ISSN No:-2456-2165

Effect of Increase of Cement on the Initial Mix of 1:2:4 Concrete on Its Characteristics Strength

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Abstract:- Prescribed mix method is the most popular method of concrete mix prescription, where the consultant structural engineer will give the proportions of the cement, sand, gravel and water to be used for the concrete production with the targeted strength. On field, it is noticed that the actual strength of concrete is always less than the targeted strength. This research aims at determining the amount of cement needed to be added to the actual mix of 1:2:4 in order to get the targeted strength. Six various set of concrete cubes were produced by increasing the cement proportion by 10%,20%,30%,40% and 50% after producing the control mix from 1:2:4 mix ratio. Compressive strength test was carried out using the automatic digital compression machine. Cubes were crushed at 7,14,21 and 28 days respectively.at 28 days, the characteristics strength of concrete for the control mix ,10% ,20%,30%,40% and 50% cement increase yielded 8.86, 9.65,10.23,10.45,11.01 and 11.43 N/mm^2 respectively.

***Keywords**:- Prescribed Mix, Concrete, Targeted Strength, Characteristic Strength.*

I. INTRODUCTION

Concrete is the most widely used material in the world next to water. (Bhami and Lakshoni, 2014). Oluyemi (2014) described concrete is an extremely versatile materials of construction which is used for a variety of works. It could either be reinforced (reinforced concrete) or unreinforced (plain concrete). The primary aim of constructing a concrete structure that can stand the test of time is to have its concrete structural elements meet the expected crushing strength value (Enesi, 2008). Concrete is a composite construction material made up of water, cement aggregates –fine and coarse and sometimes extra materials called admixtures. The constituent materials should be uniformly distributed during the process of mixing, transporting, placing and compaction so that the properties of the hardened concrete are not adversely affected. Concrete is known to be good in compression and weak under tension. Hence, for structural designers, compressive strength is one of the most important engineering properties of concrete.it is a standard industrial practice that concrete is classified based on grades.

The term 'characteristic' in current design codes normally refers to a value of such magnitude that statistically only a 5% probability exists of its being exceeded (Chanakya, 2009). BS 8110 adopts the criterion that no more than 5% of the sample should have less than a certain strength, this strength is called is called Characteristics Strength f_{cu} . Characteristic strength can be defined as that value of the cube strength f_{cu} , the yield or proof strength of reinforcement f_y or the ultimate strength of a pre-stressing tendon f_{pu}, below which 5% of all possible test results would be expected to fall (Chanakya, 2009) . The characteristics strength f_{cu} is given as

$f_{cu} = f_m - 1.64\sigma$
f_{cu} – The characteristic strength
f_m – The average values of the compressive strength (mean strength)
σ - Standard deviation.

The standard deviation σ is given by the following formula:

$$\sigma = \sqrt{\frac{\sum(x-m)^2}{n-1}}$$

Where, n is the number of values in the set of test,
x = any value in the set of numbers,
m = the average of the set of numbers.

According to Mosley et al. (2007), Characteristics compressive strength is a function of the mean compressive strength as well as a function of the variation of all the cube test results from the mean compressive strength of a set (represented by the standard deviation) . Since the compressive strength is a function of the following variables: the water/cement ratio, the degree of compaction and the properties of the aggregates, then the characteristics strength is a function of a function of all these variables.

From literature, it was noted that the actual strength of concrete is always less than the targeted strength for a particular type of sand used. Hence, this research work aims to determine the deviation of the actual compressive strength of concrete produced from the initial mix of 1:2:4 and the targeted strength using sand from a particular borrowed pit with specific water/cement ratio. Knowing the deviation of the actual and targeted strengths, the amount of cement necessary to be added the initial mix ratio of 1:2:4 in order to attain the targeted strength was determined.

II. MATERIAL AND METHODS

A. Materials Used
- Ordinary Portland cement
- Sand
- Coarse aggregate
- Water

B. Particle Size Distribution Test
The particle size analysis of a soil sample involves determining the percentage by mass of particles within the different size ranges. The particle size distribution of a coarse soil can be determined by the method of sieving. It is shown graphically on a particle size distribution curve. The particle size distribution curve can be used to get two major information about the soil sample; the range of particle size present in a soil and the type of distribution of various size particles. The test was carried out according to BS 1377: Part 2 (1990).

C. Natural Moisture Content Test
This is the determination of the of the field water content of the sand in question, it reveals the percentage of water contained in the soil. The test was carried out according to BS 1377: Part 2 (1990).

D. Aggregate Impact Value Test
Aggregate Impact value test provides a relative measure of the resistance of an aggregate to sudden shock or impact. The test was carried out according to BS 812: Part 112 (1990).

