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ENHANCING THE ENGINEERING PROPERTIES OF SANDCRETE BLOCKS

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ABSTRACT

Researchers are driven by the growing need to utilize by-products and industry wastes so as to find suitable alternatives for cement and sand, the two basic ingredients in the sandcrete block manufacturing process. In this study the effect of replacing the fine aggregate partially first with granite fines, then with granite coarse aggregate was investigated. The influence of water-cement ratio and method of manufacture on the compressive strength of the blocks was also investigated.

The results showed that the strength of the sandcrete blocks increased significantly when the sand was partially replaced with either granite fines or granite coarse aggregate, and also with increasing water-cement ratio.

INTRODUCTION

Blocks made from a mixture of river sand, cement and water are called "sandcrete" blocks. They are used throughout Nigeria and in most African countries.

Until perhaps a few years ago, these blocks were manufactured in many parts of Nigeria without reference to any specifications either to suit local building materials or for good quality work. The situation in Nigeria has since changed as the Standards Organization of Nigeria now has specifications for both the manufacture and use of these blocks in Nigeria.

Okpala (1993), concluded that if rice husk ash was found adequate for replacing cement in sandcrete blocks, it would drastically reduce the cost of buildings in Nigeria. This is because sandcrete blocks are the major cost component of the most common building found in the country. His results revealed that a sandcrete mix of 1:6 (cement-sand) ratio with up to 40% cement replacement with RHA and 1:8 ratio with cement replacement of up to 30% with RHA are adequate for sandcrete block productions for both urban and rural dwellings in Nigeria. Cisse and Laquerbe (2000) concluded that the mechanical resistance of sandcrete blocks obtained when unground ash was added revealed an increase in performance over the classic mortar blocks. Their studies in Senegal also revealed that the use of unground rice husk ash enabled production of a lightweight sandcrete with insulating properties and at a reduced cost. The ash pozzolanic reactivity was responsible for the enhanced strength obtained.

In this investigation the use of both granite fines and granite coarse aggregate as partial replacement of the fine aggregate content in the mortar matrix was for the purpose of enhancing the strength characteristics of sandcrete blocks. Both materials are readily available at limestone quarries. Granite coarse aggregate is extensively used in Nigeria in the manufacturing of concrete. Furthermore, granite coarse aggregate has been found to produce higher strength concrete than washed gravel.

The main thrust of the research presented in this paper was to determine the optimum percentage by volume of granite fines or granite coarse aggregate that should be used as a partial replacement for the sand in the sand-cement matrix for best results. The influence of water/cement ratio and production method on sandcrete block strength was also investigated.

MATERIALS AND MANUFACTURE OF SANDCRETE BLOCKS:

SAND

The sand used was clean, sharp river sand that was free from clay, loam, dirt, and organic or chemical matter of any description and was sand passing through 4.70mm zone of British Standard test sieves. The sand had a specific gravity of 2.6 and average moisture content of 0.90%. The coefficient of uniformity of the sand was 2.95.

CEMENT

The cement used was Ordinary Portland Cement from the West African Cement Company, Ewekoro in Ogun State of Nigeria with properties conforming to BS 12.

WATER

The water used was potable water, which was fresh, colourless, odourless and tasteless water that was free from organic matter of any type.

GRANITE FINES

The granite fines were obtained from the limestone quarry in Ogun State of Nigeria. The specific gravity of the granite fines was 2.7 and the average moisture content was 0.32%. The coefficient of uniformity of the granite fines was 10.7.

GRADING OF AGGREGATES

The grading of an aggregate defines the properties of different sizes in the aggregate. This grading has a considerable effect on the workability and stability of the mix. Wet sieving analysis, which is in accordance with BS 1377, was used in this investigation. The particle size analysis of the sand used in this study is shown in Figure 1. The analysis showed that the sand was poorly graded, as it was predominantly medium to coarse sand. Table 1 shows a summary of the particle size grading of the sand alone, granite fines alone, and the grading of each of the various proportions of the sand and granite fines in the mortar mix used in the manufacturing process.

MANUFACTURE OF SANDCRTE BLOCKS

The blocks can be made in a machine or alternatively approved metal or wooden moulds can also be used.

The usual sizes are as follows:

(a) 450mm x 225mm x 225mm

(b) 450mm x 150mm x 225mm

(c) 450mm x 112.5mm x 225mm

In this research effort, the blocks (all hollow) were manufactured both manually using metal moulds and with the use of the machine. Two mixes (1:6 and 1:8 cement-sand ratio) were used in this investigation. Two different sizes of blocks, namely, 450mm x 225mm x 225mm and 450mm x 150mm x 225mm were used.

This research was in three parts. In the first, granite fines were used as a partial replacement for the sand in the sand-cement matrix. The percentage of granite fines by

volume of the total fine aggregate (coarse river sand) was then varied from an initial 10%, then in steps of 5% to a maximum of 35 percent. Two mix proportions were used (1:6 and 1:8 cement-sand ratio).

In the second test, granite coarse aggregate was used as a partial replacement for the sand in the sand-cement matrix. Three different sizes of coarse aggregate were used, namely, 10mm single size, 15mm single size and 10mm and 15mm single sizes mixed in equal proportions. The percentage of the granite coarse aggregate by volume of the total fine aggregate was varied from an initial 10 %, then in steps of 5% to a maximum of 40 per cent. Only one mix proportion was used in this case.

In the third test, two methods were used for the block manufacture, namely, a manual method using metal moulds and the machine method. The water-cement ratio was also varied from 0.45 to 1.0 in the manufacture of these blocks. Only one mix proportion (1:6 cement-sand ratio) was used.

For all three tests hand mixing was employed, and the materials were turned over a number of times until an even colour and consistency was attained. Water was then added as required through a fire hose, and the materials were further turned over to secure adhesion. It was then rammed into the machine and /or metal moulds, compacted and smoothed off with a steel face tool.

After removal from the machine moulds, the blocks were left on pallets under cover in separate rows, one block high and with a space between blocks for at least 24 hours and kept wet during this period by watering through a fine watering hose. Testing for crushing strength was then carried out at ages 7, 14, 21 and 28 days.

COMPACTION

This can be done by the use of approved standard machine compaction but hand compaction can also be used when the blocks have been manually produced using metal moulds. In either case, what is essential is that the approved strength must be attained. In this research effort, both standard machine compaction and hand compaction were utilized.

PRESENTATION AND DISCUSSION OF TEST RESULTS

Granite Fines Used For Partial Replacement of The Fine Aggregate In The Sand-Cement Matrix Results are presented in both tabular and graphical forms. Figures 2 to 5 show

plots of compressive strength against percentage granite fines content for the two mix proportions and the two block sizes used in this investigation. Tables 2 to 5 also show the compressive strength results for the two sizes of blocks and the two mix proportions used in this study.

For the blocks made with a 1:6 mix proportion, the graph in Figure 2 shows that a granite fines content of 25 percent gave the highest crushing strength for all ages of the sandcrete block. In addition, the crushing strength increased to a maximum at about 25% granite fines content and then decreased as the granite fines content was increased.

At 28 days, the crushing strength for the 150mm blocks was 5.20N/mm^2, while a crushing strength of 4.05N/mm^2 was obtained for the 225mm blocks. This result is expected in the sense that the proportion of the cement to the sand-granite fines mix is higher in the 150mm blocks than in the 225mm blocks. By a similar reasoning, it was observed that for blocks made with a 1:8 mix proportion, higher strength values were obtained for the 150mm blocks. In addition, the compressive strength values increased as the granite fines content increased up to a granite fines content of about 15 percent after which the compressive strength decreased with increase in the percentage granite fines content.

The enhanced strength obtained was perhaps due to better particle packing and the consequent reduction in the volume of the voids. Furthermore, the addition of granite fines to the sand improved the grading of the fine aggregate content, thereby improving the workability of the mix and enhancing the compressive strength.

Granite Coarse Aggregate Used To Partially Replace The Coarse Sand

Results are presented both graphically and in tabular form. Tables 6 to 11 show the compressive strength results for the two sizes of blocks and the three sizes of coarse aggregate used to partially replace the fine aggregate content in the sand-cement matrix. Figures 2 to 7 show plots of compressive strength against percentage granite coarse aggregate content for the two sizes of blocks and the three sizes of coarse aggregate.

For the blocks made with a 1:6 mix proportion, there was more than a 30 % increase in strength when the granite aggregate content was only 10 % (15mm size). The highest increase of 49% was

obtained at a coarse aggregate content of 25 percent.

When the size of coarse aggregate was reduced to 10mm, more than 60% increase in strength was obtained at a coarse aggregate content of 35%.

At a mixed aggregate content of 35% the highest increase in compressive strength (66%) was obtained. In addition, for all three sizes of coarse aggregate used, the strength of the sandcrete blocks increased with age. Furthermore, irrespective of the block size, the 28-day strength values were expectedly the highest.

The Influence Of Water-Cement Ratio And Method Of Manufacture On The Compressive Strength

Results are presented in tabular and graphical forms. Table 12 shows the compressive strength test results for the sandcrete blocks at various water-cement ratios. Figure 8 shows a plot of compressive strength (at 28 days) against water-cement ratio.

The results show that the machine-produced blocks have higher strength values than those produced manually since higher accuracy and better compaction are available when the blocks are produced by machine than when they are produced manually. The strengths for the machine-produced blocks are between 7 and 30% higher than the corresponding values for the manually produced blocks depending on the water- cement ratio used for the block manufacture. The differences in strength decrease as the water- cement ratio increases.

CONCLUSIONS

The main conclusions derived from this investigation are as follows:

1. Granite fines have a significant effect on the compressive strength characteristics of sandcrete blocks. At a mix proportion of 1:6, the compressive strength values at 28-days increased appreciably, being over 50% for the 225mm blocks and over 80 percent for the 150mm blocks. A further increase in strength was obtained when the mix proportion was changed to 1:8. The enhanced strength could be due to better particle packing when granite fines are added to the sand with the consequent reduction in the volume of voids.

2. There was an optimum granite fines content above which the compressive strength began to fall as the percentage granite fines content increased. This optimum was found to be about 25% at a mix proportion of 1:6 and 15% at a mix proportion of 1:8.

3. Although the compressive strength values of the blocks fell as the percentage granite fines content went above the optimum level yet, the strength values were still well above the compressive strength values for sandcrete blocks without any granite fines.

4. Whether granite coarse aggregate or granite finess were used to partially replace the sand in the sand-cement mix, the 450mm x 150mm x 225mm sandcrete blocks generally gave higher compressive strength values than the 450mm x 225mm x 225mm blocks.

