MANTECH Publications

Journal of Transportation Engineering and Its Applications

Volume 6 Issue 1

Assessment of Strength Using Recycled Aggregates Between Bituminous Concrete and Waste Plastic Bituminous Concrete Using Marshall Stability Test

B.Bhanu Prasad[1], M.Kiran Reddy[2,] D.Prathyusha[3]

Assistant Professor[1], Student[2, 3]

Department of Civil Engineering,

St Martins Engineering College, Dhulapally, Secunderabad.

Corresponding Author's Email id: *- bhanu.highway@gmail.com*

Abstract

The present investigation was carried out to propose using waste plastic and recycled aggregates (RCA) and fly ash in a bituminous mix of flexible pavements. To improve their performance and give way for safe disposal and plastic wastes and construction demolition waste (CDW) to provide a solution to the threat of environmental pollution. The Marshall method of mix design was adopted using 60/70 grade bitumen to find the optimum bitumen content. Marshall specimens were prepared with bitumen content varying from 4% to 6%, increasing weight of aggregate by 0.5% and with waste plastic content of 0%, 6%, 8%, 10%, 12%, 14%, and 16% by weight of optimum bitumen content. This study's main objective investigates the performance of bituminous concrete made with conventional bitumen and waste plastic bitumen using fly ash as a filler material. The comparison was also made by testing the physical properties of recycled aggregates and natural aggregates (NA). It was found that there was a considerable improvement in the properties of aggregates and bituminous mix, leading to provide longer life and better pavement performance. The use of waste plastic and recycled aggregates (RCA) in bituminous concrete mix contributes to the construction of green roads and solves the problem of its safe disposal.

Keywords*: - Marshall stability, Flow value, Natural aggregates, Recycled aggregates, Bitumen, Waste plastic, Fly ash.*

INTRODUCTION

The availability of different waste materials is increasing day by day, and the disposal of these materials is a big problem. These wastes are increasing the concern of environmental pollution since many of these materials are non-biodegradable. Plastic is one of these materials, which is a very versatile material widely used in packaging many industry outputs.

A survey has shown that 500 billion plastic bags are used worldwide every year. Without thinking in a suitable way to utilize these materials in recycling industries, these wastes have occupied landfill areas and become pollution sources. Several studies have been conducted to investigate plastic's use in a bitumen mixture of flexible pavement (Chavan 2013; Gawande et al.2012; Sangia and Verinder 2011; Swami and Jirge 2012). In addition to re-purposing of waste, plastic can significantly reduce the disposal problem of this waste and minimize the problems of pollution, and they can augment pavement performance and reduce the cost of the construction of roads.

As we know that more than 140 million tons per year of construction and demolition waste (CDW) have been produced in current years in US, over 970 million tons per year in Europe and only 30 to 40% are potentially reused in pavements.To achieve the objectives for an effective circular economy, many countries are implementing some instruments, mechanisms and strategies to favour the reuse of materials.

OBJECTIVES

- Preparation of several Marshall specimen and to achieve optimum binder content by using Marshall stability test.

- To evaluate the Marshall stability, Flow value and the volumetric properties Bituminous Concrete(BC) Mix by Marshal method of mix design for both samples.

- To compare the strength value of normal Bituminous mixture and waste plastic bituminous mixture.

MATERIALS AND METHODOLOGY

Bitumen

Bitumen are engineering materials produced by distillation of crude oil during petroleum refining and exist in numerous forms and types. Bitumen are dark tacky liquids or semisolids that are

non-volatile at ambient temperatures and soften gradually when heated.Itis also known as ”Asphalt binder”. Asphalt is a term used for mixture of small stones, sand, filler and bitumen (~5%) which is used for road-paving material. The properties of bitumen are shown in table-1.

Table 1: Test on Ingredient Bitumen

Name of test	**Test result**	**Permissible value**	**IS standard**
Penetration test	63mm	50-70	IS1203:1978
Softening point test	45.5◦C	40 to 55◦C	IS 1205:1978
Ductility test	80.75mm	75mm	IS 1208:1978
Flash point test	179	175	IS 1209-1981
Fire point test	189	175	IS 1209-1981

Waste Plastic

Plastic is the common term for wide range of synthetic or semi synthetic organic amorphous solid materials derived from oil and natural gas.A marvel of polymer chemistry , plastics have become an essential part of our daily life.

Fly ash

Fly ash is finely divided by product resulting from the combustion of coal and power plants. It contains large amount of silica, alumina and small amount of unburned carbon, which pollutes the environment. The specific gravity of fly ash lies between 1.9 to 2.8.

