MARSHALL PROPERTIES OF BITUMINOUS MIXES USING BRICK DUST AND CONCRETE DUST AS FILLER

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ABSTRACT *Asphalt concrete familiarly known as bituminous concrete is a petroleum product. It is used for driveways, roadways, walking paths, curbs and for any project that requires smooth surface. The aim of bituminous mix design is to determine the proportion of its ingredients in order to produce a mix which is strong, durable, workable and economical. In bituminous mixes ingredients used are aggregates, fillers and bitumen. Voids remain in coarse aggregates which are filled by fine aggregates. But all the voids are not filled by fine aggregates. Some of the voids still remain there which are filled by fillers. Fillers paly vital role in the filling of voids. On adding fillers physical and chemical properties of mix changes and gets improved considerably. Thus it is necessary to find the stability and behavior of bituminous mixes when filler is added in it. Asphalt institute in India, has recommended usage of 4-8% of filler in bituminous mixes. The present study deals with the effect on Marshall Properties of Bituminous mixes using brick dust and concrete dust as filler is studied. For both the bituminous mixes containing brick dust as filler and concrete dust as filler properties were studied and compared with each other. Marshall Method of mix design was used for the purpose or comparison. In this study also tests were carried out on aggregates and bitumen. The results obtained were compared with the specifications laid down by BIS, MORTH and IRC in order to find whether the materials were within the specified limits. Samples were prepared with varying bitumen content using brick dust and concrete dust as filler. Those samples were then tested through Marshall Method. The results revealed that physical characteristics of bitumen improved on adding the fillers. Also stability and flow value of bitumen mix improved. Adding filler also helps in reducing the problem of waste disposal.*

Key words*: Concrete dust, flexible pavement, bituminous mix, Marshall Test, brick dust, Stability, Air voids, unit weight, voids in Mineral aggregates.*

1. Introduction

The total road network in India has increased from 2 million km in 1990s to 5.4 million km now which is the second largest around the world. Under the new program Indian government plans to develop a total of 66,117 km of roads under different programs such as National highway development project (NHDP), special accelerated road development programme in North east (SARDP-NE) and left wing Extremism(LWE). Under Pradhan mantri gram sadak yojna (PMGSY), government has planned to spend Rs 1 lakh crore during financial year 18-20. Further over the next five years government has decided to invest Rs 7 trillion for construction of new roads and highways. During the financial year 2017 highway length in India was recorded as 103, 9333 kms. The largest ongoing highway project in India under NHDP is North-south-East-west corridor. It is managed by National Highway authority of India (NHAI) under the ministry of road transport and highways. It consists of building 7300 kms of four lane expressways connecting Srinagar, Kanyakumari, Kochi, Porbandar and Silchar. 93.5% of the proposed work has been completed till date. North-South corridor is 4000 kms and is via NH 44. East-west corridor is 3300 kms and is via NH 27.

Processed materials when superimposed in layers over natural soil subgrade form a Highway Pavement. The function of these materials is to distribute the load coming from vehicles to the subgrade. The materials used should be good enough to perform their desired functions. The materials should be good enough so as to ensure that stresses that are transmitted due to wheel loads are quiet reduced, so that these stresses will not exceed the bearing capacity of subgrade. This service is generally served by two types of pavement: Flexible and rigid pavement. The present study deals with the flexible pavement. As indicated by name itself flexible pavements are those which transmit the imposed load by grain to grain mechanism. Load gets transmitted over wider area and thus with depth stress gets decreased. Bituminous pavements are the one mostly constructed around the world and thus in the present study bituminous mixes are used.

2. Objectives of Bituminous Pavement Mix

The objective of the design bituminous pavement mix is to establish an economical mixture of sand, stone aggregates and fillers such as brick dust and concrete dust that produces a mix having

- Sufficient bitumen so as to make sure that pavement is durable.
- Sufficient stability to withstand shear deformation under traffic at higher temperature.

