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Cement Stabilized Soil Blocks for Housing Construction in Urban Centers

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ABSTRACT
Housing standard in the third-world are rarely based on local materials and current local experiences. They have either been imported recently from developed countries or Inherited from the colonial past. These standards often allowed limited capacity of the people to pray for housing. It is therefore advisable for Government policy and standards on housing to be rational; so as to enable the population to owned personal Houses; especially in urban centers. This study Examines the functional part of cement stabilized soil blocks for Housing construction in urban centers; and various field and laboratory Tests carried out on samples of social with a conclusion.
Keywords: *Cement, Stabilized soil, Blocks, Construction*

INTRODUCTION
Shelter is one of the three basic necessities of life. Man is basic need after for and clothing has always been protection from the weather and other harmful substances to man. Throughout the ages, man searched for better and ages, man searched for better and new materials with which to build his structures. Has always being there among the construction of Buildings. The use of soil for building construction do not only solves the prevailing housing problem, but also protects regions from deforestation.

Soil Stabilization
Soil can be used as material for walls, floors, rendering and even roofs. However, there are not good soil construction practices and the material should be promoted to the extent that professional in the construction sector can make a choice for soil as an alternative to or in preference over other materials. It is along these lines that the objectives of wide scale adoption of the material could be achieved to meet the construction needs of low income people. The problems with unsterilized soil are the threat of water from rain or rising damp, its low tensile strength and low resistance to abrasion and impact [Hammond 1988]. A.A. Hammond has made a study of the common defects found in soil buildings and reported that the main causes of deterioration of earth buildings are cracks, shrinkage erosion, underscoring and mechanical damage directly or indirectly due to water [Hammond 1988]. But this is not an insurmountable problem. It can be overcome by stabilization with or without overhanging roofs and water resistant materials at the bottom of walls.
By using these techniques soil buildings can successfully be built in almost all climatic regimes, and with

proper care and maintenance they can last for decades [Agarwal 961].

Principles of Soil Stabilization
Any construction material has to satisfy certain quality requirements. Soil building elements should satisfy three requirements: strength durability and volume stability.

Area
Building Code Standards Vol. 7:1995 does not say much on these requirements. All it specifies is that adobe and stabilized soil blocks should be made of clay soil. And soil with high drying shrinkage (black cotton soil) should be avoided. Many countries also do not have standards for soil block building construction. In recognition of lack of standards and specifications for soil construction, an international workshop on formulation of standards and specifications for local building materials was jointly organized by United Nations Centre for Human Settlement (HABITAT), the Common Wealth Science Council (CSC) and the African Regional Organization for Standard (ARSO) in Nairobi in 1987. In consequence of the workshop, a technical recommendation was made for laterite-based materials mainly in Ghana. Experiences from other African countries including Ethiopia were incorporated. The following information is extracted from this specification [Hammond 1988]

Strength
The average compressive strength of five 24 hours soaked soil cement blocks shall be not less than 1.4Mpa.the compressive strength under dry conditions shall be not less than 2.1Mpa.

Water Absorption
The water abortion of cement blocks shall not exceed 10%

Durability (Erosion)
The block should not be appreciably pitted or eroded in two hours a fine spray of water of 1.5kg/cm² pressure. Strength recommended by different authorities differ, but a wet compressive strength of 1.4Mpa has been recommended by several building authorities throughout the world [Hammond 1988]. It is coming that soil at many localities is unsuitable wholly or partially to the requirements of construction in which case the properties of the soil have to be altered. The alteration of soil properties to meet specific engineering requirements is known as soil stabilization. For stabilization, knowledge of the properties of the soil and those properties that require upgrading is compulsory.
The properties of a soil may be altered by mechanical physical or chemical stabilization [Fekadu 1995].

Mechanical stabilization: this is the compaction of the resulting in changes in its density, mechanical strength, compressibility, permeability and porosity

Physical stabilization: the properties of the soil are altered by modifying the texture of the soil, for example by controlled mixing of different grain fractions.