Natural aggregates and recycled aggregates

Aggregates is type of material used in construction of pavements, including sand, gravel, crushed stones etc. The purpose of usage of aggregates are to improve strength, weight and economical. Natural aggregates consists of rock fragments which can be used in their natural state or used after mechanical processing likecrushing , washing and sizing.

In order to obtain good quality concrete using recycled aggregate it is necessary to follow the minimum requirements defined by the respective Building Standards. Recycled composed of original aggregate and adhered mortar. The natural properties of recycled aggregates depend on both adhered mortar quality and the amount of adhered mortar.when structures made of concrete are decimated or renovated, concrete recycling is common method of utilizing the rubble.

Recycled concrete has a number of benefits that have made it a more attractive option in this age of greater environmental awareness and the want to keep construction cost down.

The test on natural aggregate and recycled aggregate are shown in table-2.

Table 2: Test Results of the Ingredient Aggregates

Name of test	**Test results**		**Permissible value**	**IS standard**
	Natural aggregates	**Recycled aggregates**		
Aggregate impact value,%	18.79%	17.26%	Maximum 30%	IS:2386-Part IV:1963
Aggregate crushing value,%	15.85%	16.25%	Maximum 25%	IS:2386-Part IV:1963
Water Absorption,%	0.50%	0.89%	Maximum 2%	IS:2386-Part III:1963
Specific gravity	2.82	2.67	2-3	IS:2386-Part III:1963
Losangeles Abrasion value,%	19.08%	18.98%	Maximum 30%	IS:2386-Part IV:1963

RESULTS & DISCUSSSION

Marshall stability test for normal bitumen mix with fly ash:

In the marshall .method, in order to find the optimum bitumen content (OBC), the marshall sample was prepared by varying the percentage of VG30 binder without any modifier. Stability and flow analysis were performed on marshall core samples with 4.5% to 6% different bitumen content. Results shown in the table.

Table 3: Marshall stability result or normal bitumen mix

Bitumen content %	**Fly ash content**	**Stability (KN)**	**Flow value (mm)**	**Gt**	**Gb**	**Vv**	**Vb**	**Vma**	**Vfb**
4.5%	2%	14.21	4.46	2.5603	2.4536	7.54	9.51	17.05	55.77
5%	2%	14.43	4.67	2.6132	2.4367	6.89	10.65	17.54	60.71
5.5%	2%	15.74	5.44	2.6058	2.4510	5.76	11.78	17.60	67.16
6%	2%	12.26	5.91	2.5886	2.5680	5.19	12.90	18.09	71.31

Determination of optimum bitumen content(OBC): A number of 15samples each 1200 gm in weight were prepared using five different bitumen contents(4-6% with 0.5% incremental) in order to obtain the optimum bitumen content OBC curves were plotted between % of bitumen verses parameters like stability, bulk density, Air voids content and flow value.

