

Utilization of Waste Materials in Construction Activities: A Green Concept

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ABSTRACT

There is a growing awareness in India about extensive damage being caused to the environment due to accumulation of waste materials from industrial plants, power houses, colliery pits and demolition sites and it has become one of the major environmental, economical and social issues. Waste material is the material unused, unwanted and rejected as worthless into the environment in our society as whole. Waste materials coming out of industry nowadays is posing a great environmental problem in disposing them into the air, water and on the land. But, with proper utilization of these materials in construction industry as well as in making road pavements will greatly help the society to have a better and pleasant environment. Substitution of waste materials will conserve dwindling resources, and will avoid the environmental and ecological damages caused by quarrying and exploitation of the raw materials for making cement. These waste materials can partly be used, or processed, to produce materials suitable as aggregates or fillers in concrete. Use of waste products is not only a partial solution to environmental and ecological problems and it significantly improves the microstructure, and consequently the properties of concrete. The output of these waste materials in India are more than double the production of cement and other construction material used in all the civil engineering activities. So, use of waste materials not only to make the cement concrete (generally used in all the construction activities) less expensive, but to provide a blend of tailored properties of waste materials and portland cements suitable for specified purpose. This paper outlines regarding the optimum utilization of waste materials in some construction activities as a green concept, which ultimately reduces the environmental pollution.

Keywords

waste material, construction, environment, concrete

1. INTRODUCTION

The waste materials that are commonly known are blast furnace slag, fly ash, silica fume (from Power Plants) recycled aggregates (from Demolition sites), solid waste, plastic waste (Domestic waste) and rubber waste (commercial waste). Partial replacement of Portland cement with waste materials like blast furnace slag, fly ash, silica fume (from Power plants), recycled aggregates (from Demolition sites), solid waste, plastic waste (Domestic waste) and rubber waste (commercial waste) will be a great help in reducing environmental pollution and also in reduction in manufacturing of cement and other material that required for the construction activities. . One of the major challenges of our present society is the protection of environment.

Any construction activity requires several materials such as concrete, steel, brick, stone, glass, clay, mud, wood, and so on. However, the cement concrete remains the main construction material used in construction industries. For its suitability and adaptability with respect to the changing environment, the concrete must be such that it can conserve resources, protect the environment, economize and lead to proper utilization of energy. To achieve this, major emphasis must be laid on the use of wastes and byproducts in cement and concrete used for new constructions. The utilization of recycled aggregate is particularly very promising as 75 per cent of concrete is made of aggregates. The enormous quantities of demolished concrete are available at various construction sites, which are now posing a serious problem of disposal in urban areas. This can easily be recycled as aggregate and used in concrete.

As the problem of disposing these waste materials became a big environmental problem, the proper utilization of these materials again in construction activities will be a great relief to the society. Some of the important elements in this respect are the reduction of the consumption of energy and natural raw materials, systematic consumption and use of waste materials to a great extent. Research & Development activities have been taken up even in India for proving its feasibility, economic viability and cost effectiveness for the use of waste materials in all the construction activities.

2. DIFFERENT WASTE MATERIALS

There is a growing awareness even in India about extensive damage being caused to the environment due to accumulation of waste materials from industrial plants, power houses, colliery pits and demolition sites. Use of waste products is not only a partial solution to environmental and ecological problems; it significantly improves the microstructure, and consequently the properties of concrete. Because of the above factors, there is a need and increasing demand for better understanding the behavior of waste material properties as well as better control of the microstructure developing in the construction material, to increase the durability. Following are some of the properties of waste materials that can be commonly used in construction activities.

2.1 Plastic waste

The rapid Urbanization and Industrialization in India has resulted in large deposition of Plastic waste. Plastic waste, consisting of carry bags, cups etc. can be used as a coating over aggregate and this coated stone can be used for road construction as cement and asphalt concrete. This is a eco-friendly process. By using plastic waste as modifier, the

quantity of cement and sand by their weight can be reduced, thereby decreasing the overall cost of construction.

2.2 Fly ash

Fly Ash is a mineral by-product of coal combustion in thermal power plants. It is generally finer than cement and consists of mostly of spherical glassy compounds of complex composition. It is a waste material and dumped on the land adjoining thermal power plants and townships. Although fly ash is commonly used as a mineral admixture in Portland cement for rigid pavements, it has had a very limited use in flexible pavement. Although fly ash inclusion in concrete results in slower strength development initially, the ultimate strength is higher than that of the plain concrete. Aspects which add to the advantages in use of fly ash in the construction of roads like durability, easy availability, environmental protection, economy, performance, imperviousness, better resistance to fatigue and strength of concrete. Because of use of fly ash, rigid pavement behaves as a semi rigid pavement causing substantial reduction in cost of construction and also helps for environmental protection of our country.

