Partial Replacement of Ceramic Tile Dust in Bituminous Mix

G. M. H. RASHID[1], A. A. MAMUN[2], I. E. EPU[3]

[1]*Department of Civil Engineering, RUET, Bangladesh (gmharun.ruet11@gmail.com)*
[2]*Department of Civil Engineering, RUET, Bangladesh (abdullahasiya117@gmail.com)*
[2]*Department of Civil Engineering, RUET, Bangladesh (epu130055 @gmail.com)*

Abstract

Recent decades have seen a marked upsurge in industrial and economic growth, contributing to an improved quality of life and well-being for citizens. However, we should not lose sight of the fact that every production system creates by-products and waste products which can affect the environment. These effects may occur at any point in the product's life cycle, weather during the initial phase of obtaining raw materials, during the transformation and production phase, during product distribution or when the end user must dispose of products which are no longer required. To save money and keep environment pollution free recycling of waste materials is the best way. In this investigation an attempt is made to study the stability and properties of bituminous pavement materials by the partial replacement of waste ceramic tile dust as fine aggregate with an increment of 10%. Ceramic waste may come from two sources. The first source is the ceramic's industry, and second is the construction sight of ceramic's work. If ceramic tile dust can be utilized in pavement construction, the disposal and pollution problem can be minimized. The main objective of this study is to determine sufficient bitumen content and mix stability to ensure a durable pavement after being partial replacement of ceramic tile dust. And also to determine a cost effective blend this study will be conducted. The proposed mix design will be conducted in accordance with Marshall Mix design. Finally, the percentage of ceramic tile dust which can be economically replaced in bituminous mix for flexible pavement design will be analyzed.

Keywords: *Ceramic tile dust, Bitumen, Aggregate, Marshall Stability test and Cost Effective.*

1 Introduction

World population are increasing day by day and various types of waste production have also increased. Many of these waste sometimes remain in the environment for long time. Ceramic tile dust is one of these wastes. About 15%-30% waste material generated from the total production in in the ceramic industry (Bhavin and Bhatt, 2017).

In Bangladesh the National Highways are the backbone of land transportation and most of the roads of this country are bituminous road. Marshall hot mix is widely used in flexible pavement design. The pavement performance is determined by the properties of bitumen and also depends on other materials used in the mix. In this study ceramic tile dust have been used in bituminous mix as fine aggregate and have tried to find out optimum percentage of ceramic dust that would be cost effective and safe. It will also reduce the environment pollution which is caused by the disposal of ceramic tile dust.

Various studies have already been conducted with various types of waste materials such as Fly ash, Lime, Fibers, Silica Fumes, Plastics, Rubber, Synthetic, Polythene etc. Compare the compressive strength and durability properties of concrete by replacing 20% cement with ceramic waste (Torgal, 2009). Fly ashes along with conventionally used stone dust are used as filler in bituminous concrete and comparison is made between them. The results show that all fly ashes are good as filler and can be used in bituminous construction up to 7% and also fly ash group rich in calcium oxide gave better results (Sharma and Chandra, 2011). Reduction of optimum bitumen content in bituminous mixes using plastic coated aggregates which results in economic in construction of bituminous concrete and also solve disposal problem of plastic waste (Rema and Stephen., 2013). Study the (OPC) cement has been replaced by ceramic waste in the range of 0%, 10%, 20%, 30%, 40% & 50% by weight for M-3

grade concrete and concrete samples tested and compared in terms of compressive strength to the conventional concrete (Kumar et al., 2013). Study is to investigate the effects of using crushed ceramic in the production of interlocking paving units (Sadek et al., 2013). Use of ceramic wastes in concrete production with the aim of reducing cement and fine aggregate content (Zimbili et al., 2014). A study on effect of ceramic waste in bituminous concrete mixes (Singh and Patel., 2015). A study on effect of waste ceramic tiles in flexible pavement (Bhavin and Bhatt, 2017).

A tile is a manufactured piece of hard-wearing material such as ceramic, stone, metal, or even glass, generally used for covering roofs, floors, walls, showers, or other objects such as tabletops. During home decoration, exposure to dust generated from cutting, grinding or drilling ceramic tiles is one of the most important occupational hazards to decorate. An attempt has been made to use of those waste ceramic tile dust in bituminous mix design which would be beneficial.

2 METHODOLOGY

In this test Ceramic Tile dust was collected from local construction site. The appearance of the collected ceramic tile and the properties of it are represented below.

