Use Of Phosphogypsum Anhydrite In Construction Works

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About 5 million tonnes of phosphogypsum is produced as a by-product in the manufacture of wet phosphoric acid in the country. It contains phosphates, fluorides and organic matter as impurities. These impurities can be broadly classified as water soluble, lattice bound or insoluble[1, 2]. On hydration, the impurities dissolve out slowly from phosphogypsum and adversely affect the setting and strength development of plasters/cements produced from it. To overcome the adverse affect, it is essential to remove or inactivate these impurities. Many treatments classified as washing[3, 4], thermal[5, 6] and chemical[7] have been suggested to achieve this objective.

The gypsum industry refrains from using phosphogypsum mainly because of the expensive and energy consuming extra treatment involved on processing of phosphogypsum (washing or flotation etc.). A simple and economical method of processing phosphogypsum has been developed, in which only calcination and grinding is needed. Washing, flotation or drying etc. are totally eliminated. In this process, phosphogypsum is heated at 750-850°C to anhydrite. During the conversion process, the impurity of dicalcium phosphate occluded in the gypsum lattice, which adversely affects the hydration of plaster, is rendered harmless and insoluble as calcium pyrophosphate[8, 9].

Chemically, anhydrite plaster is calcium sulphate ($CaSO_4$) without water of crystallization. It does not set as such, but combines with water in presence of suitable accelerators (such as K_2SO_4, Na_2SO_4, K_2CO_3 or $Al_2(SO_4)_3.18H_2O$) added independently or in the mixture form and sets to a hard mass of considerable high strength.

To make mass utilisation of phosphogypsum, it is essential to calcine the gypsum at elevated temperature. Hence, phosphogypsum anhydrite is produced by heating the gypsum at 850°C and subsequently mixing and grinding it with a suitable accelerator. Phosphogypsum anhydrite plaster was examined for its various uses in the construction works at the Central Building Research Institute, Roorkee. The results obtained are reported and discussed in this paper.

Properties Of Phosphogypsum Anhydrite Plaster

Chemical Properties : The chemical composition of a representative sample of phosphogypsum anhydrite is described in Table 1.

Physical Properties : A representative sample of anhydrite plaster was examined for its various physical properties as per ASTM, designation C 61-50 (1981), specification for Keene's cement and IS: 2542 (Part I) - 1978 specification for gypsum plaster, concrete and products, Part-1 Plaster and concrete. Table 2 describes the results. The data in Table 2 shows that plaster complies with all the requirements given in relevant ASTM and IS specifications.

Table 1 : Chemical Composition Of Phosphogypsum Anhydrite

Constituents	Percent
SiO_2 + Insoluble	2.52
$Al_2O_3 + Fe_2O_3$	2.07
MgO	0.56
CaO	38.62
SO_3	53.26
Na_2O	0.12
Chlorides as NaCl	0.24
P_2O5	0.52
F	0.19

Uses of Phosphogypsum Anhydrite Plaster

The suitability of phosphogypsum anhydrite plaster was evaluated for use in (i) masonry mortars (ii) internal plastering (iii) light weight blocks and (iv) acoustic tiles. The results are discussed hereafter.

Masonry Mortars

Mortars used in construction work should have adequate strength, good durability and high water retention against suction. Data on compressive strength and water retentivity of different mortar mixes prepared with

Table 2 : Physical Properties Of Phosphogypsum Anhydrite Plaster

	Consistency %	Setting time (mts)	Compressive Strength (kg/cm²) 3d	7d	28d	Expansion %	Combined water %
	28.66 at 30mm penetration	285	80.40	125.20	197.20	0.062	0.02
ASTM : C 61-50 (1981) limits	30±2 mm	20-360	—	—	Min.175	—	Max 2.0
IS : 2547 (Part I) 1976 limits	—	—	—	—	—	Max 0.5 at 96 hours	—

Table 3 : Properties Of Masonry Mortars Prepared With Phosphogypsum Anhydrite Plaster And Sand

