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Performance Evaluation of Hot Mixed Asphalt using Polymers Modified Bitumen and Marble Dust as a Filler

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Abstract: The reuse of marble waste as filler material in the use of bituminous roads to replace stone dust is presented in this paper. Stone dust is used as a filler conventionally by NHA, Pakistan. Compared to traditional mixes containing stone dust as filler, modified mixes containing marble dust as filler were prepared. In both types of blends, three different percentages of fillers were used, namely marble dust and stone dust (2 percent, 4 percent and 6 percent by weight of total aggregates), along with three varying bitumen contents (4.5 percent, 5 percent and 5.5 percent) and its performance were compared with conventional stone dust used as filler in bituminous mixtures. In terms of Marshal Stability testing, the effect of both forms of mixes was measured and findings were discussed. The Marshal Mix design showed that, relative to traditional mixes, modified mixes result in higher stability. The fact that marble dust acts is due to an improvement in the stability of modified mixes as an extensor for bitumen. Stone dust consumes more bitumen and, when the summer temperature reaches 40^{0}C and more compaction by heavily loaded vehicles, enables the disintegration of aggregate particles by bleeding.
Keywords: Filler, Marble Dust, Stone Dust, Polymers Modified Bitumen, Marshal Stability

I. INTODUCTION

As a substitute filler, brick powder is being used and laboratory testing has been carried out. Different tests were carried out, including tensile strength, fatigue, and moisture susceptibility. The experiments carried out show that brick powder can be used as a complete filler and as a substitute for limestone dust in the bituminous concrete. The mechanical properties of asphalt will be improved[1]. Rice waste is used in asphalt samples as a filler. Including 4 %, 5 %, 6% and 7% of limestone dust as filler, asphalt samples were made.

The Marshal Mix design method determined the optimum binder content (OBC) for the asphalt specimen. In order to verify its properties, different proportions of rice husk 25 %, 50 %, 75 % and 100 % were used as a substitute for limestone dust. The tests conducted showed that if the limestone dust is substituted by rice husk, asphalt would have better results [2]. The filler used was dust from a baghouse.

The dust extractor is made in this way. The results obtained from gradation and volumetric characteristics indicated that the baghouse meets the criteria for filling [3]. They have been working on the use of fly ash as filler material. To substitute one another, fly ash and hydrated lime were used.

Varying percentages were used (2-8 percent). Marshall Test was performed and the findings showed that the use of 4% fly ash as filler substitute enhanced performance characteristics [4]. The dust to binder ratio has been analysed here. Their influence was investigated on the asphalt mix.

Various proportions 2.4 %, 3.4 % and 4.4 % of fillers were used. The final results revealed that, in the true sense of the word, the dust to binder ratio affects asphalt stability and volumetric properties [5].

II. EXPERIMENTAL INVESTIGATION

A. Tests of Materials Used in Paving Mixes

Aggregates, bitumen and marble dust as a filler are the main materials used in this research. A high number of field visits were coordinated for the collection of the above materials. In order to obtain materials to be used in this research, different aggregate and bitumen plants and marble factories have been visited. Aggregates and bitumen were tested for basic properties before being used for bituminous mixes.

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1) *Bitumen's characteristics:* Bitumen collected from the plant was evaluated for its physical characteristics and was used for the analysis in accordance with AASHTO specifications. In the following table, the results are given:

Table 1. Characteristics of Bitumen

Properties	Results	Standard	Specifications
Penetration Test, mm	59	AASHTO T49	60-70
Softening Point, °C	52	AASHTO T53	46-56
Ductility Test, cm	114	AASHTO T51	100+
Specific Gravity at 25 °C	1.03	AASHTO T228	1.01-1.06
Flash Point, °C	271	AASHTO T48	≥ 235
Fire Point, °C	292	AASHTO T48	≥ 235

2) *Characteristics of Aggregates:* The below findings are discussed when laboratory experiments were performed on aggregates.

