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INVESTIGATIONS OF GEOSYNTHETIC INTERLAYER BONDING IN ASPHALT LAYERS

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The paper presents the results of an extensive investigation of asphalt concrete specimens with geosynthetic interlayer. The subject of this research is evaluation of influence of geosynthetics interlayer applied to bituminous pavements on interlayer bonding of specimens. The results of the tests proves that when geosynthetic is used, the bonding of interlayer depends mainly on the type of bituminous mixture, the type of geosynthetic, and the type and amount of bitumen used for saturation and sticking of geosynthetic. The amount of bitumen used in order to saturate and fix the geosynthetic significantly changes the interlayer bonding of specimens.

Key words: interlayer bonding, shear strength, shear stiffness, asphalt concrete, geosynthetics interlayer.

1. Introduction

Concept of interlayer in asphalt pavement has been developed for many years as a way of a solution of the reflecting cracking problem [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]. The most popular solution to this problem is provided by geosynthetics such as nonwowen, geogrids or geocomposites.

Effectiveness of geosynthetics interlayer strongly depends on bonding between layers, while the practical aspects show that the use of geosynthetics decreases interlayer bonding. Negative effects of the lack of interlayer bonding were presented by Zawadzki [11], who investigated the dependency between shear strength between layers and stiffness modulus of the asphalt layers measured by FWD apparatus. He determined that a weak interlayer bonding decreases stiffness of asphalt layers and then increases the fatigue cracking of pavement. Influence of interlayer bonding on pavement bearing capacity were mentioned also in [12], while problem of FWD use for assessment of pavement interlayer bond was widely evaluated in [13] and [14].

The paper presents the results of an extensive investigation of asphalt concrete specimens with geosynthetics interlayer [15], [16], [17], [18]. The main aim of the investigation was to define factors determining interlayer bonding. To pursue the above aim the following variables were taken into account:

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– type of geosynthetic (polyester nonwoven – PN, polyester geocomposite – PG, and two geocomposites including glass grid and polyester nonwoven – GG),
– kind of bitumen used for layers bonding (hot bitumen B-70Pen, two ordinary bitumen emulsions: K1-65 and K1-70 and modified bitumen emulsion K-1-65MP),
– kind of upper asphalt layer in specimens (comparatively: two asphalt concretes – AC with grading 0/12,8mm and 0/16 mm plus SMA (Stone Mastics Asphalt) 0/12,8 mm),
– amount of bitumen used for layers' bonding (investigated for AC 0/12,8 mm).

2. Testing methods

In laboratory tests the interlayer bonding was represented by shear strength between layers and shear stiffness. Those parameters were examined by using the prototype apparatus constructed in the Laboratory of the Department of Road and Traffic Engineering of Cracow University of Technology in cooperation with the Department of Experimental Mechanics and Bio-mechanics (Fig.1).

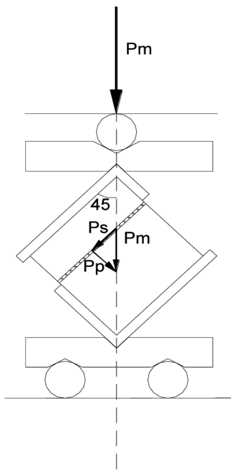


Fig. 1. Shearing of specimen of asphalt concrete with geosynthetic interlayer.
Rys. 1. Ścinanie próbki z mieszanki mineralno-bitumicznej z geosyntetyczną warstwą pośrednią

Tests were performed at two chosen levels of temperature: -2°C and +25°C, with an applied rate of shearing 1mm/min. For all types of interlayer system, 5-6 specimens were produced in the laboratory. The specimens were compacted in moulds in two layers with geosynthetic interlayer, applied on the bitumen tack coat. For the test the specimens were sawn to dimension of: 75×75×75 mm.

The following parameters of samples were recordered:
– Dimensions of specimens [mm]
– Volume of voids in compacted specimens [%]
– Maximum shearing force P_s [kN] according to Eq. (2.1)