Sl. No.	Mortar mix proportion (by wt.)	Compressive Strength (kg/cm²) 3d	7d	28d	Water Retention (percent)
	Plaster : Sand				
1.	1 : 1 (FM 1.75)	20.64	48.00	99.40	95.22
	1 : 1 (FM 1.22)	18.13	37.55	96.96	88.39
	Plaster : Sand				
2.	1 : 2 (FM 1.75)	13.20	22.40	38.85	87.61
	1 : 1 (FM 1.22)	10.36	16.79	34.40	83.80
	Cement : Sand				
3.	1 : 6 (FM 1.75)	9.20	21.00	34.60	9.5
	1 : 6 (FM 1.22)	4.40	6.50	15.60	6.0

Fineness Modulus

he anhydrite plaster and two sands of ineness modulus 1.75 and 1.22 is shown n Table 3.

It can be seen that all the mortars repared with anhydrite plaster have uch higher water retentivity than the ommonly used 1:6 cement-sand mortar. onsidering that the mortar prepared ith 1 part of plaster and 1 part of sand F.M. 1.75 and 1.22) has the maximum ater retentivity and develops onsiderable higher strength than the :6 cement-sand mortars, its use can be ade in place of 1:6 cement-sand mortars r internal masonry work.

ternal Plastering

To find out suitability of hosphogypsum anhydrite plaster for se in plastering, mortars of mix roportion 1:1 and 1:2 plaster : sand ere prepared and used in the plastering ver burnt brick wall. The fineness odulus of sand was kept 1.22. It was und that a plaster-sand mix of 1:2 roportion by weight (1:2:8 by volume) is uitable for internal plastering. The laster developed good strength after 24 ours of application having smooth finish. he plaster was hard and showed good ond with bricks. Cost-wise mortar mix :2 plaster-sand is cheaper than 1:6, ement-sand mortar.

s A Finish And Base Coat Plaster

Suitability of phosphogypsum nhydrite plaster was checked for use as finishing and base coat plastering material. In the first instance, 9 mm thick base coat consisting of 1 : 2 (1 : 2 : 8 by volume) anhydrite- sand and 1 : 6 cement-sand mixes were applied over unplastered burnt brick wall seperately. Immediately, 3 mm thick neat anhydrite plaster paste was applied over the base coat. The total thickness was kept at 12 mm. The finished coat developed good strength in 24 hours, developed a hard surface with glossy pinkish appearance. Thus, anhydrite plaster can be used as a finish as well as base coat plastering material.

Light Weight Blocks

The phosphogypsum anhydrite plaster was tested for its suitability for making light weight blocks as described below.

Anhydrite-Saw Dust Blocks

Effect of addition of washed saw dust was studied on the bulk density and compressive strength of plaster. Based on 5 cm cube data, 40 x 20 x 10 cm blocks were cast using anhydrite plaster and saw dust. The blocks were demoulded and cured in high humidity for 28 days at 27 ± 2°C and then dried in the sun to constant weight. The blocks were tested for bulk density and compressive strength. The results are given in Table 4.

It can be seen that on using 10 percent saw dust, the density is lowered and the strength data comply with the minimum strength of 200 kg/cm² specified in IS:2849-1983, a specification for non-load bearing gypsum partition blocks (solid and hollow type). These blocks are mainly suitable for internal non-load bearing partition walls or for inner leaf of cavity wall constructions. The blocks are known to be resistant to insect or fungal attack and fire. These blocks should not be used under damp conditions as they are liable to suffer deterioration as their strength is seriously reduced.