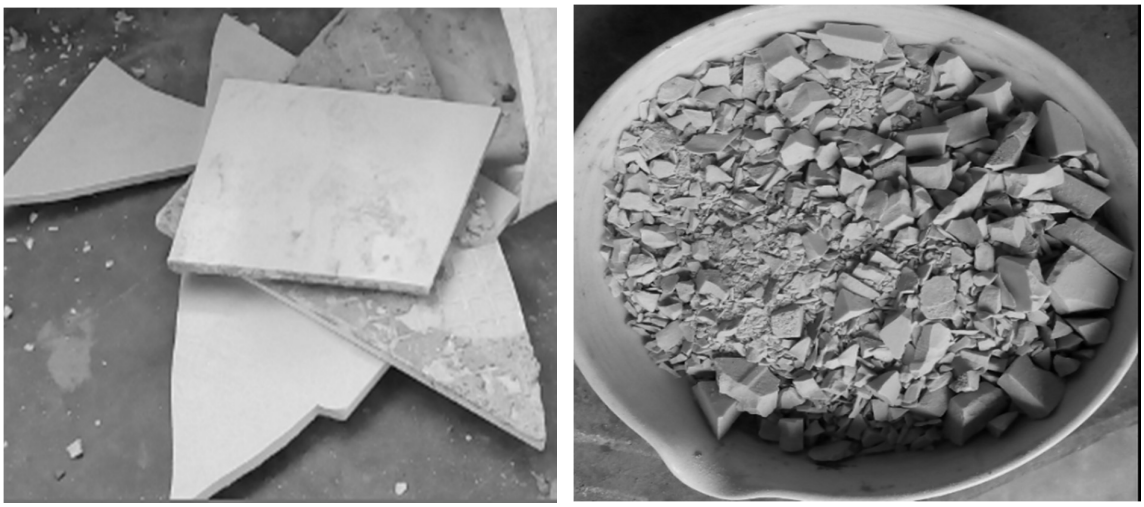

Figure 1. Physical Appearance of ceramic tile dust

Table 1. Chemical composition of ceramic tile dust

Sl. No.	Oxides	Range (%)	Typical value (%)
1	SiO_2	62.0-88.0	64.92
2	Al_2O_3	22.0-28.0	25.19
3	Fe_2O_3	0.4-0.8	0.7
4	TiO_2	0.6-0.9	0.7
5	CaO	0.2-0.5	0.36
6	MgO	0.4-0.7	0.55
7	K_2O	3.0-5.0	4.50
8	Na_2O	2.0-4.0	2.57

Source: www.allstarma.net

The specific gravity of the materials used in bituminous mix were determined according to the procedure specified by AASHTO T85,T84,T133,T229 respectively and results were given in Table 1.

Table 2. Bulk specific gravity of materials used in bituminous mix.

Materials	CA (Crushed stone)	FA (Coarse sand)	FA (Tile dust)	MF (Fine sand)	Binder (Bitumen)
Specific Gravity	2.78	2.49	2.32	2.65	1.02

2.1 Mix Design

The objective of the study is to make a comparative study of asphalt mixes with partial replacement of fine aggregate ceramic tile dust in different percentages and to find out the optimum percentages of mix. Six types of mixes were studied and these were designed as mix types A, B, C, D, E and F.

Mix A: in which fresh FA is 100%
Mix B: in which fresh FA is 90% and 10% ceramic tile dust.
Mix C: in which fresh FA is 80% and 20% ceramic tile dust.
Mix D: in which fresh FA is 70% and 30% ceramic tile dust.
Mix E: in which fresh FA is 60% and 40% ceramic tile dust.
Mix F: in which fresh FA is 50% and 50% ceramic tile dust.

2.2 Marshall properties

At a standard test temperature of 60°C, maximum load is carried by a compacted specimen as defined in Marshall stability test. The deformation of the Marshall Test specimen that undergoes during the loading upto the maximum load in 0.25 mm units is the flow value (Tambake, Kumar, and Manjunath, 2014). Hot mix aggregate with bitumen is applicable for Marshall test. Stability, flow value, unit weight, total voids in a mix, voids in mineral aggregates and voids filled with bitumen known as Marshall properties were found for fresh aggregate and for different percentages of ceramic tile dust which was replaced as fine aggregate. Bitumen content versus Marshall properties graphs were plotted. The bitumen content was found out from graphs for maximum stability, maximum unit weight and 4% air voids to determine the optimum bitumen content (OBC). The average value of these three bitumen content is the optimum bitumen content (OBC). According to Ministry of Road Transportation Highways (MORTH), the maximum permissible air voids is 3%-5%.

3 Tables and Figures

Marshall test results and OBC values for different percentages of ceramic tile dust replacement as fine aggregate is tabulated in Table 3.

