International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 12 Dec. 2022, pp: 201-206 www.ijaem.net ISSN: 2395-5252

Evaluating the Effect of Waste Foundry Sand in Asphalt Concrete Using Marshall Mix-Design Method

[1]Upasana Mishra, [2]Anil Suman
[1]*PG Scholar,*[2]*Assistant Professor*
[1,2]*Department of Civil Engineering*
[1,2]*Shri Shankaracharya Technical Campus -SSGI, Bhilai*

Date of Submission: 05-12-2022 Date of Acceptance: 13-12-2022

ABSTRACT - This works implies that the characteristics of asphalt concrete mix having different proportion of fine aggregate. The percentage of waste foundry sand rangesfrom 20 %, 25 % , 30% , 40% to analyze experimentally the Marshall Mix-Design for the making of this asphalt concrete. The test conducted is Density,Stability, Deformation, Voids in Total Mix, Total Air voids, Voids in Mineral Aggregate. The result shows that the case having waste foundry sand having 25 % are showing better performance as compared to other cases.This mix can be applied in heavy traffic flows.

Keywords - Asphalt, Natural Sand,Density, Stability, Deformation

I. INTRODUCTION

In developed countries, various types of WFS are already being used in a variety of applications, including as a sub-base material for highway construction. The casting industry in Turkey, on the other hand, is landfilling large amounts of foundry sand. Turkey produces roughly 300,000 tonnes of WFS per year (Koyuncu&Guney 2002). The majority of the WFS is considered non-hazardous waste and is currently deposited in a special WFS landfill located far from settlement areas. There is no landfilling legislation in place, nor are there high tipping fees to enable the foundry industry to use their residues. However, rather than dumping WFS in landfills, it is prudent to consider its potential use as a recycling material. Furthermore, previous research in geotechnical field applications has demonstrated that the properties of WFS provide good shear strengths, high compressibility, and low permeability when compared to conventional materials (Ruiz et al. 1997, Koyuncu&Guney 2002). Bakis, Recep (2006), HakanKoyuncustudy was conducted to investigate the reuse of waste foundry sand in asphalt concrete production by replacing a portion of the aggregate with WFS. The results showed that replacing 10% of the aggregates with waste foundry sand was the best option for asphalt concrete mixtures. In addition, the chemical and physical properties of waste foundry sand were examined in the laboratory to determine the potential environmental impact. The findings indicated that the investigated waste foundry sand had no significant impact on the environment near the deposition site.

II. MATERIALS USED

The foundry sand used in this research work are collected from Raipur, Chhattisgarh. Each materials have such physical properties which is to be studied to produce concrete blocks for engineering applications such as VG40 Grade Bitumen, PPC Grade 43, fine natural,foundry Sand and Coarse Aggregate.

III. CASE TRIALS FOR THE CONSIDERED STUDY

In this study, total no. of 12 specimens were utilized out of which 3 specimens of each trial case is been evaluated for each test. The design is been carried by Marshall Mix-design in which four basic requirement is evaluated for Stability, Density, Voids in Mineral Aggregate, Voids Filled with Asphalt to obtain optimized Asphalt content from the mix-design. The cases to be utilized in this research work for the optimized Asphalt Content by using cement as filler material is described below in terms of percentage.

Table 1 Case Trails for the Study (All Values are in percentage)

Test Specimen Case Id	Coarse Aggregate	Fine Aggregate	Filler (Cement)	WFS (Waste Foundry Sand)	Bitumen Asphalt
Sample 1	33	37	5	20	3
Sample 2	33	32	5	25	4
Sample 3	33	27	5	30	5
Sample 4	33	17	5	40	6

IV. MIX-PROPORTION FOR THE MAKING OF ASPHALT-PAVEMENT

The mix-proportion for all the cases is such that the material which were discussed above is mixed based on trial-and-error proportion are as follows-

Table 2 Quantity of Ingredients Required for Mix-Proportion of Trial Cases (in gram)

