ECONOMIC CONSIDERATION OF STABILIZED SOIL BLOCK

PROJECT REPORT

Submitted in Partial Fulfillment of the Requirements for the

Award of the Degree of

BACHELOR OF ENGINEERING IN

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OF THE BHARATHIAR UNIVERSITY

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KUMARAGURU COLLEGE OF THECHNOLOGY

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Coimbatore – 641 006.

CERTIFICATE

This is to certify that the Report entitled

ECONOMIC CONSIDERATION OF STABILIZED SOIL BLOCK

has been submitted by

Mr. ....

in partial fulfilment for the award of Bachelor of Engineering in the

Civil Engineering Branch of the Bharathiyar University

Coimbatore – 641 046 during the academic year 1998-99

15/3/99.

....

Guide *Head of the Department*

Certified that the candidate was examined by us in Project Work

Viva-Voce Examination held on .... *and the University*

Register Number was ....

....

Internal Examiner *External Examiner*

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SYNOPSIS

The aim of the present investigation is focused on the experimental work of stabilized soil block obtained by stabilizing the soil available locally at Vadavelli with stabilizers like Cement and Lime with Fly-ash, Quarry dust, Rice Husk, Saw Dust and Gypsum in various combinations, thereby reducing the cost of block with increased strength.

The economy in making of stabilized soil blocks is to be obtained only after detailed investigations on stabilized soil blocks made with different percentage of stabilizers of different combination. The soil test are being done to find its quality. The compressive strength of the block has been found after 7 days of curing.

Cost analysis has been made for all the stabilized soil blocks with various combination of stabilizers and also for optimum strength (obtained from the test data). It has been observed that blocks having combination of 5% of cement combined with 1% of rice husk and 25% of sand gives optimum strength result. There is 41% cost saving in block compared with burnt bricks.

Cost analysis is also made for soil block masonry assuming 5% Cement and 1% of Rick-husk as stabilizer and it is compared with ordinary brick masonry. The saving in cost per cu.m of wall worksout to nearly 25%.

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CHAPTER – 1

INTRODUCTION

Next to food and clothing, the third world has on it a major problem, the massive and gigantic deficit in housing.

At present India has a population of about 100 million. Nearly, about 75% of total population live in rural areas while the 25% live in urban areas. It is reported that about 25 million people are without dwelling. Low and middle income group finds it difficult to construct their own houses, and the time has come to ensure optimum utilization of the resources available.

The housing development has various complex dimensions, the important one is the use of appropriate building technologies to reduce the time and cost of the construction. To ensure economy, strength and better quality, implementation of new low cost materials with improved techniques in construction is essential.

In construction works, the building materials accounts to 70 to 80 % of total cost of construction in which about 28% of total cost account for the cost of super structure (wall). In order to minimize the cost of construction, introduce new techniques for making wall materials at low cost.

The use of traditional construction practices and local materials with appropriate technology inputs appear to be holding the key for majority of the countries. Earth is being used as a building material from time immortal. It's high thermal insulation and heat storage capacity makes it an ideal material for the hot arid zone of our country.

Building with earth requires special skills and special equipments. Each soil has its own properties, advantages and limitations. Soil never has consistent characteristics and behavior. So we should know the characteristics of soil before doing any thing on it.

The use of mud with scientifically backed technological inputs like stabilization using cement or lime has been reported to be low cost with good strength and better durability.

The strength and resistance to weathering, of almost all soils increases when treated with stabilizers. The properties increases by increasing the percentage of the stabilizers. For every soil there exists an optimum stabilizer requirement for maximum strength. The amount of stabilizer depends upon the type of stabilizer used and the properties of soil .

It is a well known fact that the cost of the construction depends on the cost of material and transportation. Hence it is obvious that if soil available at the site or nearby the construction of building, is made use of it, will result in the reduction of cost to a great extent.

Keeping all these factors in mind, the present study is conducted to explore the possibilities of reducing the cost and increase the strength of the soil blocks using soil available at Vadavalli, Coimbatore.

CHAPTER – 2

REVIEW OF EARLIER RESERACH

A brief account of the research work done by the various investigators on the stabilization of soil with cement is given in this chapter.

1. ROSENAK .S.

During 1957 Rosenak did the testing and development work in Burma on behalf of the United Nations Technical Assistance Administration, for the national housing town and country development – board, union of Burma. Part of the work was done along with R. Fitzmaurice.

In 1949 a large stabilizer soil housing project compressing the construction of 4000 houses by the rammed earth technique in the east Punjab, India. It was carried out under the guidance of Rosenak.S.

Based on his experiment and experience, he gave the following conclusion.

(i) The method (soil stabilization) is found to be too expensive compared to, say, ordinary brick work, if an addition of cement much in excess of 5% is required.

(ii) Power operated machine produced blocks under 7 N/mm^2 and the blocks had crushing strength twice as high as that of block made by hand operated machine, which exerted a pressure of 2.8 N/mm^2. It also depends upon the type of soil used.

(iii) Increased density of blocks results in increased compressive strength.

(iv) Soil having liquid limit below 25, clay content upto 20% , a minimum sand content of 35% and plastic index between 8.5 to 10.5 in found to be suitable for stabilization with 5% cement.

(v) For clayey soil (with plasticity index >12) the compressive strength increases with the increase in moulding moisture content.

For the sandy soils (with plasticity index 0 to 5) the compressive strength increases with the decrease in moulding moisture content.

(vi) Increasing percentage of cement results in the increase of wet-dry strength ratio of the block.

(vii) Wet crushing strength increased with the decrease in percentage of moisture absorption of the block.

(viii) All blocks with lower cement content disintegrate within periods of 1 hour to 116 days.

(ix) As far as moisture movement is concerned, soil stabilized blocks are inferior to ordinary burnt bricks. This requires limiting the strength of wall or provision of joints.

(x) The addition of cement considerably reduces the initial drying shrinkage of stabilized soil blocks.

(xi) Co-efficient of thermal expansion increases with an increase in the density of compacted blocks.

(xii) An increase in the cement content increases the co efficient of thermal expansion.

(xiii) The strength of the mortar, should be related to the strength of the blocks in order to control shrinkage cracks.

(xiv) Substituting a simple cement wash in the place of rendering for stabilized soil block wall is found to be satisfactory. This is because the surface of the block is much smoother than the surface of burnt bricks and hence rain water will drain off easily.

II. BRICHT SELVIN.S., DHINAKAR RAJ MOSI, & KANAGARAJ. M.

Based on their test results they gave the following conclusions :-

(1) The ultimate compressive stress of the soil stabilized block increases with the increase in cement keeping the other factor constant.

(2) The ultimate compressive stress of the blocks increases with decreasing percentage of moulding moisture content for a given percentage moisture content.

(3) The density of the blocks decreases with increasing moulding moisture content.

(4) Even though the compressive strength of block was slightly less than strength prescribed for such block by IS code, it is possible to attain this strength by suitably modifying the compaction pressure.

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Indian Institute of science, Bangalore following conclusions are made by them based on their tests and experience with stabilized soil blocks.

(1) Soils containing too manipulating sand or clay content to poor handling strength is reduced. Such soils may be utilized by adding suitable quantity of coarse sand and clayey soil.

(2) Soil containing considerable amount of clay are often not suitable for cement stabilization. Such soils can be stabilized by adding sand and lime suitably.

(3) Block having

Wet strength $\geq$ 2 N/mm^2 used for two storeyed building with span 3.6 m and less.

Wet strength 1.2 to 2 N/mm^2 used for single storeyed buildings.

Wet strength 0.7 to 1.2 N/mm^2 used for single storeyed and light roofed building.

(4) pressed mud blocks made from red soils having more than 10%clay content possess good erosion resistance. Hence it is preferable to choose soils having at least 10% clay for better performance.

(5) Soil cement block masonry does not require outside plastering , mortar volume in the masonry is less than that of brick masonry and labour cost of construction is less.

(6) Cement stabilization is often well suited for soils containing about 60-70% sand and 10-20% clay for soil cement block.

CHAPTER - 3

OBJECT OF PRESENT INVESTIGATION

The objects of present investigation is to study,

1 The compressive strength of soil blocks stabilized with different stabilizers such as cement, lime, cement and fly ash, cement and quarry dust, cement and rice husk, cement and saw dust, fly-ash, lime and gypsum combined together .

2 The cost of production of stabilized soil blocks are compared with ordinary bricks and compare the economy of stabilized soil block masonry with ordinary brick masonry .

CHAPTER – 4

DETAILS OF MATERIAL USED

1. CEMENT

The natural cement is obtained by burning and crushing the stones containing clay , carbonate of lime and some amount of carbonate magnesia. The natural cement is brown in colour and its best variety is known as the Roman cement. The natural cement resembles very closely eminent hydraulic lime . It sets very quickly after addition of water. It is not so strong as artificial cement and hence , it has limited use in practice.

Composition of ordinary Portland cement :

The ordinary cement contains two basic ingredients namely argillaceous and calcareous .In argillaceous materials, the clay predominates and in calcareous materials the calcium carbonate predominates.

Properties of cement :

The following are the important properties of a good cement which primarily depend upon its chemical composition , thoroughness of burning and fineness of grinding.

(1) It gives strength to masonry .

(2) It is an excellent binding material.

(3) It is easily workable .

(4) It offers good resistance to moisture.

(5) It possess a good plasticity.

(6) It stiffens or hardens early.

2. FLY ASH

Fly ash is a hazardous industrial waste. It posses a formidable challenge to human ingenuity, in regard to its satisfactory utilization and / or disposal. Its generation is highest at the thermal power plant . Thermal power plants in India will generate double the above in the next decade or so. Besides thermal power plants coal ash is also produced by other coal assuming industries such as cement , fertilizer, sugar , rubber, iron and steel etc.

Coal ash forms 3- 30% of burnt coal and gets separated into two parts bottom ash and Fly ash. The composition of main elements is found to be just about the same in Fly ash and bottom ash , but in the case of trace elements, concentration can vary .The minor element mainly depend upon the coal quality which usually varies from mine to mine.

The major element of Fly ash are the oxides of silicon, aluminum, iron and cerium which constitute to 95 to 99% of the ash and the rest is made up of small amount of magnesium, thorium, sulphur, and lime and (3.5 to 0.5%) and the traces of about 20 – 50 other elements.

3. LIME

Lime is a simple cementing material produced by driving of water from natural material, its cementing properties are caused by the reabsorption of the expelled water and the formation of the same chemical compounds of which the original raw materials was composed.

Due to calcination of lime stone, moisture and Co_2 are removed from it. Product which remains there after is known as lime. its chemical composition is calcium oxide (CaO).

The chemical reaction is as follows:

$CaCo_3$ ----- CaO + Co_2

(Lime stone) lime (carbon dioxide)

The building limes according to BIS 712-1984 (third revision) are classified under 6 groups , namely

Class A : Lime is the eminently hydraulic lime which is used for structural purpose, and is to be supplied in the hydroxide form only .Its minimum compressive strength with lime sand mortar , at the end of 14 days to 28 days is 1.75 N/mm^2 and 2.80 N/mm^2 respectively.

Class B : Lime is a semi hydraulic lime which is used for mortars for masonry works .Its minimum comp strength with lime sand mortar, at the end of 14 and 28 days are 1.25 N/mm^2 and 1.75 N/mm^2 respectively.

Class C : Lime is a flat lime which is used mainly for finishing coat in plastering, white washing etc., and to produce artificial hydraulic mortar.

Class D : Lime is the Magnesium or Dolomite lime which is used for finishing cost in plastering and white washing etc.

Class E : Lime is the Canker lime which is used for the masonry mortar and it is to be supplied in the hydrated form only

Class F : Lime is the siliceous dolomite lime which is used for under coat and finishing coat of plaster. It is to be supplied in hydrated of quick form.

4. GYPSUM

Calcium sulphate combined with two molecules of water or crystalline form having the approximate formula $CaSO_4 \cdot 2H_2O$

Calcined Gypsum :-

Gypsum partially dehydrated by means of heat having the approximate chemical formula $CaSO_4 \cdot \frac{1}{2} H_2O$

5. QUARRY DUST

These are the inert or chemically inactive material. The materials of rock dust which passes through BIS test sieve No. 480 is term as fine aggregate which is termed as quarry dust.

