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Use of Waste Polymer Particles as Aggregates to Repair Pot Holes in Bituminous Pavement

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Abstract: ***From the result of different laboratory tests it has been observed that the cut particles of polymer waste (which is obtained in the manufacturing process of recycled plastic pipes) possess good potential to be used as an alternative to stone aggregates. Hence it was decided to use these polymer pieces as coarse aggregates in construction of bituminous road pavement. However before directly using them on large scale for road pavement construction, it is essential to check their actual performance in some kind of road work. This object is satisfied in the present study. The cut particles of polymer waste, called Waste Polymer Aggregates (WPA) are used in an experimental work of repairing of pot holes of an existing bituminous road pavement. In the beginning pot holes to be repaired are selected and they are kept clean and dust free. Required weight of WPA is taken and slightly heated (60-65 ^{0}C). Then they are thoroughly mixed with pre decided quantity of molten, hot bitumen (90-110 ^{0}C) to prepare aggregate-bitumen mix. Using small metallic wire brush the hot bitumen is applied on inner surface of each pot hole. The painted pot holes are filled completely using WPA-Bitumen mix. While it is hot, the mix is compacted well using hand rammer, flush with the road surface. All the pot holes were filled and compacted in the same manner. The repaired road was under observation for more than a period of one year. It is found that WPA-Bitumen mix is intact in the pot holes and no considerable damage has occurred to it due to the traffic. Since WPA-Bitumen mix is performing well in the repaired pot holes, WPA can further be used on large scale in construction of bituminous road pavement.***
Key words: waste polymers, coarse aggregates, bituminous road, pot holes, recycled pipe waste.

I. INTRODUCTION

Plastics are being extensively used now-a-days almost in all walks of life due to the advantages availed from their different varieties and amazing properties. Since plastics are comparatively affordable material due to their low cost and suitability at most of the places of its intended use, it is gaining popularity day by day. Due to rapid growth in population and industrialization, use of plastics has constantly increased during past years all over the world, particularly in developing countries like India. In the present era, use of plastics has increased to such an extent that, one can't even think life without using plastics. Such an extreme use of plastics naturally gave rise to generation of high volume of its waste. Studies have shown that thousands of tons of waste plastics are being generated every day across the world. Since plastic is not a green (eco-friendly) material, the question of its proper disposal should be viewed seriously. It is not even easily biodegradable and takes more than thousands of years for its complete natural decomposition.[1]Scientists, environmentalists and researchers have consistently warned people against direct dumping of waste plastics in open ground or into the available water bodies due to its catastrophic effects on the entire ecosystem. Studies have shown that open burning of waste plastics or using the same for area reclamation or land filling is even more dangerous to the environment, since this leads to further increase in soil (land) pollution, water pollution and air pollution through high degree. So the question is what to do with such a tremendous amount of plastic waste which is getting generated every day[3].One of the answers to this question may be to utilize this waste in some appropriate and innovative manner. In the present study plastic waste is obtained from pipe industries in MIDC area Jalgaon, which produce rigid PVC pipes by recycling plastic scrap.

Considerable quantity of plastic waste is being generated at these plants during production process. This waste can neither be recycled further on economic grounds[3] nor could just be disposed of by burning, which will again raise hazardous type of air pollution.

Hence it is essential to find some appropriate way to utilize this plastic waste effectively. In the present work this waste is utilized as coarse aggregates to produce bituminous concrete and then this bituminous concrete is used for repairing pot holes in an existing bituminous road pavement.

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II. SOURCE OF WASTE

There are several polymer industries located in M.I.D.C. area Jalgaon and many of them are producing recycled rigid PVC pipes. Plastic scrap is used as raw material to manufacture these pipes. Such pipes are called as recycled pipes. In filtration stage of manufacturing process of these recycled plastic pipes, the pulverized scrap is melted and injected through filter (steel wire mesh) in hot condition at a temperature of 170-200^{o}C. When the filter mesh gets completely blocked due to impurities and other foreign particles present in the scrap, the injected material further ceases to flow out of filter mesh. The blocked mesh is then replaced by a new one and filtration process is continued. When the blocked mesh and mass of arrested foreign bodies with crude polymer material (adhered to mesh) cools down they are separated out from each other. This separated out mass of waste plastic is locally called as *JaliGulla*. It contains usually stone and metal pieces along with major portion of impure and non-recyclable polymer. In a day considerable amount of such polymer waste is generated and there is a big question of its disposal[2] & [3]. Since non-recyclable polymer waste is of great nuisance to environment, it is taken for study in the present work in a view to make an attempt to find a safe way of its disposal.

