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EXPERIMENTAL INVESTIGATION ON THE EFFECT OF CLAY IN SAND FOR COMPRESSIVE AND FLEXURAL BEHAVIOUR OF RCC MEMBERS

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ABSTRACT

In the present day construction industry in developing countries, concrete has emerged as the most common building material. Hence careful consideration must be given to factors that affect its strength. For sand having above 3.4% of clay content used in a 1: 1.6: 2.79 (M-25) mix of concrete resulted in the production of concrete with target compressive strength less than 31 N/mm^2.

The sand sample was divided into two parts. First part of the sand sample was washed free of clay and slit and sun dried, while clay and silt were sieved out of the second part using 2.36 mm sieve. The washed sand sample was divided into 8parts in such a manner that from each part, at least 3 cubes of 150mmx 150mm x 150mm can be made.

Therefore, this study was conducted to investigate suitability of soil in place of sand in producing conventional concrete. This research work mainly consist of two parts, In the first part, substitution of natural sand partially by clay/silt in concrete is done with replacement of 0%, 2%, 4%, 6%, 8%, 10% and 15%. The optimum value obtained for 3%-4% replacement of clay/silt content. The 28 days average compression strength was observed to increase by about 0.3% - 27.6%, split tensile strength by 10.5% - 30.6% when compared with control mix. In the second part, the flexural behavior of reinforced concrete beams with optimum clay/silt content is studied. The reinforced beam specimens used were 150mm x 180mm x 1200 mm, and tests were done at the curing age of 28 days.

The reinforcement is varied from 0.62% - 0.89% in the flexure zone and the parameters like deflection, cracking load, ultimate load and crack width of reinforced concrete beams was experimentally noted and compared with theoretical values as per code IS: 456-2000.Finally, it is concluded Due to high water absorption rate of clay W/C ratio was increased as replacement percentage increases and compression and tensile strength of concrete was decreases. The sieved clay/silt is added to each of the parts, of the washed sand from1% to 15% by weight of the sand. It was discovered that the higher the clay/silt content, the strength of concrete is decreases.

I. INTRODUCTION

1.1 General

Concrete can be a strong durable building material that can be formed into many varied shapes and sizes ranging from a simple rectangular column, to a slender curved dome or shell, if the constituent materials are carefully selected. The constituent materials are: cement, fine aggregate, coarse aggregate and water.Concrete is a very variable material, having a wide range of strengths. Concrete generally increases its strength with age. The precise relationship will depend upon the type of cement used. Some codes of practice allow the concrete strength used in design to be varied according to the age of the concrete when it supports the design load. IS 456 does not permit the use of strength greater than 28 – day value in calculations. It is important that the aggregates for making concrete should be clean of all sorts of impurities.

Aggregates for concrete are usually specified to comply with requirements of IS 383, which gives test for suitable aggregate.

In present day, the conventional fine aggregate has the presence of clay -soil content due to deep digging of river. The scarcity of sandy material has led to the increase in retail price and subsequently leads to higher production cost of concrete products. Thus, soil would naturally be an environmentally friendly, relatively cheap and sustainable construction material and minimizes environmental impacts .

II. REVIEW OF LITERATURE

Parsons (1933), this research investigates the effects of partially substituting clay for either 10% by volume of cement or 7.5% by volume of fine aggregate.

- Here the three different clays (red surface clay, blue clay, maryland and yellow clay) were used to found compressive strength, water absorption and permeability of concrete.
- Finally, it was observed that substituting 10% clay for cement by volume caused around 0-10% decrease in compressive strength at ages beyond three months. Also, substituting clay for 7.5% of fine aggregate increased compressive strength by up to 37%

Olanitori (1947), this investigation is higher percentage of clay/ slit content in natural river sand.

- Test were carried out (two ways) by using washing method, and ethylene blue value.
- It is involve conducting water absorbtion, bulk density, and specific gravity test.
- Finally, concluded that M20 grade concrete at 28 days compressive strength is needed to increment a cement dosage. Also, the results found to be comparatively the use of presence of clay/slit content in conventional fine aggregate and 100% of tested by using washing method river sand.
- It was absorbed that the higher percentage of clay/slit content in sand, the higher was the cement dosage increment needed to maintain the good compressive strength.

In this state of the art review of clay in partial cement and fine aggregate materials. From the critical review, the results are obtained as given below.

- The test methods most commonly specified regarding micro fines in aggregates, such as the percentage passing 75 lm or the sand equivalent test, do not correlate well with the effects of such micro-fines in fresh and hardened concrete, nor do they capture the difference between deleterious swelling clays and acceptable rock flour and sand fines.
- There is need to clarify and substantiate the rationale behind limits on aggregate micro-fines. This could be through emphasizing laboratory tests such as X-ray diffraction, which can determine the mineralogical nature of clays, and rapid field oriented tests which can assess the presence of swelling clays in micro-fines, such as Grace's improved MB colorimetric test.