- Sufficient workability for easy placement. Sufficient workability not only enhances easy placement but also avoids segregation.
- Sufficient flexibility to avoid early cracks due to repeated deformation by traffic.
- Sufficient flexibility at low temperatures to intercept shrinkage cracks.
- Sufficient mix stability to fulfill the demand of traffic without displacement or deformation.
- Sufficient air voids in the compacted bitumen to compensate for the additional compaction by the traffic.

3. Objective of the Study

Aim of the present study is to find the behavior of bituminous mixes when different fillers are added in it. Various studies pertaining to using of fillers in bituminous mixes were studied. In the present study brick dust and concrete dust is used as filler. Accordingly the properties of bituminous mixes containing filler like waste concrete dust and brick dust is studied and compared with each other mixes. For the purpose of comparison Marshall Method of Mix design was used.

4. Materials

Aggregate and bitumen are the basic ingredients of bituminous mixes. Further on the basis of size of particles aggregates are further divided into coarse aggregates, fine aggregates and filler fractions. The section discusses regarding the details of coarse aggregates, fine aggregates, fillers used, and bitumen.

- **Coarse Aggregate**

Impact value, abrasion value and crushing strength of coarse aggregates should be good enough to withstand the design loads within the design life span. All the stresses coming on the wheels are beard by coarse aggregates. Wear due to abrasion is also to be resisted by coarse aggregates. That portion of the mixture which is retained on 2.36 mm (No. 08) sieve according to the Asphalt Institute is termed as Coarse aggregates. Basalt rock was used as the coarse aggregate in the present study.

- **Fine Aggregate**

In coarse aggregates between the particles voids remain, those voids need to be filled. Those voids which remain there are filled by fine aggregates. So to fill the voids of coarse aggregates is the main function of Fine aggregates. Crushed stone or natural sand generally is termed as fine aggregates. Those aggregates which passed through 2.36mm sieve and retained on 0.075mm sieve were selected as fine aggregates in the present study. River bed was used as the source of fine aggregates in present study.

- **Filler**

After the voids are filled in coarse aggregates by fine aggregates, some of the voids still remain unfilled. Function of the fillers is to fill up the voids. Fillers used may be brick dust, stone dust, concrete dust, limestone dust, fly ash or pond ash. For the purpose of comparison and economy concrete dust and brick dust was used as filler. Size of filler used was less than 0.075mm sieve.

- **Bitumen**

Bitumen is used as a water repellant material. Grade of bitumen used in the present study used was 80/100. In order to keep the type and grade of binder constant same bitumen was used for all of the mixes.

5. Methodology

This study can be discussed in three different stages. Those three stages are: - Characterization of materials in order to find whether the materials are good enough and as per specifications, mixing of fillers and study of effect of these fillers on Marshall Properties. In the first stage, properties of the ingredients used in bituminous mixes were established by performing various tests and compared with the specifications. In second stage, brick dust and concrete dust were used as fillers with varying content of bitumen. In the final stage Marshall Mix design method was used for both the fillers to find stability, flow, air voids, VMA(Voids in mineral aggregates).

- **Laboratory Tests for the Properties of Materials**
- **Properties of Aggregates**

Various tests pertaining to aggregates were performed. Crushing test, Abrasion test, specific gravity test, elongation test, flakiness test, impact values test and water absorption test were carried out and compared with the specifications laid down by BIS, IRC and MORTH. All the tests were carried out in laboratory and results were calculated. Results along with the specifications laid down by BIS, IRC and MORTH are tabulated in Table 1.

Properties Tested		Test Result	Specification
Crushing test		17.95%	Max 30% (IRC and BIS)
Los Angles Abrasion Value		21.4%	Max 30% (MORTH)
Specific	**Fine aggregates**	2.75	2.5-3.0(MORTH)

Gravity	**Coarse aggregates**	2.9	2.5-3.0(MORTH)
Elongation test		33.4%	No recognition
Flakiness test		23.4%	Max 25% (IRC and BIS)
Impact Value		18.5%	Max 24%(MORTH)
Water Absorption		1.25%	Max 2%(MORTH)

Table 1 Different Test Results of Aggregates

- **Properties of Bitumen**

Various tests pertaining to bitumen were performed. Softening point test, penetration test, specific gravity test, ductility test and viscosity test were carried out and compared with the specifications laid down by BIS, IRC and MORTH. All the tests were carried out in laboratory and results were calculated. Results along with the specifications laid down by BIS, IRC and MORTH are tabulated in Table 2.

