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AN COMPARITIVE STUDY ON FLEXURAL BEHAVIOUR OF REINFORCED CONCRETE BEAM BY UTILISATION OF COLLOIDAL NANO SILICA,ALUMINA CEMENT, VERMICULITE WITH ADDITION OF BASALT FIBERS

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Abstract - *The mix design used in this work is M_{30}. In this work cement is being partial replaced by Alumina cement. The proportions of* ***Alumina cement*** *is being replaced by* ***5%, 10%,15%*** *and* ***20%*** *by weight of cement. In which the optimum percentage is selected based on the experiment results, Fine aggregate is being partial replaced by* ***vermiculite*** *to the optimum percentage of alumina cement based concrete in the proportions of* ***5%, 10%,15%*** *and* ***20%****weight of cement, To the optimum percentages replacements of alumina cement & vermiculite based concrete in the proportions of* ***0.5%, 1%,1.5%,2%****by weight of cement. After, CNS is added separately to the optimum percentage of alumina cement &vermiculite with addition of basalt fibers based on concrete* ***1.5%, 2 %*** *by weight of cementitious material. To the mechanical properties have to be studied on hardened as well as fresh concrete and t the results will be compared with the conventional concrete. The flexure behavior of RCC beams casted using these materials is analyzed & Performance aspects such as first crack load, ultimate load and the load deflection behavior and crack pattern of Partial replacement of RCC beams using above materials analyzed and conventional RCC beam of M30 grade concrete.*

Key Words**: Alumina cement, Vermiculite, Basalt fibers, Colloidal nano silica, Flexural behavior**

1. INTRODUCTION

Cement is the global material for producing conventional concrete. The production of the cement will cause the emission of pollutants which results in environmental pollution. There are only two possible ways to reduce the cement usage in concrete: partial replacement of cement in concrete & Develop an alternative material. Now a day's structures are damaged due to effect of corrosion and losses its strength. It can be prevented by using alumina cement as supplementary cementatious material which improves the density of concrete as well as mechanical properties and leads to additional strengthen the concrete. Fine aggregate alarming rate is demand in construction world. So, it is using Vermiculite is obtained from natural mineral & the group of micas to reduce environmental impact and cost. Fibres are discrete particles, which arrest the cracks by improving the tensile capacity of the concrete by spreading uniformly throughout the body. They are several fibres are available. Basalt fibers are fine fibers of basalt & high-strength. In this project basalt fibres are used for improving mechanical properties of concrete**.** Increase in density and volume of voids and water absorption have been found due to the introduction of Colloidal nano silica(CNS) in concrete.

2. LITERATURE REVIEW

Dona maria, Joseph, Manjula devi: Investigation of concrete with combined high alumina cement, silica fume & M-sand **W.c.oliver & c.parr:** studied a composition of HAC s which has thermal stability over a wide temperature range and which develops strength at early age

Syed abdul rahman & Gijo k babu: structural light weight aggregate concrete was designed with the use of natural vermiculite aggregate

S. Sharmila & L. Vijayan: The exfoliated vermiculite is used as a replacement of fine aggregate

Prof.S.M.Kulkarni,G.Ketan: The Performance of Basalt Fibre in High Strength concrete

RSingaravadivelan, NSakthieswaren and Dr.K.Lmuthuramu :Experimental Investigation on the Behaviour of Flexural Strengthening of Beam Using Basalt Fiber

Douglas Hendrix , Jessica McKeon and Kay Wille: Behavior of Colloidal Nanosilica in an Ultrahigh Performance Concrete Environment Using Dynamic Light Scattering

Lavizan, Tehran, Iran: Effects of colloidal nano-silica on fresh and hardened properties of self-compacting lightweight concrete.

3. MATERIALS

3.1. Cement: 53 grade of ordinary Portland cement (KCP cement) confirming to (IS: 12269:1987)[12] was used in the present investigations. The tests on OPC were conducted as per (IS 4031 - 1996 Part**(**I)[13].The normal consistency of 27% and the specific gravity of 2.96 were

found. Also, the initial and final setting times of OPC were 35 minutes and 590 minutes respectively.