L.M. Olanitori (2006), in this investigation has careful consideration must be given factors that affect its strength. For sand having above 3.4% of clay content used in a
1: 2: 4 mix of concrete,

As resulted in the production of concrete with compressive strength less than $21N/mm^2$ (1) This work determines the amount of cement needed for sand samples with varying amount of clay/silt content from 0% to 10%, to produce concrete with compressive strength not less than $20N/mm^2$ for mix 1: 2: 4.

The sand sample was divided into two parts. First part of the sand sample was washed free of clay and slit and sun dried, while clay and silt were sieved out of the Second part using 0.150mm sieve. The washed sand sample was divided into 10 parts in such a manner that from each part, at least 10 cubes of 150 x 150 x 150 mm^3can be made.

The sieved clay/silt is added to each of the parts of the washed sand from1% to 10% by weight of the sand. The amount of cement necessary to be added to each part of sand with varying content of clay/silt from 1% to 10%, so as to achieve minimum strength of 20N/mm^2 for mix ratio 1:2:4 were determined.

The results shows it can be seen that the higher the percentage of clay/silt content in sand, the higher the percentage increment of cement needed for the compressive strength of the concrete not to be less than 20N/mm^2.

It is recommended that comparative cost analysis should be carried out between % increment of cement for sand with particular percentage clay/silt content so as to maintain 20N/mm^2 compressive strength, and the cost of washing the sand free of clay/silt, so as to determine which one out of the two is cost effective.

O. Arioz, K.Kilinc (2008) has presented the study of lightweight expanded clay aggregates were produced from clay, waste brick powders, albite floatation waste, and coal at various temperatures ranged from 900 ^{0}C to 1250 ^{0}C. The effect of clay type, treatment (firing) temperature, amount and type of a pore forming agent on the water absorption, specific gravity, pore structure, and surface texture of the expanded granules were examined. In this study, lightweight expanded clay aggregates (LECA) were produced from two types of clays having different chemical compositions. One type was obtained from a pottery production industry and the second one from waste brick powder.

Test results showed that lightweight aggregates with almost 0% water absorption can be produced from clay by utilizing albeit floatation waste as a pore forming agent. The water absorption values of aggregate produced from pottery clay at 1250^{0}C decreased with increase in the amount of floatation waste. The water absorption values of aggregates produced from waste waste brick powders were found to be almost 0% when they are treated at a temperature of 1125^{0}C irrespective to the type of pore forming agent. However, the specific gravity and water absorption values of the aggregates produced from clay were found to be generally lower than those produced from brick powders.

In the present investigation, albite floatation wastes were used in the production of lightweight expanded clay aggregate granules. However, it is desirable to use different pore forming agents such as perlit and glass. The results of such studies would make enable to compare the effects of the pore forming agent for different clay types.

Osei D.Y. and Jackson E.N. (2012) has investigated the use of natural clay pozzolana as partial replacement of Portland cement in the production of cement. Six different mixes were used for the study. A control mix of ratio 1:2:4 batched by mass using a water-binder ratio of 0.55. The control mix was produced using OPC only as binder while in other mixes. Pozzolana was used to replace 10%, 20%, 30%, 40% and 50% of the mass of ordinary cement in the control mix.

The workability of the fresh concrete mixes were evaluated using the slump test and compacting factor test while compressive strength of concrete cubes were evaluated at 7, 14,21 and 28 days.

- ❖ At the end of the study, replacement of cement with pozzolana significantly increased the strength of concrete.
- ❖ Replacement of 30% of the mass of cement with pozzolana achieved the maximum value of compressive strength.
- ❖ The 7-day, 14-day, 21-day and 28-day compressive strength at 30% replacement respectively showed increase of 3%, 11%, 24% and 19% compared to the compressive strength of the control concrete at those ages.
- ❖ Increase in pozzolana replacement decrease the workability of concrete.

III. PROPERTIES OF MATERIALS

3.1 Cement

The cement used in this study was OPC 53 grade from Chettinad Cement Company. This cement is most widely used in the construction industries in Chennai.

3.2 Course aggregate

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 is being used. The Flakiness and Elongation Index were maintained well below 15%.

3.3 Fine aggregate

Fine aggregates are the aggregates whose size is less than 4.75 mm. For increased workability and for the economy as reflected by the use of less cement, the fine aggregate should have a round shape. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

3.4 Grit

Grit is a granular material that can be thought of as a transition stage between a coarse sand and small pebbles. Generally 2-6mm in size, grit has limited use in the construction industry on its own, other than as a surface dressing. However, over recent years with the development in block paving specifications, it has become a viable alternative bedding material for permeable paving and other forms of elemental paving used in areas of high water ingress.

