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National Council for Cement and Building Materials

PORSAL — AN ENERGY SAVING SULPHATE RESISTING CEMENT

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NCB TECHNOLOGY DIGEST

PORSAL — AN ENERGY SAVING SULPHATE RESISTING CEMENT

INTRODUCTION

ORDINARY portland cement finds the wide and extensive application in general construction. In special applications it is used with some admixtures. It, however, has poor resistance to aggressive environments.

Porsal cement is a special cement developed with a view to avoiding the admixtures altogether. It consists of clinker phases such as calcium sulfo-aluminate ($C_4A_3\overline{S}$), dicalcium silicate (β-C_2S) and calcium aluminoferrite (C_4AF), with temperature of clinkerisation around 1300-1350°C. C_3S, the dominent phase in OPC is not formed in porsal clinker. It is a low lime bearing cement with oxides of aluminium, iron and sulfer as its major components. Its lower clinkerisation temperature makes it highly energy saving in addition to its potentials of using low grade/byproduct wastes as raw materials, such as dolomitic limestone, red mud, sludges, phosphogypsum, etc. Its performance indicates rapid hardening characteristics and high resistance to sulphate bearing environments. This technology digest briefly discusses the R&D work done at NCB and the results achieved.

RAW MATERIALS

Various low grade and waste materials, such as dolomite, clay, red mud, sludges, phosphogypsum, etc, and bauxite, laterite having required oxide contents have been found suitable for making porsal cement. Sulfoaluminate cement compositions have a wide range in terms of raw materials base which could be utilised for making such cements. Porsal cement composition having 8-10 percent MgO, substituting CaO in clinker composition, have yielded sound cement. A substantial amount of dolomite lime-stone can therefore be utilised.

MANUFACTURING PROCESS

The porsal cement clinker can be manufactured both in rotary and vertical kilns as the temperature of clinkerisation is in the range of 1300°—1350°C. The raw materials and clinker processing are similar to that of OPC clinker.

Element and Phase Analysis of Cement

A number of cement samples having wide range of compositions were prepared at NCB under the pyroprocessing conditions are shown in Table 1.

TABLE 1

CHEMICAL ANALYSIS OF CEMENT SAMPLES

Oxide component	Composition (%)				
	I	II	III	IV	V
SiO_2	13.64	15.11	15.79	15.96	15.02
Fe_2O_3	6.65	8.83	7.96	7.26	6.99
Al_2O_3	19.44	22.52	23.02	18.38	18.12
CaO	41.77	35.72	36.69	38.53	48.98
MgO	9.24	8.94	8.60	9.43	2.12
SO_3	6.40	5.47	6.27	7.05	5.20
Na_2O	0.23	0.25	0.23	0.26	0.28
K_2O	0.19	0.26	0.21	0.19	0.22

Mineralogical analysis by x-ray diffraction (Fig 1) illustrates the presence of calcium sulfoaluminate, calcium sulfate hydrate and calcium magnesium silicate as common mineral phases. In the compositions having higher amount of MgO the main silicate phase being calcium magnesium silicate and C_2S is present in small quantity. The MgO does not affect sulfoaluminate formation. The electron micrograph indicating cubic crystals of sulfoaluminate phase in shown in Fig 2.

HYDRATION PRODUCTS

In porsal cement, the formation of ettringite is very fast and in bulk leading to rapid hardening. The hydration of C_2S leads to CSH formation which adds to strength at later stage of reaction.

