Chapter

Microwave Processing of Mixtures of Asphalt and Şırnak Asphaltite Slime - Development of The Compression Ability, Shear and Tension Strength

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Abstract

The research studied the main consideration of the road construction industry as one of the current consumptions in road aggregate-asphaltite slime mixed asphalt production in Turkey. There was a great awareness of the source of opportunities that polymer-modified mixtures had for road asphalt production (PMA). The shear strength might be developed by microwave processing on compression or during compression. This study searched for the mechanical properties of many mixtures of asphaltite slime and co-polymers by microwave treatment and compression. This study presented the model processing method for the best road cover and showed an overview on the characteristics of polymer-asphalt binders, used in the paving industry. The main fact emphasized was shear resistivity and tension strength development by asphaltite slime made on the regressed relationships of strength and advanced properties of the binder. The relationships between the mixture components of the binder and compression performance of the mixture were also determined.

Keywords: microwave radiation, pyrolysis, Şırnak asphaltite, semi-molten salt, slurries, salt reactor

1. Introduction

The evaluation of the local cheap natural rocks in the production of road pavement asphalt mixture elements will make a great contribution to the country's economy. The design of aggregate plants, crusher, and sieve selection are important in road construction [1–3] to provide ideal gradation. Formations such as truss, tuff, volcanic slag, and pumice in the regional quarries allow the production of road pavement as aggregate fillers [4, 5]. The pore structure and low mechanical strength cause a negative effect on road pavement quality and avoid the aggregate stone production and capacity [6–9]. For this reason, the texture and microstructure were critical for the quality of mixed asphalt gravel pavement at mechanical resistivity [10–12].

The crushed stone (asphalt gravel, concrete, road material, etc.) used in the construction sector is generally extracted with hammer and hammer-type crushers.

Although this type of crusher produces a higher proportion of dust, it provides advantageous angular grain formation in terms of grain shape [13–15]. However, the crushed road pavement aggregate by hammer caused to excessive cracks during impact breakage. The production of high porous, crack texture was the most suitable for mixing bitumen to easily stick, and that type of aggregate gravel and bitumen mixture should be used in road asphalt. Road pavement aggregate should not be over-broken [16–18].

In Şırnak Province, within the scope of Cizre (45 km away from Şırnak), municipalities produced a total of 1,100,000 tons of aggregate annually by ready-mixed concrete plants and approximately 1,300,000 tons of aggregate ready-mixed concrete [19–21]. The hardness and strength of the aggregate are effective on ready-mixed concrete strength. Therefore, the breaking of the rock by blasting, hammer breaker breakage, sieving, and equipment affects the quality of concrete and road pavement aggregates [18].

Limestone-type aggregates are dolomitic or calcareous rocks and marl, truss, pumice, and basalt-type aggregates are generally alkaline and sometimes contain alkali sulfate and phosphate salts, so they can be partially dissolved by aqueous acidic waste or acidic solutions [22, 23]. The natural pore textures of the medium hard rock such as granular slag, limestone, tuff, marly shale, and asphaltite slime could be mechanically or chemically developed. Macro and micropores of aggregate materials are dependent on the degree of chemical dissolution by atmospherically conditions thaw freeze and rains waters such as acidic mineral waste water contact as cover asphalt mixing use. The creep action of the chemical solution affects the pore structure and mechanical resistivity on road pavement cover [24].

Howard and Datta have determined that chemical grinding has many advantages [25, 26] and that chemical interaction is consistent with grinding of cement raw materials, and bond grindability (G) values are improved by 18% with 0.1 M sulfuric acid and waste acidic coal mine water [23, 24].

Chemical and mineralogical properties of light aggregate rocks should be examined for partial chemical dissolution and pore formation. In this study, chemical acidic interaction and mineralogical parameters of gravel aggregate limestone, marl, marly limestone, basalt, truss, tuff, and marly shale were determined and examined to determine microwave processing of a mixture of asphalt and Şırnak asphaltite slime melting and mixing at certain gradation develop with in compression ability, shear and tension strength and high creep resistivity at appropriate chemical interaction and aggregate type [27].

Limestone, porous limestone, marl, and shale-type light aggregates of Şırnak Province contain heterogeneous structures due to their strength, hardness and porosity properties. Five samples of local road pavement aggregate were investigated in this study. The samples selected in this study were subjected to two stage crushing and sieving process. As a result of these hammer crushing systems called secondary and tertiary materials, the final stage of the crushed stone production has been completed by classifying the material in accordance with the standard of ASTM C330 [28] in the dimensions below 40 mm by passing through the final sieves [29].

Due to the low porosity of marl and marly limestone sample, it is not possible to use it as road pavement aggregate, but it has been examined by evaluating the porosity by chemical solution.

Approximately 90–95% by weight of the ready-mixed concrete mixture and 80–85% by volume constitute road pavement aggregate. Asphalt mixture aggregate type, porosity, grain shape structure, gradation, such as features was investigated on aggregate regarding standard tests affect the use [29, 30]. Boiler base slag in Şırnak Province, which provides the production of semi-light aggregate by chemical interaction, produced road pavement concrete by adding 50% weight ratio (approximately 75–80% volume) The properties required for aggregates to be used in light concrete production are mainly low density and high porosity.

2. Waste rocks and road pavement rocks

In this study, 20 × 5 × 5 cm cubic marl and marl limestone samples were subjected to point-load strength and uniaxial compressive strength tests under laboratory conditions. Macrostructure, microstructure, and mineralogical investigations were conducted [28].

A modified impact shatter test was applied to determine the impact strength due to the porous structure of the road pavement aggregate.

In accordance with ASTM C330 [28], the coarser fraction over No4 sieve and dust fraction of No200 sieves were eliminated from representative aggregate samples, separated, and sieved according to $\sqrt[4]{2}$ and $\sqrt[4]{2}$ series. Samples were prepared using maximum packing density [29].

The aggregate sites that can be used in road construction in Şırnak Province are mainly found in various regions and coal quarries such as: altered limestone (Şırnak Center), marly limestone (Şırnak Center), marl (Şırnak Center), Cizre white porous limestone (Şırnak Cizre), porous limestone, (Cizre stream) volcanic cinder, Midyat limestone, Şırnak coal mine waste marly shale.

The aggregates produced in crushed quarries differ according to each other. These differences are particularly related to the geological structure and the method of operation chosen accordingly. The limestone and marl of Şırnak Province can be used as concrete aggregates due to high mechanical strength. However, the strong parts of this region consist of heterogeneous brownish-yellow limestone formations, showing a variable compression strength of 40 MPa to 70 MPa as altered rock units. This region is preferred for road pavement asphalt mixture aggregates due to the low cost of handling of aggregate from producing quarries.

Today, various industrial wastes are used as concrete pozzolan materials [31–34]. Pozzolans are defined as filler materials that do not have binding properties but which have binding properties when finely ground and react chemically with calcium hydroxide at normal temperature and in humid environments [31–33]. Pozzolans are used as mineral additives in concrete. Mineral additives are used to improve the durability of concrete by increasing the strength [34]. It is known that the addition of a pozzolanic material into concrete or cement provides many benefits, such as reducing the heat of hydration, providing high target strength and low permeability, and controlling the alkali silica reaction and the sulfate effect [35]. The most common pozzolanic materials in the world are silica fume, fly ash, and furnace slag [36]. It is estimated that there are 600 million tons of fly ash in the world today, but only 10% of it is evaluated in concrete and as filler in road pavement covering technology [37]. Fly ash as filler has a wide range of uses in concrete because of lowering the cost of concrete, saving energy, and reducing environmental problems [35]: it is used instead of decreasing the cement in certain proportions, instead of decreasing the fine aggregate in certain proportions, or instead of using both fine aggregate and cement in certain proportions [33–35]. The effects of fly ash on the mechanical properties of pavement were studied extensively. In this study, the effects of Silopi fly ash as a filler additive on hot and hardening cover in road pavement and on the properties of thaw and freeze strength were mentioned, but in this study, the effect of the amount of ash replaced to fine filler amount, change on compression ability, workability, and shear strength of mixture was determined.

Components	Seyitömer fly ash	Şırnak fly ash	ASTM C616 F	ASTM C616 C
SiO_2	54.11	40.71		
Al_2O_3	20.58	11.53		
Fe_2O_3	9.33	5.62		
S + A + F	84.52	88.6	≥70	≥50
CaO	4.72	19.56		
MgO	4.33	2.41	≤5	≤5
SO_4	0.72	1.02	≤5	≤5
K_2O	2.10	2.44		
Na_2O	0.67	0.55		
Ignition loss	3.22	4.74	$\leq 6 \leq 10$(TSE639)	$\leq 6 \leq 10$(TSE639)
Cl	0.006	0.0		
Free CaO	1.72	3.13		
React. SiO_2	39.8	34.12		
React. CaO	2.16	12.72		

Table 1.
Seyitömer and Sirnak Silopi fly ash chemical compositions and aggregate compliance with standards values, EN 450 TS EN 197-1 TS 639 ASTM C616 [37].

The ratio of clay and fly ash greatly affected the water content in the filler material significantly. As the fillers evaluated according to the percentage of clay and fly ash in the samples showed cohesive or low cohesive property. The specific unit weights are given in **Table 1**. Briquetting tests showed higher compressibility for the Şırnak Silopi fly ash, so it gave higher advantageous effect on compaction of road pavement [27].