Properties Tested	Test Result	Specification IS:73-2013
Softening Point Test temp. ^{0}C	45	40 min.
Penetration Test (mm)	90.5	80min
Specific Gravity Test	1.05	1.01min
Ductility Test (mm)	85	75min
Viscosity Test at 135^{0}C (Cst)	275	250min

Table 2 Different Test Results of Bitumen

- **Test results for the samples containing fillers:-**

Test results for the samples containing brick dust and concrete dust as filler are tabulated below.

- **Results of Specimens with Filler Concrete Dust.**

Bitumen Content (%)	Unit weight (kg/m^3)	Stability (kN)	Flow Value (mm)	Air Void Va (%)	VMA (%)
5.0	2365	10.9	3.20	5.9	18.35
5.5	2375	11.3	3.40	5.6	17.85
6.0	2390	11.9	3.65	4.3	17.20
6.5	2400	12.7	3.95	4.1	16.85

Table 3 Marshall Properties of Specimens with Filler Concrete Dust.

- **Results of Specimens with Filler Brick Dust.**

Bitumen Content (%)	Unit weight (kg/m^3)	Stability (kN)	Flow Value (mm)	Air Void Va (%)	VMA (%)
5.0	2320	14.21	2.5	7.95	18.28
5.5	2335	15.12	2.33	7.35	17.95
6.0	2348	16.65	3.45	6.35	17.35
6.5	2361	17.95	4.10	5.50	16.63

Table 4 Marshall Properties of Specimens with Filler Concrete Dust.

6. Comparison of Concrete Dust and Brick Dust Specimens Results

Comparison for both the specimens is done through graphs below. Further the results have been explained also.

➢ **Marshall Unit Weigh Curves (kg/m³)**

The graphical representation of unit weights for variation in bitumen content from 5% to 6.5% for samples containing brick dust and concrete dust as filler is shown in Fig 1. From the graphs it is observed that both the samples containing brick dust and concrete dust as filler show somewhat equal unit weight.

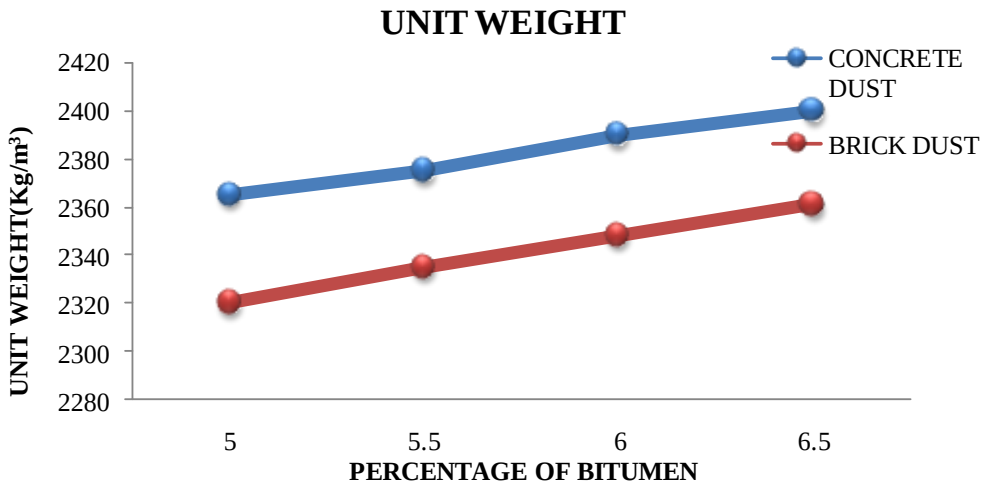

Fig. 1 Variation of Unit Weight With %age of Bitumen.