3.2. Fine aggregate: The river sand of 4.75 mm size hard, free from salt, chemically inert was used. Tests were conducted for fineness, specific gravity, etc., and have fulfilled the requirements as per (IS 2386-1963) [14]. The fineness modulus of fine aggregate and specific gravity were found to be 2.63 and 2.56 respectively. As per IS 383 - 1970 based on the fine aggregate is classified under grading zone III.

3.3. Coarse aggregate: Crushed granite roughly textured, angular shaped and well graded 20 mm maximum size that suited for the preparation of concrete. The tests were conducted for specific gravity and fineness modules of coarse aggregate are found to be 2.75 and 2.63 respectively.

3.4. Alumina Cement: Alumina Cement was first developed in United Kingdom in 1925 by a cement producer by name Lafarge. As it was found to be resistant to chemical attacks it was primarily used for marine construction. such as rapid strength gain and easy to manufacture and widely used for precast concreting. Bauxite and lime are used as the raw material. The raw materials are mixed in the required proportion and grinded into small fragments of 100 mm. These lumps are fed in kiln and heated up-to their fusion point which is 1600°C. The molten material fall down on the steel plate and it is send to cool down in rotary kiln. These clinkers are then grounded finely in tube mills unto the fineness not less than 2250 cm^2/gram is achieved.

Fig.1. Manufacturing of refractories constructions of Alumina Cement

Table1. Physical properties of alumina cement:

Physical properties	Results
Fineness modulus	9%
Specific gravity	2.32
Fineness modulus	9%

3.5. Vermiculite: Vermiculite is the geological name given to a group of hydrated laminar minerals. It appearance is aluminium-iron-magnesium silicates, resembling mica. A yellow or brown mineral found as an alteration product of mica and other minerals, used for insulation or as moisture-retentive medium for growing plants and it is a unique, naturally occurring, inert laminar mineral that finds use in many construction, industrial, home, agricultural and garden products and systems. Vermiculite is exfoliates (expands). Deposits of vermiculite are found in the states of Andhra Pradesh, Karnataka, Gujarat, Tamil Nadu, West Bengal, Madhya Pradesh and Rajasthan.

Table 2: Physical properties of Vermiculite:

S.NO	physical properties	Results
1	specific gravity	2.62
2	Fineness modulus	4.2
3	zone	II

Fig.2.Vermiculite

3.6. Basalt fibers: Basalt is a natural, hard, dense, dark brown to black volcanic igneous rock originating at a depth of hundreds of kilometers beneath the earth and resulting the surface as molten magma. The production of basalt fiber consists of melt preparation, extrusion, fiber formation, application of lubricates and finally winding. A fiber is a material made into a long filament with a density generally in the order of 300g/cm2 of 50cm. The aspect ratio of length and diameter can be ranging from thousand to infinity in continuous fibers. Availble of Basalt fibers: Filament Diameter (µm) -9 to 19µm , Chopped Length - 3, 6, 12, 24, 48, 96mm.In this work , Using of Chop Length Tolerance±0.5mm ,Uncut Fibre Content< 1% ,Filament Diameter Tolerance± 1µm.

Fig.3. Basalt fiber

3.7: Colloidal nano silica: Nano-SiO_2 is a white fluffy powder composed of high purity amorphous silica powder white dispersion solution. Because of its small particle size, large specific surface area, strong surface adsorption, large surface energy, high chemical purity and good dispersion. CNS played an irreplaceable role in medicine, physics, chemistry and biology and other fields because of its unique properties. This was mainly due to the good dispersion of hydrophilic CNS in water. In this work it is use of 5nm size of CNS.

Fig.4.Colloidal nano silica

3.8 Water: The water suitable for drinking and free from suspended solids, oil, dissolved salts, sugar and any other deleterious substances confirming to (IS : 3025 – 1964 part 22, part 23)[15] and (IS:456 – 2000)[16]was used in the preparation of concrete. Water should have a pH value of 6.5 to 8.5.

