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AN EXPERIMENTAL STUDY ON MODE-II FRACTURE OF CONCRETE MODIFIED WITH STYROFOAM AGGREGATES AND PENTA BLENDED CEMENT (POZZOLANIC MATERIALS AND NANA SiO2)

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ABSTRACT With the increase in demand for construction materials, there is a strong need to utilize alternative materials for sustainable development and the concrete made from industrial wastes is known as “Green concrete”. Styrofoam used as packaging tool in food and manufacturing production equipments to absorb vibration during handling and transportation process. After this process, the Styrofoam used to protect the equipment normally disposed off as waste and recycling process is very costly. An attempt is made to replace 100% natural aggregate with modified Styrofoam pieces as light weight aggregate. An attempt is also made to replace 11% of cement with three numbers of pozzolanic materials i.e., Silica fume, Slag and fly ash in equal proportion and varying percentages of Nano Silicon oxide at 0, .5, 1 and 1.5% on 11% of cement to study mode-II fracture properties along with corresponding compressive strength of modified concrete.

KEYWORDS : Styrofoam aggregates, Pozzolanic materials, Nano SiO2, Mode-II shear.

Introduction

In structural applications, the self-weight of the structure is quite important as it represents a major portion of its dead load. The coarser normal weight aggregate in conventional concrete can be replaced partially or fully with low density aggregates which will produce lightweight concrete that can reach a reasonably good compressive resistance. The advantages of lightweight concrete are its reduced mass and improved thermal and sound insulation properties, while maintaining adequate strength. The reduced self-weight of LWC will reduce the gravity load as well as seismic inertial mass which leads to decreased member sizes as well as forces on foundation can be reduced . Aggregates contribute an important role in concrete volume as they contribute to 60 to 70 percent of the total volume. Thus they have major influence on the different material properties like density, specific gravity; water absorption etc., Styrofoam (Thermocoal) aggregates comes under the category of light weight aggregate and is a waste material. Styrofoam aggregates contain large percentage of air, so it is naturally a better material with respect to sound absorption, sound proofing and thermal insulation. Due to its low density it helps in reduction of dead load. The most important characteristic of light weight concrete is the relatively low thermal conductivity. Due to its low specific gravity, the concrete made with it is lighter than natural concrete.

Cement industry is one of primary industrial producer of carbon-di - Oxide (CO_2) creating up to 7% man made emissions of this gas as production of every tonne of cement emits 0.87 tonnes of CO_2. One of the practical solutions to economise cement is to replace cement with industrial wastes like silica fume, fly ash and slag etc which are proven pozzolanic materials.

Besides Nano-particles has become a focus in the development of new accelerators for cement hydration. Nano-particles like SiO_2 are used to improve the physico-mechanical properties and durability of cement and concrete materials. They act as nucleation centers, contributing to the development of the cement hydration. Due to the high specific surface area Nano particles develop strong attractive properties, which act as a nucleation site and thereby stimulate nucleation reactions. They also have a large potential to accelerating effects of these particles are induced by surface area or particles size, which are the main factors to control the cement hydration kinetics. The model which describes the influence of Nano particles on cement hydration distinguishes between two methods of stimulation of Nano-particles cement hydration. Nano-particles have the best potential as accelerators for cement hydration and therefore are most suitable for further investigations.

Shear strength is of great value for multiple areas of civil engineering substances and structures. Shear and punching shear failures are fatal. Especially in concrete flat slabs and deep beams in corbels are more sensitive to this than other types of failures. For such reason this area has received greater attention in recent years. Various attempts earlier were undertaken to test specimen geometries to study Mode-II (sliding shear) type failures in concrete substance. Mode-II or edge sliding mode is associated with crack surface displacements in the crack plane and normal to the crack face. Mode II fracture is supposed to be the common type of fracture in a wide variety of civil engineering structures. It is thought to be one of the catastrophic fractures.

With the inter disciplinary research and development in material science and engineering have lead to the development of several important composite construction materials such as concrete made with partial replacement of conventional aggregate by light weight aggregate.