Chemical satiation: this involves addition of chemical such as cement, lime and bitumen. Its properties are altered due to physic chemical reactions taking place in the stabilizer or between the stabilizer and the soil. This technique is more effective if accompanied by compaction in the moist state, which is usually the case. Some stabilization act on more than one of the properties to be upgraded: strength, durability and volume stability. An example is cement stabilization that improves all the three these properties are discussed briefly as follow

Strength: strength of any wet soil is low another factor affecting strength is grading of soil. a soil with poor grading will have low strength densification by compaction or adjustment of grading is a useful means for upgrading the mechanical properties of a soil. Another method is either to convert the soil to a rigid or granular mass by addition of cement or lime or retard moisture movement by blocking pores using bitumen.

Durability: resistance to the process of weathering and erosion is desirable natural soil has a wide range of disabilities and those with poor durability have to be improved. Durability is chiefly a surface problem and is reflected in high maintenance costs

Volume Stability: many clay soil swell or shrink with change in moisture content this can be remedied by converting the soil to a rigid granular mass the particles of which are strongly bound to resist effects due to moisture ingress the other way is by blocking pores to retard moisture movement by surface treatment. Neither mechanical nor physical stabilization methods stabilize a soil high degree. Chemical stabilization is the most effective method.

Mechanism of Cement Stabilization

The mechanism by which a small proportion of cement changes the prosperities of a large mass of soil is still to be completely defined. It has been suggested that the cement forms either strong nuclei distributed throughout the mass, or else that a skeleton of hydrated cement is formed throughout the voids in such a manner as to restrain the unaffected soil. Herzog [Ingles and Metcalf 1972] has shown that in montmorillonite clay the stress-strain behavior supports a nucleated structure at low cement contents, which changes to a skeleton structure as cement contents increased and the nuclei grow into each other as a result of secondary cementation process. This continuous skeleton process in his experiments at a cement content of only 2.5 percent.

Ordinary Portland cement contains about 45 percent tricalcium silicate

(C_2S), which hydrate to form mono- and di-calcium silicate gels (CSH and C_2SH) according to the following chemical reactions.

$C_2S + 2H = C^2SH + CH$ (1)

$C_2S + H = CSH + CH$ (2)

Free lime (CH) is liberated in the hydration reaction. The insoluble mono-and di-calcium silicate gels crystallize slowly into an interlocking matrix that bind the inert soil together the magnified view of which is shown in Fig 1.

Test on cement stabilized compressed soil Blocks. The tests generally consists of two operations cored out; namely:-Test for suitability of the soil and Test on the specimen moulded from the soil with cement mixture in the Laboratory

Tests for the suitability of soil

Before the field trip; preliminary information were obtained from the previous Building design professionals and Individuals, which provide the soil used to be unstable sandy soil. A field trip was then carried out for preliminary tests, which finally provided a base that there are two types of soil namely- Le Sandy soil and silky soil. A further test was then carried out; silky sand was suitable for the construction of houses. A laboratory test was finally carried out on the silky soil to further as Crain size analysis plasticity and compaction tests were also carried out.

Grain size curve of soils should fall within the shade region in Fig. 2 for suitability for compressed soil block production Stulz and Mukerji 1988]. Range of effectiveness of different stabilizers is also shown in Fig. 3 for soils of different liquid limit and plasticity index. A combined sieve and hydrometer analysis, was made, and the result plotted in a curve from which the composition of the soil is read as

Gravel	-	5%
Silt	-	40%
Sand	-	47%
Clay	-	8%

The curve falls within grading envelope of soil suitable for compressed soil blocks except at the end (clay<10%), and hence it is suitable for production of compressed soil blocks.

The result of plasticity tests can be summarized as

Liquid Limit = 34%
Plastic Limit = 20%
Plasticity index = 14%

It is a soil of high plasticity. These value also fail within the liquid limit – plasticity index- plastic limit envelop of soils suitable for cement stabilization.

