INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

e-ISSN : 2583-1062

Impact Factor: 5.725

www.ijprems.com
editor@ijprems.com

Vol. 04, Issue 06, June 2024, pp: 123-127

TO STUDY THE APPLICATION OF RAP AND WASTE GLASS IN GSB

Ajeet Singh Bhadouria[1], Pardeep[2]

[1]Student, Sat Priya Group of Institutions, Rohtak, India.

[2]Assistant Professor, Sat Priya Group of Institutions, Rohtak, India.

*Corresponding Author

E-mail Id:- asb.ajeet82@gmail.com

DOI: https://www.doi.org/10.58257/IJPREMS34725

ABSTRACT

The topic has been selected to check the suitability of waste materials in road construction. This will help in getting the economy in road construction as well as saving the environment degradation in terms of reduction in mining and less air pollution. Construction of roads and highways involve huge amount of money and materials mainly aggregates. As millions tones of fresh aggregates are used in road construction and considering their scarcity, replacement of part of the fresh aggregate with waste glass and reclaimed asphalt pavement (RAP) is considered in the present study. The present study discusses the suitability and applicability of waste glass and RAP when used in blends with fresh aggregates for road construction. Performance of these blend are measured by performing various laboratory tests such compaction test and California Bearing Ratio (CBR) test. Granular Sub Base (GSB), grading-3 from the latest MORTH specification has been selected. The test results indicate that virgin aggregate can be replaced by waste glass and RAP up to 25% and 30% by weight respectively and provided satisfactory geotechnical results to be used in GSB.

Keywords: Reclaimed asphalt pavement, granular sub base, California bearing ratio, aggregate

1. INTRODUCTION

Waste material has been defined as any type of material by-product of human and industrial activity that has negligible value. The recycling of glass and aggregate is a process in which used glass and aggregate is reused for new construction. Reckless growth in the quantities and type of waste materials, scarcity of landfill spaces and the likelihood of less availability of fresh aggregate materials in future impose pressure and urgency on finding innovative ways of recycling and reusing waste materials. The recycling and later reuse of waste materials will also reduce the demand for fresh natural resources which leads to less usage of energy, reduction in emission of greenhouse gases and finally a more sustainable environment.

Different types of construction material used in the pavement construction consist of different grades of aggregates and binding material. The main function of the pavement is to transfer the wheel load to the soil below subgrade. Pavement are generally classified into two categories flexible and rigid pavements. A typical flexible pavement consist of subgrade, subbase, base coarse and wearing coarse layers from bottom to top and as we move from top to bottom the stresses on the layer gets on decreasing. Depending upon the requirement of pavement different mixes are used in different layers such as bituminous macadam, dense bituminous macadam, semi dense bituminous macadam and bituminous concrete. In this load transfer mechanism aggregates have to bear the wheel load and resist wear due to abrasive action of the traffic. Therefore for pavement engineers the properties of aggregates is of great significance so, the aggregates are categorized on the basis of their shape, size, texture and gradation. Therefore different agencies like A.S.T.M. , B.S.I, I.S.I and IRC specify separate gradation for different pavement mixes.In India a study (Ranjth, 2012) was conducted in 366 Indian cities constituting 70% of India's urban population. This study states that the total amount of municipal solid waste materials is 68.8 million ton per year or 188,500 tons per day. The urban waste mainly consists of organic waste (47%), paper (6%), glass (0.7%), rag (3.2%), plastic (1%) and rest is moisture content. The present study checks the suitability of the waste glass (WG) and reclaimed asphalt pavement (RAP) in the granular sub base (GSB) where WG is a mixture of different colored glass particles which comprises of different types of adulterations such as paper. plastic, gravel, metals and organic waste and RAP is generated when asphalt pavements are removed for reconstruction, resurfacing of the previous asphalt pavement.

TOPIC OF STUDY AND ITS IMPORTANCE

The topic "Application of Waste Glass and RAP in GSB" has been selected to determine the suitability of locally available WG and RAP in road construction. This will facilitate the saving of conventional natural aggregates (gravels, sand/ stone dust) and save the environmental degradation in terms of reduced mining and less pollution.

INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

e-ISSN : 2583-1062

Impact Factor: 5.725

www.ijprems.com
editor@ijprems.com

Vol. 04, Issue 06, June 2024, pp: 123-127

All over the world millions of tons of mineral aggregates are used for highway construction and maintenance. Gravels and sand are the major road construction materials. However, depending upon the location, local materials of similar engineering properties may also have to be used for highway construction and maintenance works because of financial and environmental reasons

It is well known fact that the naturally occurring material are fast depleting because of their over exploitation to meet the huge demand for construction of infrastructure projects. To cope with the huge demand of these materials at present and in future, sufficient reserves have to be ensured, as these reserves are non-replenishable. Unless we fulfil this task now. The existing reserves of natural resources of materials will ultimately disappear. Besides the amount of energy consumed for blasting the holes for quarring operations, crushing the rocks, transportation of this material to plants for mixing and laying etc. is doing unspeakable damage to the environment. On the other hand, locally occurring material like soil, gravel, Moorum, laterite, sand, surkhi, mine waste, industrial slag, jute geo textile, WG, RAP etc can be effectively used alone or in combination with other materials after studying their physical and engineering properties for their suitability in road construction. Construction of road is quite cost-intensive. Materials alone cost more than 50 percent of the total construction cost. Of this, stone aggregates, major components, consume about 30 percent of the cost of materials. It is of utmost importance to be economical in construction with proper selection of construction material, technology and design methodology. So there is a need for carrying out extensive survey of locally available pavement construction materials with a view to have their optimal utilization in road projects and achieve greater economy in construction costs. For making best use of information from such surveys, it is essential that sampling and testing of material and also recording of test results be done in a systematic manner.

Glass production in India

As per KANCH quarterly magazine (2015) issued by AIGMF (All India Glass Manufacturer's Federation), Indian capacity of glass production is 10000 tons/day i.e. 3.7 million tons/year. Out of this 40-50 % use for glass bottle which is the main cause of production WG.

As per Appenu (2012) the total municipal solid waste accounts 68.8 million tons per year or 188500 tons per day. Out of which 0.7% constitute the WG which constitute approx. 1300 tons per day.

OBJECTIVE OF THE STUDY

The research work "Application of Waste Glass and RAP in GSB" aims at experimentally determining the suitability of using WG and RAP in GSB construction; testing various combinations of WG and RAP with GSB material by replacing natural aggregates with WG and RAP and determine their suitability for road construction as per MORTH specifications. The purpose of the study is to know whether locally available WG and RAP can be used in road construction in GSB layer.

The main objective of the study are

1. To carry out sieve analysis of WG. RAP and natural aggregates used in GSB

for road construction.

2. To study various properties of selected material like specific gravity, water

absorption and bitumen content (for RAP) with a view to determine their suitability in GSB construction.

3. To design the granular mixes for GSB with different proportions of WG and RAP by replacing natural aggregates and study the Maximum Dry Density (MDD) and California Bearing Ratio (CBR) properties of these mixes with a view to determine their suitability for GSB construction.

4. To determine the hydraulic conductivity of the GSB mixes with different proportion of WG and RAP.

2. LITERATURE REVIEW

Taha et al. (2002) studied about blended mixes of natural aggregates and RAP aggregates and states that maximum dry density, CBR are decreased and there is no change in optimum moisture content whereas permeability increases with increasing content RAP aggregates. The CBR value for a 100% RAP mix was reported as 11% but when RAP content reduced to 80% in the mix, the CBR value increased to 26%.

