

The Density of Asphalt Belts as One of the Criteria for Selection of Suitable Waterproofing Material

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Abstract

Asphalt insulation belts (hereinafter referred to as “AIP”) are traditional waterproofing material for roof constructions and lower structures. This article demonstrates the possibility of selecting water-proofing depending on bulk density. The density, unlike the thickness of surface density, can take into consideration the composition of the asphalt belt. The true composition affects the waterproof function of the asphalt belts and the bulk density can help when selecting correct water-proofing.

Keywords: asphalt waterproof belts, thickness of belts, surface density, waterproof property, polymers, fillers, bulk density, technical product sheet

Introduction

AIP mainly fulfils the waterproof function. This waterproof function is ensured by the asphalt substance, its volume and quality. The quality is stated by the volume of fillers in the asphalt substance. The existing standards for production of asphalt belts – ČSN EN 13707:A2 and ČSN EN 13969, contain testing methods for various tests but do not contain the procedure for ensuring the volume of asphalt or for limiting the volume of asphalt substance as, for example, in Germany. The waterproof property index remains the waterproof test according to ČSN EN 1928. Requirements set by this test (for roof materials 10 kPa, for lower structure 60kPa) do not fulfil materials with a very low asphalt ratio, as shown in the technical sheets of some asphalt belt producers.

The possibility of how to ascertain, without laboratory tests, the volume of asphalt as the index of waterproof properties, can be by bulk density. The issue of the bulk density of AIP was investigated just by the Union of Producers of Asphalt Belts in the Czech Republic in relation to the marking of asphalt belts. The raw materials used in asphalt belts have the minimum bulk density. See Tab. 1. On the basis of the bulk density, simple orientation between

individual belts can be acquired without laboratory tests along with specific information about the value of the waterproof ability of the stated asphalt belt. The waterproof property is stated by the volume of asphalt in the asphalt substance. The lower bulk density stated the lower ratio of fillers in the asphalt substance.

Composition of the asphalt belt:

- upper protective layer (mostly fine grain or rough grain filling on the basis of minerals)
- asphalt substance (asphalt, filler, polymers)
- load-bearing insert (commonly used inserts from polymers and glass)
- asphalt substance (asphalt, filler, polymers)
- lower protection, separating layer (mostly filling on the basis of minerals or polymeric foil)

Table 1: Approximate bulk densities of raw materials used for the production of AIP

Material	Filler in asphalt substance ¹	Load-bearing insert from polymer (glass) ²	Protective filling ³	Oxidized asphalt ⁴
Bulk density (kg/m ³)	1800–2800	cca 1000 (2000)	cca 1800	cca 1020

Zdroj: ¹authors own measurement, ²(Mleziva and Šňupálek 2000), ³(Rochla 1987), ⁴(Paramo 2012)

Materials and Methods

Bulk density of AIP as composite material is stated by its composition. AIP can be considered porous material; therefore, the subject of the calculation will not be density, but bulk density. The calculation of the bulk density as stated from the formula (1).

$$\rho = m/V \quad (1)$$

ρ - bulk density [kg/m³]

m - weight [kg]

V - volume of the body [m³]

For the requirements of the calculation of the bulk density for AIP, due to input data, the formula for the calculation of the bulk density is modified into the formula (2):

$$\rho = m/d \quad (2)$$

ρ - bulk density AIP [kg/m³]

m - surface density AIP [kg/m²]

d - thickness of AIP [m]

For ascertaining the bulk density of AIP it is necessary to state the thickness and the surface density for the respective AIP.

The ascertained values are influenced by the composition of the belt. Protective filling, separating polymeric foil and the load-bearing insert have characteristics and properties for most producer's materials. The difference is mainly in the asphalt substance, which consists of asphalt, polymers (for modified belts) and fillers; minerals with different bulk density are used as filler. Example in Tab. 1.

To simplify the comparison and the calculation, an asphalt substance was used from oxidized asphalt which does not contain polymers. As the representative, the asphalt belt with the substance from oxidized asphalt was selected, as well as the upper protective layer from silica sand, the load-bearing insert from glazed mat and the lower separation layer from polymeric foil. The thickness of the belt is 3.5 mm and is a commonly used asphalt belt available on the market in the Czech Republic which is contained in the offer from nearly all AIP producers.

The bulk density was ascertained from three sources which were mutually compared from:

1. technical sheets from producers that mention both monitored parameters,
2. experimental measurement in the laboratory,
3. theoretical calculation.

