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# Sustainability and limitation of Plastic Modified Bituminous Interlocked Paving Block: A Supervision

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***Abstract*: Without the use of a binder, Interlocking paving blocks locked each other and built a stable pavement structure which suitable for sidewalk, footpath and non-traffic area etc. that reduces the construction time and cost both. A huge amount of natural and industrial materials such as cement, bitumen, aggregate and other additives are employed in pavement construction and maintenance at the same time on the other hand plastic waste generation increases day by day which becomes an eyesore. It has been suggested by the researchers that plastic can sustain 4500 years without its degradation. 6 billion tones of plastic has been produced from 1950 to 2018 out which 12% and 9% have been incinerated and recycled but 79% left as untreated. This paper provides an guidance that waste plastic improves the rheological property of binder as well as the physical-mechanical property of interlocking pavement block if it combine with Bitumen. Through this investigation, an attempt also made to identify and suggest a possible use of plastic in the paving block so that dumping and land filling problem of waste plastic can reduce.***

***Keywords* : Bitumen , Paving Block, Plastic Waste, Compressive strength.**

## I. INTRODUCTION

The most useful substance of daily life is plastic but it becomes hazardous after usage. Nowadays it becomes a unique engineering material because it can easily mix with any material and more ductile. Thus it needed to utilise the plastic in construction work otherwise it's not too far when we face the big challenge of plastic dispose of. It has been suggested by the researcher that plastic can sustain 4500 years without its degradation.[5]. The most common plastic waste management through landfill and burning which produce pollution by discharging CO2, CO, nitrogen oxide and greenhouse gasses. Landfilling of waste plastic is not likeable because it is the non-biodegradable substance [1]. The maximum amount of waste plastic generated at tourist trekking places. The utilisation of waste plastic in construction is an alternative way to save our natural resources that can never be replenished.

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Thus Cost efficiency dumping problem of plastic and greenhouse gases emission can be solved by Plastic modified sand. By the research of U.S. Department of energy, In each year 60million barrels of oil and another type of insulation would be safe by exploiting of plastic foam insulation in buildings [8]. 6 billion tonnes of plastic has been produced from 1950 to 2018 out which 12% and 9% have been incinerated and recycled but 79% left as untreated [3]. Waste generation rates estimated in the year 2015 around 1.3 billion tons/year would be increased by 2.2billion tons/year in upcoming 15 years with projected generation rate about 1.2to 1.42kg/person/day hence Plastic paving block of improved Marshall Stability and reduction in construction cost, is an effective way to recycled waste plastic [1] Penetration and ductility value was reduced but elastic recovery, flash and fire point, softening value increases as the plastic content in bitumen improved. Rheological properties and Marshall stability value was increased up to the certain limit of waste plastic (7.5%) in bitumen which enhanced durability and load-bearing capacity of the road [2]. Low-Density Polyethylene modified binder (LDPE-MB) shows significant improvement in elastic behaviour due to low value of phase angle (δ) also rutting and cracking resistance were optimum (4%LDPE) while crumb rubber modified binder (CR-MB) gives the excellent result of elastic behaviour due to maximum complex modulus values and minimum phase angle with 10% CR at 70°C[9]. 8.21% red mud (RM) and 5.77% lime dust (LD) as filler in bitumen were showed higher Marshall stability value and superior stiffness and cracking resistance than Ordinary Portland cement (OPC). Rice straw ash(RSA), Carbide lime(CL), RM and brick dust(BD) as filler were consumed a large amount of bitumen because of high air void 4.86%,4.89%, 4.15% and 4.08% respectively while Lime dust (LD), glass powder(GP) and copper tailings (CT) were consumed low bitumen due to lower air void 3.48%, 3.55% and 3.94%[6]. Bitumen (B) mix modified by rubber (R) and plastic(P) (84%B + 6%P + 10%R) gives higher value Marshall stability with flow value 3.9mm. Research showed that strength and durability of Bitumen the concrete mix can be improved by rubber tyre and plastic [7]. Rutting resistance of modified waste packing tape (WPT) asphalt mixture was improved by the addition of FT-wax (influenced the roughness of pavement) [4]. The study explained as a percentage of plastic increase in paving block as the replacement of cement, increase its compressive strength but water absorption reduces and also it becomes cost-effective. The researcher suggested these paving block can be used non-traffic area [3].

Plastic sand brick is an alternative building material which can be used as a partition wall and sand plastic bench for park. Plastic has zero water absorption, no efflorescence, good soundness property [8]. Compressive strength of plastic brick (5.12N/mm$^2$) were found lesser than 2nd class burn clay brick (7N/mm$^2$) while greater than flay ash brick (4.19N/mm$^2$)[8]. Study clearly explain as an increment in plastic content by replacement of cement in the concrete paving block increases the compressive strength[3].to the journal, rectification is not possible.