Standard proctor compaction test was carried out on the soil the result is plotied.

From the curve

Optimum moisture content = 16%
Maximum dry density = 1740 kg/m^3
Specific gravity of the soil grains = 2.7

Density and optimum moisture on the pressure of compaction. Standard proctor is developed for soil compacted into road and dam embankments and does not give precise information for the purpose at hand. Therefore,/ the compaction was made by using the machine used to mold the specimens which is a Ellson-Block Master machine on the pulverized soil mixed with cement. The Ellson-Block Master exerts a pressure of 7 MPa when operated by two people. A curve was plotted and values read as: Optimum moisture content = 21 percent

Maximum dry density = 1525 kg m^3

The soil was also tested for organic matter and sulphates content, and was found to be free of these deleterious substances.

The cement used is ordinary Portland cement produced by Mugher cement Factory.

Tests on Specimens Molded from the Soil – Cement Mixture

The purpose of the test is to come up with the least proportion of cement that results in blocks of satisfactory strength and durability. Block specimens with different cement contents were then mcided using Ellson-Block Master manual press machine. Unsterilized soil blocks were also molded and tested to see the improvements achieved by stabilization. Cement of 2.5%, 5%, 7.5%, 10% and 12.5% by weight of the dry soil and optimum moisture by weight of the soil-cement mixture was added, which is thoroughly mixed to a uniform mass manually and molded into blocks. It is recommended to take average strength of 10 blocks in some literature due to variability of the material. Therefore, average strength of 10 blocks is taken for blocks of cement the 28 days sample. For the durability test only three specimens are taken for each cement content due to lack of sufficient number of ovens. The durability test is carried out on specimens cured for 28 days. At the end of the durability test, these specimens were test for compressive strength to see the effect of weathering on strength. Proper curing is an essential prerequisite to obtain hardened effect of the blocks. The specimens were left at room temperature for 24 hours covered with polyethylene sheet and then cured by sprinkling water daily for 7, 14, 28 and 60 days and covering with polyethylene sheet. The room has a temperature of 18 + 0.5^0c and relative humidity of 85 + 3 percent. Blocks with no cement were dried in the shade for three days and in the sin for seven days [Hammond].

At the end of the curing period the specimens were ready for the different tests.

Compressive Strength Test

After each curing period, the specimens were unwrapped, immersed in water for 24 hours and tested for wet compressive strength, which is summarized in table 1 and plotted in Fig.4 to Fig.6. dry strength is also given in table 1 for 28 days specimens. The testing was carried out in a universal testing macjine at a loading rate of 3.5 MPa per minute [Eshetu 1984]. Soil block with no cement were also tested for dry strength and were found to have a strength of 1.10MPa. wet strength test could not be done because theses slaked completely after 24 hours of immersion in water.

Water Absorption Test

In order to investigate the effect of water absorption of the stabilized soil blocks during the rainy season, similar test has to be conducted in the laboratory. Therefore, after 28 days of curing, the specimens were immersed in water for 24 hours and the gain in weight determined in relation to the dry weight of the samples. Water absorption of the blocks at age of 28 days was determined for the different proportions of cement. The result are given in table 2 and shown in fig.7

Spilt Tensile Strength test

This type of test is an indirect method of applying tension in the form of splitting. The theoretical analysis of the split test is based on the theory of elasticity. It would provide a good indication of tensile strength of the blocks. The test was conducted using flexure machine that can be used for split test also. The block is spilt into two by loading edge of the machine and the peak-spilt load used to calculate the tensile strength Equation 3.

$$Ơ \quad \frac{2F}{rdd}$$

Where Ơ is spilt-tensile strength in Pa

F is maximum split load in N

I and d are length and depth of Specimens respectively in mm

The results are given in Table 3 and shown in fig8. 8.

