EVALUATION OF ANDESITE WASTE AS AGGREGATE IN THE MIXTURE OF ASPHALTIC CONCRETE

Serdal Terzi[1]   İsmail Uzun[2]*

[1]***Corresponding Author**, Assoc.Prof. Construction Education Department& Faculty of Technical Education, Suleyman Demirel University, 32260 Isparta, TURKEY, Phone: +90 246 211 14 51, Fax: +90 246 237 12 83,*
Email: serdalterzi@sdu.edu.tr

[2] *Lecturer, Construction Education Department& Faculty of Technical Education, Suleyman Demirel University, 32260 Isparta, TURKEY, Phone: +90 246 211 1707, Fax: +90 246 237 12 83,*
Email: ismailuzun@sdu.edu.tr

ABSTRACT

In the study, the use of andesite collected during the shaping process of andesite blocks was investigated in the asphalt mixtures as aggregate material. The samples having andesite and limestone aggregate were prepared and the optimum bitumen content was then determined by the Marshall Stability *Test procedure.*

In addition, the coarse aggregate as limestone and fine aggregate as andesite mixtures, and vice versa, prepared in the stability of these mixtures were determined.

Andesite aggregate mixtures gave higher stability in comparison to limestone aggregate mixtures. In addition, the optimum ratio of bitumen was determined, as the value of andesite aggregate mixtures lowered.

Keywords: Marshall Stability, Andesite, Waste, Aggregate, Flexible Pavement

1. INTRODUCTION

Asphalt concrete is the most commonly used material in pavement because of its superior service performance in providing driving comfort, stability, durability and water resistance. The escalating cost of materials and energy and lack of resources available have motivated highway engineers to explore new alternatives in building new roads [1].
One hundred million tons of aggregate is used each year in road construction in Turkey. The most important qualities of these aggregates are mechanical strength, service life, and safety and environmental aspects on road pavement layer construction [2]. Turkey, like Portugal, Spain, Italy, Greece, Iran and Pakistan, has an important place in natural stone production. The types of natural stone in Turkey number more than 250. Approximately one hundred of these stones are well known and regularly in demand in the international market [3].
Many natural stone or waste material for use as aggregate or filler in hot mix asphalt concrete has been investigated: asphaltite [1], basalt [3-4], hydrated lime [5], recycled fine aggregates powder [6], waste ceramic Materials[7], coarse recycled aggregates [8], recycled waste lime [9], cleaned oil-drill cuttings [10], and marble dust [11].
Among the volcanic rocks, andesite covers a large area where rapid population growth is observed. However, different weathering categories ranging from fresh to residual soil can be observed within the andesite [12]. Andesite has been used in Turkey and many other parts of the world for quite a long time, particularly in civil engineering and architectural procedures such as production of pavements, curbstones, staves, coping, windowsills, jambs, and friezes. Andesite is a silica-containing (53–63%), fine-grained volcanic rock, with a color between grey and black. It has a porphyritic texture and is composed of plagioclase and pyroxene microliths (clinopyroxene and orthopyroxene), feldspar, pyroxene and biotite phenocrysts in a glass matrix, and magnetite minerals in small amounts. Depending on its dark colour mineral components, the colour of andesite varies from light grey to grey, dark grey, black and reddish–brownish–pinky tones. The porosity rate of andesite is between 10% and 25%. Therefore, andesites to be used in indoor and outdoor spaces are exposed to various physical and chemical factors, such as cold, heat, moisture and chemicals commonly used at home, and various impact-induced wearing factors. Andesite materials should be resistant to factors to which they may be exposed in specific environments [13].
In this study, the effect of the use of andesite aggregate in hot-mix asphalt pavements was investigated. The study of aggregate samples was taken in Isparta province and was used as the coarse and fine aggregates in asphalt concrete mixtures.

2. MATERIALS AND EXPERIMENTS

2.1. Materials

Crushed limestone was obtained from quarries around Isparta which are mainly used for highway construction. The aggregate properties are given in Table 1.

Table 1: Properties of aggregate used in the tests

Properties	Standard	Limestone	Andesite
Specific gravity (g/cm^3)	(ASTM C 127-88, 1992)	2.660	2.269
Saturated specific gravity		2.652	2.339
Water Absorption (%)		0.130	3.388
Specific gravity (g/cm^3)	(ASTM C 128-88, 1992)	2.329	2.528
Saturated specific gravity		2.428	2.363
Water Absorption (%)		2.800	5.370
Abrasion Loss (%) (Los Angeles)	ASTM C 131(1996)	20.38	24.86

In the study, aggregate grading curves for asphalt mixtures were obtained from Turkish Highway specifications. It was seen that the available aggregates grading curve was close to the binder layer specification as shown in Figure 1. 75-100 penetration asphalt cement was used to prepare the Marshall Samples. Table 2 shows the chemical analysis results of the andesite samples.

