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Bitlis Yöresindeki Bazalt ve Kireçtaşı Agregalarının Parçalanma ve Aşınma Direncinin Araştırılması ve $MgSO_4$ ile Yassılık İndeksi Değerleri Arasındaki İlişkinin İncelenmesi

Alev AKILLI EL [1*]

[1]İnşaat Bölümü, Teknik Bilimler Meslek Yüksekokulu, Bitlis Eren Üniversitesi, Bitlis, Türkiye.
[1]aakilli@beu.edu.tr

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Öz

Agregaların mekanik özellikleri asfalt karışımların performansını doğrudan etkilemektedir. Yol yapımında kullanılacak agregaların bazı önemli özelliklere sahip olması gerekir; temiz, sert, dayanıklı, aşınmaya karşı dirençli, homojen nitelikte ve zararlı maddelerden arındırılmış olmalıdır. Aşınmaya karşı direnç, agregaların kullanımını içeren mühendislik alanlarında oldukça önemli bir özelliktir. Agregaların aşınma ve parçalanma performans özelliklerini belirlemek için yapılan en yaygın mekanik deneyler Los Angeles parçalanma ve Mikro-Deval aşınma deneyidir. Bu çalışmada bazalt ve kalker agregası kullanılarak her iki agreganın aşınma ve parçalanmaya karşı dirençleri yassılık indeksi ve dona karşı dayanımları ile aralarındaki ilişkileri analiz edilmiştir. Ayrıca Los Angeles ve Mikro-deval deney prosürlerindeki parametreler değerlendirilmiştir. Deney sonuçlarına göre Mikro-Deval deneyi ile agregaların diğer fiziksel ve dayanım özellikleri ile aralarındaki ilişkinin daha tutarlı olduğu ve Mikro deval aşınma deneyinin agregaların parçalanma direncinin belirlenmesinde daha gerçekçi değerler sunduğu belirlenmiştir. Ayrıca Los Angeles deneyinde kullanılan çelik bilyelerin agregaların iç özelliklerinin parçalanma süreci üzerindeki gerçek etkisini yansıtmadığı kanısına varılmıştır.

Anahtar kelimeler: Yol agregaları, Bazalt, Kalker, Los angeles, Mikro-deval

[*] Yazışılan yazar

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Investigation of Fragmentation and Abrasion Resistance of Basalt and Limestone Aggregates in Bitlis Region and the Relationship between $MgSO_4$ and Flatness Index Values

Alev AKILLI EL [1*]

[1]Civil Department, Techinical Sciences Vocational School, Bitlis Eren University, Bitlis, Türkiye.
[1]aakilli@beu.edu.tr

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Abstract

The mechanical characteristics of aggregates have a direct impact on the performance of asphalt mixtures. The aggregates used in road construction must possess certain essential qualities; they should be clean, hard, durable, resistant to abrasion, of uniform quality, and free from harmful substances. Resistance to abrasion is a very important property in engineering fields involving the use of aggregates. The Los Angeles fragmentation and Micro-Deval abrasion tests are among the most commonly used mechanical tests to assess the performance characteristics of aggregates in terms of abrasion and fragmentation. This study examined the abrasion and fragmentation resistance, flatness index, and frost resistance of both basalt and limestone aggregates. The study also evaluated parameters within the Los Angeles and Micro-Deval test processes. Based on the test results, it was concluded that the Micro-Deval abrasion test exhibited a more consistent relationship with other physical and strength properties of the aggregates. Moreover, the Micro-Deval test provided more realistic values for assessing the fragmentation resistance of the aggregates. Additionally, it was concluded that the steel balls employed in the Los Angeles test did not accurately represent the true impact of the internal properties of the aggregates on the disintegration process.

Keywords: Road aggregates, Basalt, Limestone, Los angeles, Mikro-deval

*Corresponging author

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1. Introduction

The demand for crushed stone aggregates is increasing rapidly with the expansion of many areas such as highways, dams, asphalt, and concrete production. With the decrease in naturally occurring aggregate resources, the need for crushed stone aggregates has become more widespread.

It is crucial to determine the properties of aggregates to assess their suitability for the intended engineering purposes. In terms of their application areas, aggregates must possess resistance to abrasion to avoid crushing, fragmentation, and deterioration when subjected to stacking, compression, feeding from an asphalt plant, laying with a paver, and most importantly, exposure to traffic loads. Aggregates with inadequate wear resistance cannot deliver sufficient efficiency in usage, as their performance properties will degrade under such conditions of use [1]. Aggregates serve as the foundational material in construction and are thus subjected to diverse physical and chemical influences depending on their application. Consequently, they must exhibit high levels of hardness and durability. Additionally, they should possess smoothness, cleanliness, and strong resistance to abrasion and fragmentation [2, 3].