3.5 Water

Combining water with a cementations material form a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely. Lower water to concrete ratio will yield a stronger, more durable concrete; while more water will give a free flowing concrete with a higher slump. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure. Hydration involves many different reactions, often occurring at the same time. As the reactions proceed, the products of the cement hydration process gradually bond together the individual sand and gravel particles and other components of the concrete, to form a solid mass.

3.6 Clay

Generally, the presence of clay in moderate amounts in a soil is desirable. Since clay has cohesive nature, it imparts plasticity to the soil when under moist conditions. Plasticity is due to the thin film of absorbed water which adheres strongly to the clay layers thus linking the particles together. Thus, the clay minerals act as natural binding agents for the cohesion less granular fractions of a soil (gravel, sand, and silt). Although, due to certain drawbacks are of clay are the facts that it has a high affinity towards water.

Figure 3.1: Blocky clay and silt content

Table 3.1: Chemical Compositions of Clayey Soil

Silicon dioxide / silica (SiO_2)	60.34-72.6
Aluminum oxide/alumina (Al_2O_3)	4.67-6.5
Calcium oxide	1.75- 3
Magnesium oxide	5.98-7.3
Sodium oxide	8.56-9.1
Manganese	0.127- 0.26
Specific gravity	2.7 (2.4 to 3.2)
Water absorption	6.78% (4.25%to 8.65%)
Size	> 4.75 mm (by using sieve analysis)
Location	Rettipalayam

3.7 Super plasticizer

For producing **sandy clay**, the most important chemical admixture is the super plasticizers; which is a high range water reducing admixture. Super plasticizers are water reducers which are capable of reducing water contents by 30%. Depending on the solid content of the mixture, a dosage of 1 to 2% by weight of cement is advisable. For the present investigation a super plasticizer by the name **conplast sp-430** has been used for obtaining workable concrete at low w/c ratio. It meets the requirements for super plasticizer according IS: 9103-1999.

Table 3.2: Physical Properties of Super Plasticizer

1	Appearance	Brownish
2	Type	Sulphonated naphthalene formaldehyde condensate
3	Specific gravity	1.220 to 1.225
4	Density	Approx 1.10
5	P_H	Approx 6.5

IV. PRELIMINARY INVESTIGATION OF MATERIAL

Material properties

The following tests are conducted for finding material properties of cube.

4.1 Cement

An OPC 53 Grade sample was tested to obtain the following characteristics:

- Specific gravity (determined by Le – Chatelier flask) (IS : 1727-1967)
- Standard consistency (IS : 4031 – 1968 Part 4)
- Initial setting time (IS : 4031 – 1968 Part 5)
- Final setting time (IS : 4031 – 1968 Part 5)

- The results of the tests on cement are given in the Table 4.1

Table 4.1: Tests on Cement

1.	Specific Gravity	3.12
2.	Standard consistency	28%
3.	Setting time	
	(i) Initial setting time	45 minutes
	(ii) Final setting time	3.32 hours
4.	Fineness	6.5%

4.2 Fine aggregate: In the present investigation, the river sand, which was available at Coimbatore, was used as fine aggregate and the following tests were carried out on sand as per IS: 2386- 1968 (iii) :

- Specific Gravity
- Sieve analysis and Fineness Modulus
- Bulk density

The results of the tests on fine aggregate are given in the Table 4.2

Table 4.2: Tests on Fine aggregate

1.	Specific Gravity	2.66
2.	Percentage of Voids	24.5%
3.	Fineness Modulus	3.752
4.	Bulk Density	1.78

Table 4.3: Sieve Analyses for Sand

Sl. No	Sieve Size (mm)	Weight Retained (g)	% Weight Retained	Cumulative % Retained	% Finer
1	10	0	0	0	100
2	4.75	38	3.8	3.8	96.2
3	2.36	15	1.5	5.3	94.7
4	1.18	82	8.2	13.5	86.5
5	0.6	331	33.1	46.6	53.4
6	0.3	347	34.7	81.5	18.5
7	0.15	167	16.7	97.6	2.4
8	0.075	19	1.9	99.5	0.5
9	Pan	5	0.5	100	0

4.3 Clay

In the present investigation, the following tests were carried out on **clay** as:

- Specific Gravity
- Sieve Analysis and Fineness Modulus
- Bulk Density
- Water Absorption

The results of the tests on clay are given in the Table 4.3

Table 4.4: Test on Clay

Sl.No	Properties	Value
1.	Specific Gravity	2.7
2.	Max liquid limit	24.5
3.	Max Plasticity Index	5.2
4.	Bulk Density	2.05
5.	Water Absorption	4.75