The quarry dust properties and characteristics mainly depend upon their parent rock from which they are being derived. The dust should be hard, durable and clean and they should be completely free from lumps of clay, organic and other impurities. The presence of all such debries prevents the effective bonding when used in the stabilized soil blocks and also the strength gets reduced.

6. RICE HUSK

Rice husk is a waste product left behind the harvest work of rice crop. Rice husk is a waste which is being used for various purpose.

The Rice husk possesses a number of valuable properties such as low heat conductivity, small bulk density and relatively high strength etc. Further it has it's own drawbacks such as susceptibility to decay, fluctuation in properties due to the changes in moisture content.

It is now used in stabilized soil blocks as a stabilizer which acts and which gives a optimum strength and gives a effective bonding between the material used and acts as fibre reinforced material.

7. SAW DUST

Saw dust is a waste product left behind the timber work. The timber simply denotes wood which is being used for various purpose.

The saw dust possesses a number of valuable properties such as low heat conductivity, small bulk density and relatively high strength etc. Further it has it's own drawbacks such as susceptibility to decay, fluctuation in properties due to the changes in moisture content.

The saw dust are used with admixtures of organic glues to make fibber slabs, fibber boards. In addition to the above, it is used in the manufacture of various products such as organic acid, rosin, paper, card board, cellulose etc.

The properties and characteristics of saw dust are obtained from their parent tree from which they are being derived.

It is now used in stabilized soil blocks as a stabilizer which acts and which gives a optimum strength and gives a effective bonding between the material used.

CHAPTER – 5

STABILIZED SOIL BLOCKS

STABILIZED SOIL BLOCKS

Stabilized soil blocks is an energy efficient, interesting and aesthetic alternative to burnt bricks. They are simply made by pressing a mixture of soil and stabilizers like cement, lime, fly ash etc., in a machine at a suitable moisture content.

Salient features of Stabilized Soil Blocks :-

The effectiveness of stabilized soil blocks can be gauged from the following points.

1. Lower cost
2. Substantial energy saving
3. Comparable strength
4. More functional efficiency
5. Better appearance / Aesthetic features
6. Use of local resources and materials
7. No plastering is required

CHAPTER – 6

SOIL TESTS

In general, it may be stated that red sandy loam's are ideal for stabilized soil blocks.

The two types of soil test which have been done are

1. Field Test
2. Laboratory Test

1. FIELD TEST :

The field test results are referred to the conclusions made by HUDCO (Zonal Training Centre, Chennai).

Field test is to determine the type of soil.

The field test is conducted before the blocks are made.

a. Dry Strength Test :

- Prepare two are three pats of soil
- Prepare the pats in the sun or in an oven, until they have completely dried
- Break a soil pats by keeping them between thumb and index finger
- Approximately estimate the strength of the pat.

OBSERVATIONS	INTERPRETATIONS	NATURE OF SOIL
High Dry strength	A dry pat is very difficult to break.	Almost pure clay.
Moderate Dry strength	A dry pat is not too difficult to break.	Silt or sand clay.
Low Dry strength	A pat can be easily broken and can be reduced to powder.	Silt or fine sand.

The soil which we have taken has moderate dry strength which indicates the soil contains silt or sandy clay.

b. Consistency Test :

1. prepare a ball of fine mortar 2 or 3cm in diameter.
2. Moisture the ball so that it can be modelled without sticking.
3. Roll the ball on a flat clean surface until a thread is slowly formed.
4. If the thread breaks before its diameter is reduced to 3mm, the soil is too dry, add water.
5. The thread should break when its diameter is 3mm
6. When the thread breaks, make it into a small ball again and crush it between thumb and index finger.

OBSERVATIONS	INTERPRETATIONS	NATURE OF SOIL
Hard Thread	Difficult to crush, does not crack or crumble.	High clay content.
Medium Thread	The ball tends to crack and crumble.	Low clay content.
Soft Thread	The ball has a soft or spongy feel.	High sand or silt content.

The soil which we used for the block making is of medium thread and of moderate clay content.

c. Cohesion Test :

1. Make a roll of soil about the size of a sausage with a diameter of 12mm.
2. The soil should not be sticky and should be capable of being shaped so that it makes a continuous thread of 3mm in diameter.
3. Place the thread in the palm of the hand, starting at one end carefully flatten it between the index finger and thumb to form a ribbon of 3 and 6mm in width as long as possible.
4. Measure the length obtained before the ribbon breaks.

OBSERVATIONS	INTERPRETATIONS
Long Ribbon (25 to 30cm)	High clay content.
Short Ribbon (5 to 10cm)	Moderate clay content.
No Ribbon	Low clay content.

The soil we used for the block making forms a short ribbon and so the soil contains moderate clay content.

2. LABORATORY TESTS

a. Specific Gravity Test – Using Pycnometer

Specific Gravity $$G = \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$$

Where, W_1 = Weight of empty pycnometer.

W_2 = Weight of pycnometer with one third amount of soil.

W_3 = Weight of pycnometer with $^1/_3{}^{rd}$ of soil and $^2/_3{}^{rd}$ of water.

W_4 = Weight of pycnometer with full of water.

TABULATION

S. No.	W_1 (gm)	W_2 (gm)	W_3 (gm)	W_4 (gm)	G
1	598	1053	1785	1506	2.60
2	598	1024	1766	1506	2.59
3	598	1041	1775	1506	2.56
					2.58

b. Liquid Limit Test

S.No.	Weight of Sample (gm)	Percentage of Water added	No. of blows	Liquid Limit
1	50	20	34	18.75 %
2	50	24	16	
3	50	28	11	

Moisture Content in the Soil Sample :

Weight of Container = 11 gm

Weight of soil Sample + Container = 48 gm

Weight of Dry Sample + Container = 46 gm

Moisture Content = 2 / 35 x 100

= 5.70 %

Therefore liquid limit of the soil sample = 18.75 + 5.70

= 24.45 %

c. Plastic Limit Test

Weight of the empty container = 10gm

Weight of container + Wet sample = 15.36 gm

Weight of container + Dry sample = 14.91gm

Plastic Limit of the soil = (15.36 – 10.00) / (15.36 – 14.91)

= 12.36 %

d. Plasticity Index

Plasticity Index of the sample = 24.45 – 12.36

= 12.09 %

According to ROSENAK . S, when the liquid limit is below 25% then the soil contains maximum of 20% clay and minimum of 40% of sand.

CHAPTER – 7

BLOCK MAKING AND CURING

BLOCK MAKING

Step – 1 : Soil Test

The first step in the block making process is to study the physical properties of soils by conducting various tests on soil as given earlier.

Step – 2 : Soil Mix Preparation

The second step in the block making is mixing of soil with stabilizers. The following steps may be followed.

1. Screen the soil through a 6mm sieve to remove gravel, roots etc.
2. Take the required quantity of soil and spread it on a level ground into a thin layer of about 10.5cm thick.
3. Take the required quantity of stabilizers and spread it uniformly on the soil.
4. If sand content of the soil is less than the required percentage, sand may be added to it.
5. Mix the soil and the stabilizer thoroughly either manually or in a concrete mixture.
6. Spread the uniformly mixed soil into a thin layer and gently sprinkle water (approximately 18 to 22 % of total volume of the block) on the mixture.

Step – 3 : Block Making In The Machine

The steps involved in the process are

1. The machine should be fixed on a level ground correctly in position.
2. Open the lid of the mould and hold the compaction lever in vertical position. Insert the thin base plate into the bottom of the mould.
3. The sides of the mould, including the base plate is lubricated with oil. The lubrication may be repeated once after 8 to 10 blocks are made.
4. The prepared soil mixture is taken in the standard scoop and poured into the mould completely.
5. Now the lid of the mould is closed with a slight impact and the screw in tightened such that the lid is held down tightly.
6. The compaction is now carried out by pulling the lever down till it reaches the stopper. During this process the maximum compaction pressure applied by the ITGE VOTH machine which we used is $3N/mm^2$
7. The lid is now opened by loosening the screw jack. The compaction lever is pushed down forcing the compacted block to come out of the mould.
8. The ejected block is removed by sliding it horizontally along with the thinner base plate.
9. The block is now stacked for curing by gently removing the base plate which is brought back to make the next block.
10. The above processes are repeated till the required number of blocks are made.

CURING

1. After block making, the blocks are stacked on a level ground preferably in a shaded area.
2. The stacking yard should be as close to the machine as possible
3. The blocks may be stacked one above the other, but the block should be numbered indicating the proportion of stabilizer used and date on which it was made.
4. Car should be taken to see that the blocks are stacked as closely as possible to prevent air circulation so that the moisture is preserved for better curing.
5. Curing is done by gently sprinkling water on them using a garden rose cane.
6. A layer of straw or gunny bag etc may be spread on the top most layer of the block.
7. The block can be cured for 7 days to find out the 7days strength.

CHAPTER – 8

TESTING OF SAMPLE SPECIMENS

The suitability of any material for construction purpose can be recommended only after testing the materials and analysing the results obtained.

The important parameters which influence the durability of the block are

1. Its compressive strength
2. The percentage absorption of moisture.

(1) COMPRESSION TEST :

The test is generally carried out in a compression testing machine, after the blocks are cured. Test the blocks by applying load on their flat surface, at the rate of $2\ N / mm^2$ / minute. A minimum of three blocks should be tested for each combination of soil-stabilizer ratio and the average strength is reported.

(2) WATER ABSORPTION TEST :

24 hours immersion cold water test.

Dry the specimen in a ventilated oven at a temperature of 105^0 to 115^0 C till at attains substantially constant weight, cool the specimen to room temperature and obtain its weight (W_1). Immerse completely dried specimen in clean water at a temperature of 27 ± 2^0C for a 24 hours. Remove the specimen and wipe out any traces of water with a damp cloth and weigh the specimen. Complete the weighing in 3 minutes after the specimen has been removed from water (W_2)

Water absorption, percent by weight, after 24 hours immersion in cold water is given by the formula

$$\frac{W_2 - W_1}{W_1} \times 100$$

The average of five results shall be reported.

The average water absorption shall not be more than 15 percent by weight.

CHAPTER – 9

TEST RESULTS, ANALYSIS AND DISCUSSIONS

TEST RESULTS

Compressive Strength Test Results : 7 Days Strength

Size of Block (in mm) : 115 x 190 x 100

UNSTABILIZED SOIL BLOCK STRENGTH

Sample Specimen No.	% of Extra Sand	Load (Kgf)				Average Compressive Strength (N/mm^2)
		Trial 1	Trial 2	Trial 3	Average Load (N)	
1	25	450	700	800	6500	0.23

STABILIZED SOIL BLOCK STRENGTH

TABLE - 9.1

Extra Sand : 25%

Stabilizer : Lime

Sample Specimen No.	% of Cement	% of Lime	Load (Kgf)			Average Load (N)	Average Compressive Strength (N/mm^2)	Weight (Kg)		Weight increased in %
			Trial 1	Trial 2	Trial 3			Before Water Absorption	After Water Absorption	
1	0	5	2650	2850	2350	26166.7	1.20	3.565	3.885	8.98
2	0	10	3500	3750	3250	35000.0	1.60	3.235	3.435	6.18
3	0	15	3750	3650	3750	37166.7	1.72	3.685	3.935	6.81
4	0	20	4000	3750	4250	40000.0	1.83	3.425	3.635	6.04

TABLE - 9.2

Extra Sand : 25%

Stabilizer : Cement

Sample Specimen No.	% of Cement	% of Lime	Load (Kgf)			Average Load (N)	Average Compressive Strength (N/mm^2)	Weight (Kg)		Weight increased in %
			Trial 1	Trial 2	Trial 3			Before Water Absorption	After Water Absorption	
1	2	0	2400	2150	2650	24000.0	1.09	3.705	4.055	9.45
2	3	0	4000	4250	3900	40500.0	1.85	3.655	3.895	6.56
3	4	0	5300	5250	5000	51833.3	2.37	3.235	3.525	8.90
4	5	0	6250	6350	6500	63666.7	2.91	3.875	4.105	5.93

