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ADDITION OF PLASTIC WASTE TO AGGREGATES AND BITUMEN IN CONSTRUCTION OF RIGID AND FLEXIBLE PAVEMENT

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ABSTRACT

Plastics are always common man's friend. It finds its use in every field and the consumption of plastics increases day by day. Nearly 50% of the plastic consumed is used for packing. The most used plastic materials for packing are carry bags, cups, s and foams. These materials are made from polymers like Polyethylene, polypropylene and polystyrene and HDPE AND LDPE. (The tubes and wires are made out of poly vinyl chloride). These materials, once used are thrown out or littered by us more because of wrong culture. They mix with Municipal Solid Waste. As they are non-biodegradable, the disposal becomes a problem and they cause environmental pollution as they are disposed either by burning or by land filling. Plastics waste is shredded into small pieces (between 4.75mm – 2.36mm).The shredded plastics waste is added to the stone. It get melted and coated over stone in just 30 seconds. Then the bitumen is added and mixed. The mix is used for road construction. Land filling of plastics into properly designed disposal sites takes up valuable room in the site for a non-toxic, non-leachable, non-decomposable material. Whether plastic is a menace or not depends how we use it and how we dispose of it minimizing the impacts on the environment. The collection of waste plastics from the source, segregating the waste and shredding, shredded plastic to make a coating over the aggregates used for road construction providing the road a tremendous strength at no extra cost. Plastic gets coated over stone and the hot plastic coated stone is mixed with bitumen (tar) and the mix is used for road laying.

INTRODUCTION

A highway pavement is a structure consisting of superimposed layers of processed materials above the natural soil sub-grade, whose primary function is to distribute the applied vehicle loads to the sub-grade. The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favorable light reflecting characteristics, and low noise pollution. The ultimate aim is to ensure that the transmitted stresses due to wheel load are sufficiently reduced, so that they will not exceed bearing capacity of the sub- grade. Two types of pavements are generally recognized as serving this purpose, namely flexible pavements and rigid pavements. This gives an overview of pavement types, layers and their functions, cost analysis. In India transportation system mainly is governed by Indian road congress (IRC).

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PAVEMENT DESIGN PROCESS

INTRODUCTION

The objectives of the pavement design process are to guide the district pavement engineer (DPE) to select a pavement type and design the pavement with an approved method using all the information needed to provide a structure that is capable of carrying traffic loads with minimum physical deterioration, maximum safety, and maximum ride comfort. The designer should document the pavement design process in a report format as discussed in Pavement Design Reports.

CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

CRCP provides joint-free design. The formation of transverse cracks at relatively close intervals is a distinctive characteristic of CRCP. These cracks are held tightly by the reinforcement and should be of no concern as long as the cracks are uniformly spaced, do not spall excessively, and a uniform non-erosive base is provided. Figure 3.4 Shows a typical section of CRCP.

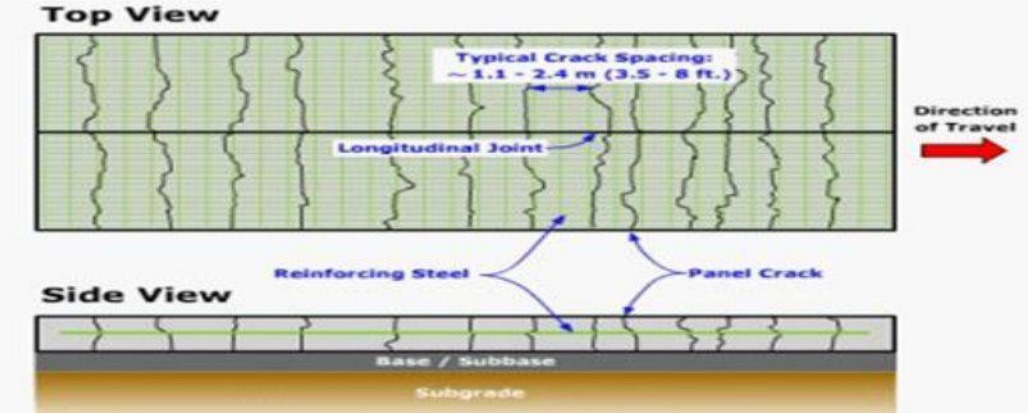

Figure:3.3 Continuously Reinforced Concrete Pavement.