Table 2. Characteristics of Aggregates

Tests Description	Results	Standard	Specifications
Fracture Particles (%)	100	ASTM D5821	90% (min)
Flakiness Test (%)	5	ASTM D4791	10% (max)
Elongation Test (%)	9	ASTM D4791	10% (max)
Sand Equivalent (%)	75	ASTM D2419	50% (min)
Los Angeles Abrasion Test (%)	24.3	AASHTO T96 ASTM C131	30% (max)
Water Absorption (%)	1.02	AASHTO T85	2% (max)
Soundness (Coarse) (%)	7.1	ASTM C88/C88M	8% (max)
Soundness (Fine) (%)	4.7	ASTM C88/C88M	8% (max)

B. *Marshall Method of mix design to assess Optimum Bitumen Content*

The Marshal Mix Design Process is the mix design methodology used in this research. In this research, asphalt mixtures are designed and prepared according to the National Highway Authority, Pakistan's specifications and requirements, which in turn adhere to the standards of AASHTO and ASTM. The products used in this research comply with the Asphalt Institute (MS-2), AASHTO and ASTM requirements. Under the Marshal Mix Process, a total of 60 mixes are prepared. .For different specimens, the Optimum Binder Content (OBC) is evaluated according to the Asphalt Institute Mix Design Method (MS-2). In accordance with the procedure recommended by AASHTO T245 and ASTM D6926, D6927, all specimens have been prepared, compacted and tested. At 105±5^{o}C, all the aggregates used in sample preparation were preheated and dried. A total of 1200gm of dry blended aggregates was measured for each sample. The proportion of materials by weight was taken in accordance with the Asphalt Institute Mix Design Method (MS-2) specification for different percentages of bitumen. At a temperature of 154°C to 160°C, the aggregate mixture was heated and mixed thoroughly. Heated bitumen grade 60 /70 penetration was added and mixed until bitumen covered all of the aggregates.

Table 3. Gradation of aggregates to assess OBC for 0 % Marble Dust

Sieves	Class Range	%age Pass	%age Retain	Bitumen Content				
				3.50%	4.00%	4.50%	5.00%	5.50%
(mm)	(%)	(%)	(%)	Weight Retained (gm)				
19	100-0	100	0	0	0	0	0	0
12.5	75-90	82.5	17.5	202.7	201.6	200.6	199.5	198.5
9.5	60-80	70	12.5	144.8	144	143.3	142.5	141.8
4.75	40-60	50	20	231.6	230.4	229.2	228	226.8
2.36	20-40	30	20	231.6	230.4	229.2	228	226.8
1.18	5-15	10	20	231.6	230.4	229.2	228	226.8
0.075	3-8	5.5	4.5	52.11	51.84	51.57	51.3	51.03
Pan			5.5	63.69	63.36	63.03	62.7	62.37
Total				1158	1152	1146	1140	1134
Bitumen				42	48	54	60	66

The bituminous mix was put into Marshall Mould with a collar and base and compacted to compact the sample to about 100 mm dia and 64 mm height with 75 blows on each face. The base plate was extracted after compaction and the mould containing the sample was allowed to cool. At room temperature, the sample was allowed to cool.

Table 4.Aggregates gradation for determination of OBC for 2% Marble Dust

Sieves	Class Range	%age Pass	%age Retain	Bitumen Content				
				3.50%	4.00%	4.50%	5.00%	5.50%
(mm)	(%)	(%)	(%)	Weight Retained (gm)				
19	100-0	100	0	0	0	0	0	0
12.5	75-90	82.5	17.5	202.7	201.6	200.6	199.5	198.5
9.5	60-80	70	12.5	144.8	144	143.3	142.5	141.8
4.75	40-60	50	20	231.6	230.4	229.2	228	226.8
2.36	20-40	30	20	231.6	230.4	229.2	228	226.8
1.18	5-15	10	20	231.6	230.4	229.2	228	226.8
0.075	3-8	5.5	4.5	52.11	51.84	51.57	51.3	51.03
Pan			3.5	40.53	40.32	40.11	39.9	39.69
			2	23.16	23.04	22.92	22.8	22.68
Total				1158	1152	1146	1140	1134
Bitumen				42	48	54	60	66

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Table 5.Aggregates gradation for determination of OBC for 4% Marble Dust

Sieves	Class Range	%age Pass	%age Retain	Bitumen Content				
				3.50%	4.00%	4.50%	5.00%	5.50%
(mm)	(%)	(%)	(%)	Weight Retained (gm)				
19	100-0	100	0	0	0	0	0	0
12.5	75-90	82.5	17.5	202.7	201.6	200.6	199.5	198.5
9.5	60-80	70	12.5	144.8	144	143.3	142.5	141.8
4.75	40-60	50	20	231.6	230.4	229.2	228	226.8
2.36	20-40	30	20	231.6	230.4	229.2	228	226.8
1.18	5-15	10	20	231.6	230.4	229.2	228	226.8
0.075	3-8	5.5	4.5	52.11	51.84	51.57	51.3	51.03
Pan			1.5	17.37	17.28	17.19	17.1	17.01
			4	46.32	46.08	45.84	45.6	45.36
Total				1158	1152	1146	1140	1134
Bitumen				42	48	54	60	66