➢ **Marshall Stability Curves**

The graphical representation of stability for variation in bitumen content from 5% to 6.5% for samples containing brick dust and concrete dust as filler is shown in Fig 2. From the graph it is seen that with the increase in the bitumen content stability increases. It is seen that specimen with concrete dust as filler has lesser stability than specimen with brick dust as filler. In case of the specimen with concrete dust as filler maximum stability is observed at 6.5% bitumen content. Stability of specimen with concrete dust as filler is 12.7 KN. Also in case of the specimen with brick dust as filler maximum stability is observed at 6.5% bitumen content. Stability of specimen with brick dust as filler is 17.95 KN

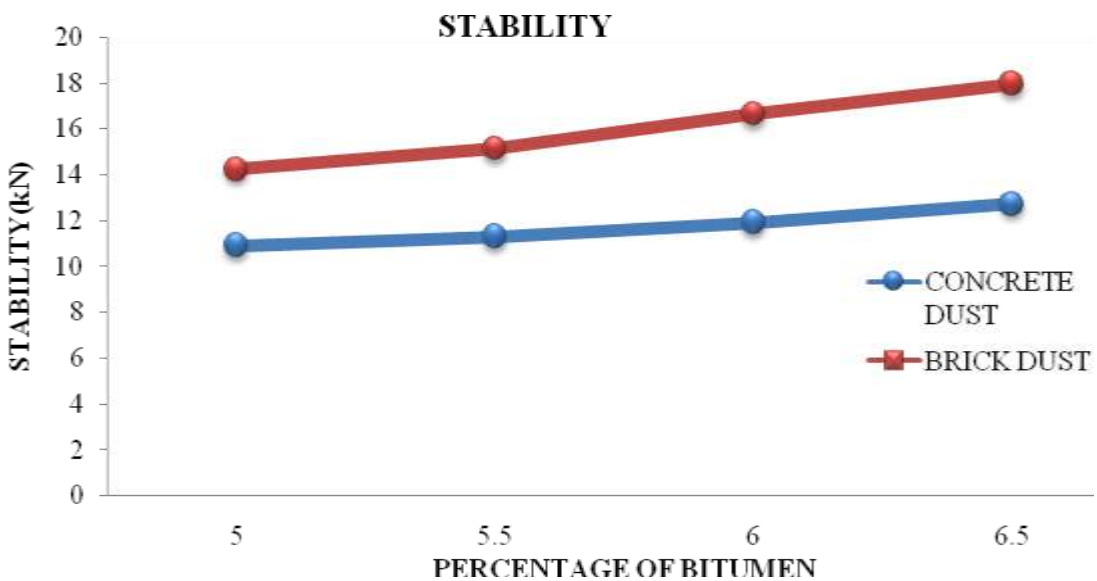

Fig. 2 Variation of Stability With %age of Bitumen.

➢ **Marshall Flow Value Curves**

The graphical representation of flow value for variation in bitumen content from 5% to 6.5% for samples containing brick dust and concrete dust as filler is shown in Fig 3. From the graph it is seen that as usual

with the increase in the bitumen content flow value increases. It is seen that specimen with concrete dust as filler has lesser flow value than specimen with brick dust as filler. In case of the specimen with concrete dust as filler maximum flow value is observed at 6.5% bitumen content. Flow value of specimen with concrete dust as filler is 4.10mm. Also in case of the specimen with brick dust as filler maximum flow value is observed at 6.5% bitumen content. Flow value of specimen with brick dust as filler is 3.95mm.