CRCP contains both longitudinal and transverse steel. CRCP does not contain transverse joints except at construction joints.

The function of the longitudinal steel is not to strengthen the concrete slab, but to control concrete volume changes due to temperature and moisture variations and to keep transverse cracks tightly closed. The function of the transverse steel is to keep longitudinal joints and cracks closed. If the steel serves its proper function and keeps cracks from widening, aggregate interlock is preserved and concrete stresses in the concrete slab due to traffic loading are reduced.

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Figure:3.4 Continuously Reinforced Concrete Pavement

JOINTED REINFORCED CONCRETE PAVEMENT (JRCP)

JRCP uses contraction joints and reinforcing steel to control cracking. Transverse joint spacing is longer than that for concrete pavement contraction design (CPCD) and, in Texas, it typically ranges from 30 ft. to 60 ft. This rigid pavement design option is no longer endorsed by the department because of past difficulties in selecting effective rehabilitation strategies. However, there are several remaining sections in service. Figure 2-6 shows a typical section of jointed reinforced concrete pavement.

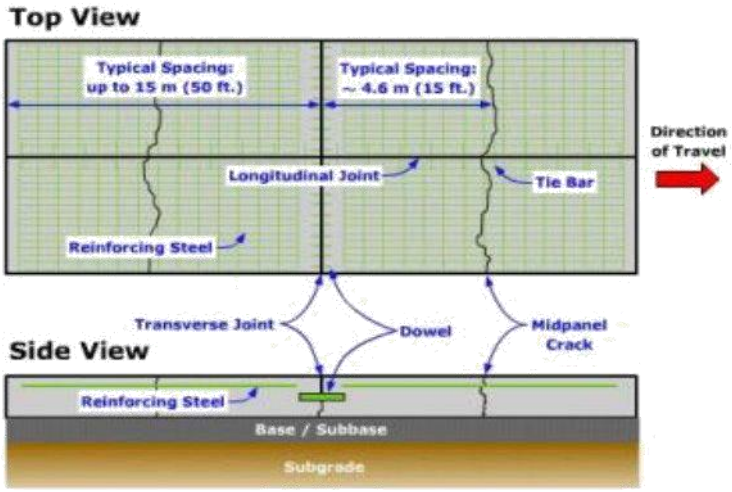

Figure:3.6 Jointed Reinforced Concrete Pavement (JRCP).

POST-TENSIONED CONCRETE PAVEMENTS

Post-tensioned concrete pavements remain in the experimental stage and their design is primarily based on experience and engineering judgment. Post-tensioned concrete has been used more frequently for airport pavements than for highway pavements because the difference in thickness results in greater savings for airport pavements than for highway pavements.

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RIGID AND FLEXIBLE PAVEMENT CHARACTERISTICS

The primary structural difference between a rigid and flexible pavement is the manner in which each type of pavement distributes traffic loads over the sub-grade. A rigid pavement has a very high stiffness and distributes loads over a relatively wide area of sub-grade – a major portion of the structural capacity is contributed by the slab itself.

The load carrying capacity of a true flexible pavement is derived from the load-distributing characteristics of a layered system (Yoder and Witczak, 1975). Figure 2-7 shows load distribution for a typical flexible pavement and a typical rigid pavement.

