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STRUCTURAL BEHAVIOR OF HELICAL REINFORCED CIRCULAR COLUMN USING MINERAL ADMIXTURE

T.Yasotha G.Gayathri, V.S.Ramya and V.Sathishkumar
Dept. of Civil Engineering
Gnanamani College of Engineering,
Namakkal

ABSTRACT

The infrastructure development is an important aspect for the overall development of country. In the present world, the use of cement is increasing day by day. The replacement of cement by supplementary material not only results in savings of the materials, but also reduces the CO2 emission in the atmosphere. Recycling of a large amount of waste materials like mineralssuch as fly ash, granulated blast furnace slag (GGBS), Rice Husk Ash, metakaolin, Lime powder, etc. is being done in large extents in the manufacture of Cement and Cementitious products. The combination of two or more cementitious waste mineral material will cause some advantageous special properties and will increase the properties of theconcrete. So this project is leading to the basic material behavior of the various and suitable mineral admixture in the concrete which is used for improving the behavior of helical reinforced column. Initially literature survey was done on admixtures and columns. Formulation and computation of limiting moment, maximum load, and area of reinforcement for helical reinforced columns were obtained by the limit stage design methodology. This phase would lead to the practical execution of the project in next phase.

I. INTRODUCTION

Recycling of a large amount of waste materials like minerals such as fly ash, granulated blast furnace slag (GGBS), Rice husk ash, metakaolin, Lime powder, etc. is being done in large extents in the manufacture of Cement and Cementitious products. Bhanumathidas and Mehta (2004) have estimated that to produce one ton of cement, nearly 1.5 tons of earth minerals are consumed and one ton of CO_2 is emitted in the atmosphere. The replacement of cement by supplementary material not only results in savings of the materials, but also reduces the CO_2 emission in the atmosphere, since one ton of cement production results in one ton of CO_2 emitted in the atmosphere. The commonly used supplementary cementing material are flyash,silica fume, rice husk ash, metakaolin, lime powder etc.The combination of two or more cementitious material will cause a synergy between them and will increase the properties of the concrete. As per the study of Kathirvel, et.al, (2012) the Quaternary blended mix of 20% fly ash, 10% RHA and 10% Lime Powder performs well in strength and durability factors, which is evidenced in the microstructure also. The quaternary mix used in this experimental work is taken from result of Kathirvel, et.al, (2012).

II. LITERATUREREVIEW

Ali A. Ramezanianpour et al(2009) investigated that the benefits of limestone as a partial replacement for Portland Cement (PC) are well established. Economic and environmental advantages by reducing CO2 emissions are well known. The paper describes the effect of various amounts of limestone on compressive strength, water penetration, absorptivity, electrical resistivity and rapid chloride permeability on concretes produced by using a combination of PC and limestone at 28, 90 and 180 days. The percentages of limestone that replace PC in this research are 0%, 5%,10%, 15% and 20% by mass. The water/(clinker + limestone) or (w/b) ratios are 0.37, 0.45 and 0.55 having a constant total binder content of 350 kg/m3. Generally results show that the Portland limestone cement (PLC) concretes having up to 10% limestone provide competitive properties with PCconcretes.

Arandigoyen et al (2009) concluded that the microstructure of blended pastes of lime and cement. An increment of complexity of the microstructure was found when pastes increase their percentage in cement. Micro structural characteristics as porosity, morphology of the pores, pore size distribution and surface fractal dimension were evaluated in the different pastes studying the modification with the variation of composition. The capillary water absorption is also evaluated obtaining higher capillary coefficients values for the pastes with higher amounts of lime. The porosity decreases in a high degree with the increment of cement in the paste. The complexity of the surface also increases with the percentage in cement, increasing the surface fractal dimension obtained with the MIP data, from a DS of 2.381 for a pure limepasteuntil a DS of 2.666 for a pure cement paste. The increment of complexity of the microstructure with the increase of cement in the paste is reflected in a deviation of the capillary absorption behaviour from the parallel tube model, while the capillary coefficient decreases almost in a linear way with the percentage in cement. Therefore, in order to choose a binding material for restoration works, high cement mixes would have a great durability in front of the moisture, due to their microstructure and capillary coefficient.