Determining the mechanical properties of aggregates allows for the prediction of their behavior under various loads. Moreover, it plays a crucial role in assessing both the physical and mechanical characteristics of aggregates and in evaluating the strength of asphalt mixture and concrete mixtures [4, 5, 6]. The mechanical properties of aggregates hold significant importance in asphalt mixture roads, particularly because coarse aggregates endure high contact stresses without the support provided by fine aggregates. Additionally, aggregates with low abrasion resistance may experience premature structural failure. Consequently, aggregates lacking in abrasion resistance can lead to severe environmental issues during the production of bituminous hot mix roads [3].

There are test methods developed to determine the mechanical properties of materials used in superstructure. When the studies are examined, many test methods are available to evaluate the toughness and wear resistance of aggregates. When we look at the commonly used test methods, Los Angeles fragmentation resistance (LA), aggregate impact value and Micro-Deval abrasion (M_{DE}) test are at the top [7].

The size distribution of aggregate particles examined through various mechanical test methods can help interpret the type of degradation occurring, whether fragmentation or abrasion resistance. A well-graded distribution comprising particles with a broad range of grain sizes suggests fragmentation, whereas a poorly graded distribution curve containing particles with a limited range of grain sizes indicates aggregate wear. [8].

The Los Angeles experiment is the most widely used method for measuring the resistance of aggregates to fragmentation. In this experiment, aggregate particles are abraded between steel spheres; to measure their resistance to fragmentation and crushing. [9]. The Micro-Deval test is a straightforward and rapid procedure, typically taking only a few hours to complete. Its smaller equipment size, reduced sample size, and simpler procedure make it more convenient and cost-effective compared to alternative experiments [7].

While there are similarities in determining abrasion and fragmentation resistance, including the preparation of aggregates and experimental procedures, examination of the procedures reveals that the processes in the degradation of aggregates differ due to various mechanical interactions. The Micro-Deval experiment assesses the abrasion resistance of only the outer layer of aggregate grains under the influence of water and steel balls. On the other hand, the Los Angeles experiment evaluates both the wear resulting from the interaction between aggregates and the resistance to deterioration caused by the impact and crushing action of steel balls. [4]. Gökalp et al. stated that conducting the Micro-Deval abrasion experimental with water is more effective than the Los Angeles fragmentation experimental because it reflects the field conditions better [7]. In their study, Fladvad and Ulvik found that the use of the tested aggregate in limited sizes brought different disadvantages. A wide range of aggregate sizes are not used in Micro-Deval and Los Angeles experimentals. Therefore, there are limited parameters in determining the differences of aggregates during the design period of the experiments [10]. Li et al. determined that the Los Angeles experimental, which involved failure of steel balls due to impacts or the crushing effect of aggregate, could not adequately simulate actual compaction or field conditions. For this reason, they determined that the disintegration test could not provide accurate results. They also observed that the internal properties of the material significantly affect the fragmentation [11].

Additional tests are needed to evaluate the long-term durability of aggregates rather than the applied test methods. In their study, Czinder et al. exposed aggregates to wear for a longer period in the Micro-Deval experiment. They determined that the total wear, which is a function of the number of revolutions, has an exponential character and used a new parameter related to wear that explains long-term aggregate durability [12].

Erichsen conducted research during the Los Angeles experiment that demonstrated the linearity of the analysis of the fragmentation process. The experiment was carried out with the Los Angeles drum rotating at up to 900 rpm. As a result of the experiment, he recommends a more comprehensive study to understand the behavior of the aggregates over a longer period of time [13]. In their study, Tunç and Alyamaç tested the degree of disintegration of ground aggregate material in the Los Angeles drum with different amounts of steel balls and different rotation numbers of the drum. In the study, they determined that the number of steel balls and drum rotations had a significant effect on LA (Los Angeles fragmentation loss) in the Los Angeles experiment. They found that with the variability of the LA (Los Angeles fragmentation loss) coefficient, the number of rotations and the increase of steel balls, the values of material loss due to wear increased up to 100% [14].

Disintegration and classification are the main basic processes that allow the production of aggregates with the desired grain size. Therefore, its effects on the aggregate production process is an important issue that needs to be examined. Miskovsky et al. stated that the strength parameters of aggregates are affected by Microcracks and mineral content. Therefore, they found that an inappropriate production process causes the destruction of the aggregate and, as a result, a decrease in its wear and chipping resistance [15].

The initial stage in verifying the usability of aggregates involves examining the composition, structure, and susceptibility to physical and chemical weathering of the rock material. Prior to use, all materials must undergo testing to assess their physical, mechanical, and geometric properties [16]. Abad et al. asserted that a quality aggregate must comprise particles possessing adequate strength and anticipated engineering characteristics, while also demonstrating resistance to the environmental conditions to which it is subjected. [2]. Fournari and Loannou determined that knowing various aggregate properties can help predict the wear resistance of the aggregate [17].

