

USE OF RECYCLED MATERIALS IN ROAD CONSTRUCTION

J ANIL KUMAR 1*, T PARIMALA 2*

1. *II.M.Tech , Dept of CIVIL, AM Reddy Memorial College of Engineering & Technology, Petlurivaripalem.*
2. *Asst .Prof, Dept. of CIVIL, AM Reddy Memorial College of Engineering & Technology, Petlurivaripalem.*

Abstract

With the evolution of the road industry and growing traffic on roads, construction materials have also been evolved and more unconventional ingredients have been incorporated. The rationale was the scarcity of conventional natural materials and the jeopardized environment which have underpinned the tendency towards evaluation other materials resources to be incorporated in the road industry. The inclusion of such materials entails several secondary and tertiary materials. Several waste by-products and materials have been investigated, assessed, evaluated for utilizations and practiced in the field. Depending on the attributes of the characteristics of the recycled material, the inclusion varies. Some recycled material have been proven to possess preferable properties over the other and have performed satisfactorily in the field. However, there are numerous concerns regarding such incorporation based on both laboratory experimental, and field observations which have turned out to be of the essence for further in-depth studies. Reclaimed asphalt pavement, recycled concrete aggregates, plastic wastes, scrap tires, mine wastes, recycled crushed glass, foundry sand, coal combustion products as fly ash, bottom ash, and pond ash, steel slag, oil sand, oil shale sand, lateritic soil, are amidst the long list. It is believed that magnificent preservation of natural and precious resources would be attained from the inclusion of secondary and tertiary materials in road construction. Nonetheless, without rigorous cooperation between the academia and the industry and educating people who are in routinely interact with paving activities, several performance-related issues would not be resolved and would remain in existence. This paper present a literature review report on the most viable recycled materials currently in practice by the industry and it aims towards developing a noble idea on better inclusion of a recycled material in the road industry.

Introduction

Historically, naturally available materials like soil, stone aggregates, sand etc. had been used for construction of roads. For example, boulders, volcanic tuff and lime were used for the construction of Roman roads (Barth 1990). Subsequently, as the civilization grew, some of the naturally available materials were processed further to derive new binding materials for example, bitumen, cement etc. However, due to considerable usage of various naturally occurring materials for building road and other infrastructures, these have started depleting gradually. The cost of procurement and processing of such materials are increasing day by day. At the same time, large amount of industrial and domestic wastes are causing serious environmental problems in terms of disposal or safe storage. It is in this connection, road researches have been trying to find out

possible ways to use some of the waste materials (after due processing) as alternative materials for road construction (Aravind and Das 2004). For success of such an initiative, the proposed material(s) should be safe, environmental friendly and cost effective. This article presents a brief review on possible use of some waste materials as reported in various literature. It may be noted that the list is no way exhaustive and the conclusions drawn may not necessarily be final. Further research is needed before such material(s) is/are finally recommended for use in road construction. Approach to utilization A processed waste material, which is proposed to be used for road construction, is to be assessed for its environment, health and safety hazards, physical, chemical and engineering properties, cost effectiveness, field performance etc. If environment, health and safety assessment results are negative, the candidate material is

rejected as a road construction material and is recommended for safe disposal. If the material satisfies the environmental, health and safety criteria, then it is further evaluated for its physical, chemical and engineering properties. If the chemical and physical properties of the candidate material are similar to that of traditional construction materials, then existing testing protocols may be used for evaluation of its engineering properties. Otherwise, new test procedures are to be developed. For standard materials, the testing procedures and acceptance specifications are prescribed by highway agencies or local public works departments. Further, cost evaluation needs to be performed to check the economic feasibility of using the candidate material as replacement of traditional pavement material.

Sometimes life cycle cost evaluation is conducted to study in detail the overall impact of the new material on the total cost of the road project (through out its service period, including all maintenance activities). Finally, it is important to conduct field trial with the new material together information on the short-term and the long-term performance of the road. Performance studies also help to develop acceptance specifications for new road materials.

Waste material used in road construction

Several researchers have tried to incorporate bottom ash and fly ash in various layers of pavement (Huang 1990). Fly ash has been used as bulk filler in construction of embankments and flyovers (Yoon et al. 2009). However, due to corrosive nature of bottom ash, its usage near metallic structures is limited (Ke 1990). Studies have indicated that bituminous concrete containing bottom ash is susceptible to rutting but more resistant to stripping. Some field studies have indicated increased skid resistance when bottom ash is used as top wearing course of road

Fly ash consists of extremely fine siliceous glass with particle size ranging from 10 and 100 micron (FHWA 2012a). Due to its smaller particle size, fly ash has been used as mineral filler in bituminous mix. Due to increased surface area of aggregates, overall demand for binder may increase when fly ash is used as filler (FHWA 2012c). Due to pozzolonic nature, fly ash with lime has been widely used in base/sub-base courses as binder (Wen et al. 2011). Lack of homogeneity, sulphates, and slow strength development are some of the issues in using fly ash in road construction (Sherwood 1995). Waste glass has been used as bulk filler in layers beneath bituminous layers (Ahmed 1991).