Table 4.5: Sieve Analysis for Clay

Sl.No	Sieve Size (mm)	Weight Retained (g)	% Weight Retained	Cumulative % Retained	% Finer
1	10	0	0	0	100
2	4.75	0	0	0	100
3	2.36	0	0	0	100
4	1.18	9.5	0.95	0.95	99.05
5	0.3	435	43.5	44.5	55.56
6	0.15	267.5	26.7	71.2	28.86
7	Pan	288	28.8	100	0.06

4.4 Coarse Aggregate

In the present investigation, the following tests were carried out on clay as:

- Specific Gravity
- Sieve Analysis
- Crushing Value
- Water Absorption

Sl.No	Properties	Value
1.	Specific gravity	2.7
2.	Water absorption	2.9
3.	Flakiness index	21.5

Table 4.6: Sieve Analysis for Coarse Aggregate

Sieve sizes (mm)	Weight of Retained (g)	Weight of Passed (g)	% Retained	Cumulative passed Percentage

				(%)
37.5	0.0	2638	0	100
25	0.0	2638	0	100
20	123.0	2515	4.7	95.3
10	1705.5	809.5	64.6	30.7
5	682.5	127.0	25.9	4.8
2.38	56.0	71.0	2.1	2.7
Pan	71.0		2.7	
Total	**2638**		**100**	

Table 4.7: Aggregate Crushing Value

Mass passing (g)		Mass retained (g)
From sieve analysis observation (2.36mm)	610	1390
- Container mass (g)	340	340
Resultant mass (g)	**270**	**1050**

Aggregate Crushing Value = 270 ÷ (270+1050) = 0.205 × 100 = **20.5%**

V. EXPERIMENTAL INVESTIGATION

5.1 Methodology

In this study on the replacement of fine aggregate in conventional concrete up to 15 % with clay. The mix proportion used for this study is 1: 1.6: 2.79 with water cement ratio 0.4. The cubes are used for determine the compressive strength and split tensile strength. The Compressive and split tensile strength test is to be conducted for cube mould and cylinder made with various proportions of clay as sand replacement.

5.2 Preparation of test specimens

5.2.1 Cube

Cube moulds of size 150mmX150mmX150mm were used. The cube moulds were cleaned thoroughly using a waste cloth and then properly oiled along its faces. Concrete mould was filled and then compacted using a table vibrator.

5.2.2 Cylinder

Cylinder moulds of size 150mm Diameter X 300mm Height were used. The cylinder moulds were cleaned thoroughly using a waste cloth and then properly oiled along its faces. Cylinder mould was filled and then compacted using a table vibrator.

5.3 Mix proportions

Specimen Name	Description (% of Replacement for Sand with Clay)
C0	0
C2	2
C4	4
C6	6
C8	8
C10	10
C15	15

Table 5.1: Details of Specimens

Sl. No	% of Replacement of Sand with Clay in Conventional Concrete	No of Cubes			No of Cylinder		
		7th day	14th day	28th day	7th day	14th day	28th day
1	0	3	3	3	3	3	3
2	2	3	3	3	3	3	3
3	4	3	3	3	3	3	3
4	6	3	3	3	3	3	3
5	8	3	3	3	3	3	3
6	10	3	3	3	3	3	3
7	15	3	3	3	3	3	3

Table 5.2: Concrete Mix Proportions Per Cube

Mix Designation	C0 Grams	C2 grams	C4 grams	C6 grams	C8 Grams	C10 grams
Cement	1708	1708	1708	1708	1708	1708
F.A	2732	2558	23858	2211	2038	1865
Clay	0	174	347	521	694	867
Water (ml)	564	564	564	564	564	564
Coarse Aggregate	4765	4765	4765	4765	4765	4765

5.4 Testing program

5.4.1 Fresh Concrete

- Slump Cone Test
- Vee bee consistometer Test
- Flow Table
- Compaction Factor

From the above fresh concrete tests are tabulated as given blow

Table 5.3: Slump Cone Test

W/C ratio	Slump value in mm			
	Trial 1	Trial 2	Trial 3	Avg
0.4	96	98	96	97
0.4	100	100	102	101

0.4	95	98	97	97

Table 5.4: Compaction Factor

Description	Value
Empty Weight of compacted mould	- 5.8Kg
Partially compacted	-17.6Kg
Fully compacted	-18.3 Kg
Compaction factor	-94.4%

Table 5.5: Flow Table Test Result

W/C ratio	Flow Percent			
	Trial 1	Trial 2	Trial 3	Avg
0.4	49	48	48.5	48
0.4	50	49.5	48	49
0.4	49	48	47	48

Table 5.6: Vee bee Consistometer Test Result

W/C ratio	Vee bee Consistometer			
	Trial 1	Trial 2	Trial 3	Avg
0.4	53	52	51	52
0.4	50	49	48	49
0.4	52	52	51	51.5

5.4.2 Hardened concrete test

- **Compressive Strength**
- **Tensile Strength**

The cube specimens were tested for compressive strength at the end of 7, 14, 28, days. The surface water and grit were wiped of the specimens and their weight were recorded before testing.

