Experimental Investigations on Pipe Industry Polymer Waste to Determine Its Suitability to Be Used as Coarse Aggregate

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Abstract- Considerable amount of polymer waste is generated during filtration stage in manufacturing process of recycled rigid PVC pipes. Locally this waste is called as *Jali Gulla.* It contains few stones, metal particles along with major portion of crude, non-recyclable polymer waste. These non-recyclable polymer particles are great environmental nuisance. The present work has attempted to investigate their feasibility to be used as aggregate in concrete for building works and road works applications. The pipe industry polymer wastes are cut by a cutting machine and particles having size like natural coarse aggregate are obtained. These Waste Polymer Aggregates (WPA) are tested in laboratory for Percentage Water Absorption, Specific Gravity determination, Impact, Crushing and Abrasion Value Test, Stripping Test with bitumen, Marshall Stability Test referring the guidelines given by Indian Standard Specifications and Indian Road Congress (IRC). The test results indicate that the particles have potential to be used in construction of bituminous road pavement. Thus, the outcome of the present work shows a way to solve the problem of disposal of pipe industry polymer waste in an eco-friendly manner. The added advantage is that the natural aggregates are getting scarce day by day. Their over exploitation is not only creating environmental nuisance but is also creating socio-economic and political conflicts. The present work thus attempts to solve two problems with a single stroke.

Keywords - Waste Polymer Aggregate, WPA, Recycled pipe, Jali Gulla.

I. INTRODUCTION

The consumption of plastic has grown substantially all over the world in recent years and this has created huge quantities of plastic based waste. Plastic waste is now a serious environmental threat to the modern way of living. Plastic waste cannot be dumped in landfills because of its bulk volume and slow degradation rate. Reusing plastic waste to produce new materials like aggregate could be one of the best solutions for disposing it due to its economic and ecological advantages. Nearly 90% of all aggregates are produced from natural resources.[1] Therefore utilization of waste materials as a substitute to aggregate in concrete for building works and road works applications will reduce the exploitation of natural resources.

Considering the benefits, efforts are being taken to utilize waste materials as alternative aggregates in preparation of cement concrete that is used for different construction works. Significant research is made on the use of many different materials as aggregate substitute such as coal ash, blast furnace slag, fiber glass waste materials, waste plastics, rubber waste, sintered sludge pellets and others.[2]

In the present work polymer wastes from pipe industry are cut by a cutting machine and particles of size like natural coarse aggregate are obtained. These Waste Polymer Aggregates (WPA) are tested in laboratory for Percentage Water Absorption, Specific Gravity determination, Impact, Crushing and Abrasion Value Test, Stripping Test with bitumen, Marshall Stability Test referring the guidelines given by Indian Standard Specifications and Indian Road Congress (IRC). The test results indicate that the waste polymer particles have potential to be used in construction of bituminous road pavement.

II. SOURCE AND PREPARATION OF WASTE POLYMER AGGREGATE

Many pipe factories use required type of plastic scrap as their raw material to manufacture rigid pipe. Therefore such pipes are called as recycled plastic pipes. In filtration stage of manufacturing process of these recycled plastic pipe, the pulverized plastic scrap is melted and injected through steel wire mesh in hot condition at a temperature 170-200^{o}C. When the filter mesh gets completely blocked because of impurities and other foreign particles present in plastic 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 impure plastic material (adhered to mesh) cools down they are separated out from each other. This separated mass of impure plastic waste is locally called as *Jali Gulla*. It contains usually stone and metal particles along with major portion of impure and non-recyclable polymer waste. In a day considerable amount of such polymer waste is getting generated and there is a big question of its disposal. Since non-recyclable polymer waste is a 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. Particles like natural coarse aggregate are obtained when *Jali Gulla* (mass of waste polymer) are applied to the cutting machine. Thus required quantity of Waste Polymer Aggregates (WPA) are derived through cutting machine available at the manufacturing plant.

Figure 1. *Jali Gulla* Material (Mass of Waste Polymer)

Figure2. Waste Polymer Aggregates (WPA) obtained from Jali Gulla Material

III. TESTING OF WASTE POLYMER AGGREGATE (WPA)

Aggregates obtained from mass of polymer waste are subjected to different tests to determine their engineering properties. The tests on natural aggregates, which are suggested by Indian Road Congress and Indian Standards, also are conducted on WPA to judge their suitability as a substitute to natural aggregate.