Recent investigations of Prakash Desai [2] shows double central notched specimen geometry which fails in predominant Mode-II failure, they also made finite element analysis to arrive at stress intensity factor.

1.REVIEW OF LITERATURE

Liu et.al., (1) (1985), examined the in-plane shear behavior of polypropylene and steel fiber reinforced concrete and investigated that the fracture toughness results in shear (K_{IIc}) are independent of the fiber content of the mix and this is in contrast to K_{Ic} results for steel fiber reinforced concrete which increases with the increasing fiber content.

Prakash Desai, Raghu Prasad B.K, and Bhaskar Desai V (2) (1993) arrived at double central notched specimen geometry which fails in predominant Mode-II failure; they also made finite element analysis to arrive at stress intensity factor. Using this DCN geometry lot of experimental investigation using cement paste, mortar, plain concrete have been studied. Details of this geometry are presented in Plate 2.1.

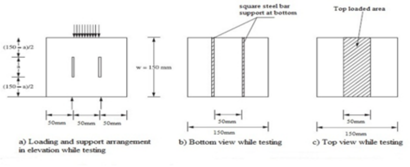

Plate 2.1: Details of DCN specimen geometry

According to **M. A. Caldarone and R. G. Burg** (3), (2004), Structural lightweight concrete is defined as concrete made with low density aggregate having an air-dry density of not more than 115 lb/ft3 (1850 kg/m^3) and a 28-day compressive strength of more than 2500 psi (17.2 MPa). This paper presented the test results of very low-density structural lightweight concrete mixtures developed in the laboratory for the purpose of finding a suitable mixture for use on a historic building rehabilitation project. Mixture parameters include a specified compressive strength of 3000 psi at 28 days and an air-dry density approaching 70 lb/ft3. Various constituent materials, mixture proportions and curing methods were examined. The result of this research exemplifies the feasibility of achieving very low densities with structural concretes.

W.C. Tang, Y. Lo, A. Nadeem, (4) (2008), stated that Polystyrene aggregate concrete (PAC) is a lightweight concrete with good deformation capacity, but its application is usually limited to non-structural use because of its apparent low strength properties. The present study is an effort to develop a class of structural grade PAC with a wide range of concrete densities between 1400 and 2100 kg/m3 through partial replacement of coarse aggregate with polystyrene aggregate (PA) in control concrete. Extensive laboratory tests have been carried out and the focus of this paper is to characterize the strength and long-term drying shrinkage properties of PAC. The parameters studied include PA content and curing conditions. The results show that the concrete density, concrete strength and elastic modulus of PAC decrease with increase of PA content in the mix.

Ramazan Demirboga, C. Abdulkadir Kan (5) (2009), in their study, a new recycling process was developed to convert the waste EPS foams as aggregate by using heat treatment. This technique reduces the volume of waste EPS about 20 times to that of the original. Before the heat treatment, the average density, thermal conductivity and compressive strength of waste EPS foams were 10 kg/m3, 0.0368 W/mK, and 0.12 MPa, respectively. The best result of modification was determined at 130 °C and 15 min. After the modification density, thermal conductivity and compressive strength of waste EPS, increased to 217 kg/m3, 0.0555 W/mK and 8.29 MPa, respectively. This new material, obtained after the heat treatment, is called as thermal modified expanded polystyrene (MEPS).

Ananya Sheth, Anirudh Goel, et.al., (6) (2013), - This paper reports an experimental investigation on the influence of Rice Husk Ash (RHA)and Expanded Poly Styrene (EPS) on the mechanical properties and the properties of fresh concrete of the produced RHA and EPS blended concrete. EPS aggregates were used to replace coarse aggregates by volume with an aim to decrease the unit weight. Locally produced RHA was used to replace cement by its weight with an aim to increase workability. The highest compressive strength of 26.55 Mpa at 7 days was achieved with replacement of 10% of cement by RHA and with 20% replacement of coarse aggregate by EPS.