The dimensions of the aggregate to be used in construction works are also very important in terms of its strength properties. Geometric properties of aggregates are closely related to their strength values. An example of this is that the higher the content of flat and longitudinal grains in aggregates, the higher the wear value [18].

Numerous researchers have examined wear and fragmentation processes employing the Los Angeles and Micro-Deval machines. Through their studies, these researchers have noted alterations in both the size and surface roughness of aggregate grains. Their findings indicate that during the initial stage of wear and disintegration processes, aggregate grains exhibit sharp edges and tips. However, as the testing advances, these edges become flattened, and the volume of the grains decreases [19-23].

The qualitative evaluation of aggregates should be based on the analysis of various aggregate properties. Comparison of these properties should also be made between various aggregate types with various geological characteristics.

The main objective of this study is to inform the relevant institutions and organizations that basalt and limestone aggregates of volcanic origin, which constitute a significant deficiency in terms of mineral resources in Bitlis region, can be used more effectively in the construction sector. In addition, considering that the abrasion and fragmentation resistance of aggregates used in road construction under traffic loads is of great importance, the factors affecting the performance of both aggregates were investigated in detail.

In this study, Los Angeles and Micro-Deval tests were conducted to assess the fragmentation and abrasion resistance of basalt and limestone aggregates. The results were evaluated to understand the impact of these aggregates on their resistance properties, considering factors such as the flatness index and $MgSO_4$ frost resistance. According to the study's results, the physical and mechanical properties of both aggregate types in the Bitlis region were presented comparatively, and it was determined that this analysis would make a significant contribution to the literature.

2. Material Method

Within the scope of the study, basalt of volcanic origin and limestone crushed stone aggregate of sedimentary origin were used. Basalt aggregate was supplied from Baysan basalt quarry, which has been operating in Bitlis region since 1992, and limestone aggregate was supplied from Mermer limestone quarry, which is also located in the same region and has been operating since 2010 (Figure 1).

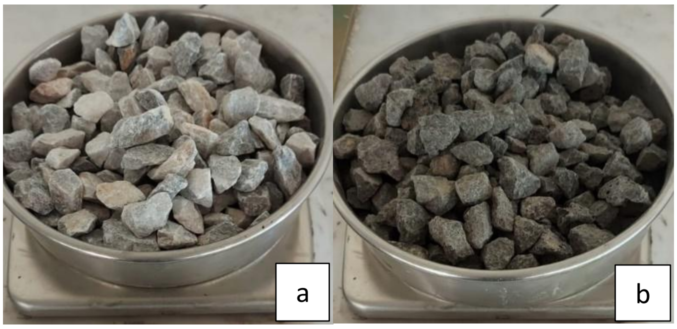

Figure 1. Used in the experiment (a) limestone, (b) basalt

XRF (X-Ray Fluorence Spectrometter) chemical analyses were performed on the aggregates to be used in Los Angeles and Micro Deval tests using the glass tablet method using the fusion method. The samples obtained as glass tablets for chemical analysis are given in Figure 2.

Figure 2. Fusing aggregates into glass tablets by fusion method

The chemical analysis of the basalt and limestone aggregates to be used in the experiment are given in Table 1 and Table 2.

Table 1. Chemical Analysis of Basalt Aggregate Results

The Compound	The values (%)
Bao	0.04
SiO_2	55.43
Al_2O_3	16.84
Fe_2O_3	8.49
CaO	4.77
MgO	1.97
Na_2O	4.61
TiO_2	1.66
Others	6.19
Ignition Loss (%)	2.91

Table 2. Chemical Analysis of Limestone Aggregate Results

The Compound	The values (%)
Bao	0.01
SiO_2	1.93
Al_2O_3	0.15
Fe_2O_3	0.14
CaO	52.74
MgO	1.38
Na_2O	0.06
TiO_2	0
Others	43.73
Ignition Loss (%)	43.33

The results of the tests carried out to determine the gradation values and physical properties of the aggregates used in the study are given in Table 3.