4. OBJECTIVES:

- To find out the mechanical properties of viz. compressive strength, split tensile strength, flexural strength of material analyzed by using alumina cement, vermiculite, Basalt fibers, Colloidal nano silica are varying proportion.
- To determine the results were compared with Nominal RCC beams with first crack load, ultimate load and the load deflection behavior and crack pattern of Partial replacements of reinforced concrete beams with above materials analyzed.

5. EXPERIMENTAL PROGRAM:

An extensive experimental Program involving the various processes of material testing, mix proportioning, mixing, casting and curing of test specimens were cube:10cmx10cmx10cm; Prism: 50cmx10cmx10cm; Cylinder:15cm (dia)&30cm (height); Beams: 150mmx125mmx1000mm. Mix design of M30 grade of control concrete was carried out for maximum permissible w/c ratio of 0.48.Experimental program was carried out in 2-phases.

I-Phase of Investigation (Study on Mechanical Properties):

To find out the mechanical properties of compressive, split tensile, flexural strength of curing of test specimens carried out 7,14,28 days. In this work Alumina cement is partially replaced with cement at different proportions i.e., 5%, 10%, 15%, 20% and are tested to get optimum percentage replacement of Alumina cement is based on concrete Vermiculite is partially replaced with Fine aggregate at different proportions i.e., 5%, 10%, 15%, 20% And tested. Now by using optimum percentage based on replacement of Alumina cement & vermiculite with addition of Basalt fibers by replacing it with cementitious material at various proportions i.e., 0.5%,1%,0.15%,0.2% and are tested. Further, take colloidal nano silica solution is adding on proportions 1.5% & 2% optimum percentages based on partial replacements of Alumina cement & Vermiculite with addition of Basalt fibers. Each proportions is taken four sets of test specimens.

II-Phase of Investigation (flexural behavior of RCC beams):

In this work three beams were casted and tested. The flexural behavior of RCC beam casted with

***BEAM-I**: conventional RCC beam*

***BEAM-II:** optimum percentages of Alumina cement & vermiculite with addition of Basalt fibers;*

***BEAM-III:** Colloidal Nano silica is addition of optimum percentages of Alumina cement & vermiculite with addition of Basalt fibers.*

Performance aspects such as first crack load, ultimate load and the load deflection behavior and crack pattern .Finally, comparing the results with conventional RCC beam.

Mix proportions: *The proportion used in preparation of the mix was calculated as per (IS 10262:2019). Mix design is M30 grade.*

Table 3: Mix proportions for Ordinary concrete:

	Cement	*Fine aggregate*	*Coarse aggregate*	*W/C ratio*
Kg/m³	*335.2*	*723.03*	*1293.42*	*160.92*
Ratio	*1*	*2.157*	*3.8*	*0.48*

Designation	Compressive strength(Mpa)			Split tensile strength(Mpa)			Flexural stength(Mpa)		
	7days	14days	28days	7days	14days	28days	7days	14days	28days
N	19.12	26.77	38.25	2.39	2.97	3.82	3.27	3.88	4.63
M-3(15%)	19.31	27.04	39.01	2.41	3.00	3.83	3.29	3.9	4.66
M3+V2(10%)	19.99	27.98	39.98	2.49	3.10	3.98	3.35	3.96	4.74
M3+V2+BF2(1%)	20.07	28.09	40.14	2.50	3.13	4.01	3.36	3.97	4.75
M3+V2+BF2+CNS2(2%)	21.07	29.49	42.14	2.63	3.27	4.21	3.44	4.07	4.86