From the brief literature summary conducted here it appears that much less attention has been paid earlier on the study of in plane shear properties of modified concrete with 100% Styrofoam aggregate along with blended cement using pozzolanic and Nano material such as Nano SiO2. Hence the present investigation has been under taken.

3. OBJECTIVE

- Determining of solution for disposal of industrial wastes hazardous to environment as a useful material in the construction industry.
- By replacing of coarse aggregate in concrete to produce light weight concrete.

4. MATERIALS USED

The following materials are used for preparing the concrete mix.

1. ACC cement of 53 grade
2. Fine aggregate i.e sand
3. Coarse aggregate i.e Styrofaom aggregate
4. Fly ash
5. Silica Fume
6. Slag
7. Nano material (Nano SiO2)
8. Water

4.1 Cement: ACC 53 grade cement with specific gravity 3.26 is used as binder.

S.No	Name of the material	Properties of materials	
1	Cement	Specific gravity	3.26
		Initial setting time	50 minutes
		Final setting time	460 minutes
		Normal consistency	30%
		Fineness of Cement	5%
2	Fine aggregate	Specific gravity	2.4
		Fineness modulus	2.63
3	Coarse aggregate	Specific gravity	2.6
		Fineness modulus	6.24

4.2: STYROFOAM AGGREGATES:

Styrofoam (Thermocoal) is widely used in food packaging and as protective devices for securing goods and materials from vibration and damage during delivering and transportation process, especially delivering process is shaped according to the delivering item's shape and after delivering process it is commonly treated as waste and seldom to be recycled as it is not economical.

The Styrofoam waste is taken from different industries and food packaging units and is broken down into irregular pieces of various sizes by hand. The broken Styrofoam is taken into a tray and was kept in oven at different temperatures. It is found that exposure to temperature of 180° for 10 minutes duration is optimum. Then the Styrofoam is removed and kept in air for some time and then the sample is taken for mixing. Styrofoam aggregate is used as coarse aggregate. For this aggregate the gradation is as follows. Passing through 20mm and retained on 10mm is 70%. Passing through 10mm and retained on 6mm is 30%.

VARIOUS TEST RESULTS ON STYROFOAM AGGREGATE

Sl. No	Name of the test conducted	Result
1	Specific gravity	0.103
2	Aggregate crushing value	N.A
3	Abrasion test	N.A
4	Density - Loose condition	64.50 kg/m3
5	Density - Compacted condition	75.50 kg/m3
6	Fineness modulus	6.62
7	Water absorption	0.00 %
8	Shape	Irregular

4.3 FLY ASH:

The fly ash admixture is procured from Rayalaseema Thermal plant, Muddanur. The test results are shown below.

Physical Properties of Fly ash	Test results
Specific gravity	2.7
Fineness (Retained on 90 micron sieve)	0%
Bulk density in the loosest state	800 kg/m3
Bulk density in the densest state	960 kg/m3

4.4 SILICA FUME:

The silica fume admixture is procured from Ferro silica unit at Ahmadabad. The test results are shown below.

Properties of Silica fume

Property	Test results
Specific gravity	2.1
Fineness (Retained on 90 micron sieve)	0%
Bulk density in the loosest state	420 kg/m3
Bulk density in the compacted state	700 kg/m3

4.5 SLAG:

The source of slag is from Jindhal steel industries, Bellary. The test results are shown below.

Properties of Slag

Property	Test results
Specific gravity	2.86
Bulk density in the loosest state	600 kg/m2
Bulk density in the compacted state	980 kg/m3
Fineness (Retained on 90 micron sieve)	0%

4.6 Nano silica or silicon dioxide (SiO2):

Nano silica is procured from AVANSA technologies, KHANPUR. The results are shown below.

Physical Properties of Silicon Oxide Nano powder (**SiO2**) (Given by the supplier)

Purity: 98+%

Colour: White

APS: 60-80nm
Bulk Density: <0.10 g/cm3
SSA: 160-600m2/g
True Density: 2.4 g/cm3

Certificate of Analysis (Given by the supplier)				
SiO_2	Ti	Ca	Na	Fe
>98%	<220ppm	<130ppm	<80ppm	<40ppm

4.7: FINE AGGREGATE

Locally available natural river sand which is procured from Chitravati River has been used as fine aggregate. Sand conforms to zone-I.

