BEHAVIOUR OF MASONRY BLOCKS USING SOIL, PHOSPHOGYPSUM AND STABILISED WITH DIFFERENT ADDITIVES, UNDER COMPRESSION AND IMPACT.

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Abstract: *Due to rapid urbanization and industrialization coupled with ever increasing population growth have pressured the agriculture industry to opt for an accelerated modern method of food production, utilizing more fertilizers, the production of which has led to an increase in solid wastes in most developing countries. The generation of solid wastes like Phosphogypsum and disposal of them is a subject that has led to intense research in this field. This paper explains masonry blocks production with conventional soil cement and in addition the waste product Phosphogypsum, the results of the tests conducted on the masonry blocks under compression and impact are presented in this paper.. The recycling of solid by-products as construction materials can reduce its deteriorating impact on our environment, the present need of the hour.*

Keywords: *Masonry blocks, Masonry prism, Phosphogypsum, compressive strength, impact resistance, RBI grade-81.*

1.INTRODUCTION

Growth of population, increasing urbanisation, rising standards of living due to technological innovations have contributed to an increase both in the quantity and variety of solid wastes generated by industrial, mining, domestic and agricultural activities. Usages of the recycled waste solves the problem of scarcity of the natural materials.

Phosphoric acid being a chemical reagent also has a lot of domestic applications such as rust inhibitor, food additive, electrolyte, fertiliser feedstock, component in home cleaning products and many more. The production of phosphoric acid from phosphate rock yields a by-product called Phosphogypsum. Phosphogypsum being a chemical by-product is non-biodegradable and is difficult to dispose large quantities of Phosphogypsum. Presently, in many parts of the world, Phosphogypsum is used as fertiliser, soil conditioner and stabiliser and also in glass and ceramic industry.

In India, Phosphogypsum is mainly used for agricultural purposes as fertiliser. But the amount of Phosphogypsum consumed is very small as compared to Phosphogypsum generated in the industry. As stated above, Phosphogypsum is a non-biodegradable chemical product and poses a major threat to the environment. Phosphogypsum has been dumped in large quantities nearby industries and is increasing every year and causing problem of disposal.

Hence, to reduce the problem of disposal of Phosphogypsum, there is a need to utilise this waste product. In this study, it is intended to use phosphogypsum for development of soil based masonry blocks stabilised with different additives.

2.REVIEW OF LITRATURE

M. Lyssandrou and I. Pashalidis (2006) studied the characteristics of phosphogypsum disposed on a coastal area in Cyprus and drew conclusion about the potential threat of phosphogypsum to the surrounding environment and also the need to mitigate the problem. S. R. Satone, D. K. Parbat, D. P. Singh (2013) carried out an investigation to check feasibility of Phosphogypsum in M25 Grade Cement Concrete and concluded that phosphogypsum impairs the strength development of calcined products and hence it can be used in construction industry for preparation of concrete replacing some quantity of cement, which is a valuable ingredient of concrete to achieve economy. Bhuyan (2010), carried out an investigation program to study the influence of RBI Grade-81 and lime on the stabilization of blast furnace slag and fly ash. Author has carried out standard proctor test and unconfined compressive strength (UCS) test for different combinations of the stabilizing agents and reported that UCS of stabilized sample increases with increase in duration of curing. It was observed that increase in strength was more due to presence of lime instead of RBI Grade-81.Anitha K. R. et al. (2009), studied the effect of RBI Grade-81 in the stabilization of kaolinite, red soil and lateritic soil. %. From the test results it was observed that substantial reduction in plasticity index for soil with RBI Grade-81 viz. 42% for kaolinite, 4% for red soil and 116% for laterite. From the review of literature, it can be concluded that Phosphogypsum when combined with cement in mortar and concrete gives satisfactory results at certain dosages. Phosphogypsum being used as a soil stabilizer at low dosage is imperative that it performs adequately in combination with soil. RBI Grade-81 has been used as a pavement material to stabilize the soil. Research work is needed to test the suitability of RBI Grade-81 in improving the strength and durability of the masonry blocks.

3.MATERIAL PROPERTIES

The major materials used for the block making are soil, phosphogypsum and cement having specific gravities 2.68, 2.8 and 3.11 respectively. chart 1 and 2 show grain size distribution, maximum dry density and OMC of soil. From chart 1, the soil consists of 70% sand and 12% clay, suitable for block making.

