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# Effect of Waste Cement Dust as Mineral Filler on Marshall Properties of Hot Mix Asphalt

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**Original Research Article**

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**Abstract:** Using cement dust in asphalt mixing can have many environmental advantages. Before widely adapting cement dust in asphalt paving, trial sections and adequate provisions should be provided. By pass cement dust is proposed within this research as an alternative to traditional mineral filler in hot mix asphalt (HMA). The effect of using waste cement dust as mineral filler on the Marshall properties of hot mix asphalt was investigated. The optimum cement dust content was determined. Five asphalt concrete mixtures with various cement dust contents, namely; 0%, 30%, 50%, 70% and 100% by weight of the filler were studied. Laboratory testing has revealed an enhancement in Marshall when cement dust was used. Marshall testing results have indicated an increase in the stability, unit weight and a decrease in the flow, voids ratio and voids in mineral aggregates when the percentage of cement dust content increases. The optimum cement dust ratio was found to be 100% of the used mineral filler. Hence, cement dust can totally replace filler in asphalt paving mixtures.

**Keywords:** Waste Cement Dust, Mineral Filler, Marshall Properties, Hot Mix Asphalt, Waste Materials.

## INTRODUCTION

Cement kiln dust (CKD) is a by –product of cement manufacturing .it is a fine powdery material similar in appearance to Portland cement. It is composed of micronized particles collected from electrostatic precipitators during the production of cement clinker.

It is generated during the calcining process in the kiln. Lime (CaO) constitutes more than 60% of CBPD composition. Other compounds include SiO2, Al2O3, Fe2O3, K2O, Na2O, Cl, etc. most of cement company generates huge quantities of CBPD every year .some CBPD is recycled back again with the clinker. However, most of the material is disposed of on –site without any further reuse or reclamation [8]. There are two types of cement kiln processes: wet-process kilns, which take feed materials in a slurry form; and the dry process kilns, which accept feed materials in dry-ground form. In both of these processes, cement kiln dust can be collected in two ways: (i) part of the dust can be separated and returned to the kiln from the dust collection system (cyclone) close to the kiln, or (ii) the total quantity of dust generated can be recycled or discarded. The chemical composition of CKD depends both on the raw materials used to produce the clinker, and on the type and source of carbon-based fuel to heat the material in the rotary kiln. Waste material recycling into useful products has become a main solution to waste disposal problems. Many highway agencies are conducting wide variety of studies and research mental suitability, and performance of using recycled products in highway construction. Major environmental problems arise from the disposal of kiln dust [7]. This dust production is not only unpleasant for the worker, but also creates equipment failures, decrease efficiency and produce maintenance problems. Therefore, the design of the plant includes different types of filters and dust collectors which investment up to 12% of the entire cost of the plant. Some fines have a considerable effect on the asphalt cement making it act as a much stiffer grade of asphalt cement compared to the neat asphalt cement grade, and thereby affect the HMA pavement performance including its fracture behavior [2-5]. The current study is performed to study the effect of using waste cement dust obtained from white cement industry in asphalt concrete mixtures as a part of the fine aggregate. The current study is performed to study the effect of using waste cement dust obtained from white cement industry in asphalt concrete mixtures as a part of the filler [6].

## MATERIALS CHARACTERIZATION

### Materials

The materials used in this work are locally available in south and middle of Iraq. The properties are evaluated according to American Society for Testing and Materials (ASTM, 2003) standards compared with

the State Organization of Road and Bridge (SORB, 1982) specification requirements.

**Asphalt Cement**

The used asphalt cement was a (40-50) penetration graded form Al- Hilla refinery. The penetration and flash point also the ductility was tested for asphalt cement to check its suitability for hot mix asphalt.

**Table-1: Properties of Used Asphalt Binder**

| Test | Result | Specification |
|---|---|---|
| penetration | 49 | (40-50) |
| Flash point | 237 | Min 232 |
| ductility | 102 | >100 |

**3-Aggregate**

The source of the aggregate used in this work from Al-Najaf city. This aggregate is widely used in south and middle areas for asphalt works. The graduation of aggregate is very important in hot mix design. The table below shows the sieve analyses for aggregate.

**Table-2: Sieve analyses for aggregate**

| Sieve | %passing | Specification |
|---|---|---|
| 19 | 100 | 100 |
| 12.5 | 90 | 90-100 |
| 9.5 | 88 | 76-90 |
| 4.75 | 59 | 44-74 |
| 2.36 | 46 | 25-58 |
| 0.3 | 12 | 5-21 |
| 0.075 | 5 | 4-10 |

**Filler**

In this study mineral filler have been used including was cement from Karbala governorate. The chemical properties of these three types are presented in Table below.