Bulk density ascertained from technical sheets from AIP producers

The bulk density was ascertained from the technical sheet according to the equation (2). For the summary, technical sheets from producers were selected which mention the bulk density, as well as the thickness of AIP. The producer is not obliged to mention both values; one value is sufficient (according to ČSN EN 1849-1). Both values are considered as the arithmetic average. Individual AIP producers are marked with letters.

The bulk density ascertained from experimental measurement

Experimental measurement was performed on two samples of one product. The samples had various types of fillers; one AIP sample contained ash as the filler, the other contained limestone. Each sample was presented by 10 testing bodies which were taken during the production of AIP in the manufacturing plant. The selection of 10 testing bodies was derived from the quantity provided by the manufacturing plants. Samples were taken in various manufacturing plants. Each testing body represented one manufacturing batch. The test sample had a size of 1.0 m (width of the belt) and the length of 0.1 m (in the direction of manufacturing). The taking of testing sample and the measurement of the thickness were in accordance with ČSN EN 1848-1. These testing bodies were weighed on calibrated digital scales with a maximum weight of 650 g with the precision 0.01 g. The result was recorded with the precision 0.1g. Sampling was done within one week. The type and volume of the filler were verified in a laboratory in the baking oven according to the testing procedures contained in ČSN 50 3602. The bulk density was calculated from individual measurements. The result was the arithmetic average from 10 measurements.

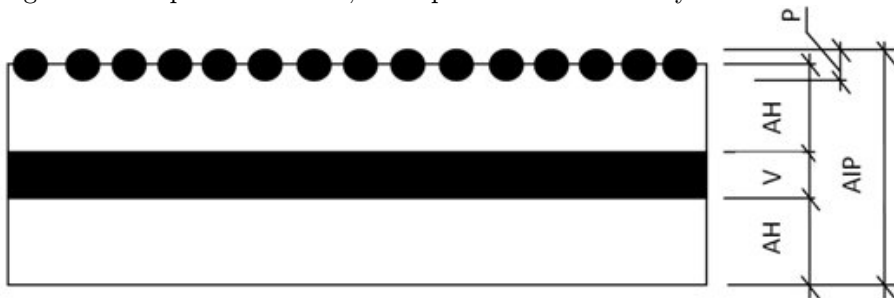
Bulk density ascertained by calculation

All three types of fillings were taken into consideration in the calculation (ash, calcite, slate powder). It was necessary to acquire the following supporting materials:

- Filler – the bulk density of fillers was ascertained experimentally in the laboratory according to the internal regulation of the manufacturing plant.
- Load-bearing insert – measured thickness and surface density of the impregnated insert during the production of AIP. The load-bearing insert was impregnated for the requirements of the calculation. In standard cases this type of load-bearing insert is not impregnated by the asphalt substance. Three samples were taken 100 x 100 mm on the width of the asphalt belt. Sampling and evaluation was in accordance with ČSN EN 1849-1.
- Asphalt substance – bulk density was taken from (BL AOSI 2012).
- Filling – a commonly used fraction of the filling for this type of belt is 0.1-0.5 mm, consumption was ascertained experimentally in the laboratory according to the internal regulation of the manufacturing plant.

The bulk density of AIP was calculated using the weighted average. The weight was the thickness of individual AIP layers according to Fig.4.

Figure 1: Composition of AIP, description of individual layers



Source: own

Total bulk density of AIP was ascertained according to the formula (3).

$$\rho_{AIP} = \frac{d_{AH} \cdot \rho_{AH} + d_V \cdot \rho_V + d_P \cdot \rho_P}{d_{AIP}} \quad (3)$$

ρ_{AIP} - bulk density AIP AIP [kg/m³]

d_{AH} - thickness of the layer from the asphalt substance [m]

ρ_{AH} - bulk density of the asphalt substance [kg/m³]

d_V - thickness of the load-bearing insert with the asphalt substance [m]

ρ_V - bulk density of the load-bearing insert with the asphalt substance [kg/m³]

d_P - thickness of the filling layer [m]

ρ_P - bulk density of the filling [kg/m³]

The bulk density of the asphalt mixture was calculated by the average weight according to the percentages of the filler and asphalt according to the equation (4) for the volume by the volumes 25, 30, 35, 40 and 45% of fillers.

$$\rho_{AH} = \frac{\%_A \cdot \rho_A + \%_P \cdot \rho_{PL}}{\%_A + \%_{PL}} \quad (4)$$