Table 4 : Strength Of Blocks Produced Using Phosphogypsum Anhydrite Plaster And Saw Dust

Sl.No.	Saw dust percent	Bulk density (kg/m³)	Compressive strength at 28 days (kg/cm²)
1.	5.0	1620	12.56
2.	10.0	1510	8.0

Anhydrite-Foamed Slag Blocks

Effect of addition of foamed slag of size 6mm and down having density 303 kg/m³ was studied on the bulk density and compressive strength of anhydrite plaster to develop insulative blocks. Based on 5 cm cube data, a mix proportion of 60:40 anhydrite plaster: foamed slag was chosen for casting large size blocks. The blocks of size 40x20x10 cm were cast, demoulded, cured in high humidity at 27±2°C for 28 days, dried at 42° C and tested for their bulk density and compressive strength. The results are reported in Table 5. It can be seen that the blocks develop strength-conforming to IS:2849-1983. These blocks can thus be used for non-load bearing partition

Table 5 : Strength Of Blocks Produced Using Phosphogypsum Anhydrite Plaster And Foamed Slag

Sl. No.	Mix Proportion (By Wt.) Plaster	Foamed Slag	Bulk density (kg/m³)	28 days Compressive strength (kg/cm²)
1	60	40	1070	14.0

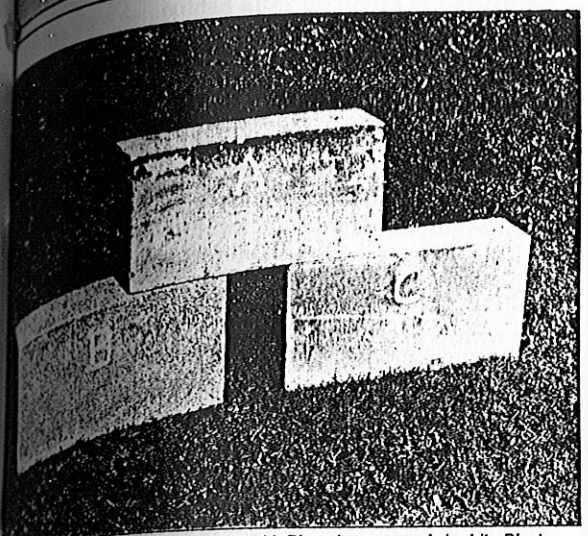

Fig. 1: Blocks (40 × 20 × 10 cms) Made with Phosphogypsum Anhydrite Plaster using (A) 10 percent saw dust (b) 40 percent Foamed Slag (c) Neat Plaster.

for internal purpose only.

According to Mydall and Diamant the vitreous materials have far er thermal conductivity than talline material. Since foamed slag in making of blocks is a vitreous erial, therefore 300×300×30 mm size ds were cast using the above position. The boards after curing for ays were dried and subjected to the rmal conductivity test as per heat w method specified in ASTM (518-71), specification for method of thermal nductivity of building insulating terials by heating flow method. The lts are given in Table 6.

The data shows that the blocks duced using foamed slag have lower rmal conductivity than the ventional building materials like light ght concrete and common burnt clay cks.

at Plaster Blocks

To make high density and high ength blocks, anhydrite plaster (with- aggregate) was gauged with water quired for normal consistency. The neaded mass was put into the moulds of e 40×20×10 cm. After 24 hours of hy-

Table 7 : 28 Days Compressive Strength Of Neat Anhydrite Plaster Blocks

No.	Bulk density (kg/cm²)	Compressive strength (kg/m³)
1	1900	176.63

dration, hardened blocks were demoulded, cured for 28 days in high humidity and then dried at 42°C before testing for compressive strength and bulk density. The results are given in Table 7.

The strength of blocks is much higher than the minimum specified value of 50 kg/cm² given in IS:3590-1976 specification for load-bearing light weight concrete blocks. Hence, the blocks produced with neat plaster at normal consistency are rightly suitable for load-bearing internal partition walls.

The typical photographs of blocks made using (a) 10 percent saw dust, (b) 40% foamed slag and (c) neat plaster is shown in Fig. 1.