The bearing surfaces of the testing machine were wiped clean and again the surface of the specimen were cleaned from sand and other materials which may come in contact with the compression plates. While placing the specimen in the machine, care was taken such that the load was applied to opposite sides of the specimen as cast and not to the top and bottom. The axis of the specimen was carefully aligned with the center of thrust of the spherically seated plate. As the spherically seated block is brought to bear on the specimen, the movable portion was rotated gently by hand so that uniform seating was obtained. The load was applied without shock and increased continuously until the resistance of the specimen to the increasing load broke. The maximum load applied to the specimen was recorded and any usual appearance in the type of failure was noted.

The measured compressive strength of the specimen was calculated by dividing the maximum load applied to the specimen by the cross sectional area, calculated from the mean dimensions of the section.

The test results are represented in the chapter 6 (Table 6.1 & table 6.2)

5.5 Compressive strength measurements

Concrete cubes of size 150mm×150mm×150mm were casted using 1:1.6:2.79 (M-25) mix with a W/C ratio of 0.4 with and without clay. During casting the cubes were mechanically vibrated using a table vibrator. After 24 hours the specimens were de molded and subjected to curing for 7, 14, 28 days in potable water. After curing, the specimens were tested for compressive and split tensile strength using compression testing machine of 2000kN capacity.

VI. RESULTS AND DISCUSSIONS

6.1 Compressive Strength

Table 6.1 shows the results of the average compressive strength tests for the varying clay content from 0 - 15%. The results showed that compressive strength for 2 and 4% increment of clay increased the compressive strength above 25N/mm^2. It can be seen that for 2 and 4% clay the compressive strength of the concrete is more than 25N/mm^2. While, for 6, 8 and 10% clay content a decreased was observed (Fig 6.1), similar to Olanitori (2006) observation. The decreased observed implies that more cement increment is needed for 6, 8 and 10% respectively, so that the compressive strength of concrete will not be less than 25N/mm^2. For drying ages the compressive strength of concrete increased consistently with time and not much variation in magnitude of strength was observed (Table 6.2). Relationship between percentage clay and bulk density showed increased with increase percent clay and decreased with increased as the days of drying increased (Fig 6.2).

Compression test was carried out on the specimens on 7th ,14th and 28th days of curing and the values are tabulated. The compressive strength also calculated and given

$$F_c = P/A$$

Where,

F_c = compressive strength (N/mm^2)

P = ultimate load (N) and

A= loaded area (150mm x 150mm)

Table 6.1: Compressive Strength for Various Mixes

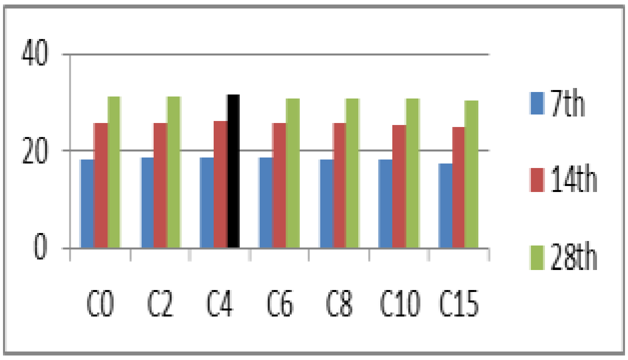


Figure 6.1: Relation between compressive strength of concrete and percentage clay

Table 6.2: Density (kg/m^3) of concrete for varying percentage clay and drying days

Concrete Cube Specimen	Tensile Strength in MPa		
	7th day	14th day	28th day
C0	1.54	1.68	2.16
C2	1.58	1.72	2.24
C4	1.6	1.73	2.25
C6	1.56	1.67	2.19
C8	1.564	1.64	2.16
C10	1.51	1.65	2.15
C15	1.48	1.60	2.10

