The Study on The Effect of Clay Content in Fine Aggregate 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 compressive strength less than 25 N/mm2.Therefore, this work was conducted to investigate the amount of cement needed for sand samples with varying amount of clay/silt cement from 0% to 10% to produce concrete with compressive strength not less than 25 N/mm2 for mix 1:1:2.The sieved clay/silt is added to each of the parts of the washed sand from 1% to 10% by weight of the sand. The amount of cement necessary to be added to each part of the sand with varying cement content of clay/silt 1% to 10%, so as to achieve minimum strength of 25 N/mm2 for the mix ratio 1:1:2 was determined. It was discovered that the higher the clay/silt content, the compressive strength of concrete is decreases. It is concluded that the higher amount of cement dosage is needed to maintain the compressive strength of concrete.
Keywords: clay, silt, sand, cement, concrete, workability, compressive strength

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/mm^2 is 3.4%.
(1). For sand with percentage clay/silt contents of 5% and 10% will produce concrete with compressive strengths of 30.2N/mm^2 and 29.6 N/mm^2 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.

Table – 1
Physical Properties of Fine and Coarse Aggregate

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*	-

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.

Table – 2
Physical Properties of Clay

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*

Silicon dioxide / silica (SiO_2) : 60.34-72.6
Aluminum oxide/alumina ($Al_2 O_3$) : 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

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 210 nos. are casted and cured for 28 days and tested as per code IS: 516-1959 and IS: 5816-1999.

Table – 3
Mix proportion For M25 Grade Concrete

Unit of batch	*Water (liter)*	*Cement (kg)*	*Sand (kg)*	*Coarse aggregate (kg)*	*Super plasticizer*
Meter cube content	*164*	*375*	*375*	*750*	*3.75*
Ingredient ratio	*0.45*	*1*	*1*	*2*	*1%*

C. Workability:

Slump test is most commonly used method of measuring consistency of concrete which can be employed either in laboratory or site work. The slump test is used vary often in concrete work. It is easily performed at a job site and is useful in detecting variations in mixes of given properties.

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.

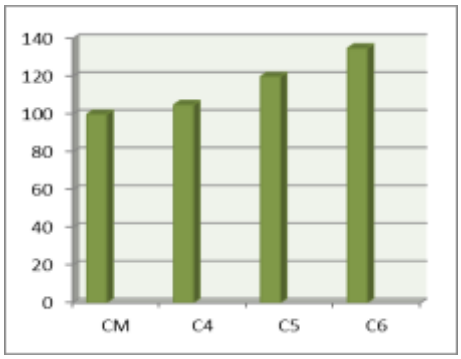

Fig. 1: Slump values for Different Mix Proportions

D. Compressive Strength Test :

A compression test is a method for determining the behavior of materials under a compressive load. Compression tests are conducted by loading the test specimen between two plates and then applying a force to the specimen by moving the crossheads together. The compression test is used to determine elastic limit, proportionality limit, yield point, yield strength and compressive strength. Compressive Strength is the maximum compressive stress that a material is capable of withstanding without fracture. Brittle materials fracture during testing and have a definite compressive strength values. The compressive strength of ductile materials is determined by their degree of distortion during testing. Dimensions of test piece are measured at 3 different places along its height/length to determine the average c/s area. Ends of the specimen should be plane. For that the ends are tested on a bearing plate. The specimen is placed centrally between the two compressions plates, such that the center of moving head is vertically above the center of specimen. Load is applied on the specimen by moving the movable head. The load and the corresponding contraction are measured at different intervals. The load interval may be as 500kg. Load is applied until the specimen fails.

The compressive strength test is carried out on various mixes by varying the percentage of clay/silt content by 0%, 4%, 5%, 6%, 7%, 8%, 9%, 10% and keeping all other parameters as constant. A cube of standard size 150x150x150mm is casted and for each mix 3 cubes were cased and cured for 28 days. Tests were conducted using 2000kN compression testing machine as per code IS: 516-1959. The compressive strength values obtained for each % replacement of clay/silt content with natural sand. In addition to the amount of cement necessary to be added to each part of sand with varying content of clay/slit 4% to 10%.

