Utilization of waste materials in pavement construction: A review

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1. Abstract:-

In present Scenario, to provide a better road network with a good pavement surface is necessary. An enormous quantity of non-renewable materials and industrial products like aggregates, bitumen, cement, lime, and other additives are consumed during construction and maintenance of the pavement. Extraction and production of these virgin materials is an unsustainable practice. Wastage of materials, environmental deterioration, depletion of resources, and the spike in material cost led researchers to search for alternative materials that can be used in road pavement. Studies have established that the use of secondary material (industrial or domestic waste products) not only provide an efficient waste disposal technique but also reduce demand for conventional material and reduce overall construction cost. This review includes various materials which were used in past in pavement making and has potential of being used as road construction material.

2. Introduction:-

Roadway is the most important mode of transportation in India. Currently India has 5.5 million km of road network available in various forms like Expressways, National Highways, State Highways, District Roads & Village Roads. Highway construction in India has increased at 21.44% CAGR between FY16-FY19. In FY21 the rate of highway construction was recorded all time high at 37 km/day. So we can say that highway construction requirements are increasing day by day and it is going to increase at the same pace.

Traditionally soil, stone aggregates, sand, bitumen, cement etc. are used for road construction. With increase in demand for highway construction. Natural materials quantity is diminishing slowly as they are available in limited quantity in the environment. Also, cost of extracting virgin and good quality of basic materials for road construction is increasing. Concerned about this, the scientists are looking for substitute materials for pavement construction, and industrial waste product is one such category. Nowadays applications of industrial wastes have been considered in road construction with great interest in many industrialized and developing countries, as this roads gave better performance in various test results compare to conventional roads. Along with that by using waste materials, the problem of disposal and environmental pollution may be partly reduced to great extent.

3. Waste Materials which are useful in Road Construction: -

3.1 Waste Plastic

Plastic has become unavoidable material for our daily life as so many things of are now being made from plastic. Like carry bags, packaging material, plastic utensils other items are slowly replacing other

material. The main disadvantage of plastic is that not every plastic is recyclable. With increase in demand of plastic the problem of dumping the waste or used plastic is also getting bigger. To reduce the severity of this problem engineers came with the solution of utilizing waste plastic in pavement construction. [3]

Plastic is mixed with the bitumen as it rises the melting point of the bitumen and makes the road retain its flexibility during winters resulting in its long life. [1] Use of shredded plastic waste acts as a strong "binding agent" for tar making the asphalt last long. By mixing plastic with bitumen the ability of the bitumen to withstand high temperature increases. The plastic waste is melted and mixed with bitumen in a particular ratio. Normally, blending takes place when temperature reaches 45.5°C but when plastic is mixed, it remains stable even at 55°C.[7] Various test around the globe shows that 5% to 10% (weight by bitumen) can be the optimized contain in a mix for road pavement construction, which mainly reduced the cost by around 45,000/- per km. [4] [9]

3.2 Crumb Rubber

Crumb rubber is small pieces of waste tyre scrapped from light motor vehicles and whose disposal is a serious hazard. The crumb rubber is created by shredding scrap tyre, which is a particular material free of fiber and steel. The major component of crumb rubber modifier (CRM) is scrap tyre rubber which is primarily natural and synthetic rubbers and carbon black. Automobile tyres have more synthetic rubber than truck tyres. Truck tyres contain a higher percentage of nature rubber than automobile tyres. Advances in tyre manufacturing technology have decreased the difference in chemical composition between the types of tyre rubber. The typical bulk CRM produced in today's market is uniform in composition. The average car tyre contains ten types of synthetic rubber, four types of natural rubber, four types of carbon black, steel cord, bead wire, and 40 kinds of chemicals, waxes, oils, pigments, etc. [3]

Bitumen-rubber is manufactured by adding graded crumbed rubber to hot bitumen which contains a quantity of heavy extender oil. The rubber never completely dissolves in the bitumen and the product is therefore classed as a non-homogenous binder. [6] Crumb rubber is also used to modify bitumen in an appropriate manner, so that its resistance to temperature, water etc. is better. [10]

This modified bitumen is one of the important construction materials for flexible road pavement. The rubber waste/crumb rubber modified bitumen show better properties for road construction. Optimum content of waste rubber tyres to be used in road construction is between the range of 5% to 20%. [12] [13]

3.3 Glass Waste

Glass is in many ways a major part of the daily lives of most persons. It is found easily as domestic and industrial solid waste. Glass is produced either from the processing of sand, soda and limestone or from waste glass feedstock. Over 80% of the total mass of glass made worldwide is either in the form of canisters for food packaging and pharmaceutical commodities or plane glass for automobile and building construction. The possible sources of glass waste includes cullet, bottle bank glass, kerb side collection glass, pubs and clubs, and other waste flat glass from demolition and replacement window industries.