Table 5: Mechanical properties

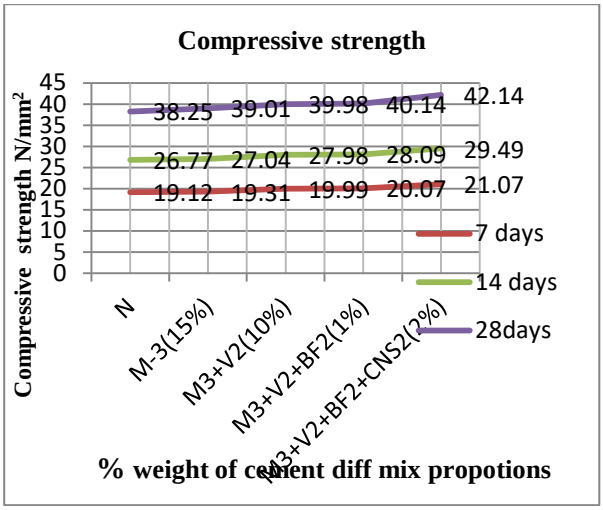
Fig.5. Mixing,casting and curing

Mix designations: ***N****: Nominal concrete;* ***M :*** *Alumina cement ;* ***V****: vermiculite ; BF : Basalt fibers ; CNS: Colloidal nano silica.*

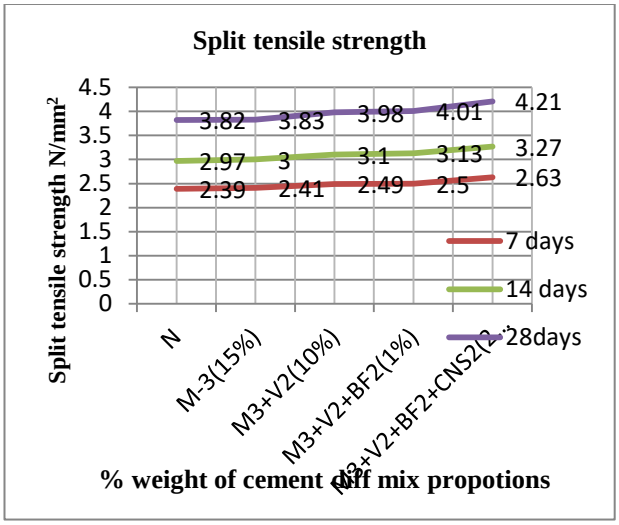
Table 4.Fresh Properties of Concrete

Designation	***Slump value(mm)***	***Compaction factor test***
N	*65*	*0.83*
M-3(15%)	*75*	*0.91*
M3+V2(10%)	*80*	*0.92*
M3+V2+BF2(1%)	*76*	*0.94*
M3+V2+BF2+CNS 2(2%)	*79*	*0.93*

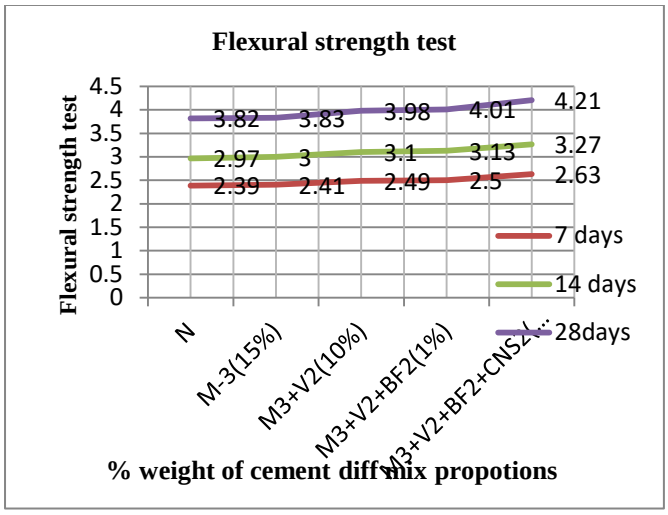
Graphical representation:



Graph no 1: Compressive strength



Graph no 2: Split tensile strength



Graph no 3: Flexural strength test

Prepartion of RCC Beams:

Fig.6. Placing of reinforcement in the beam moulds & Finishing of RCC beams after casting