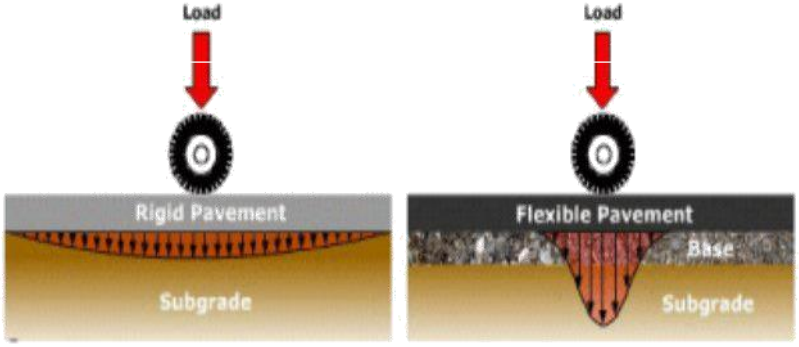


Figure:3.7 Typical stress distribution under a rigid and a flexible pavement.

TESTS ON AGGREGATES

GENERAL

Investigation of plastic waste materials aggregates requires various field test and lab tests .This chapter presents material which is collected from site given below for plastic coated aggregates in detail. The present chapter divided into three main sections. First section presents the physical requirement of aggregates. Second section presents the properties of plastic. Third section presents the preparation plastic waste materials for shredding on aggregates.

MIXING PROCEDURE AT HOT MIX PLANT:

Step I: Plastics waste like bags, bottles made out of PE and PP cut into a size between 2.36 mm and 4.75mm using shredding machine. Care should be taken that PVC waste should be eliminated before it proceeds into next process.

Step II: The aggregate mix is heated to 165^0C and then it is transferred to mixing chamber. Similarly the bitumen is to be heated up to a maximum of 160^0C. This is done so as to obtain a good binding and to prevent weak bonding. During this process monitoring the temperature is very important.

Step III: At the mixing chamber, the shredded plastics powder is added over the hot aggregate. It gets coated uniformly over the aggregate within 30 to 45 seconds. It gives an oily coated look to the aggregate.

Step IV: The plastics waste coated aggregate is mixed with hot bitumen. Then this final resulted mix is used for laying roads. The road laying temperature is between 110^oC 120^OC. The roller used should be of is 8-ton capacity.

MIXING BY MINI HOT MIX PLANT:

Step I: Plastic waste made out of PE, PP and PS cut into a size between 2.36mm and 4.75mm using shredding machine.

Step II: Similarly the bitumen is to be heated to a maximum of 160^0C to have good binding and to prevent weak bonding. (Monitoring the temperature is very important)

Step III: At the mixing chamber the shredded plastic waste is to be added to the hot aggregate. It gets coated uniformly over the aggregate within 30 Sec, giving an oily look Plastic coated aggregate is obtained.

Step IV: Hot bitumen is then added over the plastic coated aggregate and the resulting mix is used for road construction. The road laying temperature is between 110^0C to 120^0C. The roller used is 8-ton capacity.

MIXING BY CENTRAL MIXING PLANT (CMP)

The aggregates are bound together either by bituminous materials or by cement. In a few cases, the rock dust itself when mixed with water forms slurry which acts as a binding medium. The aggregates may be classified into natural and artificial aggregates. The natural aggregates again are classified as coarse aggregates consisting of crushed rock aggregates or gravels and fine aggregates or sand. The blast furnace slag obtained as by-product from blast furnaces is the one extensively used as road construction material. Stone aggregate used for road work should be hard, tough, durable and hydrophobic for bituminous surface. Gravel should be well graded (6.4mm to 38mm) and should have a fineness modulus of not lessthan4.75mm.Sand should be sharp, well graded, clean of all silts, clay and organic matter. The quantity of aggregates used in first coat of surface dressing should be0.15m^3per10m^2area of 12mm nominal size. On the other hand, the quantity of aggregate used in second coat of surface dressing should be 0.15 m^3 per 10 m^2 areas and of 10mm nominal size.

