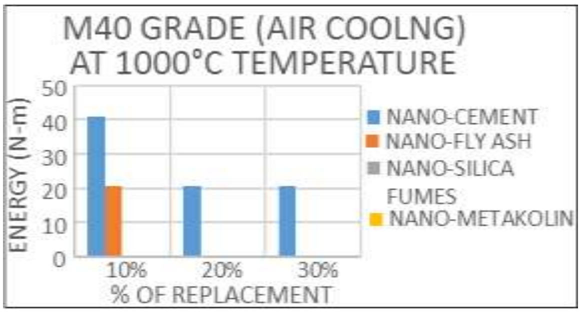


Figure 21: M40 Grade (Air Cooling) at 1000°C temperature

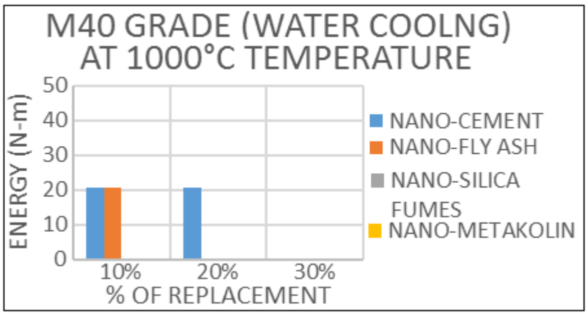


Figure 22: M40 Grade (water Cooling) at 1000°C temperature

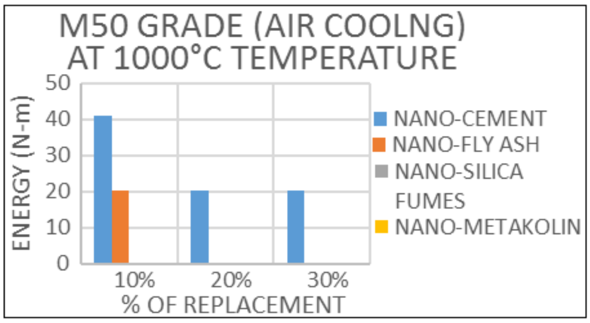


Figure 23: M50 Grade (Air Cooling) at 1000°C temperature

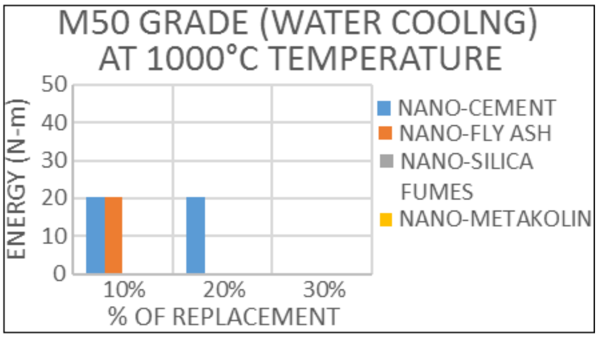


Figure 24: M50 Grade (water Cooling) at 1000°C temperature

4. Conclusions

1) Based on the experimental investigation the impact strength of heated specimens at 250°C increases in case of air cooling about 76%, 83%, 89% and 95% for the specimens of M30, M40 and M50 grades respectively with 10% replacement of cement with nano-cement compared to reference specimens.
2) The impact strength of heated specimens at 250°C decreases in case of water cooling about 81%, 89%, 93% and 98% for the specimens of M30, M40 and M50 grades respectively with 10% replacement of cement with nano-cement compared to reference specimens.
3) The impact strength of heated specimens at 500°C, 750°C, 1000°C decreases in both air and water cooling for the specimens of M30, M40 and M50 grades respectively with 10%, 20% & 30% replacement of cement with nano-cement compared to reference specimens.
4) The specimens heated up to 1000°C with 30% replacement of cement with nano cement and cooled by water failed before impact test for all the grades of concrete.
5) The impact strength for normal concrete is higher than the concrete replaced with nano-materials at elevated temperatures.

5. Future Enhancements

1) It is suggested to find the compressive strength and split tensile strength, using the same nano-materials.
2) To study the impact strength of High Strength concrete (HSC) at elevated temperature.
3) To study the ductility index of concrete with nano materials at elevated temperatures
4) To study the micro structural analysis of concrete made with nano materials.

References

[1] Bjorn Birgisson,Anal K. Mukhopadhyay, Georgene Geary, Mohammad Khan, Konstantin Sobolev 'Nanotechnology in Concrete Materials'December-2012.
[2] K. Ramesh, Dr. K. Arunachalam, S. Rooban Chakravarthy 'Studied the Impact Resistance of the Fly ash concrete reinforced with steel fibers' April 2013.
[3] Balakrishnaiah, Balaji.K.V.G, Srinivasa Rao 'Study of mechanical properties of concrete at elevated temperatures' November 2013.
[4] American Concrete Institute (ACI) code 554.2R89
[5] A Narendra Reddy, D Ramesh "Studies on impact strength of concrete with nano materials at elevated temperatures, 2015
[6] Qi Zhang , Guang Ye , Eduard Koenders,'Investigation of the structure of heated Portland cement paste by using various techniques' November 2012.
[7] Omer Arioz 'Effects of elevated temperatures on properties of concrete' March 2007.
[8] Mohamed Heikal, S. Abd El Aleem, W.M. Morsi 'Characteristics of blended cements containing nano-silica' September 2013.

[9] TanakornPhoo-ngernkham, PrinyaChindaprasirt, VanchaiSata , SakonwanHanjitsuwan ,Shigemitsu Hatanaka 'The effect of adding nano-SiO2 and nano-Al2O3on properties of high calcium fly ash geopolymer cured at ambient temperature' September 2013.
[10] NimaFarzadnia, Abang Abdullah Abang Ali , RamazanDemirboga , Mohammed Parvez Anwar 'Characterization of high strength mortars with nanoTitania at elevated temperatures' April 2013.
[11] MortezaBastami, MazyarBaghbadrani, FarhadAslani 'Performance of nano-Silica modified high strength concrete at elevated temperatures' June 2014.
[12] Byung Wan Jo, Sumit Chakraborty, Ki Heon Kim 'Investigation on the effectiveness of chemically synthesized nano-cement in controlling the physical and mechanical performances of concrete' July 2014.
[13] N. Banthia, S. Mindess, A. Bentur and M. Pigeon 'Impact Testing of Concrete Using a Drop-weight Impact Machine' March 1989.
[14] Doo-YeolYoo, Kyung-Hwan Min, Jin-Young Lee, Young-Soo Yoon 'enhancing impact resistance of concrete slabs strengthened with frps and steel fibers' July 2012.

Author Profile

Rakesh Kumar Choubey. Post graduate student in civil Enginnering from Greater Noida Institute of Technology.