3. Materials and methods

Mardin Limak composite cement type, CEM IV 42.5 N type cement, was used as a binder. The fly ash used in the experiments was obtained from the Şırnak Silopi Thermal Power Plant, and the chemical composition of the fly ash is given in **Table 2**.

In this study, it is aimed to produce asphalt aggregate mixture briquette blocks at size 10 × 10 × 10 cm^3. In order to produce a high class road cover, bitumen or asphalt/aggregate (B/A) ratio was investigated for high shear strength, creep, and thaw resistivity; the selected aggregates and binder fillers such as carbon or coal slime were added in certain amounts by considering to receive the high compressive strength from asphalt briquettes compressed under 3 tons/cm^2 load. As a result of preliminary experiments, the B/A ratio was decided to be 6–10% and 0.60% polymer and 5–10% Şırnak asphaltite slime or carbon fine. In ASTM standards [28], the amount of mixing bitumen and aggregate rates were taken; however, at the amount of coal and porous aggregate content, amounts of mixture components used in the road pavement cover used for this experimentation are given in **Table 3**.

After the concrete mixture calculations, concrete castings were made to cube molds having dimensions of 10 × 10 × 10 cm for each concrete type. In each series, four batches of concrete were produced, replacing 5, 10, 20, and 30% of the fly ash

Component,%	Şırnak limestone	Sırnak marly limestone	Şırnak marl	Şırnak porous limestone	Şırnak shale
SiO_2	3.53	9.42	24.14	2.12	48.53
Al_2O_3	2.23	6.53	12.61	1.71	24.61
Fe_2O_3	0.59	4.48	7.34	0.58	7.59
CaO	49.48	39.23	29.18	45.22	9.48
MgO	2.20	2.28	4.68	7.41	3.28
K_2O	0.41	0.53	3.32	0.40	2.51
Na_2O	0.35	0.24	1.11	0.21	0.35
Ignition loss	46.19	26.11	21.43	48.04	3.09
SO_3	0.32	0.21	0.20	0.02	0.32
Density	2.71	2.68	2.55	2.33	2.42

Table 2.
The chemical analysis of aggregate mixture fillers of Şırnak Province limestone, marl, and shale.

Component,%	Şırnak boiler bottom ash-slag	Volcanic slag	Tatvan pumice	Şırnak fly ash
SiO_2	43.48	50.50	60.13	41.48
Al_2O_3	16.10	14.61	17.22	18.10
Fe_2O_3	10.52	24.30	4.59	4.52
CaO	8.48	2.30	2.48	18.48
MgO	3.80	1.28	2.17	4.20
K_2O	2.51	2.51	3.51	2.71
Na_2O	1.35	1.35	4.35	1.95
Ignition loss	10.9	0.21	4.12	1.9
SO_3	0.32	0.12	0.52	0.22

Table 3.
Chemical composition and binder fillers for bitumen aggregate present in the Şırnak regional waste aggregate samples.

cement. To obtain reference values, a series of normal concrete block is produced without fly ash. The concrete workability of the produced concrete series was determined by shear box test and shatter experiments. For each prepared mix, the compressibility of the asphalt aggregate briquettes compressed with 3 tons/cm^2 was managed under loading 50, 100, and 500 MPa which was calculated by deformation level percentage. The shear resistivity was tested using the method of penetration resistance. Steel cone is indented over the briquette and penetration diameter calculated as shear resistivity under 50 MPa. In addition, the shear box test used for briquettes and shatter tests was carried out for shatter strength of the asphalt aggregate briquettes obtained from the prepared mixtures of Şırnak asphaltite slime, fly ash, and polymer.

There are a number of experimental methods that proposed so far that bitumen aggregate can be homogenized by heating over 100°C to set the aggregate and asphalt mixing like dough. There are different test methods to determine the quality of asphalt and mixed polymer-based components on measuring the shear of the bitumen aggregate mixtures, compressibility by the vibration, heating, hardness change at the cooled temperature following the solidification, change in compression volume, and resistance of the briquette against penetration [29–47].

3.1 Chemical analysis and bright section analysis

Mineralogical compositions of the samples were determined by means of standard chemical Ca, Mg, and silica analyses. The samples were first brought to dimensions between 40 and 10 mm in jaw crusher and were homogenized by milling to 0.1 mm. Powder samples are thawed and burned with HF in a platinum crucible for silica content. Chemical composition of the rocks provided in the vicinity of Şırnak Province in the experiments is given in **Table 1**. The amount of silica in the marly and marly limestone was reduced.

Prior to the preparation of the bright section, a yellow liquid epoxy resin was impregnated with the samples in a medium vacuum. This resin penetrates into the pores and makes the pores appear easier under the microscope. The porous texture is seen in **Figure 1** for different types of aggregates.

3.2 Effect of chemical interaction on aggregate

Chemical resistivity of grains was determined by contact of aggregates with chemically acidic waters and acidic mineral waters at a certain period of time. At the end of contact with the solutions, the aggregates dissolved at a certain level regarding their carbonates and salt content and became porous by solution. This makes it possible for the original chemical structure of the original aggregate type

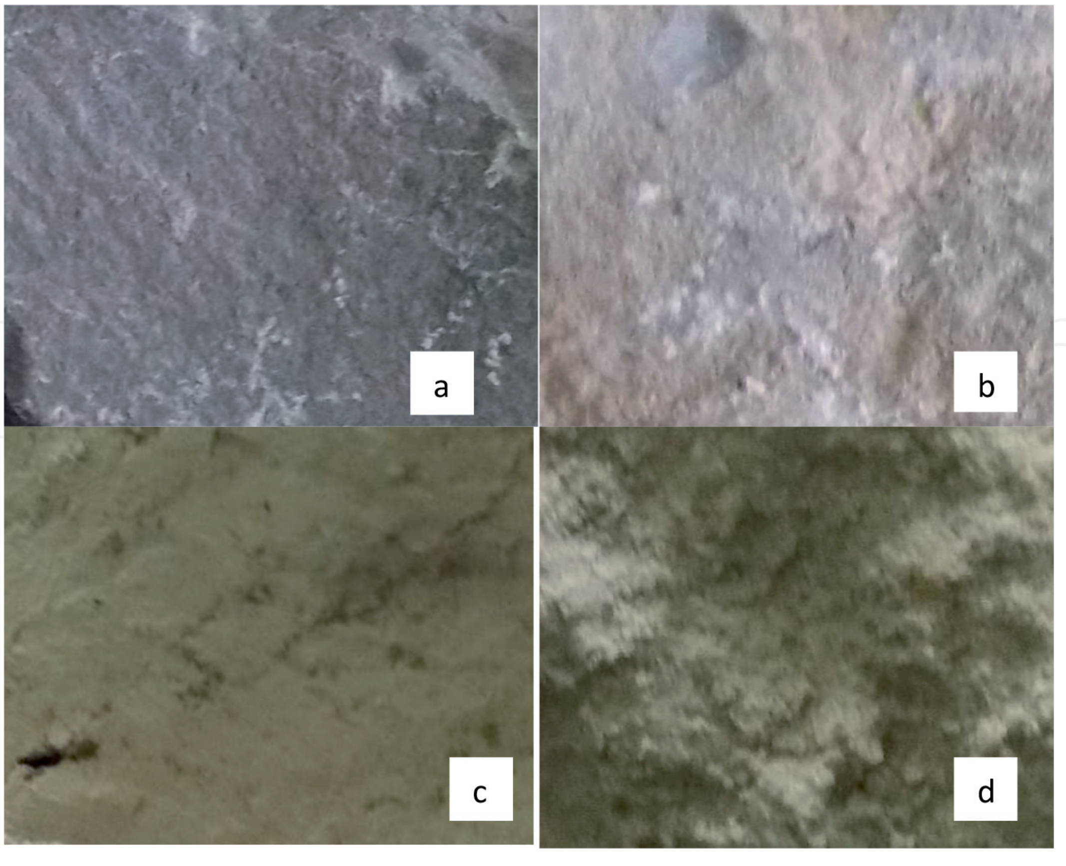

Figure 1.
(a). Marly shale, (b) Şırnak limestone, (c) Şırnak porous limestone, and (d) the chemically degraded porous limestone.

to be limestone. For this purpose, different types of aggregates were stored as 1–2 kg aggregate samples in 20 lt acid containers for 1–3 days to evaluate their effect on various aggregates in the treatment with 50–70°C 1 M HCl and 1 M H_2SO_4 acid. The products were washed to determine the weight change and apparent specificity and pore exchange with the calculation. The apparent specific gravity variation of the aggregate bulk in the visible container according to the chemical interaction is shown in **Figure 2**.

The interaction effect is shown in **Figure 2** for limestone and marl. After the chemical interaction, the limestone aggregates and porous limestone aggregates for the used asphalt mixture were tested for the modified impact loading and shatter test. Strength of asphalt aggregate mixtures was measuring the shear resistivity by cycling loads as for light concrete blocks were produced at lower compression strength and bending strengths [7–9]. Bulk unit weight, bulk void content, void percentage, and noncompact briquette strength relationships were excluded. Optimum strength for asphalt aggregate mixture and fly ash aggregate mixtures and change of amount of aggregate content were determined.

