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RESEARCH ARTICLE

Utilization of Recycled Highway Aggregate by Replacing it with Natural Aggregate

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Abstract

Recycled aggregates comprise crushed, graded inorganic particles processed from the materials that have been used in the highway roads. The aim of the present investigation is to determine and compare the maximum dry density, optimum moisture content and California Bearing Ratio (CBR) of Granular Sub Base (GSB) and Wet Mix Macadam (WMM) by using different percentages of recycled aggregates. This investigation was carried out using modified proctor CBR for total of 5 batches of mixes prepared in which 0, 10, 20, 30, 40 and 50% replacement of fresh aggregate by recycled aggregate at optimum moisture contents was carried out. The maximum dry density of recycled aggregate matrix up to 30% replacement level is about 0.01 g/cc more than the referral mix by natural aggregate. The CBR of recycled aggregate matrix up to 30% replacement level is about 1% less than the referral mix by natural aggregate. This reduction in strength may be due to lesser the strength of recycled aggregate as compared with the fresh aggregate.

Keywords: Recycled aggregate, maximum dry density, moisture content, California bearing ratio, granular sub base.

Introduction

The use of supplementary aggregate material is essential in developing low-cost construction materials and ecological benefits for use in developing countries. It is estimated that the construction industry in India generates about 12-14 million tons of wastes annually. Construction and demolition wastes are generated whenever any construction/demolition activity takes place, such as, building roads, bridges, fly over, subway and remodeling etc. The applications of recycled aggregate in the construction areas had been used long time ago. Wilmot and Vorbieff (1997) stated that recycled aggregate have been used in the road industry for the last 50 years in Australia. In view of significant role of recycled construction material and technology in the development of urban infrastructure, the Technology information Forecasting and Assessment Council (TIFAC) had commissioned a techno-market survey on 'Utilization of waste from construction industry'. The focus of their study was to assess the present knowledge of the Indian construction industry on the possibility of the recycling of construction and demolition (C&D) wastes. The survey was targeted toward the housing/building sector and road construction segment. According to findings of the survey, the most dominant reason for not adopting recycling of waste from construct in industry is "Not aware of the recycling techniques". While 70% of the respondents have cited this as one of the reason, 30% of the respondents have indicated that they are not even aware of recycling possibilities. Sagoe-Crentsil and Brown (1998) stated that the quality of natural aggregate is based on the physical and chemical properties of sources sites, where recycled aggregate depends on contamination of debris sources. It is 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 marketing. According to Bakoss and Ravindrarajah (1999) there are two methods of sorting and cleaning the recycled aggregate, dry separation process which involves removing the lighter particles from the heavier stony materials by blowing air. This method always causes lot of dust. In the wet separation process, low density contaminants are removed by the water jets and float-sink tank and this will produce very clean aggregate. Limbachiya *et al.* (2000) found that recycled aggregate had lower relative density and less water absorption capacity compared 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. Mehta (2001) found that the lack of durable materials also had serious environmental consequences. Increasing the service life of products is a long-term and easy solution for preserving the earth's natural resources. Sagoe-Crentsil and Brown (1998) stated that the difference between the characteristic of fresh recycled aggregate and natural aggregate is relatively narrower than reported for laboratory crouch recycled aggregate mixes. Mandal *et al*. (2002) found that the compressive strength was somewhat increased when the amount of replacement of recycled aggregate increased. They concluded that the properties and characteristics of recycled aggregate have sufficient deficiency when compared to the fresh aggregate. There must be some influences that cause the reduction of compressive strength of recycled aggregate. The twelfth five-year plan envisages a shortage of aggregates in infrastructure sector and presently there is a great problem of mining due to large boom in construction industry and in future, this problem may increase exponentially. Therefore, recycling or aggregate obtained from road debris is a noble idea. Considering the above facts in view, the aim of the present investigation is to determine and compare the maximum dry density, optimum moisture content and California Bearing Ratio (CBR) of Granular Sub Base (GSB) and Wet Mix Macadam (WMM) by using different percentages of recycled aggregates.

Materials and methods

Experimental design: The aggregate used in this study was stone aggregate. The properties of aggregate was found as per IS-383 (Fineness modulus = 2.78; Specific gravity = 2.67). The gradation of aggregate as per Ministry of Road Transport and Highways (MORTH) specified grading was maintained throughout the experiment. Recycled stone aggregate for the present investigation was obtained from the Siwan–Siswan State Highway (SH–89) of Bihar State which is under up gradation. The recycled road aggregate was sieved and the fraction passing sieve was used in the experiments. LOS angle abrasion value comes around 34.5% where the value up to 50% are allowed in base courses like water mix macadam and bituminous macadam as per IS: 2386 (part-4), aggregate impact value was 26.78% where as the maximum permissible value is 35% for bitumen macadam and 40% for wet mix macadam so that it is also acceptable as per IS: 2386 (part-4) or IS: 5640. The maximum dry density for GSB and WMM was found for different mix (variable % of recycled aggregate) at optimum moisture content as per procedure laid down in IS: 2720 (Part-8)-1987. CBR value is highly dependent on the condition of the materials at the time of testing. The test performed on remolded specimens using rammer. The test is conducted as per IS: 2720 (part-16)-1987. The physical view of fresh aggregate and recycled aggregate is shown in Fig. 1 and 2.