Durability Test

In actual practice, stabilized soil blocks used for external purpose will be subjected to drying and wetting during the dry and rainy season respectively. The cause of wetting and drying has effects of disintegration on the compacted soil particles resulting in loss in weight. The soil specimens were cured for 28 days and then subjected to 12 cycles of drying in oven at 71^0c for 42 hours and then immersed in water for 5 hours and to be removal of lessened material from the specimen surface by a soft hair brush [ASTM D559-57 1972]. The total loss in weight after 12 cycles of drying and wetting were determined as the percentage of the original dry weight of the blocks after 28 days of cursing. The results are given in table 4 and shown in Fig 8. Durability test was tried for blocks with no cement but the blocks slaked partially and could not taken out of water after 5 hours of immersion right at the end of the first cycle.

DISCUSSION OF THE TEST RESULTS

As the cement content increased, the compressive strength also increased due to formation of interlocking insoluble gels binding the soil together and forming a semi rigid structure having strength. The curing of the specimens for a longer period helps the completion of hydration reaction of cement causing increase in strength but the rate of increase decreased after 28 days. The different between dry and wet compressive strength for the 28 days specimens is small. This is because the sample for dry strength were cured sprinkling water daily and covering with polyetythylene sheet, which makes them nearly saturated this same reason applies to the low percentage of water absorption as to dry strength comparison cannot be made between soil-cement blocks are cured by sprinkling water daily and covering with polyethylene sheet until tasted whereas the blocks with no cement are dried in the sun for 7 days the wet strength of soil-cement blocks are tabulated in table 1 where as wet strength of soil blocks with no cement is zero. An immense improvement is achieved by stabilization. The water absorption characteristics of the specimens decreased with increase in cement content due to the formation of the semi rigid structure which is more resistant to penetration of water. The split tensile strength is between one-tenth and one fifth of dry compressive strength as expected except for the 2.5 percent cement which is smaller than one-tenth of the compressive strength. The weight loss after 12 cycles of drying and wetting also decreased as the cement content increased because the soil particles are held together by the semi rigid structure which resists disintegration

Selection of Optimum Cement Content

In order to select the economical cement content for a soil of similar nature in the field inference of the test results to the specifications necessary. It is specified that a minimum average compressive strength of 1.4 mpa at 28 days should be attained and weight loss should not exceed 10 percent. A maximum of 10 percent for economic reason are recommended. Thus, 6.1 percent cement should be used for which wet strength is 1.4 mpa and weight loss is 9.74 percent which also is in the recommended range

CONCLUSIONS AND RECOMMENDATIONS

From the result and discussions, the following conclusion and recommendations may be made Cement content has an effect on the compressive strength and spilt-tensile strength in proportion to its quantity. Both strength increased with an increase in cement content. The cement content that resulted in a wet compressive strength of 1.4 MPa and weight loss than 10 percent. This percentage can be recommended as the optimum cement content for the soil under investigation. The compressive strength of the stabilized soil blocks also increased with curing period. The rate of strength gain is relatively high at early ages. Curing the specimens above 28 days causes only a small rate of gain in strength. The percentage of weight gain during the water absorption test decreased with increase in cement content.

The weight loss decreased with increase in cement content for repeated cycles of during and wetting (durability test). Cement contents varying from 6.1-10 percent give effective results concerning strength and durability for the soil under consideration and may be recommended for use as walling material for single story buildings without rendering

Table 1: Effect of Cement Content and Curing on Compressive Strength

Cement Content(%)	**7days wet strength(MPa)**	**14day swet strength(MPa)**	**28 days wet strength(MPa)**	**28daysdry strength (MPa)**	**60 days wet strength (MPa)**
2.5	0.28	0.28	0.31	0.00	0.35
5.0	0.73	0.79	1.20	1.21	1.53
7.5	0.95	1.20	1.66	1.78	2.17
10.0	1.17	1.25	2.14	2.24	2.79
12.5	1.26	1.31	2.33	2.43	3.04

Table 2: Effect Cement Content on Water Absorption

Cement content (%)	2.5	5.0	7.5	10.0	12.5
Water-tensile strength after 28 days (%)	0.11	0.20	0.29	0.37	0.45