3.3 Grain size analysis

Representative samples of approximately 1–0.5 kg were screened with standard sieve series for 20 min (ASTM C136) [30]. No4 and No200 sieves in accordance with ASTM C330 [28] standard sieves were sieved and the samples were separated according to $\sqrt{2}$ and $4\sqrt{2}$ series, and size distributions were determined according to Gaudin-Schumann and RRS theory. The results of sieve analysis of rocks are given in **Table 4**. **Figure 3** shows fine filler material size distribution and **Figures 4** and **5** illustrate aggregate distribution in Gaudin-Schumann and RRS theory, respectively.

During these tests, Gaudin-Schumann distribution index was examined for road pavement concrete production. The distribution was determined as % s/mm. According to these tests, it was observed that the Gaudin-Schuman grain size approach provides a more suitable apparent density than RRS.

The void ratio of 40 mm maximum grain size was determined as 1/1 + v, pore%: 1 − (1/1 + v)] by 1% roughness measurement, and (1/1 + v)% was solid volume occupancy rate with pore% calculation.

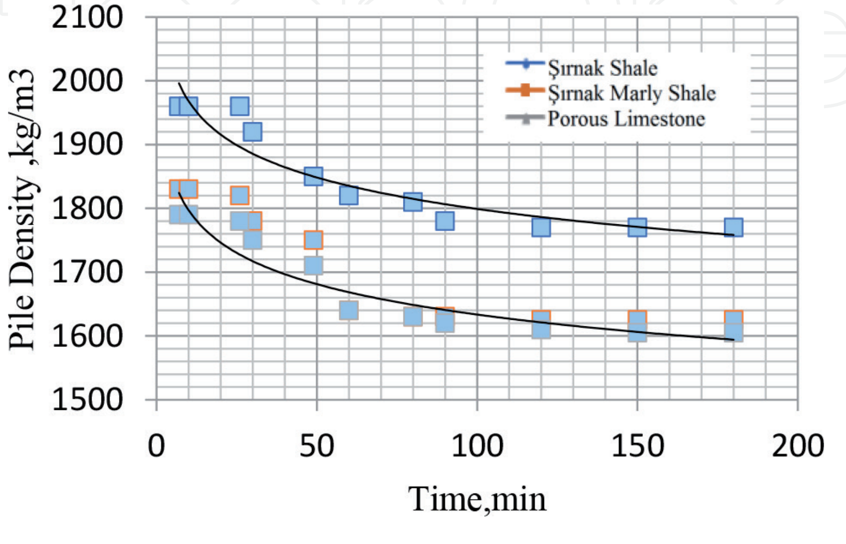

Figure 2.
Alteration resistivity by density change measurements of aggregate specimens hold in acidic solutions Şırnak marl (blue), Şırnak limestone (yellow), and Şırnak marly shale.

Aggregate type	Sieve aperture, mm	25	16	10	5	2.8	1.2	0.4	0.2
Şırnak shale	0–5				99	95	76	27	12
	5–15		100	48	0.2				
	15–40	98	3						
Sırnak marl	0–5				99	87	66	21	9
	5–15		100	38	0.2				
	15–40	98	2						
Şırnak porous limestone	0–5				99	79	60	19	7
	5–15		100	28	0.2				
	15–40	96	1						
Midyat limestone	0–5				99	77	54	17	6
	5–15		100	24	0.0				
	15–40	94	0.2						
Şırnak porous limestone	0–5				99	76	52	16	5
	5–15		100	23	0.0				
	15–40	93	0.2						
	5–15		100	21	0.0				
	15–40	88	0.1						

Table 4.
The sieve analysis of the aggregates used in this study.

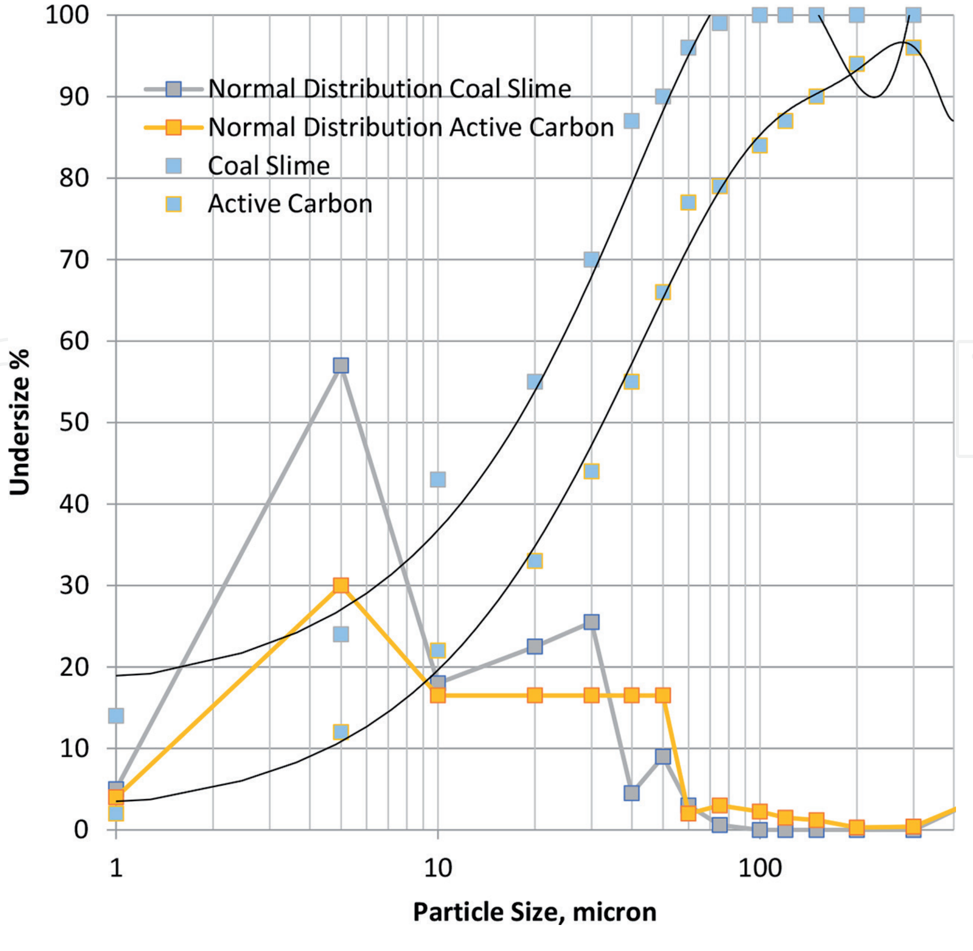

Figure 3.
Aggregate surface tension grading fillers for polymer and asphalt mixtures in Şırnak.

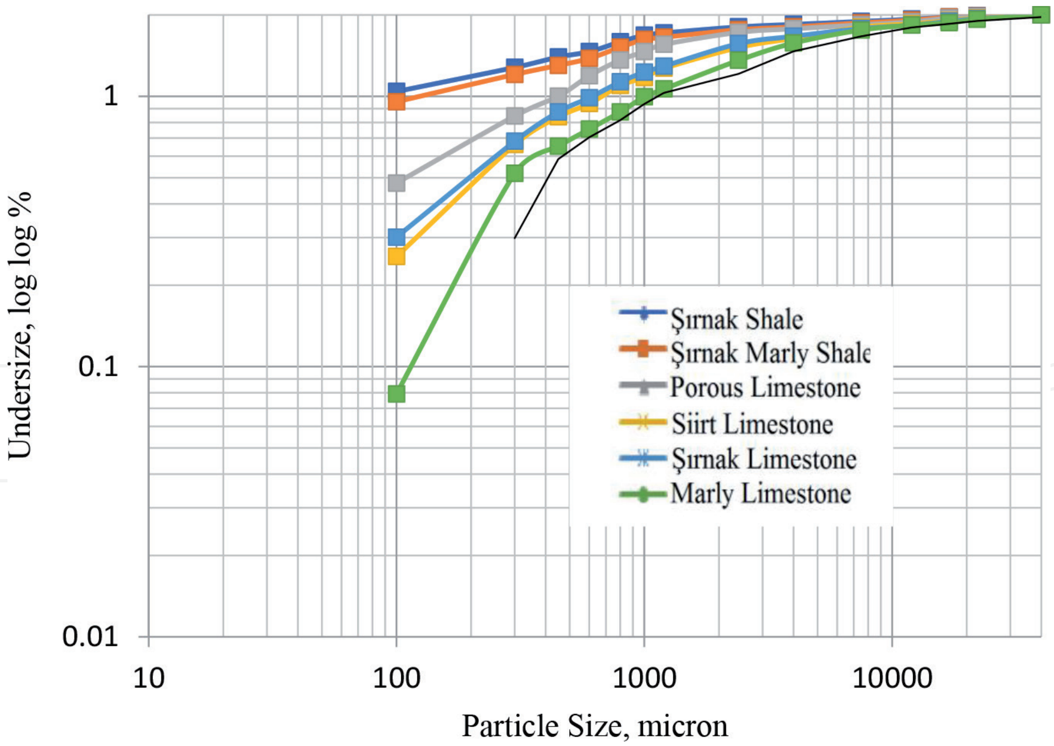

Figure 4.
Variation of Gaudin-Schumann particle size distribution and normal size distribution.