**Table-3: Physical Properties of Used Mineral Filler**

| Sieve | % Passing (Cement) |
|---|---|
| No.30 | 100 |
| No.50 | 100 |
| No200 | 92 |
| Plasticity Index | 2.6 |
| Specific Gravity | 3.14 |
| Absorption | 1 % |

**Cement Dust**

**A-Chemical properties for the cement dust**

Cement kiln dust (CKD) is a fine, powdery material, portions of which contain some reactive calcium oxide, depending on the location within the dust collection system, the type of operation, the dust collection facility, and the type of fuel used.

**Table-4: Chemical Properties of Cement Dust**

| Constituent | %by weight |
|---|---|
| Caco3 | 55.5 |
| Sio2 | 13.6 |
| Cao | 8.1 |
| K2so4 | 5.9 |
| Caso4 | 5.2 |
| Al2o3 | 4.5 |
| Fe2o3 | 2.1 |
| Kcl | 1.4 |
| Mgo | 1.3 |
| Na2so4 | 1.3 |
| Kf | 0.4 |
| Others | 0.7 |

**B-Physical properties for the cement dust**

It includes the (graduation, plasticity index, specific gravity, absorption) the table below presents these properties.

**Table-5: Physical Properties of Cement Dust**

| Sevie | Passing% |
|---|---|
| No.30 | 100 |
| No.50 | 100 |
| No.200 | 91 |
| Plasticity index | 2.6 |
| Specific gravity | 2.7 |
| Absorption | 1% |

## METHODS OF TESTING (MARSHAL TEST)

This test was carried out according to the ASTM (D1559) which covers the measurement of the resistance to plastic flow of cylindrical specimens of bituminous paving mixture loaded on the lateral surface of the specimen by means of Marshal Apparatus. The Marshall stability is the maximum load the specimen can withstand before failure when tested in the Marshall Stability test. The configuration of the Marshall Stability test is close to that of the indirect tensile strength test, except for the confinement of the Marshall specimen imposed by the Marshall testing head. Thus, the Marshall stability is related to the tensile strength of the asphalt mixture. The Marshall flow is the total vertical deformation of the specimen, in units of 0.01 in, when it is loaded to the maximum load in the Marshall Stability test. The Marshall flow can provide some indication of the resistance of an asphalt mixture to plastic deformation. Mixtures with low flow number are stiff and may be difficult to compact. However, these mixtures are more resistance to rutting than those with high flow numbers. The percent of aggregate, percent of binder air voids, stability, and flow were found for each prepared specimen, using ASTM standard methods. The Marshall stiffness was also determined for these specimens. The result and calculation are presented in chapter Four [1].

**Properties of Asphalt Concrete Mixtures**

In this study, the properties of asphalt concrete mixtures used in testing are:

•Asphalt cement Grade = (40-50)
•Aggregate maximum mineral size = 12.5 mm (1/2)
•Mixing Temperature = 160 Co
•Compaction Temperature = 120 Co

The testing variables for asphalt concrete mixtures include the following:

•Asphalt content, AC% = (4.2, 4.7 and 5.2) %.
•Filler content = cement

## RESULTS AND DISCUSSIONS

The results of all Marshall Stability tests are summarized in below Tables for mixtures with different cement dust content. All results shown for each specimen are the average value of three specimens. It is found that specific gravity and Marshall Stability value increases as the cement dust content increases. While, the flow, % of VMA and % of VTM values decrease as the percentage of cement dust increases. Thus it can be concluded that there is a marked improvement in the Marshall properties of the asphalt concrete mixtures when cement dust is used.

**Marshall Properties**

The results of all Marshall Stability tests using the designed asphalt ratio of 4%

**Table-6: Marshall Stability test results for Mixtures with different cement dust content**

| Mineral filler type Cement Dust% | Cement | Stability (Kn) | Flow Mm | Air Voids | VMA |
|---|---|---|---|---|---|
| 100% | 0% | 8.9 | 2.2 | 4.1 | 18 |
| 70% | 30% | 8.95 | 2.3 | 4 | 17 |
| 50% | 50% | 9 | 2.7 | 4.3 | 16.5 |
| 30% | 70% | 9.2 | 2.2 | 3.7 | 16.4 |
| 0% | 100% | 8.8 | 3 | 3.5 | 17 |