TABLE 3.3 VARIOUS TEST RESULTS ON SAND

Sl. No	Name of the test conducted	Result
1	Specific gravity	2.60
2	Bulking of sand	6 %
3	Sieve analysis	Confirms to Zone-I
4	Density in the loosest state	1500 kg/m^3
5	Density in the compacted state	1766 kg/m^3
6	Fineness modulus	2.65

4.8: WATER

Locally available potable water which is free from the concentration of acids and organic substances has been used in this work.

4.3 CASTING OF SPECIMENS:

Mixing, casting and curing: M20 mix design has been carried out with the mix proportions of 1: 1.49: 2.88. It means that 1 part of cement with and without replacement of cement using pozzolanic materials and Nano-materials, 1.49 parts of fine aggregate and 2.88 parts of coarse aggregate with 100% replacement of natural Granite aggregate by artificial light weight aggregates i.e., Styrofoam aggregates mixed with water cement ratio of 0.5. Keeping the volume of the concrete constant, Styrofoam aggregates are added to concrete with four different mixes by replacing cement with 11% its weight by three numbers of pozzolanic materials with varying percentage of Nano materials which are designated as follows:

Mix	% Volume replacement of Coarse aggregate	% of 3 nos of Pozzolanic materials in equal proportions	% of Nano-materials on 11% weight of cement	% of cement
N.A-0	0	0	0	100
M.S.A- 1	100	0	0	100
M.S.A -2	100	11	0	89.000
M.S.A -3	100	11	0.5	88.945
M.S.A -4	100	11	1.0	88.890
M.S.A -5	100	11	1.5	88.835

To proceed with the experimental program initially steel moulds of size 150x150x150 mm are cleaned brushed with machine oil on all inner faces to facilitate easy removal of specimens afterwards. First fine aggregate and cement along with admixtures silica fume, slag, fly ash and Nano silicon oxide in required percentages are mixed thoroughly and then Styrofoam aggregates are added with them. All of these materials are mixed thoroughly by hand mixing. Each time 15 no's of 150X150X150mm cube specimens out of which 12 no of DCN specimens with replacement of cement by 11% of its weight by pozzolanic materials (silica fume, fly ash and Slag) and Nano silicon oxide with varying percentages (0%, 0.5%, 1% and 1.5%) on 11% weight of cement for 5no's of different mixes are casted. The concrete is poured into the moulds in three layers with each layer being compacted thoroughly with tamping rod 25 times each time to avoid honey combing. Finally all specimens are kept on the table vibrator after filling up the moulds up to the brim. The vibration is effected for 7 seconds and it is maintained constant for all specimens and all other castings. The steel plates forming notches are removed after 3 hours of casting carefully and neatly finished. After 28 days of curing the specimens are taken out of water and are allowed to dry under shade for few hours.

4.4Testing of specimens

4.4.1 Compressive strength of cubes: Compressive strength of cubes shall be calculated by dividing load taken by the specimen by the cross sectional area. Values of compressive strength at different percentages of iron oxide are given in table 1 below.

4.4.2 Mode II fracture test

For testing DCN specimens of size 150x150x150mm, notches were introduced at one third portion centrally during casting. The compression test on the DCN cubes is conducted on 3000KN digital compression testing machine. The rate of loading applied is 0.5 KN/sec. Test results are shown in table 2 and graphically vide in fig.2.Uniformly distributed load is applied over the central one third part between the notches and square cross section steel supports are provided at bottom along the outer edges of the notches, so that the central portion could get punched/sheared along the notches on the application of loading. (fig: 1).