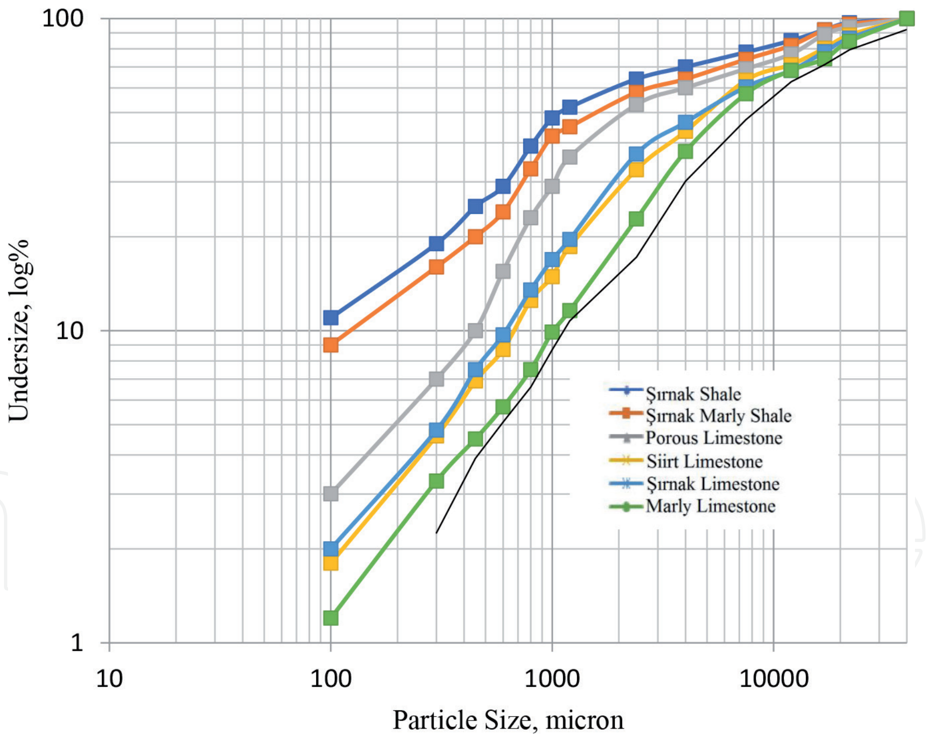

Figure 5.
Variation of RRS particle size distribution and normal size distribution of aggregates.

4. Aggregate asphalt mixture briquette stability

Regarding compression, the natural stone ground in gravel size fractions of 25 10 and over 25–36 mm is compressed hardly, according to the compression parameters in briquetting tests, hammer breaker crushed aggregate stones sieved for fine dusty particles and slightly compacted in a litter box packed again. In this case, the stability of compacted aggregate parameters such as dry density and porosity is used in the analysis. Four separate compacted block samples were taken from different briquettes of the aggregate mixture, and cutting box test was carried out to determine the shear strength parameters prior to asphalt mixing and compaction. After the experiments were made, the Mohr Coulomb criteria for compacted aggregates gave the c′ and ϕ′ values, and compression strength of briquettes σ was determined. **Figure 6** shows the deformation tension stress chart.

The elder limestone in the province of Şırnak showed a higher uniaxial compression strength of 93 MPa with high silica content, and 24–56 micron sized grains provided suitable conformity with the solid concrete specifications and even road pavement. The Midyat limestone located in Mardin Province, Urfa, Batman, Siirt region, has large potential reserves, covers a large area, and has a very porous texture with 12–14% pore content ranging in macro size 500–3 mm and therefore was very suitable for road pavement aggregate. However, the creek edges in Şırnak Province may contain Mesozoic aged sandstone-clayish schist called Siirt formation. It shows a more homogeneous structure. Especially, the mixing of clayey schists into the aggregate produced can cause problems in terms of plasticity and pore of light aggregates [4–6].

The calcareous cavities and marly formations in the late Mesozoic limestone in the Kasrik region of Şırnak are a great source for filling aggregate for road pavement on the contrary that the aggregate producers should focus on river pebble excavation from river bed due to the lower operation cost. Moreover, the water absorption rates of the aggregates in this region between 2.7 and 3.1% are advantageous in the production of road pavement concrete.

In the area where dolomitic limestones are generally exposed, the limestones are exposed to the fractures formed as a result of faulting. In the areas of aggregate production, marly shale and disseminated brown clayish muddy loose formations can be observed. There is a significant gradation problem in light aggregate production.

The mechanical tests were made related to ASTM rock standards and given in **Table 5**.

Şırnak limestone, Midyat limestone, Şırnak marl, and marly shale were sieved and −15 mm faction were compacted with fly ash under 3 ton compression The blocks were tested after certain curing time and dried in air temperature.

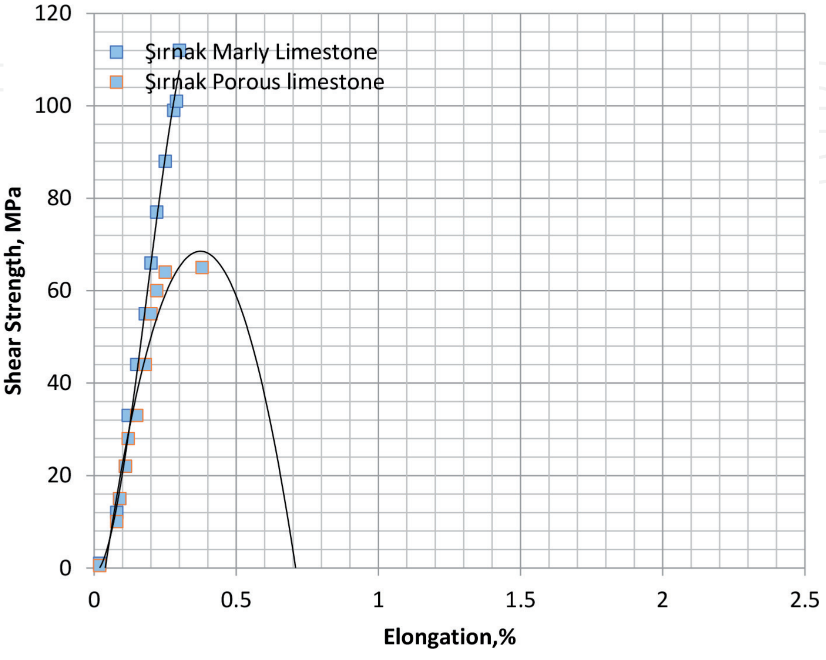

Figure 6.
The Mohr Coulomb criteria for compacted aggregate blocks by Şırnak Silopi fly ash in 14 days.

Aggregate type	Compression strength, MPa	Cohesion, MPa	Internal friction	Shear strength	Shear module
Şırnak shale	11	1	22	22	0.2
	9.8	0.8	33	33	0.3
	11.7	0.7	26	26	0.25
Sırnak marl	11	1.1	22	22	0.2
	9.8	0.8	33	33	0.3
	11.7	0.7	26	26	0.25
Şırnak porous limestone	11	1	22	22	0.2
	9.8	0.8	33	33	0.3
	11.7	0.7	26	26	0.25
Midyat limestone	11	1	22	22	0.2
	9.8	0.8	33	33	0.3
	11.7	0.7	26	26	0.25
Şırnak porous limestone	11	1	22	22	0.2
	9.8	0.8	33	33	0.3
	11.7	0.7	26	26	0.25

Table 5.
Mechanical properties of Şırnak aggregates.

Figure 7.
Uniaxial pressure tester.

Briquettes of aggregates of three different sizes were obtained from limestone and tested in uniaxial compressive strength as seen in **Figure 7**. Aggregate mixing ratios are 2–3 mm 20% natural shale, 30% sieved representative −5 mm crushed stone, 25% sieved fraction of +5 to 16 mm crushed stone, and 25% + 16 to 25 mm, with the largest grain size 32 mm and within the limit values given in TS 706 set as crushed stone. The results of sieve analysis of the aggregates used are given in **Tables 6**–**8**.

Curing time min	Uniaxial compressive strength, MPa				
Compacted binder	**1. Sample**	**2. Sample**	**3. Sample**	**4. Sample**	**Average sample**
0.5% fly ash					
	192.56	192.56	184	180	185.52
1	205.6	205.6	209.60	203.5	204.55
3	284.5	284.5	288.4	296.5	289.80
5% fly ash					182.99
0.5	192.56	183.1	180.06	185.81	185.52
1	205.6	188.81	198.39	196.1	194.43
3	284.5	304.84	319.7	301.75	308.76
10% fly ash					203.61
0.5	192.56	200.99	206.99	202.86	185.52
1	205.6	251.17	253.9	257.56	254.21
3	284.5	360.79	369.2	360.73	363.57
20% fly ash					205.50
0.5	192.56	232.86	170.49	213.15	185.52
1	205.6	300.24	220.92	241.46	254.21
3	284.5	355.13	356.99	359.21	357.11
25% fly ash					281.89
0.5	192.56	290.24	280.24	275.2	185.52
1	205.6	323.66	316.99	313.72	318.12
3	284.5	381.17	377.42	371.8	376.80

Table 6.
Compression strength of aggregate asphalt mixture of aggregate type of Şırnak limestone.