Table 3. Gradation limits and physical properties of aggregates

Sieve Size (mm)	Gradation values	Flatness index values		Water Absorption (%)		Bulk Specific Gravity (gr/cm^3)		Apparent Specific Gravity (gr/cm^3)		$MgSO_4$ Missing (%)	
		Limestone	Basalt	Limestone	Basalt	Limestone	Basalt	Limestone	Basalt	Limestone	Basalt
25	100	-	-	-	-	-	-	-	-		
19	95-100	19.2	16.1	-	-	-	-	-	-		
12.5	90-100	11.6	19.6	0.50	1.25	2.75	2.78	-	-	%8	%4.5
9.5	63-77	19.7	10.9	0.20	1.25	2.72	2.74	-	-		
4.75	11-35	19.6	19.6	0.68	1.48	2.70	2.74	-	-		
2	10-20	-	-	1.16	1.99	-	-	2.60	2.73		
0.180	5-10	-	-	1.66	1.43	-	-	2.62	2.71		
0.075	3-7	-	-	1.77	1.56	-	-	2.76	2.58		

2.1. Los angeles (fragmentation) experiment

The Los Angeles fragmentation resistance experiment performed within the scope of the study was carried out according to TS-EN 1097-2:2010 standard [24]. The aggregates to be used within the scope of the experiment were first dried in an oven at a temperature of 110±5 ℃. The samples taken out of the oven were kept at room temperature before the experiment was performed. First, 5000 g of aggregate samples with a diameter of 10-14 mm were taken and placed in the Los Angeles test device. To apply load on the aggregates, 11 steel balls with a diameter of 45-49 mm and a weight of 400 g-445 g were placed. Then, the lid of the machine was closed and it was subjected to 500 cycles at a constant speed of 31-33 rpm. In the Los Angeles experiment, as the drum rotates, a rack plate picks up the sample and steel balls and transports them until they fall on the opposite side of the drum, causing an impact crushing effect [3]. The Los Angeles device, aggregates and steel balls used in the experiment are shown in Figure 3.

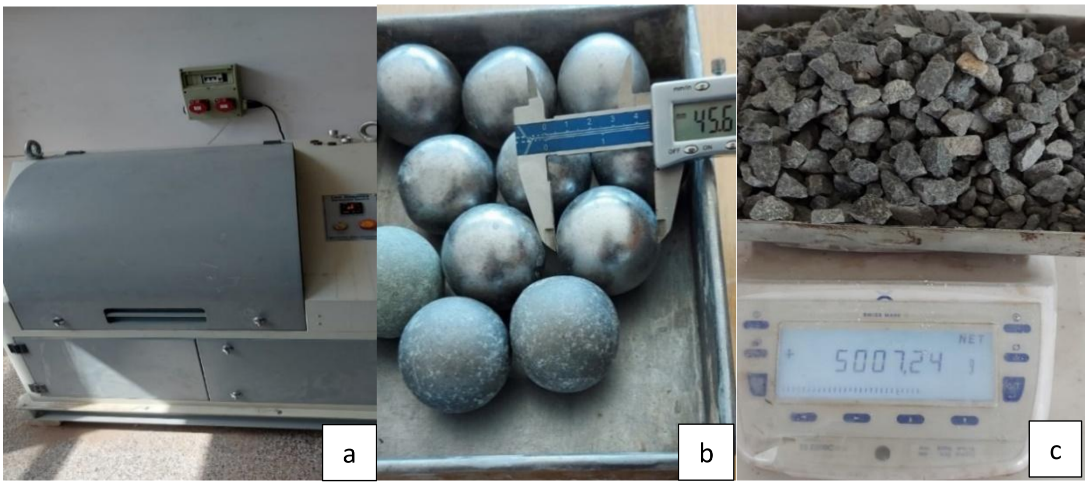

Figure 3. (a) Los Angeles Experiment Device, (b) Steel Balls and (c) Basalt aggregate

After the determined number of revolutions, the samples and steel balls are discharged from the drum into a steel tray. While discharging material from the drum, care should be taken to keep material loss to a minimum. After the cycle is completed, the drum is emptied and the aggregate is separated from the steel balls and sieved through a sieve with a 1.6 mm mesh opening and weighed (Figure 4).

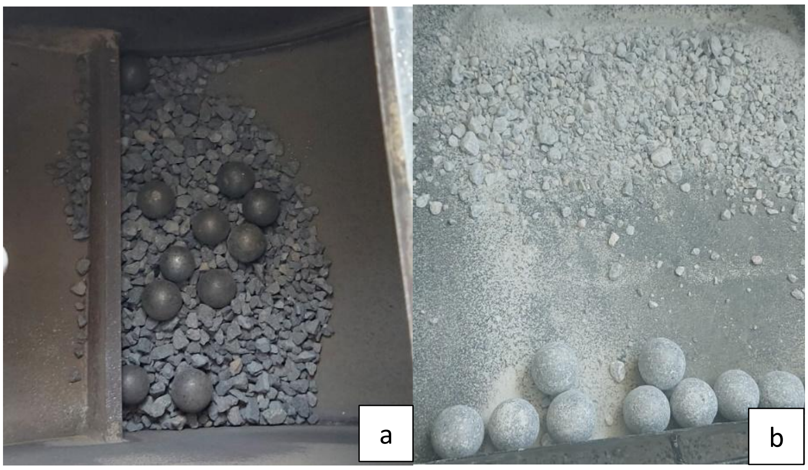

Figure 4. Aggregate and Steel balls (a) Before the cycle (b) After the cycle

Experiments were conducted twice for basalt and limestone aggregate and the average was taken. The experiment was carried out as a dry method. After the experiment, the Los Angeles coefficient of the aggregates was obtained using the formula below.

