Parametric Study of using Plastic Waste in Asphalt Mix as a Partial Replacement of Coarse Aggregate in Airfield Pavement – Green Road

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***Abstract*— Around 5.6 million tones of plastic wastes are being generated by domestic and industrial sectors last year in India. Even though plastic wastes are disposed in a safe manner to some extent, most of plastic wastes are unhandled and exposed to atmosphere. This abysmal state and challenges in plastic waste management in urban India is the motivation of our present paper study. The core problem with plastics is, it is user friendly, but not eco-friendly to environment as they are non- biodegradable, that are hazardous to nature. The best way of disposal of waste plastic is changing 3R principle to 5R principle which includes Reduce, Recycle, Reuse, Research and Remodeling. This 5R principle can be achieved by utilizing in airfield pavement construction, this in turn result in the minimization of disposal and pollution problems to a large extent.**

Hence our project tends to conduct experimental investigation to study the effects of using the plastic waste includes PE, PET and PP contained 6, 8 & 10 as percent (by weight) are used as a partial replacement of coarse aggregate and asphalt in the flexible pavements. Since the binding property of plastics in its molten state has produced good result, hence it helps to find out a best method of safe disposal of waste plastics, by using them in airfield pavement. Hence our project has put a step forward towards the development of sustainable airport and green environment.

Keywords - Non-biodegradable, 3R principle & 5R principle, binding property, sustainable, green environment.

I. INTRODUCTION

The main problem with disposal of plastic wastes, it leads to land pollution if openly dumped, water pollution if dumped in low lands and air pollution if burnt. Similarly the plastic wastes generation also keeps on increasing tremendously day by day. At a same time India needs a large network of transportation for its smooth economic and social development. Since the economic development of the nation's benefits directly links with the efficient system of transportation mainly with airways. Under this circumference, an alternate use for the waste plastics is also the needed. The waste plastic can be used effectively as a better binder in the process of construction of airfield pavement. Fundamentally, India is large country where there are many cities with no access to rail and road. So, India is naturally suited for air travel. Hence, this plastic wastes can be effectively and sustainably utilized in flexible pavement of airport. This plastic waste can be used up to 10% in airfield pavement. It will help to improve the strength and slip resistance of the airfield pavement. Airport pavements are compacted layers of material designed to provide a smooth, skid resistant surface. The pavement must support aircraft loads and withstand the abrasive action of traffic and resist adverse effect of weather conditions.

Use of waste plastic in pavement construction is one of emerging advanced technology getting famous now days which not only solve problem of waste plastics but also cost effective and save the environment.

II. NEED OF THE STUDY

- To investigate the optimum usage of waste plastic in pavement structure so as to come up with an ultimate safe disposal together with improvement in the performance of asphalt mix of airfield through better mix design is undertaken.
- This will provide more stable and durable mix for the airfield flexible pavements. The serviceability and resistance to moisture will also be better when compared to the conventional method of construction.
- Utilization of plastic waste improves the binding properties of mix.
- Impact on environment due to disposal of plastic waste is minimized.
- Reduces the cost of construction significantly & Then its future maintenance cost will be saved too.

III. PLASTIC WASTES GENERATION

India generates 5.6 million metric tons of plastic waste annually, with Delhi generating the most of at municipality at 689.5 metric tons every day, according to a report from the Central Pollution Control Board (CPCB).

The following table describes the average municipal solid waste production from 0.21 to 0.50 Kg per capita per day in India.

TABLE I: PLASTIC WASTES CONSUMPTION IN INDIA

Sl no	Description	India
1	Per captia per year consumption of plastic (kg)	12 - 15
2	Recycling (%)	60
3	Plastic in solid waste (%)	9

IV. MATERIALS REQUIREMENTS

A. CLASSIFICATION OF PLASTIC WASTE

- Plastic are typically organic polymer of high molecular mass, but they often contain other substances.
- Due to their relatively low cost, ease of manufacture, versatility, and imperviousness to water, plastics are used in enormous and expanding range of products, from paper clips to spaceships.
- The plastic used was the waste plastic bottles, LDPE/HDPE bags, wrappers, collected from the nearby houses and apartments and from the dump yards.

Plastics can be classified based on their physical properties; they are thermoplastic and thermosetting materials. The category of plastics includes:

i. Thermoplastic (Recyclable): PET, HDPE, LDPE, PP, PVC, PS, etc.

ii. Thermosetting (Non-Recyclable): Laminated Plastics, PUF, Polycarbonate, Nylon etc.

