IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Use Of Glass As Aggregate In Bitumen Asphalt Pavement

[1]Satish Pitake,[2]Onkar Tapkir,[3]Jyoti Takalkar, [4]Vaibhav Thorat, [5]Vaibhav Patil

[1]Assistant Professor,[2]Student,[3]Student,[4]Student,[5]Student

[1]Department of Civil Engineering,

[1]Pimpri Chinchwad College of Engineering And Research, Pune, India

Abstract: Flexible pavement is being used in the road construction process for a longer period of time. Bitumen, coarse aggregate, crush sand and fillers are the major constituents of the bituminous pavement. Recycled glass in the form of crushed culets or granules was used as an alternative for the fine aggregate. Glass possessing properties of high durability and skidding resistance, promised to be a better counterfeit. Various tests were carried out on the raw materials for satisfying the norms laid by IS code. It was made sure that the raw materials were to fulfill the qualifying criteria of a good pavement mix. Along with the raw materials, testing of crushed glass was also carried out. Specific gravity, penetration, flash & fire point, softening point and ductility test were the tests performed on the bitumen. Tests on the aggregates included water absorption, flakiness index, Los Angeles abrasion, aggregate impact and moisture content test. To find out the acceptable amount of glass which could be added to the design mix of the pavement, moulds containing different amount of crushed glass replaced in the aggregate content were prepared. These moulds were tested for its stability and flow value. Marshall Stability test was conducted on the moulds prepared and the results obtained were compared to a standard mould prepared without any inclusion of glass. The results were analyzed and graphically plotted, which concluded that crushed glass could be used in design mix of flexible bituminous pavement up to 10% of total mass weight. Addition of crushed glass resulted with gain in the strength of the pavement mix. Along with testing of the strength of the mix, cost analysis was also carried out. Using crushed glass as a partial alternative for the aggregates proved to be sound both structurally and financially.

Index Terms **– Waste Crushed Glass, Flexible Pavement, Stability, Flow Value.**

1. INTRODUCTION

The development of highways, expressways, district roads, etc is going at a higher pace for the past few years. An efficient road infrastructure is one of the major factors contributing the economic growth of a nation. Hence, better quality road infrastructure needs to be developed at a higher pace than ever before. Bituminous roads engulf the major portion of the road infrastructure because of its heavy hand over the financial as well as life durability features. Bitumen used as a raw material in road pavement and as an integral part of a composite along with other constituents like aggregates, binders, fillers, etc serves various advantages that prompt to utilize it widely in road pavement construction.

People living in the urban parts of India generate quite an amount of solid waste each year which gets disposed either in landfills where it is burned down releasing harmful gases in the atmosphere. Among the total waste *glass* produced in India, about 47% is recycled which rings an alarm to re utilize and create a better management system of treating waste glass.

Waste glass generation in India majorly comes from the beverage industry, automobile scrap industry and other food, material and consumer sectors contribute to the generation in small amounts.

This effort plans to replace a certain amount of crush sand aggregate used in the design of flexible bituminous pavement up to the acceptable limits. The change in the constituent shouldn't affect any of the basic functionality of the design mix in a negative way. Along with the advantage of low manufacturing cost of the pavement, if the reduce in usage of crush sand mined from stone mining yards is added, this would result in taking a big step in creating a more sustainable future in the road pavement industry. This partial replacement of fine aggregate should be done without any comprise on the strength, workability, durability and function parameters.

2. AIM

To investigate the effect of crushed waste glass as aggregate in different proportions on the stability and flow value in bitumen asphalt pavement.

3. OBJECTIVES

3.1. To study the effect of adding crushed waste glass has on the bitumen asphalt pavement.
3.2. To examine the change in stability value of the flexible pavement design mix due to addition of crushed waste glass.
3.3. To examine the change in flow value of the flexible pavement design mix due to addition of crushed waste glass.
3.4. To determine acceptable proportion of recycled glass that could be replaced in a sub-base course of flexible pavement.