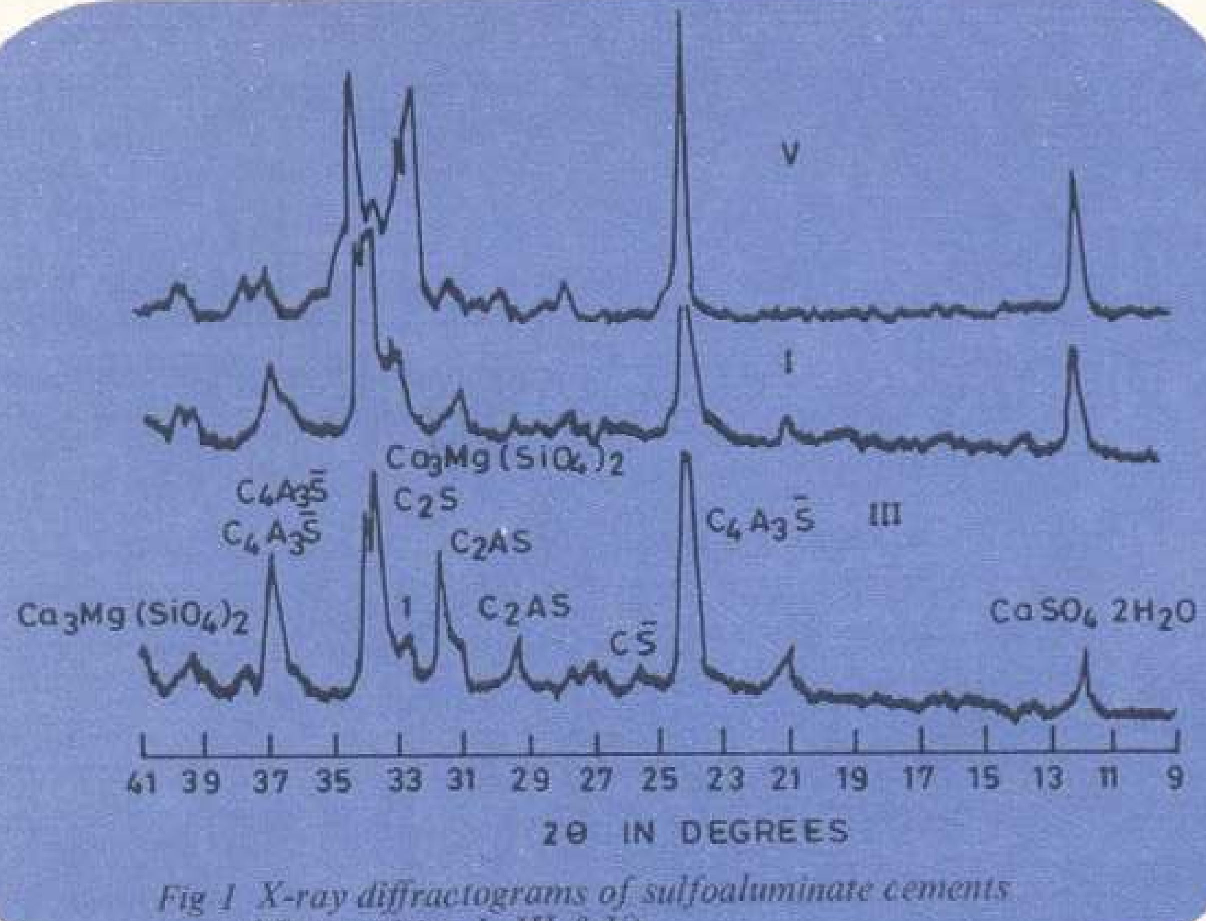

Fig 1 X-ray diffractograms of sulfoaluminate cements (Composition I, III & V)

