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A STUDY OF THE EFFECT OF SAND ON THE COMPRESSIVE STRENGTH OF STABILISED SOIL BLOCKS

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ABSTRACT

A study of the effect of sand on the compressive strength of cement stabilised soil blocks made from 'Cinva Ram' block press, has been made. In addition, the effect of sand on the compaction, water absorption and durability has been investigated. It is found that the sand content has a marked effect on the compressive strength. It shall therefore, be necessary to determine the optimum sand content for maximum compressive strength for a specified amount of stablizing agent. Typical values of optimum sand content for a local soil have been given.

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1.0 INTRODUCTION

The 'Cinva Ram' cement or lime stablised soil blocks and tiles have recently been used in Pakistan to provide low cost houses, schools, offices and godowns. In rural areas, their use was welcomed; as in comparison with the traditional mud walls, the block walls were architecturally more attractive and durable, and in comparison with the burnt clay brick walls, the block walls were cheaper.

As suggested by METALIBEC LTDA., the manufacturers of 'Cinva Ram' South America, the blocks were made by using a standard design mix like 1:7:12 (one part cement, 7 parts sand and 12 parts soil). It was also specified that the blocks must be atleast 14 days old before being put to use. Since the soil composition affects its response to stabilisation, the above mix may not always yield the optimum results for a particular soil. The present investigations were therefore conducted to study the effect of sand content on the engineering properties of cement stabilised Cinva Ram blocks. The soils from Lahore and Islamabad areas were investigated. The results of these investigations are presented here.

2.0 LITERATURE REVIEW

As pointed out by METALIBEC LTDA. in early sixtees, the only earth which is not suitable for making Cinva Ram blocks is earth having only one particle size, and the earth which will make the best blocks is made from earth having particle sizes from very fine to fairly coarse. HORD (1969) also suggested that the soils best suited for rammed earth construction are the soils with proper amounts of sand and clay and free from organic matter.

Based on grain size distribution the soils may be classified as 'uniform' if the variation in grain size is not much and well graded, if the variation in grain

size is substantial. The term uniformity co-efficient(the ratio between 60% and 10% finer sizes) is used to differentiate between the uniform and well graded materials.

The studies on compaction characteristics of soil have led to the conclusion that a well graded material may be compacted to higher maximum dry density as compared to a uniform material (HMSO, 1962). The compaction to a higher maximum dry density of a well graded material over a uniform material is illustrated in Fig.1. The finer particles accupy spaces between coarser particles.

As suggested by Metalibec Ltd., the Cinva Ram blocks may be made from an ordinary soil which is well graded, but still better results may be achieved if a coarse soil is added to a fine soil or vice versa.

Such an addition of materials is expected to:-

a) increase the maximum dry density
b) increase or decrease the optimum water content.
c) increase the compressive strength
d) decrease the water absorption
e) decrease the shrinkage and cracking
f) increase the durability

As shown by HORD (1969), CENTRAL ENGINEERING LABORATORY (1973), KHAN (1974) and BOKHARI (1976), the soils in the river flood plains in Bangla Desh and the Punjab province of Pakistan contain silt deposits that have a very low sand content. These soils may be classified as SM or ML-CL groups of the Unified Classification System. Since these soils are fine, it is therefore, possible to improve them by adding sand.

Only recently, the effect of addition of sand on the engineering properties of stabilized blocks made from local soils has been investigated, e.g. by CENTRAL ENGINEERING LABORATORY (1973) and BOKHARI (1976).

3.0 EXPERIMENTAL INVESTIGATION

To study the effect of sand on the engineering properties of stabilized soils blocks, investigations were carried out on cylindrical test specimens,2 in.dia, 4 in. long and Cinva Ram blocks, 4x6x12 inch nominal size.

Ordinary Portland cement was used in these investigations. In case of Lahore soil, river Ravi sand was used and in case of Islamabad soil, river Soan sand was used. The gradation curves of the Lahore soils and the Ravi sand are shown in Fig.2. The gradation curves of Islamabad soil and Soan sand are not available.

