WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Systematic Study of Reuse Concrete Aggregate and Its Application in Bituminous Concrete: Review of Literature

Harman Singh [1] and Prof. Shivani [2]

M. Tech Student [1] & Assistant Professor [2]
Sat Priya Group of Institutions

ABSTRACT

India has the second-largest road network in the world after United States of America, spanning a total of 5.89 million kilometres (kms). Around 90% of India's total passenger traffic uses road network to commute as well as 64.5% of all goods transport in the country as per the Road Industry report March 2022 by India Brand Equity Foundation (IBEF). Sale of automobiles is growing and even the road transportation has gradually increased over the years particularly after opening of lockdowns due to pandemic due to improvement in connectivity between cities, towns and villages in the country.

Highway construction in India increased at 17% compound annual growth rate between 2016 to 2021. Despite pandemic and lockdown, India has constructed 13,298 km of highways in FY21 which clearly shows the need of road network and Indian government intention to boost the same. Even National Highways Authority of India (NHAI) plans to construct 25,000 kilometres of national highways in 2022-23 at a pace of 50 km per day.

Out of many material required for construction of roads, aggregates is one of the bulkmaterial required for bituminous concrete pavements. Aggregate being a natural material is being fast consumed and is causing a shortage of resources required for rapid road construction development. On the other hand construction industry generated lot of wastage even in construction as well as demolition phase and cement concrete being a non biodegradable element is a challenge to dispose.Generally demolished concrete is discarded in landfills. However with new environmental regulations and limited space available, concrete disposal has been a major environmental challenge.

This review article examined the generation of construction and demolition waste generated in India and other developing economies, waste characterization of aggregate and its application in road construction. Additionally, environmental, economic and social benefits of the reuse of this waste was explored. The result of the review revealed that the reutilisation of this waste concrete aggregate would reduce the amount of raw material used in construction leading to conservation. Also, there would be reduction in the energy cost associated with quarryextraction and transportation of natural aggregates in track with the conservation of natural resources and cost effectiveness of road construction.

Keywords: Reuse Aggregate, Bituminous Concrete, Pavement Construction, Construction Industry

1.INTRODUCTION

1.1 General

At present many pavement construction projects are undertaken in various parts of country some of the projects which are more than 500 kms like Delhi to Mumbai expressway (1,350 km), Amritsar to Jamnagar expressway (1,257 km), Mumbai to Nagpur Expressway (701 km), Delhi to Amritsar to Katra Expressway (687 km), Ludhiana to Bhatinda to Ajmer Expressway (600 km), Meerut to Prayagraj Expressway (594 km) etc. which clearly shows the demand for the resources of bituminous concrete which are increasing day by day. The constituents of bituminous concrete are coarse aggregate, fine aggregate, filler material, and bitumen. The materials, used for this study, are Aggregate. The production of coarse aggregate is also getting reduced due to the restriction imposed on aggregate crushers to minimise air pollution. A huge quantity of raw material consumption inconstruction industry becomes one of the main factors that cause environmental depletion and harm to natural and mineral resources. In this research article aggregate is our prime focus of study and its reapplication sustainability in bitumen concrete pavement construction. Talking aboutAggregates formation it can either be natural or manufactured. Natural aggregates are generally extracted from quarry extraction in form of rocks. Extracted rock is typically reduced to usable sizes by mechanical crushing as per different sizes required by industries. Manufactured aggregate is often a bye product of other manufacturing industries.[1 & 2]

Aggregate is a collective term for the mineral materials such as sand, gravel, and crushed stone that are used with a binding medium such as water, bitumen, Portland cement, lime, etc. to form compound materials such as bituminous concrete and cement concrete.

The coarse aggregates used in road construction should be able to show resistance to crushing under the Roller during construction and adequate resistance to surface abrasion under traffic. The strength of coarse aggregates is assessed by aggregate impact value test and aggregate crushing value test.

Resistance to wear or hardness is another essential property for aggregates used in road construction especially in wearing course.[3]

1.2 Study Objective

The main objective of the research article is to systematic study the work carried out till now in reuse of concrete aggregate in Bitumen Concrete Construction.