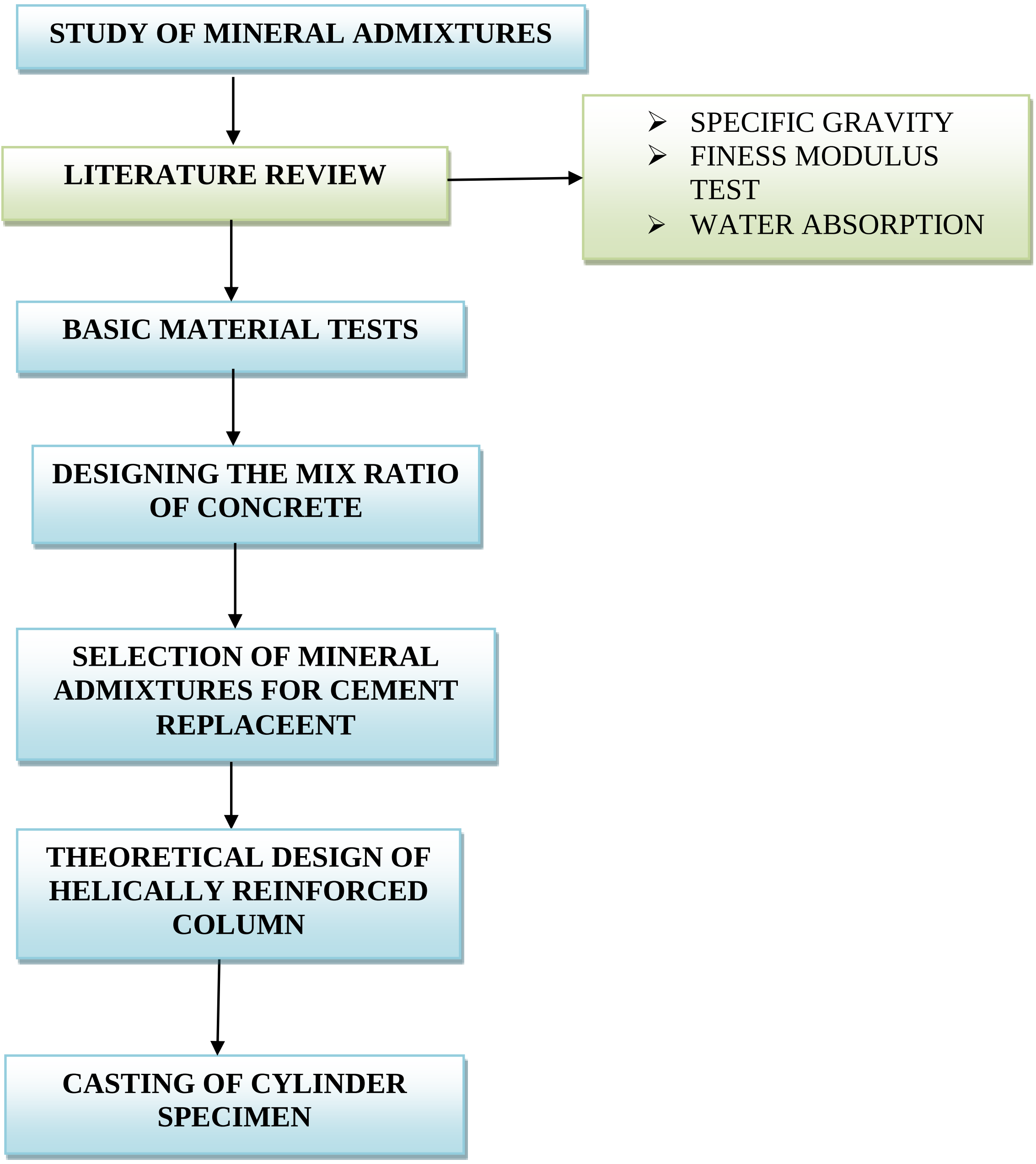
C. Selvamony et.al (2004) involved evaluating the Effectiveness of various percentages of mineral admixtures in producing SCC. Okamura's method, based on EFNARC specifications, was adopted for mixed design.

Chindaprasirt et al (2008) investigated that the sulfate resistance of mortars made from ordinary Portland cement containing available pozzolans viz., fly ash and ground rice husk ash (RHA) was studied. Class F lignite fly ash and RHA were used at replacement dosages of 20 and 40% by weight of cement. Expansion of mortar prisms immersed in 5% sodium sulfate solution and the change in the pH values of the solution were monitored. The incorporation of fly ash and RHA reduced the expansion of the mortar bars and the pH values of the solutions. RHA was found to be more effective than flyash.

De Weerdt (2008) demonstrated that interaction between limestone powder and fly ash in ternary composite cement is investigated. Limestone powder interacts with the AFm and AFt hydration phases, leading to the formation of carboaluminates at the expense of monosulphate and thereby stabilizing the ettringite. The effect of limestone powder on OPC may be restricted due to the limited amount of aluminate hydrates formed by the hydration of OPC. The additional aluminates brought into the system by fly ash during its pozzolanic reaction amplify the mentioned effect of limestone powder. This synergistic effect between limestone powder and fly ash in ternary cements is confirmed in this study and it translates to improved mechanical properties that persist over time Replacing 5% of the OPC with limestone powder at a water-to binder ratioof0.5 resulted in a reduction in compressive and flexural strength, whereas replacing 5%of the OPC with limestone powder in a fly ash blended cement with 30% fly ash and 70% OPC produced no strength loss. The composite cements consisting of 65% OPC, 30% fly ash and 5% limestone powder have a slightly higher or similar strength compared to the 65% OPC and 35%

fly ash and the 70% OPC and 30% fly ash blends at 28, 90 and 140 days. This means that, 5% of OPC or 5% of fly ash can be replaced with 5% limestone powder in this system, without impairing the compressive and flexural strength. The TGA and XRD results confirmed the change in the hydration products when limestone is included in thesystem.

WORK PLAN



BASIC MATERIAL TEST

4.1 CEMENT TO BE USED: ORDINARY PORTLAND CEMENT

Ordinary Portland cement (OPC) is better than Portland Pozzolana Cement (PPC).

It has more advantages compared to PPC. OPC is prime brand cement with a remarkably high tricalcium silicate providing long lasting durability to concrete structures. It gives more flexibility to architects and engineers to design sleeker and economical sections. OPC develops high early strength so that form work of slabs and beams can be removed much earlier resulting in faster speed of construction and savings in centering cost. OPC also produces highly durable and sound concrete due to very low percentage of alkalis, chlorides, magnesia and free lime in its composition. It provides significant savings in cement consumption while making concrete of grades M15, M20, M25 and precast segments due to high early strength.

4.2 COARSE AGGREGATE

This is one of the important ingredients in the concrete. The aggregate serves as reinforcement to add strength to the overall composite material.

In this project aggregate size of 10mm has been selected, because lesser is the size of the aggregate there would be more possibility for concrete impregnation into the geosynthetic material

4.3 FINE AGGREGATE

Sand is naturally occurring granular material composed of finely divided rock and mineral particles. The most common of sand is Silicon di - Oxide, usually in the form of Quartz. Normally river sand is used as fine aggregate for preparing concrete. An Individual particle in this range is termed as sand grain. These sand Grains are between Gravel (2mm – 64mm) and silt (0.004mm – 0.0625mm). Aggregate most of which passes 4.75mm IS sieve is used.

Locally available river sand Zone III having a specific gravity of 2.62, fineness modulus of 2.75 is used.

4.4 BASIC MATERIAL TESTS.

4.4.1 Specific Gravity of Cement

1. First the empty dry bottle was weighed and taken as W_1.
2. Then the bottle was filled with distilled water and it was weighed as W_2.
3. The bottle was dried and filled with kerosene and weight is W_3.
4. Then the kerosene present in the bottle was disposed out and some amount of cement was taken and filled with water and weight is W_4.
5. Air bubbles were removed by tilting the bottle gently inclined.