Table 6 : Thermal Conductivity Of Plaster: Slag Mix . At 28 Days Of Curing

Sl. No.	Mix proportion (By wt.) Plaster : Foamed slag	Bulk density (kg/m³)	Thermal conductivity K.cal/m/h/°C
1	60 : 40	1070	0.28
2	Light weight concrete	1200	0.60
3	Common burnt clay bricks	1700	0.70

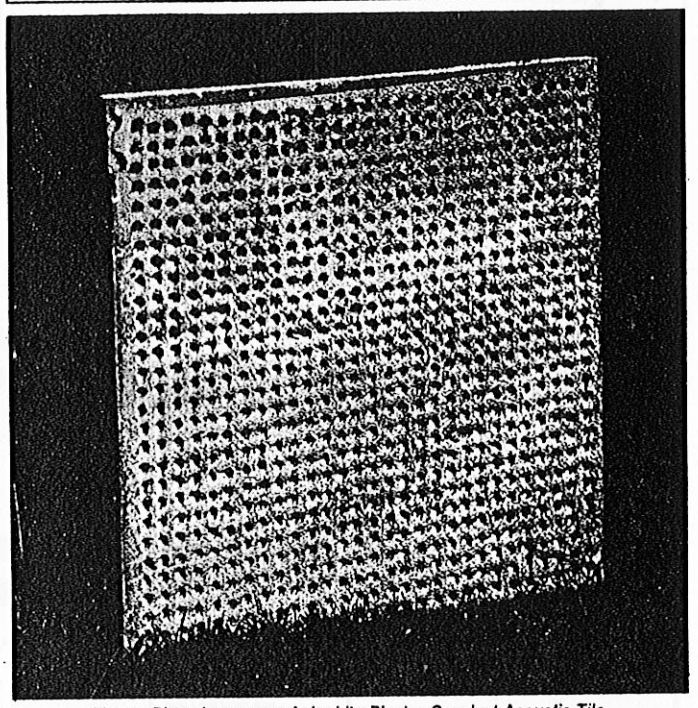

Fig. 2 : Phosphogypsum Anhydrite Plaster-Sawdust Acoustic Tile.

Acqustic Tiles

Acoustic tiles are used in large offices and auditoria to mitigate the reflected sound by absorbing the sound energy. For making acoustic tiles, the phosphogypsum anhydrite plaster and washed saw dust in proportion 90:10 parts by weight were mixed with water at workable consistency. The kneaded mass was then put into the moulds of size 300 x 300 x 300 mm uniformly. After 6 hours of hardening, the mix was pressed from to bottom with a wooden plate containing several projected pins to form slots in the

Table 8 : Sound Absorption Coefficients Of Tiles

Sl.	Characteristics	Frequency (c.p.s)					
		125	250	500	1000	2000	4000
1.	Slotted phosphogypsum anhydrite tiles	0.15	0.16	0.28	0.30	0.31	0.35
2.	Slotted gypsum tiles (UK)	0.5	0.10	0.25	0.30	0.15	0.20
3.	Sita tex plain fibre board tile (India)	0.13	0.18	0.21	0.18	0.17	0.30

The tiles were demoulded after 36 hours of hardening, in high humidity for 28 days at 27±2°C and subjected to, absorption coefficient test. The results are reported in

The data shows that sound absorption coefficient of slotted phogypsum anhydrite tiles compares fairly well with the ard slotted gypsum tiles and indigenous sita tex fibre tiles. Manufacture of these tiles can be taken up as a industry. Fig 2 shows a typical photograph of phogypsum-anhydrite-saw dust tiles.

Conclusions

om this study, the following conclusions are drawn up.
phogypsum anhydrite plaster is suitable for making ary mortars of 1:2 mix proportion for use in place of 1:6 nd cement-sand mortar for building internal walls.
e anhydrite is suitable for internal plastering of burnt wall and for neat finish coat over the base coat consisting ydrite plaster-sand/cement-sand plasters.
ght weight blocks can be produced using mix of anhydrite r and washed saw dust or foamed slag, for internal non-earing partitions and for insulation purpose.
gh density high strength blocks conforming to IS:3590-an be produced using anhydrite plaster at normal tency. The blocks are suitable for load-bearing internal ion walls.
ixture of anhydrite plaster and saw dust can be used to e slotted acoustic tiles.

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