A survey carried out by World Bank as reported by showed that annual global waste generation is up to 2 billion tons of which glass waste accounts for about 10% - 15%. Few methods have been adopted to manage the impacts of these wastes on the environment. Some of these methods include recycling, utilization of crushed glass in road works, and civil engineering assignments and as aggregates in asphaltic concrete (Harder, 2018).Glassphalt is the term used to describe glass waste composed asphaltic concrete. [2] About 225,000 tons of the glassphalt composite was used in New York in the 1990s for resurfacing. Other

applications of glass waste in highway construction include sand for bedding paving block. The blend with 15% glass content to be the optimum blend in which the material presented good workability and had sufficiently high base strength. Higher recycled glass content (30%) resulted in borderline, though still satisfactory, performance. [3]

3.4 Fly Ash

Fly Ash (FA) (also known as pulverized fuel ash) is a by-product from coal combustion. In India, it was reported that about 217.04 million tons of Fly Ash has been produced in year 2018-2019 with nearly 78% rate of utilization. In year 2019-2020 flu ash production was about 226.13 million tons. It is predicted that India will be generating around 300-400 million tons of fly ash by the year 2025 as due to electric vehicles trend the demand of electricity may go high.

To reduce the deposition of fly ash in landfills, reuse measures have been widely encouraged especially in the road construction industry. Application of fly ash in the production of road pavement base layer geo-polymers is very famous nowadays. Several other research have used fly ash as an alternative material in the modification of conventional aggregates in road construction. [3]

3.5 Blast Furnace Slag

Slag is a by-product generated during manufacturing of Pig iron and Steel. In an integrated steel plant, 2-4 tons of wastes are generated for every tone of steel produced. The major wastes produced in integrated steel plants (ISP) includes blast furnace iron slag. Among all the solid/liquid wastes, slags generated at iron making and steel making units are in such a huge quantity that management of slag has become a critical component of steel production globally.

Use of Blast Furnace Slag as a supplementary cementitious material in concrete increases the sustainability of concrete pavements. The main drawback of using BFS in concrete pavements is slower early-life strength gain which may result in longer curing periods and delays in opening pavements to traffic. Chemical admixtures can be used to accelerate the hydration of the cement paste and reduce curing time. [2]

In one of the researches, adding 30-60% blast furnace slag to the coarse aggregate fraction can improve the performance of mixtures of traditional composition. It has been noticed that the skid resistance of asphalt wearing coarse surfaces containing blast furnace slag is much better than the reference values. [15]

3.6 Sugarcane Straw

The sugarcane straws are byproduct from recyclable sugarcane crushing, which is a natural source for the material. The wastes from the sugarcane businesses have been found out to be pozzolanic material. This material is being used by many researchers for soil stabilization as they have lesser specific gravity compare to soil. By using sugarcane straw as a filler in the soil voids MDD can be lowered and OMC may increase a little bit. The sugarcane straw ash can be used to improve the engineering properties of the soil but it is not a good stabilizer. The optimum % of the sugarcane straw ash by weight the soil for improvement in the strength characteristic of the soil sample is 4%. [11]

4. Conclusion

- The utilization of various waste material in road construction is reviewed by knowing its different properties like physical, mechanical and durability. The source of generation of waste material has also been considered.
- Several researchers have studied methods in which several solid waste materials can be used in the road construction industry.
- Adequate practical utilization of these materials will lead to significant improvements in the recycling rate of these municipal and industrial solid waste.
- The use of the innovative technology helps to strengthen the road construction and also increases the road life.

- This concept effectively reduces land requirements for landfills, preserves natural aggregates against depletion, and reduces construction and maintenance costs while improving certain performance criteria.
- However, waste materials must be carefully tested and free from hazardous matter to prevent long-term adverse effects on the environment.

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