To investigate the compaction characteristics, standard Proctor compaction tests were performed.

The compressive strength measurements were made on 7, 14 and 28 days old cylindrical specimens and blocks. Water absorption and soaked strength tests were also performed to study the performance of the block under inundation conditions.

To study the durability characteristics,wetting and the drying and freezing and thawing tests were performed on blocks. The blocks were subjected to 12 cycles of wetting and drying, and freezing and thawing. At the end of these cycles, the percentage loss in weight was recorded.

4.0 RESULTS AND DISCUSSION

Some of the results of the investigations are shown in Figs. 3 to 7.

In Fig.3 is plotted the moisture dry density relationship of Lahore soil with varying percentages of sand content from 5 to 20%. It is seen that with the increase in sand content, the maximum dry density keeps on increasing and the optimum water content keeps on

decreasing. This trend indicates that the addition of sand results in a material which may be compacted to a higher degree than the ordinary soil. The decrease in optimum water content is obvious as the saturation water content of sand is lower than that of silt.

In Fig.4 are presented the results of water absorption tests on ordinary soil and soil-sand specimens stablized with different percentages of cement. It may be seen that the decrease in water absorption is considerabl at low cement contents, in comparison with high cement contents. It demonstrates the effect of sand on water absorption characteristics of stabilized material. Also, the variation in water absorptions of 15% sand and 20% sand mixture is not appreciable. It suggests that beyond a certain limit, the sand is not effective to the same degree.

In Fig.5 are presented the results of compressive strength tests performed on cement stabilized blocks made from Lahore soil. The 28-day strengths of stabilized blocks made from soils containing different percentages of sand are plotted as a function of cement percentage. It may be seen that the sand content has a marked effect on the compressive strength at different percentages of cement. The results are quite consistent and it may clearly be seen that the addition of about 20% sand almost doubles the compressive strength for cement contents upto about 7%. The effect of sand content on compressive strength beyond 7% cement content is not of the same degree.

Similar plots in case of blocks made from Islamabad soil are shown in Fig.6. Here, both 7 and 28-day compressive strengths are plotted versus cement percentage. It may be seen that the 28-day strength test results are more consistent than the 7-day strength test results. The addition of sand results in strength increase at various cement percentages and this increase is more pronounced for cement contents exceeding 3 percent. The results of 7-day strength tests show that the effect of sand content is more pronounced for cement percentages greater than

6, whilst no definite trend is found for cement percentages less than this. It is also interesting to note that the ordinary Islamabad soil showed very little increase in 7-day strength when stabilized with more than 6 percent cement. As compared to ordinary soil the soil-sand mixture showed marked gain in strength with cement percentages more than 6. The 7-day soil-sand strengths nearly approach the 28-day soil strength. It indicates that the soil-sand block gain an early strength in this range of cement content and shall therefore require lesser period for curing before being used in construction.

According to the test performed by BOKHARI(1976) on soaked blocks of Lahore soil having 15% sand and 6% cement, the average reduction in compressive strength due to soaking was about 38%. The reduction in compressive strength due to soaking of Lahore soil blocks having about 6% cement was found by the auther to be about 50%. It shows that the addition of sand decreases the reduction of compressive strength upon inundation. The reduction in percentage decrease in strength may be attributed to denser packing of the particles due to addition of sand.

Some of the blocks made from Lahore soil having composition as mentioned above were subjected to twelve cycles of wetting and drying. An average loss of 3.7 % in weight was observed. According to "Soil Mechanics for Road Engineers" the silty and clayey soils may have a tolerable loss in weight to be about 7-10 percent. The addition of sand therefore helps in making the blocks more resistent to wetting and drying.