B. ASPHALT

Asphalt is defined as any of various dark - colored, solid, bituminous substance, native in various areas of the earth and composed mainly of hydrocarbon mixtures. It is the by-product of petroleum cracking operation. Asphalt consists of highly condensed aromatic compounds of high molecular weight.

C. COARSE AGGREGATE

Coarse aggregate may be crushed stone, crushed slag or gravel. Fine aggregate are natural sand. Mineral filler may be lime or stone dust. Then the aggregate are transfer into plastic aggregate by coating with plastics improved its quality in the airfield flexible pavement.

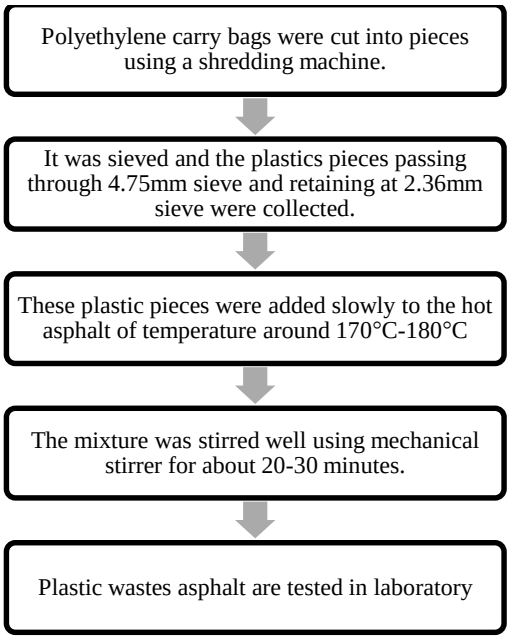
V. RESEARCH METHODOLOGY

Plastics can be utilized in pavement construction by two methods. One is incorporating plastic wastes with aggregate, which is referred as dry process; whereas plastic wastes incorporated with asphalt referred as wet process.

A.WET PROCESS

Mixing of plastic with asphalt to 6-12% by weight improves the binding properties of the mix.

Figure 1: Flow Chart for Wet Process



B. DRY PROCESS

Coating of plastic over aggregate to the tune of 6-10% by weight of asphalt improves the strength of aggregate. The plastic used were the disposed carry bags, films, cups was etc. with a maximum thickness of 60 microns. The aggregate was heated to around 1700C. The plastic waste was shredded to the size varying between 2.36mm and 4.75mm. This shredded plastic-waste was added over hot aggregate with constant mixing to give a uniform distribution. The plastic got softened and coated over the aggregate. Then the plastic aggregate are tested in laboratory

VI. LABORATORY EXPERIMENT AND RESULT ANALYSIS TESTS

The research methodology for present study has adopted various tests to investigate the results on plastic aggregate, asphalt and aggregate-asphalt-plastic mix.

A. LABORATORY TESTS FOR ASPHALT

Grade property: 85/100
Specific gravity @ 25°C = 1.05

TABLE II: EXPERIMENTAL INVESTIGATIONS ON ASPHALT BY ADDITION OF PLASTIC WASTES.

Sl.no	% of plastic wastes added	Penetration	Ductility cm	Softening point (°c)
1	6	92	80	54
2	8	89	76	60
3	10	86	69	64

B.LABORATORY EXPERIMENT OF AGGREGATE

This is the highest type of asphaltic pavement which is composed of an appropriate grade of paving asphalt and completely graded aggregate so that fine material fill the voids in the plastic coarse aggregate material and asphalt fill the voids in the fine material, thus creating a very dense mixture. This type of pavement is mostly used for heavy-duty roads and airfield pavement. The test specimen are prepared and analyzed based on IS Standard recommended for airfield pavement.

TABLE III: EXPERIMENTAL INVESTIGATION RESULT ON PLASTIC AGGREGATE FOR 10% OF PLASTIC WASTES.

Sl no	Test on aggregate	Is method	Test result
1	Specific Gravity	IS: 2386 (Part 3) 1963	2.7
2	Water Absorption Test	IS: 2386 (Part 3) 1963	0.5
3	Aggregate Impact Value Test	IS: 2386 (Part 4) 1963	18.33%
4	Aggregate Crushing Value	IS: 2386 (Part 4) 1963	20.81%
5	Los Angeles Abrasion Value	Is: 2386 (Part 4) 1963	16.09%

VII. MARSHALL STABILITY TEST

The Marshall Stability test is a type of unconfined compressive strength test. This value represents the maximum load sustained by the specimen and Marshall Flow value is the deformation of failure.

The Marshall Stability test is a main parameter in determining the optimum binder content to meets the specified requirement for stability and void content.

