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DESIGN AND CONSTRUCTION OF BITUMINOUS PAVEMENT USING GLASS WASTE

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Abstract: The use of waste materials in road construction can reduce the difficulties in disposal of such wastes. This paper aims to study the performance of pavement asphalt in which a fractional aggregate is replaced with crushed glass. In this paper, some considerable properties of asphalt mix i.e. stability, flow, specific gravity and air voids are investigated. One sample is prepared without adding glass for different percentages of bitumen. On other hand samples are prepared by adding crushed glass to the mix with 5%, 10%, and 15% by aggregate weight. The results are then analyzed. Thus crushed glass can be used in asphalt pavement with optimum replacement ratio of 10% by weight of total aggregates. Hence, the results show that the properties of glass-asphalt mixture are improved in comparison with normal asphalt pavement. It is concluded that the use of waste glass in asphalt pavement is desirable.

Keywords: Bitumen, Pavement, Waste Glass, Aggregate, Cullet, Recycling, Environment, Utilization.



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INTRODUCTION

Introduction to bituminous pavement:

Bitumen is a black or dark-colored (solid, semi-solid, viscous), amorphous, cementitious material that can be found in different forms, such as rock asphalt, natural bitumen, tar and bitumen derived from oil, which is referred to as petroleum bitumen. Currently most of the roads globally are paved with bitumen. Bitumen (specifically, asphalt concrete), sometimes called flexible pavement due to the nature in which it distributes loads, has been widely used since the 1920s. The viscous nature of the bitumen binder allows asphalt concrete to sustain significant plastic deformation, although fatigue from repeated loading over time is the most common failure mechanism. Most asphalt surfaces are laid on a gravel base, which is generally at least as thick as the asphalt layer although some 'full depth' asphalt surfaces are laid directly on the native subgrade.

Base course layer in a bituminous pavement consists of mineral aggregates such as gravel, stones and sands bonded together with bituminous materials. This layer is used as the foundation on which surface course or binder is placed.^[1]

The layers of basic bituminous (flexible) pavement are as followed:

- **Subgrade:** Subgrades are commonly compacted before the construction of a road pavement. It is the level at which excavation ceases and construction commences.
- **Sub base:** It is the layer of aggregate material laid on the subgrade, on which the base course layer is located.
- **Base course:** The base course is the layer composed of crushed stone, crushed slag etc.
- **Surface course:** The layer above the base course where bitumen is laid.
- **Surface dressing:** Thin film of bituminous binder above surface course.

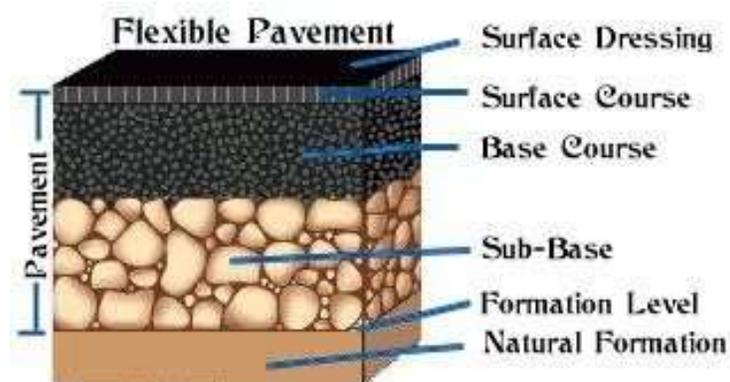


Fig (a) Flexible (Bituminous) pavement Layers (Source: Google images)

➤ **Glass waste:**

Glass was discovered 5,000 years ago. Glass is made from liquid **sand**. It is a non-metallic and inorganic material. Glass can be recycled without changing its properties. Glass industry has been part of human history for thousands of years. Glass is widely used in our daily life, and with the continuously increased consumption, a large amount of waste glass is generated annually (69 pounds per person per year. 134.2 glass bottles per person per year). In 2017, 7.70 million tonnes of solid waste was generated. [2]

The best way to deal with these wastes is to recycle and reuse them as raw materials or modifiers. Glass can be made by heating ordinary **sand** (which is mostly made of **silicon dioxide**) until it melts and turns into a liquid at extremely high temperature of 1700°C and also it takes so long... 1 million years to break down naturally. When waste glass is crushed to sand like particle sizes, similar to those of natural sand, it exhibits properties of an aggregate material.