Some of the blocks of the above somposition were subjected to twelve cycles of freezing and thawing. The results showed that the blocks had about 5% reduction in weight. At the end of fourth cycle, hair cracks appeared in three out of five blocks. In spite of the hair cracks the reduction in weight was within tolerable limits as quoted by CHADDA & KAPUR (1956).

The results of this investigation show that the sand blending increases the compressive strength and durability of stabilized blocks. It is found that when the sand content is increased from 10 to 15 percent in case of Lahore soil, there is a rapid increase in compressive strength for all percentages of cement. Beyond 15% the

rate of strength increase is relatively lower. Blending 15% sand increases the 28-day compressive strength from 300 to 410 lbs. in^2.

When cement content of blocks made from Lahore soil is increased from 4 to 6 percent, a sharp increase in strength occurs. The rate of increase in strength when cement content is increased from 6 to 8 percent, is relatively lower. As an average, 6% cement content may be taken as an optimum value for Lahore soil. Thus a mix of proportion (15:85) stabilised with 6% cement will yield optimum results in case of Lahore soil, or other silty soils of Punjab.

5.0 CONCLUSIONS

On the basis of this study it may be concluded that:-

1. Blending of soil with sand increase the compressive strength of the stabilized blocks. With a sand content of 15% the strength increase is about 37%.
2. The sand blending decreases water absorption and increases the durability against inundation, wetting and drying, and freezing and thawing.
3. A mix of the following proportion is found to yield optimum results in case of silty soils of Punjab for making stabilized blocks from Cinva Ram block press.

Soil	=	85 %
Sand	=	15 %
Cement	=	6 % of soil
Water	=	15 % of soil

6.0 ACKNOWLEDGEMENTS

The author is grateful to the University of Engineering and Technology,Lahore for providing necessary facilities for this investigation. Thanks are also due to M/s. Central Engineering Laboratory,Islamabad,Heavy Mechanical Complex, Texila, and Mr.Asghar Hussain Bokhari, for supplying useful data included in this paper.

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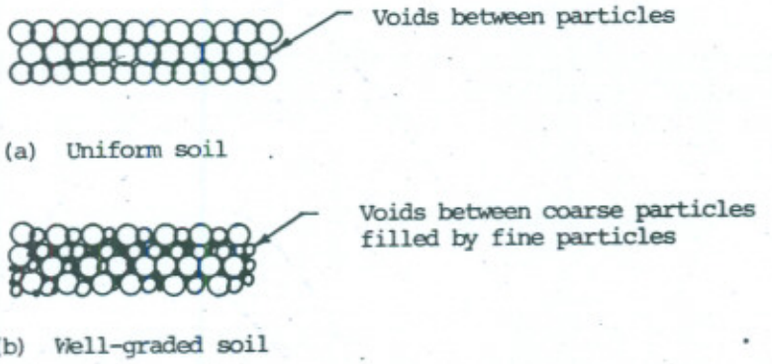


Fig. 1. Compaction of Uniform & Well Graded Soils.

