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Advantages of Waste-Phosphogypsum in Concrete

Dinesh W Gawatre

Civil Engineering Dept., P.R.M.I.T & R Badnera, Anjangaon Bari Road, Badnera - 444701, Amravati (M.S.)

ABSTRACT

This technical note summarizes role of industrial waste-phosphogypsum in concrete. Phosphogypsum is a solid byproduct of the production of phosphoric acid, a major constituent of many fertilizers, chemical industry materials. Portland cement can be replaced with phosphogypsum to develop a good and hardened concrete to achieve economy. The traditional methods for producing construction materials are using the valuable natural resources. Besides, the industrial and urban management systems are generating solid wastes, and most often dumping them in open fields. These activities pose serious detrimental effects on the environment. To safeguard the environment, many efforts are being made for the use of different types of solid wastes with a view to utilizing them in the production of concrete. This make highlights on their potentials and possible use in construction area. The alternative for replacing construction materials obtained from industrial with agro-industrial solid wastes.

Introduction

With the advance cement of technology and increased field application of concrete and mortars the strength, workability, durability and other characteristics of the ordinary concrete is continually undergoing modifications to make it more suitable for any situation. The growth in infrastructure sector led to scarcity of cement because of which the cost of cement increased incrementally. In India, the cost of cement during 1995 was around Rs. 1.25/kg and in 2005 the price increased approximately three times and increasing till. In order to combat the scarcity of cement and the increase in cost of concrete under these circumstances the use of solid wastes, agricultural wastes, and industrial by-products like fly ash, blast furnace slag, silica fume, rise husk, phosphogypsum, etc. came into use. The use of above mentioned waste products with concrete in partial amounts replacing cement paved a role for

(i) Modifying the properties of the concrete,
(ii) Controlling the concrete production cost,
(iii) To overcome the scarcity of cement, and finally
(iv) The advantageous disposal of industrial wastes. The use of particular waste product will be economically advantageous usually at the place of abundant availability and production. Much of the literature is available on the use of fly ash, blast furnace slag, silica fume, rise husk, etc. in manufacture of cement concrete. However, the literature on the use of phosphogypsum in partial replacement of cement in concrete shows more application in construction area.

Major solid wastes and their potential use in construction materials

Growth of population, increasing urbanization, and rising standards of living due to technological innovations have contributed to increase the quantity of a variety of solid wastes generated by industrial, mining, domestic and agricultural activities. Globally, the estimated quantity of solid wastes generation was 12 billion tons in the year 2010 (Yoshizawa. CPCB, 2010). The amount, 11 billion tons were industrial solid wastes and 1.6 billion tons were municipal solid wastes and other waste is 0.4 billion tone. About 19 billion tons of solid wastes are expected to be generated annually by the year 2025 (Yoshizawa et al., 2010). Annually, Asia alone generates 4.4 billion tons of solid wastes. About 6% of this amount is generated in India (Yoshizawa et al., 2010; CPCB, 2010). Malaysia is expected to exceed 15,000 tons of solid wastes generation daily. Of solid wastes in civil engineering applications has undergone considerable development over a very long time. The utilization of fly ash, blast furnace slag, phosphogypsum, recycled aggregates, red mud, Kraft pulp production residue, waste tea, etc., in construction materials shows some examples of the success of research in this area. Similarly, the recycling of hazardous wastes use in construction materials and the environmental impact of such practices has been studied for many years (Cyr et al., 2008). In fact, there is a great scope for Setting up secondary industries for the recycling and use of huge solid wastes in construction materials. The recycling of solid wastes in civil engineering applications has undergone considerable development over a very long time.

Phosphogypsum

Waste phosphogypsum (PG) is an industrial by-product of phosphate fertilizer production from phosphate ore or fluorapatite. The generation of PG is up to 280 million tons per annum throughout the world (Yang et al., 2009). Over 6 million tons of PG is produced per annum in India (Sing, 2002). There are other countries where PG is generated as a waste material. The average annual production of PG in Turkey is about 3 million tons (Degirmenci, 2008). In Korea, 30 million tons of PG is deposited as wastes (Mum et al., 2007). The average annual production of PG is over 22 million tons in China (Yang et al., 2009). The generation of PG poses various environmental as well as storage problems. PG is usually deposited in the open areas or dumped into river or sea. The lack of consumption possibility of PG causes landfill Problem and environmental pollution (Degirmenci, 2008).Therefore, it will be worthy if PG can be used

Successfully in construction materials. Untreated PG has the limited scope of utilization in construction materials due to the presence of undesirable Impurities such as P2O5, fluorides, organic matter and alkalis (Sing and Garg, 1997; Garg et al., 1996). However, PG has been used as a set controller in the manufacture of portland cement substituting natural gypsum, as a secondary binder with lime and cement, in the production of artificial aggregates for soil and road stabilization, and as a raw material for wallboard and plaster after purification or calcinations process (Pressler,1984; Sing and Garb, 1997; Singh et al., 2003). A large volume of purified PG can be used by combining with flyash and lime to produce construction materials bricks and blocks (Yang et al., 2009; Kumar, 2002; such as Kumar, 2003). Fly ash-lime-phosphogypsum bricks and blocks with suitable PG content have shown a better performance in strong sulfate environments (Kumar, 2003).