E. Aggregate Crushing Value Test
The aggregate crushing value (ACV) test set to measures how resistant an aggregate is, when being crushed under a gradually applied compressive load. The test was carried out according to BS 812: Part 110 (1990).

F. Production of Concrete Cubes
Prior to casting, standard wooden moulds (150mm * 150mm * 150mm) were made available as shown in plate 3.3 and the moulds were greased with engine oil to aid easy de-moulding. The concrete constituents were batched based on the initial mix ratio 1:2:4 (1 part of cement: 2 part of sand: 4 parts of aggregate). Then the cement proportion was increased by a definite amount for a successive period of 5 times (10%, 20%, 30%, 40% and 50% increment)

The equivalent water to cement ratio were added to a particular concrete then mixed thoroughly, the resulting fresh concrete were placed in the mould in three layers with 25 blows of tampering rod as compaction for layer. The test was carried out in accordance to BS 1881: Part 108, (1983).

G. Compressive Strength Test On Concrete Cubes
In accordance with the BS 1881: Part 108 (1983) the compressive strength test was carried out on all the cubes curing for 7, 14 21 and 28 days. The test was carried out using an automatic digital compression machine which adapts the hydraulic press system. The press consists of a ram, a crosshead, and upper and lower compression plates between which the specimens were crushed. The weights of each concrete cube were first measured before they were crushed. Care was taken to accurately position the Cubes centrally. The prime principles are that the upper machine plates shall align freely with the upper face of the cube as initial contact is made and shall be restrained from tilting with respect to the lower machine platen during loading. These principles were followed during the whole crushing exercise.

III. RESULT

Series of tests were carried out on the materials used. Slump test was carried out on fresh concrete for different proportion of cement. Compressive strength test was carried out on hardened concrete at 7, 14, 21 and 28 days for different proportion of cement.

A. Particle size distribution

sieve size (mm)	Weight of soil retained (g)	Percentage of sample retained (%)	Percentage of sample passing (%)
4.75	1.8	0.36	99.64
2.36	7.7	1.54	98.1
1.7	2.8	0.56	97.54
1.14	10.8	2.16	95.38
600	58.9	11.78	83.6
500	93.6	18.72	64.88
435	7	1.4	63.48
212	169.3	33.86	29.62
150	35.9	7.18	22.44
75	20.9	4.18	18.26
Pan	91.3	18.26	0
Total	500	100	