TABLE 4.1: TESTED RESULTS OF SPECIFIC GRAVITY OF CEMENT

Weight of empty bottle (W_1)	119 gm
Weight of bottle + cement (W_2)	213gm
Weight of bottle + cement + kerosene (W_3)	423.7gm
Weight of bottle + Kerosene (W_4)	360 gm

Specific gravity of cement = (W2-W1) / ((W2-W1) - (W3-W4))
= (213-119)/ ((213-119) - (423.9-360))
= **3.12**

4.4.2 Specific Gravity of Coarse Aggregate

1. About 5 kg of aggregate sample is taken in the wire basket and immersed in the water.
2. Lift the basket containing aggregate 25 times.
3. Weight of the saturated aggregate and the basket in the water is taken (W1).
4. Then the empty weight of basket jolted 25 times in water and the weight is taken (W2).
5. The wet aggregate is cleaned with a cloth and the free water content is removed and allow the aggregates for complete surface drying and it is weighed (W3).
6. Then the Aggregate is placed in a shallow tray and kept at an oven maintained a temperature of 110^0 for 24hrs and weighed (W4).

TABLE 4.2: TESTED RESULTS OF SPECIFIC GRAVITY OF COARSE AGGREGATE

Weight of empty basket, W_1	2.57 Kg
Weight of basket + coarse aggregate W_2	7.57 Kg
Weight of basket + coarse aggregate + water, W_3	4.24 Kg
Weight of basket + water, W_4	2.48 Kg
Weight of coarse aggregate in basket, (W_2-W_1)	5 Kg
Weight of equal volume of water$(W_2-W_1) – (W_3-W_4)$	1.76 Kg

Specific gravity of coarse aggregate = dry weight of coarse aggregate
Weight of equal volume of water = $(W_2-W_1) / ((W_2-W_1) – (W_3-W_4))$
= 5 / 1.76
Specific gravity of coarse aggregate = 2.83

4.4.3 Fineness Modulus of Coarse Aggregate

The modulus was brought to an air dry condition at room temperature. The required quantity of the sample was taken (2000g). The sieves were placed in the order of size, with larger sieve on the top, in mechanical sieve shaker. Sieving was done for 10 minutes. The material retained on each sieve after shaking, represent s the fraction of the aggregate coarser then the sieve considered and finer then the sieve above. The weight of aggregate in each sieve was measured and converted to a total sample. Fineness modulus was determined as the ratio of summation of cumulative percentage weight retained (F) to 100

TABLE 4 3: SIEVE ANALYSIS OF COARSE AGGREGATE

S.NO	IS Sieve (mm)	Wt. retained (gm)	% Wt. retained	Cumulative % Wt retained
1	40	0	0	0
2	25	120	12	12
3	20	450	45	57
4	12.5	395	39.5	96.5
5	10	35	3.5	100
6	8	0	0	100
7	6.3	0	0	100
8	Pan	0	0	100
Total		1000	100	565.5

Fineness Modulus of Coarse Aggregate = **5.65**

4.4.4 Specific Gravity of Fine Aggregate

1. The sample was washed thoroughly to remove fine particles and dust.
2. A cylindrical mould of inside diameter 150 mm and inside height 300 mm was used for specific gravity test.
3. The empty weight of the mould was taken as W_1.
4. Some amount of fine aggregate was placed in the mould and weighed as W_2.
5. Sufficient water was added to make it saturated.
6. The sample was stirred thoroughly for removing entrapped air.
7. The mould was filled with water and weighed as W_3. It was emptied, cleaned well, filled with water and weighed as W_4

TABLE 4.4: TESTED RESULTS OF SPECIFIC GRAVITY OF FINE AGGREGATE

Weight of empty mould (W_1)	683 gm
Weight of mould + Fine Aggregate (W_2)	883.5 gm
Weight of mould + Fine Aggregate + water (W_3)	1596 gm
Weight of mould + water (W_4)	1472 gm

Specific gravity of fine aggregate = $(W_2-W_1) / ((W_2-W_1) – (W_3-W_4)$=**2.69**

4.4.5 Fineness Modulus of Fine Aggregate

The sample was brought to an air dry condition y drying at room temperature. The required quantity of the sample was taken (1000g). The sieves were placed in the order of size, with larger sieve on the top, in mechanical sieve shaker. Sieving was done for 10 minutes. The material retained on each sieve after shaking, represent s the fraction of the aggregate coarser then the sieve considered and finer then the sieve above. The weight of aggregate in each sieve was measured and converted to a total sample. Fineness modulus was determined as the ratio of summation of cumulative percentage weight retained (F) to 100.

TABLE 4 5: SIEVE ANALYSIS OF FINE

AGGREGATE

s. no	is sieve (mm)	weight retained (gram)	% of weight retained	cumulative % of weight retained
1	4.75	0	0	0
2	2.36	7.8	0.78	0.78
3	1.18	64.4	6.44	7.22
4	0.60	157.6	15.76	22.98
5	0.425	510	51.0	73.98
6	0.30	1.4	0.14	74.12
7	0.15	217.2	21.72	95.84
8	Pan	41.6	4.16	100
Total		1000	100	274.92

Fineness Modulus of Fine Aggregate = 2.75

3.4 WATER

Potable water conforming to the Requirements of water for concreting and curing as per IS: 4562000.

3.5 FLYASH

Fly ash is one of the residue generated in combustion, and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash. In an industrial context, fly ash usually refers to ash produced during combustion of coal. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipmentbeforethefluegasesreachthechimneysofcoal-firedpowerplants,andtogether with bottom ash removed from the bottom of the furnace is in this case jointly known as **coal ash**. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (bothamorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rockstrata.