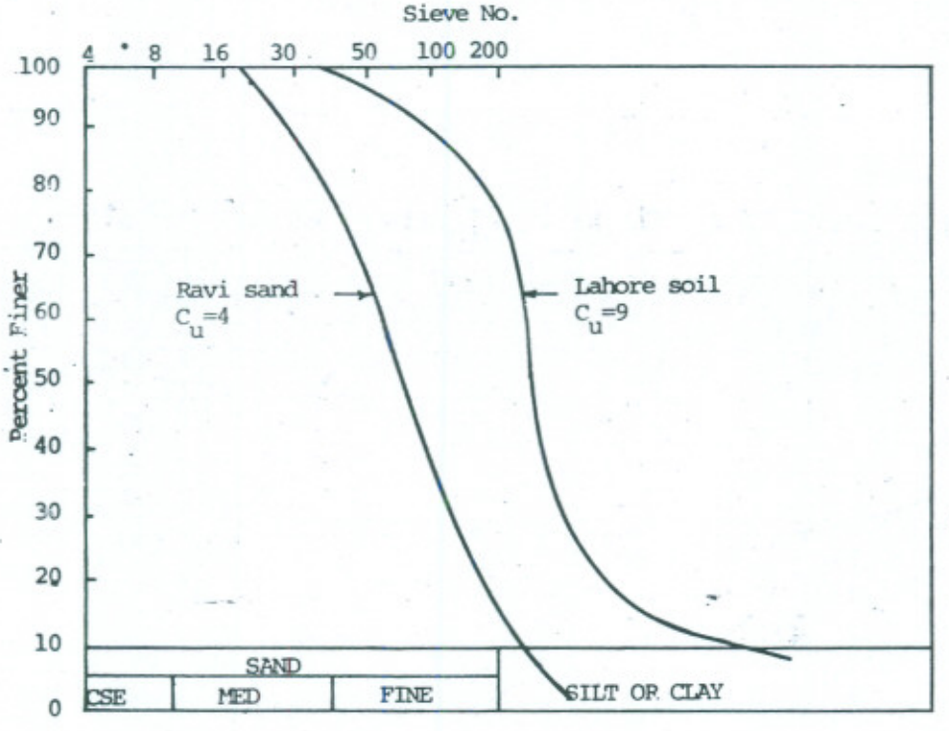


Fig. 2. Gradation Curves of Lahore Soil & Ravi Sand

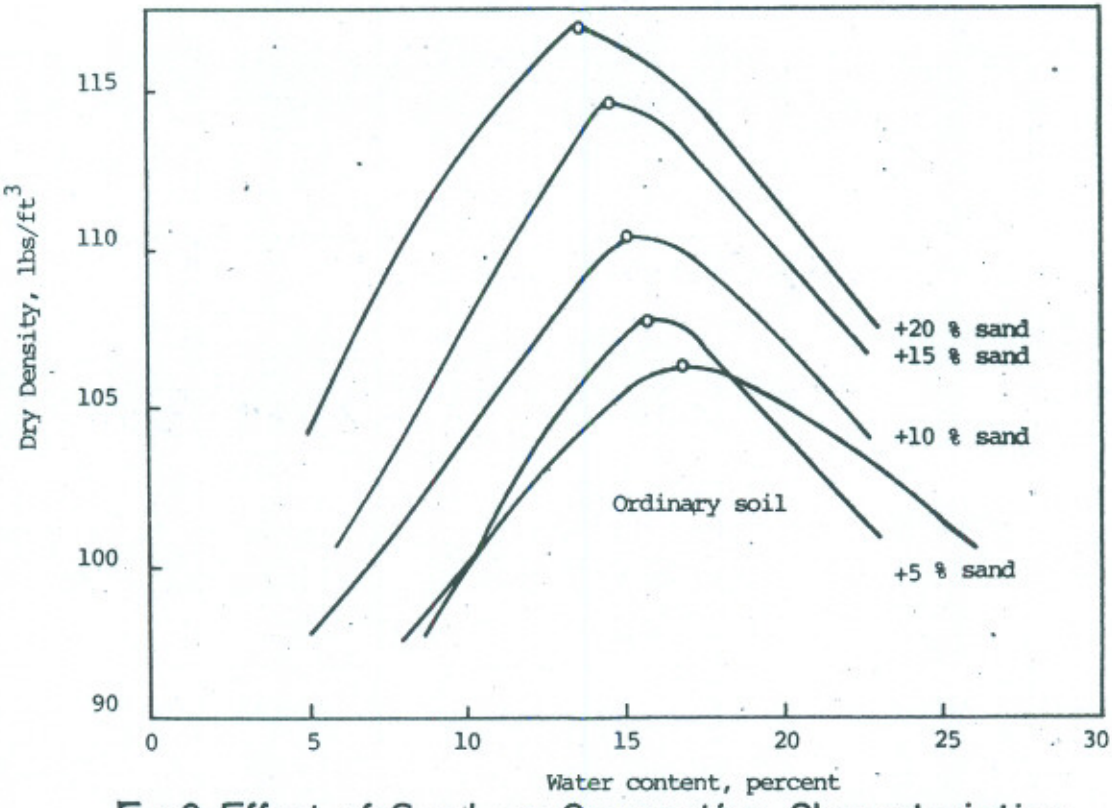