ρ_{AH} - bulk density of the asphalt substance [kg/m³]

$\%_A$ - asphalt in asphalt substance [%]

ρ_A - bulk density of asphalt [kg/m³]

$\%_{PL}$ - fillers in the asphalt substance [%]

ρ_{PL} - bulk density of fillers [kg/m³]

The bulk density of the load-bearing insert was calculated from the measured thickness and the surface density. For the calculation of the bulk density of the filler, an estimate was used. The dipping of $\frac{1}{2}$ of the largest fraction was considered (i.e. $\frac{1}{2} \cdot 0,5$ mm). Calculation according to (5).

$$\rho_P = \frac{m_P}{d_P} \quad (5)$$

ρ_P - bulk density of the filling [kg/m³]

m_P - surface density of the filling [kg/m²]

d_P - thickness of the filling layer [m]

Results

The results are presented from the asphalt belt, thickness 3.5 mm from oxidized asphalt, upper protective layer from siliceous sand, load-bearing insert from glazed mat and the lower separating layer from polymeric foil.

Bulk density ascertained from the technical sheets from AIP producers (Plachý 2012)

Table 2: Bulk density from the technical sheets of the producers

Parameters / AIP producers	Belt thickness TL (mm)	Surface density according to TL (kg/m ²)	Bulk density (kg/m ³)
A	3.5	3.9	1114
B	3.5	4.45	1271
C	3.8	4.8	1263
D	3.5	3.9	1114
E	3.5	4.4	1257
F	3.5	4.65	1329
G	3.5	4.7	1343

Source: A (Dehtochema Bitumat 2008),B (KRPA Dehtochema 2010),C (Büsscher & Hoffmann 2006),D (Icopal Vedag CZ 2010),E (Icopal Vedag CZ 2011),F (Dehtochema Bitumat 2012),G (Bohemia FR Systems 2011).

Table 3: Bulk density ascertained from experimental measurement

Testing body	Ash filler			Calcite filler		
	Belt thickness (mm)	Surface density of the testing body (g)	Bulk density (kg/m ³)	Belt thickness (mm)	Surface density of the testing body (g)	Bulk density (kg/m ³)
1	3.54	401.50	1134	3.56	468.60	1316
2	3.40	403.40	1186	3.47	448.50	1291
3	3.42	402.50	1177	3.55	478.40	1348
4	3.46	412.30	1192	3.52	461.20	1312
5	3.50	409.20	1169	3.45	467.70	1358
6	3.62	425.00	1174	3.39	451.50	1330
7	3.62	410.40	1134	3.45	472.60	1370
8	3.54	416.60	1177	3.42	438.10	1281
9	3.45	398.60	1155	3.51	471.80	1344
10	3.56	424.10	1191	3.47	461.30	1329
Arithmetic average	3.51	410.36	1169	3.48	461.97	1328

Source: author's own measurement

The bulk density from the technical sheets from producers varies within the range 1.114 – 1.343 kg/m³. Arithmetic average from bulk densities is 1.242 kg/m³.

Bulk density ascertained from experimental measurement

Bulk density from experimental measurement is for material where ash is used as the filler 1,169 kg/m³ (volume of filler 33.8%) and 1,328 kg/m³ (volume of fillers 34.9%) where was calcide used.

Arithmetic average from bulk densities is 1.248 kg/m³.

The bulk density was ascertained by calculation

Table 4: The bulk density of fillers used in asphalt belts

Material	Ash	Micro-milled slate	Calcite
Bulk density (kg/m ³)	1880	2780	2250

Source: author's own measurement

Surface density of the load-bearing insert 120 g/m²; thickness of the insert impregnated by asphalt 0.035 mm.

Table 5: Bulk density AIP depending on the type and volume of fillers

Type of filler in AIP	Volume of fillers in asphalt mixture				
	25%	30%	35%	40%	45%
Ash	1172 kg/m ³	1207 kg/m ³	1243 kg/m ³	1279 kg/m ³	1314 kg/m ³
Slate powder	1358 kg/m ³	1431 kg/m ³	1504 kg/m ³	1577 kg/m ³	1650 kg/m ³
Calcite	1249 kg/m ³	1299 kg/m ³	1350 kg/m ³	1401 kg/m ³	1452 kg/m ³