TABLE - 9.3

Extra Sand : 25%

Stabilizer : Cement and Fly ash

Sample Specimen No.	% of Cement	% of Flyash	Load (Kgf)			Average Load (N)	Average Compressive Strength (N/mm^2)	Weight (Kg)		Weight increased in %
			Trial 1	Trial 2	Trial 3			Before Water Absorption	After Water Absorption	
1	2	5	3100	3450	3200	32500.0	1.49	3.685	3.936	6.81
2	2	15	2850	3400	3150	31333.3	1.43	3.770	3.980	5.57
3	2	25	1200	1650	950	12666.7	0.58	3.970	4.300	8.31
4	3	5	3050	4400	3500	36500.0	1.67	4.030	4.300	6.70
5	3	15	2500	2500	2400	24666.7	1.13	3.125	3.400	8.80
6	3	25	1950	1950	1550	18166.7	0.83	3.800	3.955	4.08
7	4	5	4250	4750	4450	44833.3	2.05	4.650	4.950	6.45
8	4	15	1800	1850	1450	17000.0	0.78	4.315	4.560	5.68
9	4	25	3250	2100	2900	27500.0	1.26	4.220	4.505	6.75

TABLE - 9.4

Extra Sand : 25%

Stabilizer : Cement and Quarry Dust

Sample Specimen No.	% of Cement	% of Quarry Dust	Load (Kgf)			Average Load (N)	Average Compressive Strength (N/mm^2)	Weight (Kg)		Weight increased in %
			Trial 1	Trial 2	Trial 3			Before Water Absorption	After Water Absorption	
1	2	5	1750	1400	1550	15666.7	0.72	4.015	4.235	5.48
2	2	15	1250	1150	1350	12500.0	0.57	4.195	4.505	4.24
3	2	25	700	700	850	7500.0	0.34	4.005	4.325	8.00
4	3	5	3000	2950	3100	30166.7	1.38	4.075	4.205	3.20
5	3	15	2250	4750	3250	34166.7	1.56	4.135	4.335	4.84
6	3	25	3950	2500	3750	34000.0	1.56	4.145	4.445	7.24
7	4	5	4400	4100	4000	41666.7	1.91	3.990	4.185	4.89
8	4	15	4200	4700	4650	45166.7	2.07	4.110	4.355	5.96
9	4	25	4800	5950	5350	53666.7	2.46	4.055	4.415	8.88

TABLE - 9.5

Extra Sand : 25%

Stabilizer : Cement and Saw Dust

Sample Specimen No.	% of Cement	% of Saw Dust	Load (Kgf) Trial 1	Trial 2	Trial 3	Average Load (N)	Average Compressive Strength (N/mm^2)	Weight (Kg) Before Water Absorption	After Water Absorption	Weight increased in %
1	3	1	3850	4050	3550	38166.7	1.75	3.705	3.875	4.59
2	3	2	3150	3250	3200	32000.0	1.46	3.830	4.105	7.18
3	3	3	4200	5200	2700	40333.3	1.85	3.635	4.015	10.45
4	4	1	2700	1800	3050	25166.7	1.15	3.605	4.030	11.79
5	4	2	2300	2450	2650	24666.7	1.13	3.565	4.025	12.90
6	4	3	3050	2950	2450	28166.7	1.29	3.955	4.350	9.99
7	5	1	2900	2750	2600	27500.0	1.26	3.795	4.095	7.91
8	5	2	1700	2200	2950	22833.3	1.05	3.570	4.000	12.04
9	5	3	4000	2700	3500	34000.0	1.56	3.720	4.120	10.75

TABLE - 9.6

Extra Sand : 25%

Stabilizer : Cement and Rice husk

Sample Specimen No.	% of Cement	% of Rice Husk	Load (Kgf)			Average Load (N)	Average Compressive Strength (N/mm^2)	Weight (Kg)		Weight increased in %
			Trial 1	Trial 2	Trial 3			Before Water Absorption	After Water Absorption	
1	3	1	3000	2400	2800	27333.3	1.25	3.895	4.245	8.98
2	3	2	3250	2100	2050	24666.7	1.13	3.565	3.985	11.78
3	3	3	3850	5300	3950	43666.7	2.00	3.965	4.330	9.21
4	4	1	4600	5000	5050	48833.3	2.23	4.220	4.530	7.34
5	4	2	5200	4250	4900	47833.3	2.91	4.250	4.505	6.00
6	4	3	6750	5400	5150	57666.7	2.64	3.885	4.235	9.01
7	5	1	8050	6900	6150	70333.3	3.22	4.300	4.610	7.21
8	5	2	6050	5150	5850	56833.3	2.60	3.825	4.140	8.23
9	5	3	7350	6550	6400	67333.7	3.10	4.065	4.325	6.40

TABLE - 9.7

Extra Sand : 25%

Stabilizer : Flyash, Lime & Gypsum

Sample Specimen No.	FAL – G	FAL – G & Soil Ratio	Load (Kgf) Trial 1	Trial 2	Trial 3	Average Load (N)	Average Compressive Strength (N/mm^2)	Weight (Kg) Before Water Absorption	After Water Absorption	Weight increased in %
1	70% Flyash,	1 : 2	900	925	950	9250	0.423	3.555	3.785	6.47
2	25% Lime &	1 : 2.5	1400	1450	1250	13666.7	0.625	3.165	3.355	6.00
3	5% Gypsum	1 : 3	1800	1900	1750	18166.7	0.831	3.425	3.625	5.84
4	60% Flyash,	1 : 2	4750	4700	4600	46833.3	2.143	3.645	4.015	10.15
5	35% Lime &	1 : 2.5	4850	4950	5100	49500.0	2.2265	4.105	4.430	7.92
6	5% Gypsum	1 : 3	4400	5150	5050	48666.7	2.237	3.705	4.055	9.45
7	50% Flyash,	1 : 2	3950	3450	3500	36333.3	1.662	3.600	4.015	11.53
8	45% Lime &	1 : 2.5	4100	4500	4350	43166.7	1.975	3.925	4.305	9.68
9	5% Gypsum	1 : 3	4600	4200	4300	43666.7	1.998	3.815	4.160	9.04