Table 4.1 Physical Requirements of Coarse Aggregates

S1.No	Test	Permissible value
1	Abrasion Test a. Using Los Angeles machine (max) b. Aggregates impact test (max)	 35% 30%
2	Stripping test (max)	25%
3	Water absorption (except in the case of slag) max	1%
4	Soundness test: Loss with sodium sulphate 5 cycles (in case of slag only) max	12%
5	Weight unit or Bulk density (in slag only)	1120 per

Aggregate: Aggregate of 20mm, 10 mm, Stone Dust and Lime as Filler.

PLASTIC WASTE BLENDING MATERIALS

PREPARATION OF BLEND

Polyethylene carry bags are cut into pieces using a shredding machine. They are sieved and the plastic pieces passing through 2.36mmsieve and retaining at 1.18mm sieve gets collected. These plastic pieces are added slowly to the hot bitumen of temperature around 170-180^{0}C. The mixture stirred well using mechanical stirrer for about 20-30 minutes. Polymer-bitumen mixtures of different compositions can be prepared and used for carrying out various tests.

CHARACTERIZATION OF BLEND

At the time of laboratory testing for characterization of bitumen following Test is adopted.

SEPARATION TEST (IRC-SP: 53-1999)

Samples of different composition can be subjected to the separation test. Homogeneity can be obtained approximately up to 1.5% blend. Beyond this composition, the variation of softening point is much higher for the top and bottom layer of the test samples showing that there is a separation of polymer from bitumen on standing.

CHARACTERIZATION OF PLASTIC WASTE-AGGREGATE BLEND FOR FLEXIBLE PAVEMENT

The utility of the plastic waste blended bitumen-aggregate mix for flexible pavement construction is characterized by studying stripping value and Marshall Stability value of the mix for the blends having a maximum of 1.5% plastic waste.

PREPARATION OF PLASTIC-WASTE COATED AGGREGATE

The aggregate are heated to around 160^{0}C; the plastic waste shredded to the size varying between 2.36mm and 1.80mm. This shredded plastic waste is added over hot aggregate with constant mixing to give a uniform distribution. The plastic get softened and coated over the aggregate. The hot plastic waste coated aggregates are mixed with hot bitumen 60/70 or 80/100 grade (160^{0}C).

Figure:4.1 Shredding Machine Blade

For shredding of solid plastic waste of poly-propylene 'scrap grinding machine' is used. In this process, a solid plastic waste cut in small pieces with the help of with two rotating and one fixed blades. This whole process gives output in per hour rate. Following are the Specifications of Scrap Grinder.

TESTS ON AGGREGATES

AGGREGATE IMPACT VALUE

This test is done to determine the aggregate impact value of coarse aggregates as per IS: 2386 (Part IV) – 1963.

The apparatus used for determining aggregate impact value of coarse aggregates is Impact testing machine conforming to IS: 2386 (Part IV)- 1963, ∑ IS Sieves of sizes – 12.5mm, 10mm and 2.36mm, A cylindrical metal measure of 75mm dia. and 50mm depth, A tamping rod of 10mm circular cross section and 230mm length, rounded at one end and Preparation of Sample

Fig:4.2 Aggregate Impact Test Apparatus

AGGREGATE CRUSHING VALUE

The aggregate crushing value gives a relative measure of the resistance of an aggregate crushing under gradually applied compressive load. With aggregate crushing value 30 or higher' the result may be anomalous and in such cases the ten percent fines value should be determined instead.

APPARATUS

A steel cylinder 15 cm diameter with plunger and base plate . A straight metal tamping rod 16mm diameter and 45 to 60cm long rounded at one end. A balance of capacity 3 kg readable and accurate to one gram. IS sieves of sizes 12.5mm, 10mm and 2.36mm A compression testing machine. Cylindrical metal measure of sufficient rigidity to retain its from under rough usage and of 11.5cm diameter and 18cm height. Dial gauge

Fig:4.3 Aggregate Crushing Value Test Apparatus

RESULTS OF TESTS ON AGGREGATES:

Based on the tests conducted on the aggregate and bitumen following are the results obtained. The tables are followed by the standard ranges of the respective tests.