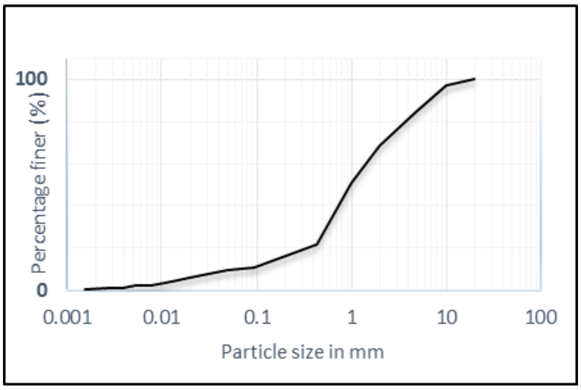

Chart 1: Grain size distribution curve

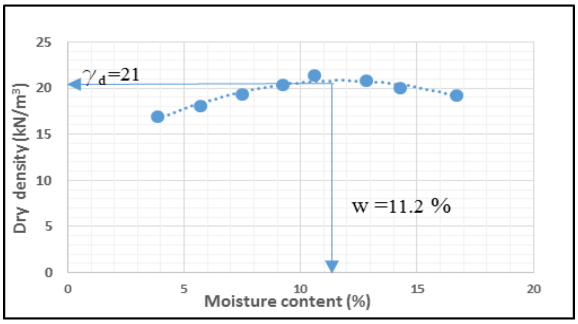

Chart 2: Water content-Density relationship of soil

4. BLOCK MAKING AND NOMENCLATURE

Block making procedure

Required quantity of soil is sieved through 4.75 mm sieve
Phosphogypsum is fully dried and lumps are powdered so as to pass through 425 micron sieve.Depending upon the combination, constituent materials are batched into different bags.Dry mix of the ingredients depending upon the combinations as tabulated in Table 1 is prepared.Water corresponding to the OMC is added and wet mix is prepared until uniform colour is obtained. Wet mix is fed into the Mardini press of mould size 230mm x 190mm x100mm by a measuring scoop. The mix is pressed manually using the Mardini press. The compacted block is taken out and stacked. Curing is done for required period by covering them with gunny bags using potable water

Table 1: Nomenclature of blocks and their composition

Block designation	Soil (%)	PG* (%)	Cement (%)	RBI g-81 (%)	Quarry dust (%)
CO	93	0	7	-	-
PG5	88	5	7	-	-
PG10	83	10	7	-	-
PG15	78	15	7	-	-
PG20	58	20	7	-	15
R2PG5	86	5	7	2	-
R2PG10	81	10	7	2	-

Note: All values in percentage by weight of block.

*PG=Phosphogypsum

5. EXPERIMENTAL STUDIES

1. COMPRESSION TEST [IS 3495 (PART 1): 1992]

Specimen selected for testing is cured for14 and 28 days. The frogs on both the sides are filled with 1:3 cement mortar ten days prior to testing and cured along with the block. The blocks are then sundried. Testing is carried out as per IS 3495 (PART 1):1992.The results obtained are as shown in Chart 3.

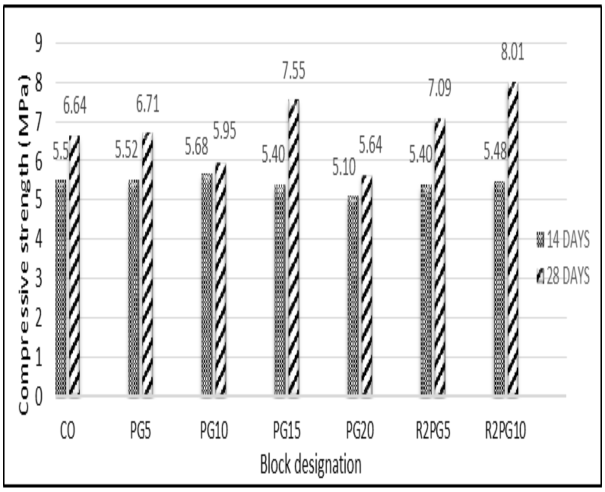

Chart 3: Comparison of compressive strength at 14 days and 28 days

Table 2: Compressive strength at 14 and 28 days

Block designation	14 day compressive strength (MPa)	28 day compressive strength (MPa)
CO	5.50	6.64
PG5	5.52	6.71
PG10	5.68	5.95
PG15	5.40	7.55
PG20	5.10	5.64
R2PG5	5.40	7.09
R2PG10	5.48	8.01

The compressive strength of control block was observed to be 6.64 MPa. At 14 days, compressive strength throughout all the combinations remains fairly around 5.1 MPa (PG20) to 5.68 MPa (PG10). At 28 days, compressive strength throughout all the combinations is in the range 5.6 MPa (PG20) to 8 MPa (R2PG10). Replacement of 15% of soil by Phosphogypsum (PG15) yielded a compressive strength of 7.55 MPa which is 13.81% greater than control block owing to Phosphogypsum fineness, chemical property and stabilizing property. Addition of 2% RBI Grade-81 (R2PG10) yielded highest 28 day compressive strength of 8.01MPa which is 20.71% greater than control block. Addition of 2% RBI Grade-81 (R2PG5 and R2PG10) along with Phosphogypsum showed considerable increase in compressive strength than blocks with Phosphogypsum only (PG5 and PG10) due to its stabilizing property and fibrous content.