Fig. 1

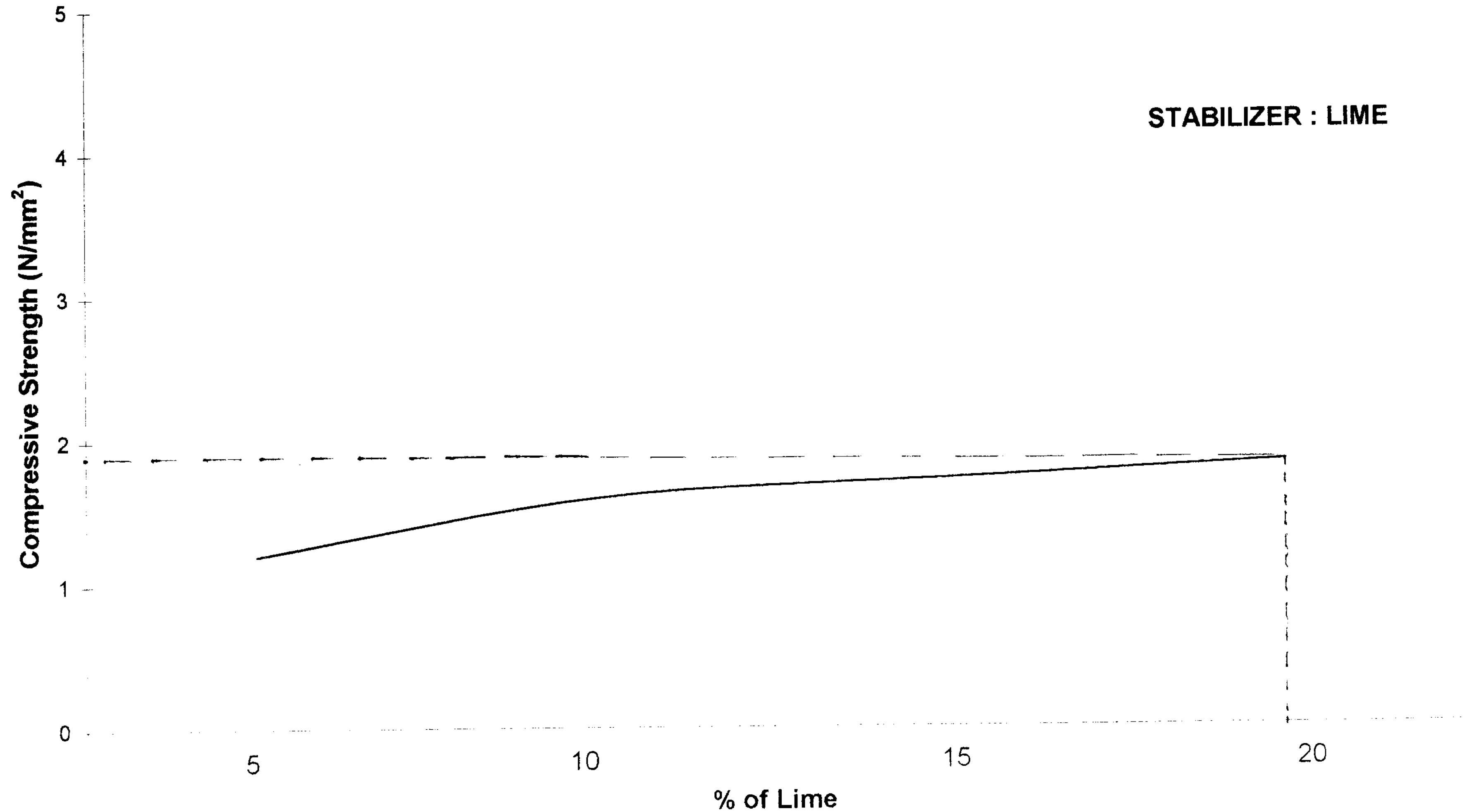

STABILIZER : LIME
Compressive Strength (N/mm²)
0
1
2
3
4
5
5
10
15
20
% of Lime

Fig. 2

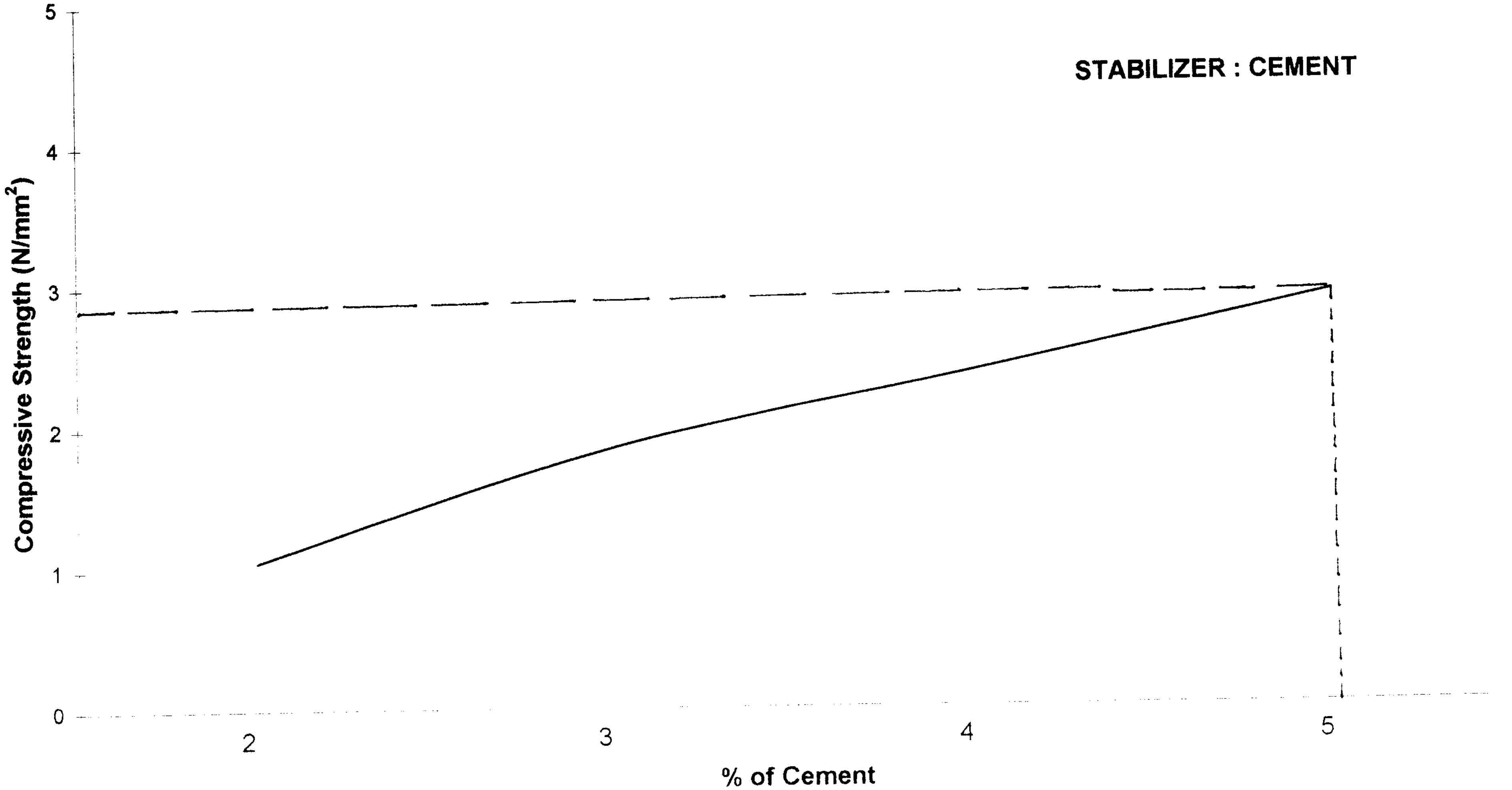

STABILIZER : CEMENT
Compressive Strength (N/mm²)
5
4
3
2
1
0
2
3
4
5
% of Cement

Fig. 3

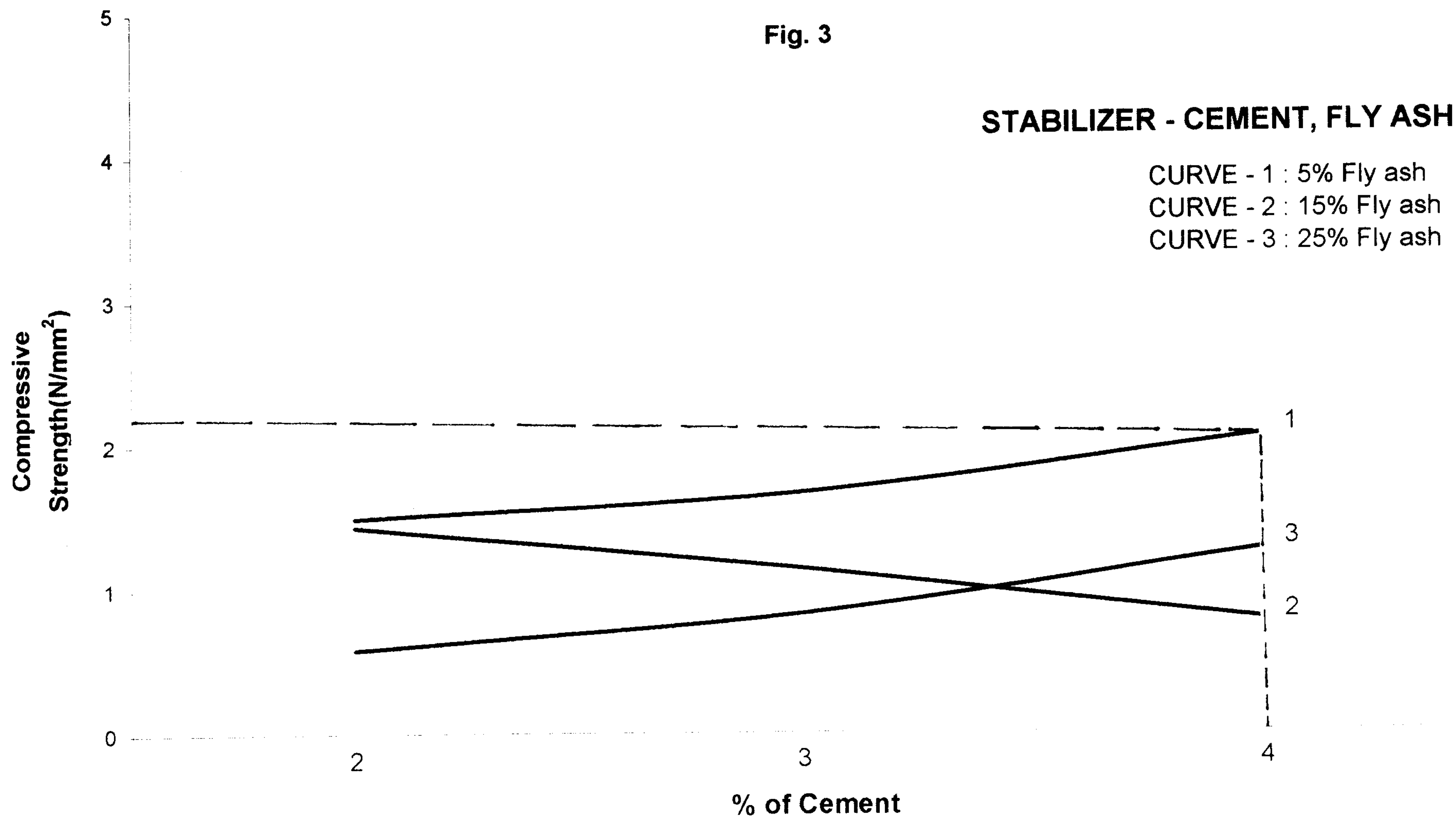

STABILIZER - CEMENT, FLY ASH
CURVE - 1 : 5% Fly ash
CURVE - 2 : 15% Fly ash
CURVE - 3 : 25% Fly ash
Compressive Strength(N/mm2)
% of Cement
0
1
2
3
4
5
2
3
4
1
3
2

Fig. 4

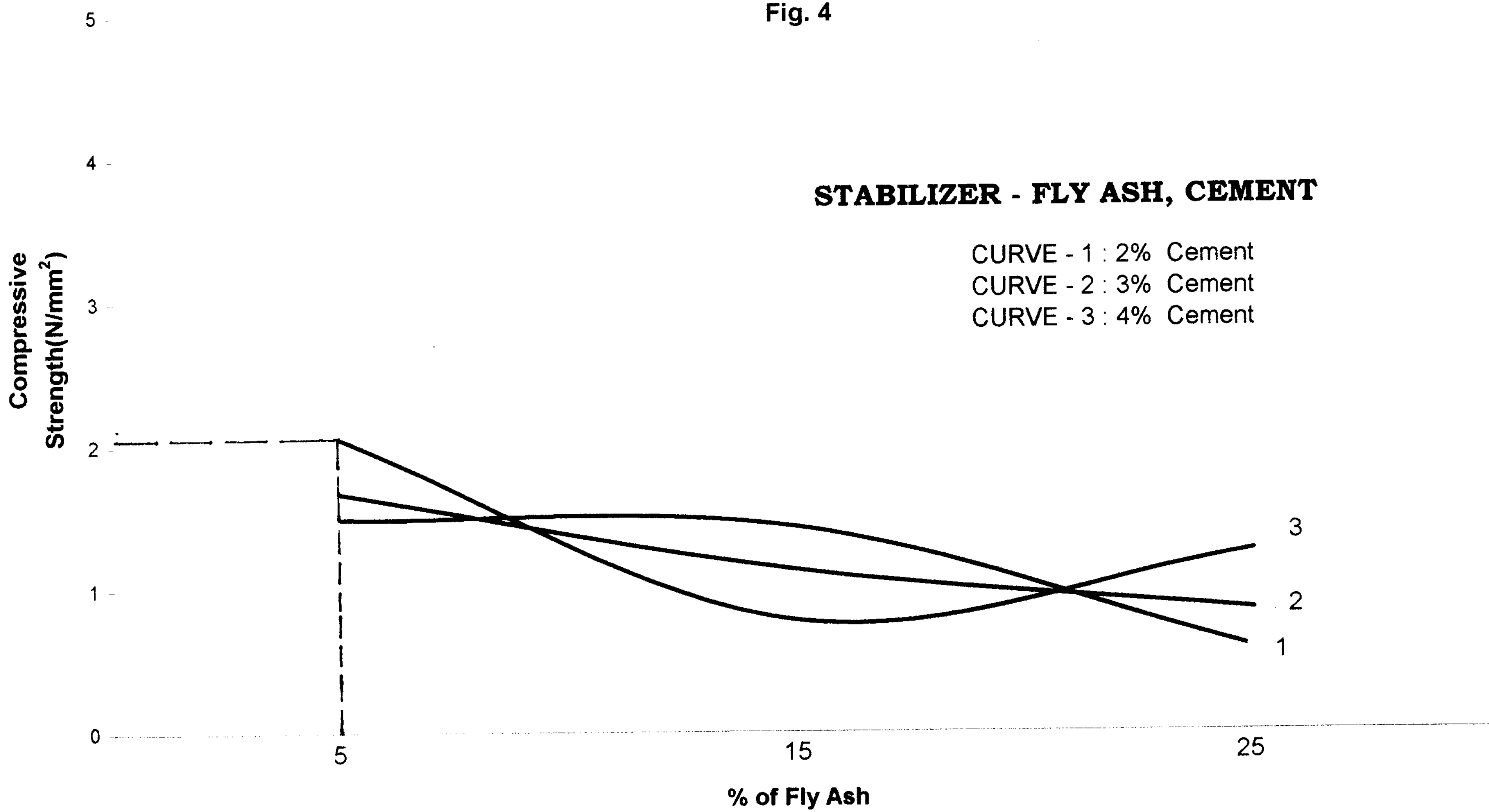

STABILIZER - FLY ASH, CEMENT
CURVE - 1 : 2% Cement
CURVE - 2 : 3% Cement
CURVE - 3 : 4% Cement
Compressive Strength(N/mm2)
5
4
3
2
1
0
5
15
25
% of Fly Ash
3
2
1