4.1 Creep characterization of asphalt mixture limestone marl and shale: thaw-drop sequential ball impact strength of porous aggregate

The chemical activation of limestone, marly limestone, shale, and marl produced from Şırnak coal mines and quarries was investigated, and the qualities of products of semi-road pavement aggregates providing the specifications required from road pavement concrete production were determined. The waste aggregates were treated with 1 M HCl and 1 M H_2SO_4 acidic solutions in order to produce a porous aggregate. A 3–4 day treatment has become sufficient. A temperature of 50°C increased activation. The compression strengths of road pavement concrete blocks varied between 7.2 and 18.4 MPa. Modified impact shatter resistance was also discussed, hence the strengths.

The semi-graded aggregate samples were subjected to compressive strength and impact shatter strength test and the size distribution and impact mechanical strength of the crushed product were determined (ASTM D6024-07) [29]. The classified aggregate samples were examined as the size of the fixed 5 kg impact sledgehammer weight of 10 × 10 × 10 cm^3 with the effect of 50 cm falling in the hive, and the product was compared to the light concrete samples. With these technological applications, the evaluation of local natural stones as a road pavement building aggregate can be further improved. In the impact shatter strength tests, 5 kg sledge weight was taken from four times 50 cm height to fall on the 40, 25 mm aggregate inside the 8 cm inner diameter steel shank, under 5 mm less and 25 mm above the weight as hard, the strength was higher. The results are shown in **Figure 8**.

Curing time min	Uniaxial compressive strength, MPa				
Compacted binder	**1. Sample**	**2. Sample**	**3. Sample**	**4. Sample**	**Average sample**
0.5% fly ash					
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Table 7.
Compression strength of aggregate asphalt mixture of aggregate of Şırnak marl.

4.2 Thaw-freeze drying creep impact resistance tests

Concrete aggregate samples were subjected to a cyclic modified creep test and the product has a concrete aggregate strength of 5 kg of steel ball impact mechanical strength (ASTM D6024) [29]. The classified aggregate samples were examined as the dusting of the size of the fixed 5 kg impact sledge hammer with the effect of 8 × 50 × 50 cm falling in the hive, and the product was compared with the concrete compressive strength. With these technological applications, the evaluation of local natural stones as a road pavement building aggregate can be further improved. In impact resistance tests, 5 kg sledge weight was taken from four times 50 cm height to fall on 50 × 50 × 25 mm like block aggregate inside the inner diameter of 8 cm inner diameter steel sleeve. The results are shown in **Figure 8**. Grain shape replacements with photographic technique assumed that there is deformation, calculated using close volume changes.

4.3 Compaction of bitumen composite and cracking tests

Compaction was carried out over 30 ton load over 5 cm thick samples, and microscopy evaluation of local aggregate stones as a road bitumen is shown in **Figures 9–12** the crack forms on additive hardener. Further polymer addition at 5% rate improved the microstructure to micronized grains. Impact shatter test resistance tests provided similar results as given in the next discussion.

Curing time min	Uniaxial compressive strength, MPa				
Compacted binder	**1. Sample**	**2. Sample**	**3. Sample**	**4. Sample**	**Average sample**
0.5% fly ash					
	192.56	192.56	184	180	185.52
1	205.6	205.6	209.60	203.5	204.55
3	284.5	284.5	288.4	296.5	289.80
5% fly ash					182.99
0.5	192.56	183.1	180.06	185.81	185.52
1	205.6	188.81	198.39	196.1	194.43
3	284.5	304.84	319.7	301.75	308.76
10% fly ash					203.61
0.5	192.56	200.99	206.99	202.86	185.52
1	205.6	251.17	253.9	257.56	254.21
3	284.5	360.79	369.2	360.73	363.57
20% fly ash					205.50
0.5	192.56	232.86	170.49	213.15	185.52
1	205.6	300.24	220.92	241.46	254.21
3	284.5	355.13	356.99	359.21	357.11
25% fly ash					281.89
0.5	192.56	290.24	280.24	275.2	185.52
1	205.6	323.66	316.99	313.72	318.12
3	284.5	381.17	377.42	371.8	376.80

Table 8.
Compression strength of aggregate asphalt mixture of aggregate of Şırnak porous limestone.

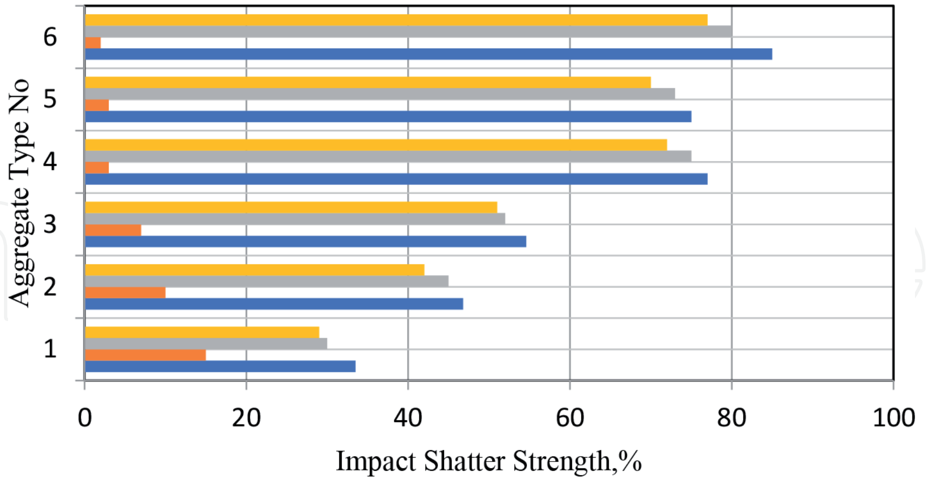

Figure 8.
Histogram view of impact, abrasion resistance, 1 M H_2SO_4 and 1 M HCl at 3 days of the 7% bitumen aggregate briquettes; (1). Sırnak porous limestone, (2) Sırnak marl, (3) Şırnak marly shale, (4) Midyat limestone, (5) Şırnak porous limestone, and (6) Şırnak marl.

The asphaltite bitumen composite cracking results are shown in **Figure 10**. Grain shape and volume replacements with photographic technique were tested assuming that there is deformation, calculated using density changes. The density change by addition and distribution of homogenized bitumen in thin sections is shown in **Figure 11**.

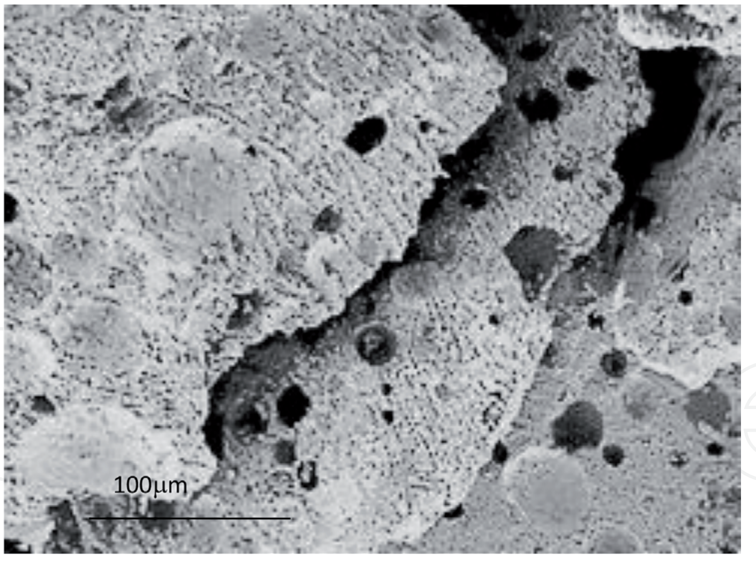

Figure 9.
Asphaltite slime and shale clay aggregate compressed briquette.

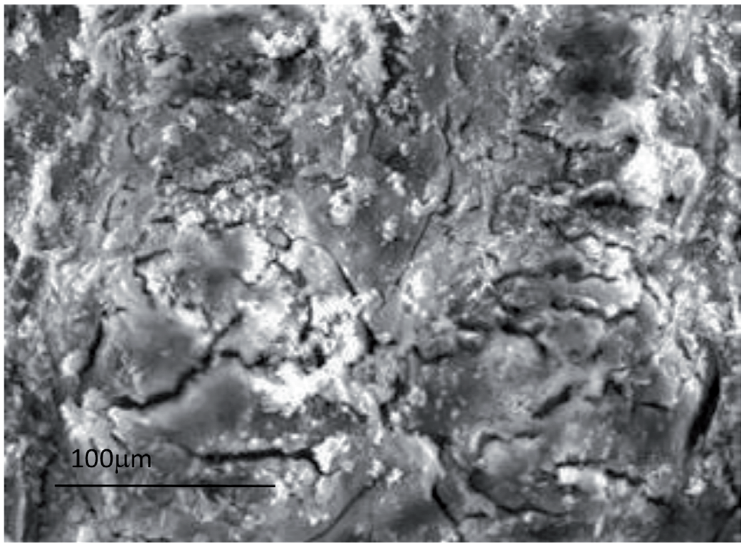

Figure 10.
Asphalt—Şırnak asphaltite and Şırnak marly shale aggregate compressed briquette.