5. At a mix proportion of 1:6, there was an appreciable increase in the compressive strength of sandcrete blocks when coarse aggregate was used as partial replacement of the sand in the cement-matrix. This was over 40 percent for the 225mm blocks and nearly 70 percent for the 150mm blocks.

6. When coarse aggregate was used to partially replace the sand, there was also an optimum coarse aggregate content above which the compressive strength of the blocks began to fall with further increase in the percentage coarse aggregate content. This optimum was found to be about 30% when 10mm single size aggregate was used, 35% when 15mm single size was used and about 25% when a mixed coarse aggregate (10mm & 15mm) was used.

7. As with the use of granite fines, the use of granite coarse aggregate brought about an appreciable increase in the 28-day compressive strength of sandcrete blocks. For example, with a mix proportion of 1:6, the 7-day compressive strength was 1.04N/msm^2, whereas at 28 days the strength increased to 1.97N/mm^2, representing an increase of nearly 90 percent (mixed coarse aggregate used).

8. Water-cement ratio had a fairly significant effect on the compressive strength of sandcrete blocks irrespective of the method used in the sandcrete block manufacture.

9. The method of block manufacture was also important. Machine-produced blocks were generally stronger than those produced manually, the strength values of the former being between 7 and 30 percent higher than the corresponding values of the latter.

10. The strength characteristics of the sandcrete blocks increased with increase in the water-cement ratio used in the block manufacture.

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TABLE 1: SUMMARY OF PARTICLE SIZE GRADING OF AGGREGATES

S/No	CONSTITUENTS	SAND COMPOSITION (%)			GRAVEL COMPOSITION (%)		
		FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
1	Sand alone	2	31	49	16	3	-
2	Granite fines alone	10	23	31	28	2	-
3	90% sand + 10% Granite fines	7	41	37	06	1	-
4	85% sand + 15% granite fines	7	39	36	12	3	-
5	80% sand + 20% granite fines	7	37	37	11	1	-
6	75% sand + 25% granite fines	7	39	38	7	1	-
7	70% sand + 30% granite fines	7	36	39	10	2	-
8	65% sand + 35% granite fines	7	36	40	11	1	-

TABLE 2: COMPRESSIVE STRENGTH OF SANDCRETE BLOCK (1:6 MIX PROPORTION)

No.	Cement – Sand Ratio	Quantity of Granite Fines (%)	Block Size (mm)	Dry Weight (kg)	Dry Density (kg/m^3)	Comp. Strength (N/mm^2)	Age of Blocks (days)
1	1:6	0	450x150x225	18.2	1198.4	2.450	7
2		10		17.3	1139.1	2.750	
3		15		16.8	1106.2	2.890	
4		20		18.0	1185.2	3.150	
5		25		17.8	1172.0	3.288	
6		30		17.2	1132.5	2.842	
7		35		17.5	1152.3	2.563	
1	1:6	0	450x150x225	17.3	1139.1	2.513	14
2		10		17.7	1165.4	3.650	
3		15		17.1	1126.0	3.830	
4		20		17.0	1119.3	4.110	
5		25		18.3	1205.0	4.309	
6		30		17.3	1139.1	3.702	
7		35		16.8	1106.2	3.492	
1	1:6	0	450x150x225	18.3	1205.0	2.664	21
2		10		18.1	1191.8	3.840	
3		15		17.7	1165.4	3.984	
4		20		17.3	1139.1	4.324	
5		25		17.6	1159.0	4.644	
6		30		17.3	1139.1	3.845	
7		35		16.5	1152.3	3.686	
1	1:6	0	450x150x225	17.5	1152.3	2.840	28
2		10		17.1	1126.0	4.540	
3		15		18.2	1198.4	4.632	
4		20		17.7	1165.4	4.980	
5		25		17.3	1139.1	5.164	
6		30		18.3	1205.0	5.145	
7		35		18.3	1205.0	4.458	

TABLE 3: COMPRESSIVE STRENGTH OF SANDCRETE BLOCK (1:6 MIX PROPORTION)

No.	Cement – Sand Ratio	Quantity of Granite Fines (%)	Block Size (mm)	Dry Weight (kg)	Dry Density (kg/m^3)	Comp. Strength (N/mm^2)	Age of Blocks (days)
1	1:6	0	450x150x225	26.3	1154.4	2.250	7
2		10		26.2	1150.1	2.298	
3		15		28.1	1233.5	3.060	
4		20		27.2	1194.0	3.190	
5		25		27.5	1207.1	3.258	
6		30		26.1	1145.7	2.534	
7		35		25.8	1132.5	2.260	
1	1:6	0	450x150x225	25.7	1128.1	2.300	14
2		10		28.0	1229.1	3.010	
3		15		27.7	1216.0	3.100	
4		20		28.0	1229.1	3.215	
5		25		27.0	1185.2	3.268	
6		30		26.1	1145.7	3.130	
7		35		26.2	1150.1	3.010	
1	1:6	0	450x150x225	26.6	1167.6	2.434	21
2		10		26.3	1154.5	3.050	
3		15		27.7	1216.0	3.150	
4		20		25.8	1132.5	3.350	
5		25		26.6	1167.6	3.537	
6		30		25.7	1128.1	3.387	
7		35		25.4	1115.0	3.100	
1	1:6	0	450x150x225	27.7	1216.0	2.658	28
2		10		27.7	1216.0	3.300	
3		15		26.3	1154.5	3.528	
4		20		27.1	1189.6	3.831	
5		25		26.2	1150.1	4.061	
6		30		26.4	1158.8	3.447	
7		35		26.3	1154.5	3.331	

TABLE 4: COMPRESSIVE STRENGTH OF SANDCRETE BLOCK (1:8 MIX PROPORTION)

No.	Cement – Sand Ratio	Quantity of Granite Fines (%)	Block Size (mm)	Dry Weight (kg)	Dry Density (kg/m^3)	Comp. Strength (N/mm^2)	Age of Blocks (days)
1	1:8	0	450x150x225	17.7	1165.4	1.750	7
2		10		16.7	1099.5	2.667	
3		15		18.0	1185.2	2.770	
4		20		17.3	1139.1	2.519	
5		25		17.7	1165.4	2.405	
6		30		17.4	1145.7	1.913	
7		35		17.7	1165.4	1.022	
1	1:8	0	450x150x225	16.7	1099.5	1.890	14
2		10		17.8	1172.0	2.823	
3		15		17.3	1139.1	2.985	
4		20		17.4	1145.7	2.693	
5		25		18.0	1285.2	2.415	
6		30		18.0	1185.2	2.370	
7		35		16.8	1106.2	2.178	
1	1:8	0	450x150x225	17.4	1178.6	2.150	21
2		10		18.2	1198.4	3.850	
3		15		17.8	1172.0	4.015	
4		20		17.5	1152.3	3.722	
5		25		16.8	1106.2	3.510	
6		30		17.7	1165.4	3.332	
7		35		18.0	1185.2	3.210	
1	1:8	0	450x150x225	18.2	1198.4	2.335	28
2		10		17.1	1130.0	5.201	
3		15		18.0	1185.2	5.337	
4		20		17.8	1172.0	5.034	
5		25		17.9	1178.6	4.737	
6		30		17.4	1145.7	4.421	
7		35		17.7	1165.4	4.179	

TABLE 5: COMPRESSIVE STRENGTH OF SANDCRETE BLOCK (1:8 MIX PROPORTION)

No.	Cement – Sand Ratio	Quantity of Granite Fines (%)	Block Size (mm)	Dry Weight (kg)	Dry Density (kg/m^3)	Comp. Strength (N/mm^2)	Age of Blocks (days)
1	1:8	0	450x150x225	25.9	1136.9	1.680	7
2		10		26.7	1172.0	2.572	
3		15		25.4	1115.0	2.830	
4		20		25.7	1128.1	2.465	
5		25		25.4	1115.0	2.272	
6		30		25.8	1132.5	1.608	
7		35		26.6	1167.6	1.543	
1	1:8	0	450x150x225	26.0	1168.6	1.830	14
2		10		26.2	1150.1	2.932	
3		15		26.6	1167.6	3.151	
4		20		26.9	1180.8	3.065	
5		25		26.4	1158.8	2.487	
6		30		26.8	1176.4	2.079	
7		35		26.0	1141.3	1.908	
1	1:8	0	450x150x225	25.7	1128.1	1.990	21
2		10		25.6	1123.7	2.932	
3		15		26.7	1172.0	3.704	
4		20		26.2	1150.1	3.473	
5		25		26.5	1163.2	3.408	
6		30		26.6	1167.6	3.920	
7		35		26.9	1136.9	2.894	
1	1:8	0	450x150x225	26.2	1150.1	2.050	28
2		10		26.9	1180.8	3.011	
3		15		26.7	1172.0	3.801	
4		20		26.2	1150.1	3.623	
5		25		26.5	1163.2	3.601	
6		30		25.8	1132.5	2.982	
7		35		25.4	1115.0	2.932	

TABLE 6: CRUSHING STRENGTH RESULTS OF SANDCRETE BLOCKS (1:6 Mix) MADE USING 15mm SINGLE SIZE COARSE AGGREGATE FOR THE PARTIAL REPLACEMENT OF SAND

S/NO	Cement – Sand Ratio	Quantity of Granite (%)	Block Size (mm)	Dry Weight (kg)	Dry Density (kg/m^3)	Crushing Strength H (N/mm^2)	Age of Block (days)
1	1:6	0	450x150x225	18.9	1244.4	1.125	7 days
2	1:6	10	450x150x225	17.7	1231.3	1.35	
3	1:6	15	450x150x225	19.0	1251.0	2.55	
4	1:6	20	450x150x225	17.8	1172.0	2.4	
5	1:6	25	450x150x225	17.8	1172.0	1.8	
6	1:6	30	450x150x225	19.2	1264.2	1.95	
7	1:6	35	450x150x225	18.2	1198.4	1.965	
8	1:6	40	450x150x225	16.9	1112.8	1.215	
1	1:6	0	450x150x225	18.0	1185.2	1.95	14 days
2	1:6	10	450x150x225	18.1	1191.8	2.85	
3	1:6	15	450x150x22	18.3	1204.9	2.7	
4	1:6	20	450x150x22	17.9	1178.6	2.85	
5	1:6	25	450x150x225	18.7	1231.3	2.25	
6	1:6	30	450x150x225	18.7	1204.9	2.7	
7	1:6	35	450x150x225	18.3	1198.4	2.625	
8	1:6	40	450x150x225	15.6	1027.2	2.25	
1	1:6	0	450x150x225	16.9	1112.8	2.79	21 days
2	1:6	10	450x150x225	17.1	1165.4	3.0	
3	1:6	15	450x150x225	18.2	1198.4	3.3	
4	1:6	20	450x150x225	18.0	1198.4	3.0	
5	1:6	25	450x150x225	18.2	1231.3	3.3	
6	1:6	30	450x150x225	18.7	1204.9	2.7	
7	1:6	35	450x150x225	18.0	1185.2	2.7	
8	1:6	40	450x150x225	16.8	1106.2	4.05	
1	1:6	0	450x150x225	17.7	1165.8	3.15	28 days
2	1:6	10	450x150x225	17.9	1178.6	3.6	
3	1:6	15	450x150x225	18.5	1218.1	4.05	
4	1:6	20	450x150x225	18.0	1185.2	4.05	
5	1:6	25	450x150x225	18.1	1191.8	3.6	
6	1:6	30	450x150x225	18.9	1244.4	3.915	
7	1:6	35	450x150x225	18.3	1204.9	4.2	
8	1:6	40	450x150x225	16.8	1106.2	4.2	