Test Specimen Case Id	Coarse Aggregate	Natural Sand	Filler (Cement)	WFS (Waste Foundry Sand)	Bitumen Asphalt
Sample 1	695	779	105	420	63
Sample 2	695	673	105	526	84
Sample 3	695	568	105	631	105
Sample 4	695	358	105	842	126

Fig. 1Marshall Bitumen-Aggregate Mix

V. RESULT

5.1 Density

The density of mixture of bitumen with waste foundry sand is previously done by HakanKoyuncu (2006) in which the percentage of foundry sand were from range five to twenty percentage. The result values according to the test are given in table and graph below in which the densities are calculated as per equation-

$$G_{mb} = \frac{W_{air}}{W_{SSD} - W_{water}} \quad \text{……………………………………………..(1)}$$

Table 3 Density values of Asphalt Bitumen Mix

Test Specimen Case Id	WFS (%)	Bitumen Content (%)	Average Density (gm/cm^3)
Sample 1	20	**3**	**2.31**
Sample 2	25	**4**	**2.42**
Sample 3	30	**5**	**2.49**
Sample 4	40	**6**	**2.21**

5.2 Stability Test

The result values according to the test are given in table and graph below in which the stability is calculated as per equation-

$$G_{mm} = \frac{W_f + W_b + W_{ca} + W_{fa} + W_{fs}}{\frac{W_f}{G_f} + \frac{W_b}{G_b} + \frac{W_{ca}}{G_{ca}} + \frac{W_{fa}}{G_{fa}} + \frac{W_{fs}}{G_{fs}}} \quad \text{.................................(2)}$$

Table 4 Marshall Stability values of Foundry Sand–Asphalt Bitumen Mixtures

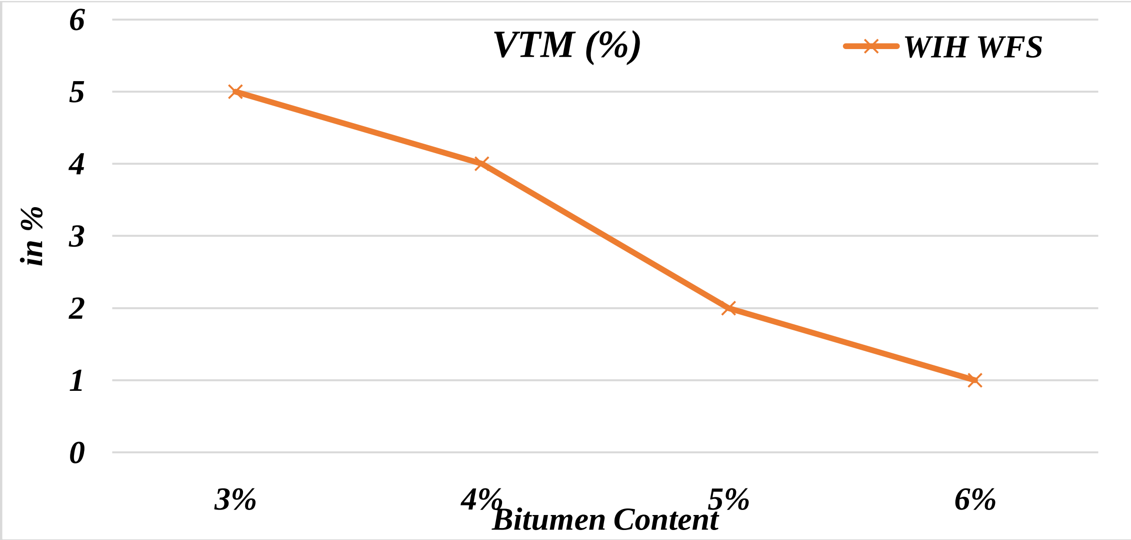
Test Specimen Case Id	WFS (%)	Bitumen Content (%)	Load (KN)
Sample 1	20	**3**	**11.36**
Sample 2	25	**4**	**11.45**
Sample 3	30	**5**	**11.53**
Sample 4	40	**6**	**10.79**