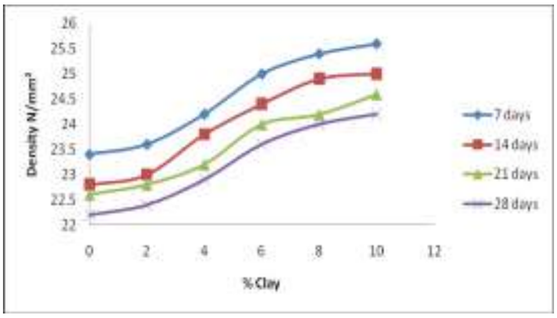


Figure 6.2: Relationship between density and

Concrete Cube Specimen	Compressive Strength in MPa		
	7th day	14th day	28th day
C0	18.25	25.6	31.2
C2	18.5	25.9	31.4
C4	18.75	26.1	31.5
C6	18.4	25.8	31
C8	18.2	25.6	30.9
C10	18.1	25.4	30.8
C15	17.5	25	30.5

percentage clay

Table 6.3: Split tensile strength for various mixes

Clay %	Density in kg/m^3		
	7 days	14 days	28 days
0	23.4	22.8	22.2
2	23.6	23	22.4
4	24.2	23.8	22.9
6	25	24.4	23.6
8	25.4	24.9	24
10	25.6	25	24.2
15	26	26.5	25.6

6.2 SPLIT TENSILE STRENGTH

Tensile test was carried out on the specimens on 7th , 14th and 28th days of curing and the values are tabulated. The tensile strength also calculated and given

$$F_c = 2P/\pi LD$$

Where,

F_c = split tensile strength (N/mm^2)

P = ultimate load (N) and

L = length of the specimen (mm)

D = Diameter of specimen (mm)

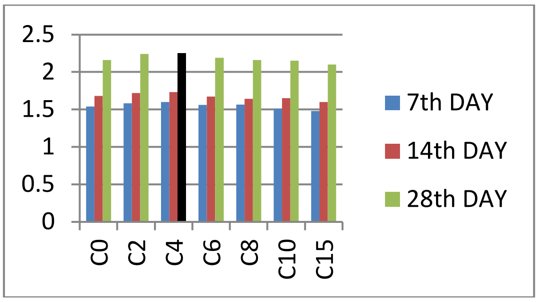


Figure 6.3: Relation between split tensile strength of concrete and percentage clay

6.3 Flexural behaviour of reinforced concrete beam

The dimension of the test beam having overall length 'L' as 1200mm, effective length 'Leff' as 1000mm, total depth 'D' as 180mm, effective depth 'd' as 150mm, breadth 'b' as 150mm and clear cover 'c' a 20mm is used. High yield strength deformed (HYSD) bars having 500 N/mm2 yield strength is used in two different ways in test beam.

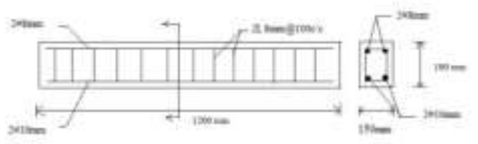


Figure 6.4: Reinforcement Details of Test Beam-1, 2, 3,4

Table 6.4: Details of Test Beams

Tests Beam Specimens	% of Clay	Beam Geometry (mm)	Reinforcement Bar		% Reinforcement (Ast)
			C	T	
TB-1	0	150X200 X1200	2#10	2#10	0.72
TB-2	3	150X200 X1200	2#10	2#10	0.72
TB-3	4	150X200 X1200	2#10	2#10	0.72

6.4 Instrumentation and set-up

The beam specimens casted were tested for pure bending under two-point loading case. All the beams are simply supported over the span of 1200 mm and test loading frame of capacity 500kN. Three dial gauge of least count 0.001mm are placed on the tension face of the beam to measure the deflection along the length. The loading was done with the hydraulic jack that is placed centrally over the channel section ISMC 250 and this channel transfers load on the beam by the help of two steel rollers of 30mm diameter placed at L/3 span from either side of support. The testing arrangements of the beam specimens are shown figure 6.5.

Figure 6.5: Test set up for flexural test of reinforced beams

6.4.1 Crack pattern and modes of failure

All the test beams were designed as under reinforced section. As the load was applied the beams started cracking at the tension zone and as the load was increased the crack started propagating toward the neutral axis. The mode of failure of all the beams was flexural failure. There was no horizontal crack at the level of the reinforcement, which shows that there was no bonding failure.

Figure 6.6: Crack pattern of control beam (Front face

Figure 6.6: Crack pattern of control beam (Rear face)

6.4.2 Experimental results

Structural parameters like cracking load, service load and ultimate load with their deflections are investigated. Totally 4 no. of test beams were casted and tested, in that 2 were control mix of 10 diameter bars, 1 were clay-3% of 10 diameter bars, 1 were clay -4% of 10 diameter bars Also, the experimental values mentioned above are compared with the theoretical values conforming to IS: 456-2000. The results are tabulated in table 6.5

Table 6.5: Average experimental results of test beams

Beam Designation	A_{st} %	P_{cr} KN	Δ_{cr} Mm	W_{cr} mm	P_s KN	Δ_s mm	W_s mm	P_u KN	Δ_u mm	W_u mm
TB-1 (C M)	0.72	18	0.83	0.01	58	3.53	0.14	116.3	9.47	0.23
TB-2 (C 3%)	0.72	22	1.44	0.01	60	3.52	0.21	123.4	9.7	0.32
TB-3 (C 4%)	0.72	24	1.90	0.01	64	3.87	0.16	126.6	10.63	0.26

6.4.3 Cracking moment

The load at which the first crack was observed was calculated as the cracking moment. The theoretical cracking moment was calculated as per the test data available and the IS: 456- 2000 recommendations. Also, the theoretical values are compared with the experimental values for the varying tensile reinforcement and are tabulated in table 6.6.