Table 6.Aggregates gradation for determination of OBC for 6% Marble Dust

Sieves	Class Range	%age Pass	%age Retain	Bitumen Content				
				3.50%	4.00%	4.50%	5.00%	5.50%
(mm)	(%)	(%)	(%)	Weight Retained (gm)				
19	100-0	100	0	0	0	0	0	0
12.5	75-90	82.5	17.5	202.7	201.6	200.6	199.5	198.5
9.5	60-80	70	12.5	144.8	144	143.3	142.5	141.8
4.75	40-60	50	20	231.6	230.4	229.2	228	226.8
2.36	20-40	30	20	231.6	230.4	229.2	228	226.8
1.18	5-15	10	20	231.6	230.4	229.2	228	226.8
0.075	3-8	5.5	4	46.32	46.08	45.84	45.6	45.36
			.5	5.79	5.76	5.73	4.56	4.536
Pan			5.5	63.69	63.36	63.03	62.7	62.37
Total				1158	1152	1146	1140	1134
Bitumen				42	48	54	60	66

1) *Stability Determination:* Under the Marshall Load frame, samples were put and the load was vertically applied at a rate of 50 mm per minute. The sample's maximum failure load is stated as the value of Marshall Stability.
2) *Stability Curve and Flow Curve:* The variation of the Marshall Stability curve and flow value for the varying percentage of bitumen content is shown in Fig 1 and Fig 2. It can be concluded from the curve that in bituminous mixtures with a bitumen content of 4.5 percent, stability (i.e. load-taking capacity) was higher, after which it started to decline. It may be concluded from this that the optimum bitumen content for a good bituminous mix is 4.5 percent. Typically, the flow curve shows a linear pattern, with the increase of bitumen content.

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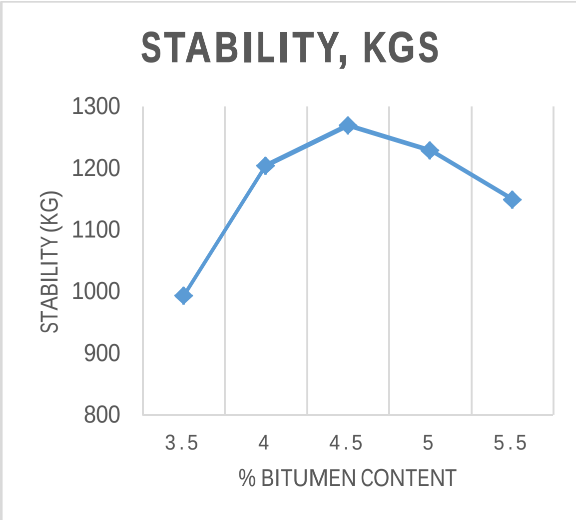