2. Reuse of Aggregate in New Road Construction

The reuse of waste generated by construction industry is voluminous and drastically increase load of dumping yard so necessary need to be carried out appropriately disposal otherwise creates an ugly site and cause environmental issues [4]. Consequently, it leads to economic losses, and contamination of the groundwater through leaching particularly in rainy seasons[5]. In addition, Construction and Demolition Waste (CDW) are bulky and not suitable for composting and incineration. Furthermore, the utilisation of this waste would reduce the amount of raw material used in construction leading to conservation. Also, there would be reduction in the energy cost associated with quarryingextraction and transportation of natural aggregates[6]. Furthermore, there are other economic benefits attached to successful recycling [7]. This prompted developed countries to reuse CDW in various sector including road construction. The developed countries understand the importance and consequently increase the reuse.It has being established that several tonnes of materials are needed for road construction.

Before exploring the aggregate quantum used in pavement construction and its methods to reduce. Following is the CPW constitute in India formulated in Tabular form.

Table 1 CPW Constituents in India

Srl No.	Constituent	Qty Generated (in Million Tonnes)
1	Sand and gravel	4.20 to 5.14
2	Brick	3.60 to 4.40
3	Concrete	2.40 to 3.67
4	Metals	0.60 to 0.73
5	Wood	0.25 to 0.30
6	Others	0.10 to 0.15

Aggregate in asphalt pavement commonly used in developing countries comprises of up to 90 to 95 percentage natural aggregates. The quantum required is directly depend upon the factors like roadsubgrade, expected traffic loading and the projects size. As per 4-R solid waste management principal to save guard the aggregated following need to applied.

Fig.1: WasteManagement– 4R's

(Source: Self-Created Image)

From the golden rule of waste management for construction industry, reduction is first. For weak subgrade (< 10% CBR), stabilisation using waste can be done [8 & 9]. This would significantly reduce pavement thickness and the amount of materials needed for construction. Next is the application of reuse. Several research have scientifically proven that recycled aggregate can be used in pavement construction. This provides economic, environmental and social benefits.Reclaimed asphalt pavement (RAP), recycled concrete aggregate (RCA) and recycled aggregate (RC) from CDW can be used in pavement interlayers (sub-base and base).

3.LITERATURE REVIEW

A literature review of scholarly articles, books, dissertations, conference proceedings and other resources which are relevant to the study of reuse of aggregate for bitumen concrete payment construction, carried out to set the background on what has been explored on the topic so far. An extensive literature review provides background information on current knowledge related to the research topic.

The suitability of any aggregate for pavement interlayer is based on certain characteristics. They include the gradation, angularity, soundness and solubility [10]. Typically, recycled aggregates have lower relative densities as well as high water absorption of about 3 to 10% [11 & 12]. This is due to the presence of mortar surrounding the aggregate and masonry. Also, the presence of micro cracks due to second crushing, collision, and sliding during processing affects these aggregates. Furthermore, Road Construction (RC) have lower crush values and adhesion levels [13]. And also subjective to the vertical pressure and number of loading cycle [14].

Different countries have designed various specification and guidelines for the use of RC in pavement structure. These specifications differ from each other considerably. Different standards use traffic load, field trial, experience, material purity or material properties to classify RC. A lot of work needs to be done to provide a detail workable specifications as most are limited. Developing countries have not written and public their own specification. [15]. argued that even without a clear specification, the use of RC is viable and cost effective.