Table1: Compressive strength of cubes

Name of the mix	% Volume replacement of Styrofoam aggregate	% of cement replaced by 3 nos of pozzolanic materials	% of Nano Fe_2O_3 on 11% weight of cement	% of Cement	compressive strength in N/mm^2	% variation with respect to modified LWAC
N.A-0	0	0	0	100	41.08	270.76
M.S.A- 1	100	0	0	100	11.08	0.00
M.S.A -2	100	11	0	89.00	11.97	8.03
M.S.A -3	100	11	0.5	88.945	12.28	10.83
M.S.A -4	100	11	1.0	88.890	12.74	14.98
M.S.A -5	100	11	1.5	88.835	11.77	6.23

M.S.A: Modified Styrofoam aggregate

Table 2: Ultimate loads in Mode-II fracture test

Name of the mix	a/w=0.3		a/w=0.4		a/w=0.5		a/w=0.6	
	Ultimate load in KN	% variation w.r.to LWAC	Ultimate load in KN	% variation w.r.to LWAC	Ultimate load in KN	% variation w.r.to LWAC	Ultimate load in KN	% variation w.r.to LWAC
N.A-0	144.00	196.30	131.00	211.90	118.70	249.12	90.33	216.95
M.S.A- 1	48.00	0.00	42.00	0.00	34.00	0.00	28.50	0.00
M.S.A -2	53.00	9.05	50.00	14.29	41.00	20.59	35.00	22.81
M.S.A -3	65.00	15.23	62.00	19.05	52.00	29.41	47.00	50.88
M.S.A -4	58.00	19.34	56.00	23.81	46.00	41.18	41.00	57.89
M.S.A -5	51.00	7.00	48.00	21.43	42.00	26.47	35.00	40.35

Table 3: In plane shear stress in Mode-II fracture

Name of the mix	a/w=0.3		a/w=0.4		a/w=0.5		a/w=0.6	
	In plane Shear Stress- N/Sq-mm	% variation with respect to modified LWAC	In plane Shear Stress- N/Sq-mm	% variation with respect to modified LWAC	In plane Shear Stress- N/Sq-mm	% variation with respect to modified LWAC	In plane Shear Stress- N/Sq-mm	% variation with respect to modified LWAC
N.A-0	4.57	196.30	4.85	211.90	5.27	249.03	5.02	216.95

M.S.A- 1	1.54	0.00	1.56	0.00	1.51	0.00	1.58	0.00
M.S.A -2	1.68	9.05	1.85	19.05	1.82	20.59	1.94	22.81
M.S.A -3	2.06	33.74	2.30	47.62	2.31	52.94	2.61	64.91
M.S.A -4	1.84	19.34	2.07	33.33	2.04	35.29	2.28	43.86
M.S.A -5	1.62	4.94	1.78	14.29	1.87	23.53	1.94	22.81

Table 4: Stress intensity factor KIIc from finite element analysis

Name of the mix	Stress intensity for a/w=0.30	Stress intensity for a/w=0.40	Stress intensity for a/w=0.50	Stress intensity for a/w=0.60	Average stress intensity factor for aspect ratios
N.A-0	24.03	21.86	19.80	15.07	20.19
M.S.A- 1	8.11	7.01	5.67	4.76	6.39
M.S.A -2	8.85	8.34	6.84	5.84	7.47
M.S.A -3	10.85	10.35	8.68	7.84	9.43
M.S.A -4	9.68	9.35	7.68	6.84	8.39
M.S.A -5	8.51	8.01	7.01	6.17	7.43

Table 5: Stress intensity factor KIc from finite element analysis

Name of the mix	Stress intensity for a/w=0.30	Stress intensity for a/w=0.40	Stress intensity for a/w=0.50	Stress intensity for a/w=0.60	Average stress intensity factor for all aspect ratios
N.A-0	3.31	3.01	2.72	2.07	2.78
M.S.A- 1	1.12	0.96	0.78	0.65	0.88
M.S.A -2	1.22	1.15	0.94	0.80	1.03
M.S.A -3	1.49	1.61	1.49	1.42	1.50
M.S.A -4	1.33	1.46	1.31	1.24	1.34
M.S.A -5	1.17	1.25	1.20	1.12	1.18