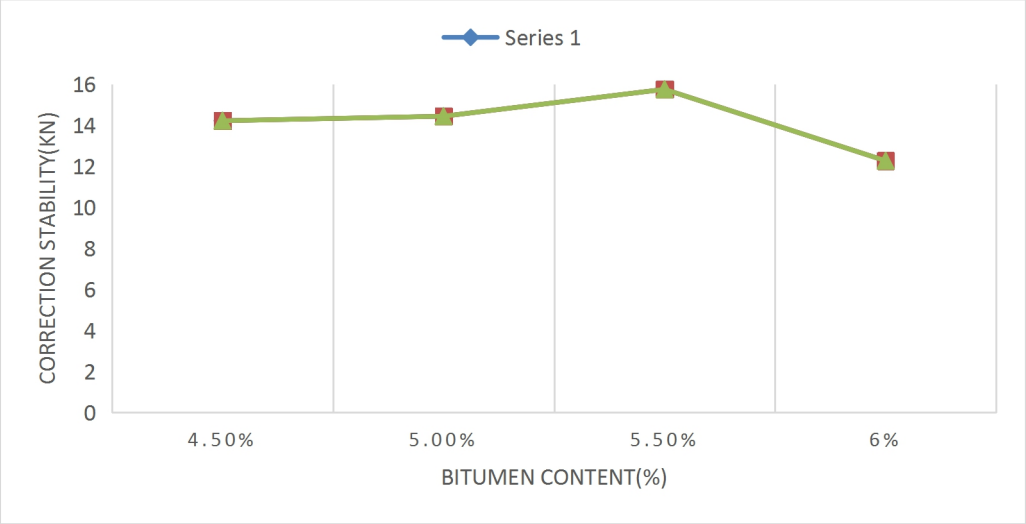


Figure 1:Variations of stability to the bitumen content

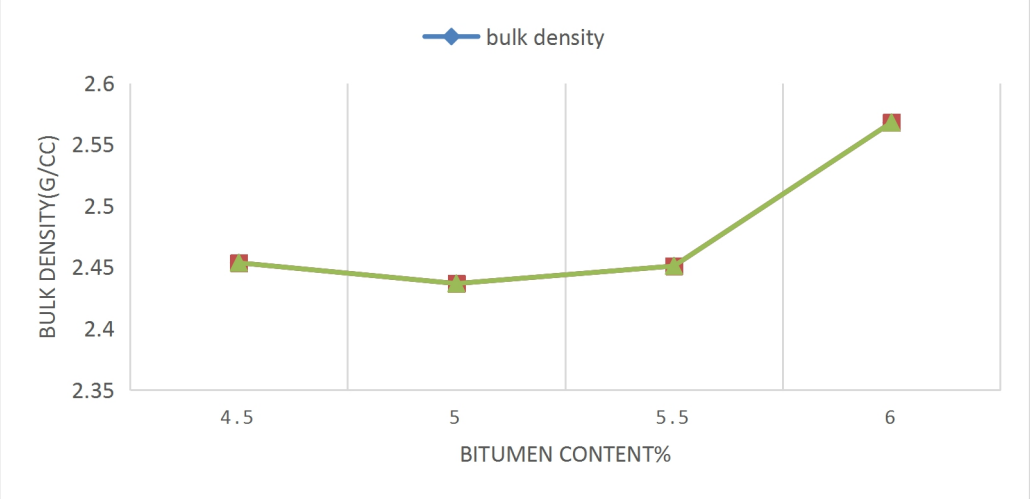


Figure 2: Variations of bulk density to the bitumen content

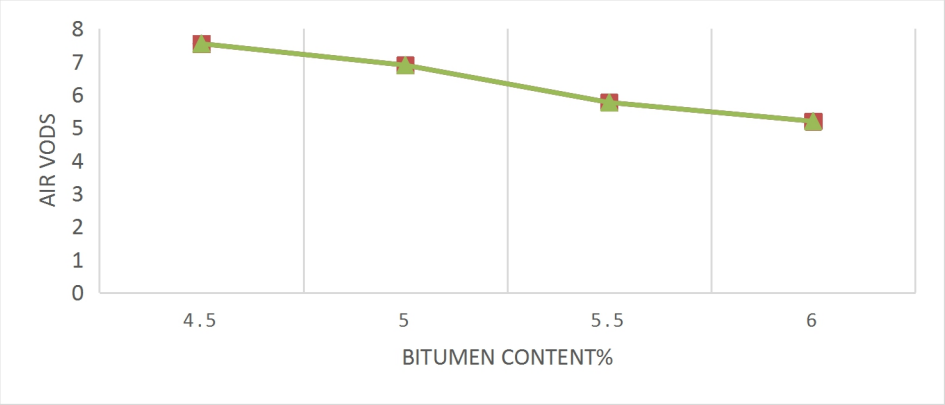


Figure 3: Variations of air voids to the bitumen content

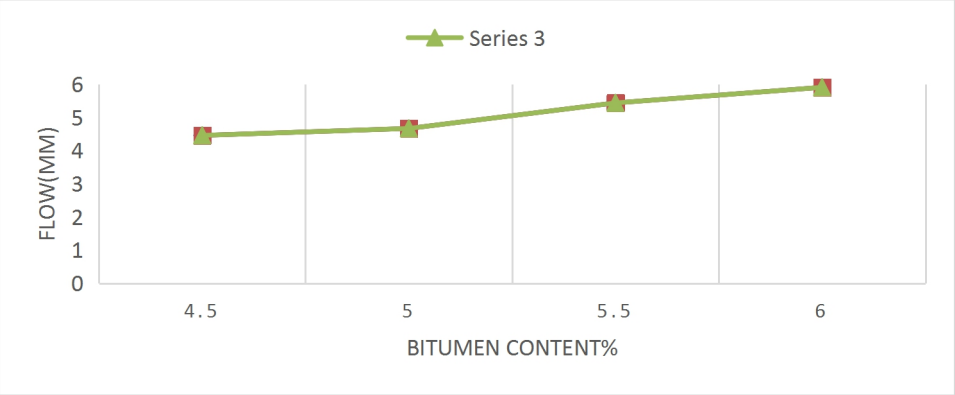


Figure 4:Variations of flow value to the bitumen content

Marshall stability result for bituminous mixture using fly ash and waste plastic

Table 4: properties of bituminous mix using waste plastic additive by weight of optimum bitumen content (OBC)