2.3 Recycled aggregates

Recycled aggregates are the aggregates obtained from construction and demolition waste (CDW), from residential, commercial, industrial structures or from pavements. These aggregates can be re-used in all the construction activities with some % of volume of construction, in order to have the same mechanical properties of hardened concrete, without disposing these waste materials in to the environment. It has been felt that recycling would be the most promising waste management process for the disposal of materials. This will also help in less dependence of aggregates required in making rigid or flexible pavements over a long period. Due to issues related to sustainability and limited natural resources, it is clear that the use of recycled, like crushed concrete and asphalt, will be very useful in cost of saving also.

2.4 Ground granulated blast furnace slag (GGBFS)

The blast furnace slag is the by-product obtained during the process of manufacturing of steel that mainly consists of about 35% calcium oxide. The nonmetallic waste that develops simultaneously with iron in a blast furnace consists essentially of silicates and alumina silicates of calcium and other bases. The unit weight of blast furnace slag is less than that of stone aggregate, which in turn having lower unit weight of concrete when it is used in concrete. It can be utilized as a coarse aggregate in concrete, though strength in concrete increases slowly compared with traditional concrete. BFS can be used directly at the end of the production process, without further processing that is an integral part of this production process.

2.5 Silica fume

Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. The individual particles are extremely small, approximately 1/100th the size of an average cement particle. Because of its fine particles, large surface area, and the high SiO₂ content, silica fume is a very reactive pozzolana when used in concrete. Silicafume is one of the most researched pozzolanas that have been used to improve strength and durability characteristics of concrete. It is an

ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. The main field of application is as pozzolanic material for high performance concrete. It will be used in high strength or high performance concrete to improve the properties.

2.6 Rubber Waste

Discarded vehicle tires constitute an important part of waste material, which had historically been disposed of into landfills. The production of waste by the tire industry has been a growing problem, indicating the need for its reuse in the construction field. Rubber can be added to asphalt, which increases its durability and improve pavement quality and safety conditions by absorbing the rubber elastic properties. Rubber can also be used for concrete pavements for light traffic. Over the years, research is going on for the use of recycled tire rubber in PCC mixture as a possible alternative aggregate (partially replacing some part of aggregate). Rubber aggregates from discarded tire rubber in sizes 20-10 mm, 10-4.75mm and 4.75 mm down can be partially replaced natural aggregates in cement concrete construction also.

3. LITERATURE REVIEW

Some of the significant research works that have been reported in the literature review in the context of the different waste materials cited in the afore-mentioned section is discussed in brief in the subsequent paragraphs.

3.1 Plastic waste and solid waste

Malagavelli and Paturu (2011) carried out an experimental investigation on the performance of the concrete using solid waste fibers and found that the increase in the load carrying capacity of concrete. It was further reported that the maximum 2% of fibres could be used for strength purpose and that up to 6%, for disposal purpose. Sultana and Prasad (2012) observed the improvement in the properties of aggregates with the utilization of waste plastic as a coating over the aggregates and further, reported the optimum percentage of plastic to be 6-8 percent based on the stability values.

Further, Pandey (2012) carried out the experimental studies on the use of recycled plastic in the form of a network of cells of size 150mm × 150mm to 200mm × 120mm and depth from 50mm to 100 mm; and placed over a compacted foundation. The investigation revealed that with the little maintenance, the method of construction can make the concrete flexible, and moreover, the surface does not crack. The expected life is about 15-20 years.

3.2 Fly ash

Ramesh *et al.* (2003) reported that the replacement of cement with high volume fly ash up to 20% has been in practice for several years for durability and economy for concrete roads. Basak *et al.* (2004) indicated in their studies that the part replacement of cement with fly ash is accepted and pointed out further that approximately 25% of the volume of cement of actual consumption is expected to be saved; thereby 15% of cost of construction could be saved if fly ash is collected properly. Sagar (2007) studied fly ash concrete possessing higher flexural strength and concluded that the fly ash can be utilized for constructing semi-rigid pavements in the form of lime-fly ash concrete.

Sharma *et al.* (2010) found that the fly ash as a filler from different power plants demonstrated good potential for their use in Bitumen Concrete mixes. The optimum performance of mixes with different contents of fly ash was shown at 7% filler content. Prabhakar *et al.* (2011) emphasized that durability of the concrete structures could be improved by using fly ash as a mineral admixture and further concluded that up to 35% of the cement could be replaced with fly ash without affecting the mechanical properties of the concrete.

Kumar (2012) found that Fly ash and fly ash based products have been established for economic, durable and eco-friendly construction and development in rural sector. Suryawanshi *et al.* (2012) reported that fly ash cement concrete does not gain appreciable strength in the initial 7-14 days; but in 28-days, the cement constituents and pozzolanic reaction results in rapid hardening properties, with 25% replacement of cement with fly ash. Chaudhary (2012) found that the compressive strength with 50% fly ash as admixture showed the improvement over conventional concrete.

