International Journal of Civil Engineering Research.
ISSN 2278-3652 Volume 7, Number 2 (2016), pp. 125-133

http://www.ripublication.com

A Review on Various Methods of Road Construction Using Waste Materials

Manoj Sharma[1], Dr. Ashutosh S. Trivedi[2] Rohit Sahu[3]

[1] Assistant Professor, Department of Civil Engineering
RGPV, Bhopal, Madhya Pradesh, India.
Email: manojsharma623@ymail.com

[2] Professor, Department of Civil Engineering
RGPV, Bhopal, Madhya Pradesh, India.
Email: ashnriju@rediffmail.com

[3]PG Scholar, Department of Civil Engineering
RGPV, Bhopal, Madhya Pradesh, India.
Email: rohitsahuu26@gmail.com

Abstract

The waste materials is always a problem for the environment, some waste may be disposed easily some cannot. Plastic is also a kind of material whose disposal is always a tedious job. The disposal of waste effected the environment drastically, for minimizing this effect several research in various field is going on to recycle plastic safely. One of its ways is to use the waste plastics in road construction. Plastic road is a need of an hour as they not only consume waste plastic in an eco-friendly way, but also helpful in increasing the quality of the road. In this review paper we will thoroughly study some of the methods and technique through which plastic is used in the road construction and how these technologies suits in various conditions.

Keywords: Crumbed rubber, Marshall Stability, Plastic modified bitumen, Plastic waste

Introduction

In the present scenario dumping of several waste raised from diverse industries is a big complication. These substance acts as a career of environmental infection in the

neighboring area such as many of them are non-biodegradable. Plastics lasts very long as they deteriorate very slowly, the chemical composition that makes plastics so enduring makes it equally opposite to natural course of deteriorate. Plastic can be categorizing in two parts (a) thermoses (b) thermoplastic, a thermosets are synthetic materials that strengthen during being heated , but cannot be reheated after this initial heat forming, it is mainly use in automobile sector and construction industry. These plastics are polyethylene, polypropylene, polyethylene tetra phthalate, polyoxymethylene, polyamide, polytetrafluroethylene. A thermoplastic is a plastic polymer that becomes pliable above a specific temperature and solidifies upon. It is generally used in the consumer goods, machine parts and packing material s, ATM cards these plastic are known as melamine, phenolic, epoxy resin silicone, unsaturated polyester. During the last two decades India has seen a remarkable economic growth. According to central pollution control record (CPCB). Our country produces 5.6 million tons of plastic waste per year and the waste recycled is 9,200 tons per day which is approximately 60 % of the total waste, that means 40 % is even remain indisposed very few institutions and organization in our country employed bags and waste plastic in various forms, whose results are very encouraging, but the secondary market for reclaimed waste are not matured till now. According to data published in the United States, plastic contribute about the total landfill zone. World has produced 3 million poly vinyl chloride (PVC) per year, which is very difficult to recycle and it is almost one-fifth of the whole production of plastic waste. In India the gathering, transportation and dumping of solid waste are very irrational and tumultuous. Uncontrolled disposal of waste on periphery of cities has creates hazardous landfills, by which very severe environmental danger regarding groundwater and exceeds to global warming. If there will be restriction on the adoption of plastic, it would be more difficult and inconvenient , the situation will be more dangerous as health and safety decreased drastically and most important environmental anxiety would be complex. Therefore, the issue is not ‘no plastic vs. not plastic’ but the actual solution is the suitable use with the sustainable development to re-use plastic. And that we can do in a best way to use the plastic in the construction industry in flexible pavement. There are many methods by which we can effectively use the plastic in a ecofriendly way and save virgin material and environment both. Some of them we are discussing in this review paper.

Use of plastic waste in flexible pavement (R. Vasudevan method)

This is one of the most ecofriendly way to dispose various types of waste plastics like poly ethylene (PE), polystyrene (PP), Poly propylene, Laminated plastics and others in road construction, in this process plastic is coated on the stone aggregate, Dr. R. Vasudevan originated this technique where polymer coated aggregate acts as a raw material for the road construction and later on it will mixed either with stone aggregate or bitumen, it possess different results.