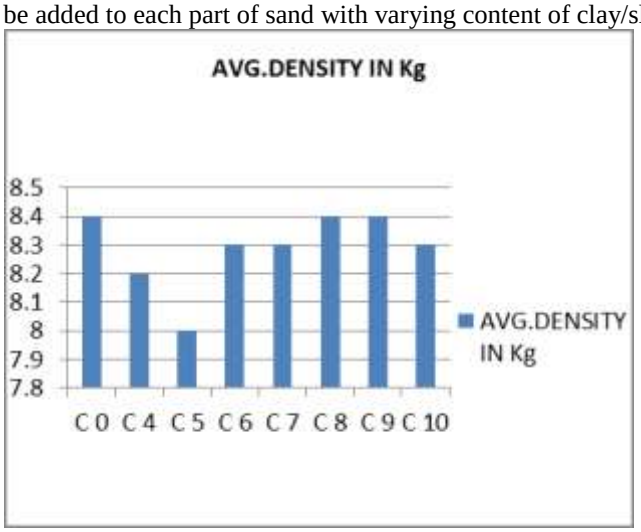

Fig. 2: Average Density of Concrete with Varying Percentage of Clay/Slit Content

Table – 4
The results of the Average Compressive Strength Tests for samples AA and samples 1 to 10.

Samples	*Average weight of Samples (kg)*	*Percentage Clay/Silt Content (%)*	*Average 28 Days Compressive strength (N/mm^2)*
A(Control specimen)	*8.4*	*0*	*27.80*
1	*8.5*	*1*	*27.60*
2	*8.5*	*2*	*26.40*
3	*8.4*	*3*	*25.83*
4	*8.2*	*4*	*24.61*
5	*8.0*	*5*	*23.20*
6	*8.3*	*6*	*23.00*
7	*8.3*	*7*	*22.80*
8	*8.4*	*8*	*22.00*
9	*8.4*	*9*	*21.62*
10	*8.3*	*10*	*21.40*

Table – 5
The results of the Average Compressive Strength Tests for samples 4, with varying increment cement percentage.

Samples	*Average weight of Samples (kg)*	*Percentage Clay/Silt Content (%)*	*Cement Increment (%)*	*Average 28 Days Compressive Strength (N/mm^2)*
A	*8.2*	*4*	*2*	*24.60*
B	*8.2*	*4*	*4*	*25.21*
C	*8.4*	*4*	*6*	*25.46*
D	*8.5*	*4*	*8*	*25.94*
E	*8.3*	*4*	*10*	*26.12*

Table – 6
The results of the Average Compressive Strength Tests for samples 5, with varying increment cement percentage.

Samples	*Average weight of Samples (kg)*	*Percentage Clay/Silt Content (%)*	*Cement Increment (%)*	*Average 28 Days Compressive Strength (N/mm^2)*
A	*8.4*	*5*	*2*	*23.21*
B	*8.4*	*5*	*4*	*23.43*
C	*8.3*	*5*	*6*	*23.92*
D	*8.5*	*5*	*8*	*24.21*
E	*8.2*	*5*	*10*	*24.67*
F	*8.2*	*5*	*12*	*24.89*
G	*8.2*	*5*	*14*	*25.43*

Table -7
The results of the Average Compressive Strength Tests for samples 6, with varying increment cement percentage from 2% to 10%

Samples	*Average weight of Samples (kg)*	*Percentage Clay/Silt Content (%)*	*Cement Increment (%)*	*Average 28 Days Compressive Strength (N/mm^2)*
A	*8.0*	*6*	*2*	*22.42*
B	*8.2*	*6*	*4*	*22.93*
C	*8.4*	*6*	*6*	*23.26*
D	*8.4*	*6*	*8*	*23.68*
E	*8.5*	*6*	*10*	*23.85*
F	*8.3*	*6*	*12*	*24.18*
G	*8.3*	*6*	*14*	*24.49*
H	*8.3*	*6*	*16*	*24.75*
I	*8.3*	*6*	*18*	*24.92*
J	*8.3*	*6*	*20*	*25.24*

Table – 8
The results of the Average Compressive Strength Tests for samples 7, with varying increment cement percentage.