$$LA = (5000 - m)/50 \quad [1]$$

In this equation;
LA: Los Angeles Coefficient
m: Weight of dry aggregate remaining on 1.6 mm sieve (g)

Los Angeles fragmentation loss, reflects properties such as the hardness and brittleness of the minerals that make up the aggregate, the interlocking of the grains, porosity, the effect of mineral fractionation and the strength of the intergranular bond [25].

The Los Angeles fragmentation loss varies within the same rock type due to certain characteristics. Rocks exhibiting good and robust features such as strong texture, high density, grain interlocking, rough grain surfaces, sturdy intergranular bonding, and low porosity are less prone to degradation compared to rocks with looser textures. In igneous rocks, the Los Angeles fragmentation loss correlates with grain size and porosity. Fine-grained igneous rocks tend to be more resistant to fragmentation than coarse-grained counterparts with similar levels of porosity [26].

Table 4 shows the Los Angeles Fragmentation resistance specification values of the coarse aggregates to be used in the road layers specified in the Highways Technical Specifications [27].

Table 4. Limit values of fragmentation resistance of aggregates used in road construction layers in highway technical specifications

Layers	Fragmentation Resistance (Los Angeles) %	Experiment Standard
Subbase	≤45 (LA_{45})	TS EN 1097-2
Base	≤ 35 (LA_{35})	TS EN 1097-2
Bituminous chip seal	≤ 30 (LA_{30})	TS EN 1097-2
Macadam chip seal	≤ 30 (LA_{30})	TS EN 1097-2
Bituminous base	≤ 30 (LA_{30})	TS EN 1097-2
Wearing Course	≤ 27 (LA_{27})	TS EN 1097-2
Bınder Course	≤ 30 (LA_{30})	TS EN 1097-2
Stone Mastic Asphalt	≤ 25 (LA_{25})	TS EN 1097-2
Porous Asphalt	≤ 25 (LA_{25})	TS EN 1097-2

2.2. Micro deval (abrasion) experiment

The experiment was carried out according to TS EN-1097-1 standard [28]. The Micro-Deval test is an experiment carried out with aggregate and 2.5 liters of water in cylindrical steel drums.500 g of material from aggregate samples with a diameter of 9.5 mm is weighed and water is added with 5000 g of spherical steel balls into a hollow drum with an inner diameter of 200 mm (Figure 5).

Figure 5. Micro-Deval Device, Micro-Deval drum, aggregate, steel shot and water mixture

The steel drum was rotated 12000 revolutions at a rotation speed of 100±5 revolutions per minute. Experiments were performed twice for each aggregate sample and averaged. After the cycle is completed, the drums are removed from the device and their covers are carefully opened. The drum is emptied onto a 1.6 mm sieve without causing sample loss, thus steel balls, water and aggregate are separated. Steel balls are separated from the aggregate samples with the help of a magnet.

The aggregate samples separated from the steel balls are washed on the sieve, the remaining sample is weighed and the Micro-Deval coefficient is calculated by measuring the average mass loss.

The Micro-Deval coefficient (M_{DE}) is calculated by the formula below.

$$M_{DE} = (500 - m)/5 \quad [2]$$

In this equation;
M_{DE}: Micro-Deval Coefficient
m: Total amount of aggregate remaining in the 1.6 mm sieve (g)

Table 5 shows the Micro Deval Abrasion resistance specification values of the coarse aggregates to be used in the road layers specified in the Highways technical specifications [27].

Table 5. Limit values of abrasion resistance of aggregates used in road construction layers in highway technical specificatione

Layers	Abrasion Resistance (Micro Deval) %	Experiment Standard
Subbase	-	TS EN 1097-1
Base	-	TS EN 1097-1
Bituminous chip seal	≤ 25 (M_{DE}25)	TS EN 1097-1
Macadam chip seal	≤ 25 (M_{DE}25)	TS EN 1097-1
Bituminous base	≤ 25 (M_{DE}25)	TS EN 1097-1
Wearing Course	≤ 20 (M_{DE}20)	TS EN 1097-1
Bınder Course	≤ 25 M_{DE}25)	TS EN 1097-1
Stone Mastic Asphalt	≤ 20 (M_{DE}20)	TS EN 1097-1
Porous Asphalt	≤ 20 (M_{DE}20)	TS EN 1097-1

4. Results and Discussion

In the micro-deval test, the surface texture, grain corners and sharp edges of the aggregates are abraded, while in the Los Angeles test, the entire aggregate disintegrates. Aggregates with long, straight and sharp edges generally show weaker resistance to continuous fragmentation and abrasion. However, the frequency of the tests and the deformation behavior also depend on the duration of the test. To understand the wear development of aggregate grains, the use of 3D (three-dimensional) analysis instead of 2D (two-dimensional analysis) in conjunction with numerical simulations is shown to be an effective method to study the morphological behavior of aggregates before and after impact [21, 29].