In this method, characteristics of plastic coated aggregate is found to be better than the conventional aggregate, the results obtained from the research tells us some

interesting facts about like most of the plastics have a softening about 130 – 140 ^{0}C without any gaseous evolution, so we can easily use the plastics in flexible pavement, binding property of coated aggregate with higher percentage of plastic shows compressive strength of almost 130 tones, and it clearly indicates that PCA has good adhesion property, and it also validation of the material to act as binder. The PCA shows better resistance towards the greater wear and tear load, the brittleness is measured by impact value, and in this research due to the coating of polymer it reduces the air cavities and voids and results into the lesser impact value as compared to plain aggregate. The PCA has also possessed low crushing strength. As the moisture absorption in PCA is almost negligible as compare to 4%-5% in the aggregate without plastic coating, with the property of Soundness is also not found in the PCA. The above mentioned waste plastics is also better in the bonding between bitumen and PCA, which makes this road and method greater resistance from water and increased the durability and performance of the roads. Significant test of Marshall Stability is conducted on PCA and very encouraging results came out as the use of PCA increases the Marshall stability of the mix as compared to PMB mix. It is noted that the PCA bitumen mixes have 50-60 % higher valued instead of PMB which shows that the binding strength is higher in PCA mixes. These all above values coming from various test proves that the PCA mix is superior than that of conventional one, the another approach is environmental aspect as the waste plastic when burned produces greenhouse gases, and as in this process plastic is only softened not burnt which does not produce any evolution of gases, in one kilometer single lane road minimum of one ton of waste plastic is utilized which means it also restrict harmful gases like carbon dioxide to evolve in the atmosphere.

This method is also checked by the performance analysis done on various roads laid down according to the above mentioned method through various tests performed like deflection test using Benkelman beam method, studies on unevenness, field density by sand replacement method and skid resistance, and surface condition survey, in almost all the tests very encouraging results came out and many state governments are now very enthusiastic about this, and now they are planning to make roads with this sustainable approach.

Use of rubber in the road construction

Now-a-days very few percentages of squander tyres are being discarded. The recycled tyres rubber is used to make new tyres, in construction Industry, sports activities, agriculture sector, as a molded rubber product. There is an immense opportunities in the combination of tyres into asphalt. The ‘wet process’ is hereby 40 years old and various roads are laid down using this technology with very encouraging results as they are also improving the performance of the road. But the method is still struggling for coming in the mainstream of the construction industry.

There are mainly two methods by which we can use waste tyres into the road construction.

They are mainly:-

1. Wet process high viscosity
2. Wet process no agitation

The wet process high viscosity was invented by Charles Macdonald. This method has various benefits which are mainly linked with the binder's capability increasing elasticity and viscosity at a high temperature. The recycled tyres rubber modified bitumen (RTR - MB's) that enables rotational viscosity threshold of 1500 cps at 177 ^{0} C over the interaction period should be described as 'wet process' high viscosity.

Wet process high viscosity binders typically needed at least 15 % CKM to achieve the threshold viscosity for some specifications. The continuous agitation is needed with special equipment to keep RTR particles uniformly distribution. This process is categories in following technologies which tells us in brief the benefits and limitations of the wet process high viscosity.

A. Asphalt rubber binder
B. Bitumen rubber binder
C. Crumb rubber binder

The basic reason for using RTR-MB's is that it provides significantly improved engineering properties over conventional paving grade bitumen. The most important benefit is to withstand against the high climate, as generally in many parts of north India temperature reaches 40-60 ^{0}c. In these temperature RTR-MB's shows physical and rheological properties significantly different than those of neat paving grade bitumen likewise reduced several properties like fatigue, rutting, reflection cracking, and improved oxidation resistance, aging and better chip retention due to thicker binder films with additional increased viscosity that permit greater film thickness in mixed pave without bleeding and excessive drain down. It also shows greater values of the elasticity and resilience especially at high temperature. In Indian scenario this method proves to be very useful as the availability of waste rubber is in abundant and there is also no need of any special arrangement to prepare them for the use in road construction.

Usage of waste PVC in the road construction

Tthe most ambiguous plastics in today's scenario are polyvinyl chloride. The world is producing more than 20 million tons of PVC per year. The PVC evolves dioxin when burnt. Increasing use of PVC leads to mass deposition of the material in the landfill sites, as the life span of the PVC is 30 years; it is more complicated and hazardous to dispose the same.