Table 3. Marshall Test results

Aggregate types	OBC (%)	Unit Wt. ($kg/m^{3)}$	Marshall stability (KN)	Flow value (0.25mm)	%Va	%VMA	%VFB	Marshall Stiffness (KN/mm)
A	5.48	2348	14.60	14.8	4.10	13.75	72	3.95
B	5.55	2328	13.55	14.10	4.00	14.40	75	3.84
C	5.45	2352	14.54	14.50	3.51	14.40	78	4.01
D	5.4	2348	14.10	14.60	3.60	14.55	80	3.86
E	5.52	2347	14.50	13.80	3.80	15.60	78	4.20
F	5.58	2320	14.80	14.80	4.10	17.40	72	4.00

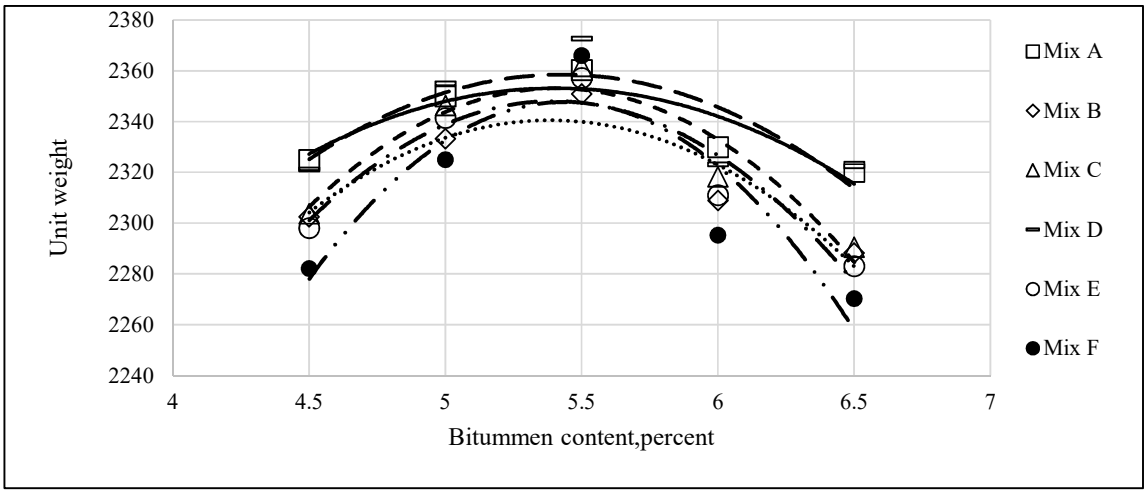

Figure 1. Relationship between Unit weight and percent bitumen content for different mixes

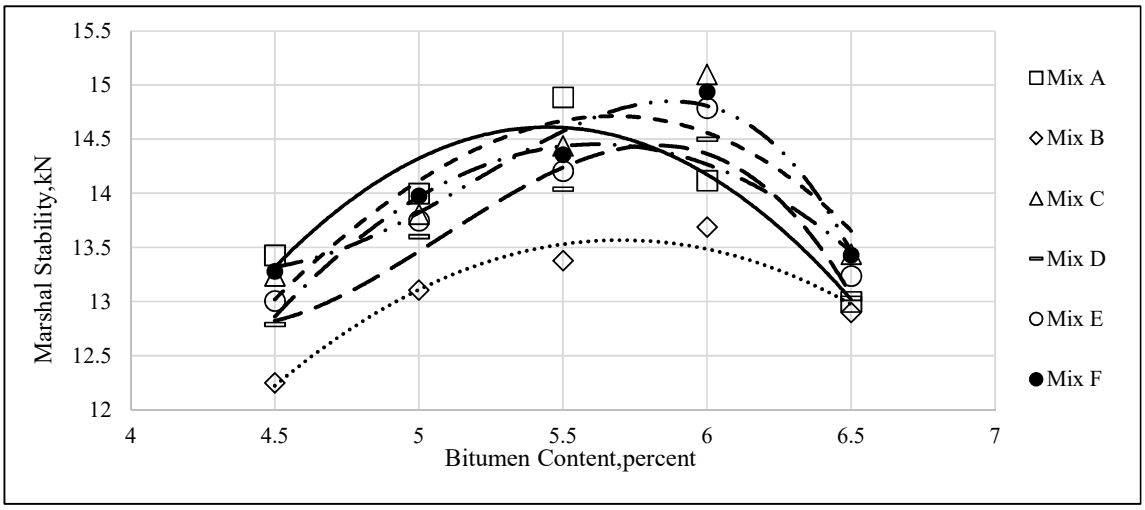

Figure 2. Relationship between Marshall Stability and percent bitumen content for different mixes