Fig. 5

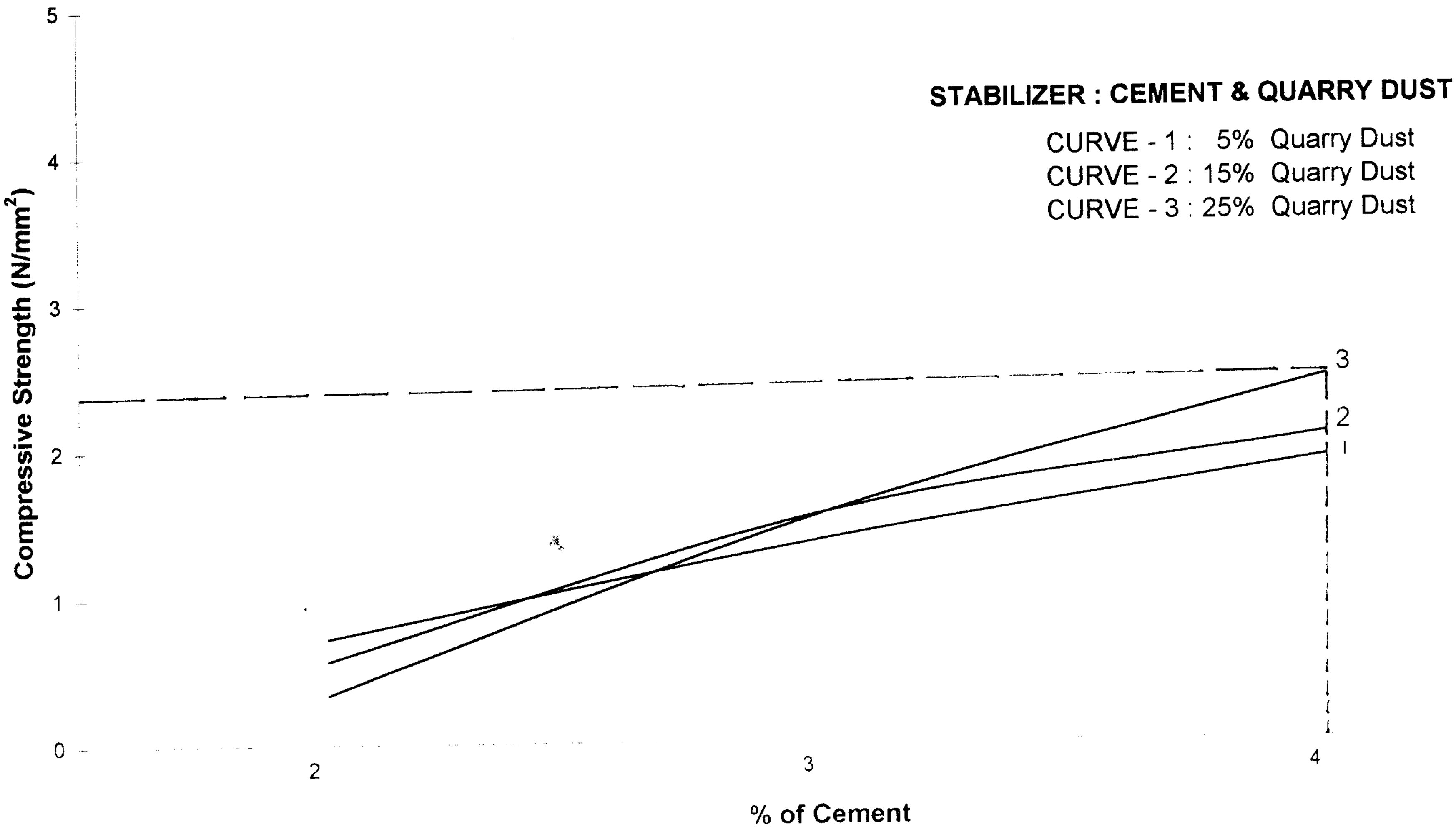
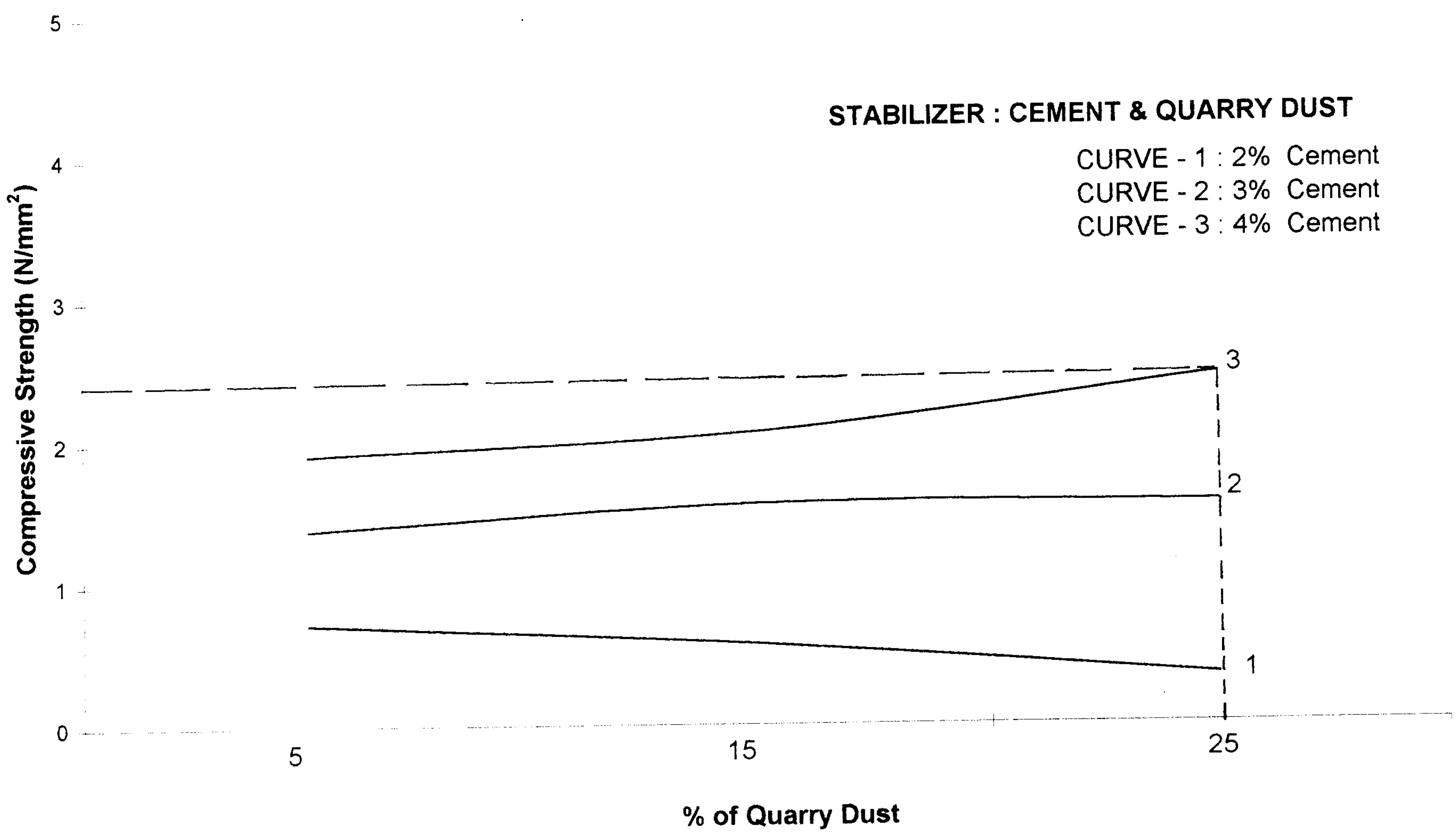

STABILIZER : CEMENT & QUARRY DUST
CURVE - 1 : 5% Quarry Dust
CURVE - 2 : 15% Quarry Dust
CURVE - 3 : 25% Quarry Dust
Compressive Strength (N/mm²)
0
1
2
3
4
5
2
3
4
% of Cement
1
2
3

Fig. 6



STABILIZER : CEMENT & QUARRY DUST
CURVE - 1 : 2% Cement
CURVE - 2 : 3% Cement
CURVE - 3 : 4% Cement
Compressive Strength (N/mm²)
0
1
2
3
4
5
5
15
25
% of Quarry Dust
1
2
3

Fig. 7

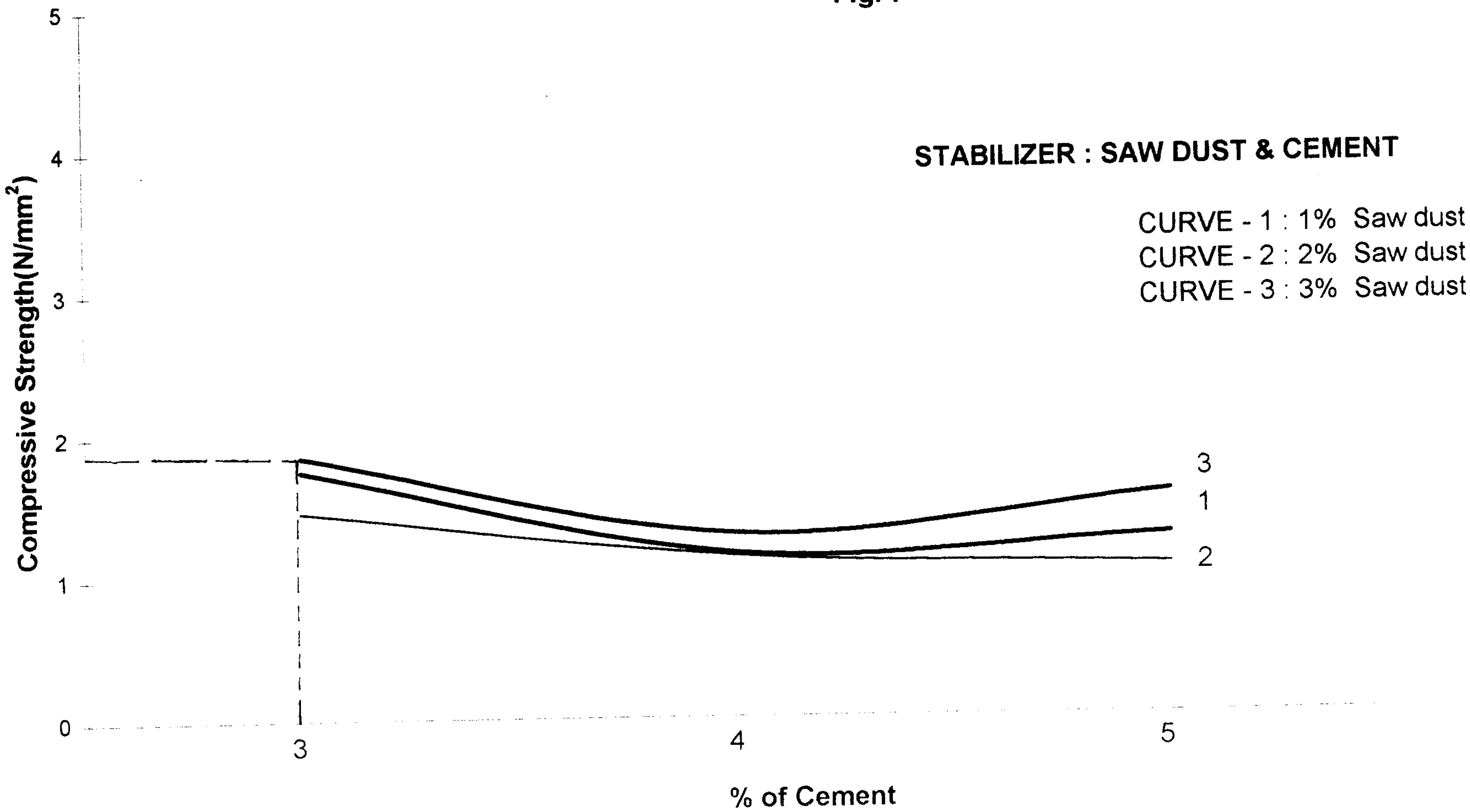

STABILIZER : SAW DUST & CEMENT
CURVE - 1 : 1% Saw dust
CURVE - 2 : 2% Saw dust
CURVE - 3 : 3% Saw dust
Compressive Strength(N/mm2)
0
1
2
3
4
5
3
1
2
3
4
5
% of Cement