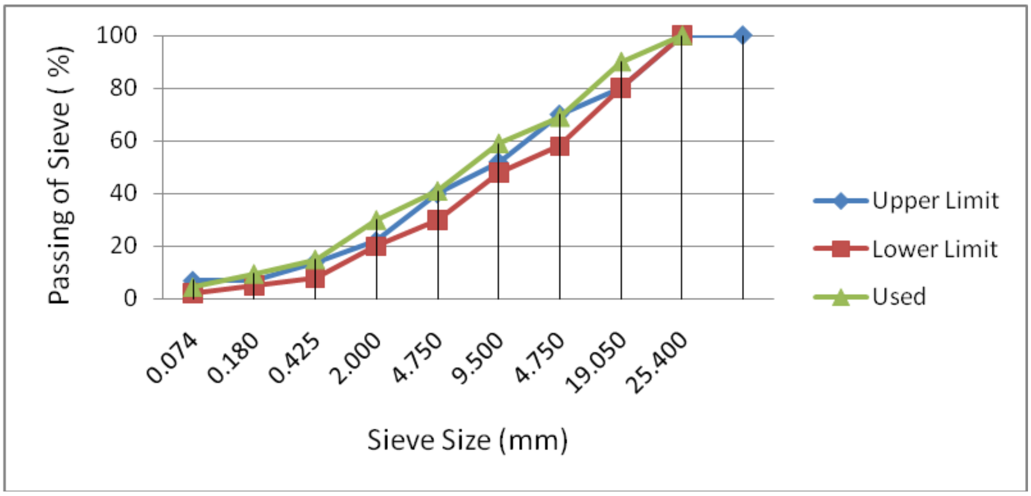

Figure 1: Grading curves of aggregate

Table 2: Chemical analysis results of andesite samples [17]

Properties (%)	**Andesite**
SiO_2	54.27
Al_2O_3	17.65
Fe_2O_3	7.92
CaO	4.12
MgO	1.38
SO_3	0.10
Na_2O	5.88
K_2O	5.63
TiO_2	0.67

3. MARSHALL TESTS

The Marshall Test method was used to determine the optimum percentage of bitumen. Marshall Samples were prepared using the same aggregate gradation with a 4, 5, 6, 7, and 8 percent rate of bitumen.

The samples having andesite and limestone aggregate were prepared and optimum bitumen content was then determined by Marshall Stability Test procedure. In addition, the coarse aggregate (upper No 4 sieve) as limestone and fine aggregate (under No 4 sieve) as andesite mixtures, and vice versa, prepared in the stability of these mixtures were determined.

As shown in the figures, uniform aggregate type mixtures do not give good stability results. The best stability was obtained from using limestone coarse aggregate and andesite fine aggregate. But it should be considered that this mixture needs more bitumen content.

