The Study on the Effect of Clay Content in Sand and its Impact on the Compressive Strength of Concrete

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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: 2 (M-25) mix of concrete, resulted in the production of concrete with target compressive strength less than 31.75N/mm2. 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. 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.

Key words: Clay/silt content, workability, compressive strength, split tensile strength, flexural strength, deflection, surface strain, crack width, cracking moment, ultimate moment

I. INTRODUCTION

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 (1). Concrete generally increases its strength with age. The precise relationship will depend upon the type of cement used. (2). 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. BS 8110 does not permit the use of strength greater than 28 – day value in calculations (3). It is important that the aggregates for making concrete should be clean of all sorts of impurities (4). Aggregates for concrete are usually specified to comply with requirements of BS 882, which gives test for suitable aggregate (5). The maximum percentage clay/silt of content of sand for which the target compressive concrete strength will not be less than 31.75N/mm2 is 3.4%.

(1). For sand with percentage clay/silt contents of 5% and 10% will produce concrete with compressive strengths of 30.2N/mm2 and 29.6 N/mm2 respectively, and the higher the percentage of clay/silt in sand the lower the concrete strength. It is very important to control the quality of the aggregate to be used in concrete making. Most importantly, the effect of the clay/silt content of sand on the compressive strength of concrete must be controlled.

II. EXPERIMENTAL PROGRAMME

A. *Materials used*

Ordinary Portland cement of grade 53 is used for this experimental work. The fine aggregates used was natural sand and clay/silt content. The basic material test was done as per code IS: 383-1970. Coarse aggregate used is locally available crushed angular aggregate of size 20mm and down. Campus water is used with pH value of 7.5. The Super plasticizer, conplast SP430 is used for this experimental work. The physical properties are given in table 1.

Particular	Natural sand	Coarse aggregate
Specific gravity	2.60	2.65
Water absorption (%)	1	0.5
Fineness modulus	2.61	7.30
Bulk density (g/cc)	1.47	-
Percentage of voids	43.46	-
Grading	Zone II	-

Table I: Physical Properties of Fine and Coarse Aggregates

1) *Clay*

There has long been concern that clay particles may be harmful to concrete because of their ability to absorb water and swell, which increases the water demand in fresh concrete.

Particular	Physical properties of clay
Specific gravity	2.08
Water absorption %	18.3
Fine material	5.9
Fineness modulus	3.07
Los angles	-
Practical size distribution in (mm)	-
19mm	-
12.5mm	-
9.5mm	-
4.75mm	100
2.36mm	80.5
1.18mm	51.2
600μm	31.3

300 µm	20.3
150 µm	9.7

Table 2: Physical Properties of Clay

- 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

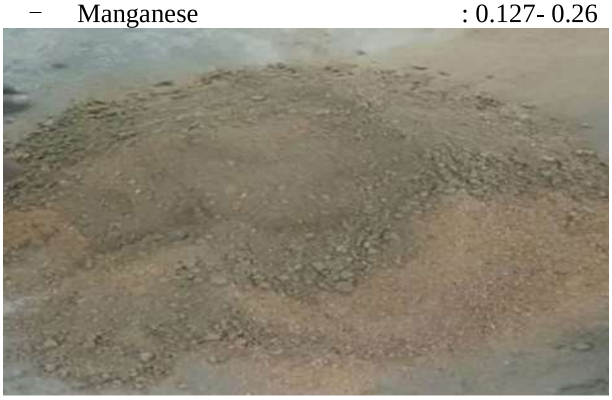

Fig. 1: Presence of clay in sand.

B. Mix Design:

The mix proportion chosen for this study is M25 grade (1:2.01:3.56) with water-cement ratio of 0.45. Cubes of standard size 150x150x150mm of total 48 no. and cylinders of standard diameter 150mm and height 300mm of total 48 no. are casted and cured for 7 and 28 days and tested as per code IS: 516-1959 and IS: 5816-1999.

Unit of batch	Water (liter)	Cement (kg)	Sand (kg)	Coarse aggregate (kg)	Super plasticizer
Meter cube content	168	380	765	1356	3.75
Ingredient ratio	0.45	1	2.01	3.56	1%

Table 3: Mix Proportion for M25 grade Concrete

C. Workability

Slump test was conducted to determine the workability of concrete. In this experimental work, as the percentage of clay/silt content increases, the workability of concrete mix also increases. The slump value obtained from different percentage of clay/silt content mixes are shown in figure 1.