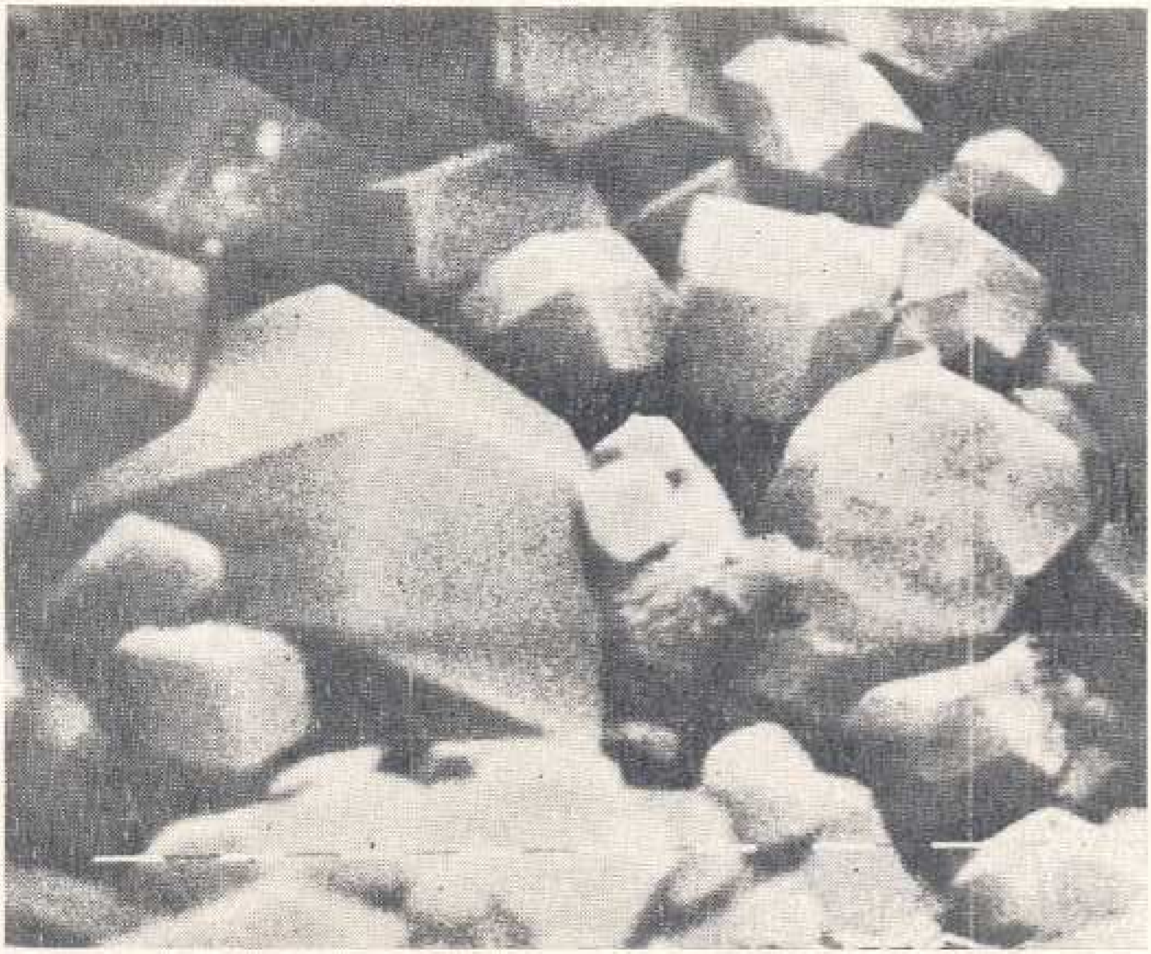

Fig 2 SEM of porsal clinker

PERFORMANCE CHARACTERISTICS

Physical Properties

Physical performance characteristics of the porsal cement indicates rapid strength gain(Table 2). The compositions, I, IV and V indicate comparatively higher strength values as the clinkers are rich in desired phases. The higher early strength is due to ettringite formation as shown in Fig 3. The autoclave expansion is found to be nil, which indicates absence of periclase formation during clinkerisation.

Table 2

PERFORMANCE CHARACTERISTICS OF PORSAL CEMENT SAMPLES

Composition	Fineness (cm^2/g)	Autoclave expansion (%)	Compressive Strength (kg/cm^2)			
			1-day	3-day	7-day	28-day
I	2600	0.05	370	435	470	490
II	2500	0.026	170	227	245	290
III	2600	0.036	165	210	240	300
IV	2400	0.047	245	300	340	360
V	3000	0.25	215	240	300	360

Fig 3 OM of hydrated neat porsal cement (2 hrs)

Potential Sulphate Expansion

Porsal cement when tested for potential sulphate expansion as per IS : 12330—1988 was found to be less than 0.02 percent which indicates its high resistance to sulphate bearing environment. The high sulphate resistance is due to its super saturation wrt sulphate which is a component of a mineral phase in the cement. Long-term corrosion study of porsal and ordinary portland cement carried out in sea water has also indicated high order of resistance of porsal cement towards corrosion compared to OPC. The porsal cement is, therefore, suitable for applications in marine constructions.

Techno-economics of Manufacture

The processing equipment for making porsal cement shall be same as that used for OPC. The economic feasibility will be mainly based on the raw materials and fuel cost. As the raw materials required should contain considerable quantities of sulphate, alumina and iron oxide, there is opportunity to make use of low grade raw materials. Limestones bearing large quantity of MgO could be used for such cement. In addition various byproduct wastes, such as red mud from aluminium industry, byproduct gypsum from fertilisers and sludges from paper and carbide industries can also be the potential raw materials. Conventional coal is suitable as fuel.

Energy Saving Potentials

The composition of porsal clinker is modified to contain only 50% CaO instead of 65% CaO as in OPC. As such, there is a large saving in heat energy of calcination of $CaCO_3$ which amounts to ~120 kcal/kg of clinker.

As the mineral phases are completely formed at less than 1300°C temperatures, this results in an additional heat saving compared with OPC clinkers which require heat treatment to at least 1400°C. A reduction in clinkeisation temperature by ~100°C will not only lower the total sensible heat required to raise the materials to clinkernig temperature but also reduce the overall heat losses. Considering clinkering temperature at 1300°C, a total saving in terms of heat energy for making porsal clinker works out to ~150 kcal/kg clinker.

The porsal clinkers are comparatively porous owing to generation of sulphur oxides at higher temperature. The grindability of the clinker is therefore higher. It is evident that the net energy requirement for producing finished porsal cement is much less and has potentials of saving >200 kcal/kg clinker compared to OPC.

NCB EXPERTISE

NCB, under its technology transfer scheme, extends all technical and technological assistance to cement plants and entrepreneurs to adopt the technology of manufacturing porsal cement.

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