TABLE 7: CRUSHING STRENGTH RESULTS OF SANDCRETE BLOCKS (1:6 Mix) MADE USING 15mm SINGLE SIZE COARSE AGGREGATE FOR THE PARTIAL REPLACEMENT OF SAND

S/No	Cement – Sand Ratio	Quantity of Granite (%)	Block Size (mm)	Dry Weight (kg)	Dry Density (kg/m^3)	Crushing Strength H (N/mm^2)	Age of Block (days)
1	1:6	0	450x150x225	24.7	1084.2	0.93	7 days
2	1:6	10	450x150x225	25.8	1132.5	1.05	
3	1:6	15	450x150x225	25.4	114.9	1.13	
4	1:6	20	450x150x225	24.4	1071.1	1.095	
5	1:6	25	450x150x225	26.7	1172.0	1.23	
6	1:6	30	450x150x225	25.2	1106.2	1.71	
7	1:6	35	450x150x225	25.7	1128.1	1.85	
8	1:6	40	450x150x225	24.8	10886	1.44	
1	1:6	0	450x150x225	24.95	1099.3	1.73	14
2	1:6	10	450x150x225	24.8	1088.6	2.07	days
3	1:6	15	450x150x225	24.9	1093.0	1.49	
4	1:6	20	450x150x225	26.6	1167.6	1.95	
5	1:6	25	450x150x225	25.7	1128.1	2.61	
6	1:6	30	450x150x225	24.2	1062.3	1.88	
7	1:6	35	450x150x225	24.6	1079.8	2.19	
8	1:6	40	450x150x225	26.6	1167.6	2.39	
1	1:6	0	450x150x225	24.7	1084.2	1.77	21
2	1:6	10	450x150x225	24.8	1088.6	2.16	days
3	1:6	15	450x150x225	25.1	1101.8	1.89	
4	1:6	20	450x150x225	25.1	1101.8	2.19	
5	1:6	25	450x150x225	25.9	1136.9	2.75	
6	1:6	30	450x150x225	24.7	1084.2	1.98	
7	1:6	35	450x150x225	25.1	1101.8	2.43	
8	1:6	40	450x150x225	25.2	1119.3	2.78	
1	1:6	0	450x150x225	24.4	1071.1	2.06	28
2	1:6	10	450x150x225	24.4	1071.1	2.4	days
3	1:6	15	450x150x225	25.5	1119.3	2.67	
4	1:6	20	450x150x225	25.5	1119.3	2.70	
5	1:6	25	450x150x225	25.0	1097.4	3.08	
6	1:6	30	450x150x225	24.5	1075.4	2.97	
7	1:6	35	450x150x225	24.4	1071.1	2.64	
8	1:6	40	450x150x225	26.1	1145.9	3.03	

TABLE 8: CRUSHING STRENGTH RESULTS OF SANDCRETE BLOCKS (1:6 Mix) MADE USING 15mm SINGLE SIZE COARSE AGGREGATE FOR THE PARTIAL REPLACEMENT OF SAND

S/NO.	Cement – Sand Ratio	Quantity of Granite (%)	Block Size (mm)	Dry Weight (kg)	Dry Density (kg/m^3)	Crushing Strength H (N/mm^2)	Age of Block (days)
1	1:6	0	450x150x225	18.5	1218.1	1.8	7 days
2	1:6	10	450x150x225	18.3	1204.9	2.01	
3	1:6	15	450x150x225	18.6	1224.7	2.36	
4	1:6	20	450x150x225	18.1	1191.8	1.62	
5	1:6	25	450x150x225	18.4	121.5	2.81	
6	1:6	30	450x150x225	17.8	1172.0	1.95	
7	1:6	35	450x150x225	17.7	1165.4	2.48	
8	1:6	40	450x150x225	18.1	1191.8	2.63	
1	1:6	0	450x150x225	18.0	1185.2	2.06	14 days
2	1:6	10	450x150x225	18.1	1192.0	2.49	
3	1:6	15	450x150x225	17.8	1172.0	2.91	
4	1:6	20	450x150x225	17.5	1152.3	1.95	
5	1:6	25	450x150x225	17.9	1178.6	2.99	
6	1:6	30	450x150x225	18.3	1204.9	2.03	
7	1:6	35	450x150x225	18.0	1185.9	2.76	
8	1:6	40	450x150x225	18.2	119.4	3.0	
1	1:6	0	450x150x225	18.1	1192.0	2.97	21 days
2	1:6	10	450x150x225	18.2	1198.4	3.29	
3	1:6	15	450x150x225	18.8	1237.9	3.38	
4	1:6	20	450x150x225	17.3	1139.1	2.78	
5	1:6	25	450x150x225	17.6	1158.8	3.18	
6	1:6	30	450x150x225	18.0	1185.2	2.36	
7	1:6	35	450x150x225	18.0	1185.2	2.91	
8	1:6	40	450x150x225	17.8	1172.0	3.09	
1	1:6	0	450x150x225	17.9	1178.6	3.15	28 days
2	1:6	10	450x150x225	17.7	1165.6	3.51	
3	1:6	15	450x150x225	18.3	1204.9	3.41	
4	1:6	20	450x150x225	17.5	1152.3	2.94	
5	1:6	25	450x150x225	17.8	1172.0	3.29	
6	1:6	30	450x150x225	17.7	1165.4	3.49	
7	1:6	35	450x150x225	18.3	1204.9	3.24	
8	1:6	40	450x150x225	17.8	1172.0	3.24	

TABLE 9: CRUSHING STRENGTH RESULTS OF SANDCRETE BLOCKS (1:6 Mix) MADE USING 15mm SINGLE SIZE COARSE AGGREGATE FOR THE PARTIAL REPLACEMENT OF SAND

S/No.	Cement – Sand Ratio	Quantity of Granite (%)	Block Size (mm)	Dry Weight (kg)	Dry Density (kg/m^3)	Crushing Strength H (N/mm^2)	Age of Block (days)
1	1:6	0	450x150x225	23.1	1013.9	0.9	7 days
2	1:6	10	450x150x225	25.9	1136.9	1.22	
3	1:6	15	450x150x225	24.8	1088.6	1.29	
4	1:6	20	450x150x225	26.2	1150.1	1.8	
5	1:6	25	450x150x225	26.5	1163.2	1.83	
6	1:6	30	450x150x225	26.1	1145.7	1.8	
7	1:6	35	450x150x225	26.4	1158.8	2.9	
8	1:6	40	450x150x225	23.5	1031.6	0.99	
1	1:6	0	450x150x225	23.7	1040.3	1.5	14 days
2	1:6	10	450x150x225	24.0	1053.5	1.67	
3	1:6	15	450x150x225	24.8	1088.6	2.31	
4	1:6	20	450x150x225	25.6	1123.7	2.01	
5	1:6	25	450x150x225	25.5	119.3	2.61	
6	1:6	30	450x150x225	25.7	1128.1	1.83	
7	1:6	35	450x150x225	25.4	1114.9	2.97	
8	1:6	40	450x150x225	27.0	1185.2	1.82	
1	1:6	0	450x150x225	24.8	1088.6	1.55	21 days
2	1:6	10	450x150x225	25.5	1119.4	1.79	
3	1:6	15	450x150x225	24.5	1075.4	2.45	
4	1:6	20	450x150x225	25.7	1128.1	2.73	
5	1:6	25	450x150x225	26.0	1141.3	2.63	
6	1:6	30	450x150x225	25.6	1123.7	2.72	
7	1:6	35	450x150x225	26.1	1145.7	3.02	
8	1:6	40	450x150x225	26.2	1150.1	2.73	
1	1:6	0	450x150x225	25.0	1097.4	1.96	28 days
2	1:6	10	450x150x225	24.0	1079.8	2.18	
3	1:6	15	450x150x225	25.1	1101.8	2.96	
4	1:6	20	450x150x225	25.1	1101.8	3.05	
5	1:6	25	450x150x225	25.5	1119.4	2.97	
6	1:6	30	450x150x225	25.8	1132.5	3.9	
7	1:6	35	450x150x225	26.0	1141.3	3.17	
8	1:6	40	450x150x225	25.5	1119.3	3.15	

TABLE 10: CRUSHING STRENGTH RESULTS OF SANDCRETE BLOCKS (1:6 Mix) MADE USING MIXED COARSE AGGREGATE (10mm & 15mm) FOR THE PARTIAL SAND REPLACEMENT