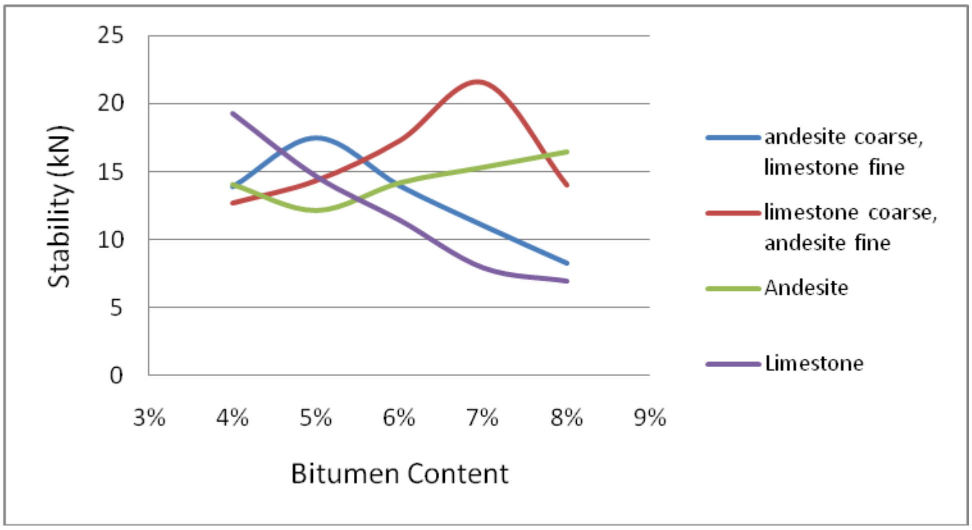

Figure 2: Relationship of stability and bitumen content

For a given asphalt and aggregate mixture, the durability is enhanced if adequate film thickness is attained. For the given effective asphalt content, the film thickness will be greater if the aggregate gradation is coarser. This can most effectively be accomplished by decreasing or minimizing the percentage of fines. Establishing an adequate Voids in Mineral Aggregate
(VMA) during mix design, and in the field, will help establish adequate film thickness without excessive asphalt bleeding or flushing [18]

In this study, limestone mixtures and limestone coarse aggregate with andesite fine aggregate mixtures gave lower air void percentages (Figure 3). Also, voids filled with bitumen give the same results (Figure 4).

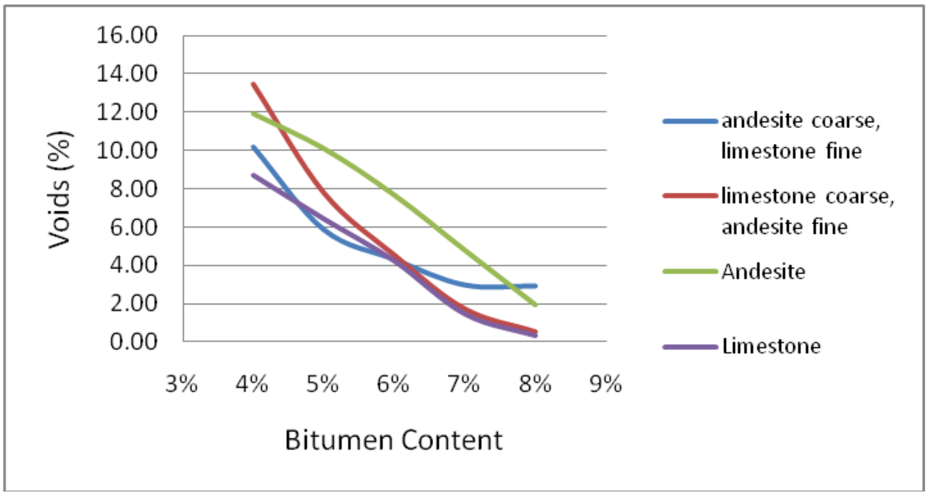

Figure 3: Relationship between air voids and bitumen content

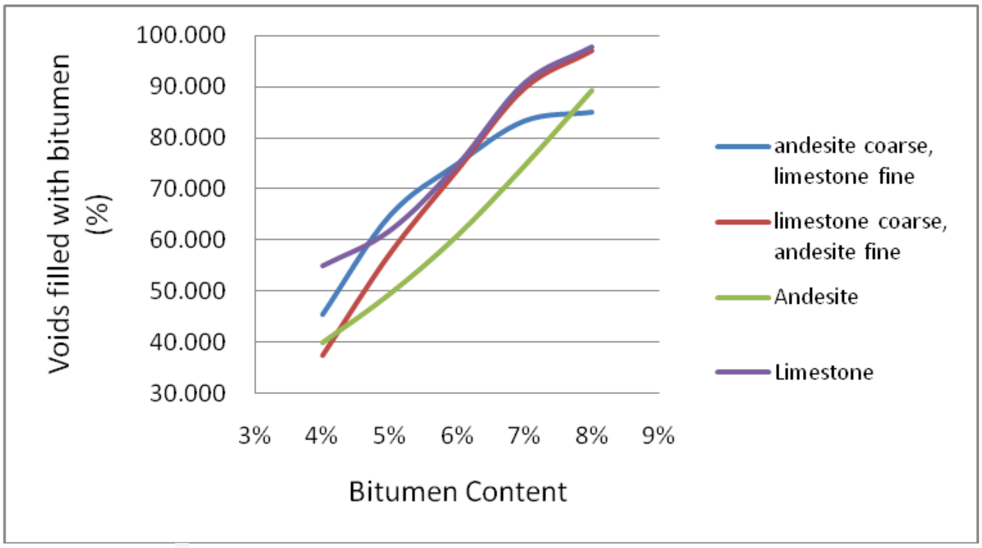

Figure 4: Relationship between voids filled with bitumen and bitumen content

Flow value reflects the properties of plasticity and flexibility of asphalt mixtures. Marshall Samples corresponding to the deformation of the load are broken, which represents a measure of the flow, and also the value of mixing and flow with the value of the internal friction. Flow has a linear inverse relationship with internal friction [19]. Figure 5 shows the relationship between flow and bitumen content. Flow of the mixture with asphalt bitumen, as a result of the experiment showed a linear relationship. Increasing the asphalt cement percentage also increases the flow value.