Table 3: Effect of Cement Content on Split-Strength

Cement content (%)	2.5	5.0	7.5	10.0	12.5
Split-tensile strength after 28 days (%)	0.11	0.20	0.29	0.37	0.45

Table 4: Effect of Content on Durability of Stabilized Specimen

Cement content (%)	2.5	5.0	7.5	10.0	12.5
Water-tensile strength after 28days(%)		10.84	8.52	5.83	3.55

Fig 1. Magnified View of Hardened Mono- and Di-Calcium Silicate Gels [Ingles and Metcalf 1972]

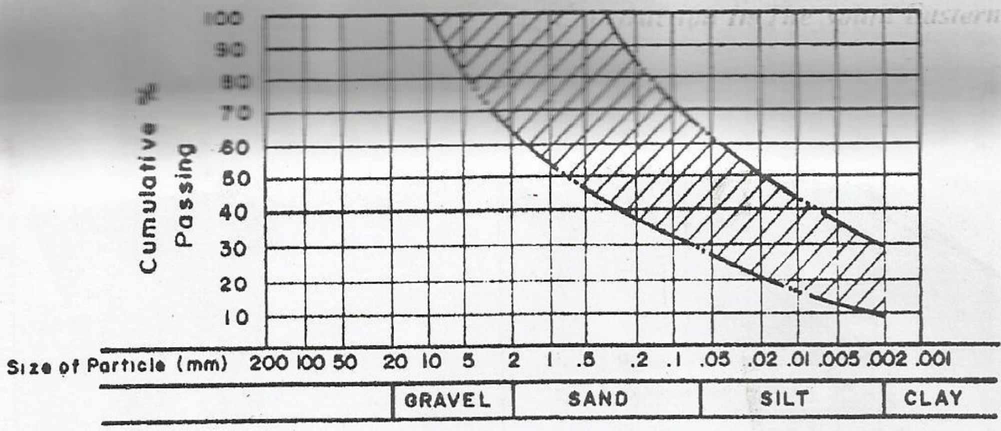

Fig.2. Soils with Good Gradation for Compressed Earth Block Production [Stulz and Mukerji 1988].

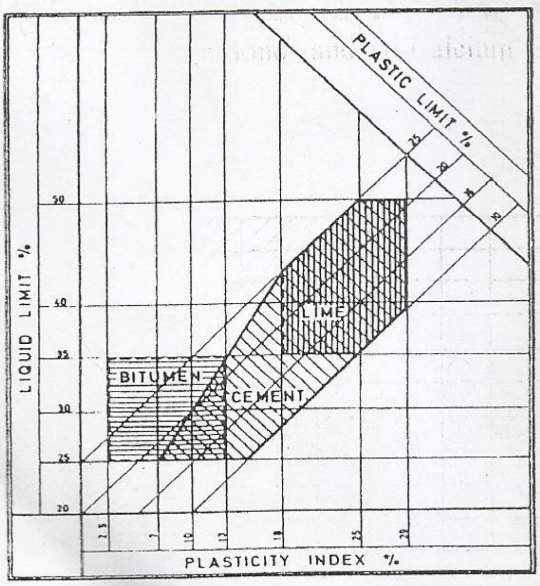

Fig.3. Range of Values of Liquid Limit and Placiticity for Different Stabilizers [Stulz and Mukerji 1988]