Source: author's own measurement

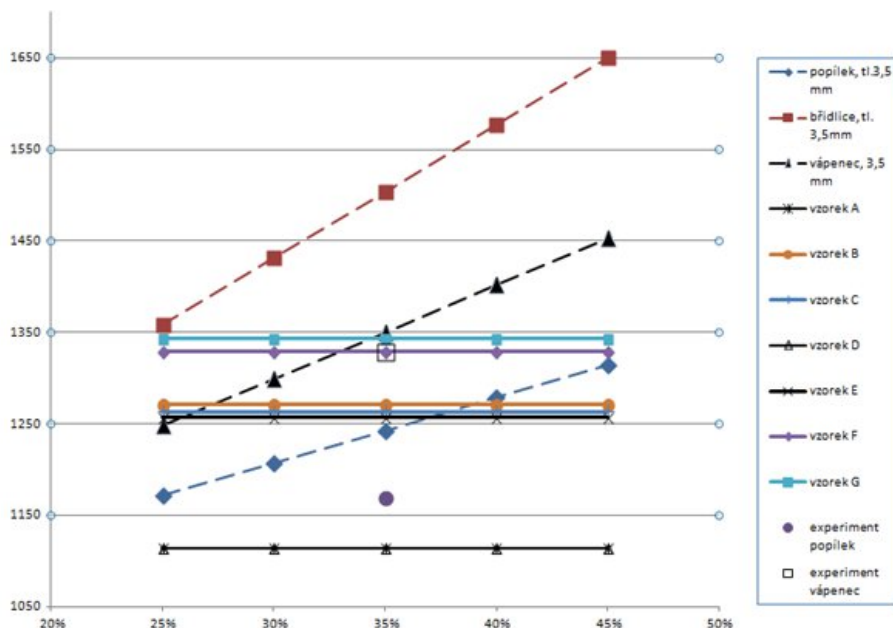
Discussion

When comparing the bulk density ascertained experimentally and by calculation, in the case of the filler **calcite** there was a difference of 22 kg/m³, which represents a deviation of 1.6%. In the case of the filler **ash** the difference is 74 kg/m³, which represents a deviation of 6.3%. This deviation is caused by another volume of fillers than in the calculation. In both cases, it is necessary to take into consideration the estimated calculation of the bulk density of the filler. It results from comparing TL arithmetic averages and laboratory measurements that among TL there are products with ash or calcite.

It is evident from the results that the producers of asphalt belts only use calcite and ash. The use of micro-milled slate in a volume of approximately 25%, due to the higher price compared with ash and the comparable price of the calcite is much less probable. For samples A, D, due to the small bulk density, ash is used; its volume in the asphalt substances is very low. For samples F, G, calcite was used as the filler in the volume of approximately 35%. The dosing of the ash in the volume of 45% can be problematic in terms of processing the mixture. For samples B, C, E, ash or calcite can be used as the filler. With

respect to the situation on the AIP market and the overall economic situation of producers, then the use of cheaper fillers, i.e. ash, can be expected. Provided that raw materials will be used which were used in the experimental and calculation part, then A, D samples in terms of the waterproof property can be considered to be the most suitable due to the lowest ratio of fillers.

Graph 1: Comparison of individual bulk densities ascertained by calculation and measurement



Source: author's own measurement

Conclusion

The results of this article may provide fast orientation for mutual comparison between asphalt belts where there is the thickness and surface density of AIP. If only the thickness of the belt or surface density is mentioned, it is possible to use the arithmetic average of the bulk density from TL producers to calculate the thickness of bulk density. For recalculation, a bulk density of approximately 1,245 kg/m³ can be used. However, this formula is valid for belts with a thickness of 3.5 mm from oxidized asphalt, upper protective layer from siliceous sand, load-bearing insert from glazed mat and the lower separating layer from polymeric foil.

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Objemová hmotnost asfaltových pásů jako jedno z kritérií pro výběr vhodného hydroizolačního materiálu

Asfaltové izolační pásy (dále v textu AIP) jsou tradičním hydroizolačním materiálem pro střešní konstrukce a spodní stavbu. Tento článek poukazuje na možnost výběru hydroizolace v závislosti na objemové hmotnosti. Objemová hmotnost, na rozdíl od tloušťky a plošné hmotnosti, může zohlednit složení asfaltového pásu. Právě složení ovlivňuje hydroizolační funkci asfaltových pásů a objemová hmotnost tak může napomoci výběru správné hydroizolace.

Keywords: asfaltové hydroizolační pásy, tloušťka pásů, plošná hmotnost, hydroizolační schopnost, polymery, plnivo, objemová hmotnost (*Bulk density*), technický list výrobku

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