Fig. 3. Effect of Sand on Compaction Characteristics

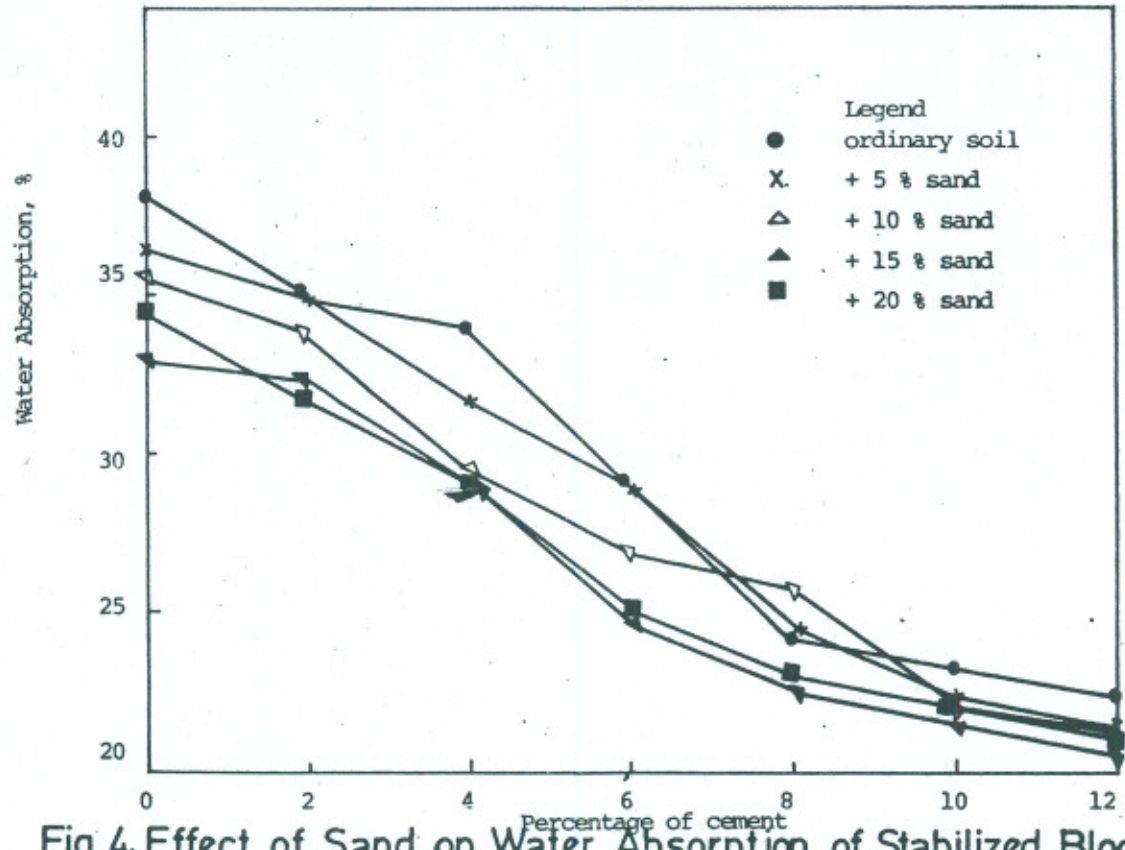


Fig. 4. Effect of Sand on Water Absorption of Stabilized Blocks