4. LITERATURE REVIEW

Khalil Nabil Dalloul recommended doing more studies on the use of glass in the asphalt mixes using different percentages and different sources of glass. He also recommended testing glass with other waste materials such as plastic and iron filings to then find out their effects on the pavement mix properties.
Johnny Bolden, Taher Abu-Lebdeh and Ellie Fini investigated an initial understanding of the present strengths and weaknesses of the practice intended to support construction industry in developing effective policies regarding uses of waste and recycled materials as construction materials.
M. M. Disfania, A. Arulrajaha, M.W. Bob & N.Sivakugan investigated if the test outcomes were accorded with the environmental protection authorities' standards and denoted that no leaching hazard will be experienced during the service life of recycled glass in road work applications.
T. Phani Madhavi, V. Sampathkumar, P.Gunasekaran proposed that the use of fly ash as cement replacement material and glass aggregate as fine aggregate material partially in concrete. Natural sand was partially replaced with sheet glass aggregate.
Manoj Kumar, Sangita Chandra, SatishVerma, Shashikant Shukla investigated the behavior of glass fiber modified bituminous mixes to conclude that glass fiber enhanced the fatigue life by considerable % and also reduced the cracks in the bituminous pavement.
S.P. Gautam, Vikas Srivastava and V.C. Agarwal conducted laboratory experiments to further explore the utilization of waste glass as coarse and fine aggregates for both ASR (Alkali-Silica-Reaction) alleviation as well as the decorative purpose in concrete.

5. METHODOLOGY AND INVESTIGATION

5.1. METHODOLOGY

1. Collection and testing of all the raw ingredients for the pavement.
2. Preparation of conventional asphalt bitumen pavement samples.
3. Preparation of asphalt bitumen pavement samples with crushed glass.
4. Experimental procedures.
5. Experimental analysis.
6. Result and discussion.
7. Conclusion.

5.2. PROPERTIES MAKING GLASS AN EFFECTIVE ALTERNATIVE

Durability, Resistance, Striping resistance, Binding property with bitumen

5.3. RAW MATERIALS REQUIRED:

Coarse Aggregates

1. 4.75mm Stone Aggregate
2. 10mm Stone Aggregate
3. 12.5mm Stone Aggregate

Fine Aggregates

1. Crushed Sand
2. Crushed Glass

Binder

1. Bitumen of VG30 (60/70) Grade

6. TESTING

6.1. TESTS ON BITUMEN

Following tests were conducted on the bitumen sample of grade VG30 to check for conformity with relevant Indian standards.

1. Specific Gravity Test
2. Penetration Test
3. Flash & Fire Point Test
4. Softening Point Test
5. Ductility test

Table 1 Tests on Bitumen

Sr. No	Test Particular	Test Results	Minimum Requirement for VG30 Paving Grade (IS 73: 2013)	Test Method
1	Specific Gravity	1.034	-	IS 1202-1978
2	Penetration at 25℃in1/10 of mm	50	45	IS 1203-1978
3	Flash Point in ℃	241	220	IS 1448 Part 69
4	Softening Point in ℃	51	47	IS 1205-1978
5	Ductility at 25℃ in cm	81	40	IS 1208-1978

6.2. TESTS ON COARSE AGGREGATE

Following tests were conducted on the coarse aggregate sample to check for conformity with relevant Indian standards.

1. Specific Gravity Test
2. Flakiness Index
3. Water Absorption Test
4. Los Angeles Abrasion Test
5. Aggregate Impact Test

Table 2 Tests on Coarse Aggregate

Sr. No	Test Particular	Test Results	Specified Limits	Test Method
1	Specific Gravity	2.89	-	IS 2386 P-3 2016
2	Water Absorption in %	0.77	Max. 2%	IS 2386 P-3 2016
3	Flakiness Index in %	7.67	Max. 30%	IS 2386 P-1 2016
4	Los Angeles Abrasion Value in %	13.40	Max. 35% (Wearing surface)	IS 2386 P-4 2016
5	Aggregate Impact Value in %	12.12	Max. 30% (Wearing surface)	IS 2386 P-4 2016

6.3. TESTS ON FINE AGGREGATE

Following tests were conducted on the fine aggregate sample to check for conformity with relevant Indian standards.

1. Sieve Analysis
2. Specific Gravity Test
3. Water Absorption Test
4. Bulk Density Test
5. Moisture Content Test

Table 3 Tests on Fine Aggregate

Sr. No	Sieve Size (mm)	Percentage Passing	Specified Percentage Passing as per IS 383:2016 Zone -1	Zone -2	Zone- 3	Zone- 4
1	10	100.0	100	100	100	100
2	4.75	98.9	90-100	90-100	90-100	95-100
3	2.36	86.5	60-95	75-100	85-100	95-100
4	1.18	49.9	30-70	55-90	75-100	90-100
5	0.600	27.5	15-34	35-59	60-79	80-100
6	0.300	20.9	5-20	8-30	12-40	15-50
7	0.150	16.5	0-20	0-20	0-20	0-20
		Fineness Modulus	3.00			
		Aggregate Conforming to Zone	Zone-1			

Table 4 Tests on Fine Aggregate (Cont.)

