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MECHANICAL PROPERTIES OF BITUMINOUS AGGREGATE MIXTURE BNS 22A PREPARED WITH FLY ASH FROM POWER PLANT "GACKO" AS A FILLER REPLACEMENT

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ABSTRACT
This paper presents results of investigation the possibility of replacing the mineral filler with fly ash from power plant "Gacko" in the bituminous aggregate mixture BNS 22A. The most important physical-mechanical properties of bituminous aggregate mixture with fly ash from power plant "Gacko" used as filler were investigated. Based on the results obtained it was concluded that fly ash from power plant "Gacko" can be used successfully for the production of bituminous aggregate mixture BNS 22A.
Key words: bituminous aggregate mixture, BNS 22a, fly ash utilization, filler

1. INTRODUCTION
Fly ash is finely divided residue resulting from the combustion of coal. The quantity of fly ash is growing along with the steady global increase in coal use. Coal fly ash has been successfully used as a mineral admixture in portland cement, as a constituent material of mortars, concretes and flowable fill mixtures, as a cost-effective mineral filler in hot mix asphalt paving applications, etc. One of the major benefits of using fly ash is that it will considerably reduce the use of natural raw materials and thus will enhance considerably industrial sustainability. However, the ash that isn't used ends up in landfills or containment ponds. Disposal of fly ash causes significant economic and environmental problems**.** In order to increase its utilization percentage, an investigation was carried out to evaluate its potential for producing of bituminous aggregates mixtures [1,2]. Bituminous aggregates are mixtures of asphalt with a higher percentage of voids in comparison to a mixture of asphalt concrete, which consists of coarse stone aggregate with less sand, stone dust and bitumen, as compared to asphalt concrete. Their application in pavement usually include composition of base course, the layer immediately beneath the surface course. It provides additional load distribution and contributes to drainage and frost resistance [1].

Mixture characteristics are heavily dependent on the properties of the aggregate and bitumen that constitute the paving mixture. The filler is an integral part of the aggregate used in bituminous mixtures, so its characteristics and content in the mix are very important for modifying the mixture characteristics. The optimum bitumen content and air voids percentage, and thus all mechanical properties of mixture, are influenced by the filler [3,4].

2. MATERIALS

2.1. Bitumen

Bitumen BIT 50/70 (Oil refinery "Bosanski Brod") was used as a binding component for the production of bituminous aggregate mixtures. Main properties of bitumen used are shown in Table 1.

Table 1. Physical-mechanical characteristics of bitumen BIT 50/70

Characteristics	Softening point (Ring and ball apparatus)	Penetration (1/10 mm)	Index of penetration	Specific weight at 25°C (g/cm^3)
Bitumen BIT 50/70	49°C	60	-0,23	1.0078

2.2. Aggregate

As the mineral aggregate in the mixture BNS 22A were used:

- fraction 0 / 4 - dolomite aggregate "Bučići" Rakovica,
- fraction 4 / 8 - calcareous aggregate "Sokolica" Zavidovići,
- fraction 8 / 16 - calcareous aggregate "Sokolica" Zavidovići,
- fraction 16 / 22 - calcareous aggregate "Sokolica" Zavidovići.

Composition of mineral mixture for BNS 22A is given in Table 2, and particle size distribution curve is shown in Figure 1.

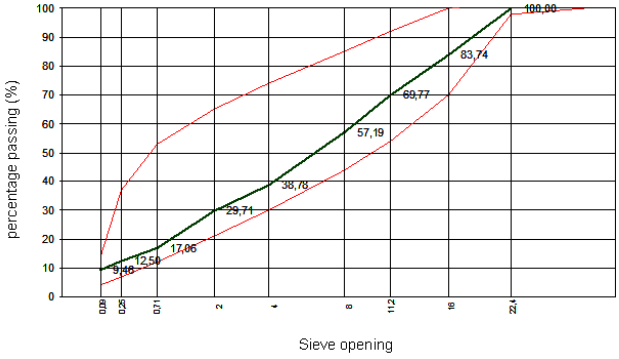

Figure 1. Particle size distribution of mineral mixture

Table 2. Composition of mineral mixture

Aggregate fraction	Percentage (%)
16/22	20.00
8/16	24.00
4/8	23.00
0/4	30.00
Total	100.00

2.3. Fly ash

Fly ash from power plant "Gacko" is used as mineral filler for mixtures of bituminous aggregate. The chemical composition of fly ash is shown in Table 3, and its main physical-mechanical properties in Table 4.

Table 3. Chemical composition of fly ash from power plant „Gacko"

Component	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Lost of ignition	Total
%	8.84	4.53	2.89	54.92	1.38	11.66	11.02	9.24

Table 4. Physical-mechanical characteristics of fly ash from power plant „Gacko"

Sieve analysis [%]			Specific weight (g/cm^3)	Specific surface (cm^2/g)	Bulk density (g/cm^3)
>200 µm	>90 µm	>63 µm			
0,6	2,5	9,40	2,55	4330	0,70

3. RESULTS AND DISCUSSION

To determine the optimum bitumen content, it is required to perform Marshall tests and carry out some analysis on these test results. Samples of bituminous aggregate mixtures were prepared with: 3.5, 4.0, 4.5, 5.0 and 5.5% bitumen. Results of laboratory investigation of bituminous aggregate mixtures with fly ash as filler replacement are shown in Table 5 and Figure 2.