Table 1:- Result of sieve analysis of fine aggregate

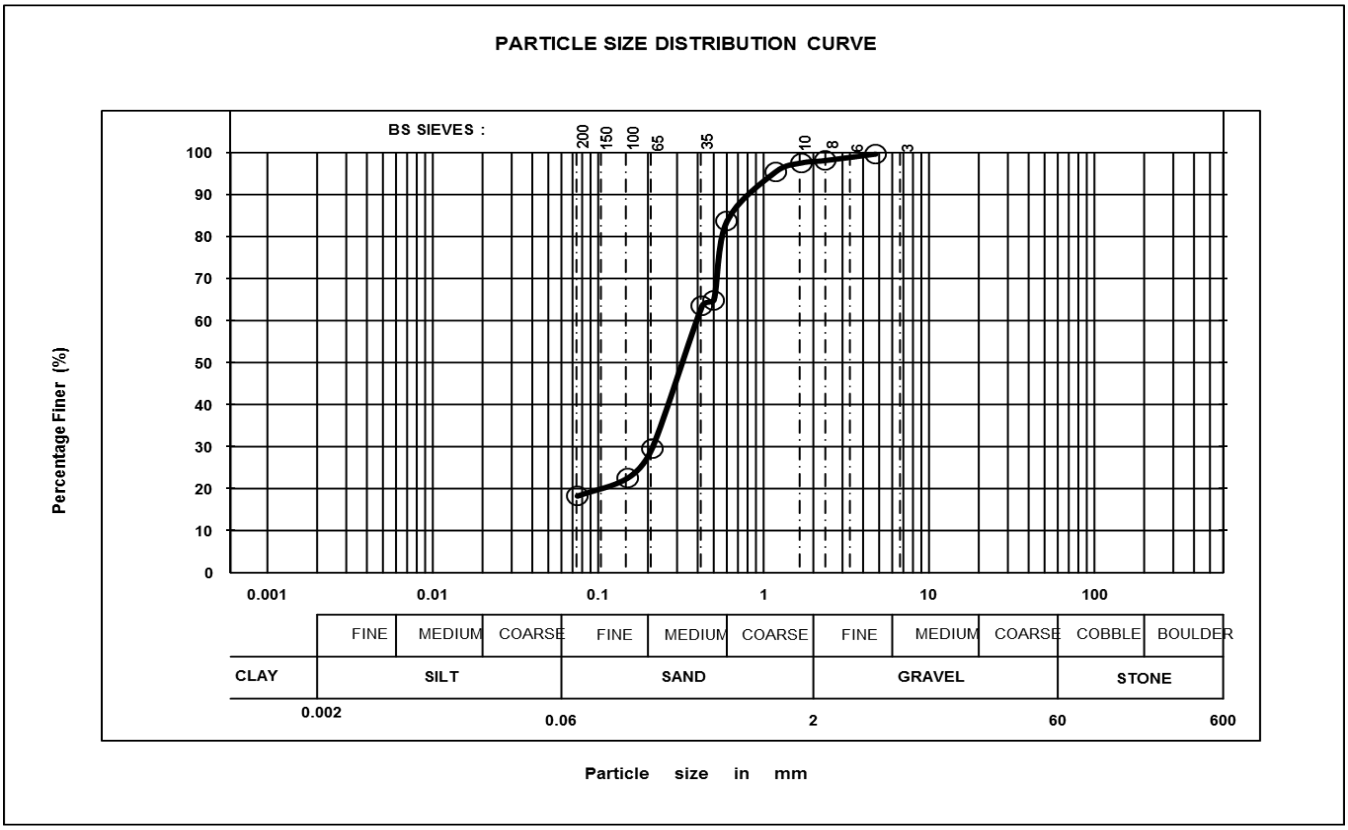

Fig. 1:- Particle size distribution chart

B. Moisture content test

	Sample 1	Sample 2	Sample 3
W1	24.6g	25.7g	23.3g
W2	138.4g	149g	134.9g
W3	130.7g	139g	129.69

Table 2:- Moisture content test results

W_1 =Weight of can
W_2 =Weight of can + wet sample
W_3 =Weight of can + dry sample

$$M.C\ (\%) = \frac{W_2 - W_3}{W_3 - W_1} \times 100$$

Sample 1

$$M.C\ (\%) = \frac{138.4 - 130.7}{130.7 - 24.6} \times 100 = 7.25\ \%$$

Sample 2

$$M.C\ (\%) = \frac{149-25.7}{139-25.7} \times 100 = 8.8\ \%$$

Sample 3

$$M.C\ (\%) = \frac{134.9-129.6}{129.6-23.3} \times 100 = 4.98\ \%$$

$$Average\ moisture\ content\ (\%) \frac{7.25+8.8+4.98}{3} = \frac{21.03}{3} = 7.01\ \%$$

C. Aggregate crushing value

OBSERVATIONS	Sample 1	Sample 2	Sample 3
M	509.8	526.3	513.5
M_1	175.5	162.6	150.2
ACV (%)	34.4	30.9	29.3

Table 3:- Aggregate crushing value result

M = Total weight of dry sample
M_1 = Weight of portion passing 2.36mm sieve

$$Mean = \frac{34.4 + 30.9 + 29.3}{3} = 31.5\ \%$$

D. Aggregate impact value

OBSERVATIONS	Sample 1	Sample 2	Sample 3
W	505.4	493.6	517.1
W_1	120.1	100.5	131.9
AIV (%)	23.8	20.4	25.5

Table 4:- Aggregate impact value result

W = Total weight of dry sample
W_1 = Weight of portion passing 2.36mm sieve

$$Mean = \frac{23.8 + 20.4 + 25.5}{3} = 23.2\ \%$$

E. Compressive strength test results

Cement increase	Characteristics strength of concrete (N/mm^2)			
	7 days	14 days	21 days	28 days
0%	2.43	6.01	7.96	8.86
10%	4.17	7.07	8.58	9.65
20%	4.2	8.2	8.68	10.23
30%	4.43	8.45	8.87	10.45
40%	5.16	8.75	8.94	11.01
50%	5.43	8.92	9.15	11.43

Table 5:- Summary of result of characteristics strength of concrete with increase in cement proportion at an initial mix ratio of 1:2:4