Use of solid waste based construction materials in real construction

Significant research studies have been conducted on the development of new construction materials using different kinds of solid waste. However, the application of these construction materials in real construction is limited. More research is needed to study the actual behavior or performance of solid waste based construction materials under field conditions to encourage their practical applications.

Other solid wastes and their potential use in construction materials

Textile effluent treatment plant (ETP) sludge is a waste material produced from textile industry. Balasubramanian et al. (2006) revealed that the use of textile ETP up to30% substitution of cement may be possible in the manufacturing of non-structural construction materials although the addition of sludge delays the setting process of cement. Kavas (2006) carried out a research to use boron waste in red mud brick production. He found that the mechanical performance of bricks is enhanced

considerably due to the addition of boron waste. The recent research studies revealed that waste tea (Demir, 2006), waste ceramic tiles (Ay and Unal, 2000), cotton and limestone powder wastes (Algin and Turgut, 2008), and Kraft pulp production residues (Demir et al., 2005)

Research needs

The use of solid wastes is manifold. They can be used as coarse aggregates, fine aggregates, or supplementary cementing material for the production of construction materials. Many research studies had been conducted utilizing solid wastes. Most of these research works focused the effects of solid wastes on the physical and mechanical properties of construction products. Some of those studies attempted to investigate the durability performance of several construction materials including solid wastes. However, more research is needed to confirm the beneficial effects of solid wastes on the key properties and durability of new construction products. In this context, the following research needs have been identified for further investigation to enforce the use of solid wastes in construction materials:

1. Commercial utilization of different solid wastes in the production of construction materials.
2. Optimization of the content of various solid wastes to produce sound and useful construction materials.
3. Comprehensive investigation on the potential use of different solid wastes to produce load-bearing construction materials.
4. Feasibility assessment for using various solid wastes in the production of environment-friendly and sustainable construction materials.
5. Systematic investigation of the effects of different solid wastes on the durability performance of construction products under various exposure conditions.
6. Examination of the possibility of using various solid wastes in higher grade construction materials.
7. Cost-benefit analysis of the solid waste based make the lab-based production processes feasible in real world, the technology-enabling centers are needed to facilitate entrepreneurs for effective commercialization.Good mechanical and durability performance of the newer products, dissemination of technologies emphasizing cost-benefit analysis, and feasibility assessment report will significantly contribute to the successful commercialization of the innovative processes. The alternative construction materials obtained from industrial, agro-industrial and mining solid wastes have ample scope for introducing new building components that will reduce the cost of Construction some extent. Therefore, the entrepreneurs and construction agencies must be encouraged to develop new products and processesusing the solidwastesas raw materials, Thus paving the innovative way for settingupsecondary-industries.

Concluding remarks

During different industrial, mining, agricultural and domestic activities, huge quantity of solid wastes are being generated as by-products, which pose major environmental problems as well as occupy a large area of lands for their storage/disposal. There is a tremendous scope for setting up secondary industries for recycling and using such huge quantity of solid wastes as minerals or resources in the production of construction materials. Environment-friendly, energy-efficient, and cost-effective alternative materials produced from solid wastes will show a good market potential to fulfill people's needs in rural and urban areas. To effectively utilize the solid wastes in producing alternative construction materials, the detailed physico-chemical, engineering, thermal, mineralogical and morphological properties of these wastes need to be evaluated with good accuracy.The construction products from solid waste practically will not be useful despite their good mechanical properties if the durability performance is not satisfactory. Therefore, rigorous quality control and assurance should be practiced for durability improvement while using solid wastes in construction materials. In addition, the impact of solid wastes to durability performance of construction materials must be properly assessed before commercialization. The performance of solid waste based construction materials in real construction must also be evaluated prior to setting up secondary industries for recycling and utilization of solid wastes. In order to maximize the use of alternative construction materials produced from different types of solid waste and to make the lab-based production processes feasible in real world, the technology-enabling centers are needed to facilitate entrepreneurs for effective commercialization.Good mechanical and durability performance of the newer products, dissemination of technologies emphasizing cost-benefit analysis, and feasibility assessment report will significantly contribute to the successful commercialization of the innovative processes. The alternative construction materials obtained from industrial, agro-industrial and mining solid wastes construction materials must be properly assessed before commercialization. The performance of solid waste.

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