As we can see the amount of waste glass is tremendous and some glass type i.e. hazardous glass, etc. are difficult to recycle or reuse. So we should find the way to perform out the use of waste glass.

MATERIALS & TEST RESULTS

Aggregates, VG-30 bitumen, glass waste

a) Aggregates were collected from a local place at Gandhinagar. Aggregates inclusive of coarse aggregates of 20 mm (Aggregate 1) and 10 mm (Aggregate 2) and quarry dust were used. The physical properties such as the Aggregate Impact Value, Aggregate Crushing value, Flakiness Index, Elongation Index and Specific Gravity were determined and are given in Table 1. The aggregates used in this investigation for BC mixes satisfied all the physical requirements specified

Table 1: Test Results of Aggregate

PROPERTY/TEST	RESULT
Aggregate impact value	14.866 %
Aggregate crushing value	13.54%
Elongation index	16.45%
Flakiness index	10.2%

b) Bitumen

Tests were conducted on VG-30 bitumen and the results are tabulated in Table 2.

Table 2: Test Results of Bitumen

PROPERTY / TESTS	RESULTS
Softening Point (°C)	44
Ductility (cm)	47
Penetration (mm)	63
Specific Gravity	01

b) Glass Waste (powder)

Fine glass powder was used as filler material and this glass waste was collected from local shops as used glass bottles, glass jars, etc. at various places. Nine samples of crushed glass are prepared with 5%, 10%, and 15% by the weight of total aggregates to be (60, 120, and 180 gm) respectively. These weights were replaced from the fine aggregates as shown in table 3.

Table 3: Fine Aggregate weights at different Glass/Bitumen %

Glass%	0%	5%	10%	15%	Bitumen%
Weight(gm)	340	280.0	220.0	160	4.5%
Weight(gm)	342	282.0	222.0	162	5%
Weight(gm)	338.2	278.2	218.0	158.2	5.5%

After that, the mixture of aggregate and glass is heated to a temperature of 135°C before mixing with asphalt bitumen. The mixture was then compacted at temperature of 160 ± 5 °C. All samples were subjected to 75 blows of compaction by Marshall Hammer on each side of specimen at temperature of 145°C.

DISCUSSION

➤ **Comparison of Marshall and Volumetric Properties of Bitumen Mixes with Different % of glass waste content**

The samples were prepared with glass powder at different dosages of 4%, 8% and 10% by weight of aggregates. The volumetric and Marshall properties of these samples were determined and compared. The comparisons are shown in **chart I, chart II and chart III**.

Bitumen mixes with glass powder gave relatively higher stability values compared to normal mix. Glass modified Bitumen mixes have relatively higher stability values than normal Bitumen mixes. Also glass modified Bitumen mixes has slightly lower flow values compared to normal mixes. Hence glass powder can be used as an alternative for aggregate or conventional fillers too.