Figure 1. Curve of Marshal-Stability Test to assess OBC

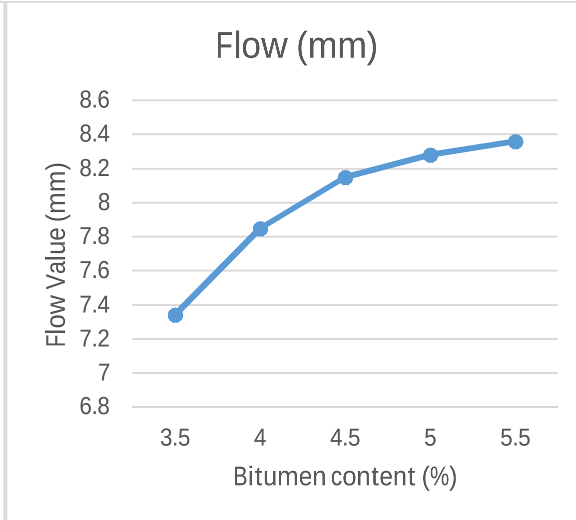

Figure 2. Curve of Marshal-Flow Test to assess OBC

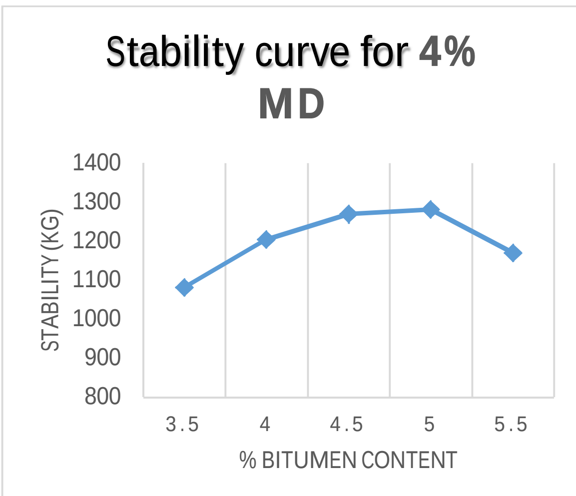

Figure 3. Curve of Marshal-Stability Test to assess OBC

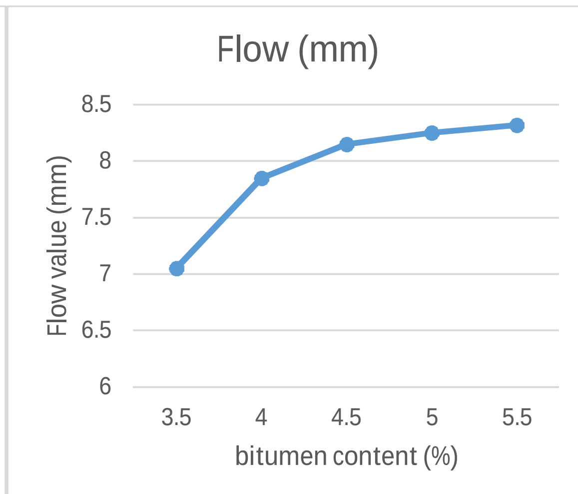

Figure 4. Curve of Marshal-Flow Test to assess OBC

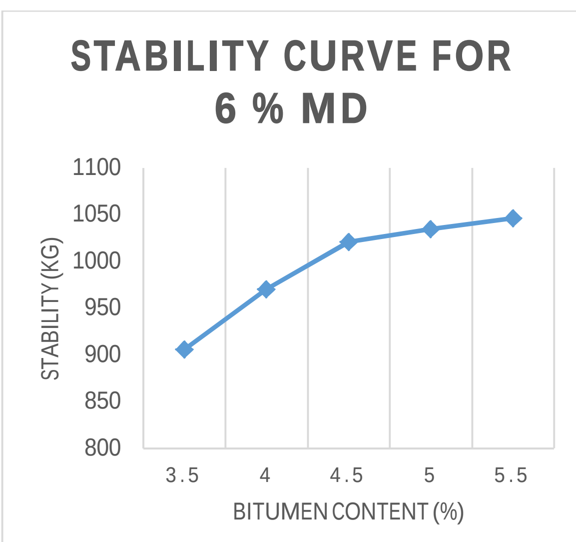

Figure 5. Curve of Marshal-Stability Test to assess OBC

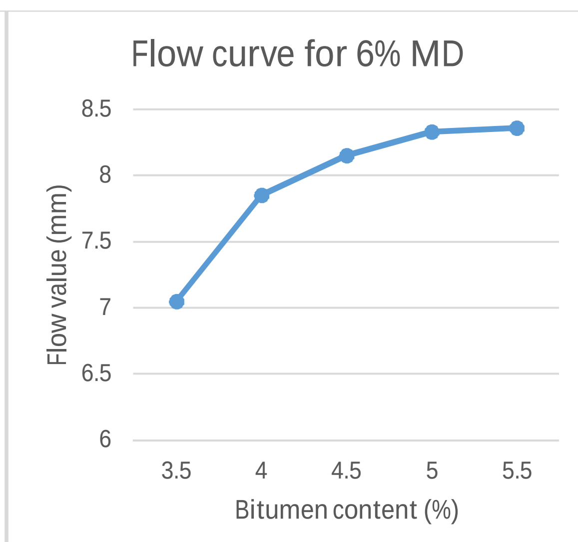

Figure 6. Curve of Marshal-Flow Test to assess OBC

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C. *Marshal Stability Test for the Determination of Optimum Marble Dust (%) in Bituminous Mix*