S/No.	Cement –Sand Ratio	Quantity of Granite (%)	Block Size (mm)	Dry Weight (kg)	Dry Density (kg/m^3)	Crushing Strength H (N/mm^2)	Age of Block (days)
1	1:6	0	450x150x225	18.6	1224.7	1.47	7 days
2	1:6	10	450x150x225	18.9	1244.9	1.56	
3	1:6	15	450x150x225	18.9	1244.9	1.73	
4	1:6	20	450x150x225	18.9	1244.9	2.25	
5	1:6	25	450x150x225	17.9	1178.6	2.18	
6	1:6	30	450x150x225	17.5	1152.3	1.94	
7	1:6	35	450x150x225	18.1	1191.8	1.95	
8	1:6	40	450x150x225	18.5	1218.1	1.95	
1	1:6	0	450x150x225	17.5	1152.3	1.53	14 days
2	1:6	10	450x150x225	17.3	1139.1	1.89	
3	1:6	15	450x150x225	18.6	1224.7	2.25	
4	1:6	20	450x150x225	18.4	1211.5	2.40	
5	1:6	25	450x150x225	19.4	1277.4	2.45	
6	1:6	30	450x150x225	17.9	1178.6	2.18	
7	1:6	35	450x150x225	18.4	1211.5	2.22	
8	1:6	40	450x150x225	18.1	1191.8	2.73	
1	1:6	0	450x150x225	17.0	1119.3	2.173	21 days
2	1:6	10	450x150x225	17.1	1125.9	2.85	
3	1:6	15	450x150x225	17.5	1152.3	2.78	
4	1:6	20	450x150x225	17.8	1172.3	3.45	
5	1:6	25	450x150x225	20.1	1323.5	3.47	
6	1:6	30	450x150x225	18.0	1185.2	2.85	
7	1:6	35	450x150x225	18.5	1218.1	2.25	
8	1:6	40	450x150x225	18.2	1198.4	2.78	
1	1:6	0	450x150x225	17.2	1132.5	2.52	28 days
2	1:6	10	450x150x225	17.5	1152.3	2.96	
3	1:6	15	450x150x225	17.6	1158.8	3.71	
4	1:6	20	450x150x225	18.6	1224.5	3.83	
5	1:6	25	450x150x225	19.4	1277.4	3.87	
6	1:6	30	450x150x225	18.4	1211.5	3.15	
7	1:6	35	450x150x225	18.6	1224.7	2.27	
8	1:6	40	450x150x225	18.7	1198.4	3.33	

TABLE 11: CRUSHING STRENGTH RESULTS OF SANDCRETE BLOCKS (1:6 Mix) MADE USING MIXED COARSE AGGREGATE (10mm & 15mm) FOR THE PARTIAL SAND REPLACEMENT

S/No.	Cement – Sand Ratio	Quantity of Granite (%)	Block Size (mm)	Dry Weight (kg)	Dry Density (kg/m^3)	Crushing Strength H (N/mm^2)	Age of Block (days)
1	1:6	0	450x150x225	23.5	1031.6	0.9	7 days
2	1:6	10	450x150x225	23.6	1035.9	1.26	
3	1:6	15	450x150x225	25.0	1097.4	1.59	
4	1:6	20	450x150x225	24.4	1071.1	1.01	
5	1:6	25	450x150x225	25.1	1114.9	0.95	
6	1:6	30	450x150x225	24.3	1066.7	1.35	
7	1:6	35	450x150x225	25.5	1119.3	1.29	
8	1:6	40	450x150x225	24.4	1071.5	0.93	
1	1:6	0	450x150x225	23.4	1027.2	1.23	14 days
2	1:6	10	450x150x225	23.6	1025.9	1.44	
3	1:6	15	450x150x225	24.4	1071.1	1.74	
4	1:6	20	450x150x225	24.5	1075.4	1.02	
5	1:6	25	450x150x225	25.2	1106.2	1.29	
6	1:6	30	450x150x225	24.0	1053.5	1.67	
7	1:6	35	450x150x225	25.7	1128.1	1.77	
8	1:6	40	450x150x225	25.4	1114.9	2.16	
1	1:6	0	450x150x225	24.5	1075.4	1.52	21 days
2	1:6	10	450x150x225	24.8	1088.6	1.62	
3	1:6	15	450x150x225	24.5	1075.4	2.13	
4	1:6	20	450x150x225	24.5	1075.4	2.04	
5	1:6	25	450x150x225	25.0	1097.4	1.70	
6	1:6	30	450x150x225	24.1	1071.1	1.94	
7	1:6	35	450x150x225	25.1	1114.9	1.98	
8	1:6	40	450x150x225	25.3	1110.6	2.39	
1	1:6	0	450x150x225	23.7	1040.3	2.18	28 days
2	1:6	10	450x150x225	24.1	1057.9	2.48	
3	1:6	15	450x150x225	24.6	1079.8	2.25	
4	1:6	20	450x150x225	25.7	1128.1	2.45	
5	1:6	25	450x150x225	25.0	1097.4	1.79	
6	1:6	30	450x150x225	23.9	1049.1	2.04	
7	1:6	35	450x150x225	25.9	1136.9	3.62	
8	1:6	40	450x150x225	25.7	1128.1	2.91	

TABLE 12: COMPRESSIVE STRENGTHS OF SANDCRETE BLOCKS (450mm X 225mm X 225mm) FOR VARIOUS WATER/CEMENT RATIOS

MIX PROPOR-TION	WATER-CEMENT RATIO	7-DAY STRENGTH (N/mm^2)		14-DAY STRENGTH (N/mm^2)		28-DAY STRENGTH (N/mm^2)	
		MANUAL	MECHANICAL	MANUAL	MECHANICAL	MANUAL	MECHANICAL
1:6	0.45	0.82	1.00	1.01	1.30	1.37	1.81
1:6	0.52	0.94	1.09	1.21	1.41	1.48	1.94
1:6	0.55	1.31	1.74	1.62	1.99	1.72	2.19
1:6	0.65	1.59	1.83	1.71	2.31	2.14	2.67
1:6	0.75	2.17	2.29	2.26	2.57	2.54	2.86
1:6	1.00	2.47	2.67	2.57	2.77	2.77	2.96

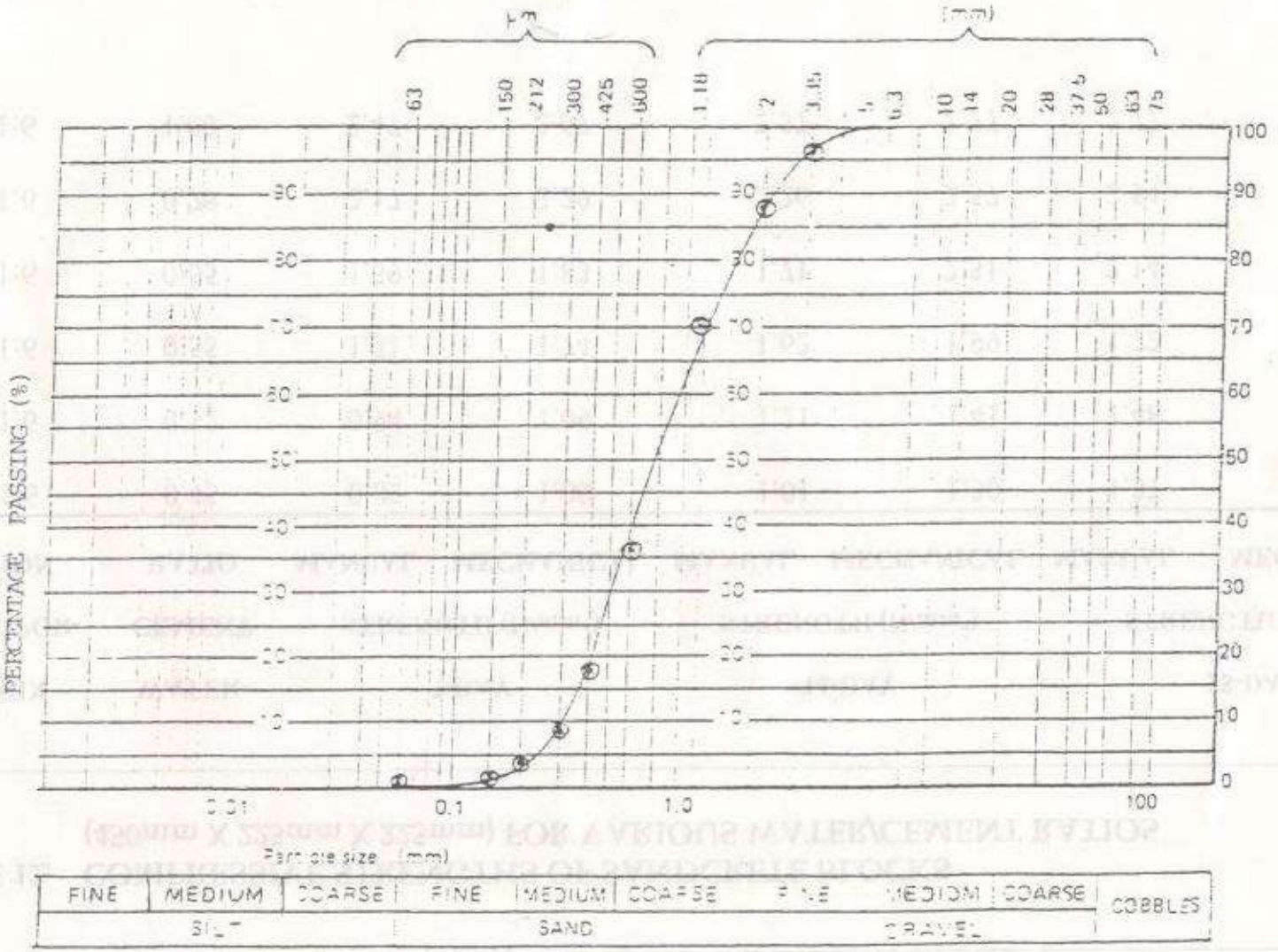

FIGURE I : RESULT OF SIEVE ANALYSIS OF FINE AGGREGATE (SAND)