The study revealed that recycled aggregates are not always homogenous. They consist of various type of material. RAC might consist of ceramic materials, or bricks. Therefore, a study to examine the effects of various wastes was designed. The use of different processing systems was observed. The results showed that out of the 23 materials tested, 14 met the Spanish regulation of Los Angeles coefficient less than 40. Also, others only failed narrowly. The study also showed that RC had high California Bearing Ratio (CBR) values. The study encourages the use of RA with less than 23% masonry for subbase application. Furthermore, [16] investigation reported that there is no significant variation in compressive strength, flexural strength and split tensile strength of concrete made with RC and NA. However, it stated that there was increase in water absorption as well as reduced modulus of elasticity and resistivity. The author concluded that concrete mixtures needed for pavement construction can use RC but long field performance test should be carried out. [17] In this article author examined the impact of RC (RCA) on asphalt concrete. The investigation revealed that resilient modulus of asphalt containing RC reduced as binder was added. The values obtained with RC were lower than the control. Stripping potential is higher with RC. There are significant variations in strength under moisture conditions. The study recommended a more comprehensive research into various samples or content of RCA as it is viable.

A review by [18] mentioned that several works had been done by [18-22] through laboratory test. The authors concluded that RC is suitable for pavement interlayer. Ranging from CBR tests, permanent deformation properties, resilient response, degree of compaction, gradation, shear resistance and

stability, examined by several researcher from various countries, they all recommended the use of RC in pavement construction. However, the review mentioned that soundness test for recycled materials would not be accurate. It was revealed that cement mortar would adhere to the aggregate which would increase the loss in soundness test.

The author carried out a field trial to test the performance of recycled aggregate to natural aggregates. [11] The study showed that the use of recycled aggregate during construction would demand more water for compaction. However, the result from the dynamic monitoring test showed that the recycled aggregate was better. It concluded that a combination of concrete waste (75%), asphalt (20%) and ceramic material (5%), would provide a satisfactory load-bearing capacity similar to what a natural aggregate would provide. Some reports have stated that recycled aggregate provides more volume than conversional aggregates for the same weight [8].

The ability of RC to provide the required characteristics necessary for it suitability in pavement construction has being well researched. Depending on the specification for sub-base and base course, different research works have mentioned that it satisfies various specifications and requirements. However, more research into the stress state and permanent strains of RC should be done as asserted by [23]. The durability as well as the aggregate characteristics as regards shrinkage and self-cementing should be examined. Different studies have mentioned that the higher alkali content in RC should be examined. More studies into RC gradation especially fine grains should be done less than 1.18 mm. Also, effects of different pozzolans on RC concrete should be explored.

The next step would be more field trials especially in developing countries. When RC do not meet the specification, stabilization can be carried out to improve the properties of the RC [26 & 27] However, attention must be placed on the resilient modulus due to effects of hydration process.

In any typical asphalt pavement, 4-5% of the structure is bitumen. This bitumen portion can be re- laid every 10 to 20 years depending on it performance. The removal is done with a milling machine, then sorted and batched afterward. RAP can be used as the asphalt layer again as part of the asphalt mixture. Asphalt can be recycled 100% [8].

Wastes such as Fly ash FA, Waste lime, Cement kiln dust (CKD), have been explored as fillers for asphalt mixture. Studies have shown that the inclusion of these and fine RC would have negative impact on asphalt mixture instead improving its engineering characteristics. They are effective and economical [28-32]. Utilised recycled fine aggregates powder as a filler in asphalt mixture. [33] The study revealed that properties such as water sensitivity, high-temperature properties and fatigue resistance were improved on. Conversely, the low temperature performance decreased.

The research of [6] compared the performance of recycled brick powder and limestone stone filler as asphalt filler. The brick powder was obtained by drying washed brick at 80°C for 10 hours. After which the brick was grounded using a jaw crusher and ball mill for 15 minutes. The study carried out water sensitivity tests, indirect tensile tests, static and dynamic creep tests and fatigue tests. The tests were carried out in accordance to AASHTO T-283, AASHTO TP31 and AASHTO T-321 respectively. Draindown test according to AASHTO T-305 was performed. The material compared had similar properties. However, the recycled brick powder had higher specific surface area and absorption. The study observed that the asphalt with recycled brick filler and concrete aggregate had better indirect tensile modulus, decreased permanent deformation at 60°C as well as improved fatigue life and water sensitive. More research needs to be carried out, as recycled brick powder would varies from place to place. [28]

For recycled aggregate to be used in asphalt mixes, the moisture content must be low. An increase in the moisture content by 1% would require 10% more fuel per tonne. Consequently, several reports have stated that the reduction of the aggregate moisture content by 2%, would save 8.7 kWh and 2.02 kg CO_2 per ton [8].

