Use of Plastic in Road Construction Material: Towards Solid Waste Minimization

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Abstract—The disposal of biodegradable waste can be carried out in open dumping, sanitary landfill or composting methods. Incineration can also be used for solid waste treatment. Pretreatment of agricultural waste and vermicomposting are effective ways to convert solid waste into manure and combustible gases. Critical problem of solid waste minimization lies with non-biodegradable waste. Use of plastic in construction material is becoming more and more acceptable due to the improved properties of materials. The optimum quantity of the waste plastic in bitumen was reported to be 10 percent in most of the investigations. With increase in plastic share, the strength and flow property increases. Most of the investigators have advocated use of waste plastic up to 10 percent. The cost of construction materials also decreases considerably due to use of waste plastic.

Keywords—Stability, strength, stiffness, cost, binders, recycled concrete.

I. INTRODUCTION

Solid waste material can be classified as putrescible and nonputrescible. Putrescible solid waste undergoes decay or putrification. The disposal of biodegradable waste can be carried out in open dumping, sanitary landfill or composting methods. Incineration can also be used for solid waste treatment. The critical problem of solid waste minimization lies with non-biodegradable waste. Waste Plastics can be used for efficient flood protection systems [1]. Waste plastic can be converted into ethanol and other products [2,3]. Hazardous waste treatment includes treatment of medical, pharmaceutical waste which also contains plastic [4]. Plastic waste treatment problem is partially solved by recycling and reusing the plastic waste [5,6,7]. Non-biodegradable waste material causes serious problem due their non-decomposable nature. Use of plastic in construction material is becoming more and more acceptable due to the improved properties of construction materials [8,9,10]. Deteriorating road quality is increasingly becoming cause of concern. The increase in vehicle and poor quality construction material can be reason for this. Use of plastic in road construction material, asphalt and with bitumen is widely explored alternative [11]. Investigations are reported for estimation of optimum proportion of mixture and finding out strength of the materials prepared from waste plastics. The current review summarizes research and studies carried out on utilization of waste plastic material in road construction material.