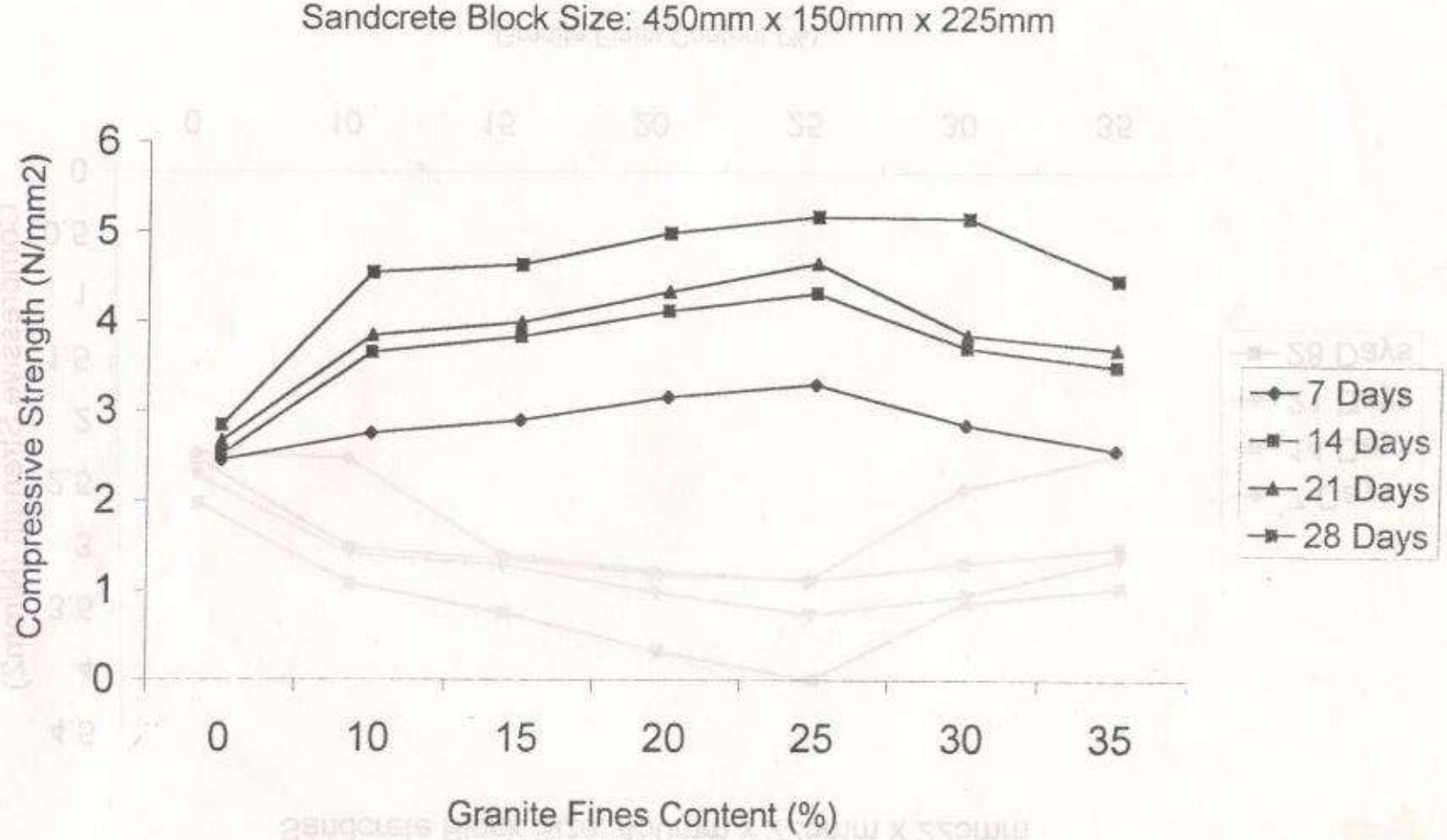

Fig. 2 : Plot of Compressive Strength Against Granite Fines Content (1:6 Mix Proportion)

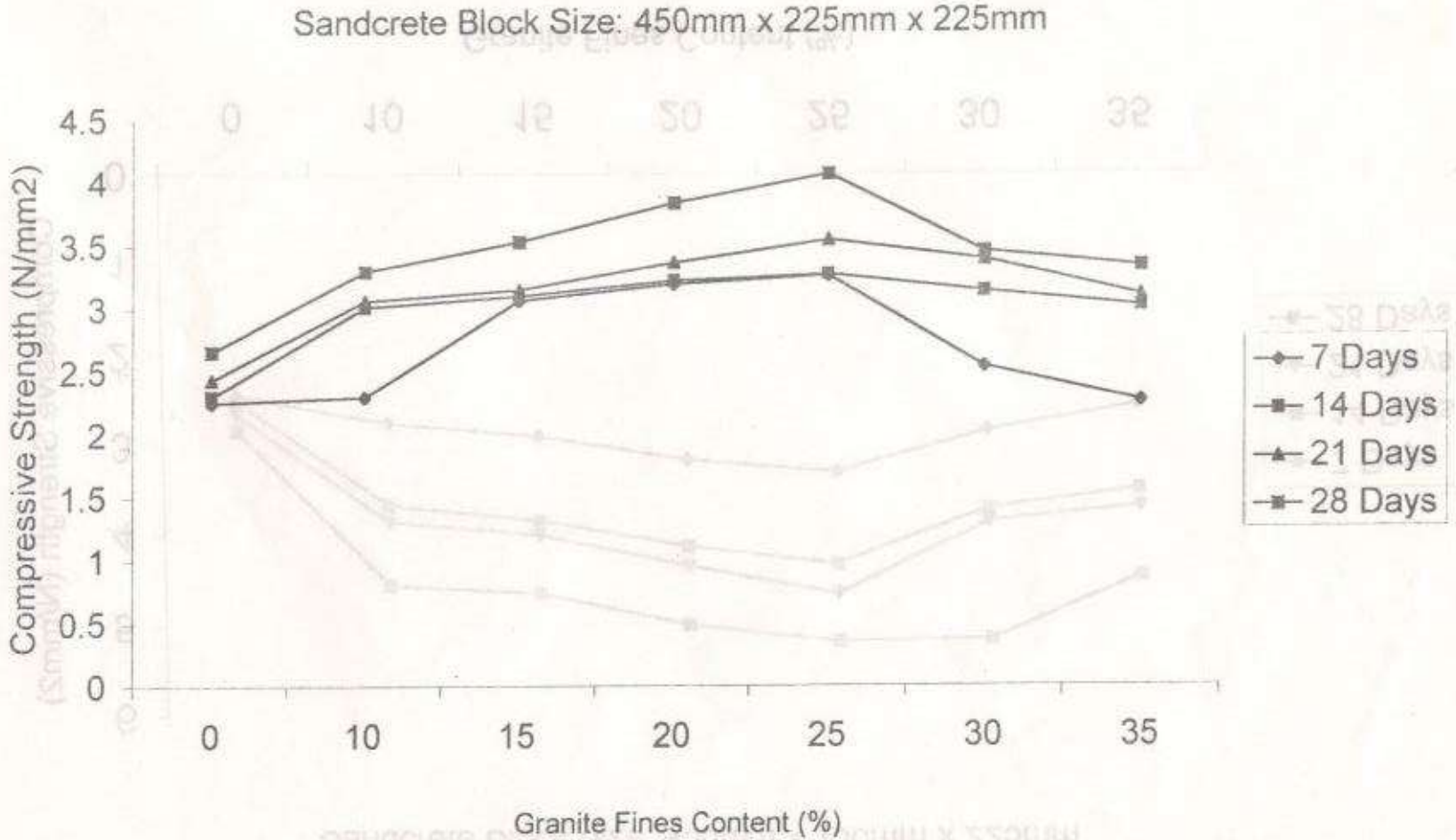

Fig. 3 : Plot of Compressive Strength Against Granite Fines Content (1:6 Mix Proportion)

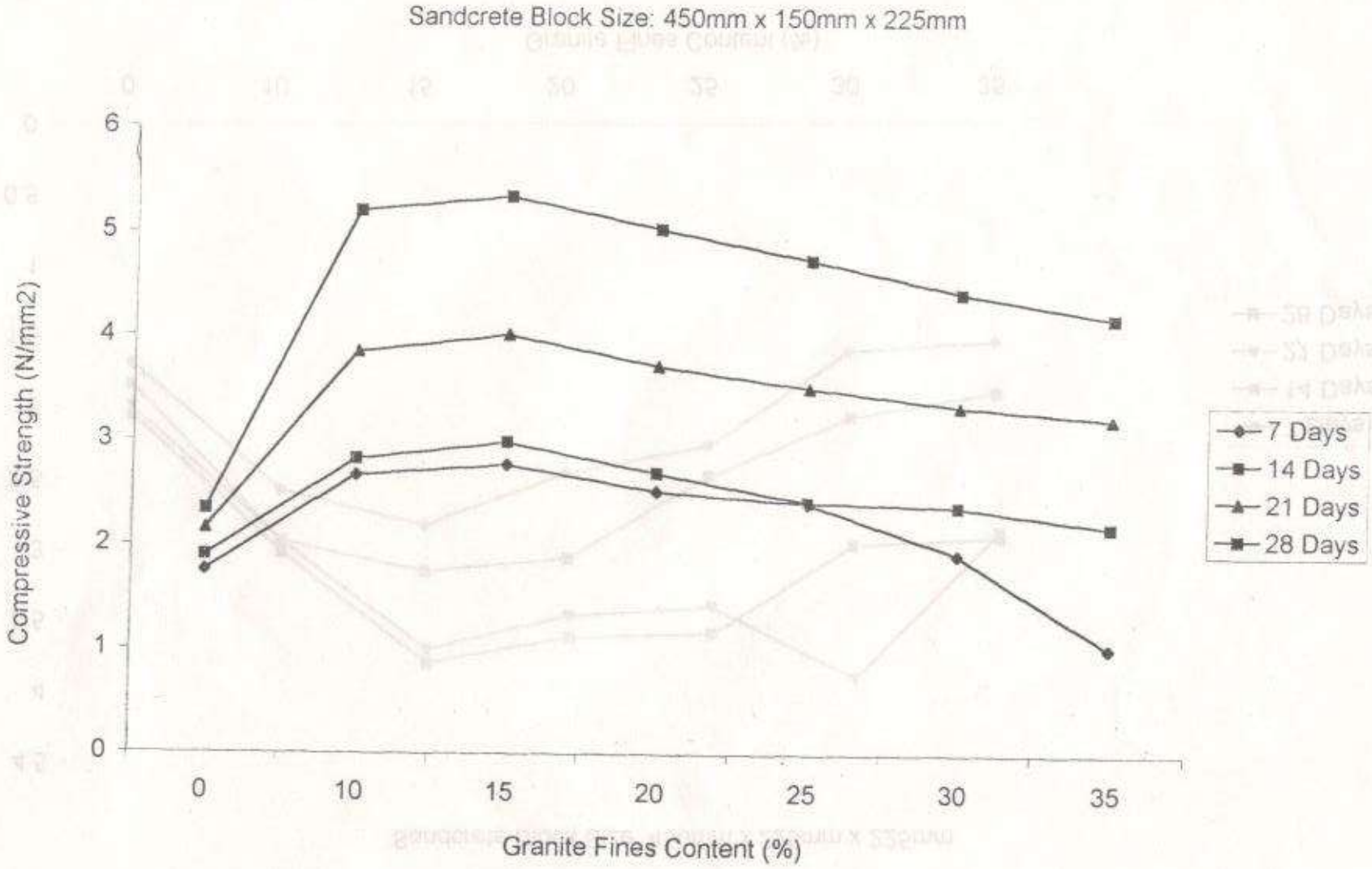

Fig. 4 : Plot of Compressive Strength Against Granite Fines Content (1:8 Mix Proportion)