Table 3.3 –Components of Flyash

Component	Bituminous	Sub-bituminous	Lignite
SiO_2(%)	20-60	40-60	15-45
Al_2O_3(%)	5-35	20-30	20-25
Fe_2O_3(%)	10-40	4-10	4-15
CaO(%)	1-12	5-30	15-40
LOI(%)	0-15	0-3	0-5

Two classes of fly ash are defined by ASTM C618: Class F fly ash and Class C fly ash. The chief difference between these classes is the amount of calcium, silica, alumina, and iron content in theash.

3.6 Class FFlyash

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 20% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds. Alternatively, the addition of a chemical activator such as sodium silicate (water glass) to a Class F ash can lead to the formation of ageopolymer.

3.7 Class CFlyash

Fly ash produced from the burning of younger lignite or subbituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over time. Class C fly ash generally contains more than 20% lime (CaO). Unlike Class F, self-cementing Class C fly ash does not require an activator. Alkali and sulfate (SO_4) contents are generally higher in Class C fly ashes. For this project class f flyash isused.

Fig 3.1 Flyash

3.8 Specific Gravity ofFlyash

At first, the empty dry bottle was weighed and taken as W_1. Then the bottle was filled with kerosene and it was weighed as W_2. Then some amount of fly ash was taken and filled with kerosene and weighed as W_3. The bottle was dried and filled with kerosene and weighed as W_4. Air bubbles were removed by tilting the bottle gently inclined.

MATERIAL	WEIGHT (grams)
Weight of emptybottle (W1)	667.6gm
Weight of bottle + fly ash(W_2)	727.6gm
Weight of bottle + fly ash + kerosene(W_3)	1321.4gm
Weight of bottle + Kerosene(W_4)	1289 gm

Specific gravity of Fly ash = $(W_2 – W_1) / ((W_2 – W_1) – (W_3 – W_4))$

= (727.6 - 667.6) / ((727.6 - 667.6) - (1321.4 -1289))=2.17

3.9 Metakaolin

Metakaolin is neither the by-product of an industrial process nor is it entirely natural. It is derived from naturally occurring mineral and is manufactured specially for cementing applications. Metakaolin is produced under carefully controlled conditions to refine its colour, remove inert impurities, and tailor particle size such, a much high degree of purity and pozzolanic reactivity can be obtained.

Table 3.4 Chemical Composition of Metakaolin

Component	Percentage	Component	Percentage
SiO2	51-53 %	CaO	<0.20%
Al2O3	42-44-%	MgO	<0.10%
Fe2O3	< 2.20%	Na2O	<0.05%
TiO2	< 3.0%	K2O	<0.40%
SO4	< 0.5%	L.O.I.	<0.50%

3.9 Specific Gravity ofMetakaolin

At first, the empty dry bottle was weighed and taken as W_1. Then the bottle was filled with kerosene and it was weighed as W_2. Then some amount of fly ash was taken and filled with kerosene and weighed as W_3. The bottle was dried and filled with kerosene and weighed as W_4. Air bubbles were removed by tilting the bottle gently inclined.

MATERIAL	WEIGHT (grams)
Weight of emptybottle (W1)	667.6gm
Weight of bottle + fly ash(W_2)	724.92gm
Weight of bottle + fly ash + kerosene(W_3)	1321.4gm
Weight of bottle + Kerosene(W_4)	1289 gm

Specific gravity of Fly ash = $(W_2 – W_1) / ((W_2 – W_1) – (W_3 –W_4))$

= (724.92 - 667.6) / ((724.92-667.6) - (1321.4 -1289))=2.30

MIX DESIGN

5.1 DESIGNING OF MIX RATIO

Based on the initial test results mix design was arrived for M20 concrete according using is 10262:2009,

TABLE 6: MIX DESIGN

DESCRIPTION	VALUE	UNIT	REFERENCE
GRADE DESIGNATION	M20		
F_{CK}	20	N/mm^2	
TYPE OF CEMENT	OPC 53		
MAXIMUM NOMINAL SIZE OF AGGREGATE	20	mm	
MINIMUM CEMENT CONTENT	300	Kg/m^3	IS 456 TABLE 5
MINIMUM WATER CEMENT RATIO	0.50		IS 456 TABLE 5
WORKABILITY (SLUMP)	100	mm	
EXPOSURE CONDITION	MILD		
MAXIMUM CEMENT CONTENT	450	Kg/m^3	
TEST DATA			
SPECIFIC GRAVITY OF CEMENT (SP.GR CEM)	3.12		TEST RESULTS
SPECIFIC GRAVITY OF COARSE AGGREGATE(G .C)	2.83		TEST RESULTS
SPECIFIC GRAVITY OF FINE AGGREGATE (G. f)	2.69		TEST RESULTS
SEIVE ANALYSIS			
ZONE OF FINE AGGREATE	3		IS 383
TARGET MEAN STRENGTH			
$F'_{CK} = F_{CK} + 1.65\ S$			
STANDARD DEVIATION (S)	4		TABLE 1 , IS 10262
F'CK	26.6	N/mm^2	
WATER CEMENT RATIO			
MAXIMUM W/C RATIO (M20)	0.50		TABLE 5 IS 456
W/C VALUE ADOPTED	0.50		
WATER CONTENT			
FOR 20mm AGGREGATEWATER CONTENT	186	Kg	TABLE 1 , IS 10262
INCREEMENT OF WATER CONTENT FOR 100mm SLUMP	6	%	CL 4.2 ,IS 10262
WATER CONTENT REQUIRED	197.16	Kg	
CEMENT CONTENT			
W/C VALUE ADOPTED	0.50		
CEMENT CONTENT	394.32	Kg/m^3	
MINIMUM CEMENT CONTENT	300	Kg/m^3	TABLE 5 IS 456
ADOPTED CEMENT CONTENT	394.32	Kg/m^3	