3.3 Recycled aggregates

Bindra *et al.* (2003) found and reported 15%-20% of recycled aggregates by volume can be used to achieve all the properties of normal concrete. Barai (2005) suggested for correction in water content is necessary to obtain properties of normal concrete. Dhir and Kevin (2010) reported that Recycled and secondary aggregates maximum 20%-30% by volume can be used without changing w/c ratio for achieving all the required characteristics of normal concrete. Desai (2010) reported that the use of recycled aggregates in construction is beneficial; with a certain limit of 3 %- 40% by volume without altering the properties of concrete. Marius *et al.* (2011) found that the lab tests proved the recycled aggregates (maximum 30%) had similar performance characteristics with crushed gavel as chipping sand used in rigid pavement construction.

3.4 Blast furnace slag

Surajit *et al.* (2005) reported not significant improvement in strength of concrete in 7 and 28 days, but revealed the much improvement in the compressive strength at the age of 90 days in respect of blast furnace slag aggregate concrete (10.71%) that of stone aggregates.

3.5 Silica fume

Raju *et al.* (2003) found that the concrete cubes exposed to 0.1%, 1.0%, 5% Sulphuric acid concentration, the cubes containing 10% Silicafume are performed better than cubes for M50, M60 and M70 grades.

3.6 Rubber/Tire waste

Kaush Kal Kishor (1993) found that the rubber concrete reduces the concrete strength; however, this may be used where M₁₀ and M₁₅ grade concrete is needed. With proper mix design, about 20 percent density will be reduced in comparison to control mix when 30 percent rubber aggregate is replaced with coarse aggregate of control mix. Khatib and Bayomy (1999) reported that the rubber waste should not

exceed 17-20% of the total aggregate in volume for better results in cement concrete.

Huang *et al.* (2004) opined that very little progress was made in this field by that time. They concluded that that rubberized concrete has very high toughness and pointed out further that its strength decreases significantly as the rubber content increases. The experimental studies by Zheng *et al.* (2008) revealed that strength and modulus elasticity of the rubberized concrete decreased with increasing amount of rubber in concrete. Rosa *et al.* (2009) found the addition of rubber to concrete should not exceed 10%, due to resistance losses verified. Mavroulidou *et al.* (2010) revealed that the use of rubber 0-10% in concrete gives good results for workability, density, cube compressive strength after 28-days. Beyond that, use of rubber in concrete has negative results.

Sara *et al.* (2010) found that incorporation of rubber aggregates in concrete obtained from waste tires, is a suitable solution to decrease the weight in some engineering applications and underscored the necessity of further extensive research in order to investigate the durability, toughness, etc. of rubberized concrete

From the above findings, it is found that various researchers have extensively worked out in using and application of various waste materials in pavements and other construction activities. Based on the literature germane to the use of the different types of waste materials that has been reviewed and its subsequent summarized findings, it is seen that there are many studies carried out in India on the utilization of these waste materials as the construction materials.

4. SUMMARY AND CONCLUSIONS

Minimum waste promotes not only reuse and recycling, but also and more importantly, promotes prevention - designs that consider the entire product life cycle. These new designs will strive for reduced materials use, use of recycled materials, use of more benign materials, longer product lives, repairability, and ease of disassembly at end of life. It strongly supports sustainability by protecting the environment, reducing costs and producing additional jobs in the management and handling of wastes back into the industrial cycle. A maximum use of waste materials may be applied to businesses, communities, industrial sectors, schools and homes. Also the utilization of waste materials like solid waste, hazardous waste will protect the environment and lead to a much more productive, efficient, and sustainable future. Following are some of the guidelines for implementation of use of waste materials in construction activities to have a green environment.

1. The idea of reusing the waste material is very exciting and encouraging specially when it will be helpful in minimizing destruction to earth's crust and green forest cover by virtue of reduced mining.
2. By suitable recycling and reuse, these waste materials will not contribute to waste loads at dumping and disposal sites.
3. Construction industry can contribute towards its commitment to protection of environment by encouraging use of recycled concrete stones and bricks.
4. Recycling and reuse of the waste materials are found to be an appropriate solution to the problems of dumping hundreds of thousand tons of waste on natural soil, which

will result in consumptions natural materials required for all construction activities.

5. Reuse of materials is an efficient way to reduce the use of energy intensive materials. Instead of discarding tonnes and tonnes of wastes from the factories and homes, some part of it could be used for creative construction. This will help in achieving Waste reduction and help us to move one step forward towards the sustainable environment i.e Green Environment.
6. A minimum waste strategy improves upon cleaner production and pollution prevention strategies by providing a visionary endpoint that leads us to take larger, more innovative steps. Since waste is a sign of inefficiency, the reduction of waste usually reduces costs.
7. Social well being is enhanced through efficiency improvements that allow more resources to be available for all. In addition, maximum use of wastes will create jobs in return logistics and reprocessing activities.
8. Environmental protection is enhanced by reducing hazardous and solid wastes to nature and by reducing the need for energy generation and hydrocarbon extraction.

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