SNO	Property of bituminous mix evaluated from tests	Waste plastic expressed as % by weight of optimum bitumen content (OBC) i.e., 5.6% & 2% fly ash(filler)						
		0%	6%	8%	10%	12%	14%	16%
1	Marshall stability (KN)	15.34	16.21	18.00	19.00	21.49	19.63	18.72
2	Flow value (mm)	3.82	3.20	3.50	4.0	4.25	4.0	3.50
3	Theoretical max density (Gt) (g/cc)	2.45	2.44	2.43	2.44	2.43	2.41	2.41
4	Bulk density (Gb) (g/cc)	2.36	2.335	2.338	2.354	2.344	2.335	2.324
5	Volume of air voids (Vv%)	3.70	4.48	3.68	3.59	3.54	3.11	3.43
6	Void filled with mineral aggregate (VMA)%	15.56	16.12	16.18	16.22	16.31	16.35	16.39
7	Void filled with bitumen (VFB)%	76.26	76.95	76.99	77.10	77.53	78.32	76.12

Determination of optimum plastic content (by weight of OBC):

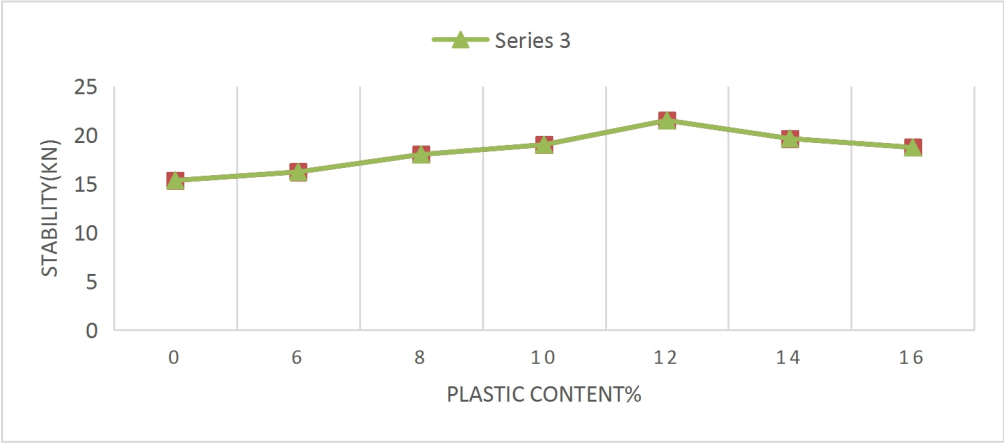


Figure 5: Variations of plastic content to the stability

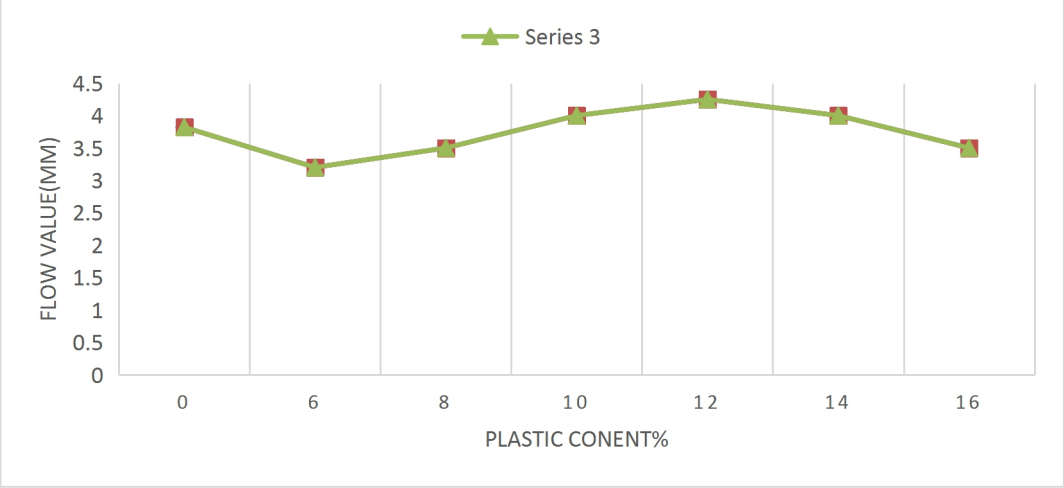
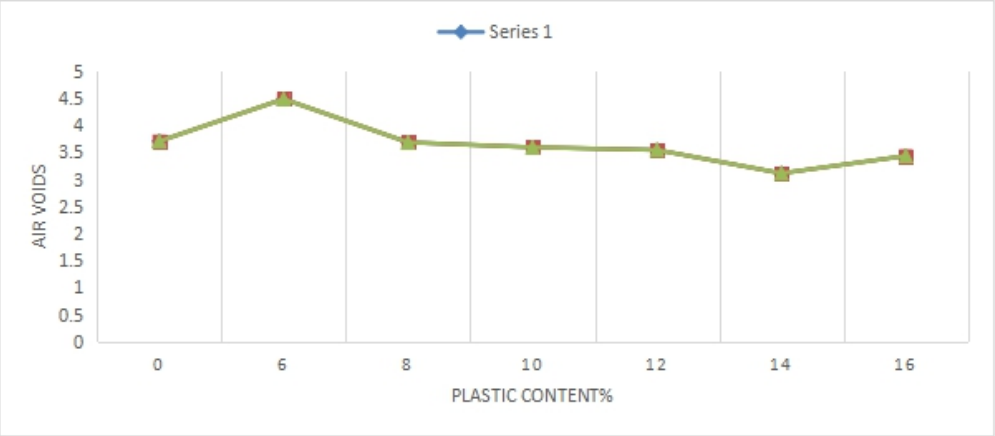