– Shear strength [MPa] written as Eq. (2.2) expressed by
– Tangent shearing modulus [N/mm] as Eq. (2.3)
– Shear stiffness [N/mm/mm^2] according to Eq. (2.4)

$$P_s = \frac{P_m}{\sqrt{2}} \tag{2.1}$$

$$\sigma_s = \frac{P_s}{F_s} \tag{2.2}$$

$$M = \frac{\Delta P_m}{\Delta s} \tag{2.3}$$

$$S_s = \frac{M}{F_s} \tag{2.4}$$

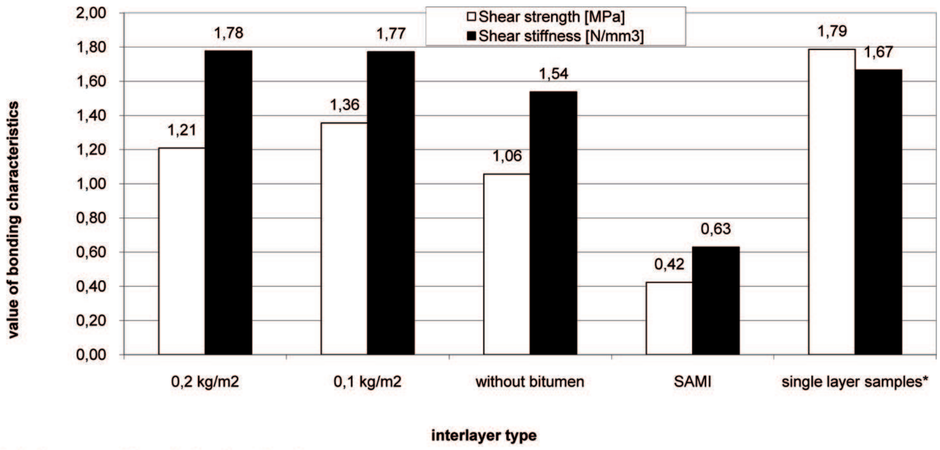
where: P_s – loading force [N]
F_s – area of shearing [mm^2]
ΔP_m – increment of loading force [N]
Δs – increment of displacement [mm]

3. Characteristics of investigated materials

Asphalt mixes prepared in a mixing plant were used for preparation of the specimens. Geosynthetics and bitumen used to saturate and bond geosynthetics were obtained from distributors. Detailed data concerning the material characteristics are given in the reports [15] and [16], whereas parameters of geosynthetics applied in the tested specimens are given in Table 1.

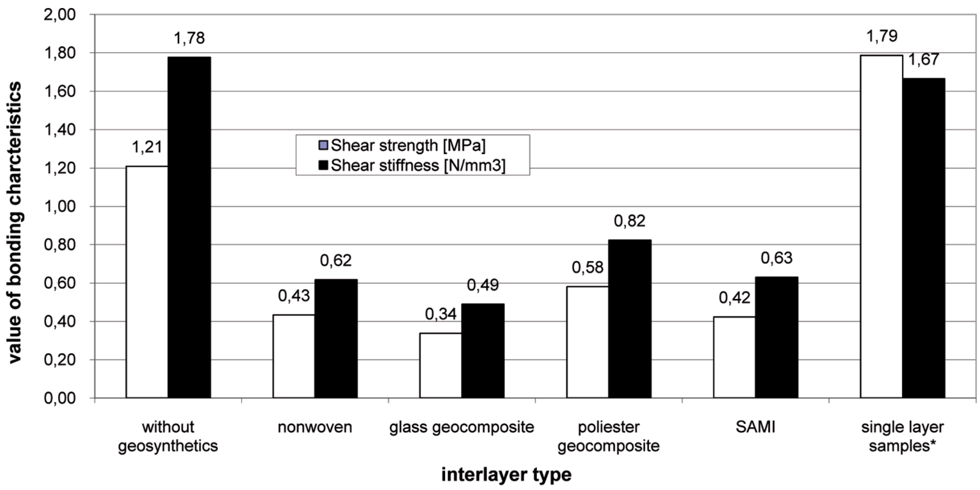
4. Results of shearing test

According to schedule of the tests, the results of shear strength and shear stiffness are determined. Selected results of shearing tests are presented in the figures below, where:
– (Fig. 2) – specimens without geosynthetic
– (Fig. 3-6) – interlayer type for various bitumen type applied to the interlayer
– (Fig. 7) – type of asphalt mixes applied to layers of specimens
– (Fig. 8-9) – amount of bitumen applied to interlayer



** single layer samples submitted to shearing*

Fig. 2. Relations between interlayer bonding characteristics and type of interlayer for AC 12,8 specimens without geosynthetic, T= 25°C
Rys. 2. Zależność charakterystyk związania międzywarstwowego od rodzaju warstwy pośredniej dla próbek z BA 12,8 bez geosyntetyków, T = 25°C