In our country picking, transportation and disposal of waste material is very unorganized and chaotic, especially in case of solid waste. The landfills are not also

properly managed which results into overflowing landfills, barren lands and polluted ground water which is very hazardous to the environment. We also cannot ban the plastic because of the true fact that our society and industries dependent on plastic in so many ways and it is totally factious to ban the plastic, the only solution is to manage it smartly and dispose it eco-friendly. One of the most important ways to dispose the PVC is to use it in asphalting of roads.

Bitumen has been always conventionally used as binder in the road construction, but the bitumen is surrounded by lots of question like its quality and performance. It has been proved by the various researches that the bitumen blended with PVC improved various properties significant in the road construction. The utilization of waste plastic improved so many qualities like strength, fatigue life, reduced low temperature cracking and bituminous surfacing. This makes the material not only to solve the environment problem but also to reduce the overall waste. "A sustainable approach: utilization of waste PVC in asphalting of roads" Behl, Ambika et al described in her research paper by performing several test to analyze the utility of PVC in the road construction. PVC plastic waste used in 2-4 mm pieces and then washed in the dried at 60^0c and modified by the chemical modifier which is very important to mix as PVC will separate from the bitumen otherwise. The retained stability which indicates the moisture induces in the mix, can also be improved by adopting this method as the stability is improved by 20 % with the mixing of PVC(Behl, Ambika et al) the very important property i.e. indirect tensile strength which plays a very vital role to check the resistance of bituminous mixture in cracking. The bituminous is more resistive towards moisture damage when added with PVC. The conventional binder has the tensile strength of 12 kg/sq. m as compared to PVC added bitumen has 18 kg/sq. m. The property of rutting can also be improved by using the PVC waste in the bitumen. Fatigue behavior which also has a deep impact on the durability of roads is improved a lot by using PVC in the bituminous mix. By the above research and figures we can surely say that the PVC can be added in the paving application, the main advantage of adding the PVC into bitumen is that it can improve both the property either of mix or of binder, in addition of this it also shows more resistant towards permanent deformation, cracking, fatigue. Rutting values can be improved by adding the PVC in the bitumen. So we can say that that the hazardous waste materials like PVC can be disposed in an ecofriendly way with also reducing the overall cost, and improved performance of the roads.

Use of plastic waste for improving the sub grades in the road construction

The waste plastic is used in the road construction as a mixing material in the top layer, but its utility is not limited as plastic can also be used as reinforcement in the sub grades, the plastic waste can be used as strip in the soil, it is an effective and dependable technique to improve the strength of sub grades in soil. Better sub grade require comparatively thinner section especially in the flexible pavement as compare to the weaker or untreated sub grade which results into cost reduction also. The increasing use of geo textiles or polymeric reinforcement like geo grids in the

geotechnical application encourages using the plastic waste in the sub grade. In comparison with systematically reinforced soil, randomly distributed fiber reinforced soil, randomly distributed fiber reinforced soil has been found effective in improving the soil CBR reported in the literature (gosavi et al. 2004, Yetimoglu et al. 2005). Plastic container generally made up of high density polyethylene (HDPE) dispose immediately after use. HDPE will collect and recycle but the secondary market of HDPE is not yet so effective and developed and the solid waste reaches more than 50 million tones. The most appropriate way to use plastic waste is to use them in engineering application. The recycled HDPE strip can be very useful, easy, and economical to improve the properties of soil in sub grades as compared to geo grids. Through various test like CBR and secant modulus very impressive result came out as the strip content lies between (0.25% - 4%). The HDPE strip in the soil increased the piston load significantly as compared to that of unreinforced soil, as the load of the unreinforced sand corresponding to 2.5 mm and 5.0 mm penetration were found to be 1920N and 3880N respectively but when the soil was reinforced with 0.25% waste plastic strip having strip length of 12mm, the piston load increased to 3320 N and 6000 N respectively (choudhary et al. 2010). We can easily use the reclaimed HDPE in the sub grade in local soil with an appreciable increment in CBR and the secant modulus. The CBR value is almost three times of reinforced soil as compared to unreinforced soil.