A. Particle size and Appearance of WPA -

The size of screening attached from underside of a cutting machine decides the range of particle size, while obtaining WPA from *Jali Gulla*. The particle size may be changed as per requirement by adopting appropriate size of screening. In the present work a major portion of WPA was of particle size ranging between 10mm to 12.5mm. The surface texture of WPA is rough like natural stone aggregate and shape of the particles is irregular.

B. Specific gravity determination -

Indian Standard Specification IS 2386 (Part III) of 1963 gives various procedures to find out the specific gravity. In the present work specific gravity of WPA is determined using Standard Pycnometer bottle.

C. Percentage water absorption -

This is determined following the guidelines given in IS 2386 (Part III) of 1963. Oven drying of WPA at prescribed temperature of 110^{o}C is avoided purposely. Instead Waste Plastic Aggregate are oven dried at a lesser temperature of 65^{o}C for 24 hours and then percentage water absorption is calculated.

D. Determination of aggregate impact value -

To determine toughness of WPA, this test is conducted as per the steps given in IS 2386 (Part IV) 1963.

E. Determination of aggregate crushing value -

This test provides a relative measure of the resistance of an aggregate sample to crushing under gradually applied compressive load. The test is carried out referring the procedure given in IS 2386 (Part IV) 1963.

F. Determination of abrasion value -

Testing of aggregate for its resistance to wear is of importance for aggregates to be used for road construction. WPA are also subjected to this test to determine their performance in wear by Los Angeles abrasion value method, following the guidelines given in IS 2386 (Part IV) 1963.

G. Stripping test (with bitumen of grade 80/100) -

This test is conducted to determine the effect of moisture upon the adhesion of the bituminous film to the surface particles of WPA. This test is of significant value to ascertain the suitability of the two materials for satisfactory biding action. The test is conducted referring the guidelines given in IS 6241-1971.

H. Marshall Stability test -

This test determines the optimum bitumen content corresponding to the maximum load supported by test specimen before failure. The specimen is a compacted mixture of aggregate and bitumen prepared in cylindrical shape in specified manner. This test is conducted following the procedure given by ASTM D 1559. Thus Marshall Stability of a test specimen is the maximum load required to produce failure when the specimen is preheated to a prescribed temperature placed in a special test head and the load is applied at a constant strain of 5 cm per minute.

IV. RESULT AND DISCUSSION

Above tests are conducted taking three different samples of WPA for each test. The average test results obtained are tabulated below. Little changes are required in the test instructions regarding weight and volume of the sample, heating and oven temperature, percentage addition of bitumen, as base material of the sample is polymer.

Table-1 Engineering properties of WPA

Sr. No.	Type of property	Specifications	Test Results	Recommendation for N.A.
1	Particle size	IS 2386 (Part I) 1963	10mm-12.5mm	Recommended size.
2	Specific Gravity	IS 2386 (Part III) 1963	1.5	1.5to2.9
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	Strippig 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

It is observed that the WPA have all the engineering properties within the acceptable range as prescribed by the relevant IS codes. Their size is 10 – 12.5 mm which is acceptable as coarse aggregate. Their specific gravity is 1.5. Generally most of the aggregates being used in construction industry have specific gravity near to 2.6. The lower value of specific gravity indicates that the material is light weight. Hence it will be more workable, easy to be transported, easy to be placed and compacted. The percentage water absorption is well below the permissible value. The impact value, crushing value and abrasion values are very much below the upper limit of acceptance. This shows that the WPA is a very strong material and has ability to be used in road pavements. It will prove durable pavements. Generally the plastic aggregates show poor performance in terms of stripping value. Yet the WPA has shown agreeable performance in terms of aggregate stripping value also. Finally the Marshal Stability test is the single ultimate test which prescribes the suitability of a bitumen mix to be used in road construction. All the test results in the present work are quite encouraging. Hence the suitability of the WPA as road pavement constituent is well justified.

V. CONCLUSION

The pollution concerns associated with waste plastics and reducing availability of the natural aggregate has forced the researchers to look for alternatives. The present work has successfully proved the feasibility of pipe industry polymer waste as road pavement aggregate. The WPA has qualified all the relevant tests prescribed by IS codes. It has opened a new dimension for the road construction industry of Jalgaon district region. The present work is a laboratory scale study. Of course the work needs to be extended to the field scale trials also. The technological feasibility of using WPA for road pavements has been well proved by the present work. The economic analysis is left for the future researchers. Now it is up to the field engineers to carry forward the work for the environmental protection and economic benefit of the road construction industry.

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