PROPORTION OF VOLUME OF F.A & C.A				
VOLUME OF C.A / VOL OF TOTAL AGGREGATE FOR 0.5 W/C RATIO		0.64		CL 4.4 ,IS10262
VOLUME OF FINE AGGREAGATE (1- VOLUME OF COARSE AGGREGATE)		0.36		
MIX CALCULATION				
VOL OF CONCRETE		1	m^3	
VOL OF CEMENT = MASS OF CEMENT /(SP GR OF CEMENT*1000)		0.12638462	m^3	
VOL OF WATER =MASS OF WATER /(SP GR WATER *1000)		0.19716	m^3	
TOTAL VOL OF AGG= (1-(V0L OF CEMENT + VOL WATER))		0.67645538	m^3	
MASS OF CA= TOTAL VOL OF AGG* VOL OF CA* SP GR CA*1000		1225.19599	Kg	
MASS OF FA= TOTAL VOL OF AGG* VOL OF FA* SP GR FA*1000		655.079394	Kg	
MASS OF INGREDIENTS				
MASS OF CEMENT		394.32	Kg	
MASS OF F.A		655.08	Kg	
MASS OF C.A		1225.2	Kg	
W/C		0.5		
WATER CONTENT		197.16	Kg	
MIX RATIO				
CEMENT		1		
F.A		1.66		
C.A		3.1		
W/C RATIO		0.5		
RESULTS				
INGREDIENTS	**WATER**	**CEMENT**	**FINE AGGREGATE**	**COARSE AGGREGATE**
MASS (Kg/m^3)	197.16	394.32	655.08	1225.2
RATIO	0.5	**1**	**1.66**	**3.1**

Table 5.2 Mix Proportion for various mineral admixtures with replaced with cement in concrete.

Specimens	CEMENT (Kg/m^3)	COARSE AGGREGATE (Kg/m^3)	FINE AGGREGATE ((Kg/m^3)	WATER (Kg/m^3)	FLY ASH(Kg/m^3)	ETAKAOLIN (Kg/m^3)
Control	394.32	655.08	1225.2	197.16	0	0
0% MK – 10%	354.489	655.08	1225.2	197.16	0	39.43

FLYASH						
0% MK – 20 % FLYASH	315.47	655.08	1225.2	197.16	0	78.86
10% MK – 0% FLYASH	354.489	655.08	1225.2	197.16	39.43	0
20% MK – 0% FLYASH	315.47	655.08	1225.2	197.16	78.86	0
10% MK – 10% FLYASH	315.47	655.08	1225.2	197.16	39.4	39.4

5.1 CASTING

Fig 5.1 Casting Specimens

For determining the compressive strength of concrete three Cube each for specimen mentioned in the table 5.2 werecasted.

Fig 5.2Casted specimens

TEST RESULTS AND DISCUSSION

9.1 MECHANICAL PROPERTY

9.1.1 COMPRESSIVE STRENGTH TEST

Compressive strength tests were carried out on cubes of 150 mm size using a compression testing machine of 2000 KN capacity as per IS 516:1959.

Table 9.1 Compressive strength

S.No	Mix proportion	Compressive strength N/mm^2
1	Control	29.25
2	0% MK-10% FA	36.42
3	0% MK-20% FA	38.42
4	10% MK-0% FA	37.41
5	20% MK-0% FA	36.85
6	10% MK-10% FA	37.59

Fig 9.1 Test setup for Compressive Strength

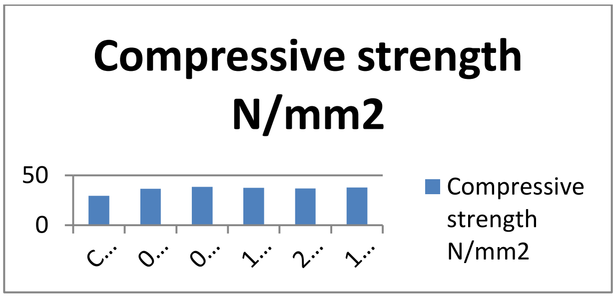


Fig 9.2 .Compressive strength

9.1.2 SPLIT TENSILE STRENGTH TEST

Split tensile strength tests were carried out on cylinders of 150 mm diameter and 300 mm height using a compression testing machine of 2000 KN capacity as per IS 5816:1999.

Table 9.2.Split tensile strength

S.No	Mix proportion	Split tensile strength N/mm^2
1	Control	2.45
2	0% MK-10% FA	2.66
3	0% MK-20% FA	2.68
4	10% MK-0% FA	2.72
5	20% MK-0% FA	2.81
6	10% MK-10% FA	2.9

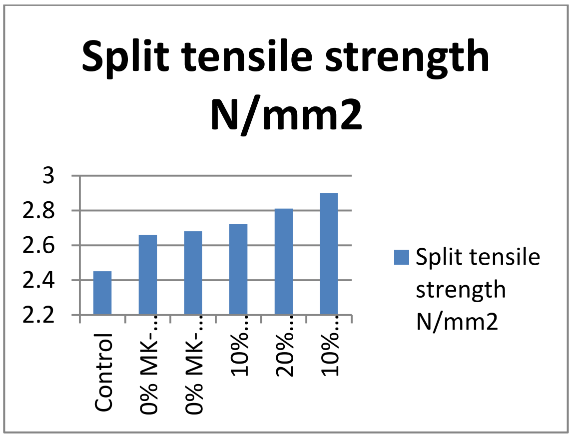


Fig 9.3 .Split tensile strength

Fig 9.4 Test setup for Split Tensile Strength

9.1.3 FLEXURAL STRENGTH TEST

Flexural strength tests were carried out on prisms of size 100×100×500 mm on flexure testing machine of capacity 100 KN as per IS 516:1959.