Sr. No	Test Particular	Test Results	Specified Limits	Test Method
1	Specific Gravity	2.67	-	IS 2386 P-3 2016
2	Water Absorption in %	1.07	Max. 2%	IS 2386 P-3 2016
3	Dry Loose Bulk Density	1.94	Max. 3.0	IS 2386 P-3 2016

6.4. TESTS ON CRUSHED GLASS

Following tests were conducted on the crushed glass sample to check for conformity with relevant Indian standards.

1. Sieve Analysis
2. Water Absorption Test
3. Dry Loose Bulk Density Test

Table 5 Tests on Crushed Glass

Sr. No	Test Particular	Test Results	Specified Limits	Test Method
1	Sieve Analysis	Zone-1	-	IS 2386 P-3 2016
2	Water Absorption in %	0.8	Max. 2%	IS 2386 P-3 2016
3	Dry Loose Bulk Density	1.94	Max. 3.0	IS 2386 P-3 2016

6.5. SAMPLE PREPARATION:

For this experimental process, a group of different specimens were prepared. Initial specimen without recycled crushed glass (0%) as reference to specimens made with 5%, 10% and 15% recycled crushed glass. Along with it, in order to assess the effect of crushed glass on the bituminous pavement of asphalt mixtures, three groups of specimens were prepared with 4.5%, 5.0% and 5.5% bitumen content with crushed waste glass content at the same percentage of 5%, 10% and 15% of the total weight.

7. RESULT AND DISCUSSION

7.1. TESTS ON MOULD SAMPLE

7.1.1. Marshall stability test

7.1.1.1. Sieving

All the aggregates are cleaned and dried before sieving. Aggregates are then sieved according to the given standard sizes. Coarse aggregates are passing through sieves of 12.5mm, 10mm and 4.75mm are used. Fine aggregate or crushed sand passing through 0.075mm sieve is used for the sample preparation

7.1.1.2. Mixing

All the aggregates are mixed with bitumen in a heating pan. A thorough mix is required to ensure better compaction and proper bonding between the bitumen and aggregates. The sample is mixed for a period of 5 minutes.

7.1.1.3. Moulding

Marshall Compaction moulds are used for compacting the design mix. For compaction, a hammer weighing 4.54 kilograms is used which is released from a height of 0.4 meters. A total of 50 blows are given on both the sides of the sample. A sample extractor tool is used to remove the sample from the mould.

7.1.1.4. Weighing

All the dimensions of the sample are measured along with its weight in air and water. Initially, weight, radius and height of the sample is measured without any coat of paraffin wax. Then the sample mould is coated with a layer of paraffin wax and again its weight, radius and height is measured.

7.1.1.5. Hot water bath

The sample is kept in hot water bath for 30 minutes at 60^0C. Constant monitoring is carried out to ensure temperature of the water bath does not exceed 60^0C.

Table 6 Weight of Aggregates with 4.5% Bitumen Content

BITUMEN (gm)	GLASS (gm)	4.75 MM (gm)	10MM (gm)	12.5 MM (gm)	CRUSH SAND (gm)
54	0	123	570	230	223
54	60	121	565	228	172
54	120	119	560	226	121
54	180	117	555	224	70

Table 7 Weight of Aggregates with 5% Bitumen Content

BITUMEN (gm)	GLASS (gm)	4.75 MM (gm)	10MM (gm)	12.5 MM (gm)	CRUSH SAND (gm)
60	0	120	570	230	220
60	60	118	565	228	169
60	120	116	560	226	118
60	180	114	555	224	67

Table 8 Weight of Aggregates with 5.5% Bitumen Content

BITUMEN (gm)	GLASS (gm)	4.75 MM (gm)	10MM (gm)	12.5 MM (gm)	CRUSH SAND (gm)
66	0	117	570	230	217
66	60	115	565	228	166
66	120	113	560	226	115
66	180	111	555	224	64

Results for stability and flow value of specimens with 0%, 5%, 10%, and 15% of crushed glass by weight are shown in the following table:

Table 9 Stability and Flow Value

TEST RESULTS	BITUMEN (%) GLASS (%)	4.5 %	5 %	5.5 %
STABILITY (KN)	0 %	11.56	13.28	13.98
FLOW (MM)		3.1	2.7	3.1
MARSHALL QUOTIENT		4.45	4.92	4.51
STABILITY (KN)	5 %	12.35	12.76	13.14
FLOW (MM)		2.5	2.8	3.0
MARSHALL QUOTIENT		4.94	4.56	4.38

Table 10 Stability and Flow Value (Cont.)