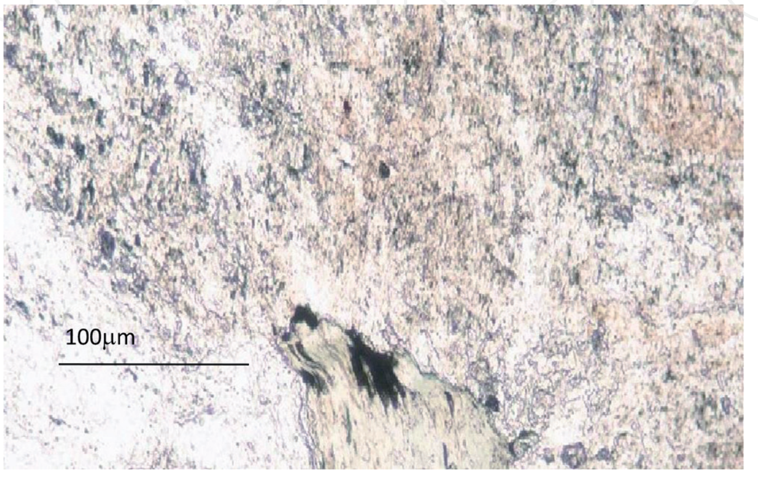

Figure 11.
Asphalt mixed Şırnak asphaltite shale thin section.

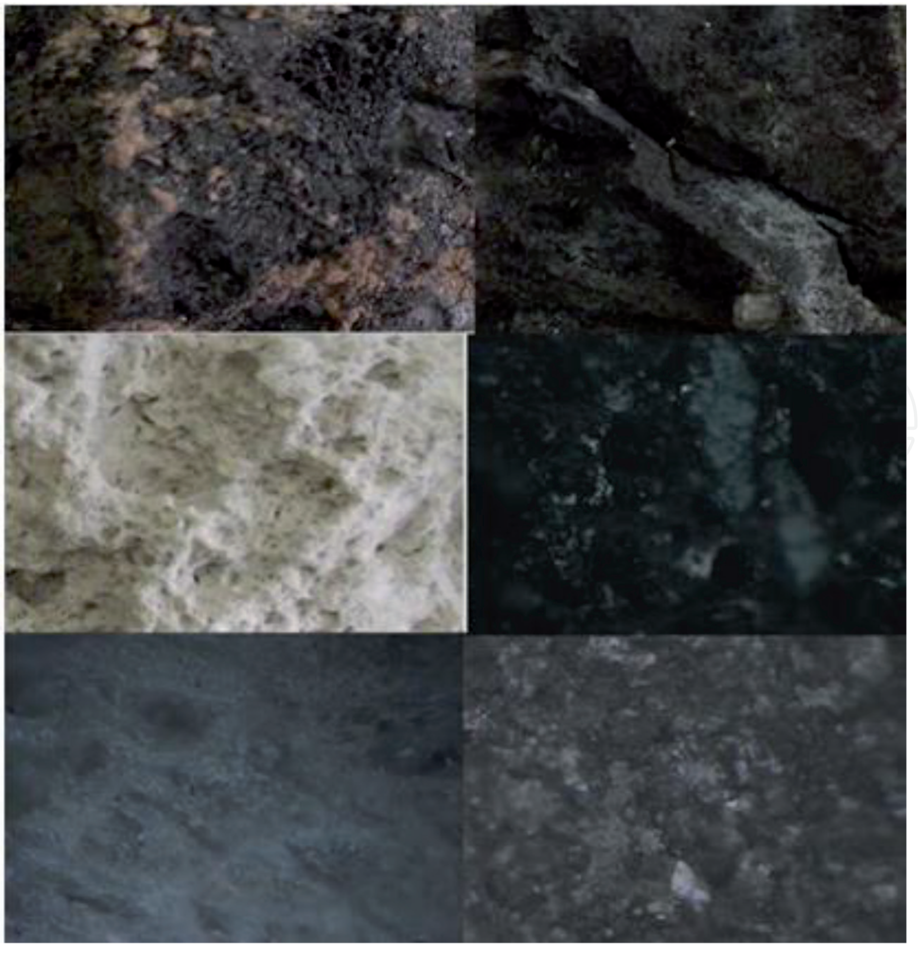

Figure 12.
Microchange of bitumen compression on compression test.

The cracking on compaction overload of 30 ton is shown in **Figure 12**, and crack occurrence was odd with higher breakage and no bitumen contact in cracks.

5. Results and discussions

5.1 Tension loading and compressibility shear tests of bitumen mixtures

The high-graded bitumen samples were subjected to tension, shear, and compressive strength and tension meter deformation test, and the size distortion was determined (ASTM D6024-07). The classified asphaltite slime and bitumen polymer acrylate samples were homogenized at 110°C in a microwave oven for 10 min and the size of the fixed thin plate of 5 × 20 × 100 mm^3 was examined with the effect of 1 ton loading cm in the tension meter ring, and the final elongation and broken state was compared to the start-up state. With these standard applications, the evaluation of local composite bitumen as a road pavement aggregate can be further improved. Test results are shown in **Figure 13** for the tension meter ring and tension stress through deformation. The tests of shear resistance were made in a shear box of 50 mm length ring. The results are shown in **Figure 14**. Shear distance changed over the 250 mm the compressibility with the 3 cm inner diameter steel barrel, under 25 mm swelling compression stress as hard, the strength was higher. The results are shown in **Figure 15**.

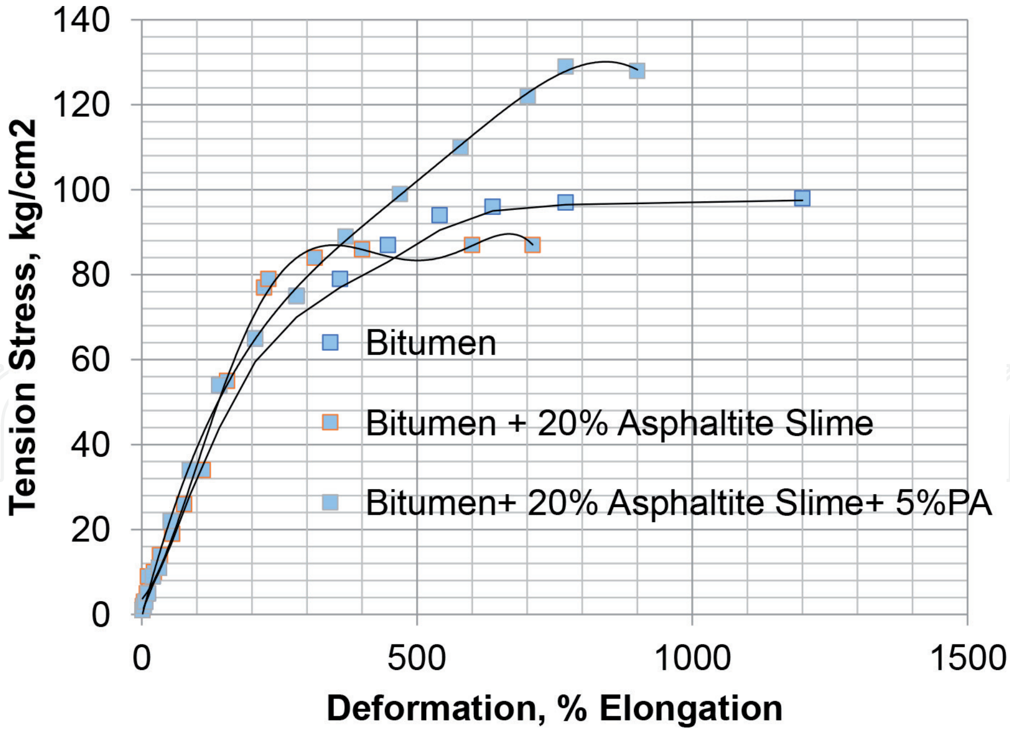

Figure 13.
Deformation change with tension stress test results of wire deformation test rig.

