Analysis of Different Properties of Concrete in Pavements using Phosphogypsum

Ishfaq Ul Abass
Department of Civil Engineering
Vivekananda Global University
Jaipur, India

Ms Payal Bakshi
Department of Civil Engineering
Vivekananda Global University
Jaipur, India

***Abstract*— In the present century different industrial bi-products are presently utilized in the production of environmental friendly materials which replace the traditional construction materials such as concrete, bricks, solid blocks, hollow blocks, tiles and pavement blocks. These industrial wastes emits toxic matters which contaminates air, water, soil, flora, fauna and aquatic life, thus influences human health as well as their living standards. Studies reveal that in recent years, industrial wastes were successfully used in road construction in many developed countries. The use of these waste materials in road construction is based on economical, ecological, and technical criteria. India has a vast network of industries located in different states of the country. Million tons of industrial wastes are generated in these industries. In order to provide good alternative materials for construction of pavement layers, phosphogypsum may be used as a replacement for conventional sand. Phosphogypsum primarily consists of calcium sulphate up to 93% rest is a combination of impurities such as calcium fluoride, chlorides, sand, and organic compounds. This study is based on proper utilization of phosphogypsum waste by analyzing various properties of the pavement material. The main object of work is to enhance the strength in different layers of cement concrete pavements as well as WBM course. In this study, the different characteristics of phosphogypsum viz. sieve analysis, moisture content, specific gravity and workability can be determined.**

Keywords-industrial wastes, phosphogypsum, pavement, utilization

I. INTRODUCTION

Phosphogypsum is a solid secondary product material resulting from the production of phosphoric acid, a major constituent of many fertilizers. Depending upon the source of natural rock approximately 4.5-5.0 tons of phosphogypsum are produced per ton of phosphoric acid produced. Phosphoric acid is an important raw material for the production of fertilizers (88%), detergents (6%), and other agricultural products. World manufacturing consists of approximately 25 million tons per year of phosphoric acid. Of the several different phosphoric acid production processes, the wet process is the most commonly used. In this processes the phosphate rock $Ca_{10}F_2(PO_4)_6$ is dissolved in phosphoric acid to form a mono-calcium phosphate solution. Later sulfuric acid is added in a series of tanks to react with mono-calcium phosphate to produce a di-hydrated calcium sulphate ($CaSO_4.2H_2O$) which can then be separated from phosphoric acid by filtration. The resulting filter cake is either slurried with water or pumped to sedimentation ponds and the finally transported through conveyor belts where the phosphogypsum is allowed to settle.

Phosphogypsum generated from phosphoric acid plants is presently stacked and a few amounts are used by other industries especially in cement manufacturing, as a raw substituent for mineral gypsum and plaster board manufacturing. In order to have minimal impacts of phosphogypsum on environment safe guidelines, disposal and proper utilization is to be taken. The scope and main objective of my work is to utilize the phosphogypsum waste for different pavement construction purposes in order to solve negative environmental impacts. The mix design selected for this analysis is M-20 and w/c ratio 0.47. The phosphogypsum is added to mix for the partial replacement of the fine aggregates. Test results indicate that fine aggregate should be replaced with the utilization of phosphogypsum.

II. MATERIAL

A. Phosphogypsum

The material is obtained from J.S Minerals and Chemicals Pvt Ltd. Lakadwas girwa Udaipur, Rajasthan as shown in Fig 1. The plant is situated 13 km's from Udaipur city. The total production of phosphogypsum waste is about 60-70 tons per day. The rate of phosphogypsum in that area is 400-450 per ton. The phosphogypsum waste generated from phosphate industries are stockpiled in dump yards rather being utilized in construction purposes of different pavement layers.

Fig. 1 Phosphogypsum stockpiles

B. Natural Sand

The material is obtained from the Banas River (Bani), Tonk, Jaipur, Rajasthan, 100 km's from Jaipur city, it is a naturally occurring granular material composed of finely divided rock and mineral particles. The natural sand is shown in Fig.2 below.

Fig.2 Natural sand from Bani

III. EXPERIMENTAL PROGRAMME

In order to determine the gradation of the phosphogypsum and natural sand sieve analysis test, were performed as per IS 2386 (Part I)-1963 (methods of test for aggregates for concrete) reprinted in august 1997. The specific gravity was determined by pycnometer method as per IS: 2720(Part III)-1980 and the workability was determined by compaction factor test as per IS: 1199-(1959).

IV. RESULTS AND DISCUSSION

A. Gradation of Particles

The gradation of the particles of phosphogypsum and natural sand was determined by the sieve analysis of fine aggregates. In this analysis 200 grams of the sample were taken and sieved for the period of 10 minutes. The test results were express in the tubular form.

Type of Sieve analysis: Dry (passing 4.75mm sieve)
Total weight of phosphogypsum / natural sand = 200g
Weight of dish = 2886g

Table.1 Results of dry sieve analysis on phosphogypsum

IS Sieve Openin g, mm,µ	Wt. of dish, (g)	Wt. of (dish+ PG) retained, (g)	Wt. of PG retained, (g)	Cum. wt. retaine d, (g)	Cum. % retaine d	Cum. % finer
4.75	375	375	0	0	0	0
2.36	311	312	01	01	0.5	99.50
1	397	403	06	07	3.5	96.50
600	415	424	09	16	8.0	92.00
300	373	386	13	29	14.5	85.80
150	352	372	20	49	24.5	75.50
75	336	398	62	111	55.5	44.50
Pan	327	416	89	200		

Table.2 Results of dry sieve analysis on natural sand

IS Sieve Opening , mm,µ	Wt. of dish, (g)	Wt. of (dish+ sand) retained, (g)	Wt. of sand retained, (g)	Cum. wt. retained, (g)	Cum. % retained	Cum. % finer
4.75	375	375	0	0	0	0
2.36	311	312	01	01	00.50	99.50
1	397	414	17	18	09.00	91.00
600	415	438	23	41	20.00	80.00
300	373	456	83	124	62.00	38.00
150	352	412	60	184	92.00	08.00
75	336	351	15	199	99.50	00.50
Pan	327	330	03			

The gradation of the particles in the phosphogypsum and natural sand are nearly comparable. Therefore, the fine aggregates in concrete should be replaced by utilizing the phosphogypsum.

B. Specific Gravity

The specific gravity was determined by pycnometer method as per IS: 2720(Part III)-1980, as shown in Fig.3. The specific gravity calculated for phosphogypsum and natural sand are 2.41 and 2.77 respectively.

Fig.3 Specific gravity test by pycnometer

C. Workability

The workability test indicates the ease with which a concrete can be mixed, transported, placed, and finally finished without segregation. The workability was determined by compaction factor test as per IS: 1199-1959, as shown in Fig.4.The workability of the concrete remains unaffected at addition of 5% of phosphogypsum, while as it decreases with increase in phosphogypsum content at higher percentages. The workability at 5% phosphogypsum replacement and w/c ratio of 0.47 is calculated and equals to 0.72. At 10% phosphogypsum replacement and same w/c ratio, workability falls to a value of 0.67.

Fig.4 Compaction factor test apparatus

V. CONCLUSIONS

The laboratory studies completed to the data warrant the following conclusions:

1) Due to the nearly comparable gradation of the particles, phosphogypsum can be utilized as a partial replacement of the fine aggregate in concrete.

2) The specific gravity of phosphogypsum and natural sand are comparable.

3) As the percentage of phosphogypsum is increased beyond 5% the workability of concrete mix decreases leads to segregation and honeycombing. So, the water cement (w/c) should be increased by 1% at higher percentage ranges of phosphogypsum to maintain the workability in concrete.

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