III. WASTE POLYMER AGGREGATES (WPA)

In production of recycled pipes, plastic scrap is used as main raw material. In the process of hot filtration of manufacturing of this pipes, a non recyclable mass of waste is generated which contains crude polymer constituent along with foreign bodies like stone and metal pieces. This mass of waste polymer (JaliGulla), is allowed to cool to room temperature. Considerable amount of such waste is getting generated in pipe factories during the filtration process and stacked aside as non recyclable solid waste[2] & [3]. This waste polymeris taken for producing coarse aggregates. To satisfy this requirement, the mass of waste polymer are applied to the hopper of cutting machine to cut it into small pieces of size less than 25mm. Thus, with the help of cutting machine required quantity of cut pieces are obtained from solid mass of waste polymer (JaliGulla). These cut pieces of waste polymer are called as Waste Polymer Aggregates (WPA).



Fig.1 Waste Polymer Aggregates (WPA) derived fromJaliGulla.

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IV. LABORATORY TESTING ON WPA

An attempt has already been made for laboratory assessment of this Waste Polymer Aggregates (WPA). Traditional tests have been mostly adopted as per Indian Standards and Indian Road Congress (IRC) specifications to study the basic properties of WPA. They are tested in laboratory for Percentage Water Absorption, Specific Gravity Determination, Impact, Crushing and Abrasion Value Test, Stripping Test with bitumen and Marshall Stability Test. The test results indicate that, the waste polymer pieces have potential to be used as an alternative material to stone aggregates in construction of bituminous road pavement [7] & [8].This can be clearly understood from the following table.

Table I
Engineering Properties Of Wpa[7]

Sr. No.	Type of property	Specifications	Test Results	Recommendation for natural stone aggregates
1	Particle size	IS 2386 (Part I) 1963	Less than 25mm size.	Recommended size.
2	Specific Gravity	IS 2386 (Part III) 1963	1.5	2.6 to 2.9
3	Water Absorption	IS 2386 (Part III) 1963	1.55%	Should not be more than 2%
4	Impact Value	IS 2386 (Part IV) 1963	1.47%	Should not be more than 30%
5	Crushing Value	IS 2386 (Part IV) 1963	1.7%	Should not be more than 30%
6	L.A. Abrasion Value	IS 2386 (Part IV) 1963	2.24%	Should not be more than 30%
7	Stripping Test	IS 6241-1971	17%	Should not be more than 25%
8	Marshall Stability Value	ASTM D 1559	848 Kg	Should not be less than 340 Kg

V. REPAIRING POT HOLES USING WPA

In the present study, efforts are taken to observe actual performance of WPA (Waste Polymer Aggregates)in an experimental work of repairing of pot holes of an existing bituminous road pavement. For this purpose an existing bituminous road is selected, where the upper layer of the road was damaged at intermittent locations along its stretch. At some places along the road, pot holes were also developed due to stripping out of road material. Among these a few pot holes were decided where repair and maintenance work was required to be done.

In the beginning approximate size (length, width and depth) of every pot hole is measured using ordinary ruler scale. Loose stone particles, soil and dust are removed completely from each pothole, using a small broom and a cleaning brush. Thus the inner part of every pot hole was kept dry, clean and dust free before repairing. To prepare required WPA-Bitumen mix, percentage addition of bitumen was decided from the previously conducted Marshall Stability Test results.

Referring this percentage, estimated weight of bitumen is taken and it was heated to 90-110 ^{0}C. Similarly, required weight of Waste Polymer Aggregates was taken and the aggregates are slightly heated to 60-65^{0}C and added to previously heated bitumen. It is seen that the molten bitumen should get evenly applied on the surfaces of all WPA particles.

Thus, the required type of bituminous concrete was prepared by thorough and careful mixing of WPA with bitumen. After this, molten (hot)bitumen was applied on the inner side and base area ofpot holes using a small steel wire brush. This is done in view to provide good scope for development of strong bond between old and new materials.

Just after finishing bitumen painting, pot holes were completely and carefully filled adopting WPA-Bitumen mix. The poured mix was well compacted flush with the existing road surface using hand rammer. In this way all the pot holes were repaired one by one using WPA-Bitumen mix[4].