5.3 VTM (Voids in total mixture)

The results based on void of total mixture are given below which is calculated as per equation (3)

$$\text{Voids in Total Mix (VTM)} = \left(1 - \frac{G_{mb}}{G_{mm}}\right) X\ 100 \quad \text{...................................... (3)}$$

where G_{mb} = bulk specific gravity of mixture and G_{mm} = maximum specific gravity of mixture



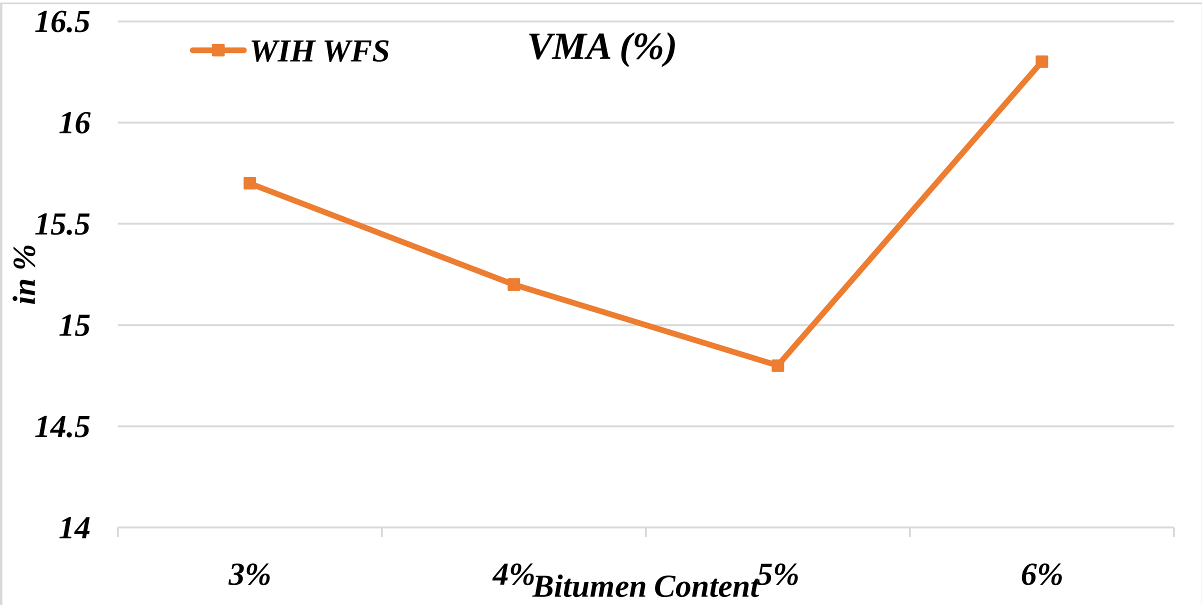
Graph 1Total Voids in Foundry Sand–Asphalt Bitumen Mixtures

5.4 VMA (Voids in Mineral Aggregate)

The results based on mineral aggregate are given in table and graph below which is calculated as per equation (4) -

Voids in Mineral Aggregate (VMA) = $\left(1 - \frac{G_{mb}\ X\ (1-P_b)}{G_{sb}}\right) X\ 100$ ………………………..(4)

Where Pb = asphalt binder content of mixture



Graph 2 Voids in Mineral Aggregate of Foundry Sand–Asphalt Bitumen Mixtures

5.5 VFA (Voids Filled with Asphalt)

The results based on filled asphalt are given in table and graph below which is calculated as per equation (5)

Voids Filled with Asphalt (VFA) = $\left(1 - \frac{VTM}{VMA}\right) X\ 100$ …………………………..(5)

Table 5 Voids in Asphalt of Foundry Sand–Asphalt Bitumen Mixtures

Test Specimen Case Id	WFS (%)	Bitumen Content (%)	VFA (%)
Sample 1	20	**3**	**57**
Sample 2	25	**4**	**68**
Sample 3	30	**5**	**85**
Sample 4	40	**6**	**92**

5.6 Optimum Asphalt Content

From the above result, we must evaluate the optimum asphalt content. The procedure is such that addition of the asphalt content carries maximum density, maximum stability, and the produces exactly 4% air voids (VTM) divided by 3. The mathematical approach is given below-

Optimum Asphalt Content (OAC) = (Max Density + Max Stability + 4% air voids) /3 = (4 + 5 + 4.5) /3 = 4.5 % bitumen content.