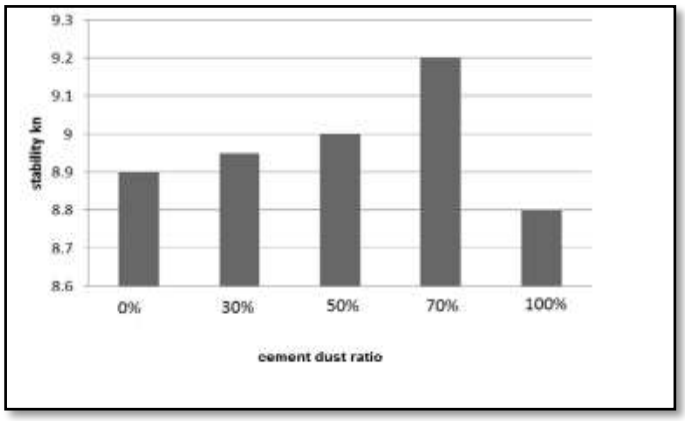


**Fig-1: Stability at Different Cement Dust Percentage**

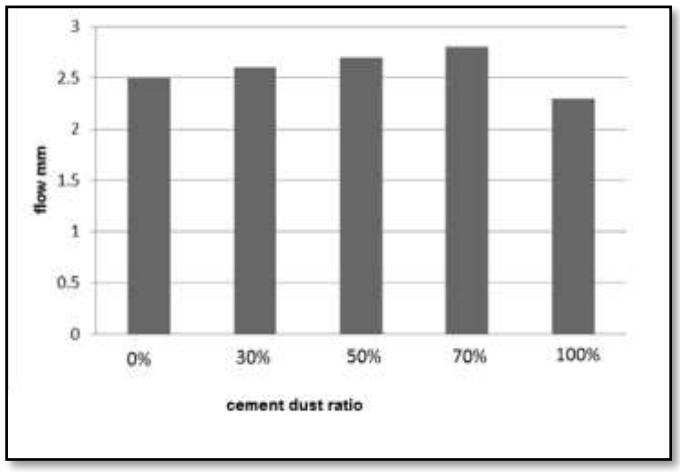


**Fig-2: Flow at Different Cement Dust Percentage**

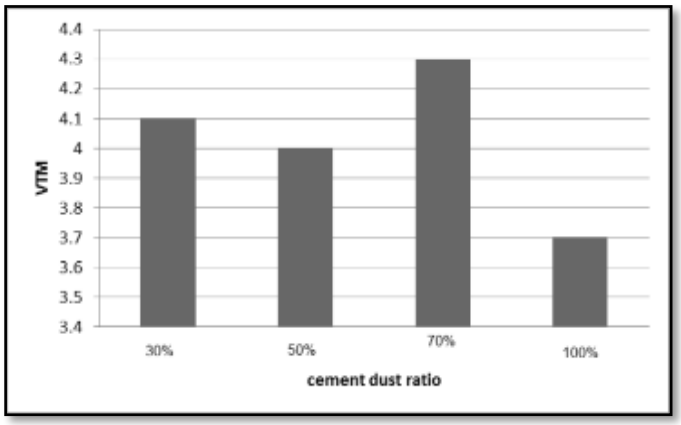


**Fig-3: Void in Total Mix**

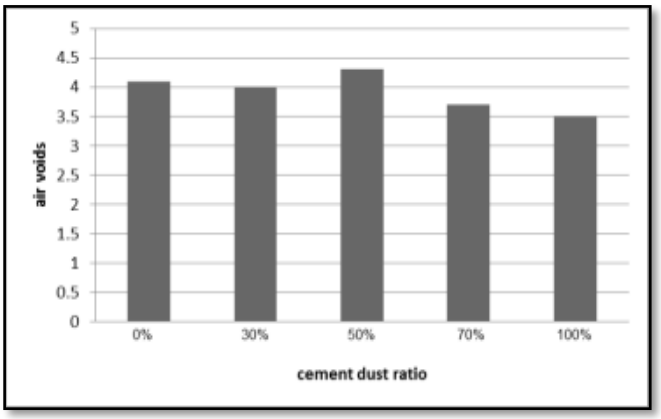


**Fig-4: Voids in Total Mixture for Mixtures with Different Cement Dust Content**

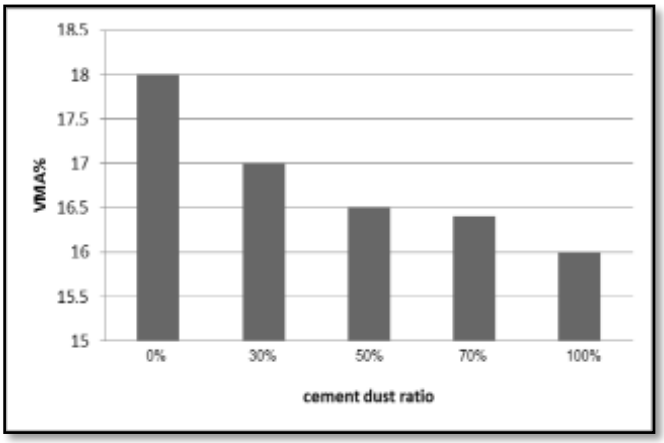


**Fig-5: Voids in Mineral Aggregate at Different Cement Dust Percentage**

## CONCLUSION

Cement dust because more environmental pollution so we proposed in this study using it as mineral filler in hot mix asphalt for paving. It was found that each of Marshall Stability, specific gravity, and increase as the cement dust increase. Flow values, void ratio and voids in mineral aggregates decreases as the cement dust content increases. %. Cement dust can replace as mineral filler in asphalt mixtures because of Optimum cement dust content was found to be 100%.

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