Table 5: Ratio of average KIIC / KIc from finite element analysis

Name of the mix	Stress intensity for a/w=0.30	Stress intensity for a/w=0.40	Stress intensity for a/w=0.50	Stress intensity for a/w=0.60	Average stress intensity factor for all aspect ratios
N.A-0	7.27	7.27	7.27	7.27	7.27
S.F.A-1	7.27	7.27	7.27	7.27	7.27
S.F.A-2	7.27	7.27	7.27	7.27	7.27
S.F.A-3	7.27	6.42	5.84	5.52	6.26
S.F.A-4	7.27	6.42	5.84	5.52	6.26
S.F.A-5	7.27	6.42	5.84	5.52	6.26

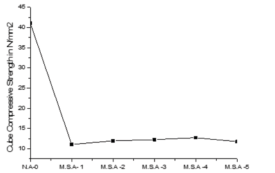

Fig 1 : Cube compressive strength

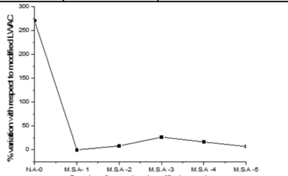

Fig 1.1: Super imposed variation od compressive strength w.r. to LWAC

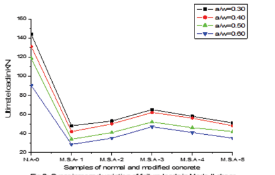

Fig 2: Super imposed variation of failure loads in Mode-II shear

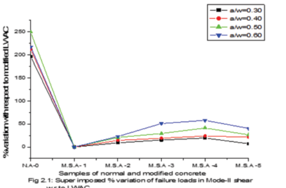

Fig 2.1: Super imposed % variation of failure loads in Mode-II shear w.r.to LWAC

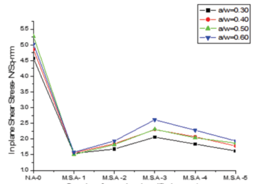

Fig 3: Super imposed variation of in plane shear stress in Mode-II fracture

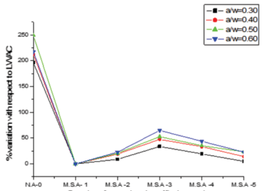

Fig 3.1: Super imposed % variation of shear stress in Mode-II fracture w.r.to LWAC

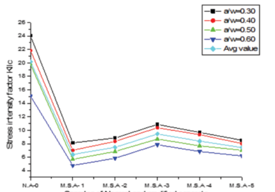

Fig 4 Super imposed variation of stress intensity factor KIIc in Mode-II fracture

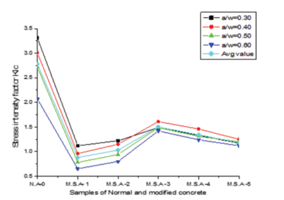

Fig 5: Super imposed variation of stress intensity factor KIc in Mode-II fracture

5. DISCUSSION OF TEST RESULTS

5.1 Influence of Nano SiO_2 on cube compressive strength

In the present study natural aggregate is replaced with 100% Styrofoam aggregate. The variation of compressive strength of samples of N.A-0 and M.S.A-1 to M.S.A-5 is shown vide table 1 and fig 1. It is observed that the cube compressive strength of modified concrete with 100% Styrofoam is 11.08 N/mm^2 compared to 41.08 N/mm^2 i.e., a variation of 270.76%. With partial replacement of cement by 11% of its weight by 3 nos of pozzolanic materials it is increased to 11.97 N/mm^2 i.e., a variation of 8.03%. With further addition of Nano SiO_2 in the spells of 0.5, 1 and 1.5% on 11% of weight of cement the strength is increased with the optimum percentage of Nano SiO_2 as 0.5% with strength of 14.02 N/mm^2 i.e., a variation of 26.53% and with more addition of Nano SiO_2 the strength is decreased.