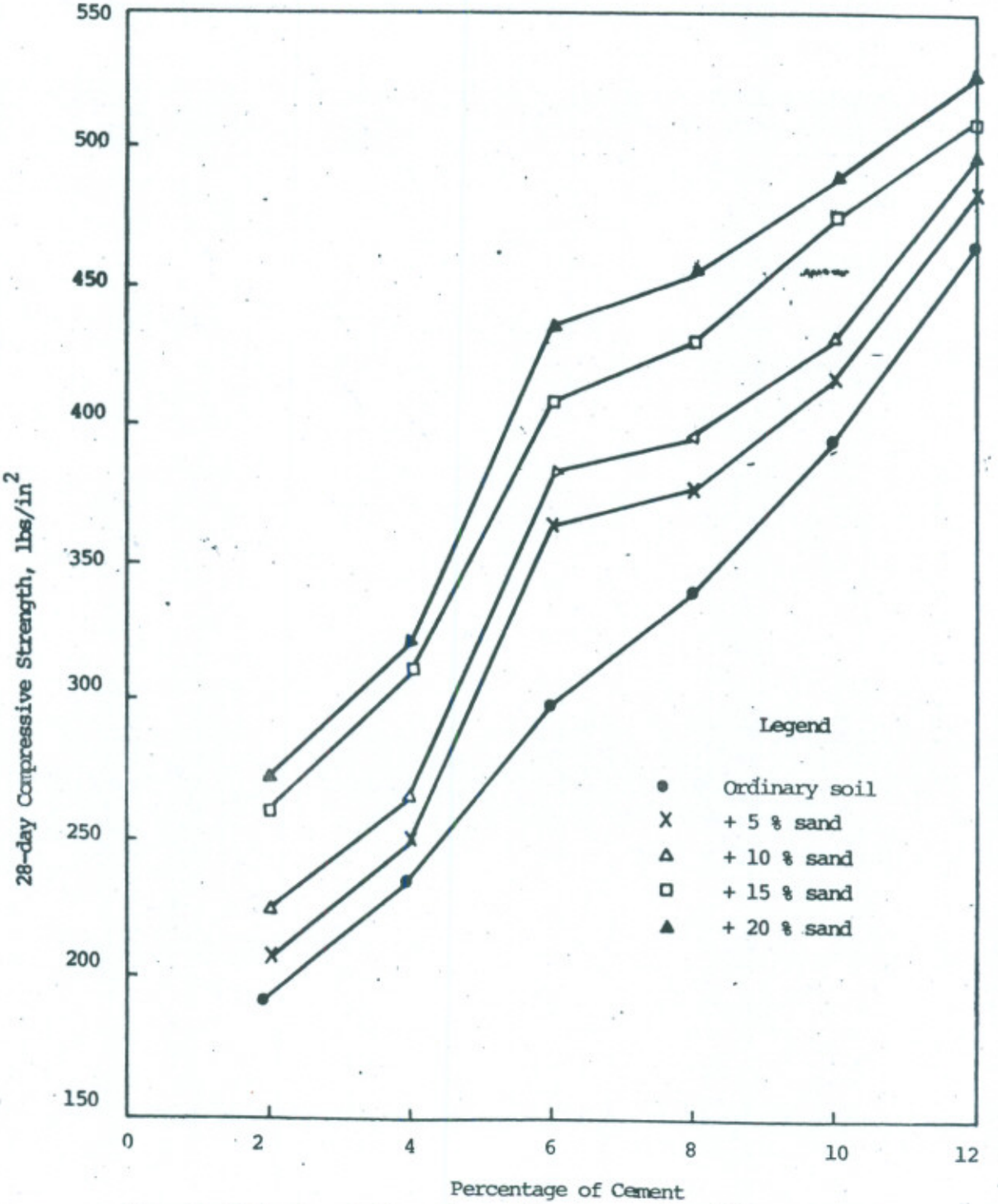


Fig. 5. Effect of Sand on Compressive Strength of Blocks Made from Lahore Soil.