Test	Normal Aggregates	Plastic 1%		Plastic 2%		Plastic 4%		**Plastic 5%**		Plastic 6%		Plastic 8%	
		PP8	PP10	PP8	PP10	PP8	PP10	**PP8**	**PP10**	PP8	PP10	PP8	PP10
MA	1.7	0.5	0.1	0.2	Nil	Nil	Nil	**Nil**	**Nil**	Nil	Nil	Nil	Nil
AIV	5.43	5.25	5.43	5.18	5.05	5.07	4.76	**4.91**	**4.26**	4.79	4.04	4.26	3.93
ACV	19.2	19	13.17	17.2	11.66	14.6	10.8	**13.33**	**9.82**	13.6	9.06	11.9	8.5

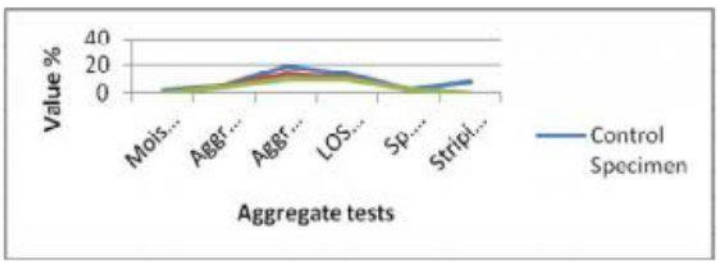
LAV	13.42	13	12.3	12.4	10.99	11.3	10.5	**10.74**	**9.41**	10.3	9.05	9.7	8.9
Specific Gravity	2.45	2.4	2.65	2.5	2.72	2.62	2.8	**2.7**	**2.85**	2.72	2.92	2.79	2.95
Stripping Value	8%	5	2	3	Nil	1	Nil	**Nil**	**Nil**	Nil	Nil	Nil	Nil

Table4.4 Observation Table for Aggregates Test Results

Percentage of Plastic	**MA(%)**	**AIV(%)**	**ACV (%)**	**LAV (%)**	**Specific Gravity**	**Stripping Value (%)**
Control Specimen	1.7	5.43	19.2	13.42	2.45	8%
PP8	Nil	4.91	13.33	10.74	2.7	Nil
PP10	Nil	4.26	9.82	9.41	2.85	Nil

COMPARISON OF TESTS RESULTS

Graph 7: Comparison of Aggregate Test results



The above figure shows the comparison of test results. It is evident from the figure that the use of polymer gives better results as compared to plain bitumen. Also higher percentage of polymer content gives

lower values of impact, crushing, abrasion. The percentage of moisture content and the stripping value is nil in plastic coated aggregates.

BENEFITS OF WASTE PLASTIC ROADS

- Environmental benefits
- MSWM (Municipal Solid Waste Management)
- Employment Generation, Farming Community
- National Economy

CONCLUSIONS AND RECOMMENDATIONS

- Use of plastic waste for modifying bitumen for road construction is an idea which will save environment as well as cost of construction of road.
- The roads can withstand heavy traffic and show better durability.
- The population growth, industrialization and technological development have lead to uncontrollable accumulation of waste and hence it is necessary for environmental engineers to use wastes materials effectively
- The use of innovative technology not only strengthens the road construction but also increased the road life as well as will help to improve environment and will also create source of income and control the noise pollution.
- Coating of recycled material on aggregate is used for its better performance. This helps to have a better binding of bitumen with recycled material waste coated aggregate are increase in bonding and increase in area of contact between polymers and bitumen.

RECOMMENDATIONS:

- Better road without any deformation due to rain and traffic loading. Saving natural resource.
- Use of plastic waste effectively.
- Eco-friendly way for the use of waste plastics.
- Long-term performance of Polymer Bitumen Compatibility(PMB) Recyclability of Polymer Bitumen Compatibility(PMB)
- Enhancing Adhesion from Polymer Modifiers.

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