Table 9.3 Flexural Strength Test

S.No	Mix proportion	Flexural strength N/mm^2
1	Control	3.625
2	0% MK-10% FA	4.125
3	0% MK-20% FA	3.825
4	10% MK-0% FA	3.784
5	20% MK-0% FA	3.85
6	10% MK-10% FA	5.12

Fig 9.5 Test setup for Flexural Strength

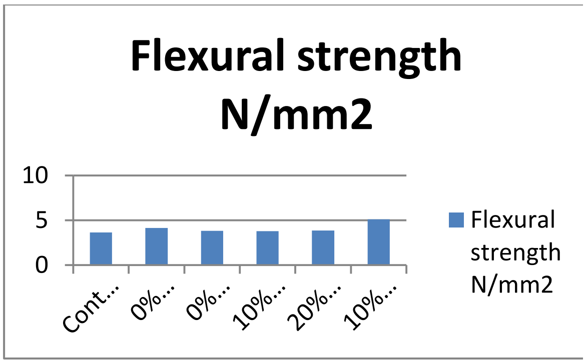


Fig 9.6. Flexural Strength

9.1.4 YOUNG'S MODULUS TEST

Young's modulustests were carried out on cylinders of 150 mm diameter and 300 mm height using a Universal testing machine

Fig 9.7. Test Setup for Young's modulus

Table 9.4 Young's Modulus Test

mix proportion	stress	strain	E	E' as per IS 456
Control	10	2.18E-04	45871.56	27041.63
0% MK-10% FA	7.2	1.78E-04	40449.44	30174.49
0% MK-20% FA	7.9	1.79E-04	44134.08	30991.93
10% MK-0% FA	8.3	1.98E-04	41919.19	30581.86
20% MK-0% FA	9.2	1.88E-04	48936.17	30352.10
10% MK-10% FA	9.89	2.10E-04	47095.24	30352.10

9.1.5 STRESS STRAIN CURVE

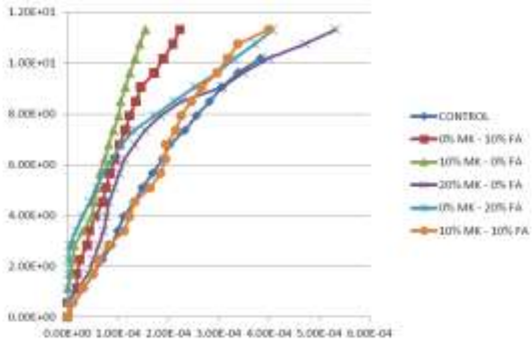


Fig 9.12. Stress Strain Curve

9.2 DURABILITY PROPERTIES

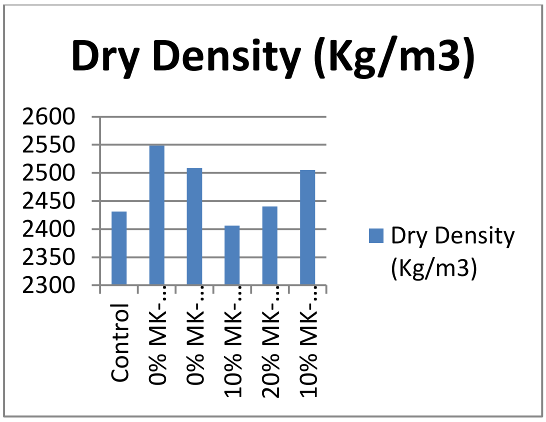
9.2.1 DRY DENSITY (ASTM C 642-97)

For determination of dry density of the cured concrete mixture samples, specimens of size 150 mm x 150mm x 150 mm cube samples were casted and cured for 28 days in water. The samples must be free from observable cracks, fissures and shattered edges. The dry density of the sample is calculate,

Dry density = dry mass of the specimen / Volume of the specimen

Table 9.5 Dry Density Test

Mix proportion	Dry Wt in Kg	Volume in m^3	Dry Density (Kg/m^3)
Control	8.205	0.003375	2431
0% MK-10% FA	8.602	0.003375	2549
0% MK-20% FA	8.466	0.003375	2508
10% MK-0% FA	8.121	0.003375	2406
20% MK-0% FA	8.236	0.003375	2440
10% MK-10% FA	8.456	0.003375	2505



9.2.2 SATURATED DENSITY (ASTM C 642-97)

For determination of saturated density of the cured samples specimens are immersed in water for a minimum period of 52 hours and the moss is weighted using digital balance. The specimen must be free from observable cracks, fissures and shattered edges. The saturated density of the specimens are calculated as,

Saturated density = Saturated mass of the specimen / volume of specimen

Table 9.6 Saturated Density Test

Mix proportion	Saturated Wt in Kg	Volume in m^3	Saturated Density (Kg/m^3)
Control	8.258	0.003375	2447
0% MK-10% FA	8.659	0.003375	2566
0% MK-20% FA	8.526	0.003375	2526
10% MK-0% FA	8.192	0.003375	2427
20% MK-0% FA	8.298	0.003375	2459
10% MK-10% FA	8.518	0.003375	2524

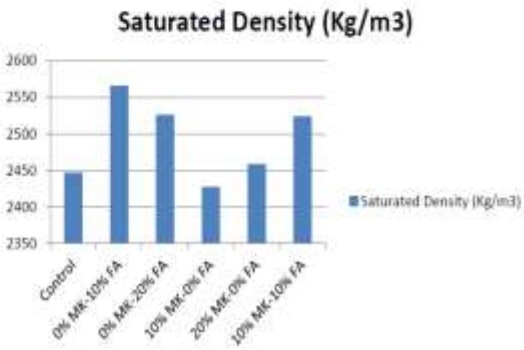


Fig 9.13 Density

9.2.3 WATER ABSORPTION (ASTM C 642-97)

For determination of water absorption of the cured samples, specimens of size 150 mm x 150 mm x 150 mm cube were used. The mass of water absorbed by the dry mass of specimen gives the capacity of water absorption. It is normally expressed in percentage,

Percentage of water absorption = (B-A / A) x 100

where,

A = Mass of the oven dried sample

B = Mass of the saturated sample

Table 9.7 Water Absorption Test

Mix proportion	Dry Wt in Kg	Wet Wt in Kg	% Water absorption
Control	8.205	8.258	0.64
0% MK-10% FA	8.602	8.659	0.66
0% MK-20% FA	8.466	8.526	0.70
10% MK-0% FA	8.121	8.192	0.87