** single layer samples submitted to shearing*

Fig. 3. Relations between interlayer bonding characteristics and type of interlayer for AC 12,8 samples bonded with 70Pen bitumen, T= 25°C
Rys. 3. Zależność charakterystyk związania międzywarstwowego od rodzaju warstwy pośredniej dla próbek z BA 0/12,8 mm połączonych asfaltem 70Pen, T = 25°C

Table 1

Parameters of geosynthetics applied in testing specimens.
Własności geosyntetyków zastosowanych w badaniach

Geosynthetics type	Surface mass [g/ m^2]	Tensile strength [kN/m]		Elongation at break [%]		Temperature [°C]	
		along	crosswise	along	crosswise	softening	melting
Polyester nonwoven	189	8.23	8.41	79	92	230-240°C	257-264°C
Polyester geocomposite	360	grid: 50	grid: 50	grid: 12	grid: 12	230-240°C	257-264°C
geocomposite glass grid + polyester nonwoven	360	grid: > 35	grid: > 56	grid: 3	grid: 3	glass: 500-750°C polyester: 230-240°C	glass: various temp. polyester: 257-264°C

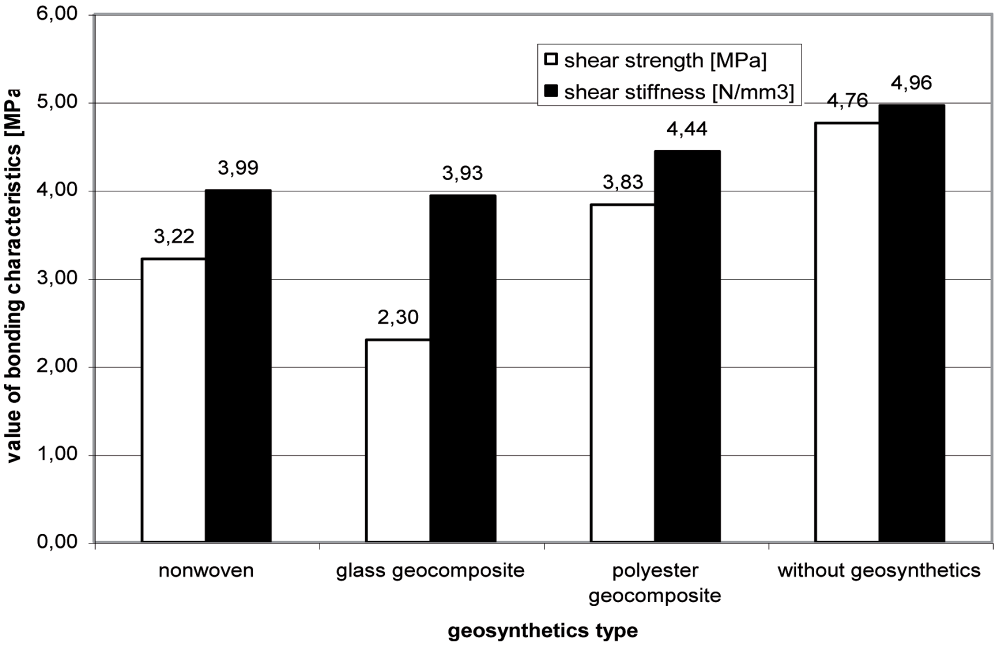


Fig. 4. Relations between interlayer bonding characteristics and type of interlayer for samples bonded with 70Pen bitumen, T= -2°C
Rys. 4. Zależność wytrzymałości na ścinanie od rodzaju geosyntetyku, dla próbek połączonych asfaltem 70Pen, T = -2°C

Statistical analysis of the achieved results were conducted with the use of computer program Statgraphics Plus v. 5.1. [19] according to the procedure given in [20]. To examine normality of the results, the Shapiro-Wilks test and the chi-square test were applied. In most of the cases there was no indication of rejecting the hypothesis of normal distribution. Then, the null hypothesis was tested to find out if the standard