Increasing the standard cycle level in the micro deval test causes changes in the wear properties of the aggregates [23]. However, in the Los Angeles experiment, increasing cycle numbers could significantly reduce the steepest peak of the aggregates and negatively affect their interlocking properties. The reason for this can be explained by the presence of larger, rounder and stronger corners, which increase the resistance to fragmentation [30].

As a result of the studies, Los Angeles and Micro-Deval tests were performed separately on basalt and limestone aggregates. The experiments were performed twice on each aggregate and average values were obtained. The results of Los Angeles and Micro-Deval tests of the aggregates are given in Figure 6-Figure 9 in comparison with the flatness index and $MgSO_4$ loss values.

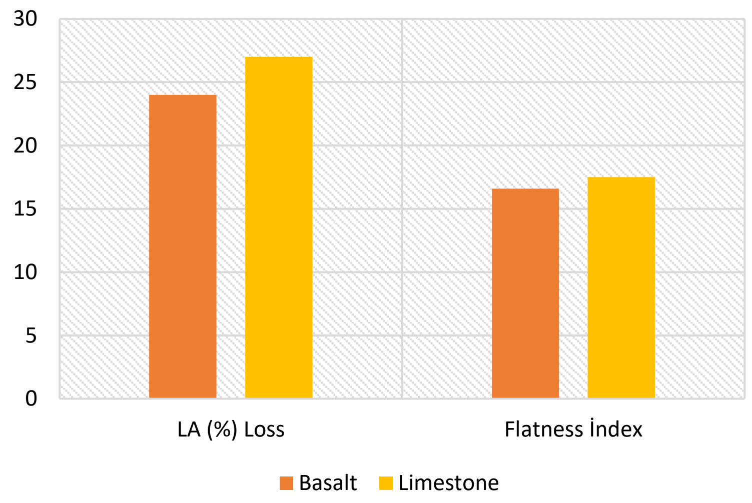

Figure 6. Relationship between LA (%) loss values of aggregates and Flatness index values

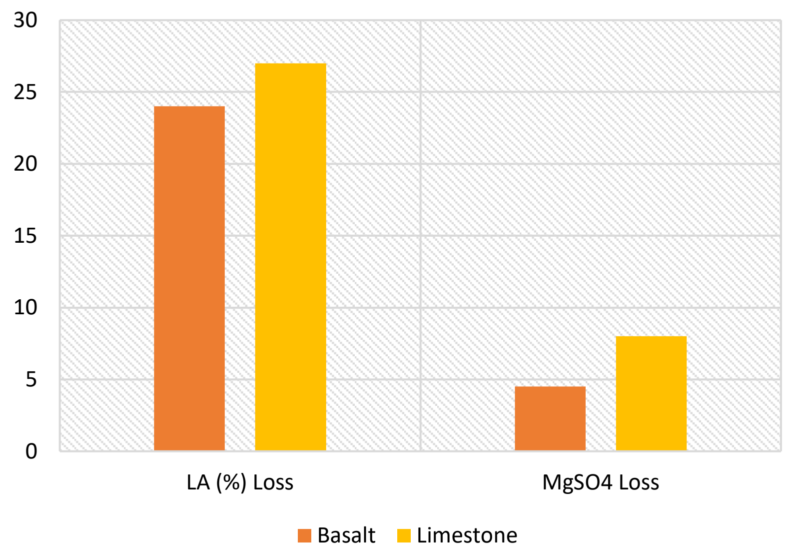

Figure 7. Relationship between LA (%) loss values of aggregates and $MgSO_4$ loss values

In the Los Angeles test, the aggregate is subjected to the effects of fragmentation and impact. In general, Los Angeles fragmentation values are affected by different geological and crushing properties of aggregates. When the Los Angeles test results with basalt and limestone aggregates were analyzed, Los Angeles loss for limestone aggregate was 27%, while Los Angeles loss for basalt aggregate was 24%. When the test results were evaluated, similar findings were reported in the literature. Pang et al. found the Los Angeles fragmentation value for limestone aggregate to be 25% and suggested that LA performance might be influenced by the calcite mineral content of the aggregate [31].