It has been seen that the 4.5 % bitumen content is suitable enough for the application in heavy traffic load and in asphalt pavement.

VI. CONCLUSIONS

The flow value indicates that the maximum deformation obtained for the mixture having fine natural sand is 3.7 mm and 3.2 mm for the mixture with waste foundry sand. This exhibit that the less deformation is obtained in foundry-asphalt mix.The stability value indicates that the maximum Marshall stability obtained for the mixture having 11.53 KN for the mixture with waste foundry sand. The stability first increases with increase in bitumen content reach the extreme point then reduces. This curve is common for both with or without foundry sand.The Optimum bitumen content obtained for asphalt mix is about 4.5 %.

REFERENCES

[1]. Akbulut, H. and Gurer, C., 2007. Use of aggregates produced from marble quarry waste in asphalt pavements. Building and Environment, 42 (5), 1921–1930.

[2]. Aramide, F. O, Aribo, S, and Folorunso, D. O (2011), Optimizing the Molding Properties of Recycled Ilaro Silica Sand, Leonardo Journal of Sciences, vol 19, pp. 93- 102.

[3]. Siddique, R., and Sandhu, R. K (2013). Properties of Self Compacting Concrete Incorporating Waste Foundry Sand. Leonardo Journal of Sciences, ISSN-1583-0233 , PP 105-124.

[4]. Joni, H. H., &Zghair, H. H. Effect of adding used-foundry sand on hot asphalt mixtures performance. Eng. &Tech. Journal, 34(6), (2016).

[5]. National Cooperative Highway Research Program, "Recycled Materials and Byproducts in Highway", Washington, D.C., 2013.

[6]. Federal Highway Administration," Foundry Sand Facts for Civil Engineers", Federal Highway Administration (FHWA), Report.

[7]. Goh, Boon Hoe, PushanSunnasee, Kok Hon Chin, Byung Gyoo Kang, and SienTiKok. "Utilisation of Rice Husk Ash in Asphaltic Concrete Pavement." In Advanced Materials Research, vol. 1030, pp. 961-964. Trans Tech Publications Ltd, 2014.

[8]. Shuaibu, A. A., A. I. Mohammed, U. Hassan, B. H. S. Amartey, S. A. Wada, A. Mohammed, and A. M. Rimi. "An Experimental Study on the Performance of Bituminous Concrete Mixtures with Silica Sand as Filler Replacement." Arid Zone Journal of Engineering, Technology and Environment 17, no. 4 (2021): 453-468.

[9]. Shuaibu, A. A., H. S. Otuoze, H. A. Ahmed, and M. I. Umar. "Effect of Waste Foundry Sand as Partial Replacement of Fine Aggregate in Bituminous Concrete Mixture." Nigerian Journal of Engineering 28, no. 2 (2021): 73-73.

[10]. Alves, B. S.Q, Dungan, R. S. C, Raquel L. P. G, Rosa de Carvalho P, Catia R. S (2014), Metals in waste foundry sands and an evaluation of their leaching and transport to groundwater Water, Air, and Soil Pollution vol 225(5), pp 1-11 DOI – http://10.1007/s11270-014-1963-4 .

[11]. Yazoghli-Marzouk, O. Vulcano-greullet, N. Cantegrit, L. Friteyre, L. Jullien, A. (2014), Recyclingfoundry sand in road construction–field assessment, Construction and Building Materials, vol. 61, pp 69-78, https://doi.org/10.1016/j.conbuildmat.2014.02.055 .

[12]. Javed, S. & Lowell, C.W. (1994) Uses of Waste Foundry Sand in Civil Engineering. Uses of Waste Foundry Sand in Highway Construction; Final Report, pp. 109–113. Geotest Engineering, Inc., Houston, Texas, USA