Grubb et al. (2006) prepared three crushed glass and dredged material blends and evaluated them in field to explore the feasibility of using crushed glass and dredged material in embankment and structural fill. The mix proportions are prepared of crushed glass/dredged material as 20/80, 50/50 and 80/20 with a tolerance of 5% of the dry unit weight. The construction 20/80 blend embankment was compacted to a minimum of 90% modified proctor compaction, whereas the 50/50 and 80/20 blend embankment was compacted to a minimum of 95% modified proctor compaction. The results states that as the percentage of crushed glass vary from 20, 50, 80 the respective maximum dry density are

INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

e-ISSN : 2583-1062

Impact Factor: 5.725

www.ijprems.com
editor@ijprems.com

Vol. 04, Issue 06, June 2024, pp: 123-127

15.1, 16.6. 18.2kN/m3 and optimum water content are 11, 15 and 10 respectively. Ali et al. (2011) checks the suitability of using recycled glass and crushed rock blends for pavement subbase. The results of the laboratory tests show that adding up to 50% of recycled glass has low to minimal effect on the physical and mechanical properties of crushed rock. The mix varying proportion of recycled glass/crushed rocks are 50/50, 40/60, 30/70, 20/80, 15/85. 10/90 meets the VicRoads requirements. All recycled glass and crushed concrete blends tested for CBR and Los Angle's abrasion values passed VicRoads requirements for pavement subbase material. Initial laboratory repeated load triaxial testing on the blends indicate that permanent strains are sensitive to moisture content and a higher content of glass additive could potentially produce higher permanent strains. However, the resilient modulus was not sensitive to either changes in moisture or glass additive content. The permanent deformation and resilient modulus of the recycled glass and crushed concrete blend, with up to 30% recycled glass content, is comparable to those of natural granular subbase.

Disfani et al. (2011) conducted a comprehensive suite of geotechnical laboratory tests on samples of recycled glass produced in Victoria, Australia. Depending upon the size of recycled glass they are classified in three categories as coarse, medium and fine sized glass. Laboratory test result indicate that medium and fine sized recycled glass sources exhibit geotechnical behavior similar to natural aggregates however coarse recycled glass was found to be unsuitable for geotechnical engineering applications. Shear strength tests indicate that the fine and medium glass shows shear strength parameters similar to that of natural sand and gravel mixture comprising of angular particles.

Ali and Arulrajah (2012) studied about the use of recycled crushed concrete and recycled glass blends in pavement subbase. The laboratory work in this research work has incorporated 50% of recycled glass into recycled crushed concrete which shows minimal effect on the physical and mechanical properties of the original materials. The recycled glass and recycled crushed concrete blends with maximum percentage of 30% of recycled glass were found to satisfactorily meet the VicRoads requirements. Vyas and Khara (2013) computed specific gravity, water absorption and aggregate impact value (AIV) besides conducting gradation test and flakiness and elongation test for RAP aggregates as per MORTH. They concluded that specific gravity ranges from 2.8 to 3. water absorption ranges from 0.3% to 2%, aggregate impact value is 15.28% (max. 30%) and combined flakiness and elongation index value is 27.64% (max.30%). However, large size of aggregates were deficient in the mix because of crushing and aging action and so the recycled aggregates could not satisfy the gradation requirements as per MORTH.

Arulrajah et al. (2014) perform the laboratory and field evaluation on the use of blends of fine recycled glass, recycled concrete aggregate and waste rock as pavement base or subbase materials. The field and laboratory testing results indicates that fine recycled aggregate blends are suitable in pavement subbase applications. The field testing results indicate variation in each recycled blend within each pavement sections which can be attributed to the nature of mixing of the recycled blends used. Blends of 20% fine recycled glass with coarse size recycled concrete aggregate and waste rock met the requirements as a subbase material.

Berwal et al. (2014) conducted water absorption test, specific gravity test, aggregate impact value test and modified proctor test for compaction and CBR test and finally concluded that Values of Maximum dry density and Optimum moisture content of RAP mixes are nearly equal to values for virgin aggregates. Maximum dry density for Granular sub base is found to be 2.06 and 2.04g/ce in case of virgin aggregates and recycled aggregates respectively. Aggregate impact value and water absorption values are within the permissible limits. Permeability results show that the permeability of recycled aggregates is more than the fresh aggregates. Finally they reported that we can use RAP aggregates of 50% in GSB. Herbert et al. (2015) studied about the use of reclaimed asphalt pavement aggregate in Granular sub base (GSB), Wet mix macadam (WMM) by replacing of RAP aggregates with altering percentage of 0, 15, 30, 45, 60 and 75% with natural aggregates and concluded that the value of maximum dry density obtained with addition of 45% of RAP which is less than 0.01g/cc for GSB, 0.09g/ce more for WMM when compared with referral mix and the value of California bearing ratio with the addition of 45% RAP aggregate is 0.5% less than that of referral mix in the both the cases i.e. GSB and WMM.