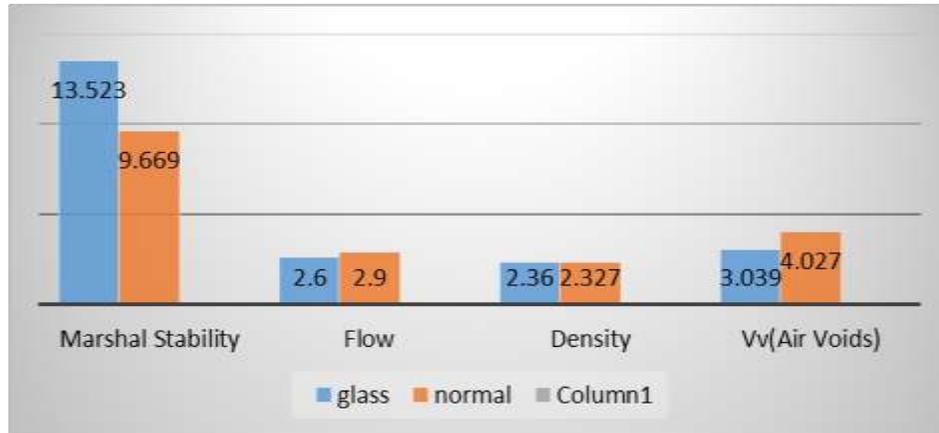


Chart -I: Comparison of Marshall and Volumetric Properties - 4% Glass Material

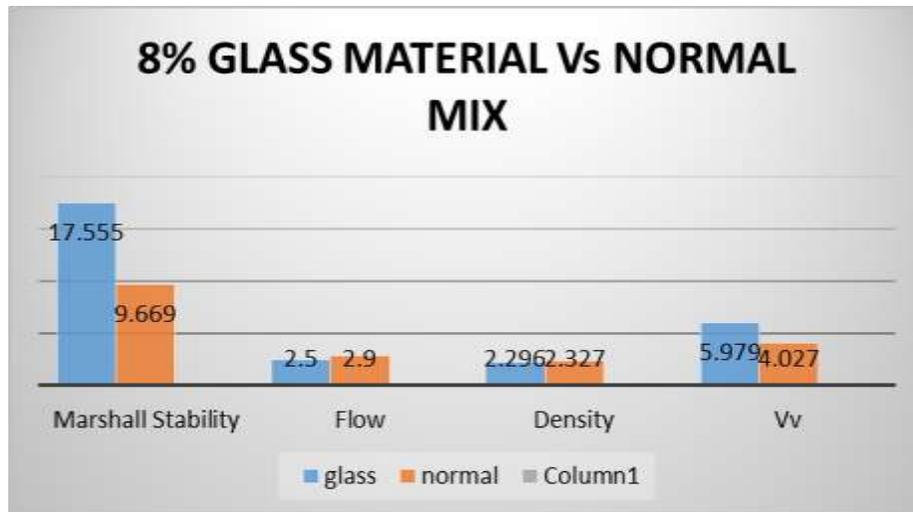


Chart-II: Comparison of Marshall and Volumetric Properties - 8% Glass Material

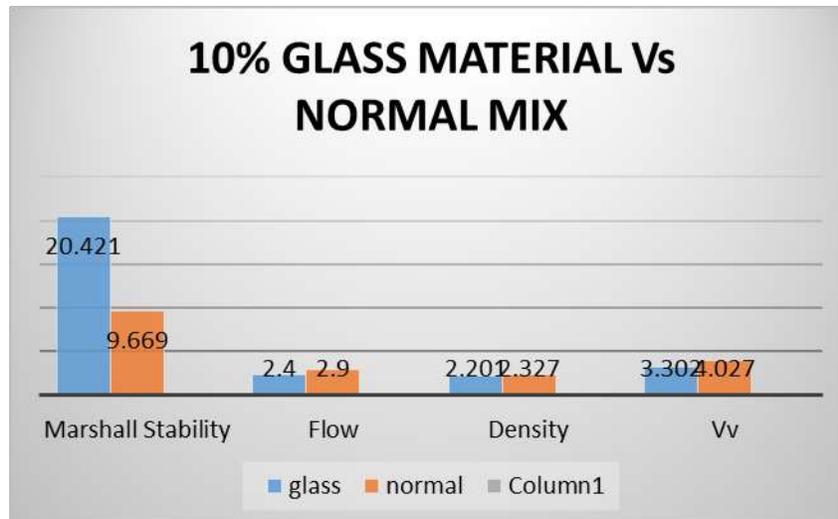


Chart-III: Comparison of Marshall and Volumetric Properties - 10% glass material

CONCLUSION

The use of waste materials i.e. glass waste, plastic waste, solid waste etc. in road construction can reduce the problems in disposal of wastes and ease the utilization of solid waste. In the current study, the possibility of improving the properties of Bitumen mix with waste glass as filler in place of aggregate was studied. Bitumen mixes were prepared with glass powder at three different dosages (4%, 8% and 10%). The Marshall and volumetric properties of these mixes were studied and compared. Bituminous mixes with glass powder as filler gave about the same Marshall and volumetric properties as normal mix. The addition of glass powder instead of aggregate in bitumen mix was thus found to make the bituminous mix more stable and resistant to deformations and lower percentage of air voids also. Thus considering the above mentioned benefits, industrial and domestic glass waste can be used as an alternative for aggregate to produce more stable and durable bituminous paving mix. In addition, the use of waste glass in road construction provides a safe and efficient means to dispose of glass waste.

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