After evaluating the optimum bitumen content for a good mix, the percentage of marble dust as a filler material was measured. In addition to the bituminous mix, the amount of marble dust collected from the nearest site ranged from 0 percent to 6 percent of the total weight. The sample was weighed for density determination, at room temperature, in air and clean water. To measure the volume, the distinction between the two weights in gram was used. Sample bulk density
(Gb) is given by

$$Gb = \frac{Weight\ of\ specimen\ in\ air}{Volume\ of\ specimen}$$

1) *Marshal Stability Curves:* Figures 7 and 8 show the schematic illustration of the stability curve for the variation in the percentage of marble dust for Marshall Samples at the optimum bitumen content. Maximum stability is obtained for marble dust samples is 2363.7 kg at 4 percent marble dust. By further increasing the percentage of marble dust, the reduction in the stability value may be related to the reduction in the percentage of sample air voids needed for the bituminous mix design.
2) *Marshal Flow Value Curves (mm):* Figures 9 and 10 display the schematic illustration of the flow value curve for variance in the percentage of marble dust for Marshall Samples at optimum bitumen content.

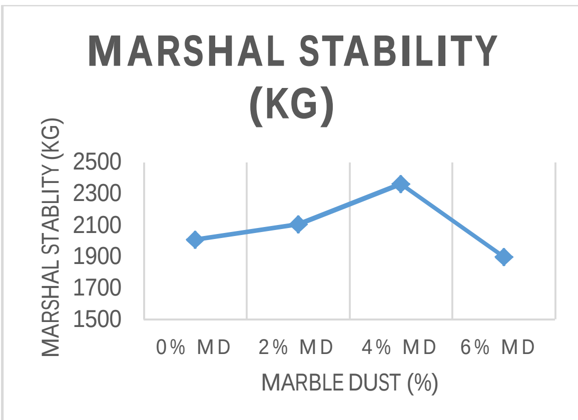

Figure 7. Curve of Marshal-Stability Test to assess OBC

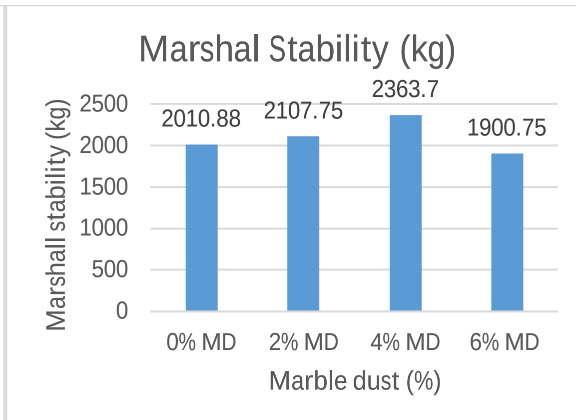

Figure 8. Curve of Marshal-Stability Test to assess OBC

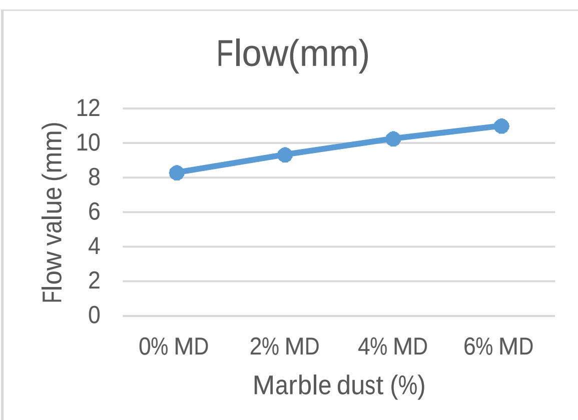

Figure 9. Curve of Marshal-Flow Test to assess OMD

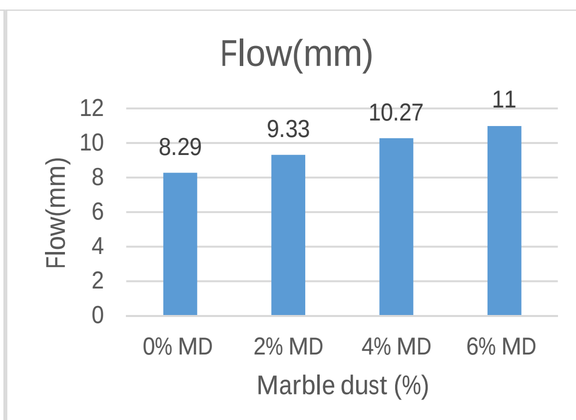

Figure 10. Curve of Marshal-Flow Test to assess OMD

3) *Air Voids and VMA:* For each series of test samples, after completion of the flow and stability test, a void and density analysis was conducted. The percentage of the specimen's air voids is given by