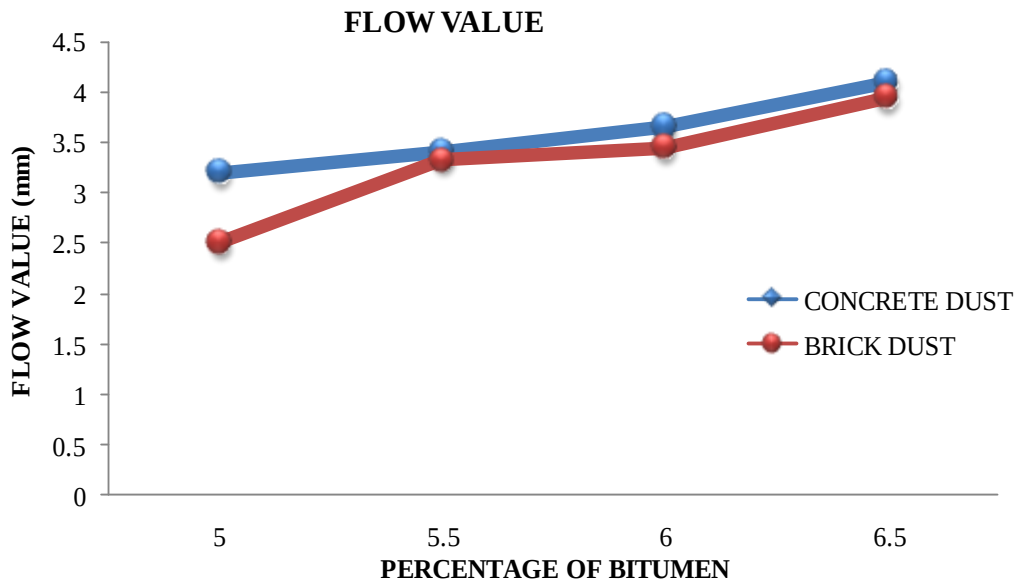

Fig. 3 Variation of Flow Value With %age of Bitumen.

➢ **Marshall Air Void Curves**

The graphical representation of Marshall Air void for variation in bitumen content from 5% to 6.5% for samples containing brick dust and concrete dust as filler is shown in Fig 4. From the graph it is seen that with the increase in the bitumen content air void decreases. It is seen that specimen with concrete dust as filler has lesser air void than specimen with brick dust as filler. In case of the specimen with concrete dust as filler minimum air void is observed at 6.5% bitumen content. Air void of specimen with concrete dust as filler is 4.1%. Also in case of the specimen with brick dust as filler minimum air void is observed at 6.5% bitumen content. Air void of specimen with brick dust as filler is 5.50%.

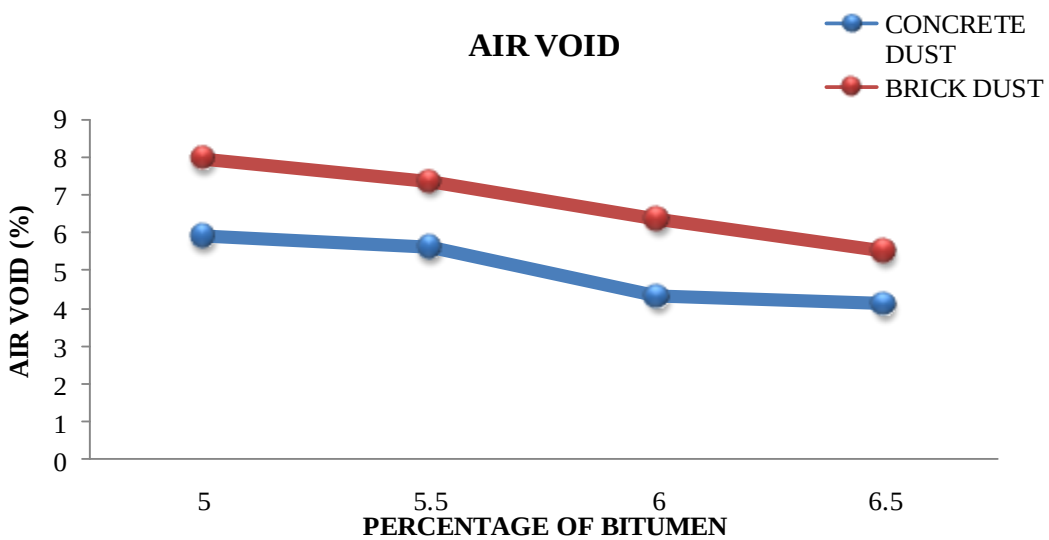

Fig. 4 Variation of Air Void With %age of Bitumen.