Due to the presence of inherent porosity in usual stone aggregates, bitumen adheres to the surface strongly, compared to broken glass pieces used as substitute for aggregates. Thus, the strength of bituminous mix with glass as aggregates are found to show lower strength than normal bituminous mix (Su and Chen 2002). It has been also observed that glass particles break under traffic and finally leads to raveling (Larsen 1989).

Some studies indicated that resilient modulus and indirect tensile strength of bituminous concrete containing glass are unaffected up to 15% of glass (Sultan 1990). Construction and demolition wastes has been used as bulk filling material in road structure, well as in recycled aggregate concrete (Rao 2005).

In fine powder form, it can also be used as fillers in bituminous mixes (Chen et al. 2011). Some studies have indicate that performance of construction and demolition waste as sub-base material is comparable to the conventional material (Rao et al. 2007).

Plastic Wastes

Most littered plastic are rich in polymers. It can be used either as a stabilizing agent in soil and

subgrade applications or as an additive to aggregates blends in hot mix asphalt pavement . It is either added to the binder as pellets in the rate of 0.25-0.5% of binder weight in the wet approach or to the aggregates in the dry approach All in all, the wet method outstrips the dry method in easiness and applied shearing forces to ensure dispersing of the plastic chips. HDPE is preferred over LDPE in enhancing HMA mechanistic properties The higher the rate of added plastic less susceptible to temperature the bitumen becomes].It improves stripping resistance 30% of LDPE in the dry method developed the mixture stability and in the rate of retained tensile strength HDPE with HMA posed improvement to deformation resistance, high stability, and a low flow value. An optimum HDPE rate was about 5% for higher acceptable performance and reduced cost of HMA HDPE revealed better properties of subgrade when added at 0.25% Incorporating plastic up to 25% resulted in enhanced HMA performance in terms of stability, skidding, deformation resistance, fatigue, and no defects observed.

Recycled Asphalt Shingles

Asphalt shingles are categorized into two groups, fiberglass, and organic shingles. Both types are composed of varying rates of mineral fibres, mineral fillers, and hard rock granules (ultra-tiny particles ceramic – coated granule) in addition to asphalt cement of an average percentage of 30% by total mass In the province of Ontario in Canada, organic shingles have recently become produced and a harder bitumen type than that commonly used in HMA works covered with aggregates granules of high quality However, each manufacturer would have a relatively varied composition for the produced asphalt shingles. Fiberglass shingles are of an asphalt cement rate of about 15% less than that contained in the organic shingles, which in-turns makes fiberglass shingles cheaper and preferable over organic ones. The content of asphalt cement in Recycled asphalt shingles ranges from 19% to 31% The aim of utilizing asphalt

shingles in road construction is to reduce amount of virgin binder

Crumb Rubber “Scrap tires”

Whether it is processed in either the wet or dry approach, the crumbed rubber used in asphalt surfacing applications has several other advantages other than improved resistance to skidding. It also provides asphalt mixtures with high shear strength, which is favourable in withstanding imposed traffic load and preventing the occurrence of rutting in the underneath pavement layers.

In addition, during freezing and thawing cycles in cold weather conditions, the presence of scrap rubber in the underneath layer compositions plays a crucial role in reducing the frost penetration level Some other benefits of using crumbed rubber in road construction applications include but not limited to rendered temperature susceptibility, fostered rutting and fatigue resistance, and increased stability and reduced flow value (up to a rate of 10% of crumb rubber) and improving stripping resistance When added to asphalt binder up to a percentage of 30%, significant enhancement in properties such as weathering and stripping resistance have been achieved

Conclusion

Despite all researches on potential use of recycled material in road structure, yet there is mounds of concerns and knowledge gaps that require intensive investigation and assessment to the interest of building better roads and preserving natural resources. In should be emphasized other potential recycled materials for road construction such as mine wastes [53-57] were not discussed in this paper.