$$Vv = \left(\frac{Gt-Gb}{Gb}\right) * 100$$

Where, $Gb = Bulk\ Density$

$$Gt = Theoretical\ specific\ gravity\ of\ mixture\ = \frac{100}{\frac{W1}{G1}+\frac{W2}{G2}+\frac{W3}{G3}+\frac{W4}{G4}}$$

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Where,

$W1$ = %age weight of coarse aggregates in total mix ; $W2$ = %age weight of fine aggregates on total mix; $W3$ = %age weight of filler in total mix; $W4$ = %age of bitumen in total mix

$G1$ = Apparent specific gravity of coarse aggregate; $G2$ = Apparent specific gravity of fine aggregate; $G3$ = Apparent specific gravity of filler; $G4$ = Apparent specific gravity of bitumen

Using the formula given below, the percent voids in mineral aggregate (VMA) were calculated.

$$VMA = Vv + Vb$$

Where, $Vv = Volume\ of\ air\ voids$

$$Vb = Volume\ of\ bitumen = Gb * \left(\frac{W4}{G4}\right)$$

Table 7. Marshall Test results for different sizes of bituminous mix

Marble Dust (%)	Wt. in air (gm)	Wt. in water (gm)	Stability value (kg)	Flow value (mm)	Gt	Gb	% air voids	VMA (%)
0	1187.8	683.8	2010.88	8.29	2.31	1.03	7.56254	16.035
2	1190.6	684.75	2107.75	9.33	2.32	1.03	6.37263	15.9812
4	1200.1	693.4	2363.70	10.27	2.34	1.03	6.12236	15.7024
6	1160.85	669.15	1900.75	11	2.32	1.03	5.79653	17.7651

III. RESULTS AND DISCUSION

A. The optimum bitumen content was found to be 4.5 percent, 5 percent and 5.5 percent for a bituminous concrete (2%, 4% and 6% Marble-Modified bituminous concrete) that displayed a high stability value and then slowly decreased. This may be due to the decrease of the minimum air void needed for further mix densification.

B. Bituminous mixes displayed overall stability of 2363.7 kg at 4 percent with different percentages of marble dust as filler at optimum bitumen content, showing an increasing trend to 4 percent and then decreasing.

C. The flow value displayed an ascending pattern, and the percentage of air voids acquired was seen to decrease with an increase in marble dust.

IV. CONCLUSIONS

It can be determined from the analysis that the waste dust produced from marble can be effectively used as a filler material in bituminous mixes without affecting its strength characteristics. However, more studies have to be carried out to understand the characteristics of the filler and its effect on the performance of fatigue and rutting. Further modification of design mixes can result in the use of marble dust as fillers in bituminous pavement, thus partly resolving the disposal of construction and industrial waste. After the cost has been carried out, the cost effectiveness of these unconventional filler materials may be assessed.