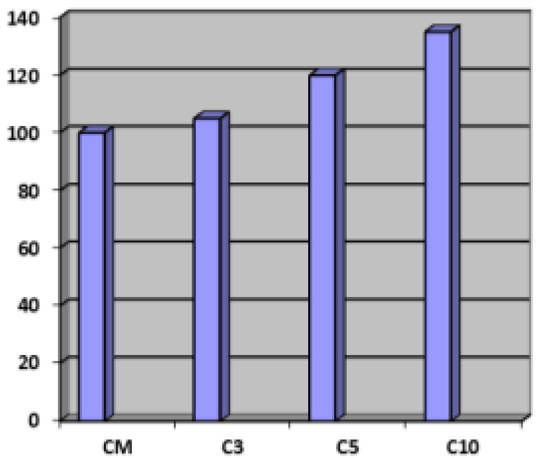

Fig. 1: Slump values for different mix proportions

D. Compressive Strength Test

Table 4 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 2), 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 3). Relationship between percentage clay and bulk density showed increased with increase percent clay and decreased with increased as the days of drying increased (Fig 3).

Compression test was carried out on the specimens on 7$^{th,\ 14th}$ and 28$^{th\ days}$ 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)

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

Table 4: Compressive Strength for Various Mixes

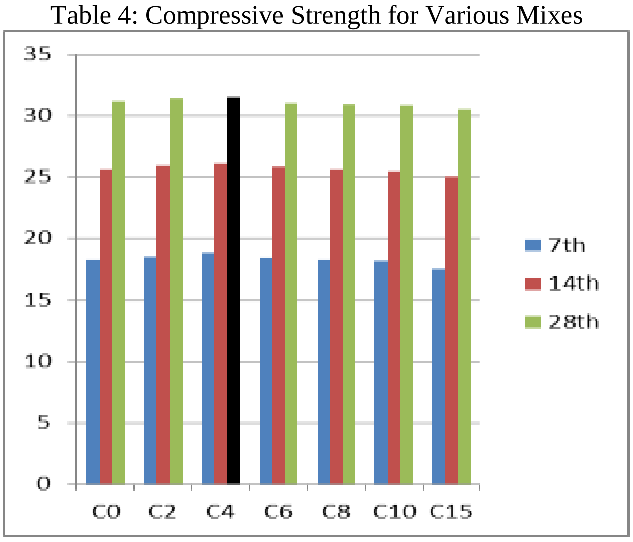

Fig. 2: Compression Strength Variation of Different Mix for 7, 14, & 28 Days

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

Table 5: Density (kg/m3) of concrete for varying percentage clay and drying days

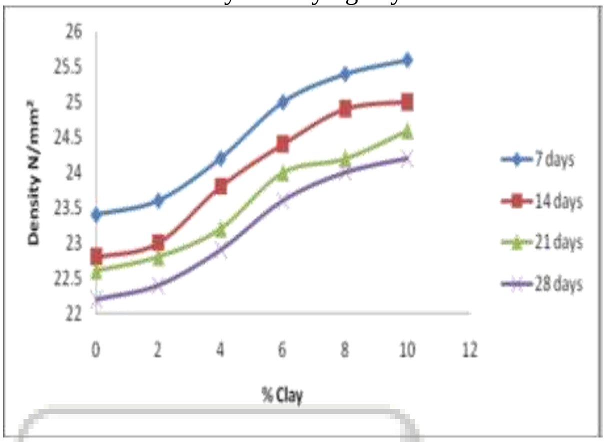

Fig. 3: Relationship between density and percentage clay

E. Split Tensile Strength Test

The size of cylinder used for this test was of diameter 150mm and height 300mm. For each mix, 2 cylinders were casted and cured for 28 days. Then testing was done in 2000kN compression testing machine as per code IS: 516-1959.The calculation was done by using the formula f_{cr}= (2P) ÷ (πdl).

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

Table 6: Split tensile strength for various mixes

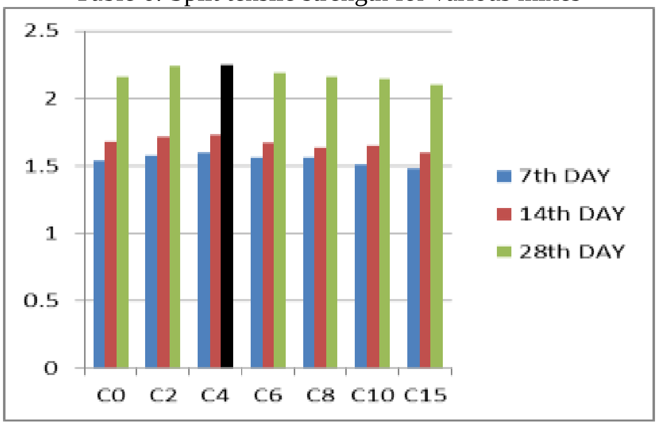

Fig. 7: Relation between split tensile strength of concrete and percentage clay

III. 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.

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