Samples	*Average weight of Samples (kg)*	*Percentage Clay/Silt Content (%)*	*Cement Increment (%)*	*Average 28 Days Compressive Strength (N/mm^2)*
A	*8.5*	*7*	*4*	*23.92*
B	*8.5*	*7*	*8*	*24.21*
C	*8.3*	*7*	*12*	*24.68*
D	*8.3*	*7*	*16*	*24.89*
E	*8.4*	*7*	*20*	*24.97*
F	*8.2*	*7*	*24*	*25.31*

Table – 9
The results of the Average Compressive Strength Tests for samples 8, with varying increment cement percentage.

Samples	*Average weight of Samples (kg)*	*Percentage Clay/Silt Content (%)*	*Cement Increment (%)*	*Average 28 Days Compressive Strength (N/mm^2)*
A	*8.4*	*8*	*4*	*23.81*
B	*8.4*	*8*	*8*	*23.94*
C	*8.4*	*8*	*12*	*24.23*
D	*8.2*	*8*	*16*	*24.48*
E	*8.2*	*8*	*20*	*24.65*
F	*8.3*	*8*	*24*	*24.86*
G	*8.3*	*8*	*28*	*24.98*
H	*8.3*	*8*	*32*	*25.12*

Table – 10
The results of the Average Compressive Strength Tests for samples 9, with varying increment cement percentage.

Samples	*Average weight of Samples (kg)*	*Percentage Clay/Silt Content (%)*	*Cement Increment (%)*	*Average 28 Days Compressive Strength (N/mm^2)*
A	*8.2*	*9*	*4*	*22.83*
B	*8.3*	*9*	*8*	*22.98*
C	*8.2*	*9*	*12*	*23.21*
D	*8.5*	*9*	*16*	*23.57*
E	*8.4*	*9*	*20*	*23.78*
F	*8.4*	*9*	*24*	*23.94*
G	*8.3*	*9*	*28*	*24.05*
H	*8.3*	*9*	*32*	*24.81*
I	*8.3*	*9*	*36*	*24.93*
J	*8.3*	*9*	*40*	*25.14*

Table – 11
The results of the Average Compressive Strength Tests for samples 10, with varying increment cement percentage.

Samples	*Average weight of Samples (kg)*	*Percentage Clay/Silt Content (%)*	*Cement Increment (%)*	*Average 28 Days Compressive Strength (N/mm²)*
A	*8.1*	*10*	*4*	*21.76*
B	*8.2*	*10*	*8*	*22.02*
C	*8.4*	*10*	*12*	*22.58*
D	*8.2*	*10*	*16*	*22.75*
E	*8.2*	*10*	*20*	*22.97*
F	*8.5*	*10*	*24*	*23.12*
G	*8.5*	*10*	*28*	*23.36*
H	*8.4*	*10*	*32*	*23.61*
I	*8.5*	*10*	*36*	*23.89*
J	*8.4*	*10*	*40*	*24.12*
K	*8.3*	*10*	*44*	*24.45*
L	*8.3*	*10*	*48*	*24.81*
M	*8.3*	*10*	*52*	*25.23*

Table – 12

Percentage of Clay/Silt content in sand and corresponding percentage increment of cement so that Compressive Stress is not less than 25N/mm².

% Clay/Silt Content in Sand	*% increment of Cement*
4	*4*
5	*14*
6	*20*
7	*24*
8	*32*
9	*40*
10	*52*

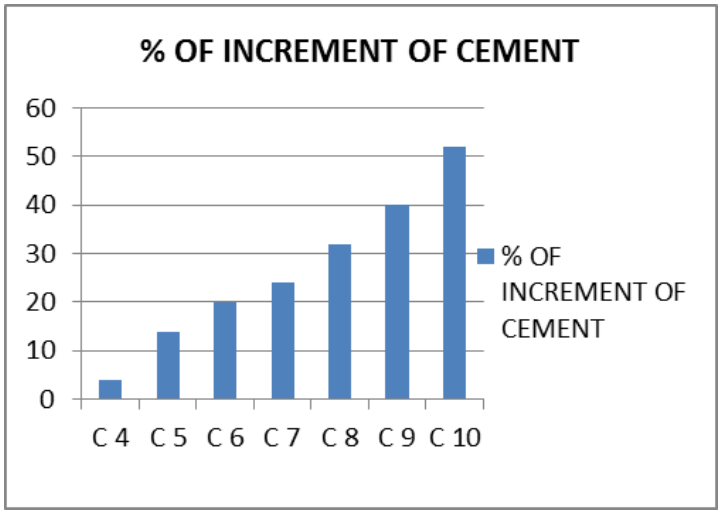

Fig. 3: Percentage of Clay/Silt content in sand and corresponding percentage increment of cement so that Compressive Stress is not less than 25N/mm2.