Flexural test on RCC beams:

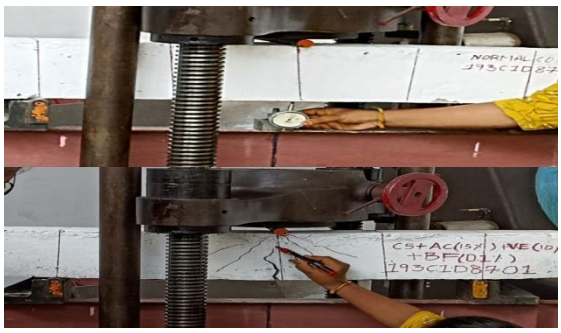
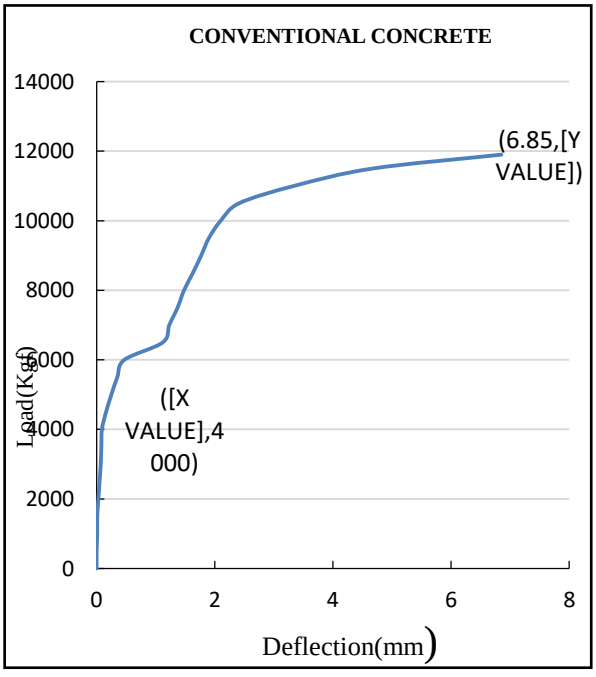


Fig.7. Dial gauge adjusting & Observing and marking of crack patterns by using UTM

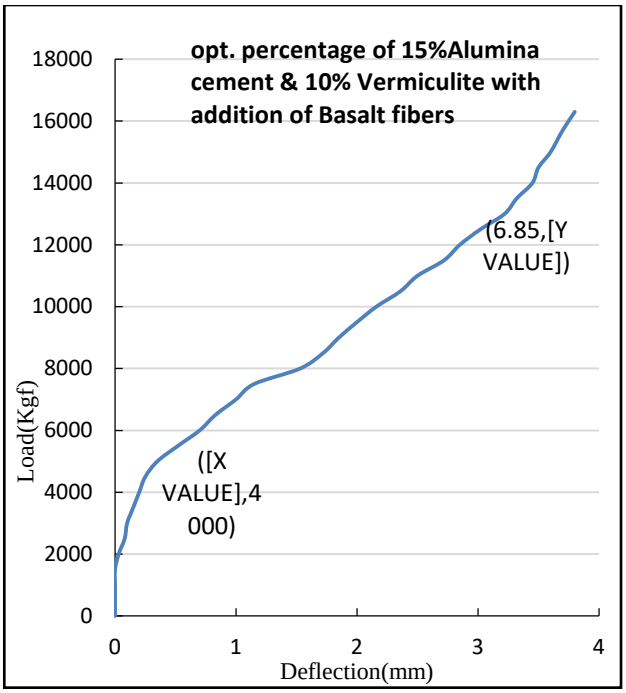
Table 6. Observation &Calculations:

Type of the Beams	RCC BEAM-I	RCC BEAM-II	RCC BEAM-III
Ulitimate Deflection Δ (mm)	6.85	3.75	3.89
Ulitimate LOAD (W) KN	116.69	159.84	169.65
U.Bending stiffness K=W/ Δ (N/mm^2)	17.03x10^3	42.62x10^3	43.61x10^3
Deflection at permissible limit Δ	0.09	1.15	1.8
Permissible LOAD (W) KN	39.22	73.54	98.06
Permissible Bending stiffness K=W/ Δ (N/mm^2)	435.77x10^3	49.02x10^3	54.47x10^3
Young's Modulus E=Wl^3/48ΔI (N/mm^2) l=850;I=24.41x10^6	228.41x10^3	33.51x10^3	28.54x10^3

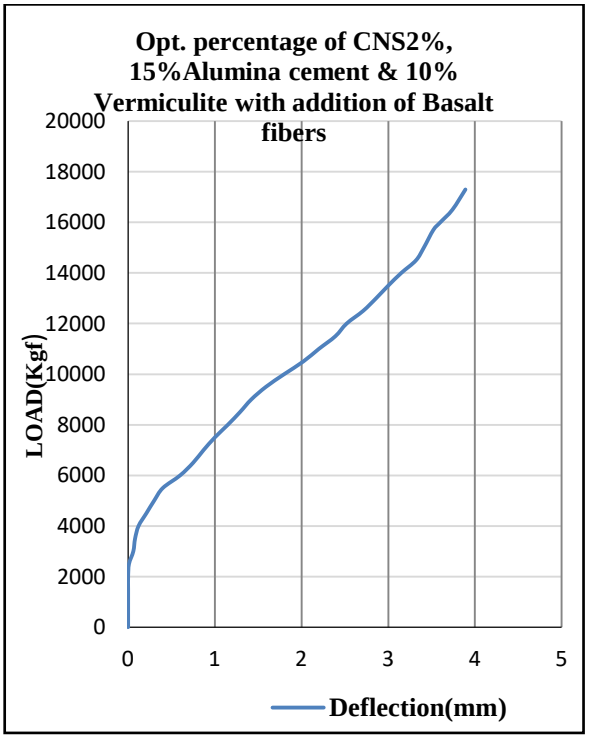
Load vs. Deflection curves of RCC Beams:



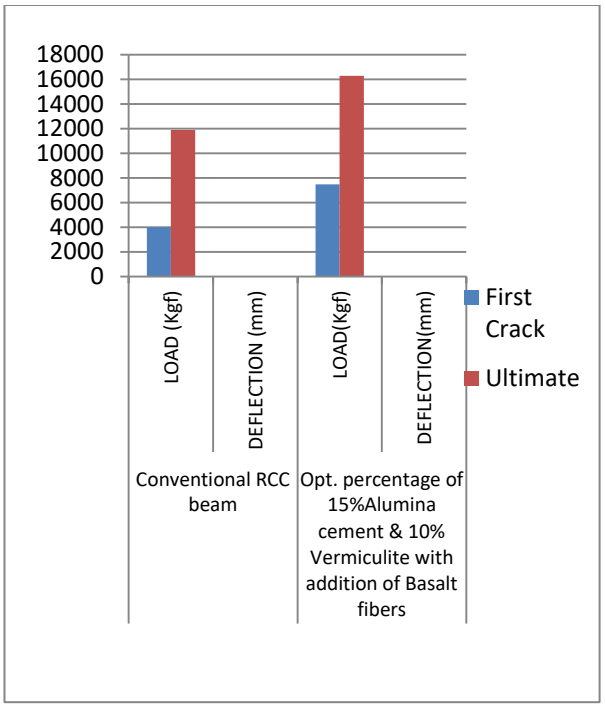
Graph.4. Load vs. Deflection curve Conventional RCC beam