Considering the Los Angeles fragmentation resistance values specified in the Highways Technical Specification for road layers constructed on highways, both aggregate types generally meet these limit values. According to the test results shown in Figure 6, when examining the relationship between Los Angeles particle loss strength and the aggregate flatness index values, the flatness index for basalt aggregate is 16.6%, while for limestone aggregate it is 17%. Both types of aggregates are generally quite angular in structure and have many sharp edges due to their crushed stone composition. Basalt aggregate generally has greater strength than limestone aggregate in terms of its physical and mechanical properties. For this reason, the fragmentation loss value should be lower than the limestone aggregate, but since the angularity and flatness of the aggregate are close to the limestone aggregate, it has experienced approximately the same loss in terms of fragmentation as the limestone aggregate.

The gradual loss of aggregate corners in the Los Angeles test depends on the rate of flaking and elongation index of the aggregates. Therefore, it was determined that aggregates with high mass loss have a high rate of flaking and elongation index and become more susceptible to fracture under fragmentation test [32].

When the relationship between the Los Angeles particle loss value and the $MgSO_4$ loss value is examined in Figure 7, the loss in basalt was 4.5%, while this loss in limestone aggregate was 8%. Aggregates exposed to the freeze-thaw cycle crumble and decrease in size due to the effect of the solution inside. The freeze-thaw loss value of basalt aggregate shows that it is approximately 2 times more durable than limestone aggregate. Despite this, the fact that the fragmentation loss value was obtained at approximately the same value as the limestone aggregate appears as an experiment that should be discussed regarding how accurate the results of the Los Angeles fragmentation test are.

When examining the M_{DE} (Micro-Deval) loss values obtained from the Micro-Deval test for basalt and limestone aggregates, it was found to be 17% for basalt aggregate and 19% for limestone aggregate. According to the highway technical specifications, the M_{DE} loss limit values for aggregates used in road construction layers fall within the maximum range of 20%-25%. Based on these limit values, it has been determined that both types of aggregates can be utilized in road construction based on their abrasion loss values.

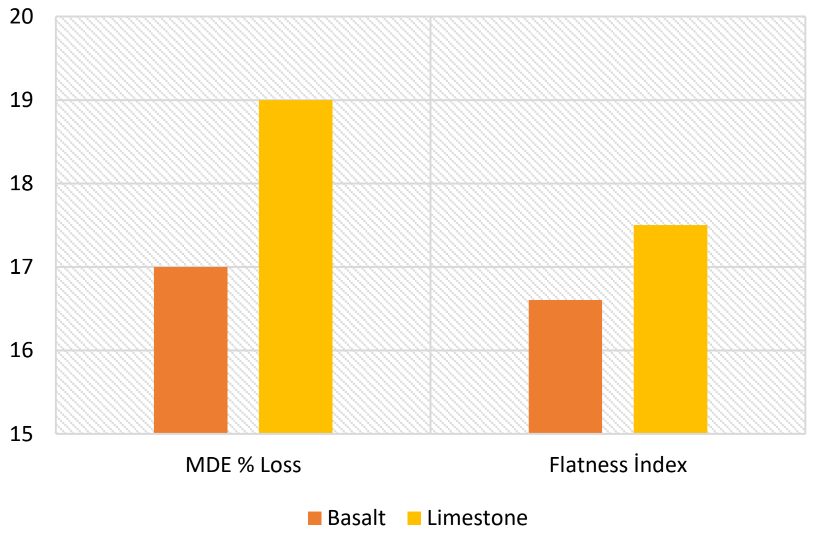

Figure 8. Relationship between M_{DE} (%) loss values of aggregates and Flatness index values

Examination of figure 8 reveals that increasing angularity of the aggregates accelerates wear. This is primarily due to the interaction between the aggregate surfaces and the steel balls used in the test, as well as the internal hard surfaces of the steel cylinder molds employed in the Micro-Deval test. The extent of degradation of morphological properties, as determined by the Micro-Deval test, varies depending on other mineralogical properties of the aggregates, such as the Mohs mineral hardness value. Aggregates with a high Mohs hardness value experience less abrasion [33].

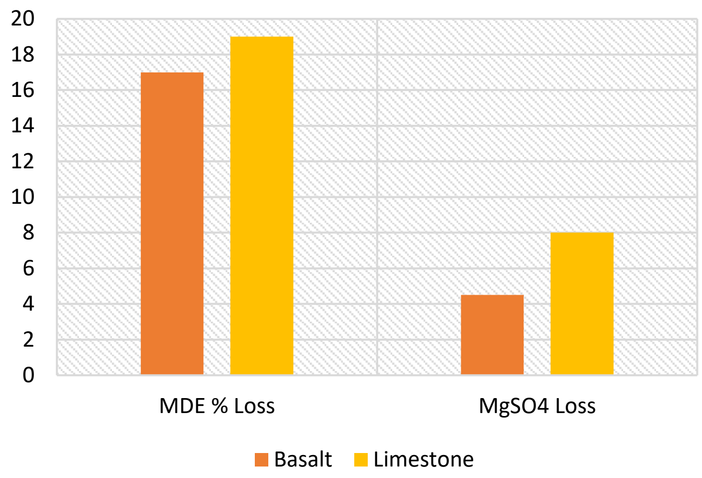

Figure 9. Relationship between M_{DE} (%) loss values of aggregates and $MgSO_4$ loss values