Fig. 8

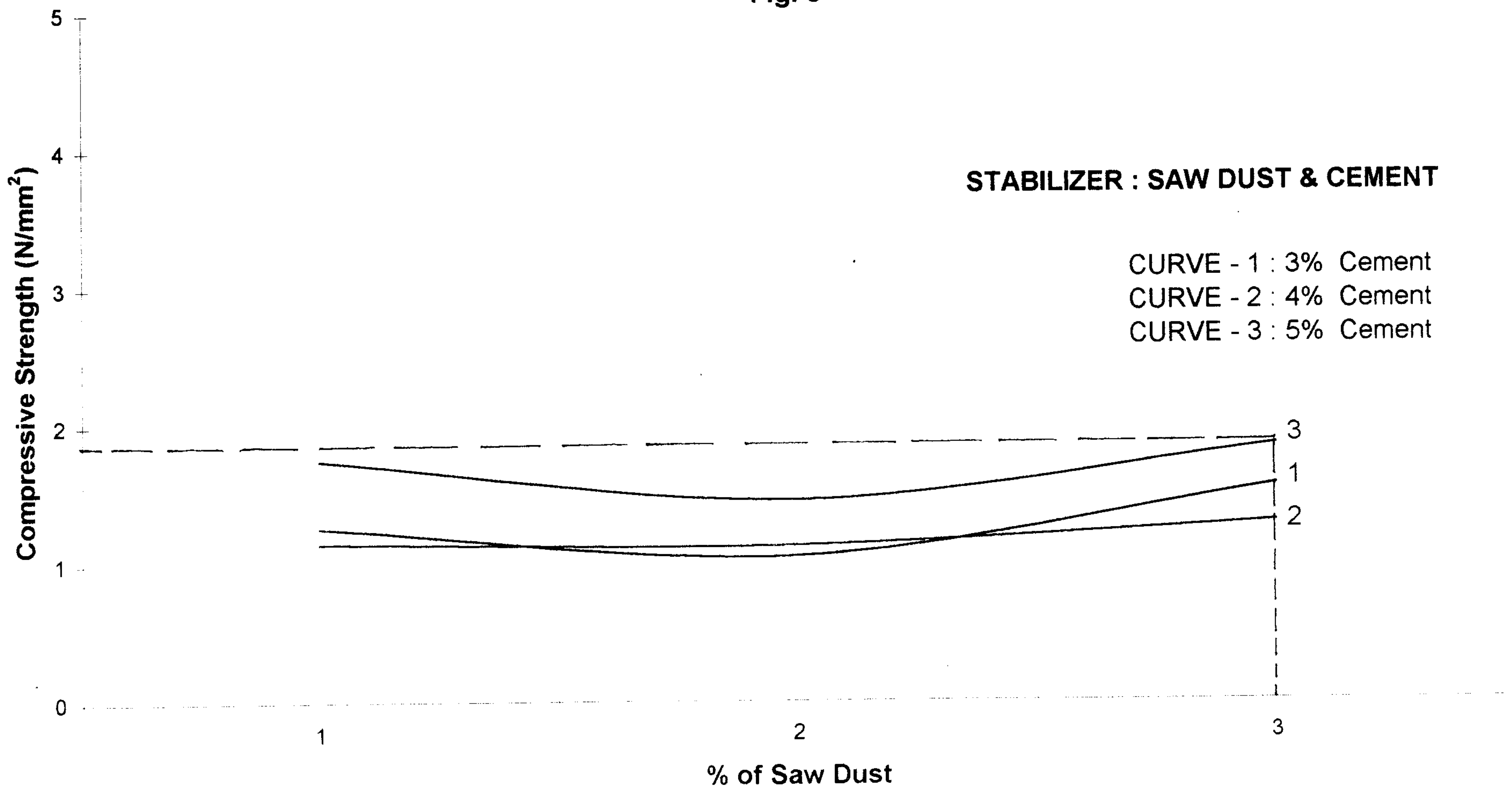

STABILIZER : SAW DUST & CEMENT
CURVE - 1 : 3% Cement
CURVE - 2 : 4% Cement
CURVE - 3 : 5% Cement
Compressive Strength (N/mm²)
% of Saw Dust
0
1
2
3
4
5
1
2
3
3
1
2

Fig. 9

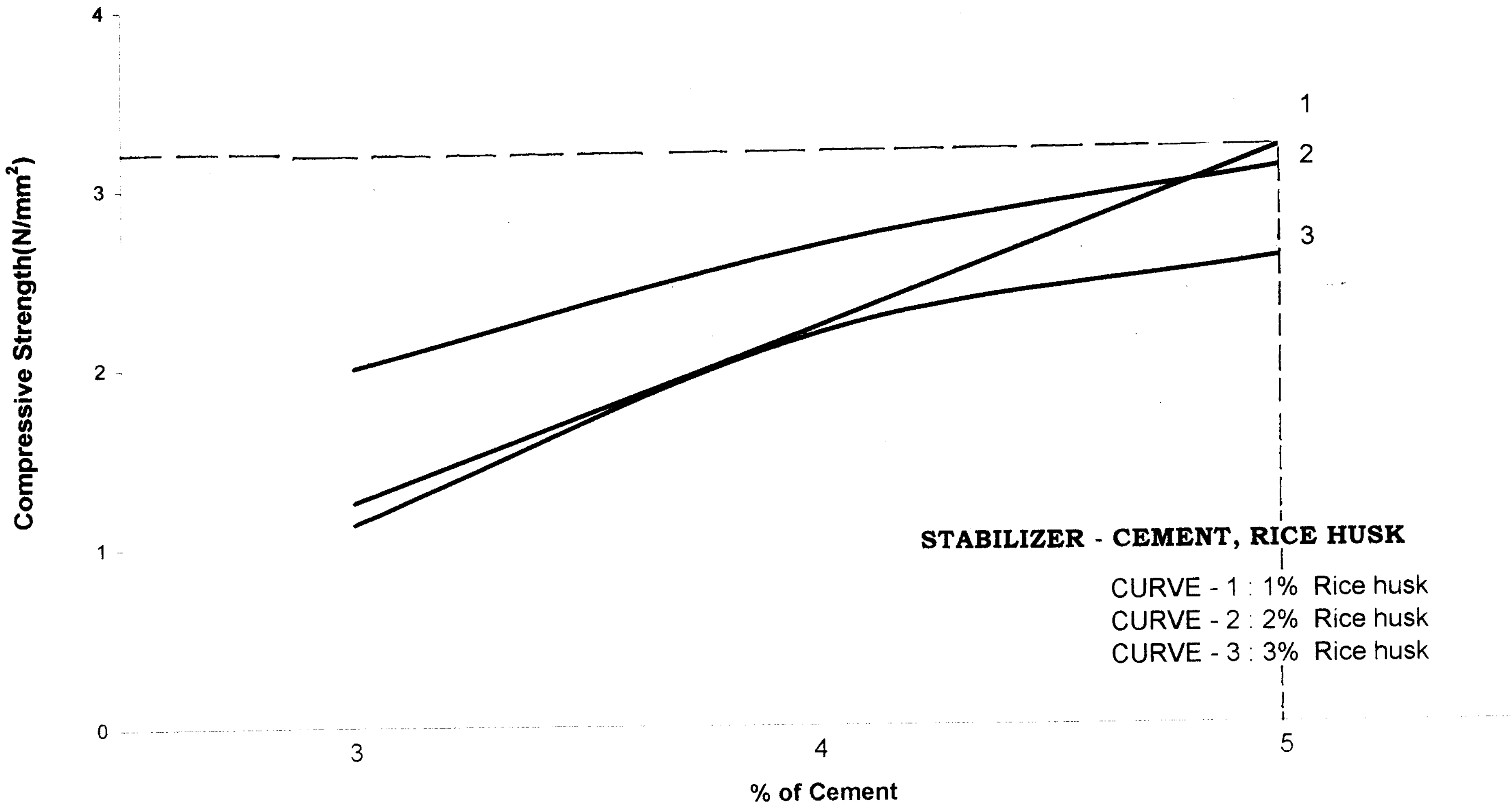

Compressive Strength(N/mm²)
4
3
2
1
0
3
4
5
% of Cement
1
2
3
STABILIZER - CEMENT, RICE HUSK
CURVE - 1 : 1% Rice husk
CURVE - 2 : 2% Rice husk
CURVE - 3 : 3% Rice husk