Use of brick aggregate with plastic modified bitumen in bituminous concrete

There are so many places in India where rock is not available in plenty, and bricks comes into the existence in construction industry, the over burnt brick are also considered as waste material in construction as its property are very adverse and we cannot use these bricks except inferior works, that is why we can use over burnt bricks in many ways like in sub base in road construction and filler and many more, one such method is to use of brick aggregate with modified plastic bitumen in road construction. The plastic waste is shredded into small pieces, so that it can pass through 4.75 mm sieve. Bitumen will be heated and plastic is added up to the 10 % by weight of bitumen. The mix will then added with hot aggregate and then laid down into the road. The results of the mix is very encouraging as by this we can use the waste material in the construction, in addition of this some properties of the road specified by the ministry of road (MoRTH 2003) can be improved by adding plastic over the brick aggregate like Marshall value, binding capacity, stripping value, tensile strength. Mixing of plastic in bitumen can increase the tensile strength ratio of the mix. It is 78.57% for the mix with bitumen having 8% plastic and 63.23% with bitumen having 1% plastic. It is 15.34% higher and indicates better resistance to moisture damage (dipankar sarkar et al. 2016). By increasing the plastic in the mix, water damage decreases, use of plastic added aggregate can also reduce the problems of waste management and disposal of brick aggregate can be done in an eco- friendly way.

Conclusion

From the study of some of the methods in which waste products are used in so many ways in the road construction by which we can utilize the plastic waste, industrial waste, agricultural waste, in addition to this they can also improve various properties of roads specified by various authorities like Ministry of road transport and highways, Indian Road Congress, ASTM and many others. So we can say that there is dual benefit to use these methods in various places majorly in low volume roads where loading conditions are limited and economy can be maintained which is very important for any developing country especially like India where more than 50,000 km of existing roads needs to be upgrade, whose estimated cost is around 50,000 crores (PMGSY 2012), but due to less traffic low volume roads cannot attract much to the researchers from the design and construction point of view, but it is also the fact that out of total road network of 4.69 km low volume roads commonly known as village road has a share of 80% (MoRTH 2011). Another problem which also hinders the development of such technologies is that there is absence of documented design procedures and manuals and that is why highway engineers are not encouraged by such sustainable technologies, so to implementing on the ground and to brought up these technologies in the mainstream construction industry we need to make such documents. At last we can say that there is a lot of potential in the waste materials produced by various means to dump those waste is serious concern for the environment, and that is why it is better to utilize these materials in the road construction, as it can also save the virgin construction materials which also get shortens now a days, and adding improved properties as well.

Figure 1: Crumb rubber

Source: http://www.rubber-granules.com/tag/crumb-rubber/

Figure 2: Brick Aggregate

Source: (https://civil-engg-world.blogspot.co.at/2012/01/1.html)

REFERENCES

[1] Anuar Sharuddin, S.D. et al. (2016). A review on pyrolysis of plastic wastes. *Energy Conversion and Management*, 115, pp.308–326. [online]. Available from: http://dx.doi.org/10.1016/j.enconman.2016.02.037.

[2] Babu, G.L.S. et al. (2014). Strength and Deformation Characteristics of Fly Ash Mixed with Randomly Distributed Plastic Waste. , 26(12), pp.1–7.

[3] Behl, A., Sharma, G. and Kumar, G. (2014). A sustainable approach: Utilization of waste PVC in asphalting of roads. *Construction and Building Materials*, 54, pp.113–117. [online]. Available from: http://dx.doi.org/10.1016/j.conbuildmat.2013.12.050.

[4] Ossa, A., García, J.L. and Botero E, E. (2016). Use of recycled construction and demolition waste (CDW) aggregates: a sustainable alternative for the pavement construction industry. *Journal of Cleaner Production*, 135, pp.379–386. [online]. Available from: http://www.sciencedirect.com/science/article/pii/S095965261630765X.

[5] Papers, T. (2014). Utilization of Fly Ash and Waste Recycled Product Reinforced with Plastic Wastes as Construction Materials in Flexible Pavement. , pp.3890–3902.

[6] Vasudevan, R. et al. (2012). A technique to dispose waste plastics in an ecofriendly way - Application in construction of flexible pavements. *Construction and Building Materials*, 28(1), pp.311–320. [online]. Available from: http://dx.doi.org/10.1016/j.conbuildmat.2011.08.031.

[7] Zhao, D., Kane, M. and Do, M.T. (2010). Copyright ASCE 2010 GeoShanghai 2010 International Conference GEOTECHNICAL SPECIAL PUBLICATION NO . 203 Copyright ASCE 2010 GeoShanghai 2010 International Conference., pp.8–18.