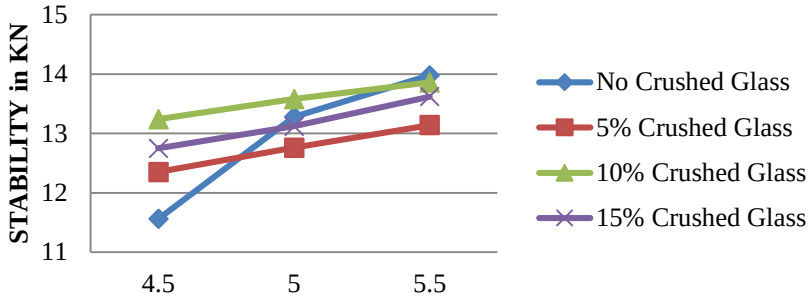
TEST RESULTS	BITUMEN (%) GLASS (%)	4.5%	5%	5.5%
STABILITY (KN)	10%	13.24	13.58	13.86
FLOW (MM)		2.7	2.8	3.0
MARSHALL QUOTIENT		4.90	4.85	4.62
STABILITY (KN)	15 %	12.75	13.12	13.62
FLOW (MM)		2.6	2.7	2.9
MARSHALL QUOTIENT		4.90	4.86	4.70

From the experimental results given in the above tables, it is observed that stability and flow value of the design mix increased in value with the addition of crushed glass at different proportions. The mix including 10% crushed waste glass as replacement showed substantial increase in the flow value and surpassed stability as compared to the sample mix with no crushed glass.

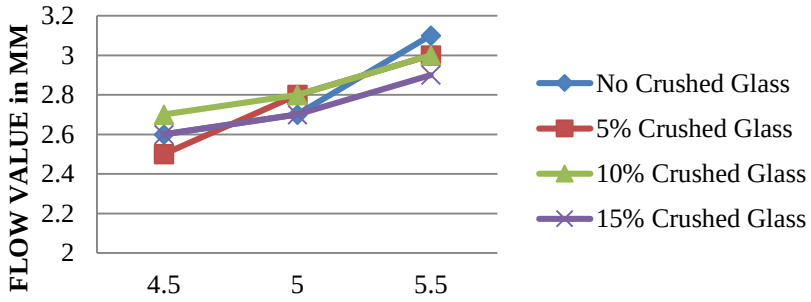
7.2. GRAPHICAL RESULTS

Graphs plotted based on the data acquired from the testing of the sample mould mix are given below:

Graph 1 STABILITY GRAPH FOR VARIOUS GLASS %



Graph 2 FLOW VALUES FOR VARIOUS GLASS %



8. CONCLUSION

1. The purpose of this project study was to carry out tests to calculate the permissible amount of crushed glass which could replace fine aggregate in the bituminous pavement.
2. Based on the analysis conveyed, it can be concluded that crushed glass could replace fine aggregates up to 10% which would result in increase of stability and flow value of the design mix.
3. The flow value and stability increased substantially with increase in the percentage of crushed glass added.
4. Along with the increase in the structural properties of the mix, this would also result in the decrease of glass waste accumulation.
5. This partial alternative for fine aggregate would certainly be helpful to increase the strength of the flexible bituminous pavement but would also reduce the waste glass dumping.

9. REFERENCES

1. M.S.Kuttimarks, R.Shruthi, “Experimental Studies on Replacement of Fine Aggregate with Glass and Fly Ash”, International Journal of Emerging Engineering Research and Technology Volume 2, Issue 2, May 2014, PP 205-208.
2. Khalil Nabil Dalloul, “Study of the Effect of Crushed Waste Glass as Coarse Sand and Filler in the Asphalt Binder Course”, 2013, pp13-34.
3. Johnny Bolden, Taher Abu-Lebdeh and Ellie Fini , “American Journal of Environmental Science”, 9 (1): 14-24, 2013 ISSN: 1553-345X ©2013 Science Publication doi:10.3844/ajessp.2013.14.24 Published Online 9 (1) 2013
4. T. PhaniMadhavi,V. Sampathkumar, P.Gunasekaran , “Partial replacement of cement &fine aggregate by using fly ash & glass aggregate", International journal of research in engg. & tech. ISSN: 2319-1163, November 2013.
5. S.P. Gautam, VikasSrivastava and V.C. Agarwal, “Use of glass wastes as fine aggregate in Concrete”, Research, November 2012, ISSN: 2278-5213
6. https://trid.trb.org/view/1566737/ Use of glass fibers in bituminous mixes for retardation of cracks in composite pavement