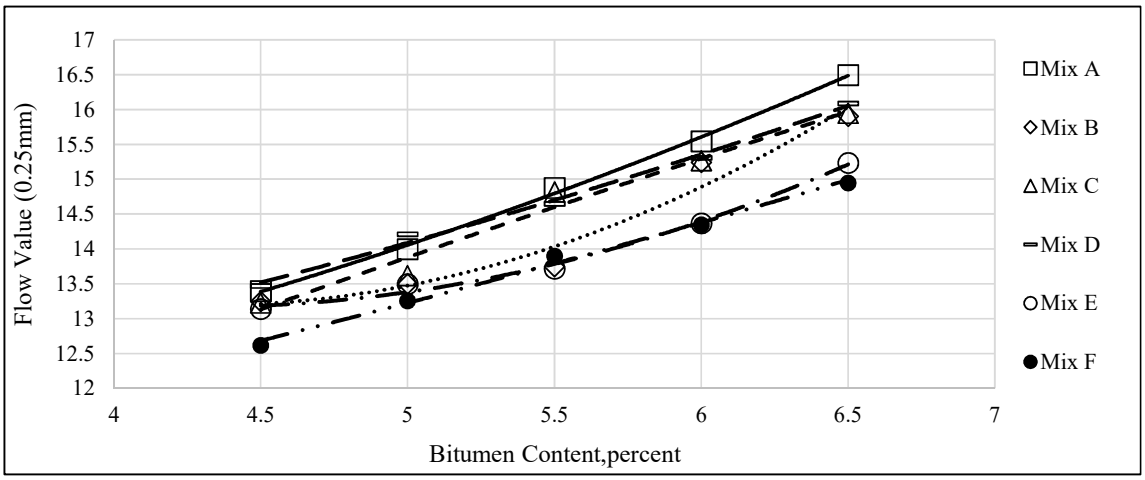

Figure 3. Relationship between Flow Value and percent bitumen content for different mixes

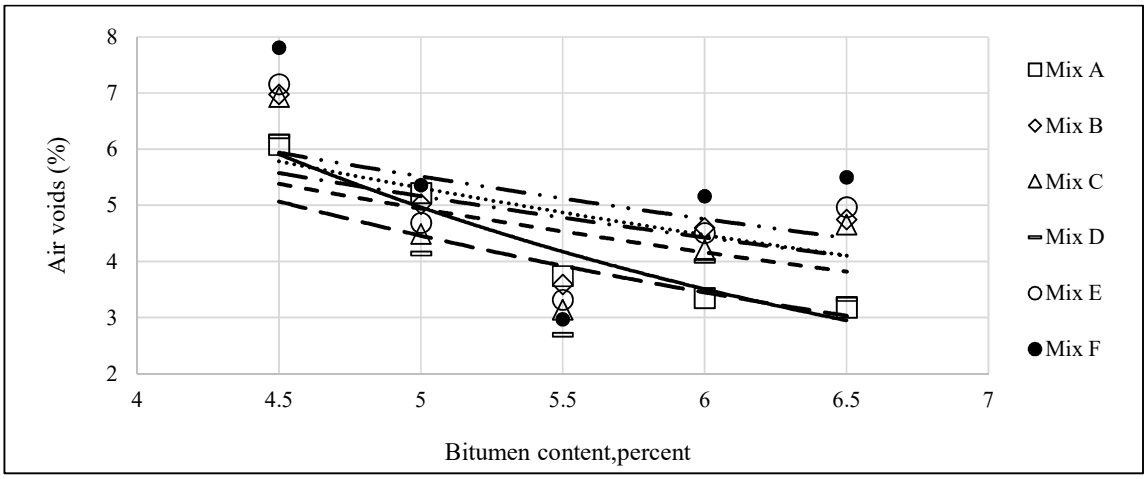

Figure 4. Relationship between Air voids and percent bitumen content for different mixes