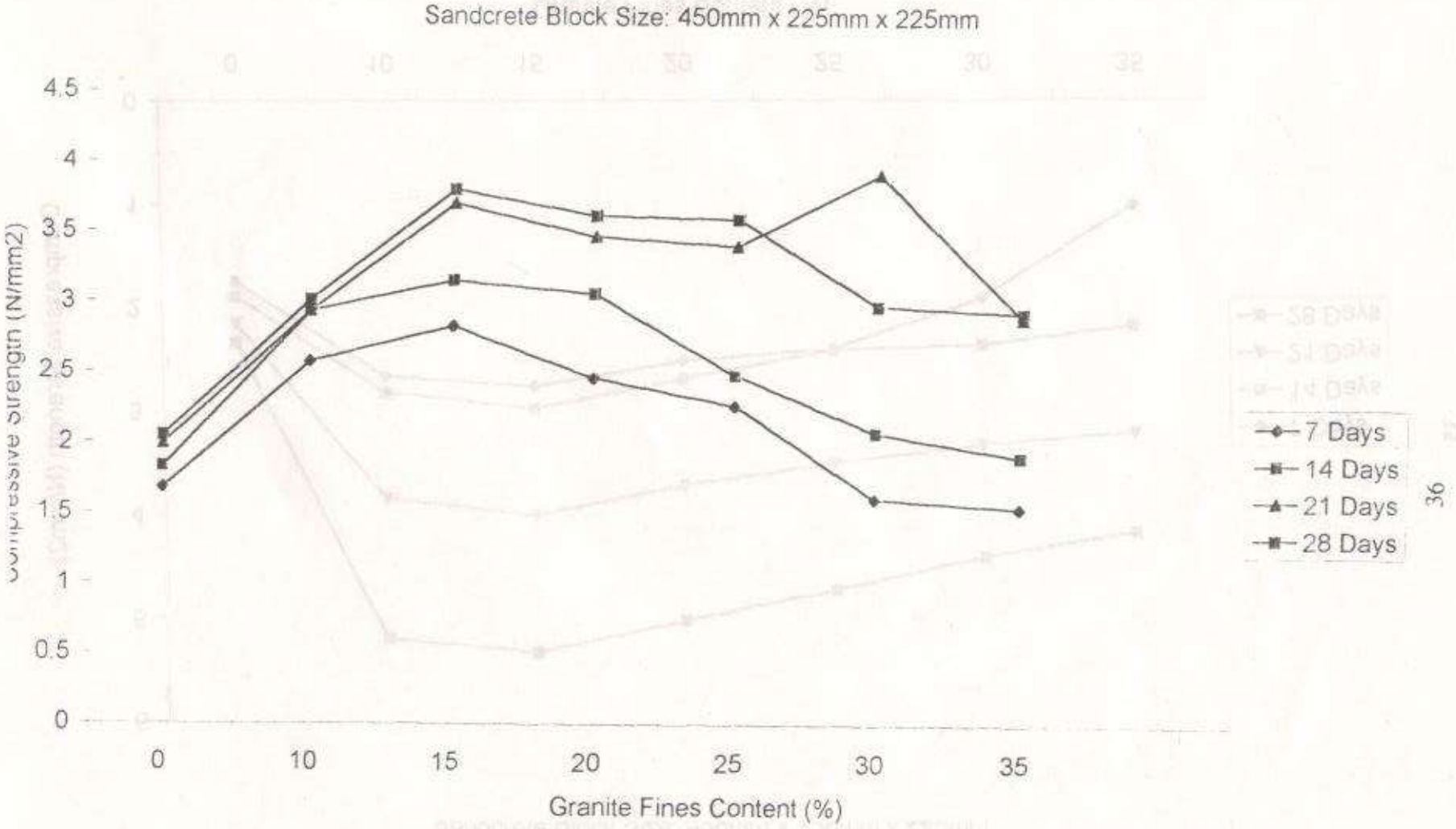

Figure 5 : Plot of Compressive Strength Against Granite Fines Content (1:8 Mix Proportion)

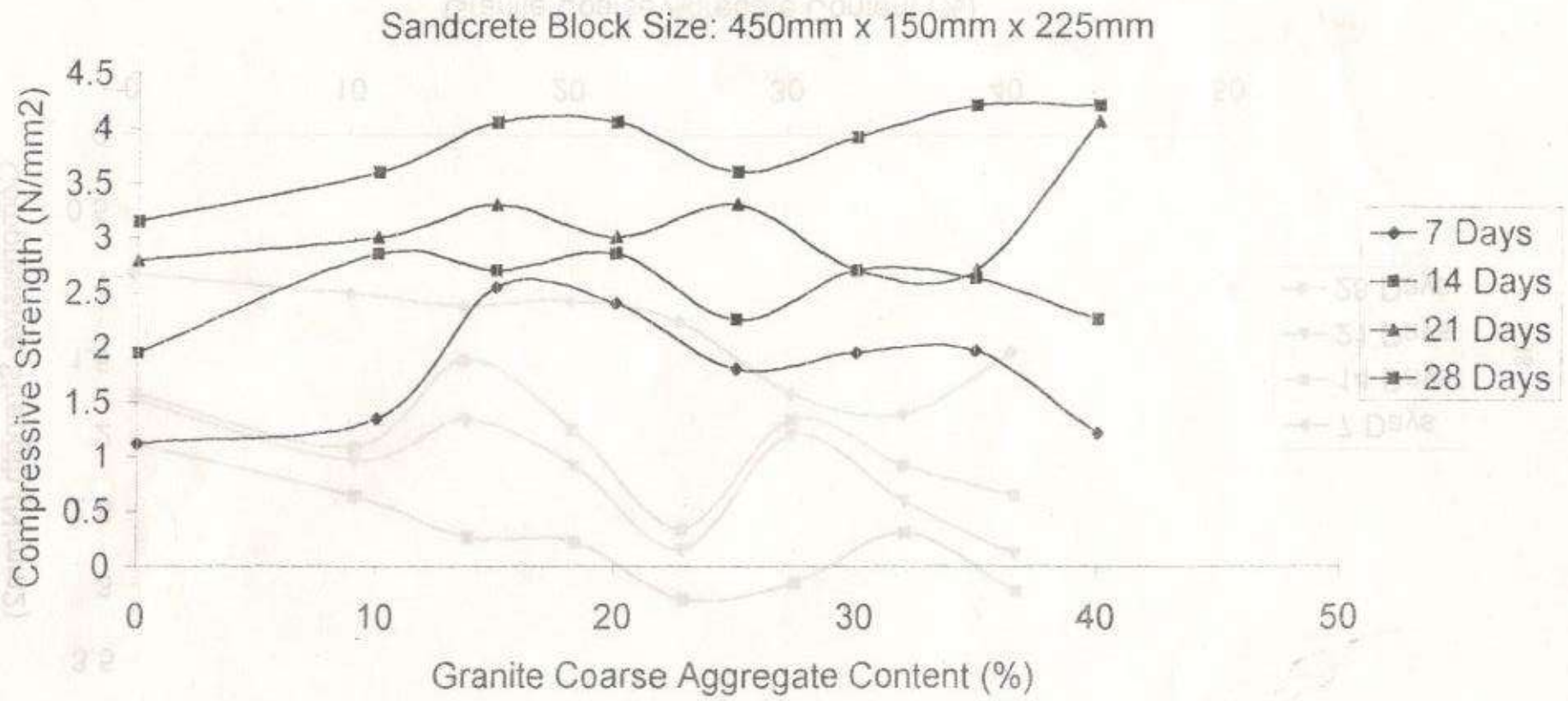

Figure 6 : Plot of Compressive Strength Against Percentage Granite Coarse Aggregate Content (15mm), (1:6 Mix Proportion)

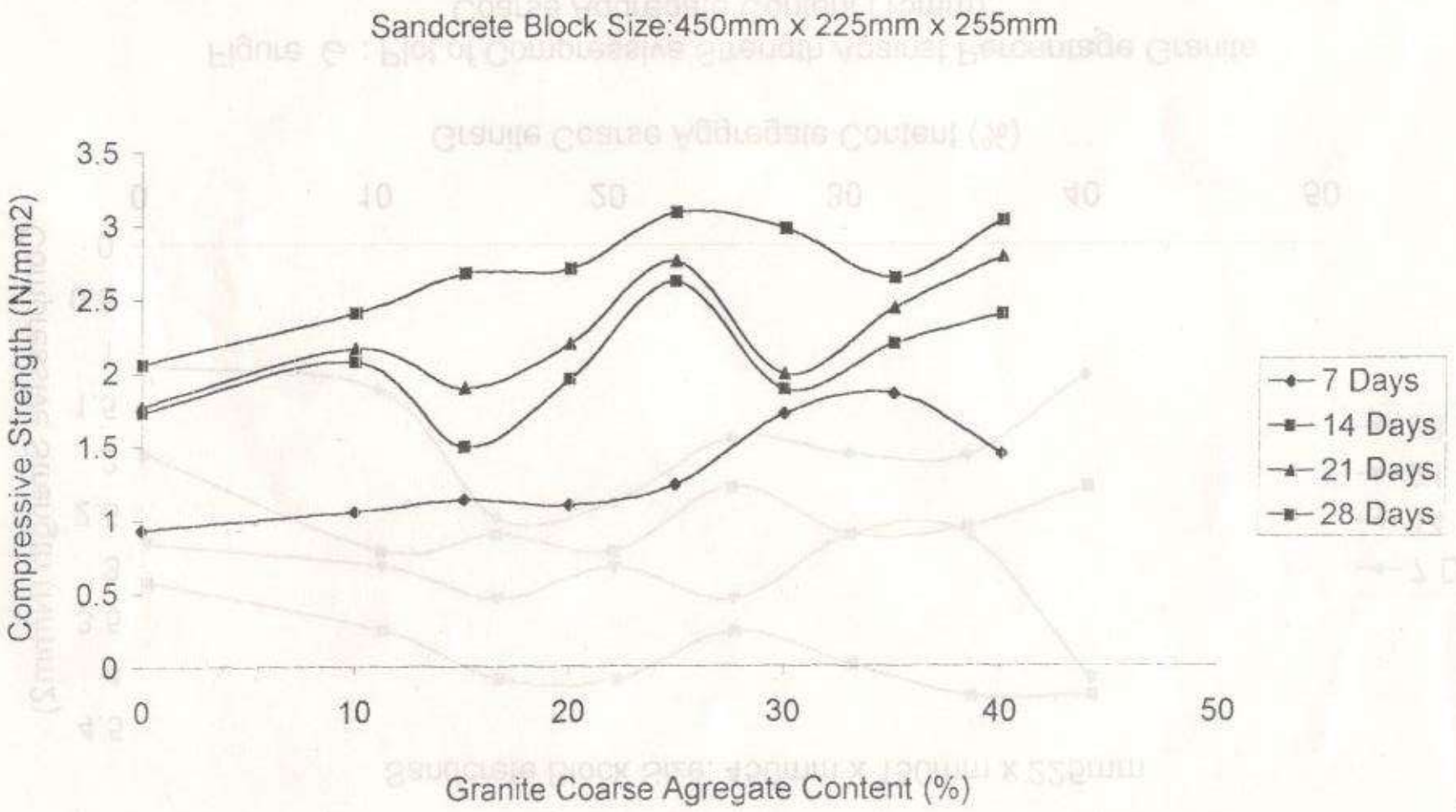

Figure 7 : Plot of Compressive Strength Against Percentage Granite Coarse Aggregate Content (15mm), (1:6 Mix Proportion)