➢ **Marshall VMA**

The graphical representation of Marshall VMA for variation in bitumen content from 5% to 6.5% for samples containing brick dust and concrete dust as filler is shown in Fig 5. From the graph it is seen that with the increase in the bitumen content VMA decreases. It is seen that specimen with concrete dust as filler has lesser VMA than specimen with brick dust as filler. In case of the specimen with concrete dust as filler minimum VMA is observed at 6.5% bitumen content. VMA of specimen with concrete dust as filler is 16.35%. Also in case of the specimen with brick dust as filler minimum VMA is observed at 6.5% bitumen content. Air void of specimen with brick dust as filler is 16.63%.

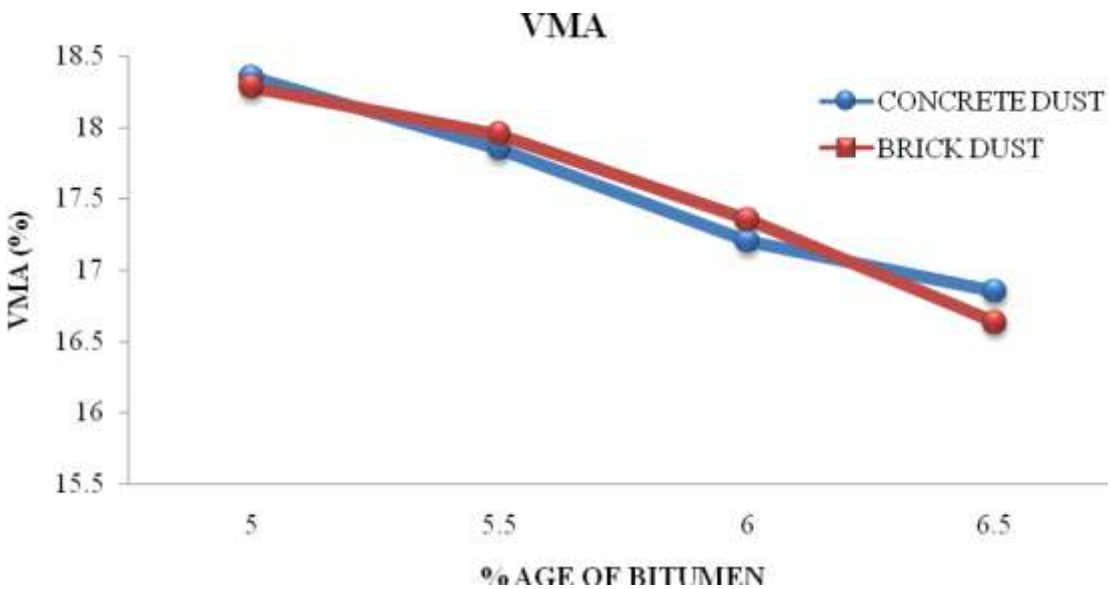

Fig.5 Variation of VMA With %age of Bitumen

Table No. 5 Comparison of Results against Various Parameters for Optimum Bitumen Content

Filler Type	Maximum Unit Weight	Maximum Stability Value	Maximum Flow Value	Minimum Air Void	Minimum VMA
Concrete Dust	6.5%	6.5%	6.5%	6.5%	6.5%
Brick Dust	6.5%	6.5%	6.5%	6.5%	6.5%

7. Conclusions

After performing all the necessary tests and plotting of results on graphs, conclusions drawn are listed below:-

1. The specimen with brick dust as filler is found to have nearly same Marshall Properties as that of the specimen with filler concrete dust.
2. The specimen with concrete dust as filler is found to have maximum unit weight at bitumen content of 6.5%. Unit weight of that particular sample at 6.5% bitumen content is found to be 2400 kg/m^3. Further it is shown that with the increase in bitumen content unit weight goes on increasing.
   For the specimen with brick dust as filler it is found to have maximum unit weight at bitumen content of 6.5%. Unit weight of that particular sample at 6.5% bitumen content is found to be 2361 kg/m^3. Further it is shown that with the increase in bitumen content unit weight goes on increasing.
3. The specimen with concrete dust as filler is found to have maximum stability at bitumen content of