References

- M. Tuncan, A. Tuncan, & A. Cetin, “The use of waste materials in asphalt concrete mixtures,” Waste management

- & research, vol. 21, no. 2, pp. 83-92, 2003.
- H. Akbulut & C. Güreş, "Use of aggregates produced from marble quarry waste in asphalt pavements," *Building and Environment*, vol. 42, no. 5, pp. 1921-1930, 2007.
 - A. Athanasopoulou & G. Kollaros, "Fly ash exploited in pavement layers in environmentally friendly ways,"
 - S. Paravithana & A. Mohajerani, "Effects of recycled concrete aggregates on properties of asphalt concrete,"
 - J. M. Reid, "The use of alternative materials in road construction," in *International Symposium on Unbound Aggregates in Roads-UNBAR*, 2000, vol. 5.
 - LVM-JEGEL, "State of The Aggregate Resource In Ontario Study (SAROS) – Paper 4. Ontario: Queen's Printer for Ontario," 2009. Print.
 - S. W. Lee & K. L. Fishman, "Waste products as highway materials in flexible pavement system," *Journal of transportation engineering*, vol. 119, no. 3, pp. 433-449, 1993.
 - A. El-Assaly & R. Ellis, "Evaluation of recycling waste materials and by-products in highway construction," *The International Journal of Sustainable Development & World Ecology*, vol. 8, no. 4, pp. 299-308, 2001.
 - C. Holbert, J. Drelich, W. Zmierczak, & J. D. Miller, "Viscosity of bitumen-crumm rubber blend (new paving material)," *Petroleum science and technology*, vol. 15, no. 5-6, pp. 523-543, 1997.
 - Uses of Asphalt. (n.d.). [Online]. Available: <http://www.epa.org/asphalt.php?c=78>.
 - M. Pettnari & A. Simone, "Effect of crumb rubber gradation on a rubberized cold recycled mixture for road pavements," *Materials & Design*, vol. 85, pp. 598-606, 2015.
 - S. Saride, A. J. Puppala, & R. Williammee, "Civil Engineers Ground Improvement 163 February 2010 Issue GI1," *sta*, vol. 717, no. 715, 2010.
 - M. Saltan & F. S. Fındık, "Stabilization of subbase layer materials with waste pumice in flexible pavement," *Building and Environment*, vol. 43, no. 4, pp. 415-421, 2008.
 - A. Emersleben & N. Meyer, "The use of recycled glass for the construction of pavements," in *GeoCongress 2012@ sState of the Art and Practice in Geotechnical Engineering*, 2012, pp. 1642-1649.
 - D. H. Kang, S. C. Gupta, A. Z. Ranaivoson, J. Siekmeier, & R. Roberson, "Recycled materials as substitutes for virgin aggregates in road construction: I. Hydraulic and mechanical characteristics," *Soil Science Society of America Journal*, vol. 75, no. 4, pp. 1265-1275, 2011.
 - M. Bassani, E. Santagata, O. Baglieri, M. Ferraris, M. Salvo, & A. Ventrella, "Use of vitrified bottom ashes of municipal solid waste incinerators in bituminous mixtures in substitution of natural sands," *Advances in Applied Ceramics*, vol. 108, no. 1, pp. 33-43, 2009.
 - L. R. de Rezende, M. O. Marques, & N. L. da Cunha, "The use of non-conventional materials in asphalt pavements base," *Road Materials and Pavement Design*, vol. 16, no. 4, pp. 799-814, 2015.
 - M. Pasetto & N. Baldo, "Laboratory investigation on foamed bitumen bound mixtures made with steel slag, foundry sand, bottom ash and reclaimed asphalt pavement," *Road Materials and*

- Pavement Design, vol. 13, no. 4, pp. 691-712, 2012.
- L. R. de Rezende, J. C. de Carvalho, & E. M. Palmeira, "The use of alternative and improved construction materials and geosynthetics in pavements," Elsevier Geo-Engineering Book Series, vol. 3, pp. 765-786, 2005.
 - Y. Huang, R. N. Bird, & O. Heidrich, "A review of the use of recycled solid waste materials in asphalt pavements," Resources, Conservation and Recycling, vol. 52, no. 1, pp. 58-73, 2007.
 - Z.N. Kalantar, M. R. Karim, & A. Mahrez, "A review of using waste and virgin polymer in pavement," Construction and Building Materials, vol. 33, pp. 55-62, 2012.
 - S. Karmakar & T. K. Roy, "Effect of Waste Plastic and Waste Tires Ash on Mechanical Behavior of Bitumen," Journal of Materials in Civil Engineering, pp. 04016006, 2016.
 - M. M. A. Aziz, M. T. Rahman, M. R. Hainin, & W. A. W. A. Bakar, "An overview on alternative binders for flexible pavement," Construction and Building Materials, vol. 84, pp. 315-319, 2015.
 - K. H. Moon, A. C. Falchetto, M. Marasteanu, & M. Turos, "Using recycled asphalt materials as an alternative material in asphalt pavements," KSCE Journal of Civil Engineering, vol. 18, no. 1, pp. 149-159, 2014.
 - S. Angelone, M. C. Casaux, M. Borghi, & F. O. Martinez, "Green pavements: reuse of plastic waste in asphalt mixtures," Materials and Structures, pp. 1-11.
 - A. K. Choudhary, J. N. Jha, & K. S. Gill, "Utilization of plastic wastes for improving the sub-grades in flexible pavements," Paving Materials and Pavement Analysis, pp. 320-326, 2010.