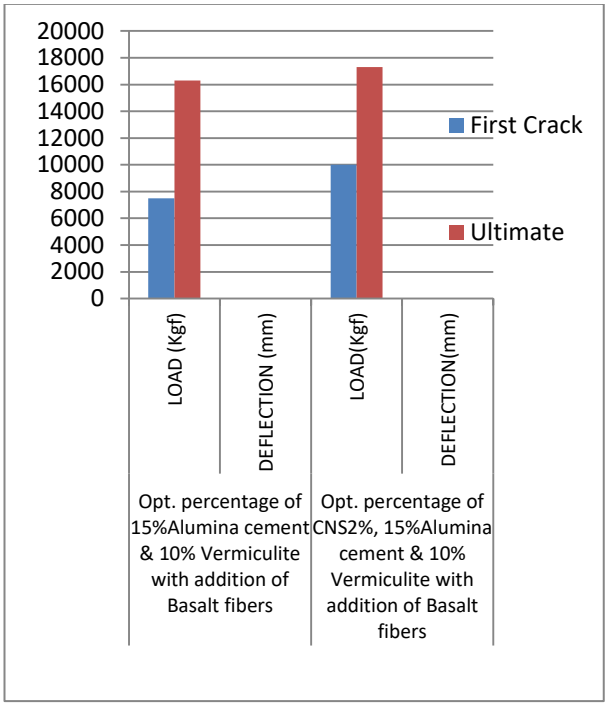
Graph.5.Load vs. Deflection of RCC beam with opt. percentage of 15%Alumina cement & 10% Vermiculite with addition of Basalt fibers



Graph 6.Load vs. Deflection of RCC beam casted with Opt. percentage of CNS2%, 15%Alumina cement & 10% Vermiculite with addition of Basalt fibers



Graph 7.Comparison of First rack(Kgf), Ultimate loads(Kgf) & Maximum Deflection (mm) for Conventional beam and opt. percentage of 15%Alumina cement & 10% Vermiculite with addition of Basalt fibers



Graph 8. Comparison of First rack(Kgf), Ultimate loads(Kgf) & Maximum Deflection (mm) for Opt. percentage of 15%Alumina cement & 10% Vermiculite with addition of Basalt fibers for and Opt. percentages of after addition of CNS2%, 15%Alumina cement & 10% Vermiculite with addition of Basalt fibers of RCC beam.

6. CONCLUSIONS:

- In this work observed in partial replacement of cement with alumina cement is increases compressive strength, Split tensile strength ,comparative to more than nominal concrete .
- Alumina cement on based cement concrete replacement of fine aggregates with vermiculite is increases compressive strength 4.32% , it's comparative to more than nominal concrete.
- It's observing vermiculite is light weight & bulky material and split tensile is increased due to addition of alumina cement based concrete.
- Alumina cement and vermiculite is addition of Basalt fibers is increases compressive strength 4.73%,split tensile strength 5.11%,flexural strength 2.67% comparative to more than nominal concrete at 28 days.
- It's observed basalt fibers is increased in high split tensile strength of comparative to Alumina cement & vermiculite.
- Colloidal nano silica is addition of Optimum percentages of alumina cement, vermiculite with addition of basalt fibers to increases at compressive strength 9.25%,split tensile strength 9.26%,flexural strength 4.94% more than nominal concrete for 28 days.
- It's observed CNS is powder form of colloidal state, So it is mixing of concrete is CNS is adding of Nominal concrete of water/cement ratio 0.48 .
- In flexural strength test is the maximum deflection for three RCC beams casted with conventional concrete beam is **0.09mm**, RCC BEAM-II is **1.15 mm &** RCCBEM-III **1.8mm.**
- In flexural strength test, the maximum deflection is different materials analyzed of RCC beams are comparative to more than conventional RCC beam.
- In flexural strength test is first cracking load of RCC BEAM-II (7500 Kgf) **46.6% &** RCC BEAM-III(10000Kgf) **60%** are more than conventional RCC beam(4000Kgf).
- In flexural strength test observed compared to different materials analyzed of RCC beams are can sustain more loading and shows better resistance against cracking than the conventional RCC beam.
- In the flexural strength test results, the ultimate bearing load of RCC BEAM-II (16300Kgf) **26.99% &** RCC BEAM-III (17300 Kgf) **31.2%** are more than the conventional RCC beam(11900Kgf).

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