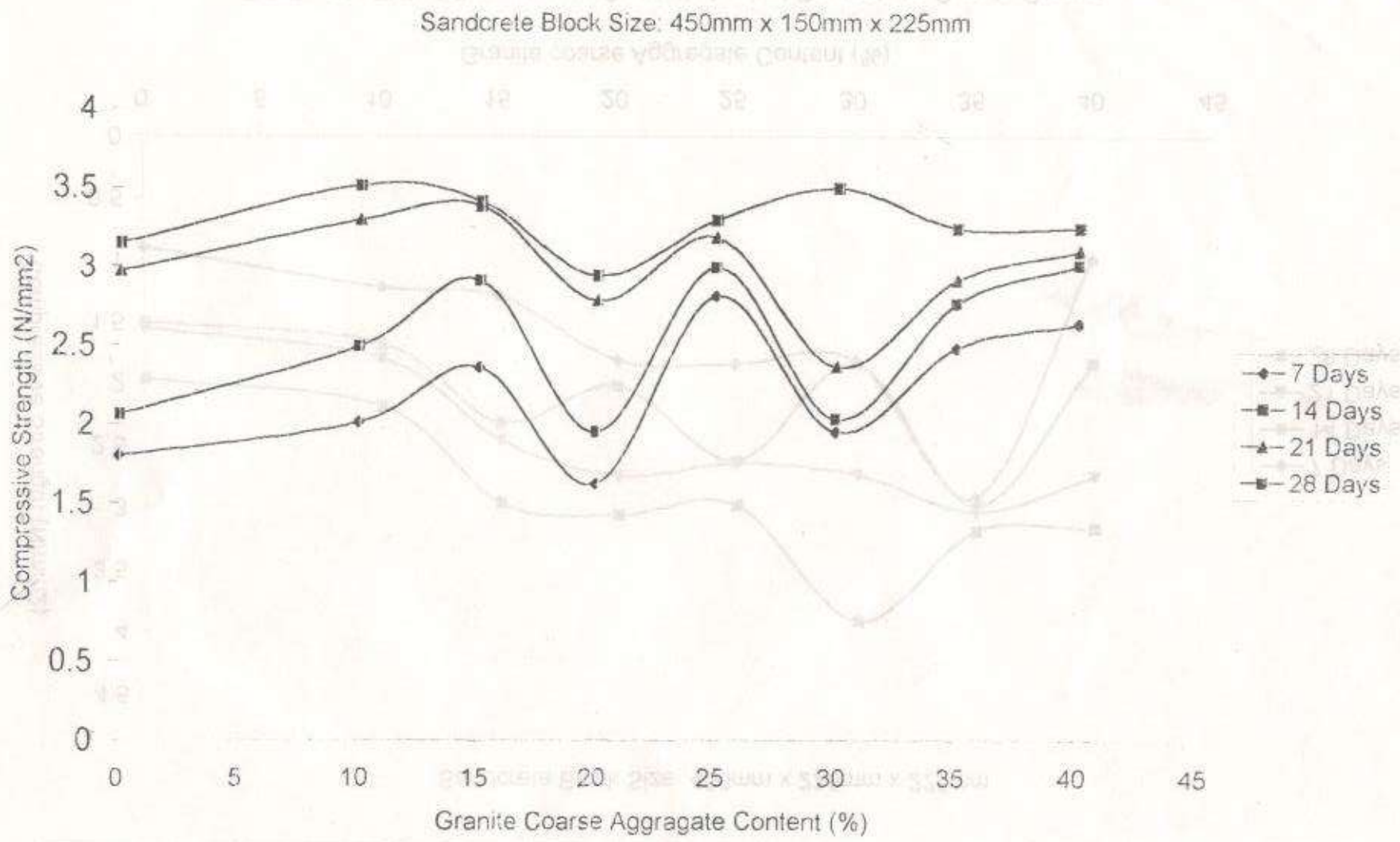

Figure 8. Plot of Compressive Strength Against Percentage Granite Coarse Aggregate Content (10mm), (1:6 Mix Proportion)

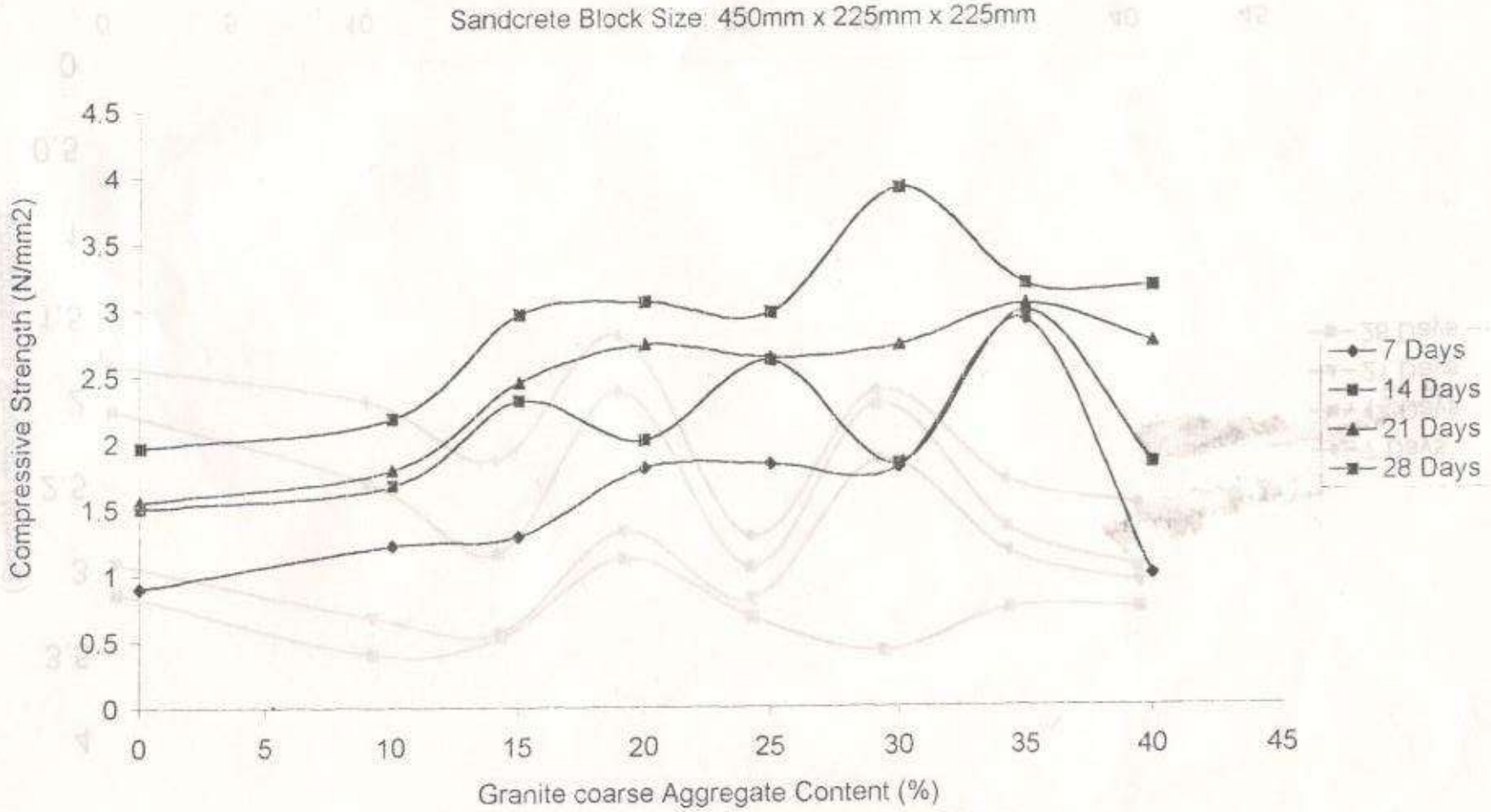

Figure 9 : Plot of Compressive Strength Against Percentage Granite Coarse Aggregate Content (10mm), (1:6 Mix Proportion)