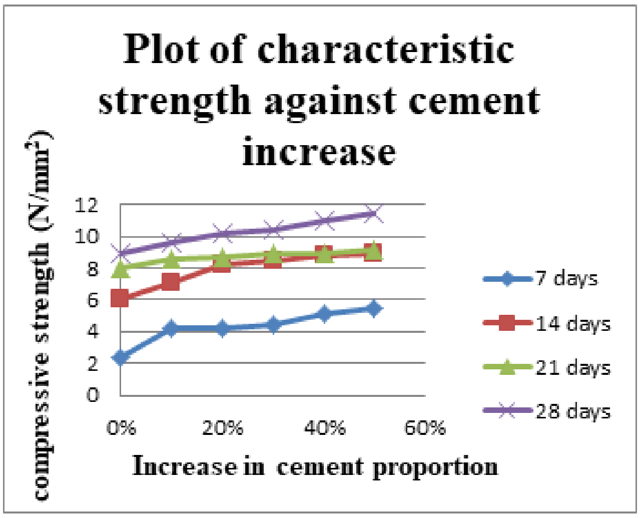

Fig. 2:- Graph of characteristics strength against cement increase

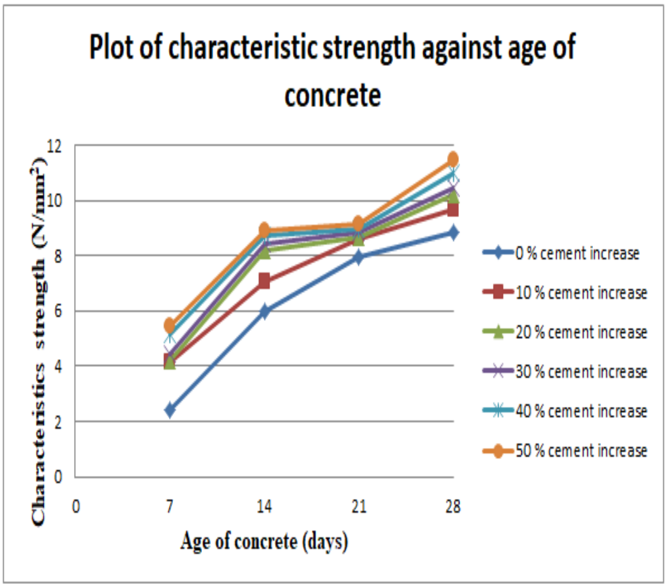

Fig. 3:- Graph of characteristics strength against crushing days

F. Workability test

Test type	Slump(mm)
Control	51
10% cement increase	46
20% cement increase	31
30% cement increase	29
40% cement increase	23
50% cement increase	19

Table 6:- Workability test result

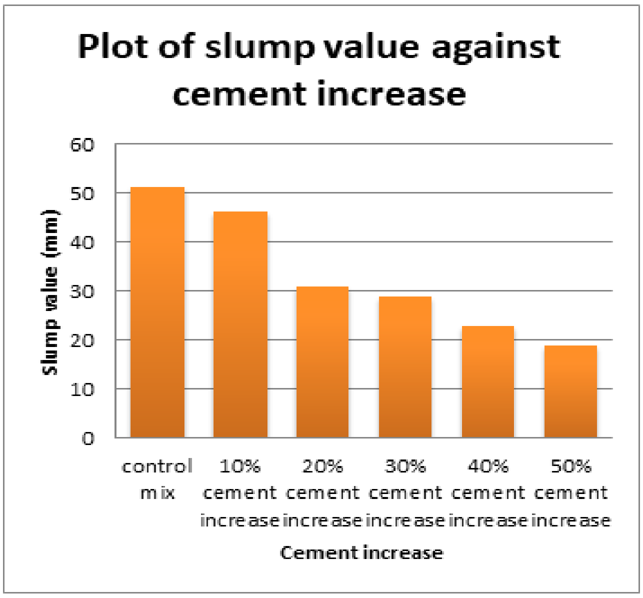

Fig 4: Graph of slump value against cement increase

IV. CONCLUSION

Following the results above, it can be concluded that from the production of concrete cubes by increasing the cement proportion at an initial mix of 1:2:4 will have remarkable effect on the characteristics strength of concrete.

From Figure 2, which shows plot of characteristics strength against cement increase , it can be seen that the characteristics strength of concrete increases gradually from the control mix (1:2:4) to 50% cement increase for 7, 14 , 21 and 28 days concrete. Also, from Figure 3, it can be observed that characteristics strength increases with crushing days for the control mix, 10%, 20%, 30%, 40%, and 50% cement increase.

At 28 days, the concrete produced from the control mix yielded a characteristics strength of 8.86 N/mm^2 and concrete produced from 50 % cement increase yielded a characteristics strength of 11.43 N/mm^2. It can therefore be deduced that 50% increase in cement proportion will give the targeted strength.

The quality of fine aggregates available and used is good and well graded quality. However, this project research work had shown that, despite the fact that there are little or no silt/clay particles in them (see figure 1), the fine aggregates used were well graded. Also, the quality of the coarse aggregates used was not good as shown from the aggregate crushing value test and the aggregate impact value test. However, it was not shown how this phenomenon affected the characteristic strength; further research in this line might prove more helpful.

RECOMMENDATION

Based on the challenges encountered and practical knowledge gained in this research work, the following can be recommended:

- Further research should be done on how the disparity of strength from the mean compressive strength of a range of cube test results can be reduced.
- Where higher characteristics strength at very low workability is desired, machine mixing should be used to prepare concrete and mechanized compaction should be adapted to compact concrete.

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