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VI. CONCLUSION

The compacted mix exhibits similar kind of surface texture as that of the ordinary bituminous pavement. The repaired road is observed for a period of more than a year under normal traffic condition. It is found that no considerable damage has occurred to the WPA-Bitumen mix in the repaired pot holes. A negligible number of fine particles from the top portion of some pot holes are stripped out and removed away may be due to road traffic or weathering agencies. However maximum portion of WPA-Bitumen mix in the repaired pot holes is stable and intact. The mix in pot holes is still performing well like usual pavement material. This indicates that Waste Polymer Aggregates (WPA) could be used as an alternative material to natural stone aggregates and when added with bitumen in proper manner, they produce usable quality of pavement mix. So WPA could also be used as pavement material as far as construction of bituminous road pavement is concerned.



Fig.2 Typical Pot Hole in Pavement before Repairing.



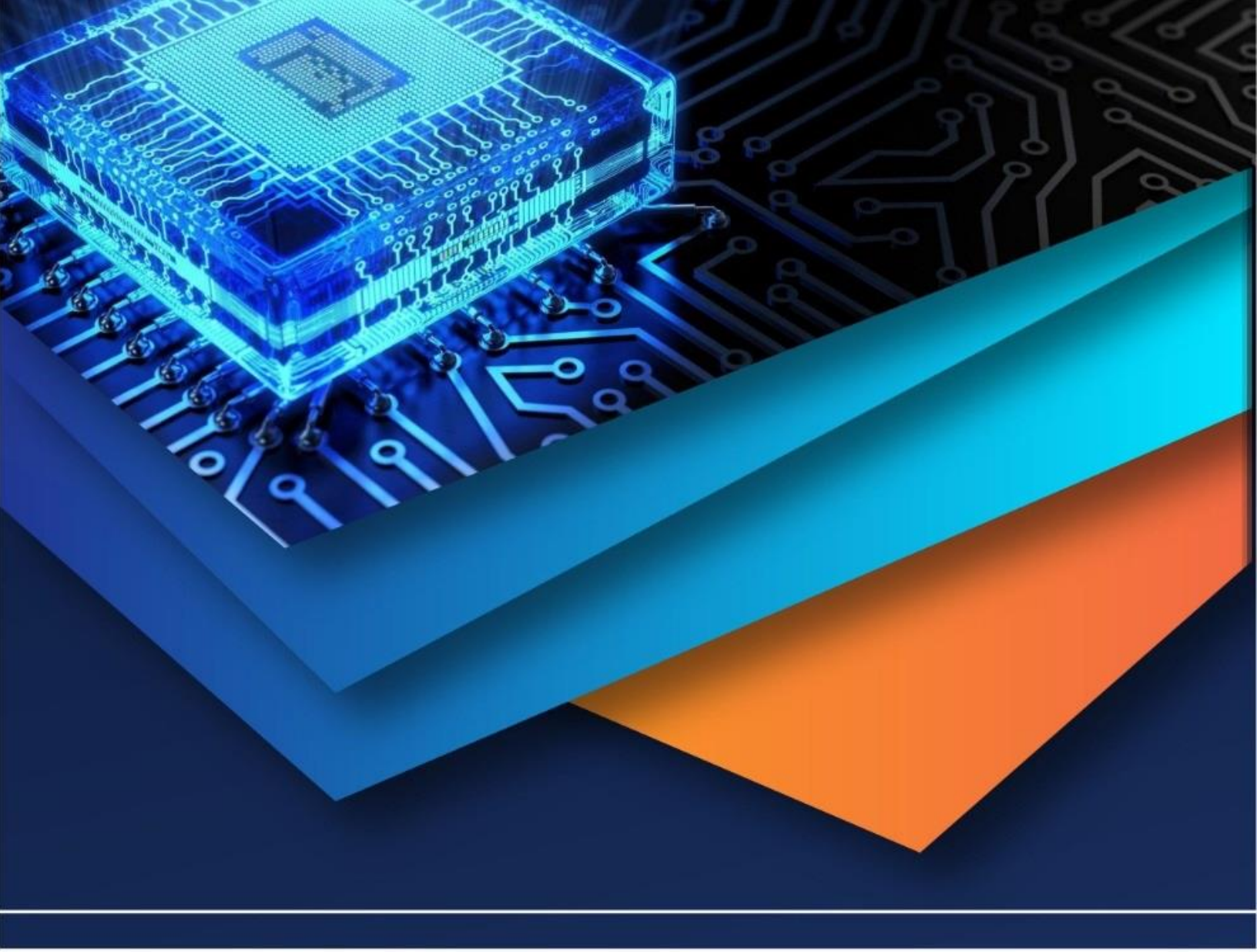
Fig.3 Pot Hole Repaired using WPA-Bitumen Mix.

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