20% MK-0% FA	8.236	8.298	0.75
10% MK-10% FA	8.456	8.518	0.73

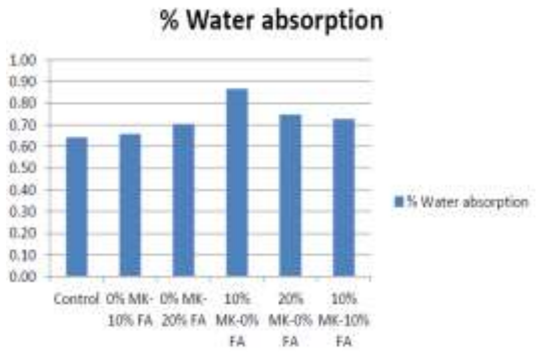


Fig 9.14 Water Absorption Test

EXPERIMENTAL AND ANALYTICALMETHOD

6.1 EXPERIMENTALMETHOD

6.1.1 Design ofHelically Reinforced Circular Column

Axially LoadedColumn
Factored Load= 100KN
Concrete Grade=M20
Characteristic Strength of Steelfy = 415N/mm^2
Unsupported LengthofColumn= 1m
Size ofColumn=150x150mm
Slender Ratio(Lx/D) =1000/100=10 <12
Hence it is designed as a SHORTCOLUMN

Check for theEccentricity

emin = l/500+D/3 =4.6mm
emin/D=7/150=0.0310<0.05
The minimum eccentricity ratio is less than 0.05 in the bothdirection

According to the IS456:2000 Clause 39.4Compression member with Helical reinforcement

Area of Steel inConcrete

P_U = 1.05 {(0.4 fck Ac) + (0.67 fy As)
100X10^3= 1.05 {0.4 X 20 X (0.7854 x 100 x100) +0.67X415XAsc}
100x10^3=1.05 {270x10^3+278.05Asc}
Asc=122.375 mm^2

Minimum Area of Steel inCompression

Asc=0.8/100X150X150=180mm^2
Provide8mmdiabar=180⁄((π⁄(4)x8^2))
=3.58 Hence Provided 4nos of 8mm DiameterBar.
Design of spirals
Diameter = 6mm
Area = 28.27 mm^2
Spacing S = {(11.1 a D fy) / ((D^2 - D$_C$^{2}) X fck) }= 180 mm

Spacing of LateralTies

1. not more than 75 mm
2. not less than 25 mm
3. 6 x 3 = 18 mm

Hence provide 6mm diameter Bar in spirally with the spacing of 180 mm for the research purpose.

EXPERIMENTAL RESULTS

Table. Load deflection for helical control column

CONTROL		
	DIAL READING	**DEFLECTION in mm**
LOAD in kN	**MID**	**MID**
0	**0**	**0**
10	0	0.00
20	0	0.00
30	0	0.00
40	0	0.00
50	5	0.05
60	10	0.10
70	18	0.18
80	24	0.24
90	36	0.36
100	56	0.56
110	61	0.61
120	76	0.76
130	84	0.84
140	99	0.99
150	110	1.10
160	118	1.18
170	126	1.26
180	134	1.34

Table. Load deflection for helical 0% MK -

10% FA column

0% MK - 10% FA		
	DIAL READING	**DEFLECTIO N in mm**
LOAD in kN	**MID**	**MID**
0	**0**	**0**
10	**0**	0.00
20	**0**	0.00
30	**0**	0.00
40	**0**	0.00
50	**0**	0.00
60	5	0.05
70	9	0.09
80	13	0.13
90	15	0.15
100	20	0.20
110	38	0.38
120	48	0.48
130	63	0.63
140	72	0.72
150	83	0.83
160	97	0.97
170	104	1.04
180	108	1.08
190	113	1.13
200	118	1.18
210	124	1.24
220	124	1.24
230	128	1.28

Table. Load deflection for helical 10% MK - 0% FA column

10% MK - 0% FA		
	DIAL READING	**DEFLECTION in mm**
LOAD in kN	**MID**	**MID**
0	**0**	**0**
10	0	0.00
20	0	0.00
30	3	0.03
40	7	0.07
50	9	0.09
60	16	0.16
70	19	0.19
80	23	0.23
90	25	0.25
100	31	0.31
110	36	0.36
120	42	0.42
130	45	0.45
140	52	0.52
150	55	0.55
160	63	0.63
170	69	0.69
180	77	0.77

Table. Load deflection for helical 20% MK - 0% FA column

20% MK - 0% FA		
	DIAL READING	**DEFLECTION**
LOAD in kN	**MID**	**MID**
0	**0**	**0**
10	0	0.00
20	1	0.01
30	10	0.10
40	19	0.19
50	30	0.30
60	41	0.41
70	51	0.51
80	70	0.70
90	130	1.30
100	141	1.41
110	146	1.46
120	152	1.52
130	156	1.56
140	161	1.61
150	166	1.66

Table. Load deflection for helical 0% MK - 20% FA column

0% MK - 20% FA		
	DIAL READING	**DEFLECTION in mm**
LOAD in kN	**MID**	**MID**

0	**0**	**0**	80	51	0.51
10	0	0.00	90	58	0.58
20	4	0.04	100	63	0.63
30	15	0.15	110	78	0.78
40	22	0.22	120	86	0.86
50	29	0.29	130	92	0.92
60	35	0.35	140	106	1.06
70	40	0.40	150	111	1.11
80	48	0.48	160	123	1.23
90	50	0.50	170	142	1.42
100	56	0.56	180	149	1.49
110	61	0.61	190	153	1.53
120	70	0.70	200	163	1.63
130	76	0.76	210	165	1.65
140	86	0.86	220	172	1.72
150	97	0.97	230	193	1.93
160	105	1.05	240	201	2.01
170	130	1.30	250	224	2.24
180	162	1.62	260	229	2.29
190	174	1.74			
200	179	1.79			
210	186	1.86			
220	195	1.95			
230	206	2.06			
240	215	2.15			
250	223	2.23			