2. PRISM TEST [IS: 1905-1987]

The assembled specimen had heights ranging from 450 mm to 465 mm, and had a height to thickness ratio (h/t) which varied from 2.04 to 2.11. If the h/t ratio of the prism tested is less than 5 to case of brickwork and more than 2 in case of blockwork, compressive strength values indicated by the tests shall be correct by multiplying with the factor indicated in Table 12 of IS 1905-1987. Prisms shall be tested after 28 days between sheets of nominal 4 mm plywood, slightly longer than the bed area of the prism. The load shall be evenly distributed over the whole top and bottom surfaces of the specimen and shall be applied at the rate of 350 to 700 KN/m. The load at failure (ultimate Load) should be recorded in MPa. The results obtained from the experiment are

Table 3: Compressive strength of prisms

Combination	Compressive strength of prisms (MPa)
CO	2.80
PG5	3.09
PG10	3.66
PG15	2.40
PG20	2.63
R2PG5	2.29
R2PG10	2.52

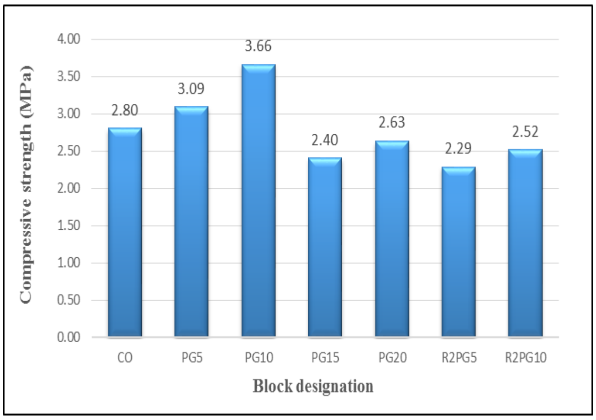

Chart 4: Compressive strength of prisms

From Chart 4, it can be observed that masonry prisms of blocks PG10 combination showed the highest strength (3.66 MPa) and the masonry prism of block PG15 showed the least (2.4 MPa) among other combination of masonry prisms consisting only Phosphogypsum. Masonry prisms with blocks of RBI Grade-81 and Phosphogypsum (R2PG5 and R2PG10), showed a compressive strength in the range 2.29 MPa to 2.52 MPa. When 10% Phosphogypsum was added to the blocks the compressive strength of prism increases by 30% w.r.t CO .Block with RBI Grade 81 and 5% Phosphogypsum (R2PG5) also showed decrease in compressive strength of masonry prism.

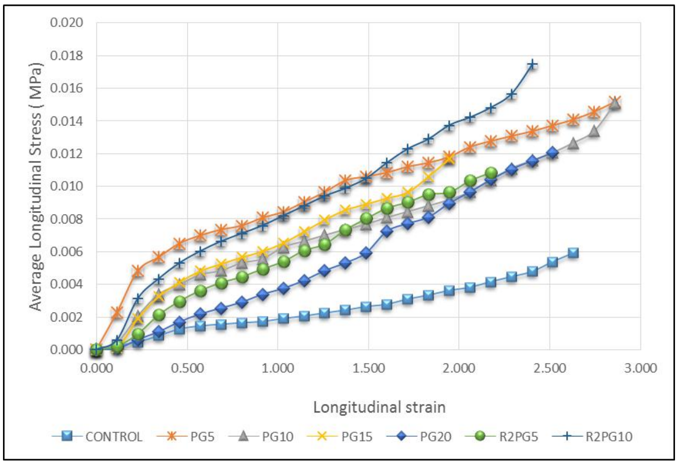

Chart 5: Stress v/s strain response of prisms

Table 4: Young's Modulus of different prisms

Combination	Young's modulus, E (N/mm²)
CO	484.525
PG5	123.374
PG10	178.444
PG15	148.052
PG20	252.648
R2PG5	186.599
R2PG10	123.968

Prisms of CO combination have highest Young's modulus and prisms of PG5 combinations have least Young's modulus. It can be inferred from Chart 5, that prisms other than CO have more longitudinal strain.