The environmental and economic impact of various disposal methods of CDW were evaluated using dynamic model [29]. The study revealed that recycling was the best method. Theoretically, recycling 20% of CDW would reduce the cost over a 20 year period. It concluded by reinforcing the facts that recycling helps to conserve raw materials and landfills space, reduce Greenhouse Gas Emissions (GHG) and costs to mitigate pollution. Author stated that recycling of aggregates requires about 4.0 kg CO_2 per tonne, which is 22 to 46% lower than the convention aggregate. The utilization of 50% RC during in road construction would reduce the embodied energy and GHG emission of material component by 23% [30]. The use of RC helps to reduce GHG emission by 65% while saving 58% non-renewable energy consumption [31].

4. CONCLUSION

By reusing the concrete aggregate debris into bitumen concrete pavement construction will definitely lower the amount of waste materials into the landfills. This will therefore surely reduce the amount of quarrying which is about 40 billion tonnes of natural aggregatesannually to meet the global demand and extending the life of natural resources and help in preventing the environmental degradation.

- Using recycled aggregates in the construction of bituminous concrete surface course is economically feasible.
- Water absorption may be on higher side, mainly due to the residualcoating of mortar surrounding the recycled aggregates.
- Recycled aggregates are not always homogenous.
- It concluded that a combination of concrete waste (65 - 75%), asphalt (20 - 30 %) and ceramic material (5%), would provide a satisfactory load-bearing capacity similar to what a natural aggregate would provide.
- Recycled aggregate provides more volume than conversional aggregates for the same weight.
- Resilient modulus of asphalt containing recycled aggregates reduced as binder was added.
- It was concluded that bulk density, voids in mineral aggregates, voids filled with binder in the compacted bitumen specimens containing RCA, were lower than those for the control mix made with natural aggregates.
- Recycled concrete aggregates from construction and demolition debris have a high potential for use in the low-volume road construction industry and support sustainable growth.

5. SCOPE FOR FUTURE STUDY

The results found in this study are encouraging. However, further investigations are required to examine the findings in this research using different percentages of recycled concrete aggregates in bituminous concrete and examine the laboratory or field test to evaluate the performance for longer duration.

REFERENCE

[1] SD H., HM P., and SK R., (2008). A study on engineering characteristics of asphalt concrete using filler with recycled waste lime. *Waste Manag.* 28(1). 191–9.

[2] Pusks, A., Corbu, O., Szilgyi, H., and Moga, L. M. (2014) Construction waste disposal practices: The recycling and recovery of waste. *WIT Trans. Ecol. Environ.*, 191, 1313– 1321.

[3] Martinho, F. C. G. (2018) Feasibility Assessment of the Use of Recycled Aggregates for Asphalt Mixtures.

[4] USEPA. (2016) Advancing sustainable materials management: 2014 fact sheet, United States Environmental Protection Agency, Office of Land and Emergency Management, Washington, DC 20460.

[5] UNEP. (2015) Global Waste Management Outlook, International Environmental Technology Centre, Osaka, Japan.

[6] Chen, M., Lin, J., Wu, S., and Liu, C. (2011). Utilization of recycled brick powder as alternative filler in asphalt mixture *Constr. Build. Mater.*, 25(4), 1532–1536.

[7] Osmani, M., (2011) *Construction waste*..

[8] Waste and Report, ”Construction and demolition waste status report.”

[9] Sabai, S. M. M., Lichtenberg, J. J., Egmond, E. L. C., Florea, M. V. M., and. Brouwers, H. J.(2013). Construction and Demolition Waste Characteristics in Tanzania.

[10] Bester, J., Kruger, D., and Miller, B. (2017). South African construction and demolition waste procedure and its sourced material effects on concrete *MATEC Web Conf.*, 02008, 1–9.

[11] Geometry R. and Analysis G. (2007), *Sustainable industrial design and waste management: Cradle-to-cradle for sustainable development.* California 92101-4495.