Fig. 1. The physical view of fresh aggregate.


Fig. 2. The physical view of recycled aggregate.


Results and discussion

The aim of the present investigation is to determine and compare the maximum dry density, optimum moisture content and California Bearing Ratio (CBR) of Granular Sub Base (GSB) and Wet Mix Macadam (WMM) by using different percentages of recycled aggregates. This investigation was carried out using modified proctor CBR for total of 5 batches of mixes prepared in which 0, 10, 20, 30, 40 and 50% replacement of fresh aggregate by recycled aggregate at optimum moisture contents was carried out. A comparative study of mix design GSB and WMM through job mix formula at different replacement levels to the fresh aggregate are presented in Table 1.

Table 1. Maximum dry density and California Bearing Ratio of mix at different level.

Replacement level of recycled aggregate (%)	Granular Sub Base (GSB)		Wet Mix Macadam (WMM)	
	Max. dry density (g/cc)	California Bearing Ratio (%)	Max. dry density (g/cc)	California Bearing Ratio (%)
0	2.29	33	2.32	38
10	2.26	30	2.30	34
20	2.24	28.5	2.29	32
30	2.28	32.5	2.31	37.5
40	2.24	27	2.28	30
50	2.18	26	2.25	28

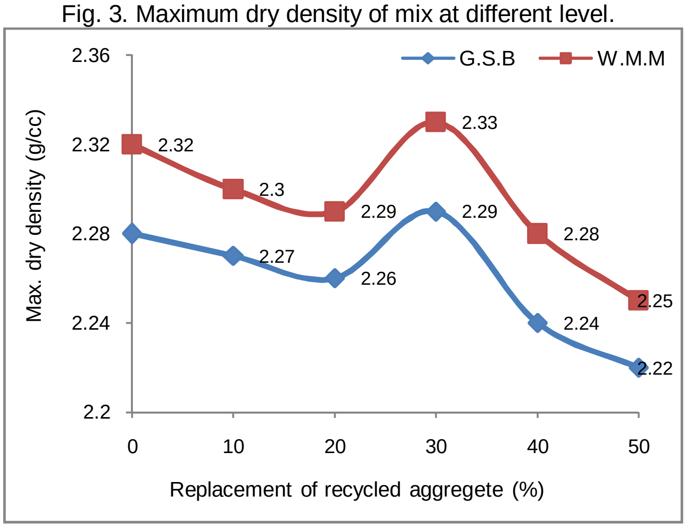
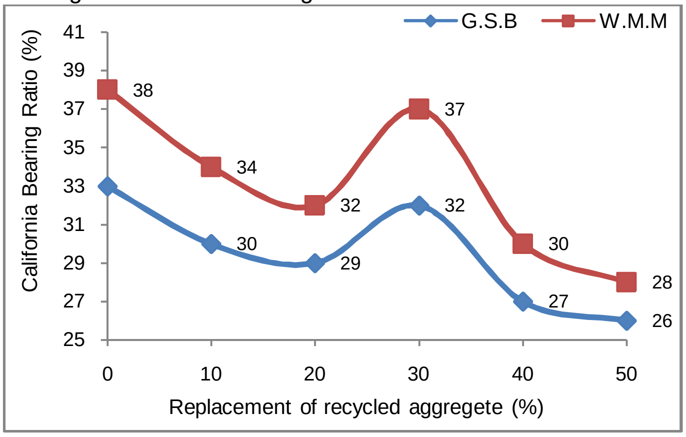
Fig. 3. Maximum dry density of mix at different level.


Fig. 4. California Bearing Ratio of mix at different level.



The maximum dry density of recycled aggregate matrix up to 30% replacement level is about 0.01 g/cc more than the referral mix by natural aggregate (Fig. 3). The CBR of recycled aggregate matrix up to 30% replacement level is about 1% less than the referral mix by natural aggregate (Fig. 4). This reduction in strength may be due to lesser the strength of recycled aggregate as compared with the fresh aggregate.

Conclusion

1. The use of recycled aggregate in road construction in GSB and WMM not only used to achieve economy in the road projects, but also minimizes mining pollution.
2. Recycling aggregate from the demolition projects can save the cost of transporting the material to the land fill and the cost of disposal.
3. An economic analysis may be useful in quantifying the financial benefits of using recycled aggregates over fresh one.

Present study may be extended in following directions:

1. Characteristics of other mixes such as Bituminous Macadam etc. can also be studied using recycled aggregate.
2. Effect of recycled aggregate processed through ‘heating and rubbing method’ (HRM) may also be included in the future studies.

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