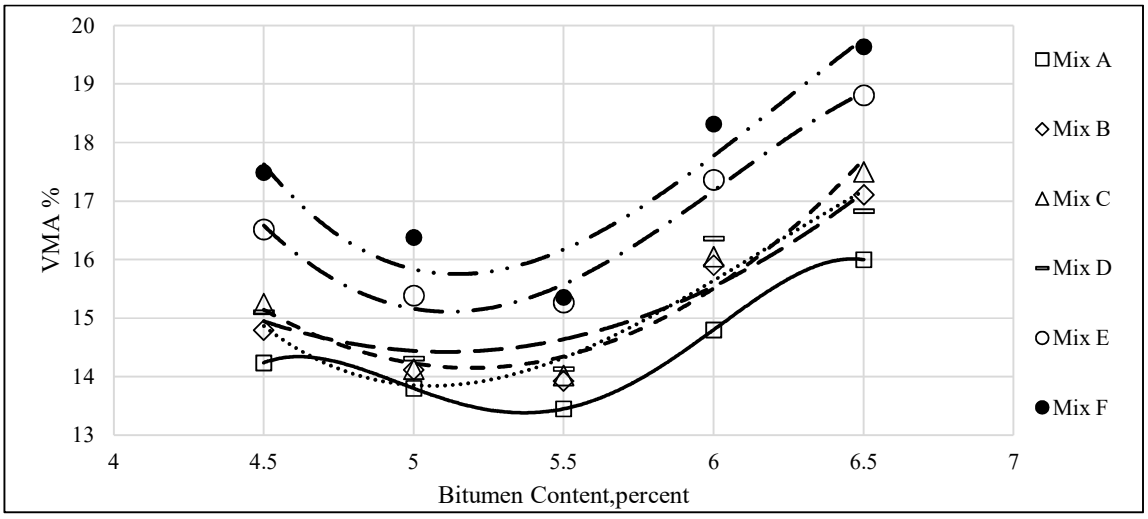

Figure 5. Relationship between %VMA and percent bitumen content for different mixes

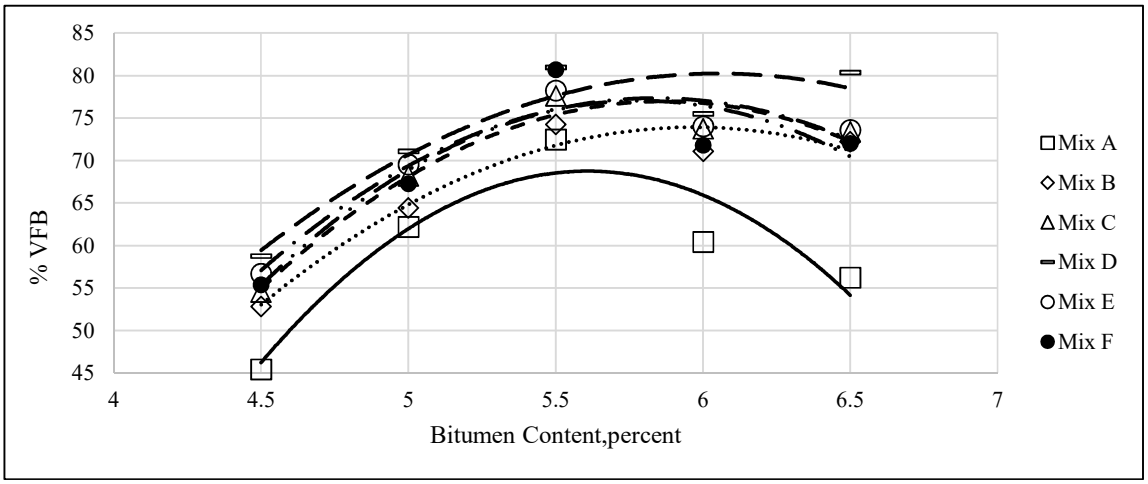

Figure 6. Relationship between %VFB and percent bitumen content for different mixes

4 Results and Discussions

In the Marshall Mix design generally sand is used as fine aggregate. In this experiment Marshall Properties have been examined by partial replacement ceramic tile dust as fine aggregate. This experiment has conducted as the specific gravity of sand and ceramic tile dust are very close. From the test result it has seen that with the increasing percentage of ceramic dust up to 30%, OBC has decreased but it has increased only by 1.8% for 50% replacement of ceramic tile dust.

Unit weight has increased up to 20 % replacement, then decreases and Marshall Stability gradually increases after 20% replacement of ceramic dust. Unit weight has decreased to a negligible amount but stability has increased to a significant amount. Flow value has decreased up to 20% replacement and then gradually increased. But it has remained within the allowable limit for medium traffic condition according to Asphalt Institute, 1997.

The air void is another significant parameter which has considered during this test. The limiting value of air void is 3% to 5% for flexible pavement design and the values of air voids obtained from this experiment have remained within the permissible limit. %VMA and %VFB have also remained within the range. Marshall Stiffness has also increased with the increasing of percentage of ceramic tile dust as fine aggregate.

5 Conclusions

- Ceramic tile dust is suitable for bituminous mixes from the consideration of aggregate properties.
- With the increasing percentages of ceramic tiles dust the Marshall stability is gradually increasing. So, it is recommended to use higher percentages of replacement as fine aggregate.

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