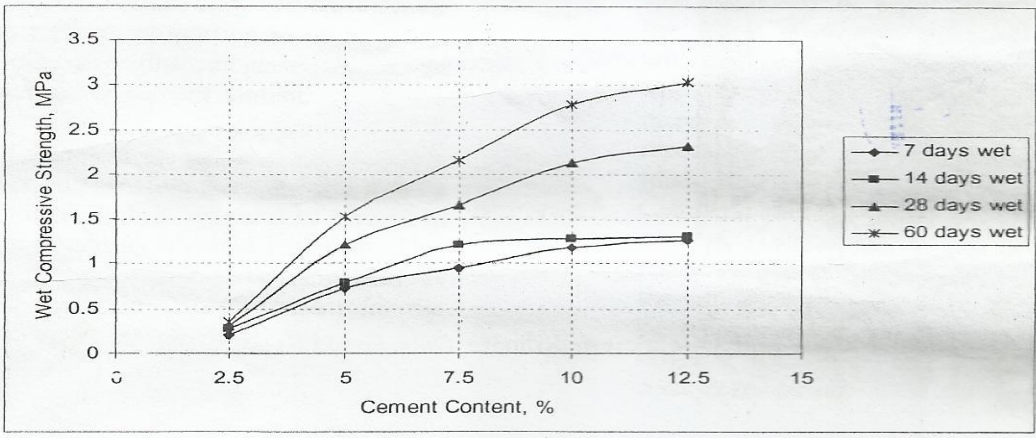

Fig. 4 Effect of Cement Content and Curing on Compressive Strength

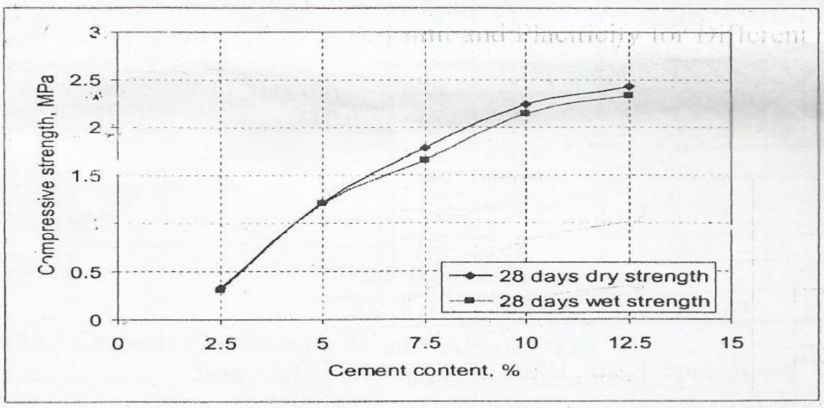

Fig. 5 28 Days Wet and Dry Strengths of Specimens

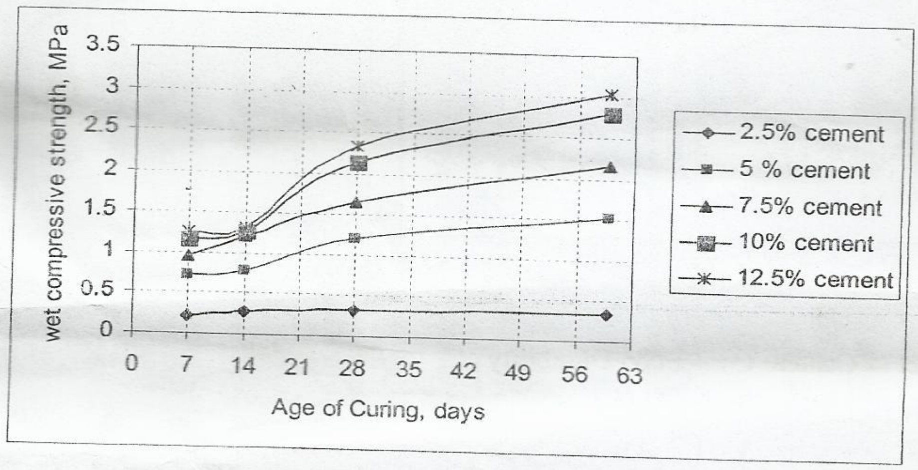

Fig. 6 Effect of Age of Curing on Compressive Strength