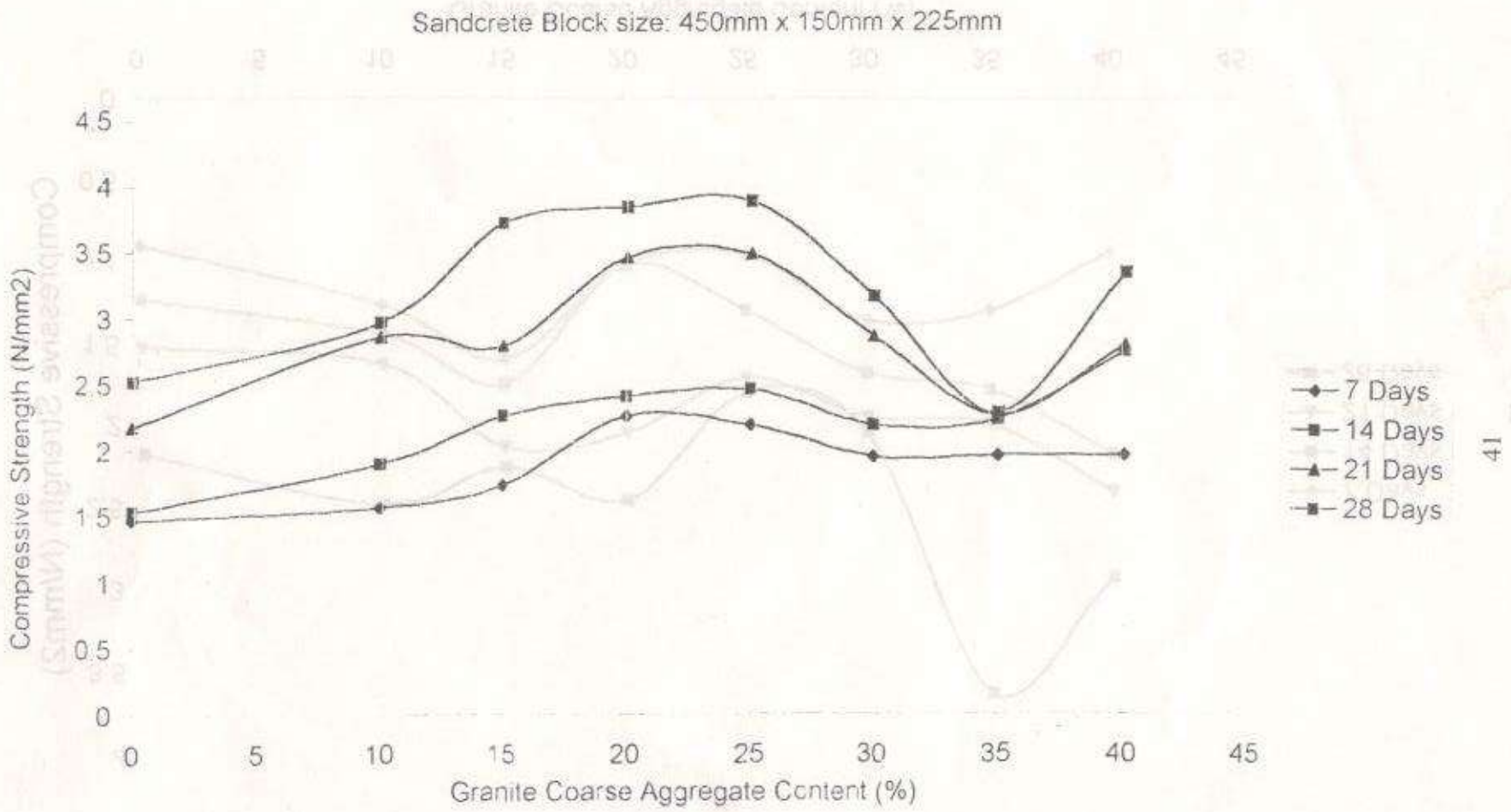

Figure 10: Plot of Compressive Strength Against Percentage Granite Coarse Aggregate Content (10mm & 15mm), (1:6 Mix proportion)

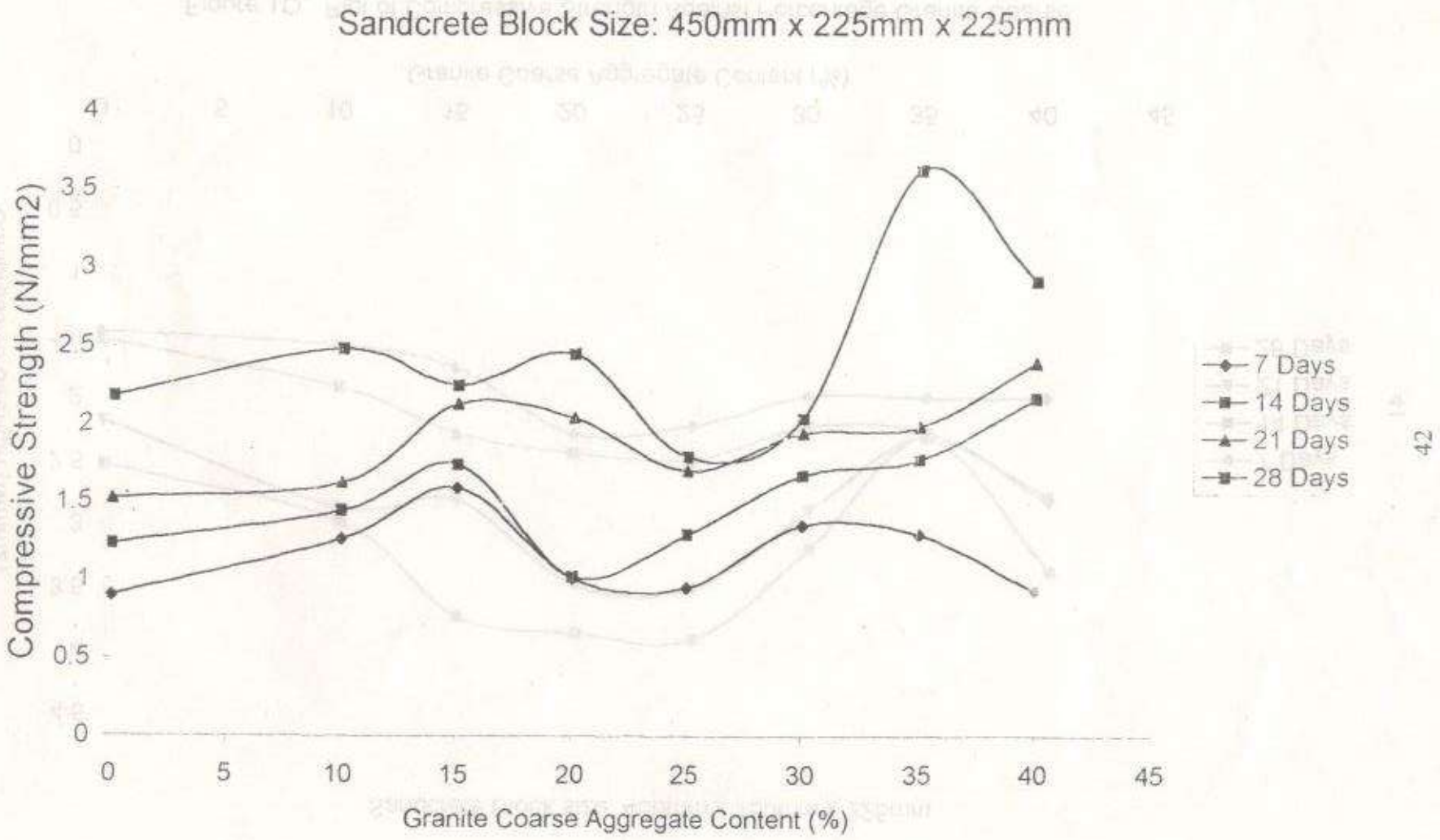

Figure 11: Plot of Compressive Strength Against Percentage Granite Coarse Aggregate Content (10mm & 15mm). (1:6 Mix Proportion)

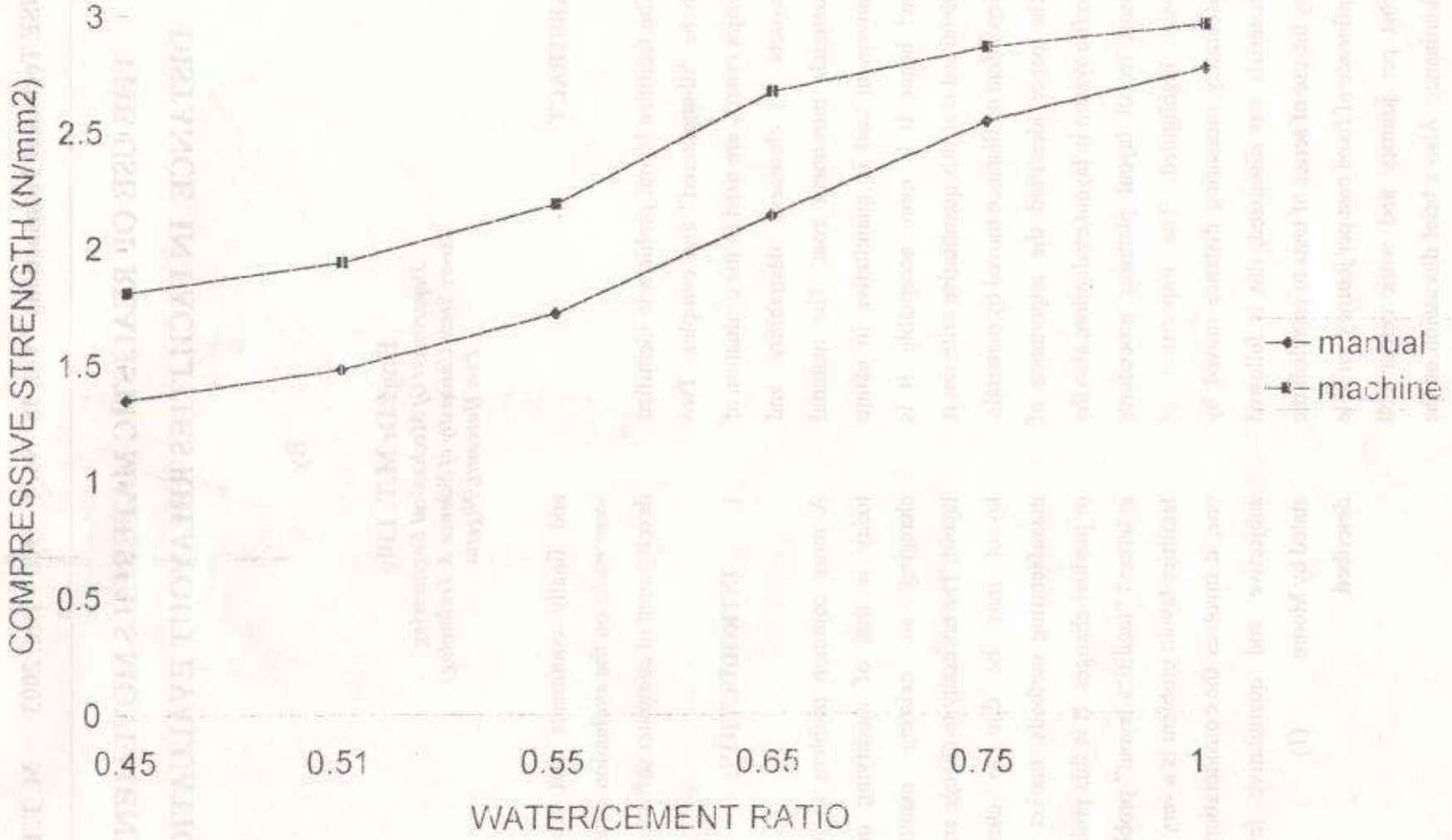

FIGURE12: PLOT OF COMPRESSIVE STRENGTH AGAINST WATER/CEMENT RATIO (28 DAYS)