## II. LITERATURE SURVEY

Samuel Kofi Tulashie and Enoch Kofi Boadu[1] 2020 The prominent reason for this examination is to modify waste plastic into pavement block with the help of pit sand and sea sand. Total 20 cubes were formed of dimension 50mm x 50mm x 50mm by Shredded plastic flakes of size 2.36 to 4.75mm with pit sand or sea sand by melting at varying proportions. PPPB (36.96N/mm$^2$) has higher compressive strength than PSPB (27.81 N/mm$^2$) after 28 days at 2500KN with loading rate 24KN/sec but water absorption of PPPB (3.98%) is less than PSPB (4.60%) at 20% waste plastic content. This study has also explored by performing exclusive testing which is tensile strength, Fourier transform infrared spectroscopy (FTIS), Scanning electron microscopy (SEM), depth of penetration test. Sudheer Ponnada and Vamsi Krishna K[2]2020 The approach of this perusal was concentrated on exploiting of plastic to enhance the rheological characteristics of bitumen. In this approach, bitumen (grade VG30) and the shredded waste plastic water bottle was mixed at 180 ℃ to form plastic modified bitumen(PMB) in order to characterise the properties such as softening point, elastic recovery, penetration value, ductility value, specific gravity, flash and fire point and also Marshall stability test conducted to stabilised the optimum percentage of plastic, i.e.,7.5%.the final conclusion of this approach was (1) a high percentage of plastic in bitumen reduces penetration value and ductility also but improves the elastic recovery, flash fire point (2) Marshall stability value increased by 6.53% but flow value reduces by 11.67% at 2.5% replacement of bitumen with plastic (PET). (3) Marshall stability value increased by 14.30% but flow value reduced by 18.32% at 5% replacement of bitumen with plastic. (4) Marshall stability value increased by 19.40% but flow value reduced by 26.5% at 7.5% replacement of bitumen with plastic S.Agyeman and N.K. Obeng-Ahenkora[3]2019 This present work seeks to explore the perspective of waste plastic as ligation material in concrete paving block. Three class of paving block (8 specimens for each) were prepared i.e., (a) concrete paving block (1:1:2) having cement, quarry dust and sand (b) less plastic(LP) composite paving block (1:1:2) and (c) high plastic(HP) composite paving block (1:0.5:1) of dimension 200 mm*100 mm*100mm. After 21 days of curing compressive strength of LP and HP, paving block have 7.31N/mm$^2$ with water absorption 2.7% and 8.53N/mm$^2$ at water absorption 0.5% respectively higher than a concrete paving block (6.07N/mm$^2$ with water absorption 4.9%).

Huayang Yu and Zihan Zhu[4]2019 The point of this study to discover the probability of application of waste packing tape (WPT) also enhanced engineering properties of asphalt mixture. There were two-phase of modification effect of WPT on the binder (1) effect produce due to WPT (2) effect produce by a particle of insoluble fibre. A hot and warm mixture of WPT in the presence of asphalt (6%of raw bitumen by weight) raw and SBS binder prepared with FTwax were named as HWPT, WWPT HSBS and WSBS which were compared with each other. The researcher introduced result in terms of moisture resistance, fatigue failure and rutting. outcomes of this study were WPT modified asphalt mixture shows quite similar properties to SBS modified asphalt mixture. Arvind Singhal and Dr. Omprakash Netula[5] 2018 This experimental study aims to assess the mechanical and physical characteristics of the plastic sand brick. In this study work, the mixture of waste plastic used in small crushed fine size particles with stone dust (particle size less than 4.75mm) is heated in the ratio of 3:7. The brick moulded-in 19cm X 9cm X 9cm size has water absorption 0%, compressive strength 5.6N/mm$^2$ at 96KN compressive load, and weight 2.5Kg of moulded brick. Plastic sand brick has a higher compressive strength in comparison of fly ash brick 3.83N/mm$^2$ and 3$^{rd}$ class clay brick 3.5N/mm$^2$ . Jayvant Choudhary and Brind Kumar[6]2018 The intention of this venture to calibrate the impact of seven different waste material (glass powder, limestone dust, red mud, rice straw ash, brick dust, carbide lime and copper tailings) in replacement of Ordinary Portland cement (OPC) as conventional filler in dense-graded bitumen macadam mix (DBM). Optimum bitumen content (OBC) of Viscosity Grade 30 (VG30) were found 4.60% for DBM mix with 2% of conventional filler OPC. Three samples per waste material (24 samples) were prepared as the replacement of OPC at OBC. This investigation shows a mix constituted with (1) porous filler (red mud, rice straw ash, carbide lime) shows improved air void and VMA and with finer filler (red mud, limestone dust) shows higher stiffness and cracking resistance, as compared to convention mix (2) limestone dust and carbide lime produces a good bond with bitumen.