3. IMPACT TEST

Impact test helps to know the resistance offered by blocks to sudden loads. Impact test is conducted on the masonry blocks and energy absorption is studied for various combinations.
The masonry blocks of size 230mm x 190mm x 100mm are cast and cured for 28 days. A drop-weight apparatus fabricated as shown in Figure 6 is used for the test. The impact is simulated by dropping 2 kg weight from a height of 600mm. The pulley in the apparatus is used to maintain the guide line straight without any disturbances. The masonry block is kept and the hammer is dropped at the center of the block. The number of blows at first crack (N_1) and the number of blows at ultimate failure (N_2) are noted for all the specimens. The results of the Impact strength in terms of number of blows are tabulated. The Impact energy absorbed is calculated and the results are studied.

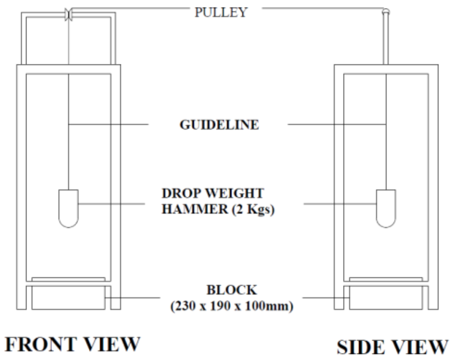

Figure 6: Drop weight apparatus

The Impact energy delivered to the specimen by the total number of blows is calculated using the formula:

$$E = Nmgh$$

E – Impact energy (N-m)
N – Number of blows
M – Mass of the drop hammer (kg)
g - Acceleration due to gravity (m/s²)
h - Height of drop (m)

Table 5: Impact energy of various blocks at failure

Combination	Average impact energy at failure (N-m)
CO	392.40
PG5	207.97
PG10	270.76
PG15	258.98
PG20	223.67
R2PG5	176.58
R2PG10	286.45

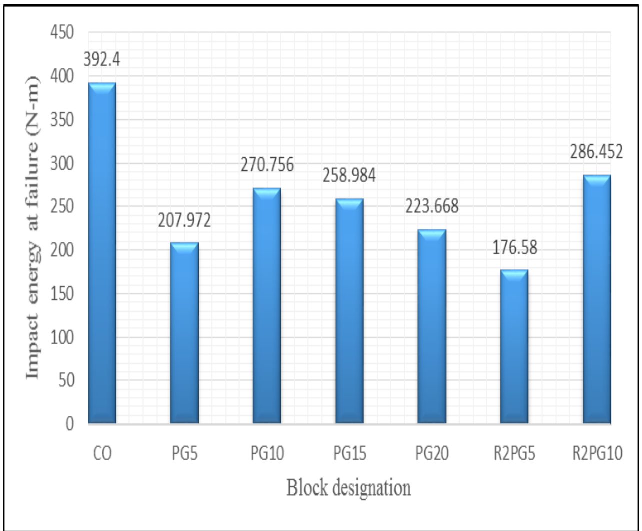

Chart 7: *Comparison of impact energy of various blocks*

From Chart 7, Control blocks showed maximum average impact resistance (392.4N-m). The Blocks with 5% Phosphogypsum with RBI Grade 81 (R2PG5) showed least average impact resistance (176.58 N-m). The average impact resistance of the blocks with only Phosphogypsum is within the range 207.97 N-m to 270.76 N-m. The average impact resistance of blocks with RBI grade 81 and Phosphogypsum is in the range 176.58 N-m to 286.45 N-m. It can be observed that any addition to CO block will reduce the average impact resistance of blocks.

6. CONCLUSIONS

After a detailed study of different types of masonry blocks subjected to various tests, we can conclude that the blocks obtained from Phosphogypsum, soil, quarry dust, and cement showed maximum compressive strength of 7.5 MPa (PG15).

The average dry compressive strength was about 6.96 MPa, whereas the control blocks possessed dry compressive strength of 6.6 MPa. Addition of RBI Grade-81 aided in increasing the strength. The maximum compressive strength obtained was 8 MPa (R2PG10). The average strength obtained with the addition of 2% RBI Grade-81 was about 7.5 MPa.

Hence all blocks can be classified as Class 5 bricks as per IS 1077:1992 and are having better compressive strength than the locally available bricks in the Karnataka market whose compressive strength ranges from 4.8 MPa to 5.7 MPa. The blocks with Phosphogypsum showed comparatively less impact resistance in the range of 207.97 N-m to 270.76 N-m. The average impact resistance of the blocks with RBI Grade-81 is 231.5 N-m. Control blocks showed the highest impact resistance of 392.4 N-m.

Hence all blocks can be classified as Class 5 bricks as per IS 1077:1992 and are having better compressive strength than the locally available bricks in the market whose compressive strength ranges from 4.8 MPa to 5.7 MPa. Hence blocks prepared using Phosphogypsum can be used as a suitable construction material.

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