5.2 Discussion on the effect of Nano SiO_2 on ultimate loads in mode-II fracture.

All the DCN specimens with different a/w ratios i.e 0.3, 0.4, 0.5 and 0.6 and with different percentages of Nano SiO_2 are tested with load in Mode-II (in plane shear). The variations of ultimate loads along with percentage variation with respect to modified concrete with 100% Styrofoam aggregate for the a/w ratios are presented vide Table no: 2 and fig 2 & 2.1 after 28 days of curing and the same trend as that of compressive strength is observed. The ultimate loads are increasing with blended cement using Pozzolanic and Nano materials up to certain percentage of Nano materials (0.5% of Nano SiO_2) there after the failure loads are decreasing. The ultimate loads are continuously decreasing with increase in a/w ratios.

5.3 Discussion on the effect of Nano SiO_2 on in-plane shear stress in mode-II fracture.

All the DCN specimens with different a/w ratios i.e 0.3, 0.4, 0.5 and 0.6 and with different percentages of Nano SiO_2 are tested with load in Mode-II (in plane shear). The variations of in plane shear stress along with percentage variation with respect to modified concrete with 100% Styrofoam aggregate for the a/w ratios are presented vide Table no: 3 and fig 3 & 3.1 after 28 days of curing. It is observed that with an increase in a/w ratio the in-plane shear stress is increased up to 0.50 and thereafter it is decreased for M_{20} grade concrete. But in case of samples of modified concrete increase is observed with increase in a/w ratios.

5.4 Discussion on the effect of Nano SiO_2 on Stress intensity factor in mode-II fracture.

All the DCN specimens with different a/w ratios i.e 0.3, 0.4, 0.5 and 0.6 and with different percentages of Nano SiO_2 were tested with load in Mode-II (in plane shear). The variations of stress intensity factors of samples of N.A-0 and S.F-1 to S.F-6 for all the a/w ratios are presented vide Table no: 4 and fig 4 after 28 days of curing and the same trend as that of compressive strength is observed.

5.5 Discussion of crack patterns in cubes and DCN specimens:

In case of cubes, the initial cracks are developed at top and propagated to the bottom with the increase in load and they are widened along the edges of cubes. The failure of the DCN specimen is such that the crack patterns obtained for DCN specimen geometry are mostly along the notch depths. During testing, for most of the specimen initial hair line cracks started at the top of one or both the notches, and as the load was increased further, the cracks widened and propagated at an inclination and sometimes to the middle of the top loaded zone. In a few cases, initial cracks started at the bottom of the one or both notches. As the load is increased propagation of these cracks at an inclination is observed along with the formation of cracks at top of the notches. These cracks finally propagated toward the middle of the top loaded zone leading to failure of the specimen. In some cases cracks formed either side at two edges of the supporting load bearing plate at the bottom or at the loaded length at top side. For most of the specimens with a/w = 0.3, 0.4, 0.5, 0.6, as the load is applied formation of initial hair line cracks at the top of one or both the notches is observed. With the increase of load propagation of these cracks in more or less vertical direction along with the formation of new cracks at the bottom of one or both the notches is observed.

6. CONCLUSIONS

The target mean strength of M_{20} concrete is 26.60 N/mm^2. From the experimental study it is observed that the 28 days cube compressive strength of modified concrete with 100% Styrofoam aggregate is 11.08 N/mm^2 and with replacement by 11% of cement with three numbers of pozzolanic materials i.e., silica fume, Slag and Fly ash in equal proportions and 0.5% of Nano SiO_2 on 11% weight of cement, the cube compressive strength of modified concrete rises to 14.02 N/mm^2 and with further increase of Nano materials the strength is decreased.

- It is observed that with the increase in the a/w ratio there is decrease in ultimate load and there is increase in ultimate loads with 1.5% of Nano SiO_2 and further increase in Nano SiO_2 content there is decrease in ultimate loads for all a/w ratios.
- From the study it is observed that K_{II} values (Punching shear) are almost seven times the K_I values (Open mode i.e., tension failure) and hence it can be concluded that Mode-II fracture is predominant.
- The light weight concrete prepared by 100% Styrofoam aggregate as coarse aggregate is no way inferior to the natural aggregate especially for plain concrete but is not suitable for structural grade concrete.

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