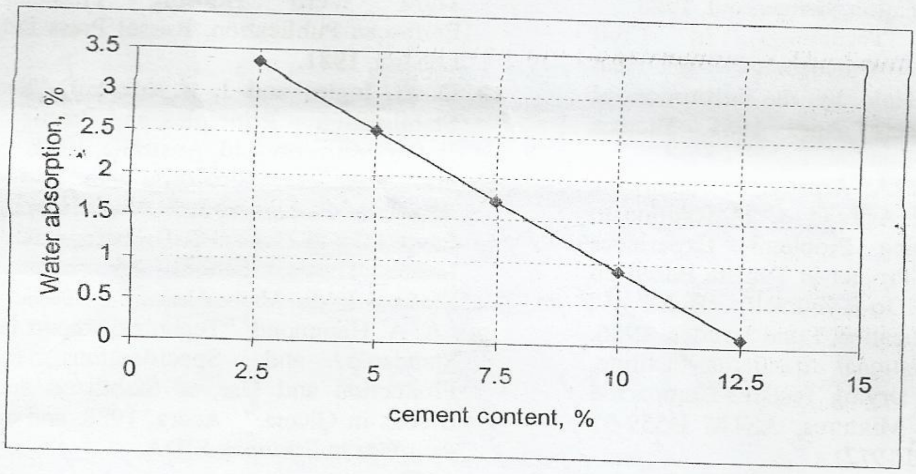

Fig.7. Effect of Cement Content on Water Absorption

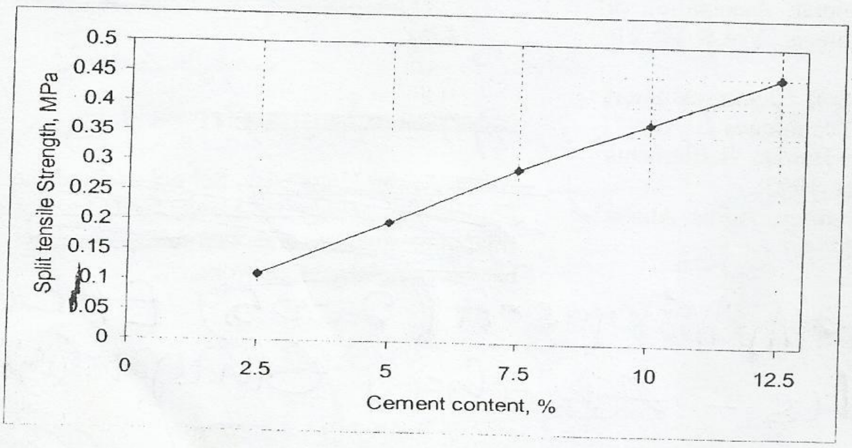

Fig.8 Effect of Cement Content on Split-Tensile Strength

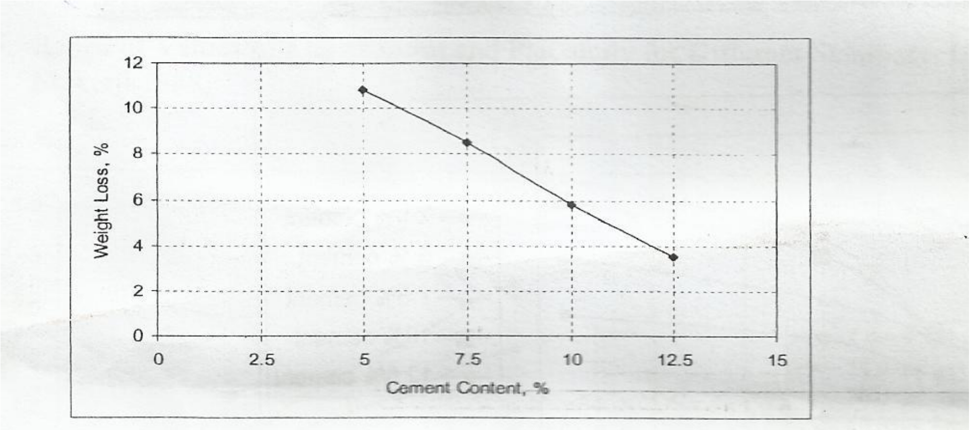

Fig.9 Effect of Cement Content on Durability

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