Shubham Bansal and Anil Kumar Misra[7] 2017 This investigation enlighten us the conclusions of a test done on bituminous concrete that attempts to utilize the waste plastic and rubber as partly replaced the bitumen to modify the binder There are three series binder mixture having a different proportion of plastic (4%, 6%, 8% and 10%) and rubber (5%, 10% and 15%) at temperature 200℃ and 220℃ i.e., binder A and B signify a mixture of Bitumen (B) + Plastic(P) and Bitumen (B)+ Rubber (R) respectively while binder C is prepared by Plastic and rubber both use in bitumen. Value of Marshall stability for non-modify bituminous concrete (6% by wt of aggregate), is 9.06 KN significant lesser than stability value for 84%B+6%P + 10%R (BM9) of series C, 90%B + 10%R (BM6) of series B and 92%B + 8%P (BM3) of series and as well as 16% strength increases by plastic and 50% increases by rubber. The investigation also analysis the effect of plastic and rubber waste on Stability-Flow & Volumetric the Characteristics Bitumen Concrete of Bituminous concrete. Dinesh.S and Dinesh. A[8] 2016 In this research work, the explorer has focused on pollution control by waste plastic and estimating the properties of waste plastic sand brick and paving block manufactured by a combination of a plastic bag, polyethylene and river sand.

Characteristics of the paving block compared with an ordinary paving block while waste plastic sand brick compared with fly ash and burnt clay brick. Red oxide gives required colour for a paving block ( less than 10% by total weight) .1:2, 1:3, 1:4, 1:5, 1:6 ratio of plastic and river sand used to build five paving block and plastic sand brick for each ratio.

**TABLE 1. Comparison between various mix design proportion of compressive strength**

| Mix designation | Plastic sand ratio | Compressive strength ($N/mm^2$) |
|---|---|---|
| M1 | 1:2 | 4.65 |
| M2 | 1:3 | 4.78 |
| M3 | 1:4 | 5.12 |
| M4 | 1:5 | 4.92 |
| M5 | 1:6 | 3.17 |

**TABLE 2.Comparison of compressive strength and water absorption of Plastic sand brick**

| Si.No | Type of Brick | Water absorption | Compressive strength ($N/mm^2$) |
|---|---|---|---|
| 1 | Fly ash | 8.012 | 4.19 |
| 2 | Burnt clay | 9.086 | 3.15 |
| 3 | Plastic brick | 1.10 | 5.12 |

**TABLE 3. Comparison of compressive strength of Plastic paving block**

| SI.NO | Type of paver block | Water absorption | Compressive strength($N/mm^2$) |
|---|---|---|---|
| 1 | Plastic sand | 1.082 | 8.19 |
| 2 | Ordinary | 3.709 | 7.17 |

The researcher here exhibits the results that production cost could be reduced by replacing river sand with other waste products Imran M. Khan and Shahid Kabir[9] 2016 The centre point of this paper is to settle the environmental problems in Saudi Arabia by recycling plastic waste with crumb-rubber(CR) in addition to base bitumen (PG 64-10). A modified binder has formed with the help of low density and high-density polyethylene (LDPE) and CR which shows prominent reclamation in rheological elastic characteristics of binder. 2,4,8 and 10% by the weight of bitumen, plastic waste, and crumb rubber mixture were added with bitumen for 2 hours at 165°C.The investigator here exhibits a result in terms of complex modulus (G), phase angle ($\delta$).

## III. CONCLUSIONS

As the several perusals performed by the researcher over the utilization of waste plastic and other waste material as an alternative in pavement construction in order to replace the natural resources by waste material, many after effect were concluded related to improved rheological properties, Marshall Stability, compressive strength and water absorption value etc. As the well-planned exercise will role as a breakdown in globally spread waste disposal problem related to waste plastic also saved construction cost and plastic will not produce a hazardous long-term effect on the environment. The research exhibits result such as the waste plastic used with other material like river sand, pit sand or cement, compressive strength and water absorption resistance were improved[1,3,5,8,9]. It was also observed as waste plastic is used for replacement in conventional binder rheological properties were improved up to certain limit [2,4,6]. Use of plastic in bitumen increase the Marshall stability value but flow value reduces [2,7]. High air void filler material consumed high bitumen [6].

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