Figure 6: Variations pf plastic content to the flow value



.

Figure7: Variations Of Plastic Content To The Flow Value

- Plastic content at maximum stability value = 12%
- Plastic content at maximum value of bulk density = 10%
- Plastic content value at VA % air voids within allowed range = 7.2

Optimum plastic content (OPC) = 12+10+7.2/3=9.73%

TABLE 5: Comparison of waste plastic modified asphalt mix and conventional mix

Properties	**Conventional mix**	**(9.73%) OPC modified asphalt mix(by weight of OBC)**	**Limit as per IRC:SP:98-2013**
Optimum bitumen content	5.43	5.43	5.2 minimum
Marshall stability	15.34	18.89	12 minimum
Flow value	3.82	3.90	2-4
Voids filled with aggregate(VMA)%	15.56	16.1	16
Voids filled with bitumen(VFB)%	76.26	77.50	65-75
Air Voids(Va)%	3.7	3.6	3-5
Bulk density(g/cc)	2.36	2.34	-

CONCLUSIONS

The experimental results showed that waste plastic can be conductively used as a modifier for bituminous concrete mix.

1. polymer content in the mix will reduce the voids. This prevents the moisture absorption and oxidation by entrapped air.
2. By using construction demolitions as recycled aggregates cost can be reduced by 10% in natural aggregates for surface course.
3. It is observed that optimum bitumen content 5.5% and 2% fly ash & 50% Recycled aggregates the stability value increases from 14.43 to 15.74 KN in normal Bituminous concrete
4. But optimum bitumen content with 9.73% waste plastic and 2% fly ash & 50% Recycled aggregates the stability value increases from 15.74 to 18.89KN
5. Bituminous concrete mix modified with waste plastic showed higher stability value and flow value as compared to nor mal bitumen mix.
6. The properties displayed by plastic coated bitumen are beneficial without

incurring much cost leading for effective, economic, and efficient laying of roads

7. The cost of construction of the road is less when we use waste plastic and recycled aggregates and fly ash.
8. In this way plastic and recycled aggregates can be re-used.

REFERENCES

I. AI-HadidyA.I., Yi-qiuTan (2009), "Effect of polyethylene on life of flexible pavements", Construction and Building Materials, Vol. 23.

II. Annete R. Hill, Andrew R. Dawson, Michael Mundy (2001). "Utilisation of aggregate materials in road construction and back fill", Resources, Conservation and Recycling, Vol. 32, School of Civil Engineering, University of Nottingham, Australia, pp 305-320.

III. Aravind K, Das Animesh, (2007), "Pavement design with central plant hot-mix recycled asphalt mixes", Construction and Building Materials, Vol.21, Dep. Of Civil Engg., Indian Institute of Technology Kanpur, India, pp 928-936.

IV. Bandopandhyay T.K., (2010), "Construction of Asphalt Road with Plastic Waste", Indian Center for plastic in Environment (ICPE), ENVIS-Eco-Echoes, Vol. 11, Issue 1.

V. Dhodapkar A N., (2008), "Use of Plastic Waste in road construction", Indian Highways, Technology paper, Journal, P No.31-32.

VI. Himshog Lu Shinan Agar Emine "Use of waste high density polyethylene as bitumen modifier in asphalt mix", Materials Letters, Vol. 58, pp 267-271.