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Cost Optimization of Rural Roads by using Waste Materials

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ABSTRACT

Roads are major source of transportation throughout the world. In India about 69% Population live in rural area. It is estimated that out of total road constructed in India about 60% is rural road. Roads are key point for rural development. Cost of per kilometer construction of rural road (Rigid Pavement) is more than 55 Lakh (excluding leveling, cutting and filling). Unit cost of Road construction can be reduced by using different waste material as partial replacement of cement and aggregates. In the present study attempt is made to explore the possibility of reduction of cost of rural road by using Fly ash as partial replacement of cement and construction waste as partial replacement of aggregate.

Keywords: Rigid pavement; Road; Cement; Concrete; Fly Ash; Aggregate.

1. INTRODUCTION

India is the second largest country in terms of population. According to census 2011, 83.3 crore population (approximately 69%) resides in rural areas. The provision of basic amenities to such a humongous population is the biggest challenge so far. Road networks play a significant role in providing the basic amenities to the rural population. Hence, roadways are considered as the backbone of our nation's progress and road networks are most essential for the entire zone. According to a survey conducted by National Highway Authority of India (NHAI), India has 5532482 km of road network in totality out of which 3337255 km exists in rural areas. This answers to only 60% of the total road network of our nation. A contingency of Rs. 19000 crore have been granted for construction of roads in rural areas in the annual budget of 2016. Roads in rural areas can be broadly categorized into two types: Asphaltic Roads and Cement-concrete Roads. Due to longer life span of cement concrete roads, these roads are preferred over asphaltic roads in recent times. Cement concrete roads have a life span of 20-25 years. Construction of cement concrete roads requires cement, sand and aggregates which are found in nature. Reckless use of such sources in road construction has led to its source depletion and also raised the economic dimensions of these materials. Therefore, it is necessary to reduce the consumption of such resources to prevent it from exhaustion. 60% of power generation in India is primarily associated with coal and fly ash is produced as waste in large quantities during coal consumption.

Improper disposal of fly ash may lead to harm to the environment. Fly ash finds its use in construction of cement roads which reduces the consumption of PPC cement during its manufacturing.

Globalization and changing patterns of human needs has lead to replacement of older frameworks and structure with modern design of buildings. Construction of buildings results in production of large amount of demolition waste also. Demolition wastes can be utilized in making cement concrete roads in conjunction with sand and aggregate. Reuse of wastes proves to be beneficial for the environment as well as reduces the cost of construction of roads.

This paper is mainly concerned with use of fly ash and demolition wastes which can be utilized in construction of roads in rural areas as it reduces the cost of construction as well as diminishes the consumption of natural and beneficial sources like cement, sand and aggregates.

2. FLY ASH AND ITS USE IN CEMENT CONCRETE ROAD

Fly ash is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash. In an industrial context, fly ash usually refers to ash produced during combustion of coal. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipments before the flue gases reach the chimneys of coal-fired power plants, and together with bottom ash removed from the bottom of the furnace is in this case jointly known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rock strata. Fly ash consists of fine, powdery particles that are predominantly spherical in shape, either solid or hollow, and mostly glassy (amorphous) in nature. The carbonaceous material in fly ash is composed of angular particles. (Singh *et al.* 2015).

Fly ash may be used in the construction of road in different ways such as pavement, embankment and as filling material in base. It is reported that in rigid pavement PPC cement can be partially replaced by fly ash up-to 20% by weight (Harison *et al.* 2014) By using of fly ash in concrete pavements as partial replacement material of PPC cement, we can improve the strength and durability of the pavement. It is also helps in reducing the construction costs. In addition, fly ash increases the workability of the concrete and usually reduces the water demand. The resulting concrete typically has a higher ultimate strength, and is more dense, providing resistance to infiltration from deicers Normally use of fly ash slightly retards the setting time of concrete, but it is compensated by reduction in the admixture dosage to maintain the same workability. In different studies it is reported that Use of fly ash in road works results in reduction in construction cost by about 10 to 20 per cent.(Berndt, 2009).