Ali and Kushwaha (2015) studied about partial replacement of recycled aggregates with natural aggregates of varying percentages of recycled aggregates of 0. 20, 30, 40, 50 and 60%. They carried out modified proctor test and California bearing ratio test on granular sub-base (GSB) and wet mix macadam (WMM) with RAP-natural aggregate mixes and found that the values of maximum dry density and CBR are obtained with addition of 40% of RAP are less than 0.01g/ce and 0.5-0.6% respectively as compared to no addition of RAP to the natural aggregates. The aggregate impact value and Los Angeles abrasion value for recycled aggregates are 28,69% and 38.5% respectively which are within permissible limits: whereas maximum permissible Los Angeles abrasion value and aggregate impact value for bituminous macadam are 50% and 35% respectively as per MORTH specifications.

INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

e-ISSN : 2583-1062

Impact Factor: 5.725

www.ijprems.com
editor@ijprems.com

Vol. 04, Issue 06, June 2024, pp: 123-127

3. MATERIALS

GENERAL

The materials used for this research work include waste glass (WG), reclaimed asphalt pavement (RAP), natural aggregates of sizes 40 mm, 20 mm, 10 mm and stone dust. Natural aggregates are collected from construction site at NIT

Kurukshetra and RAP and WG are obtained from construction sites near LNJP hospital and Delhi respectively.

MATERIALS USED

Waste glass (WG)

Glass which has negligible salvage value or can't be used in original condition is known as waste glass. After crushing and screening process this WG can be used as a pavement material. Glass that has been reduced to a fine aggregate size fraction i.e. less than 4,75 mm size exhibits properties similar to that of a fine aggregate or sandy material, with relatively higher stability, due to the angular nature of crushed glass particles. To satisfy the standard requirement for gradation blending of WG it has to be mixed with other conventional materials before using it as a pavement material (FHWA 2016).

Reclaimed Asphalt Pavement (RAP) aggregates

RAP is the term given to those removed or reprocessed pavement materials containing asphalt and aggregates. These materials are generated when asphalt pavements are removed for reconstruction, resurfacing or to obtain access to buried utilities. There are two methods of sorting or cleaning of recycled aggregates, first one is dry separation method, which involves removal of lighter matter from heavier stony materials by means of blowing air and second one is wet separation method, which separates a low density impurity by water jets or float-sink tank and produces clean aggregate. Recycled aggregate has inferior relative density and less water absorption capacity as compared to fresh aggregate.

STANDARD SPECIFICATION

Aggregates are used in various layers of pavement like granular subbase (GSB), water bound macadam (WBM). water mx macadam (WMM) and various concrete and bituminous layers. Keeping in view the objective of the study, the use of WG and RAP in GSB has been focused. The standard specifications related to aggregates are covered in Indian Road Congress (IRC) and Ministry of Road Transport and Highway (MORTH) guidelines.

Characteristics of aggregates

Aggregates form the major part of the pavement structure and are the prime materials to be used in the pavement construction. Aggregates have to bear the load stresses occurring on the roads and runways. They are used in bituminous and cement concrete pavement. Aggregates are used in underlying layer of the pavements like GSB, WMM etc.

Aggregates which are used in the surface course have to withstand the load stresses and wear and tear due to abrasion. Therefore such aggregates should have high strength of resistance to crushing and should be hard enough to resist the wear due to abrasive action of traffic.