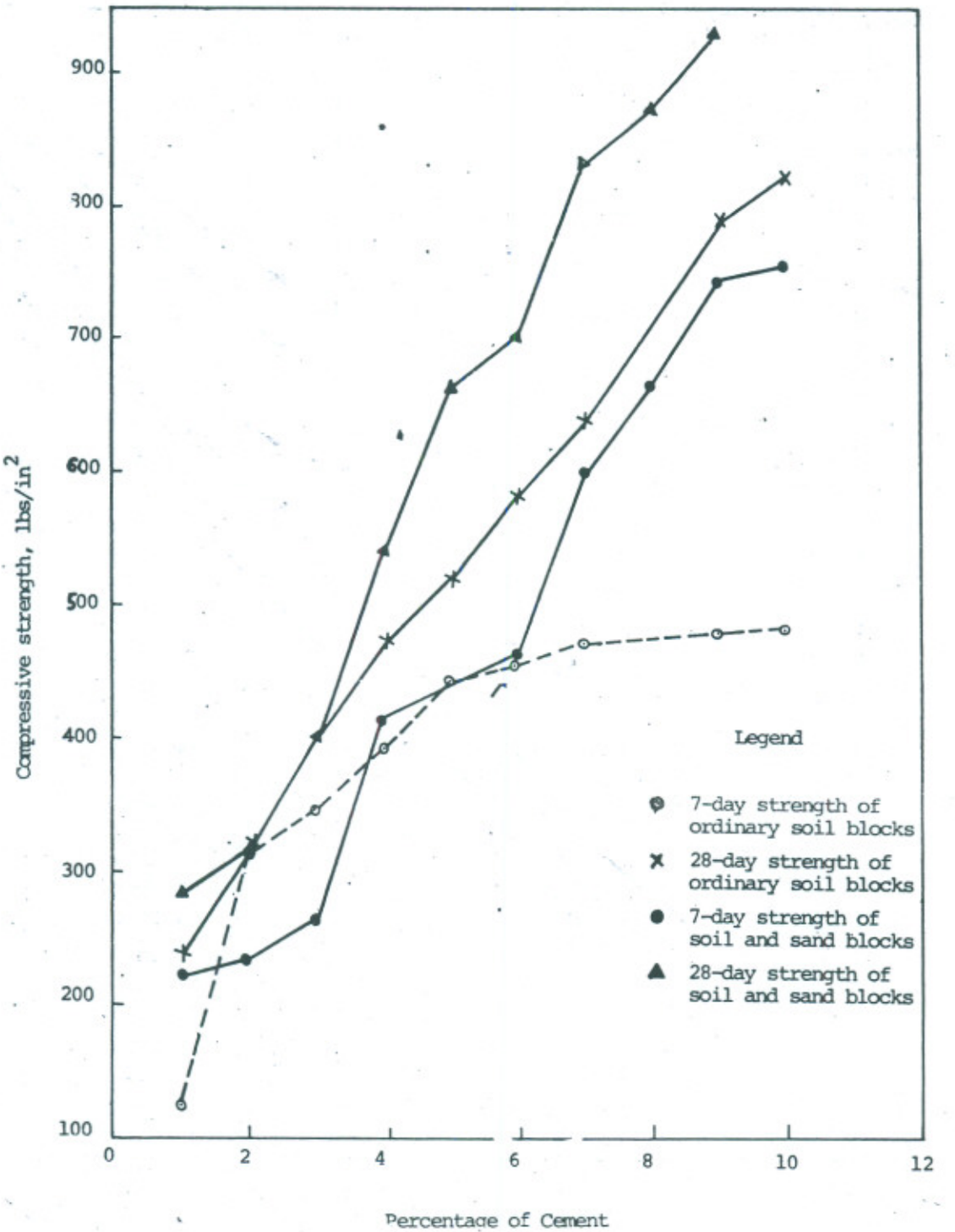


Fig. 6. Effect of Sand on Compressive Strength of Blocks Made from Islamabad Soil.