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RECYCLING OF ROAD CONSTRUCTION MATERIAL & CHECK THEIR SUITABILITY IN ROAD CONSTRUCTION

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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 construction and maintenance of roads consume large amounts of quarried aggregates. The use of secondary (recycled), instead of primary (virgin), material helps in reducing demand of extraction. 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. 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. 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.

1. INTRODUCTION

Recycling of aggregate is a process in which used aggregate is reused for new construction. Use of recycled aggregate is not very common in India and other developing countries. There is huge requirement of the aggregate because of fast development in the infrastructure area. In order to reduce the usage of fresh aggregate, recycled aggregate can be used as a replacement materials. Recycled aggregate used in the present study is obtained from the debris of dismantled roads.

Road infrastructure is an essential requirement of economic growth. It provides the facility for man and material, links industries, help in trade. In addition, road system provides last mile connectivity to all other modes of transport such as railways, airways etc. The overall development of a country depends upon on a good and well connected road network. Various construction material used in the road construction include different grade of aggregate and binding material. Aggregate form the major portion of pavement structure. The major function of the pavement is to transfer wheel load to the sub grade. In this load transfer mechanism aggregates have to bear stresses occurring due to the wheel loads on the pavement and on the surface course, they also have to resist wear due to abrasive action of traffic. Therefore the properties of aggregate are of considerable significance to the highway engineers. The aggregates are categorized based on their size, shape, texture and gradation. Different pavement mixes (such as bituminous macadam, dense bituminous macadam, semi dense bituminous macadam and bituminous concrete) require separate gradation as has been specifying by various agencies like A.S.T.M, B.S.I, I.S.I and IRC.

1.1 Importance of Research Topic

The topic "Recycling of Road Material in Civil Engineering" has been selected for the present study to determine suitability of recycled material in road construction. This will help in achieving economy in road construction as well as saving on environment degradation in term of reduced mining and less pollution. Construction and maintenance of roads and highways involve millions of tones of aggregate. Considering the scarcity of fresh aggregate, replacement of part of the fresh aggregate with recycled aggregate is considered in the present study. Construction of the road is quite cost intensive. Material alone cost more than 60% of the total construction cost, out of which aggregate cost component, is approximately 30%. We can use recycled aggregate in place of fresh aggregate in construction of road and provide economy to the project. For making best use of recycled aggregates, it is essential to study the suitability of the same in various pavement components. In the present study use of recycled aggregate in Granular Sub Base (GSB) and Wet Mix Macadam (WMM) is evaluated.

1.2 Objective of the study

The objective of the study "Recycling of Road Construction Material" includes collection of recycled material from MDR (Nandgarh to Bhud kalan) and fresh aggregate from Yamunanagar quarry. A series of test as per IRC guideline is carried out to access the suitability of the material for road construction. The purpose of the study is to assess the suitability of the recycled material for road construction work.

The main objective of the study include-

(1) Collection of study material.

(2) To study the various properties of selected material like gradation, water absorption, maximum dry density, impact value, flakiness and elongation with a view to determine their suitability in GSB and WMM construction.

(3) Design of Job Mix Formula for GSB

(4) Design of Job Mix Formula for WMM

2. LITERATURE REVIEW

The applications of recycled aggregate in the construction areas are wide and they had been used long time ago.

1. Wilmot and Vorobieff (1997) stated that recycled aggregate have been used in the road industry for the last 100 years in Australia. They also stated that the use of recycled aggregate for the construction and rehabilitation of local government roads has a great improvement in the last five years. C & D Recycling Industry, the fact file stated that from the time of the Romans, the stones from the previous roads were reused when rebuilding their vaunted set of roads. It also stated that since the end of world war two, the recycling industry had been well established in Europe. The applications of recycled aggregate in the construction area are very wide. There are many testing based on the recycled aggregate have been carried out all around the world.

2. Hanson and Torben (1986) stated that, the research on recycled aggregate had been carried out in many countries. The main aim that testing the recycled aggregate is to find out the result of the strength characteristic on it and analysis whether recycled aggregate is suitable to apply in the place of fresh aggregate in construction of road. According to Ramamurthy and Gum aster (1998), in some cases the compressive strength of recycled aggregate was same as fresh aggregate.

3. Limbachiya and Leelawat (2000) found that recycled aggregate had lower relative density and water absorption capacity is less to fresh aggregate. According to their test results, there was no effect with the replacement of 30% coarse recycled aggregate used on the strength of fresh aggregate.