Fig. 10

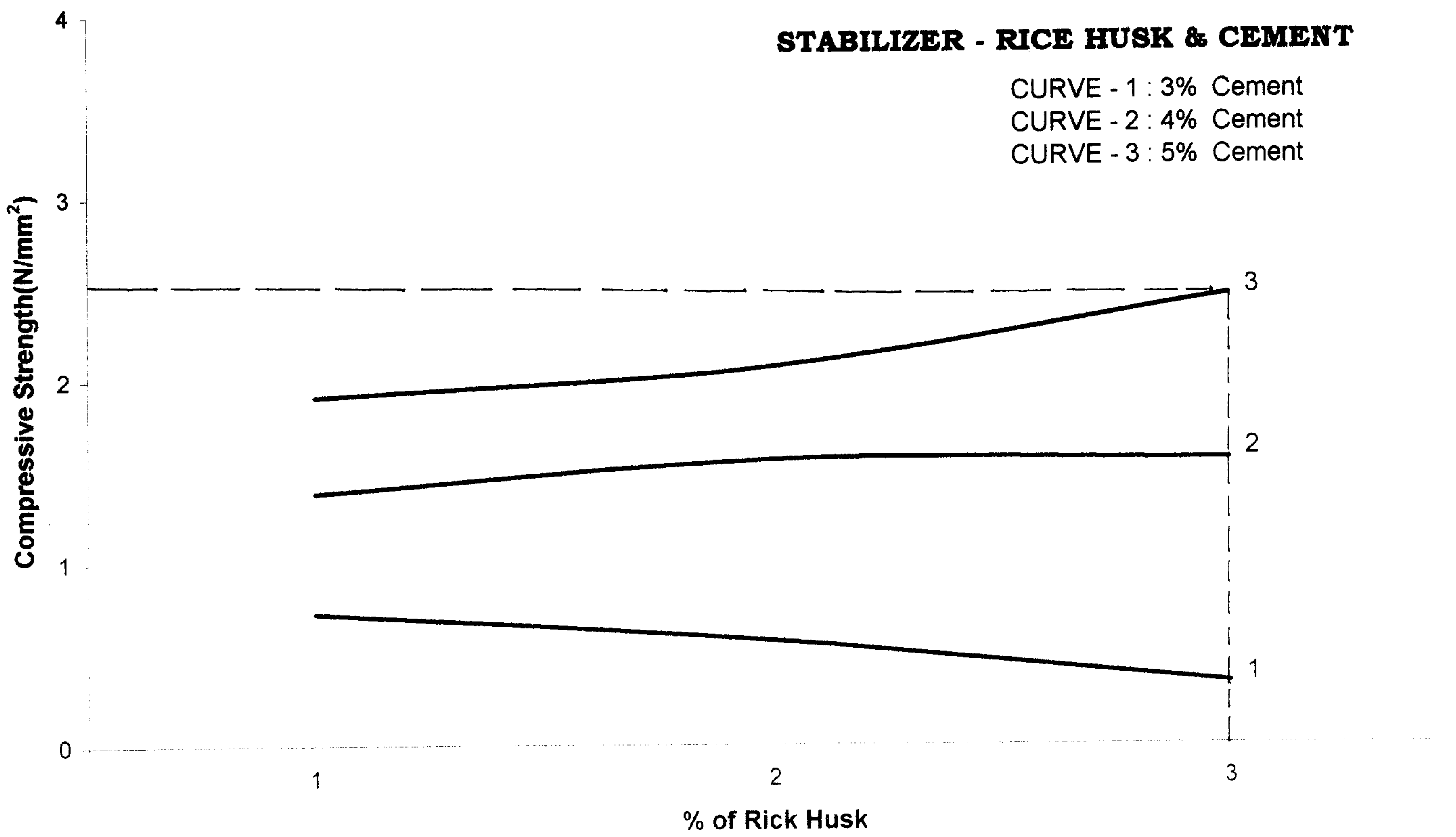
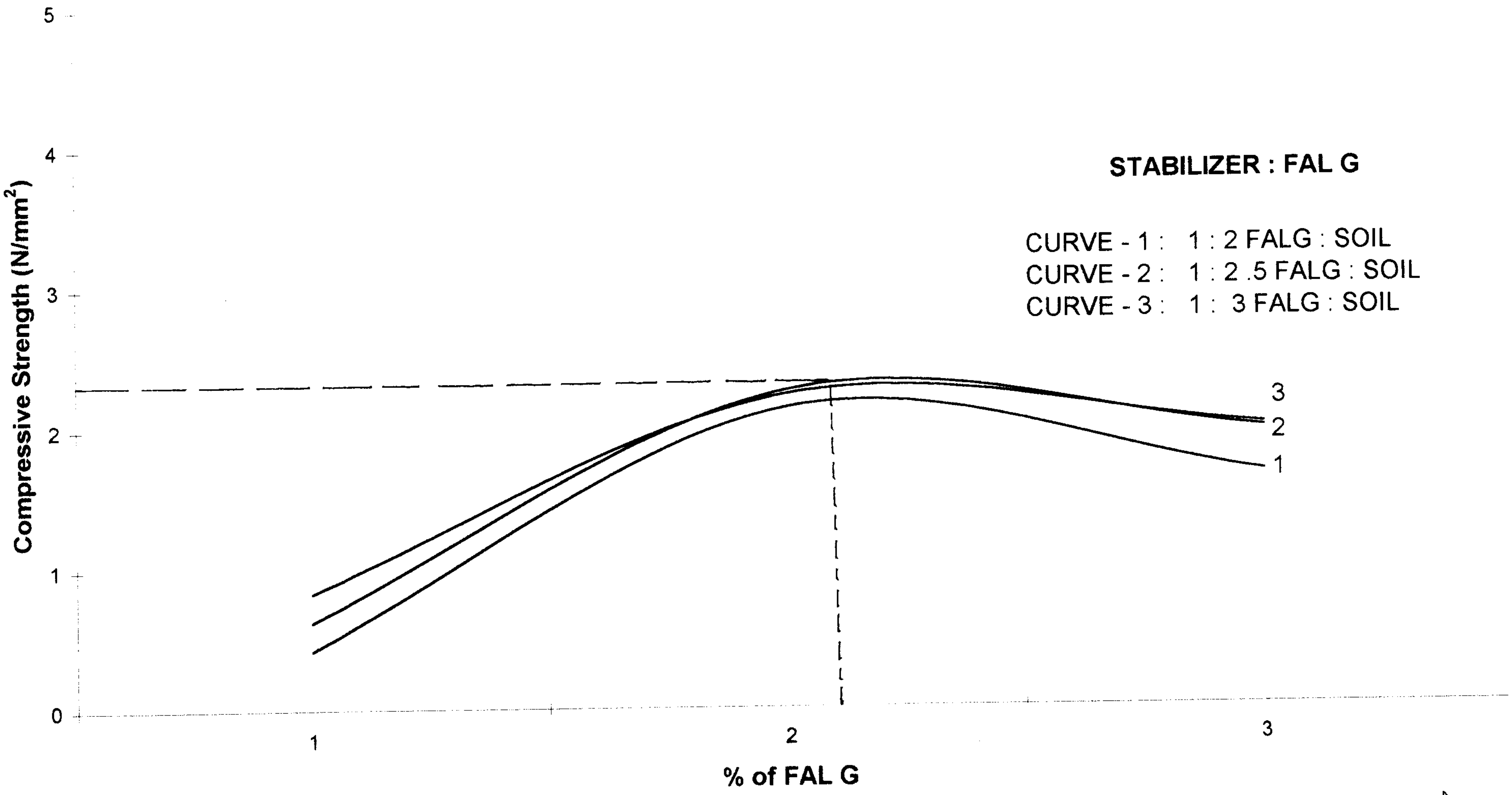
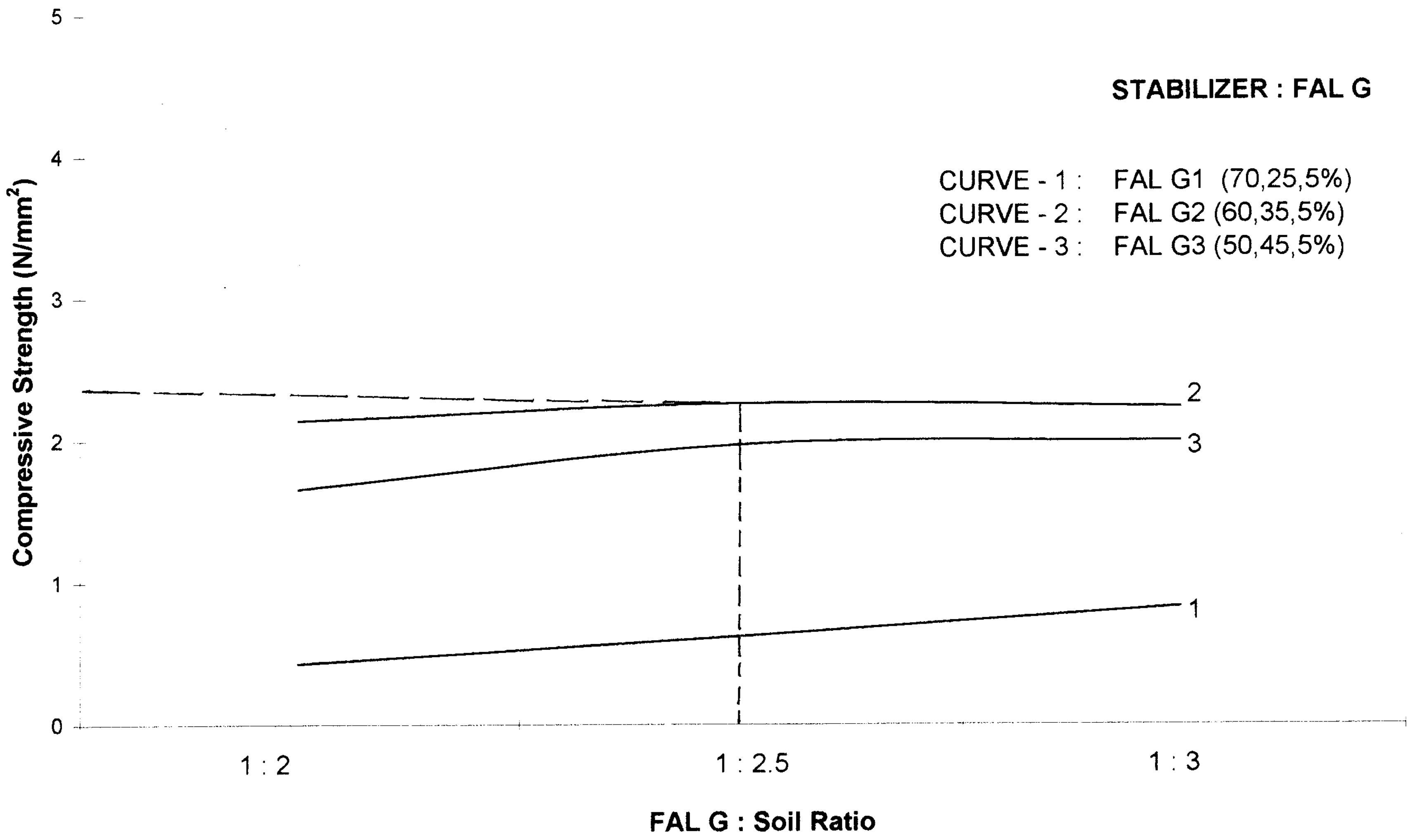

STABILIZER - RICE HUSK & CEMENT
CURVE - 1 : 3% Cement
CURVE - 2 : 4% Cement
CURVE - 3 : 5% Cement
Compressive Strength(N/mm²)
0
1
2
3
4
% of Rick Husk
1
2
3
1
2
3

Fig. 11



STABILIZER : FAL G
CURVE - 1 : 1 : 2 FALG : SOIL
CURVE - 2 : 1 : 2 .5 FALG : SOIL
CURVE - 3 : 1 : 3 FALG : SOIL
Compressive Strength (N/mm²)
% of FAL G
0
1
2
3
4
5
1
2
3
3
2
1

Fig. 12


STABILIZER : FAL G
CURVE - 1 : FAL G1 (70,25,5%)
CURVE - 2 : FAL G2 (60,35,5%)
CURVE - 3 : FAL G3 (50,45,5%)
Compressive Strength (N/mm²)
0
1
2
3
4
5
1 : 2
1 : 2.5
1 : 3
FAL G : Soil Ratio
1
2
3

ANALYSIS AND DISCUSSIONS

1. Referring Table 9.1 from Fig – 1

The curve shows that compressive strength of the lime block which increases gradually as the lime content increases gradually.

2. Referring Table 9.2 from Fig – 2

The curve shows that compressive strength increases gradually as the % content of cement increases gradually. It starts from 1 N/mm^2 to 3 N/mm^2.

3. Referring table 9.3 from Fig - 3

Stabilizer – Cement and fly ash

Curve 1 & 3, Shows 5% & 25% of fly ash respectively the strength increase mildly up to 3% of cement and then increases gradually

Curve 2 Shows that due to increase of cement with 15% of fly ash combination shows a decrease in strength.

4. Referring table 9.3 from Fig – 4

(1) Curve 1 shows 2% of cement, the decrease in compressive strength is mildly upto 15% of fly ash and then decreases steeply from 15 to 25% of fly ash

(2) Curve 2 shows 3% of cement, the compressive strength decreases gradually from 5 % to 25% of fly ash.

(3) Curve 3 shows 4% of cement, the compressive strength decreases steeply from 5% of fly ash to 15% of fly ash and then from 15% to 20% of fly ash the strength increases gradually.

5. Referring Table 9.4 from Fig – 5

The curve 1 and 2 shows the 5% and 15% of Quarry dust. The compressive strength gradually increases from 2% to 4% of cement.

The curve 3 shows the25% of Quarry dust. The compressive strength increases gradually from 3% to 4% of cement.

6. Referring Table 9.4 from Fig – 6

The curve 1 shows the 2% of cement. The compressive strength of block decreases gradually from 5% to 25% of Quarry dust.

The curve 2 shows the 3% of cement. The compressive strength of the block increases slightly from 5% to 15% of Quarry dust and then the strength remains the same from 15 to 25% of Quarry dust.

The curve shows the 4% of cement. The compressive strength of the block increase slightly from 5 to 15% of Quarry dust and then increases gradually up to 25% of Quarry dust.

7. Referring Table 9.5 from Fig - 7

Curve 1 and 3 shows the 1% and 3% of saw dust. The compressive strength decreases gradually from 3% to 4% of cement.

Curve 2 shows the 2% of saw dust. The compressive strength decreases gradually from 3% to 4% of cement and then strength decreases slightly from 4% to 5% of cement.

8. Referring Table 9.5 from Fig – 8

The curve 1 and 3 shows the 3% and 5% of cement. The compressive strength decreases gradually upto 2% of saw dust and then strength increases very slightly from 2 to 3% of saw dust.

9. Referring Table 9.6 from Fig - 9

(1) Curve 1. Shows 1% of rice husk, the compressive strength increases steeply from 3% of cement to 5% of cement

(2) Curve 2 & 3 shows 2% & 3% of rice husk respectively. The compressive strength increases gradually from 3% to 5% of cement.

10. Referring Table 9.6 from Fig - 10

Curve 1,2,3 represent the 3%, 4% and 5% of cement respectively. The compressive strength decreases gradually from 1% to 2% of rice husk and then the strength increase gradually from 2% to 3% of rice husk for different percentage of cement.

11. Referring Table 9.7 from Fig – 11

The curve in this fig shows the FAL G : Soil ratio of blocks. The curve 1,2,3 show the 1:2, 1:2.5, 1:3 of FAL G : soil ratio blocks respectively. The compressive strength increase steeply from FAL G1 to FAL G2 and then strength decrease gradually from of FAL G2 to of FAL G3.

12. Referring Table 9.7 from Fig – 12

(1) The curve 1 & 2 shows the FAL G1 & FAL G2,. The compressive strength increase gradually from FAL G : Soil ratio

(2) The curve 3 show the FAL G3. The compressive strength increase gradually from FAL G : soil ratio is 1 : 2 to 1 : 2.5 and then the strength remains constant upto FAL G : soil ratio is 1 : 3.

13. Referring Table 9.1 from Fig 1

The optimum strength is obtained when 20% of lime is used as stabilizer. The percentage increase in strength is 695.65% (1.83N/mm^2) with respect to unstabilized block.

14. Referring Table 9.2 from Fig 2

The optimum strength is obtained when 5% of cement is used as stabilizer. The percentage increase in strength is 1165.21% (2.93 N/mm^2) with respect to unstabilized block.

15. Referring Table 9.3 from Fig 3 and 4

The optimum strength is attained at 4% of cement combined with 5% of fly ash. The percentage increase in strength is observed as 797.90% (2.013 N/mm^2) with respect to the unstabilized block.

16. Referring Table 9.5 from Fig 5 and 6

The optimum strength is attained at 4% of cement combined with 25% of Quarry dust. The percentage increase in strength is observed as 969.56% (2.456 N/mm^2) with respect to the unstabilized block.

17. Referring Table 9.5 from Fig 7 and 8

The optimum strength is attained at 3% of cement combined with 3% of Saw dust. The percentage increase in strength is observed as 704.34% (1.85N/mm^2) with respect to the unstabilized block.