Aggregates in the pavement are also subjected to impact due to moving of wheel loads. In monsoon season stones protrude out easily from WBM layer due to movement of heavily loaded steel tyred wheel, jumping of these steel tyred wheels from one stone to another at different levels cause severe impact on the stones. Therefore resistance to impact can also be a desirable property of aggregates

Specific gravity is considered to be a measure of strength characteristics of aggregates. Higher the specific gravity better is the aggregate. The presence of air voids or pores affects the strength characteristics of the aggregates, more the voids the lesser is the specific gravity and the strength of such aggregates will also be lower.

The size of aggregate is defined as that sieve size through which only 10% of the the sample can pass. All aggregates that fall in a particular size range may not have same strength and durability when compared with cubical, angular or rounded particles of the same aggregate. Too flaky or elongated aggregates should be avoided as far as possible as they can be crushed easily under load.

Affinity of aggregates to bituminous binders is an important property for the bituminous pavements. If the bitumen binder does not have good affinity to the aggregates, then stripping is likely to occur.

The desirable properties of the aggregates may be summarized as follows: 1. Resistance to crushing.
2. Resistance to abrasion.
3. Resistance to impact.

4. Flaky and elongation index of coarse aggregates. 5. Good adhesion with bituminous materials.

Granular Sub Base (GSB)

GSB is used as a sub base layer in one or more layers in the pavement. It serves the purpose of separation and drainage of the pavement layers. The work consists of laying and compacting of well graded material on prepared subgrade in accordance with the requirements of these specifications. The material shall be laid in one or more layers as sub base or upper sub base and lower sub base.

Materials

Conventional materials used for the GSB construction may consist of natural sand, gravel, crushed stone or combination depending upon the grading required. Materials like crushed slag, crushed concrete, brick metal and kankar may also be used. These materials should be free from organic or other deleterious

material.

Physical Requirement

The value of water absorption should not be more than 2% for aggregates. In case if it is more, then aggregates should be tested for wet aggregate impact value.

Material passing through 425μ sieve shall have liquid limit and plastic limit not more than 25 and 6 respectively. The material should have a 10 per cent fines value of 50 KN or more (in soaked condition).

4. CONCLUSIONS

The research work on the topic "Application of waste glass and RAP in GSB", has been carried out to evaluate the suitability of waste glass and RAP aggregates in road construction as per MORTH specifications. In this study natural aggregates are replaced by waste glass and RAP in varying percentages. The study was divided in various groups having WG percentages as 10, 15, 20 and 25% with RAP percentages in each group varying as 0. 10, 20 and 30%. Properties of various mixes are evaluated and compared with base/standard mix without WG and RAP. In the present study 40 mm, 20 mm, 10 mm, stone dust. RAP and waste glass are the materials that are used for the mix design for the GSB grading III.

All investigation including proctor test. CBR test and permeability test do have a limitation of maximum size of particle i.e 19 mm, therefore in all the investigation particle size greater than 19 mm were replaced by particle size 4.75 mm and 19 mm as per standard guidelines.

5. REFERENCES

[1] Ali M. M. Y. and Arulrajah A. (2012) "Potential Use of Recycled Crushed Concrete-Recycled Crushed Glass Blends in Pavement Subbase Applications" in Geo Congress D ASCE (2012).

[2] Ali M. M. Y., Arulrajah A., Disfani M. M. and Piratheepan, J. (2011) "Suitability of Using Recycled Glass-Crushed Rock Blends for Pavement Subbase Applications" in Geo-Frontiers Congress ASCE (2011).

[3] Annepu K.R. (2012) "Sustainable Solid Waste Management in India" Columbia University New York City.

[4] Arpan Herbert, Ehsan Ali and Yogendra Kushwaha (2015) "Recycled Highway Aggregate as a Partial Replacement with Natural Aggregate", IJISET (2015).

[5] Arulrajah, A., Ali M. M. Y., Disfani M. M. and Horpibulsuk S. (2014) "Recycled- Glass Blends in Pavement Base/Subbase Applications: Laboratory and Field Evaluation" in Journal of Materials in Civil Engineering © ASCE (2014).

[6] Berwal P., Aggarwal P. and Goel R. (2014) "Use of Recycled Aggregates in Granular Sub Base" in IJIRSET (2014).