4. Sagoe, Brown and Taylor (2002) stated that the difference between the characteristic of fresh recycled aggregate and natural aggregate is relatively narrower than reported for laboratory crush recycled aggregate mixes.

5. Mandal, Chakaborty and Gupta (2002) found that the compressive strength was somewhat increase when the amount replacement of recycled increased. They concluded that the properties and characteristic of recycled aggregate has sufficient deficiency when compared to the fresh aggregate. There must be some influences that cause the reducing of compressive strength of recycled aggregate.

6. According to Tavakoli (1996) the strength characteristics of recycled aggregate were influenced by the some inorganic impurities, the ratio of coarse aggregate to fine aggregate, and the ratio of top size of the aggregate in the in the recycled aggregate. There are some methods used to improve the strength of the recycled aggregate. From the obtained result, recycled aggregate had the same engineering and durability performance when compared to the fresh aggregate.

7. Florida Department of Transportation (FDOT) specifications recommended that Los Angeles abrasion loss should be less than 45% and Soundness by sodium sulphate test should be less than 15% for the use of recycled concrete aggregate as a base material in flexible pavements.

2.1 Comparison of Recycled Aggregate and fresh Aggregate

(1) Texture

Recycled aggregate has the elongated particles and stick with bitumen where fresh aggregate is smooth, angular and rounded compact aggregate. The angular and elongated particles with bitumen content require less water than the smooth and rounded compact aggregate when producing the workable aggregate. The void content will increase with the angular aggregate where the larger sizes of well and improved grading aggregate will decrease the void content.

(2) Quality

The quality of recycled aggregate and fresh aggregate is different. According to Sagoe and Brown (1998), the quality of fresh aggregate is based on the physical and chemical properties of sources sites, where recycled aggregate is depended on contamination of debris sources. It also stated that natural resources are suitable for multiple product and higher product have larger marketing area, but recycled aggregate have limited product mixes and the lower product mixes may restrain the market.

(3) Location

The fresh aggregates are derived from a variety of rock sources. The processing plant for fresh aggregate depends on the resource. It usually occurs at the mining site and outside the city. Recycled aggregate are derived from debris of building constructions and roads. The recycling process is often located in the urban area.

2.2 STANDARD SPECIFICATIONS

General

Aggregate is used in various layers of pavement, be it GSB, WBM and WMM and various bituminous and concrete layers. Keeping in view the objective of this study, the use of recycled aggregate in GSB and WMM has been focused. The standard specifications relating to aggregate are covered in

relevant Indian standard; Indian Road Congress codes and Ministry of shipping, road transport and highway (MORTH) guideline.

Characteristics of aggregate

Aggregate is an important constituent of granular sub base (GSB) and wet mix macadam (WMM), and for satisfactory performance, its requirements for cleanliness, free from impurities and particle size will depend on the purpose for which it is used. Aggregate form the major part of the pavement structure and it is the prime material used in pavement construction. The aggregate in the pavement are also subjected to impact due to moving wheel loads. Severe impact like hammering is quite common when heavily loaded steel tyred vehicle move on WBM roads. Jumping of steel tyred wheel from one aggregate to another at different level causes severe impact on the aggregates. The resistance to impact or toughness is hence another desirable property of aggregate. The size of the aggregate is identified by the size of sieve opening through which the same may pass. All the aggregate that happen to fall in a particular size range may not have the same strength and durability when compared with cubical, angular or rounded particles of the same stone. Too flaky and elongated aggregate should be avoided as far as possible as they can be crushed easily under load. Aggregate having angular shape is preferred in road construction works due to their better interlocking strength.

The desirable property of the aggregate may be summarized as follows:

(1) Resistance to crushing.

(2) Resistance to abrasion.

(3) Resistance to impact or toughness.

(4) Good shape to avoid flaky and elongated particles of coarse aggregate.

(5) Good adhesion with bituminous materials in presence of water.

The required properties of aggregates depend upon the type of pavement construction, traffic and climatic conditions. All the above mentioned properties need not necessarily be possessed by the aggregate for a particular construction.

Granular sub base (GSB)

The work consists of laying and compacting well graded material on prepared sub grade in accordance with the requirements of these specifications. The material shall be laid in one or more layers as sub base or lower sub base and upper sub base as necessary according to lines, grades and cross sections shown on the drawing or as directed by the engineer.