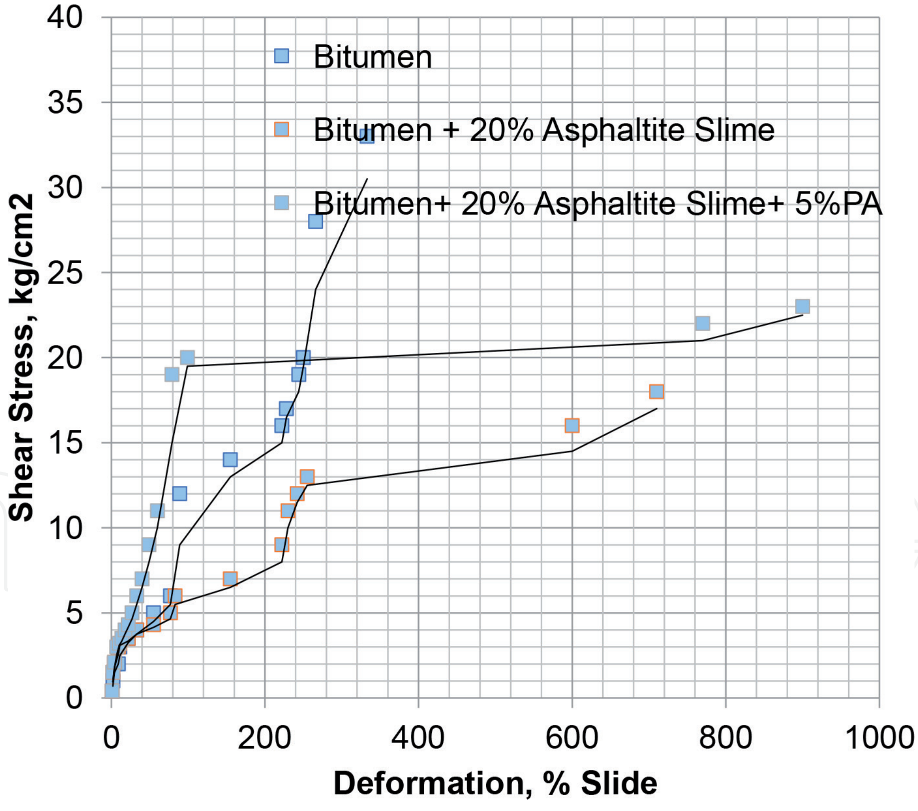

Figure 14.
Shear deformation change with shear box test results of wire deformation test rig.

5.2 Point loading and compressive strength tests of aggregates

The test samples were produced as 5 × 5 × 5 cm blocks and 10 samples were determined to show 95% accuracy rate by prestigious ELE brand. The results are shown in **Figures 16** and **17**.

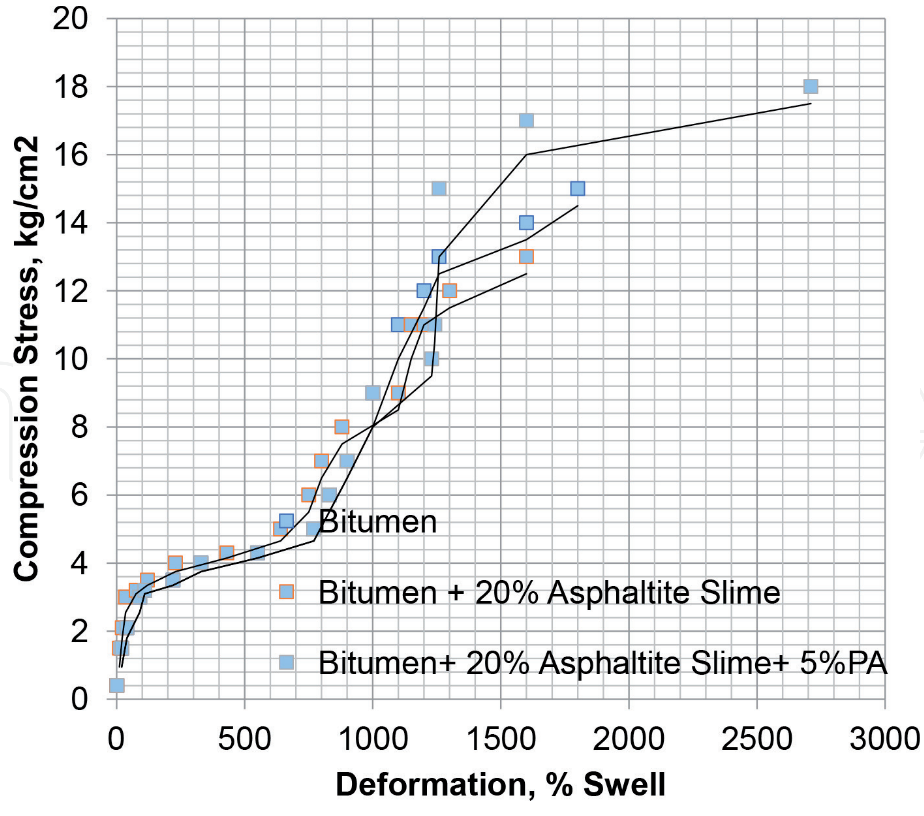

Figure 15.
Compressibility deformation change with compression stress test results of wire deformation test rig.

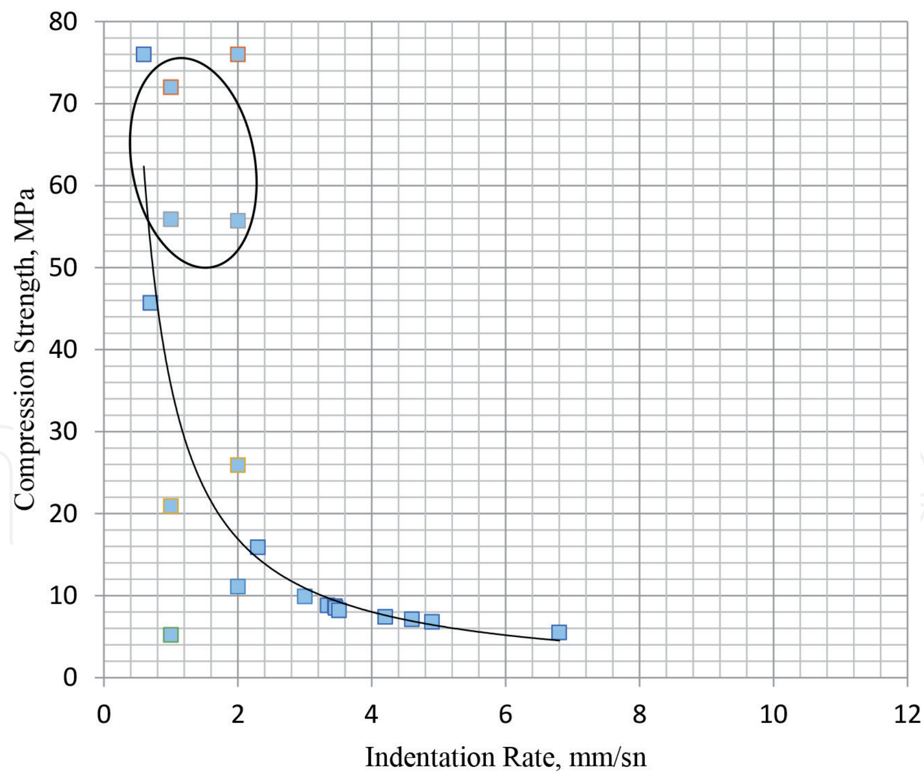

Figure 16.
Compression strength change of the Şırnak aggregates.

Chemically treated samples have also increased the chemical impact of small grain sizes. Approximately, the aggregate in 5 mm contained 13.6% of the pore in bulk pile as 25 mm fraction showed a pore rate as lower at 9.2%. The results are shown in **Figure 2**. **Figure 2** also proved that the chemical interaction of 2 days is sufficient. Hence, the dissolution process reached the alkaline lime salt saturation of the solution. The pores in the limestone sample reached 13.6%.

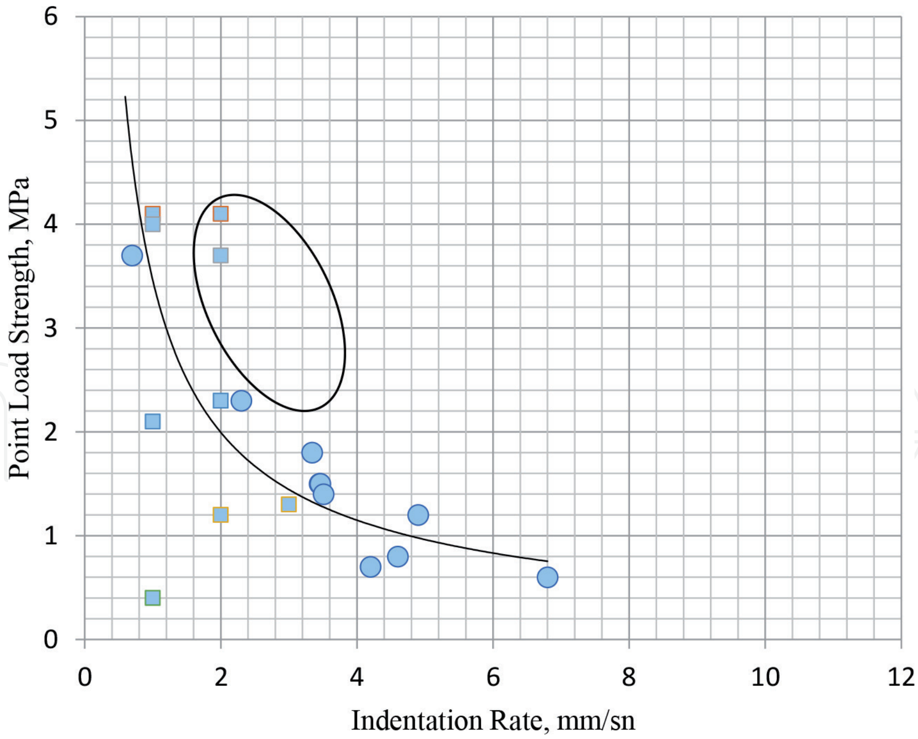

Figure 17.
Point load strength change of the Şırnak aggregates.