18. Referring Table 9.6 from Fig 9 and 10

The maximum optimum strength is attained at 5% of cement combined with 1% of rice husk. The percentage increase in strength is observed as 1300% (3.22 N/mm^2) with respect to the unstabilized block.

19. Referring Table 9.7 from Fig 11 and 12

The optimum strength is attained when 60% of fly ash 35% of Lime and 5% of gypsum all combined together. When the stabilizer : soil ratio is 1 : 2.5. The percentage increase in strength is 884.95% (2.265N/mm^2) with respect unstabilized block.

CHAPTER – 10

COST ANALYSIS

Cost analysis is made for the following

(i) Stabilized soil block which gave optimum strength obtained from test results and also for the soil block stabilized with different percentage of cement as stabilizer and its cost is compared with burnt bricks.

(ii) Stabilized soil block masonry without facing work and its cost per unit quantity is compared with ordinary brick masonry without plastering.

Economics of burnt bricks and stabilized soil blocks are also dealt in this chapter.

Preliminary Data :

Type of block making machine	:	ITGE VOTH
Size of Block (in mm)	:	230 x 190 x 100
Weight of Block (Wet)	:	8.5 kg approximately
Cement	:	Portland Cement
Lime	:	Slaked Lime (Powder form)
Soil Location	:	Kattida Maiyam, Vadavalli.
Sand	:	River Sand
Brick	:	Country Brick
Brick Size (in mm)	:	230 x 110 x 75

COST DATA

# Capital cost of the machine / block	:	17 paise
1 Kg of the Cement cost	:	Rs. 2.60
Cost of water and soil	:	Rs 0.30/block
Brick cost	:	Rs. 1.50 Each
Sand cost	:	Rs. 310 / m^3
Lime cost	:	Rs. 0.80 per kg
Rice husk cost	:	Rs. 2.00 per kg

Cost of stabilized soil block

Cost details for one block		Cost (paise)
(i) Capital cost of the machine	:	17
(ii) Cost of sand,soil &Water	:	64
*(iii) Labour cost	:	53
Cost of block without stabilizer	-	134

Cost of block for optimum strength (Block with 5% cement and 1% rice husk as stabilizer) as obtained from test results.

Cost of cement	:	110
Cost of rice husk	:	10
Cost of block without stabilizer	:	134
Total cost of block	=	254 paise

Note :- # It is assumed that one machine will produce 1 lakh blocks in its life time with minor repairs and cost of machine Rs.17,000/-

* It is observed by experience that 7 persons will produce 800 block per 8 hour working day. (Rs. 60 per person per day)

Cost of unfaced stabilized soil block masonry wall

Cost at one block is Rs. 2.54

Consider 3m x 3m wall of thickness 230mm.

Volume of wall = 3.0 x 3.0 x 0.23

= 2.07 m^3

Assuming thickness of mortar as 10 mm, header bond type of construction.

In horizontal direction, number of blocks required is 15

(i.e. 15 x 190 + 15 x 10 = 3000 mm)

In vertical direction, number of blocks required is 27

(i.e. 27 x 100 + 29 x 10 = 2990 mm, say 3000 mm)

Therefore number of block required for 1 m^3 of soil cement block masonry = 15 x 27 / 2.07

= 195 blocks

Therefore volume of block alone in 1 m^3 masonry = 0.855m^3

Volume of mortar required = 0.145 m^3

Data for 1m^3 of soil cement block masonry using CM 1 : 6

Quantity	Description	Rate Rs.	Per	Amount Rs.
195 Nos.	Stabilized soil block	2.54	Each	495.30
0.145 m^3	Cement mortar 1 :6	1060	1m^3	153.70
1m^3	Labour charges	150	1m^3	150.00
				799.00

Data for cost of burnt brick masonry for 1m^3 in CM 1 : 6

Quantity	Description	Rate Rs.	Per	Amount Rs.
415 Nos.	Bricks (230 x 110 x 75 mm)	1.50	Each	622.50
0.22m^3	Cement mortar 1 :6	1060	1m^3	233.20
1m^3	Labour charges	200	1m^3	200.00
	Sundries			0.30
				1056.00

Note :- Sub data for Cement Mortar 1 : 6 – 1m^3

Quantity	Description	Rate Rs.	Per	Amount Rs.
240 Kg	Cement	3.04	Kg	729.60
1 m^3	Sand	310	1m^3	310.00
1m^3	Mixing charges	20	1m^3	20.00
	Sundries			0.40
				1060.00

COMPARSION OF BURNT BRICKS AND STABILIZED SOIL BLOCKS

S. No.	Parameter	Burnt Bricks	Stabilized Soil Blocks
1	Dimensions (mm)	230 x 110 x 75	230 x 190 x 100
2	Volume (mm^3)	1.89×10^6	4.37×10^6
3	Volume Ratio	1	2.303
4	Weight	2.2 kg	8.5 kg
5	Stabilizer	Fire	Cement
6	Cost / Unit on Site	Rs. 1.50	Rs. 2.54
7	Units / M^3 Raw material	527	228
8	Water Absorption	10 to 15 %	4 to 13 %
9	Cost of Wall / m^3	Rs. 1056.00	Rs. 799.00

CHAPTER – 11

CONCLUSIONS AND SUGGESTIONS FOR FURTHER INVESTIGATION

Conclusions :

The following conclusions are drawn from this investigation

1. The optimum strength of 3.22 N/mm^2 is attained for the stabilized soil block with 25% extra sand, using 5% cement combined with 1% rice husk as stabilizer and the percentage savings in cost compared with burnt bricks is found to be 41%.
2. 25% savings can be achieved in wall construction by using stabilized soil block than using ordinary brick correspondingly without plastering the walls.
3. Soil block masonry gives good appearance and it does not require plastering.

Suggestions :

Attempts should be made to study

1. The suitability of soil block for multistoried load bearing structures.
2. The micro analysis effect of stabilizers, with soil in soil block.
3. The thermal resistance of the soil block.
4. The permeability characters of soil block.
5. The acoustic effect on stabilized soil block.
6. Face protection for stabilized soil block.
7. Cost analysis can be made for all types of stabilized soil blocks having optimum value and compared with bricks also for masonry.

CHAPTER – 12

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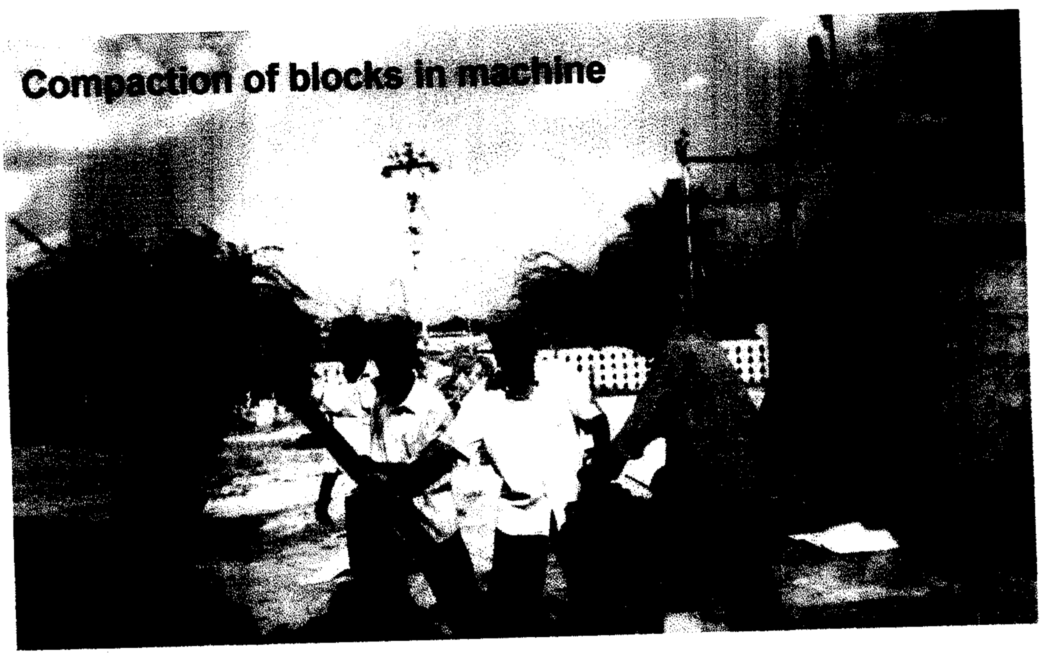
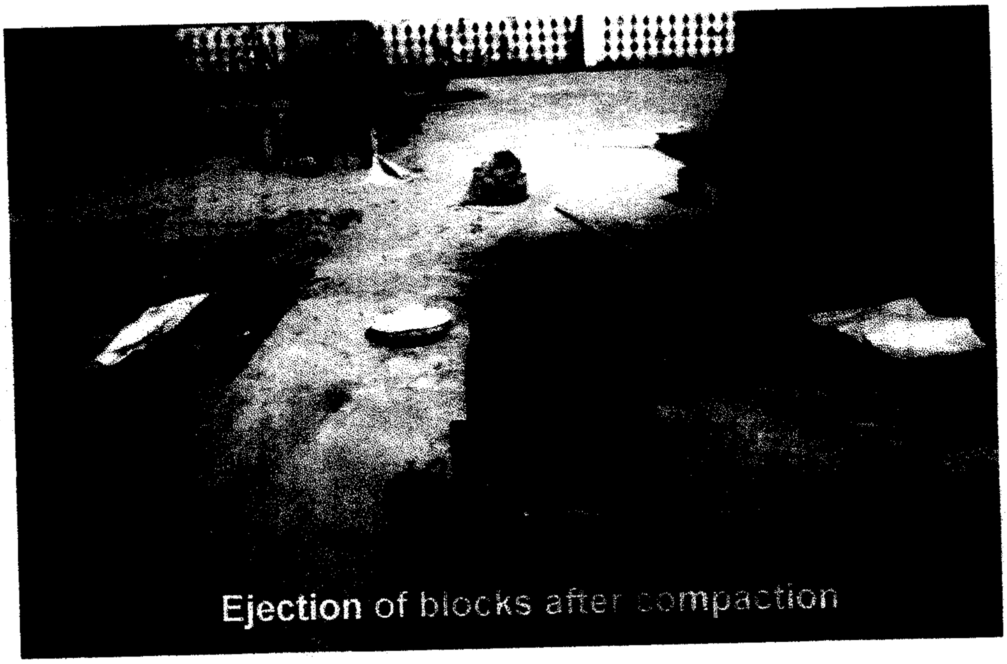
Soil Mix Preparation

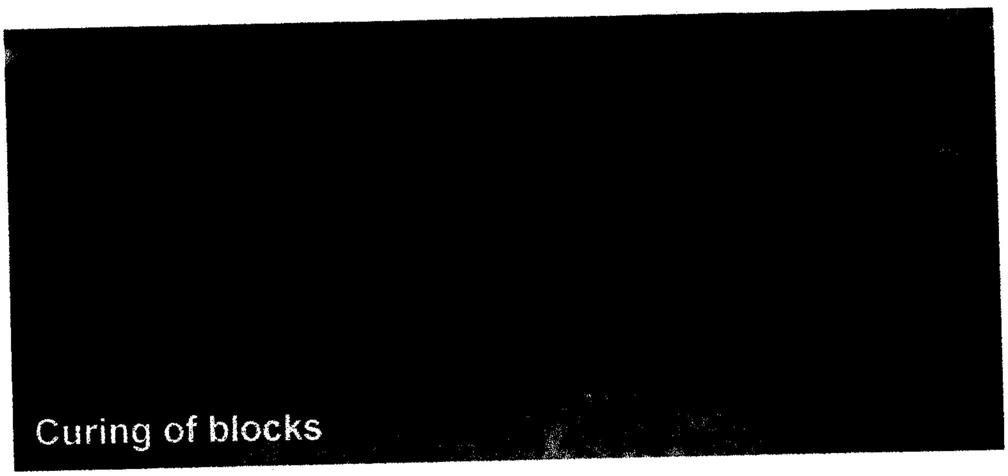
Block making Machine


Soil compaction with hand


Compaction of blocks in machine



Ejection of blocks after compaction



Curing of blocks