Materials

The material to be used for the work shall be natural sand, moorum, gravel, crushed stone or combination thereof depending upon the grading required. Material like crushed slag crushed concrete, brick metal and kankar may be allowed only with the specific approval of the engineer. The material shall be free from organic or other deleterious constituents.

Physical requirements

The water absorption value of these aggregate shall be determined as per IS: 2386 (part 3), if this value is greater than 2%, the soundness test shall be carried out on the material delivered to site as per IS: 2386(part5).

Strength of granular sub base

It shall be ensured prior to actual execution that the material to be used in the sub base satisfied the requirement of CBR and other physical requirement when compacted and finished.

Wet mix macadam (WMM)

Wet Mix Macadam is a pavement layer where in crushed graded aggregates and granular material, like, graded course sand are mixed with water in mixing plant and rolled to a dense mass on a prepared surface. It has many advantages over the WBM construction. These include superior gradation of aggregate, faster rate of construction, higher standard of densification that can be achieved, less consumption of water and stricter standards of quality achievable. The specification can be adopted for sub-base and base courses. The work may be done in many layers. The thickness of an individual layer shall not be less than 75 mm and can be up to 200mm provided suitable; type of compacting equipment is used.

3. Testing program

A series of test were conducted on aggregates, GSB and WMM.

3.1 Test on aggregate

(1) Flakiness test

(2) Water absorption test

(3) Aggregate impact value

(4) Specific gravity test

3.2 Test on GSB

(1) Job mix formula

(2) Proctor test

(3) CBR test

(4) Permeability test

3.3 Test on WMM

(1) Job mix formula

(2) Proctor test

(3) CBR test

(4) Permeability test

3.4 Test on stone dust

(1) Specific gravity test

4. Advantages

There are many advantages through using the recycled aggregate. The advantages that occur through usage of recycled aggregate are listed below.

(1) Environmental gain

The major advantage is based on the environmental gain. According to Commonwealth Scientific and Industrial Research organization (CSIRO), construction and demolition waste makes up to around 40% of the total waste each year going to land fill. Through recycling this material, it can keep diminishing the resources of urban aggregated. Therefore, fresh aggregate can be used in higher grade applications.

(2) Save energy

The recycling process can be done on site. According to Kajima Technical Research Institute (2002), Kajima has developed a method of recycling that used in the construction, known as the Within-Site Recycling System. Everything can be done on the construction site through this system, from the process of recycled aggregate, manufacture and use them. This can save energy to transport the recycled materials to the recycling plants.

(3) Cost

The cost of recycled aggregate is cheaper than fresh aggregate. It depends on the local availability of the aggregate. This is just around half of the cost for natural aggregate that used in the construction works. The transportation cost for the recycled aggregate is reduced due to the availability in local region. Recycling aggregate from the demolition projects can saves the costs of transporting the material to the land fill, and the cost of disposal beside that, Aggregate Advisory Service also state that the recycling site may accept the segregates materials at lower cost than landfill without tax levy and recycled aggregate can be used at a lower prices than primary aggregate in the construction works.

(4) Sustainability

The amount of waste materials used for landfill will be reducing through usage of recycled aggregate. This will reduce the amount of quarrying. Therefore this will extend the lives of natural resources and also extend the lives of sites that using for landfill.

(5) Market is wide

The markets for recycled aggregate are wide. According to Environmental Council Organization, recycled aggregate can be used for sidewalk, curbs, bridge substructures and concrete shoulders, general and structural fills. It also mentioned that recycled aggregate can be used in sub bases and support layers such as unsterilized base and permeable bases.

5. Future Scope of Work

Presently there is a great problem of mining due to large boom in construction industry and environmental, and in fiiture this problem may increase exponentially. Therefore recycling of aggregate obtained from road debris is a noble idea. In the present study test results reveal that GSB and WMM mixes using recycled aggregate fulfils the MORTH specifications.

Present study may be extended in following directions

- Characteristics of other mixes such as Bituminous Macadam etc. can also be studied using recycled aggregate.
- Effect of Recycled aggregate processed through 'heating and rubbing method' (HRM) and like methods may also be included in the future studies.
- An economic analysis may be useful in quantifying the financial benefits of using recycled aggregates over fresh one.
- Field performance on test section could also be part of future studies.

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