Figure 9 shows a clear relationship between the flatness index of basalt and limestone aggregates and their MgSO4 loss values as well as abrasion loss values.The abrasion loss value of basalt aggregate, with a flatness index of 16.6%, was determined as 17%, while the abrasion loss value of limestone aggregate, with a flatness index of 17.5%, was determined as 19%. It's observed that the abrasion loss of basalt aggregate, with a lower flatness index value, is lower, whereas the abrasion loss of limestone aggregate, with a higher flatness index value, is higher. Therefore, there exists a close relationship between the flatness index values of the aggregates and their abrasion values.

When examining the relationship between abrasion loss values and $MgSO_4$ loss values, a result similar to the relationship between flatness index value and abrasion loss value was observed. In basic, it has been found that the abrasion resistance value of basalt aggregate, which is stronger and exhibits a lower value in terms of frost resistance, is low, while the abrasion loss value of limestone aggregate, with a % loss value higher than that of basalt aggregate due to frost resistance, is high. The experimental results obtained from the study are presented collectively in Table 6.

Table 6. Experiment results

Agrregate/Experiment Results	M_{DE} (%) Loss	LA (%) Loss	Flatness İndeks	$MgSO_4$ Loss (%)
Basalt	17	24	16.6	4.5
Limestone	19	27	17.5	8

There are similarities in the procedures for testing aggregates to determine abrasion and fragmentation resistance. Both methods reveal different aspects of aggregate degradation due to mechanical interactions. While the Micro-Deval test assesses the resistance of only the outer layer of aggregate grains to abrasion caused by steel balls, the Los Angeles fragmentation test evaluates the aggregate's resistance against both fragmentation resulting from aggregate-to-aggregate interaction and deterioration caused by the impact and crushing movement induced by the steel balls [4]. In a study comparing both methods, it was concluded that the Micro-Deval abrasion test was more effective than the Los Angeles fragmentation test because it more accurately reflected field conditions [7].

According to these results, the Micro-Deval test used for abrasion loss resistance of aggregates gives better results than the Los Angeles test used for disintegration loss resistance, more consistent results are obtained when compared to other physical properties of aggregates, and it reflects field conditions better. It was concluded that more clear results would be obtained by using the Micro-Deval experiment to determine the value.

As a result of the research and experiments, there are many factors that affect the abrasion and fragmentation of aggregates. For this reason, more extensive studies on the Los Angeles and Micro Deval tests should be carried out to select the most appropriate test method, extensive analyzes should be made indicating that the tested aggregates should be made in a wider grain size range, and the effect of the aggregates on the physical and mechanical properties of the crushers in the production process should be examined in more detail should be investigated accordingly. In addition, both experiments should be carried out under the same conditions and larger studies should be conducted focusing on the geological properties of the aggregates.

5. Conclusion

In this study, methods for determining the behavior of aggregates in abrasion and fragmentation resistance tests for different aggregate types are described and also proposes further research steps aimed at developing test procedures that take into account the existing conditions.
The results presented in this paper indicate that:

- In light of the results presented in the study, variations are observed in the disintegration values of aggregates depending on the application of both test methods, the type of materials, classification size, and the experiments conducted under different conditions.
- Aggregates tested for abrasion and fragmentation should be analyzed over a wider size range and the most appropriate test method should be selected accordingly.
- It was concluded that the fragmentation and abrasion tests conducted on aggregates were inadequate for drawing a comprehensive conclusion regarding aggregate performance solely based on a single textural factor.
- A comprehensive examination of how the production process affects the physical and mechanical characteristics of aggregates is necessary.
- In addition to scrutinizing the physical and mechanical attributes of aggregates, it is imperative to conduct a comprehensive analysis of their geometric parameters and the interrelations among them, with particular emphasis on the geological properties of the aggregates.
- Furthermore, there is a need for further exploration into the correlation between micro-cracks, mineral distribution, and mineral shape of aggregates within the context of Los Angeles and Micro-Deval tests.

6. Author Contribution Statement

Author 1 contributed to the idea, design and literature review, evaluation of the results obtained, procurement of the materials used and examination of the results, spell check and content control of the manuscript.

7. Ethics Committee Approval and Conflict of Interest Statement

"There is no need to obtain ethics committee permission for the prepared article"

8. References

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