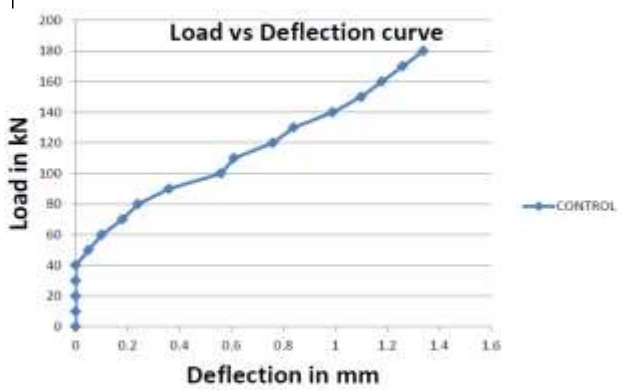
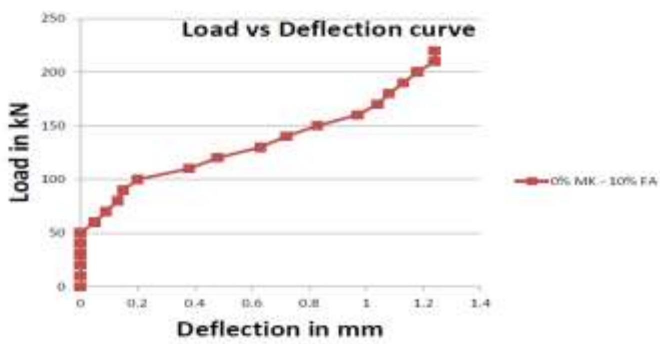
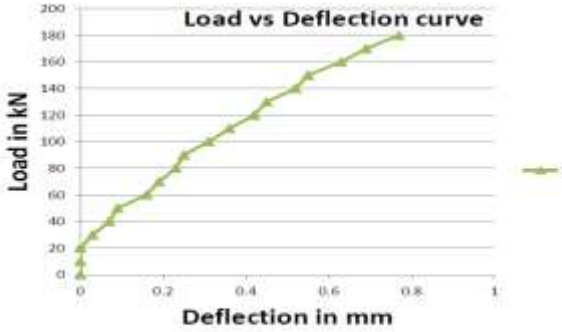
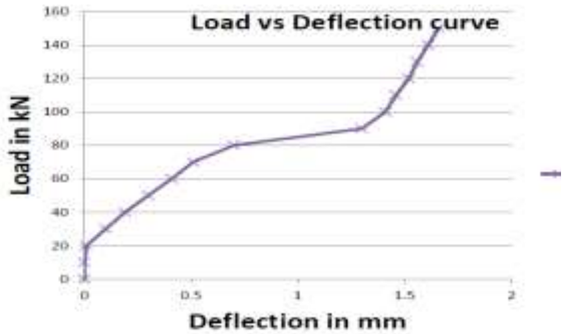


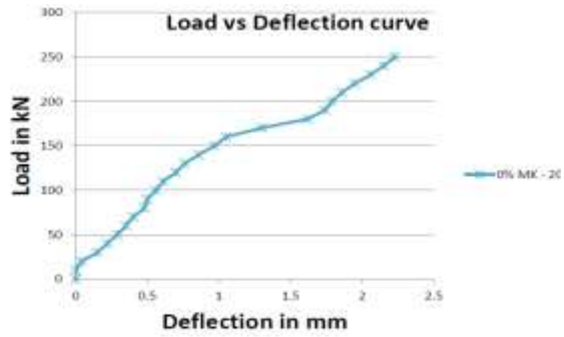
Table. Load deflection for helical 10% MK - 10% FA column

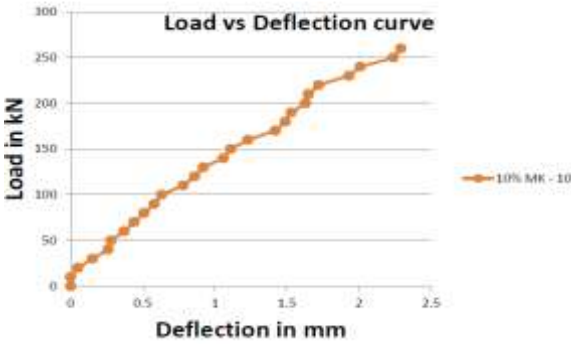
10% MK - 10% FA		
	DIAL READING	**DEFLECTION in mm**
LOAD in kN	**MID**	**MID**
0	0	0
10	0	0.00
20	5	0.05
30	15	0.15
40	26	0.26
50	28	0.28
60	37	0.37
70	44	0.44

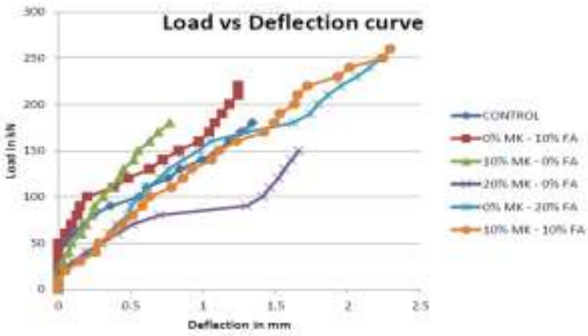












CONCLUSION

This study shows an alternative approach of combined utilization of flyash and metakaolin in the replacement with the cement in the concrete. This combined synergy property of the mineral admixtures may effectively be increase the several property for the structural behavior of helically reinforced concrete column. The use of mineral admixture surely decreases the pollution due to themineral waste material in the environmental. In this project the concept of limit state of design is used for the arrival of theoretical design short helically reinforced concrete column and the replacement of flyash and metakaolin mineral admixtureswith the cement were done by the volume basis. Further if fiber percentage increases then it was seen a great loss in the strength. With Portland cement keeping varies percentage of MK & FA the compressive, splitting tensile, flexural strength affected remarkably.

Under testing, based up on the load vs deflection graph while comparing normal reinforcement with control, yields high strength where as on the other hand helical reinforcement of all the Six gives better performance of strength. On the whole making comparison with normal and helical reinforcement as per load vs deflection graph, it concludes that helical reinforcement satisfiesthe better performance of attaining high strength.

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