II. AN INSIGHT INTO RESEARCH AND INVESTIGATIONS ON WASTE PLASTIC USE FOR ROAD CONSTRUCTION MATERIAL

Bhageerathy et.al. carried out research for exploring possibilities of use of waste material for road construction [12]. According to them disposal of waste plastic is major solid waste problem. Deteriorating road quality is increasingly becoming cause of concern. The increase in vehicle and poor quality construction material can be reason for this. In their investigation, they used autoclaved medical plastic waste in the form of shredded syringes. According to this research 5 percent of plastic in bitumen yielded best results. Also they found that the Marshall stability index was 51 percent more than normal mix. Also they found that aggregate crushing value was reduced by 27 percent. They concluded that mixes prepared with biomedical plastic waste had better properties compared to the conventional bituminous mixes. Paul and Bhattacharya blended different ratios of
plastic such as polypropylene (PP), low density polyethylene (LDPE), and high density polyethylene (HDPE) with paving grade asphalt[13]. They conducted rheological tests for the unmodified and modified asphalt binders. Better performance was observed for asphalt concrete as indicated by Marshall stability test and loss of stability test. They concluded that waste plastic can be effectively utilized as binder material with excellent results. Gawatre et al. studied environmental effects of plastic use in road construction[14]. According to them properties of concrete can be better than bitumen roads. Their study indicated that 7.5% E-plastic content in mix yielded stability. They observed reduction in compressive strength of concrete by 52.98% when fine aggregate is replaced by 21.5% of E-waste. Also, when fine aggregate is replaced by 7.5% with Electronic waste., they obtained maximum compressive strength. Poweth et al. carried out investigation to study different proportions of plastic waste with the soil sample and their influences on geotechnical properties[15]. Their investigation revealed that plastic alone is not suitable for pavement subgrade. They found that, as the percentage of plastic waste in mix increases, the dry density decreases whereas optimum water content increases. They fixed optimum percentage of plastic 10% based on the results of the tests. They also observed increase of maximum dry density and CBR value, with increase in percentage of quarry. Bondre et al. used higher plastic material, which reduced the bitumen requirement by 10 percentage[16]. Their study indicated that, on an average 40000 rs. per km are saved by use of 10-15 percent waste plastic. Use of polymer coating can increase quality of aggregate. Use of plastic waste also shows a lower crushed fraction under load. Unde and Potnis carried out experimental analysis to study the effects of the use of plastic waste[17]. They carried out investigation with various percentages of plastic addition to bitumen. Their investigation also reiterated that plastic addition to bitumen can be a better binding alternative. Noufal and Maalla explored possibilities of use of plastic bags and recycled concrete aggregate (RCA) for road construction[18]. In their paper they presented laboratory test results of investigation on waste plastic and RCA in production of asphalt mixture. In their experimentation they produced four different asphalt mixes. In first, they mixed standard asphalt mix with optimum bitumen content. Second was waste plastic modified bitumen mix. Waste plastic modified bitumen mix with 100% recycled concrete aggregate, asphalt mix with 100% recycled concrete aggregate were other two mixes. They found that waste plastic in asphalt mix produced better asphalt mixture compared with conventional mix. They concluded that Marshall stability, strength, fatigue life and other desirable properties of asphalt mix can be improved by the use of recycled material (RCA and waste plastics) in the pavement of the road. Recycled polyethylene terephthalate (PET) was mixed in engineering materials by Sulyman et al.[19]. According to them, utilization of waste plastics has become an attractive. The disposal is becoming more and more inconvenient due to limited space on landfills. They obtained waste PET from three main sources namely bottle, foils and cord from tires. Their studies indicated that the addition of little amounts of a number of different polymer binders can bring about improvements in road pavement asphalt. Similar studies were carried out by Sojobi[20]. They emphasized need for eco-friendly road construction. This ecofriendly road construction includes incorporating waste material in road building, thereby reducing solid waste, especially non-biodegradable material. Plastic bottles are used for cold drinks and water. Large number of plastic bottles is disposed every day. These bottles if used in roads, can increase properties of road materials. Sadadiwala and Patel carried out investigation on waste plastic utilization in road construction[21]. They observed a maximum increase of 17.63% in the Marshall stability for 10% of waste plastics. Bolden et al. conducted survey to verify use of waste materials in road construction[22]. Their survey indicated that the use of swine manure, animal fat, silica fume, roofing shingles, empty palm fruit bunch, citrus peels, cement kiln dust, fly ash, foundry sand, slag, glass, plastic, carpet, tire scraps, asphalt pavement and concrete aggregate in construction is increasing. Increasing cost of construction material and solid disposal problem, are twin reasons for this. Ojha and Kumar presented design of flexible pavement using waste plastic[23]. According to them, long lasting, durable, strong and reliable road network is backbone of development. They used materials like bags, cups, thermocole after shredding and cutting. Bale carried out review on potential reuse of
plastic waste in road construction [24]. According to them, use of plastic in bitumen increases melting point. In our country the high temperature conditions calls for such alternative. Bituman gets soft at high temperature. Investigation on similar topic was carried out by Nassir et.al.[25]. They used plastic bags up to thickness 60 micron. These bags are easy to mix with bitumen. They found that 10 percent addition was optimum. After 10 percent, though strength increases but the flow also increases. In addition to usual benefits of plastic mixing, they also emphasized that the serviceability and resistance to moisture were also valuable outcomes. Sahu and Singh presented paper on waste plastic use in road construction[26]. They explained dry and wet processes for plastic. According to them, due to better binding, increased strength and better surface conditions for a prolonged period of exposure, it is advisable to use plastic tar road methodology. Similar investigation was carried out by Barad[27]. He found that the blend is a more polymer dispersion in bitumen at higher percentage of polymer bitumen blend. For better binding of bitumen with the plastic-waste coated aggregate, plastics-waste is coated over aggregate. Patel et.al. investigated use of plastic waste in road[28]. According to them, plastic bottles, polymers, cups, etc. can be re-used by powdering and blending. They explained various aspects of utilization of plastic waste in construction of roads. They emphasized need for re-examining and formulating new guidelines/specification with regard to design and construction of concrete roads. Data from various construction agencies and from research and development fraternity can lead to more effective solution of plastic waste and road quality. According to Mir, economic, technical and ecological criteria govern extent of use of plastic in road materials [29]. According to their studies, thermoset plastics constitute 20% of total post-consumer plastic waste generated. Rest is thermoplastics, which can be remolded after heating. Use of plastic, according to them can bring about 8 percent reductions in bitumen requirement. Also rs.500 per cu.m. can be saved for the roads. Also there are other factors like increased compressive strength, better durability and indirect tensile strength. Rasel et.al. mixed waste PVC with bitumen and studied properties[30]. They determine optimum content of PVC, strength properties of coarse aggregates and Marshall design properties of bituminous mixes. According to their studies PVC up to 10% can be used for bituminous pavement construction in warmer region. They concluded that the bitumen can be modified to obtain high strength mixes by mixing with scrap PVC available from domestic and other waste. Waste plastic bottles were used as mix with asphalt mixture by Moghaddam et.al.[31]. Their studies indicated that there was increase in bulk specific gravity and stiffness of mixtures by addition of lower amount of plastic bottles. They examined stiffness and fatigue characteristics at optimum asphalt content (OAC).

III. CONCLUSION

Critical problem of solid waste minimization lies with non-biodegradable waste. Use of plastic in construction material is becoming more and more acceptable due to the improved properties of materials. Investigations are reported for estimation of optimum proportion of mixture and finding out strength of the materials prepared from waste plastics. The optimum quantity of the waste plastic in bitumen was reported to be 10 percent in most of the investigations. The properties like bulk specific gravity and stiffness are improved by addition of plastic. Investigations indicate that PVC up to 10% can be used for bituminous pavement construction in warmer region. Plastic bottles, polymers, cups, etc. can be re-used by powdering and blending. Recycled polyethylene terephthalate (PET) can be mixed in engineering materials to reduce cost and improve properties.

REFERENCES


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