Table 6.6: Experimental results and theoretical results of cracking moment

Beam Designa tion	Ast (%)	Experimen tal cracking moment, Mc (kNm)	Theoretical cracking moment, Mr (kNm) (IS:456-2000)	Ratio Mc/Mr (IS:456 -2000)
TB- 1, TB- 2	0.72	5.0	3.837	1.25
TB- 1, TB- 3	0.72	5.2	3.837	1.30

6.4.4 Flexural capacity

The ultimate moment carrying capacities of the beams are calculated theoretically conforming to IS: 456- 2000 and compared it with the experimental results. The experimental and theoretical results are tabulated in the table 6.7.

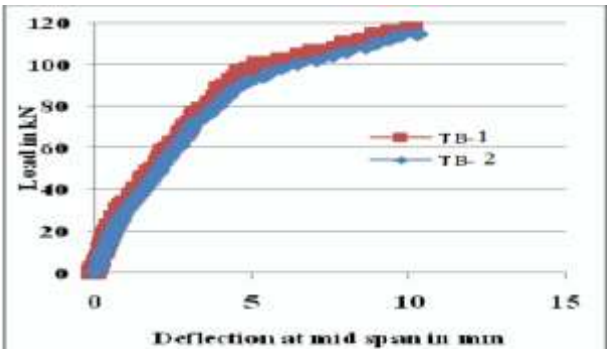
Table 6.7: Experimental results and theoretical results of cracking moment

Beam Designation	Ast (%)	Experimental cracking moment, Mc (kNm)	Theoretical cracking moment, Mr (kNm) (IS:456-2000)	Ratio Mc/Mr (IS:456-2000)
TB- 1, TB- 2	0.72	16.54	10.60	1.56
TB- 1, TB- 3	0.72	17.2	10.60	1.62

From above table we can see that there increase in the tested flexural capacity compared to the theoretical ultimate moment of beams.

6.4.5 Deflection

The deflection of the beam were measured at an interval of 2kN at mid span and 1/3rd span from both the sides of support till the failure of the beams. The deflections recorded are compared with the theoretical values conforming to IS: 456- 2000 at the all the loads.



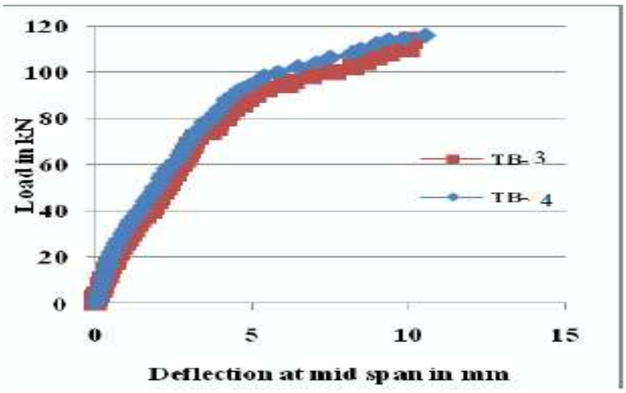


Figure 6.8: Relation between load and deflection at mid span

6.4.6 Crack width

Crack width is an important factor from the durability point of view and IS: 456-2000 specifies that the width of surface cracks should not exceed 0.3mm. The cracks formed propagated towards the compression zone from the tension zone and the observations were made.

Table 6.8: Test Results Of Crack Width

Beam Designation	Service Load (kN)	Experimental Crack width, Wcr,e (mm)	Theoretical Crack width, Wcr,t (mm)	Permissible Crack Width (mm)
TB- 1, TB-2	56	0.202	0.1212	0.3
TB- 3, TB-4	58	0.2143	0.1212	0.3

VII. CONCLUSION

Based on the experimental investigations, the following conclusions were drawn.