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%, 4%, 5%, 6%, 7%, 8%, 9%, and 10% by weight of natural sand were designed.
2) The optimum level of replacement of clay/silt content was found to be 3-4%.
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) It is concluded that the higher percentage of clay/silt content in sand, the higher the percentage increment of cement needed for the compressive strength of concrete not to be less than 25N/mm².
5) It is recommended that comparative cost analysis should be carried out between percentage increments of cement for sand with particular percentage clay/silt content so as to maintain 25N/mm² compressive strength.

REFERENCES

[1] Iyappan G.R. & Manu S.S (2015): Experimental investigation on the effect of clay content in sand for flexural behavior of rcc beams. (IJST) vol3 issue3
[2] Olanitori, L.M. & Olotuah, A.O. (2005): The Effect of Clayey Impurities In Sand On the Crushing Strength of Concrete (A Case Study of Sand In Akure Metropolis, Ondo State, Nigeria), 30th Conference On Our World In Concrete & Structures: 23-24 August 2005, Singapore, PP 373 – 376.
[3] Mosley W.H. Bungey J. H. & Hulse R. (1999): Reinforced Concrete Design, 5th Edition, Palgrave Press.
[4] Mosley, W.H., Bungey, J.H, and Hulse, R, (2007): Reinforced Concrete Design, 6th Edition. BookPower with Palgrave Macmillan.
[5] British Standards (1992): Specification for Aggregates from Natural Sources for Concrete. BS882:1992. British Standards Institution, London, UK.
[6] Olanitori L.M. and Olotuah A.O (2005): The effect of clayey impurities in sand on the crushing strength of concrete (a case study of sand in Akure metropolis, Ondo State, Nigeria). Proceedings of 30th Conference on 'Our World in Concrete and Structures', Singapore, 23-24 August. Pp 373-376.
[7] Olanitori L.M. (2006): Mitigating the Effect of Clay Content of Sand on Concrete Strength; 31st Conference on Our World in Concrete and Structures; 15-17 August 2006, Singapore. Pp 344- 352.
[8] Ahmad S. and Mahmood S. (2008); Effects of Crushed and Natural Sand on the Properties of Fresh and Hardened Concrete. 33rd Conference on Our World in Concrete & Structures. 25 – 27 August 2008, Singapore. Pp 405-410.
[9] Ukpata J.O, Ephraim M.E. and Akeke G.A. (2012): Compressive Strength of Concrete Using Lateritic Sand and Quarry Dust as Fine Aggregate. ARPN Journal of Engineering and Applied Sciences, Vol.7, No 1. Pp 81-92.
[10] Raju, N. K, (2009): Design of Concrete Mixes, 3rd Edition, Delhi, India. CBS Publishers & Distributors.
[11] British Standards (1957): The Structural use of Concrete in Buildings. CP114. British Standards Institution, London, UK. 9. Reynolds, C.E, and Steedman, J.C. (1981): Reinforced Concrete Designer's Handbook, 9th Edition. Viewpoint Publication. London.
[12] British Standards (1972): Code of Practice for the Structural use of Concrete - Part 1: Design, Materials and Workmanship. CP110: Part 1. British Standards Institution, London, UK.
[13] British Standards (1997): Structural use of Concrete-Part 1: Code of Practices for Design and Construction. BS 8110 Part 1. British Standards Institution, London, UK.
[14] British Standards (1997): Concrete: Part2: Methods for Specifying Concrete Mixes. BS5328: Part1. British Standards Institution, London, UK.
[15] McCormac J.C. and Nelson J.K.(2006): Design of Reinforced Concrete. 7th Edition. ACI 318-05 Code Edition. John Wiley & Sons Inc.