The most important thing of fly ash, that it can be effectively used in cement as well as in concrete as a partial replacement of sand and cement so it is indirectly eco friendly because we know that in the manufacturing of cement near about 90-92% Carbon dioxide (CO_2) emitted in nature so with the help of fly ash we can save our environment up to 30% by the emission of CO_2 and the other hand fly ash is a waste material and its create serious problem for environment if not properly disposed off.

3. CONSTRUCTION WASTE AND ITS USE

Re-utilization of construction waste is showing prospective application in construction as partial replacement of fine aggregate and coarse aggregate. It conserves natural resources and reduces the space required for the landfill disposal. Aggregate composed of construction waste generally has a lower specific gravity and a higher absorption than conventional gravel aggregate and will produce concrete with slightly higher drying shrinkage and creep. These differences become greater with increasing amounts of recycled fine aggregates. New concrete made with recycled concrete aggregate typically has good workability, durability and resistance to saturated freeze-thaw action. The compressive strength varies with the compressive strength of the original concrete and the water-cement ratio of the new concrete. It is found that recycled coarse aggregate are reduced to various sizes during the process of crushing and sieving, which gives best particle size distribution. The amount of fine particles (<4.75mm) after recycling of demolished were in the order of 5-20% depending upon the original grade of demolished concrete. The best quality natural aggregate can be obtained by primary, secondary & tertiary crushing whereas the same can be obtained after primary & secondary crushing in case of recycled aggregate. The single crushing process is also effective in the case of recycled aggregate. The particle shape analysis of recycled aggregate indicates similar particle shape of natural aggregate obtained from crushed rock. The recycled aggregate generally meets all the standard requirements of aggregate used in concrete.

Smaller pieces of concrete are used as gravel for new road construction projects. Sub-base gravel is laid down as the lowest layer in a road, with fresh concrete or asphalt poured over it. The Federal Highway Administration may use techniques such as these to build new highways from the materials from old highways. Crushed recycled concrete can also be used as the dry aggregate for brand new concrete if it is free of contaminants. It has been found that concrete made with recycled concrete aggregate has at least two-thirds the compressive strength and modulus of elasticity of natural aggregate concrete. It is reported that more than 15 million tons construction waste generated per annum out of which 8-9 million tons are concrete and brick waste (Oikonomou, 2005).

It is reported that we can reduce the quantity of fine aggregate up-to 40 percent (by weight) by using construction waste as partial replacement material of fine aggregate (Hota *et al.* 2016). The crushing & impact values of recycled aggregate satisfy the BIS specifications of recycled aggregate for impact value as originally it is low grade rubbles.

It is reported that the compressive strength of Recycled concrete aggregate is same such as conventional concrete made from similar mix proportions. Construction waste can be easily use in the construction of rigid pavement as partial replacement level up-to 30% for sand and up to 50% replacement of coarse aggregate at a same mix proportion (Srivastava *et al.* 2016).

As the above mentioned we can reduce the exploitation of natural aggregate and also reduce the project cost with the help of construction waste which is good for environment because we reduce the consumption of natural materials such as aggregate and sand up to 30-40% by weight.

4. CONCLUSION

1. India is facing serious air, water, soil, food and noise pollution problems. Every effort therefore necessary to prevent pollution on top priority basis.

2. Use of fly ash leads to saving the natural material and transport cost.

3. Fly ash may be used in different element of road such as pavement, embankment and as filling material in base.

4. Use of fly ash in concrete pavements also improves the strength and durability of the pavement while reducing construction costs.

5. By using Fly ash reduce the Portland pozzolona cement up to 20 by weight in the construction of rigid pavement.

6. Construction waste can be used as sand up-to 40 percent as alternative material of conventional sand.

7. Construction waste can be used as recycled aggregate up-to 50 percent as alternative material of conventional aggregate.

8. By using of waste materials, cheaper and durable road construction can be obtained besides environmental protection is achieved.

9. It is hoped that in near future it will have strong, durable and eco-friendly roads which will relieve the earth from all type of waste material.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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