1. The control mix for M25 grade and the replacement of clay/silt content by 0%, 1%, 2%, 3%, 4%, 5%, 10% and 15% by weight of natural sand were designed.
2. The optimum level of replacement of clay/silt content was found to be 3-4% and the results were better than that of control mix.
3. The workability of fresh concrete decreases with increase in the replacement of clay/silt content for the additional dosage of super-plasticizer is required.
4. The compressive strength gradually increases from 0%, 1%, 2%, 3% replacement of clay/silt content and decreases for above 5% replacement of clay/silt content.
5. The 28 days average compressive strength obtained for clay/silt content mix concrete shows 0.3% to 27.6% increase in compressive strength when compared to control mix concrete.
6. The 28 days average split tensile strength obtained for clay/silt content mix concrete shows 10.61% to 36.8% increase in split tensile strength when compared to control mix concrete.
7. The maximum strain at service load should not exceed 0.0035 as per code IS: 456-2000. Therefore the experimental results shows that the maximum strain in all test beams are well within the limits.
8. The flexural results show that there is an increase in cracking moment by 31.84% for 0.62% tensile reinforcement.
9. The ultimate moments obtained from experimental results are greater that the theoretical results by 27.58%.
10. Concrete incorporating clay/silt content exhibits good mechanical properties and therefore up to 3-4% by weight of natural sand can be replaced by clay/silt content.
11. Based on their test results, a higher limit of impurities (5%) in fine aggregate was recommended.

REFERENCES

1. Adam, E. A. and Jones, P. J. (1995). “Thermo physical properties of stabilized soil building blocks.” Building and Environment. Vol. 30,No. 2, pp. 245-253.
2. Adesanya, D. A. (1996). “Evaluation of blended cement mortar, concrete and stabilized earth made from ordinary Portland cement and corn cob ash.” *Construction and Building Materials*, Vol. 10,No. 6, pp. 451-456.
3. Alhozaimy AM. Correlation between materials finer than No. 200 sieve and sand equivalent tests for natural and crushed stone sands. Cement Concrete Aggregate 1998;20(2):221–6.
4. Aly MH, Olabi Messeiry MSG, Hussain I. Effect of nano clay particles on mechanical, thermal and physical behaviour of waste–glass cement mortars. Mater Sci Eng 2011;528:7991–8.
5. Amorima CLG, Lopesa RT, Barrosob RC, Queirozc JC, Alvesc DB, Perezd CA, et al. ‘‘Effect of clay–water interactions on clay swelling by X-ray diffraction’’. Nucl Instrum Methods Phys Res A 2007;580:768–70.
6. Anderson RL, Ratcliffe I, Greenwell HC, Williams PA, Cliffe S, Coveney PV. ‘‘Clay swelling – a challenge in the oilfield’’. Earth Sci Rev 2010;98:201–16.
7. K.S. Jagadish, Building with Stabilized Mud, IK International Publishing House Pvt. Ltd, New Delhi, 2007. [2]. Rogers, Sara B, Evaluation and Testing of Brick Dust as a Pozzolanic Additive to Lime Mortars for Architectural Conservation. (MastersThesis). University of Pennsylvania, Philadelphia, PA 2011. [3]. Walker P and Stace, T., Properties of some cement stabilized

compressed earth blocks and mortars, Mater.Struct.30, pp545-551, Nov 1997 [4]. B. V. Venkatarama Reddy and Ajay Gupta, Characteristics of Cement-Soil Mortars, Materials and Structures, Vol.38, pp 639-650, July 2005.

8. Adepegba D. A., (1975) "Comparative Study of Normal Concrete which Contains Laterite Fines Instead of Sand" *Building Science*; 10:135–41.
9. Akintorinwa, O. J., Ojo, J. S. and Olorunfemi, M. O. (2012) "Geo-electric Reserve Estimation of Laterite Deposits Along a Basement Complex Underlain Osogbo-Iwo Highway, Southwest Nigeria" *Journal of Emerging Trends in Engineering and Applied Sciences* (JETEAS) 3 (3): 490-496
10. Osadebe N. N. and Nwakonobi T. U. 2007. Structural Characteristics of Laterized Concrete at Optimum Mix Proportion. Nigerian Journal of Technology, Nsukka, Nigeria. 26(1): 12-17.
11. Makasa B. 1998. Utilization and improvement of lateritic gravels in road bases. International Institute for Aerospace survey and earth sciences (ITC), Delft, Netherlands. http://www.itc.nl.
12. Adoga E. A. 2008. Durability and Fire Resistance of Laterite Rock Concrete. Unpublished M. Tech. Thesis. Department of Civil Engineering, Rivers State University of Science and Technology, Port Harcourt,Nigeria.
13. BIS: 383 – 1970, "Specification for coarse and fine aggregates from natural sources for concrete".
14. IS 456-2000 Indian Standard Plain and Reinforced Concrete - Code of Practice. (Fourth Revision).
15. IS 10262-2009 Recommended guideline for concrete mix design
16. BIS: 9103-1991, "Specification for Admixture for Conrete".
17. BIS: 12269-1987, "Specification for 53 Grade Ordinary Portland Cement"