Porous limestone texture, chemical interaction result, and petrographic changes are seen in **Figure 2**. It was determined that the amount of silicate of 2, 3, 3, and 4% of Şırnak altered limestone was changed and the pore size was at a macro size of 1–3 mm and partly micro sized of 50–300 micron. The pore rate was in micro-crystalline microporous structure of 13.4–14.8% silica in Şırnak marly limestone and as 5–30 micron micro porous. The degree of chemical interaction in marinated limestone and marls was not sufficient due to the silica content and the microcrystalline pore structure.

The ideal gradation according to **Figures 4** and **5** can be determined by the Gaudin-Schumann approach. The distribution factor in the marly limestone was increased by 81%, and in Shale, it decreased to 45%. The effect of chemical interaction time was tested. The treatments of 3 days have increased. As shown in **Figure 2**, impact shatter strength values were decreased by about 24% over a two-day period. The pore ratio was also similar in the limestone and shale samples. It was increased by 17%. It was caused by the similarity of the original pore sizes and grain structures of the structural structures. In addition, the calcite and dolomite component within the shale stone provided this. The results did not change in 2 and 3 days. In these evaluations, the values obtained in the impact resistance test are shown in **Figure 8**.

The homogeneous fine-grained structure has increased the strength even more. The heterogeneous silicate component, especially in Şırnak, has a high impact resistance. Since the silica content of Şırnak and Siirt limestone is low, they are soft and have less impact and abrasion resistance.

Figure 8 shows the resistance values. Limestone samples vary depending on the amount of silicate they contain, and also have changed its microstructural properties and related to the pore. Wear conditions of the pore density in the development of abrasion and consequently the formation of brittle surfaces and lower wear resistance values were observed.

Although the Şırnak marl limestone and marllyleyl rocks are of the same type, they have different wear and strength properties. Regarding impact shatter tests, the impact strength of the limestones of Şırnak is higher than that of the other samples. The reason for this is their porosity and clay texture.

5.3 Bituminous aggregate mixture block production

In this study, 50% weight of Şırnak Province with 2% chemically interacted limestone aggregate and 50% weight ratio of Şırnak Kazan slags were evaluated as light aggregate and road pavement concrete production. Slag samples were crushed to size 40 mm below the aggregate [6, 7, 13]. Aggregate mixing ratios were below 28 mm. The bituminous mixture aggregate (% 50 coarse aggregate), fine aggregate (% 50 fine sand) and% 25 is set to bituminous mixture. In this study, it is aimed to produce C 20 class aggregate bituminous polymer asphaltite slime homogenized at 90°C. Coal tar as bitumen was used as a binder. Polymer/bitumen (p/B) ratio was critical and pre-determined to be 0.30 as a result of preliminary tests. The compressive strength of bıtumen asphaltite and polymer rods extruded at 3 ton with different aggregate types and cooled to ambient temperature was determined as shown in **Figure 18**.

In the uniaxial compressive strength tests, the highest strength values were determined to vary between 76 and 35 MPa depending on the type of limestone and the silicate compositions. The plume ratio with low uniaxial compressive strength exceeds 5%. Midyat limestone with more than 4% silicate phases was observed. Şırnak porous limestone was found to be 39.3 MPa with a low density of 3.6% in porous matrix and 34.6 MPa with 7.4% porous matrix.

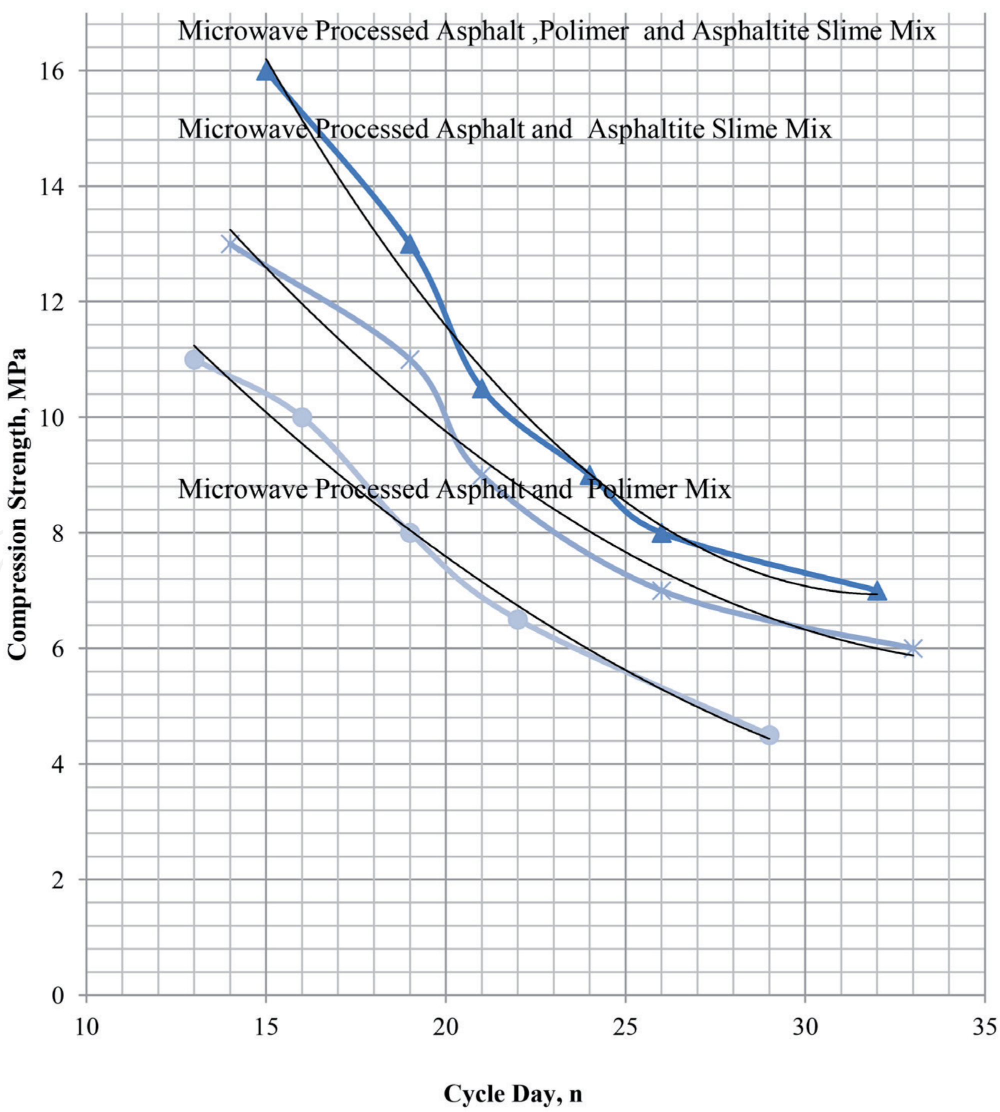

Figure 18.
Bitumen-Şırnak asphaltite slime PA mixed aggregate block compression strength test results.

In **Figure 16**, a similar change was observed when the compressive strengths of different pore and coarse density limestones were examined. Clearly, when the stress-strain diagram is examined in uniaxial compressive strength tests, it is seen that marls and limestone exhibit high strength and this is caused by 0.5–1.8% porosity.

As seen from the point load strength values of **Figure 17**, the coarse grained structure was weaker and more brittle than the marl matrix, and heterogeneous hard marls showed higher compressive strength.

As shown in **Figure 18**, point creep load strength values, the coarse grained structure, marl concrete which is most affected by frost and frost cycle is weaker and more fragile and heterogeneous hard marl has higher compressive strength.

As shown in the strength values of the aggregate concrete blocks produced in **Figure 9**, the structure, chemical interaction, and aggregate concrete produced made the concrete more durable. Heterogenous texture of hard marl reached higher pore. This study showed that the chemical interaction in the altered limestone stopped with saturation and was insufficient in the production of solid blocks.

6. Conclusions

At least the gradation of quarries and the processing of limestone will be of great benefit in the production of porous aggregated bulk.

The most important factor in the formation of a gapless structure in concrete is the regular surface contact and aggregation between the aggregates, that is, in order to fill the gap between coarse aggregates, it is necessary to use technologies that will produce porous light fine aggregates in different ratios (depending on the properties of the fine aggregate). It is very important to use fine aggregates at optimum levels in pavement cover.

In chemical interaction, the amount of pore in the sulfuric acid solution for 3 days increased by 27–37%. It produced about 0.190 kg/lt weight loss, so highly compressible aggregate production.

When the compressive strength results were examined, it was seen that as the pore amount increased, the compressive strength values did not increase the strength of the aggregate.

Light-weight concrete blocks with high-strength slag and road pavement concrete blocks have high strength values, although the impact strength values can be low.

According to these tests, the Gaudin-Schumann particle size approach was found to provide a more favorable approach and tight packing density than the RRS. Certain large and fine-sized aggregate samples are produced with more permeable and porous block asphalt cover.

The highest strength values are controlled by the general texture and micro-structural properties of the aggregate.

It has been observed that shear strength yields successful road pavement cover results in asphalt/asphaltite slime/Şırnak porous limestone aggregate mixing at a weight rate of 8/8/88% briquette compared with truss and volcanic cinder. It was determined that the impact strength values were directly related to the compression resistance of road pavement blocks.

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