6.5%. Stability of that particular sample at 6.5% bitumen content is found to be 12.7 KN. Further it is shown that with the increase in bitumen content Stability goes on increasing.
For the specimen with brick dust as filler it is also found to have maximum Stability at bitumen content of 6.5%. Stability of that particular sample at 6.5% bitumen content is found to be 17.95 KN. Further it is shown that with the increase in bitumen content Stability goes on increasing.

4. The specimen with concrete dust as filler is found to have maximum flow value at bitumen content of 6.5%. Flow value of that particular sample at 6.5% bitumen content is found to be 3.95 mm. Further it is shown that with the increase in bitumen content flow value goes on increasing.
For the specimen with brick dust as filler it is also found to have maximum flow value at bitumen content of 6.5%. Flow value of that particular sample at 6.5% bitumen content is found to be 4.10 mm. Further it is shown that with the increase in bitumen content flow value goes on increasing.
5. The specimen with concrete dust as filler is found to have minimum air voids at bitumen content of 6.5%. Air voids of that particular sample at 6.5% bitumen content are found to be 4.1%. Further it is shown that with the increase in bitumen content air voids go on decreasing.
For the specimen with brick dust as filler it is found to have minimum air voids at bitumen content of 6.5%. Air voids of that particular sample at 6.5% bitumen content are found to be 5.50%. Further it is shown that with the increase in bitumen content air voids go on decreasing.
6. The specimen with concrete dust as filler is found to have minimum VMA at bitumen content of 6.5%. VMA of that particular sample at 6.5% bitumen content are found to be 16.85%. Further it is shown that with the increase in bitumen content VMA goes on decreasing.
For the specimen with brick dust as filler it is found to have minimum VMA at bitumen content of 6.5%. VMA of that particular sample at 6.5% bitumen content are found to be 16.63%. Further it is shown that with the increase in bitumen content VMA goes on decreasing.
7. For both the samples containing brick dust as filler and concrete dust as filler satisfactory results are obtained at bitumen content of 6.5%.
8. Both the bituminous mixes displayed higher air voids and VMA than required for normal mixes.
9. It is also found that in order to satisfy the design criteria bitumen content is to be increased.
10. One of the advantages of using these as fillers is of reducing the problem of disposal of industrial wastes; with in turn help in reducing pollution and making environment clean.
11. Also it is found that concrete dust and brick dust generated as waste materials can effectively utilized in the making of bitumen concrete mixes for paving purposes.
12. By performing cost analysis of these non-traditional materials against traditional materials, cost effectiveness of these fillers can be realized.

8. Future Scope

- In order to improve the quality of pavement mixes Stone dust, cement, fly ash, can also be used as fillers.
- The tensile strength of the bituminous mixes can be studied through Creep test and indirect tensile strength test.
- In bituminous mixes we can also use various types of binders and additives like rubber, plastic waste, polymer etc in order to improve the various properties of mixes.
- Quality of pavement mixes can also be improved by using various types of fibers like synthetic and natural fibre.
- Also waste plastic in the form of molten polythene can be used as binding material.
- We can also use fine ground slag as filler in bituminous mixes. Further it can also be used for the purpose of soil Stabilization.
- Mill tailings which is waste product of Mineral processing industry can also be used as aggregate in bituminous mixes, thus reducing the disposal problem.
- Cement kiln dust which is waste product of Cement industry can also be used as filler in bituminous mixes. Further it can also be used as a material in soil stabilization.
- Waste tyres which also is a waste product generated in Automobile industry can be used as a raw material in rubber modified bitumen.
- China clay generated from Bricks and tile industry can be used as aggregates in the bituminous mixes.
- Non-ferrous slag which is also a waste can also be used as aggregate in the bituminous mixes.

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