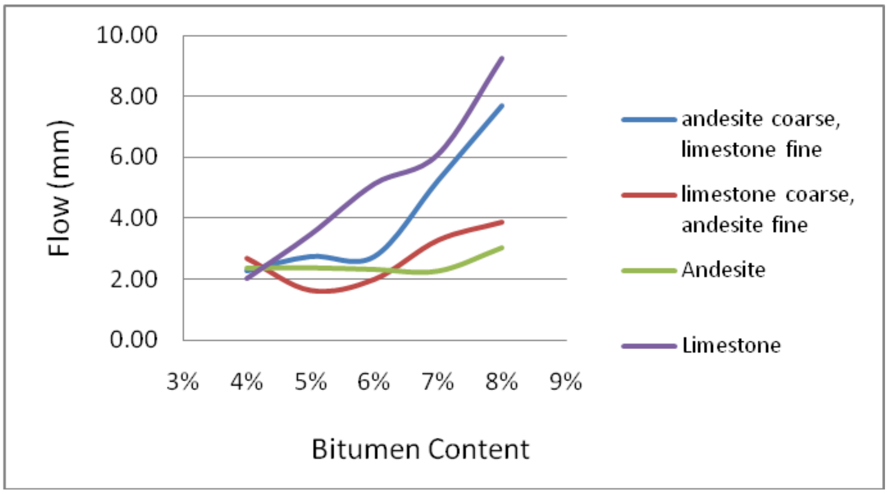

Figure 5: Relationship between flow and bitumen content.

4. TEST RESULTS

Determine the optimum bitumen content for the mix design by taking average value of the following three bitumen contents taken from the above graphs.

1. Bitumen content corresponding to maximum stability
2. Bitumen content corresponding to maximum bulk specific gravity
3. Bitumen content corresponding to the median of designed limits of percent air voids in the total mix (i.e. 4%)
4. Bitumen content corresponding to the median of designed limits of percent voids filled with bitumen in the total mix (i.e. 80 %)

Limestone optimum bitumen content: $\frac{4.0+4.0+6.4+6.1}{4}=5.125$

The flow value corresponding to this ratio is 3.6, which is under the maximum values in the specification.

Andesite optimum bitumen content: $\frac{8.0+4.0+7.45+6.2}{4}=6.41$

The flow value corresponding to this ratio is 2.3, which is under the maximum values in the specification.

Andesite coarse limestone fine optimum bitumen content: $\frac{4+5+6.60+6.20}{4}=5.45$

The flow value corresponding to this ratio is 2.5, which is under the maximum values in the specification.

Andesite fine limestone coarse optimum bitumen content: $\frac{6+6.90+6.40+6.20}{4}=6.375$

The flow value corresponding to this ratio is 2.0, which is under the maximum values in the specification.
In this way, an asphalt concrete mix according to the rate determined in the bitumen characteristics is carried to desired specifications.

4. CONCLUSIONS

In this study, the andesite waste stones cutting to take proper geometric shape were investigated the availability of the using as aggregate in asphalt mixtures.
First of all, andesite stone and limestone samples with the same grading curve were prepared. The Marshall Stability test was applied to find the optimum bitumen percentages. As a result of the test, samples with limestone aggregate, 5.125%, and 6:41% andesite stone aggregate of the specimen were found to be the optimum percentages of bitumen. Andesite aggregate samples were shown by the need for more bitumen.

Then, the Marshall Stability test samples having the limestone coarse aggregate and andesite fine aggregate, and vice versa were prepared changing the bitumen content from 4 to 8%. As a result of the experimental study, limestone coarse aggregate with andesite fine aggregate samples gave higher stability than the other mixture. But these mixtures were needed for more bitumen than other mixtures.
Comparing all the mixtures, it was found that limestone coarse aggregate with andesite fine aggregate samples gave higher stability than all other mixtures.

As a result, especially in areas where there is widespread andesite waste, if transportation costs do not exceed the cost of limestone, andesite stone can be used instead of limestone in asphalt concrete mixtures as fine aggregate.

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