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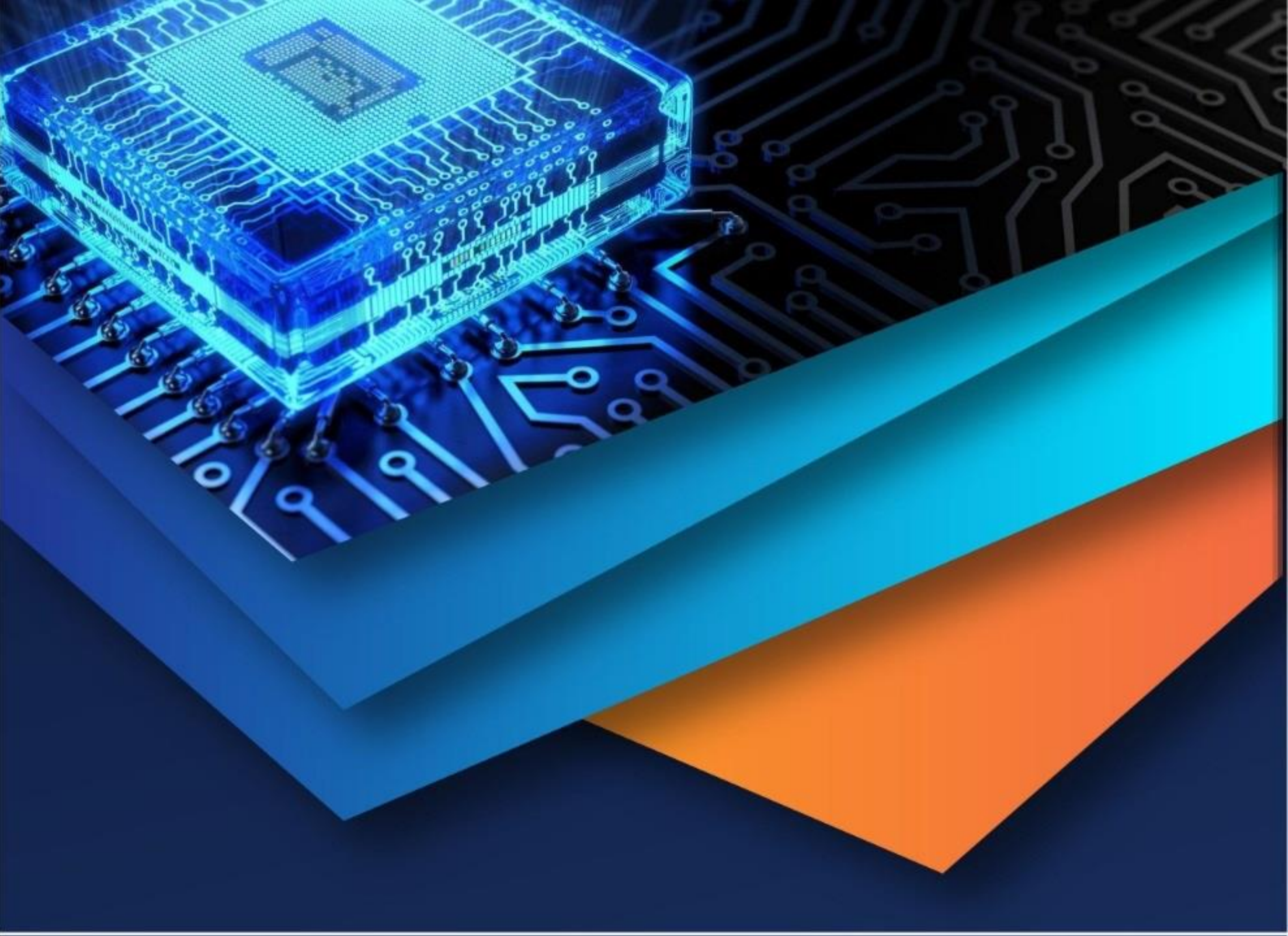
REFERENCES

[1] M. Z. Chen, J. T. Lin, S. P. Wu, and C. H. Liu, "Utilization of recycled brick powder as alternative filler in asphalt mixture," Constr. Build. Mater., vol. 25, no. 4, pp. 1532–1536, 2011.
[2] Ş. Sargin, M. Saltan, N. Morova, S. Serin, and S. Terzi, "Evaluation of rice husk ash as filler in hot mix asphalt concrete," Constr. Build. Mater., vol. 48, pp. 390–397, 2013.
[3] J. Wilanowicz, W. Grabowski, M. Andrzejczak, and A. Chromiec, "Assessment of the suitability of baghouse dusts from a dust extractor as fillers for hot-mix asphalt," Procedia Eng., vol. 57, pp. 1269–1277, 2013.
[4] R. Mistry and T. K. Roy, "Effect of using fly ash as alternative filler in hot mix asphalt," Perspect. Sci., vol. 8, pp. 307–309, 2016.
[5] I. Hafeez and M. A. Kamal, "Effects of Mineral Filler to Polymer Modified Bitumen Ratio on the Design Properties of Hot Mix Asphalt and its Performance," vol. 29, pp. 581–588, 2010.
[6] AASHTO Guide for Design of Pavement Structures, 1993
[7] AASHTO 2004 Determining the Soundness of Aggregates by Sodium Sulphate or Magnesium Sulphate, AASHTO Designation T104.
[8] National Highway Authority, NHA., 1998, "General Specifications", Surface Courses, Item No.305, Pakistan.



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