A. MARSHALL MIX DESIGN:

Mix designs are made for Aircraft > 12,500 and < 60,000 lbs or tire pressures < 100 psi.

The Marshall Mix design procedure requires three specimens of asphalt mix be prepared at 4 to 6 different binder contents in half percent increments i.e. 4%,4.5%, 5%, 5.5% & 6% respectively. For airport pavements with design aircraft weight equal to or greater than 60,000 pounds, the specimens are compacted by 75 blows on each side.

The maximum load before failure is the Marshall stability (pounds) and the amount of deformation is the flow. The unit weight, percent voids, voids filled, and voids in the mineral aggregate (VMA) for each specimen is also calculated.

Figure 2: preparation of sample

Laboratory result for Marshall Stability

TABLE IV: MARSHALL STABILITY TEST FOR 5% PLASTIC

Sl.No	% binder	Marshall stability value (kN)	Flow value (mm)	Bulk density (gm/cc)	Air voids (Va) %	Volume of asphalt (Vb)	V.M.A (%)	V.F.B (%)
1	4	17.73	3.17	2.003	4.97	8.26	11.5	65.06
2	4.5	18.91	3.89	2.010	4.55	9.11	12.3	68.72
3	5	19.89	4.24	2.014	3.73	9.95	12.63	72.84
4	5.5	19.32	4.63	2.028	2.61	10.56	13.21	75.31
5	6	18.61	5.06	2.019	1.86	10.62	13.65	79.83

Like this we take reading for various % of waste plastic and noted down readings and various graphs related to stability were plotted.

Table V: Marshall Stability test for 5% plastic

% binder	Stability (kN)		
	5% asphalt replaced by plastic waste	*10% asphalt replaced by plastic waste*	*15% asphalt replaced by plastic waste*
4.5	18.91	20.23	18.47
5	19.89	22.40	19.11
5.5	19.32	21.01	18.08
6	18.61	20.18	16.49

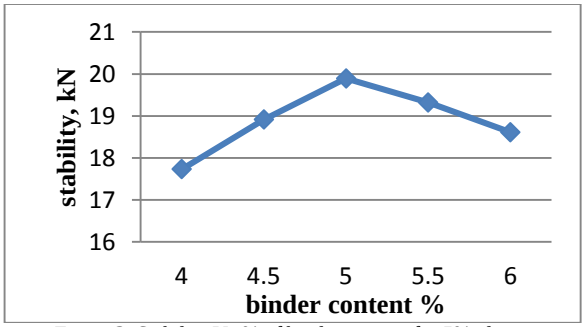


Figure 3: Stability Vs % of binder content for 5% plastic mix

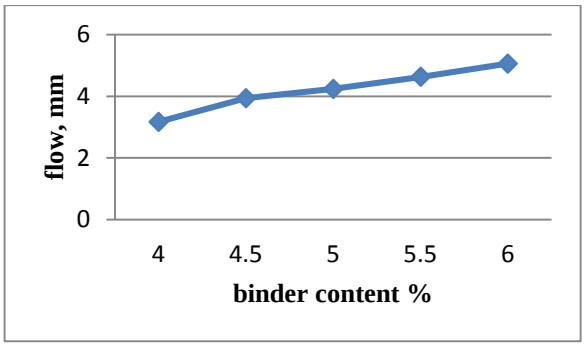


Figure 4: Flow Vs % of binder content for 5% plastic mix

CONCLUSION

- The use of plastic mix asphalt by processed waste plastic of about 10% by weight of asphalt(binder) helps in substantially improving the Marshall stability, strength, fatigue life and other desirable properties of bituminous mix, resulting which improves the longevity and pavement performance with marginal saving in asphalt usage.
- Laboratory performance studies were conducted on bituminous mixes and it studies proved that waste plastic enhances the property of the mix.
- Plastic coating on aggregates has better performance of pavement. This improves a binding of asphalt with plastic wasted coated aggregate due to increased bonding and increased area of contact between polymers and bitumen.
- This has resulted in reducing rutting, raveling and there is no pothole formation. The airfield pavement can withstand heavy traffic and show better durability.
- The operational flexibility of asphalt with plastic wastes contributed to the success of its use as a surfacing material for airfields, with early high impact trafficking possible.
- This asphalt plastic wastes mix contributes to increases the life of airfield pavement up to 5 years.
- It is cost effective and reduces the impact on environment; hence it is eco-friendly.

Use of plastic waste on the airfield has helped to provide better place for burying the plastic waste without causing disposal problem.

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