[12] Yang, H., Xia, J., Thompson J. R., and Flower, R. J. (2017). Urban construction and demolition waste and landfill failure in Shenzhen, China *Waste Manag*, 63, 393–396.

[13] Nunes, M. C. M. (1996) ASSESSMENT OF SECONDARY MATERIALS FOR 3$9(0(17 &216758&7,21 ☐7(&+1ICAL AND ENVIRONMENTAL ASPECTS.
16, 87–96.

[14] Huang, Y., Bird, R. N., and Heidrich O. (2007). A review of the use of recycled solid waste materials in asphalt pavements *Resour. Conserv. Recycl.*, 52(1), 58–73.

[15] Adebanji, O., Ayobami, B., and Emmanuel, A. (2018) Pavement interlayer material improvement using industrial waste: Review of literatures *Int. J. Civ. Eng. Technol.* 9(6), 1114–1122.

[16] Adeyanju, E. A. and Okeke, C. A. (2019). Clay soil stabilization using cement kiln dust, 1st International Conference on Sustainable Infrastructural Development, 1–10.

[17] Sciences Construction Waste Management in Newly Industrialized Countries. 12–24.

[18] UEPG. (2016). A sustainable industry for a sustainable Europe.

[19] Tam V. W. Y., Soomro M., and Evangelista A. C. J. (2018) A review of recycled aggregate in concrete applications (2000–2017) *Constr. Build. Mater.*, 172. 272–292,.

[20] Pellegrino C. and Faleschini F., (2016). Sustainability and the Concrete Industry,".

[21] Ebrahim Abu El-Maaty Behiry A. (2013). Utilization of cement treated recycled concrete aggregates as base or subbase layer in Egypt. *Ain Shams Eng. J.* 4(4). 661–673.

[22] Herrador, R., Pérez, P., Garach, L., and Ordóñez J. (2011). Use of Recycled Construction and Demolition Waste Aggregate for Road Course Surfacing. *J. Transp. Eng.*, 138(2) 182–190.

[23] Barbudo, A., Agrela, F., Ayuso, J., Jiménez J. R., and Poon, C. S. (2012). Statistical analysis of recycled aggregates derived from different sources for sub-base applications. *Constr. Build. Mater.* 28(1) 129–138.

[24] Zhang, Z., Shen, B., Ren, H., Wang, J., Li, S., and Liu, H. (2017). The Variability and Evaluation Method of Recycled Concrete Aggregate Properties. 2017.

[25] Sivakumar, V., McKinley, J. D., and Ferguson, D. (2004). Reuse of construction waste: performance under repeated loading. *ICE—Geotech. Eng.* 157. 91–96.

[26] Gabr, A. and. Cameron, D. A. (2011) Comparison of Specifications for Recycled Concrete Aggregate for Pavement Construction.

[27] Bennert T., Papp W. J., Maher A., and Gucunski N. (2007). Utilization of Construction and Demolition Debris Under Traffic-Type Loading in Base and Subbase Applications. *Transp. Res. Rec. J. Transp. Res. Board.* 1714(1), 33–39.

[28] Arulrajah, A., Disfani, M. M., Horpibulsuk, S., Suksiripattanapong, C., and Prongmanee N. (2014). Physical properties and shear strength responses of recycled construction and demolition materials in unbound pavement base/subbase applications. *Constr. Build. Mater.* 58. 245–257.

[29] Surya, M., VVL K. R., and Lakshmy, P. (2013). Recycled Aggregate Concrete for Transportation Infrastructure," *Procedia - Soc. Behav. Sci.* 104. 1158–1167.

[30] Paranavithana, S. and Mohajerani, A. (2006). Effects of recycled concrete aggregates on properties of asphalt concrete. *Resour. Conserv. Recycl.* 48(1). 1–12.

[31] Vieira C. S. and Pereira P. M. (2015). Use of recycled construction and demolition materials in geotechnical applications: A review. *Resour. Conserv. Recycl.* 103. 192–204.