Table 5. Physical-mechanical characteristics of bituminous aggregate mixtures with fly ash as filler replacement

No.	Binder content (%)	Bulk density (kg/m^3)	Air voids content (%)	Void filled with bitumen (%)	Stability at 60°C (kN)	Flow at 60°C (mm)	Stifness at 60°C (kN/mm^2)
1.	3.50	2372.87	9.04	47.63	10.45	2.53	4.13
2.	4.00	2412.90	6.75	58.61	11.20	2.70	4.15
3.	4.50	2427.75	5.41	61.27	10.21	3.06	3.34
4.	5.00	2442.81	4.06	74.88	10.16	3.21	3.17
5.	5.50	2432.43	3.70	78.17	8.91	3.16	2.82

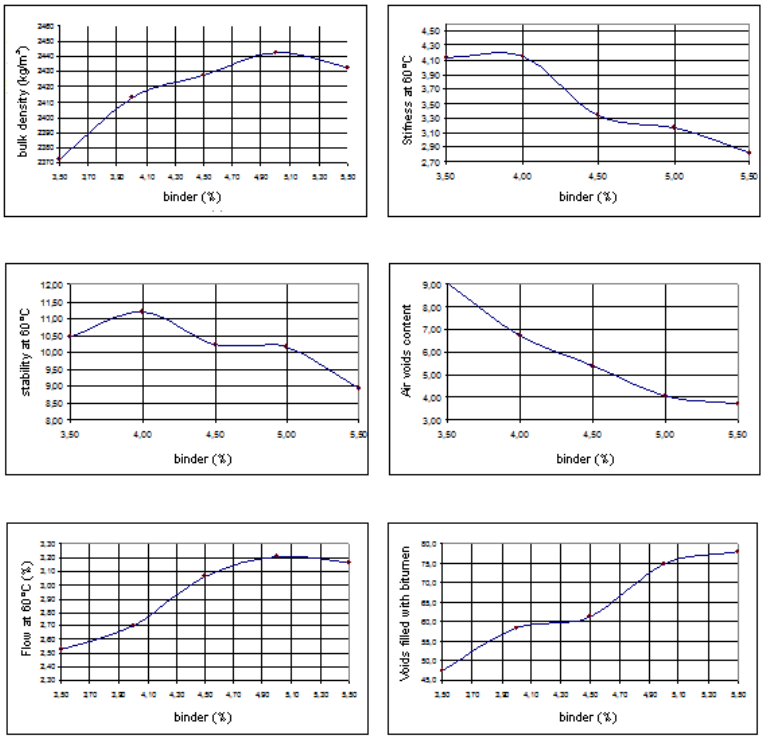

Figure 2. Physical-mechanical characteristics of bituminous aggregate mixtures with fly ash as filler replacement

Based on the results shown in Table 5 and graphical representation of physical and mechanical properties in Figure 2, optimum bitumen content is calculated as the mean size of the following values:

- Bitumen content for the maximum value of specific weight of the mixture sample …… 5%.
- Bitumen content for maximum stability ……... 4%
- Bitumen content for the mean value of air voids criterion …… 4.25%

- Bitumen content for the mean value of voids filled wit bitumen criterion …… .. 4.55%

Optimum bitumen content = (5+ 4 + 4.25 + 4.55)/4 = 4.45%

As a reference sample served a mixture that was identical to the test mixture, except that mineral dolomite filler was used instead fly ash. The results of testing the physical-mechanical properties of mixtures with dolomite filler are presented in Table 6.

Table 6. Physical-mechanical characteristics of bituminous aggregate mixtures with dolomite filler

No.	Binder content (%)	Bulk density (kg/m^3)	Air voids content (%)	Void filled with bitumen (%)	Stability at 60°C (kN)	Flow at 60°C (mm)	Stifness at 60°C (kN/mm^2)
1.	3.00	2310.4	12.16	36.07	8.48	2.68	3.16
2.	3.50	2371.4	8.22	47.46	9.44	3.18	2.97
3.	4.00	2398.48	7.31	56.52	10.44	3.31	3.15
4.	4.50	2415.24	5.89	64.59	10.80	3.44	3.14
5.	5.00	2450.77	3.74	76.42	9.95	3.52	2.83

The optimum bitumen content for bituminous aggregate mixture with dolomite filler was 4.54%, and for mixture with fly ash is 4.45%, indicating the advantages of using fly ash as a filler in these types of asphalt mixtures.

Better results for the mixtures with flay ash as a filler achieved at lower bitumen content are explained by the fact that the ash particles are spherical, with smooth surface and large specific surface area, compared to the dolomite filler particles of irregular shape and rough surface with a smaller specific surface. Due to the large specific surface area of fly ash, for mixtures that can be adequately mixed, minimum quantity of bitumen required is 4%. However, once the bitumen content reaches value enough for complete wrapping of fly ash particles, the mixture is easier to mix and compacting, and achieve better physical-mechanical properties compared to mixtures with dolomite filler, because of the favorable shape and smooth surface of the fly ash particles.

4. CONCLUSIONS

From the test results it can be concluded that:

- fly ash from power plant "Gacko" can be successfully used as a filler for asphalt mixtures BNS 22A,
- optimum bitumen content is lower for mixtures with fly ash,
- mixtures with fly ash as filler replacement show better performances at optimum bitumen content.

Some ecological and economic issues are resolved by using fly ash bituminous aggregate mixtures, such as:

- reducing fly ash disposal expenses,
- saving natural resources,
- lowering the costs of production.

5. REFERENCES:

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