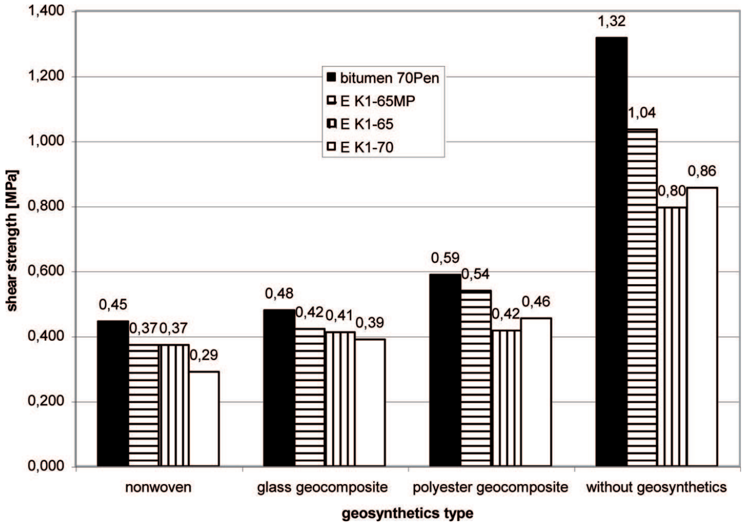


Fig. 5. Relations between shear strength and type of interlayer for AC 16+AC 16 samples bonded with the various type of bitumen, T= 25°C

Rys. 5. Zależność wytrzymałości na ścinanie od rodzaju warstwy pośredniej dla próbek z BA 16+BA 16 połączonych różnymi rodzajami lepiszczy, T = 25°C

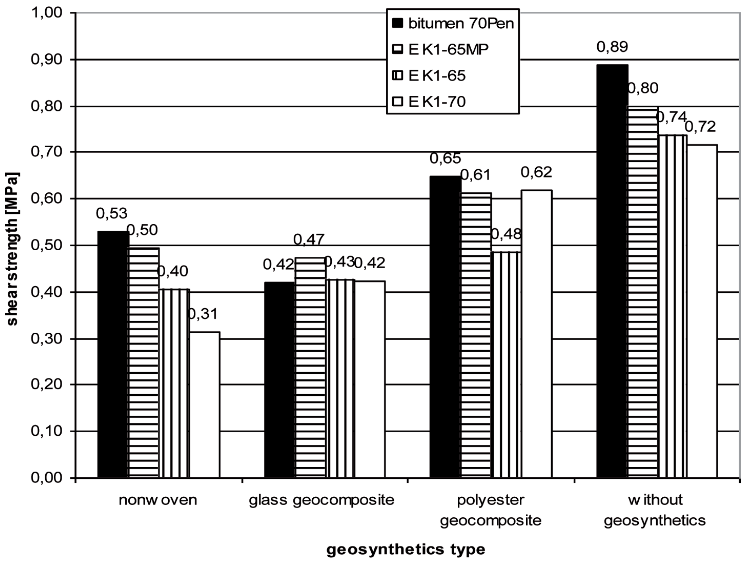
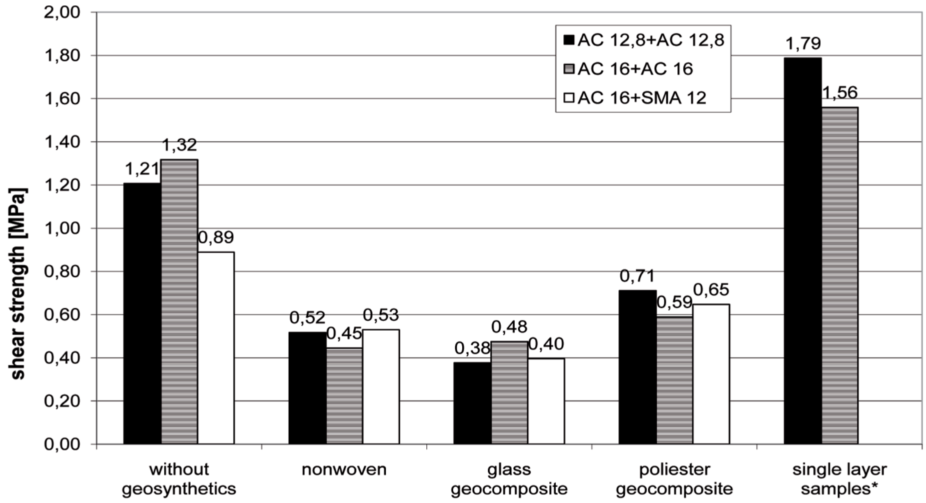


Fig. 6. Relations between shear strength and type of interlayer for AC 16+SMA 12,8 samples bonded with the various type of bitumen, T= 25°C

Rys. 6. Zależność wytrzymałości na ścinanie od rodzaju warstwy pośredniej dla próbek z BA 16+SMA 12,8 połączonych różnymi rodzajami lepiszczy, T = 25°C



** single layer samples submitted to shearing*

Fig. 7. Relations between shear strength and type of interlayer for various types of mixes, T= 25°C
Rys. 7. Zależność wytrzymałości na ścinanie od rodzaju warstwy pośredniej dla różnych mieszanek, T = 25°C

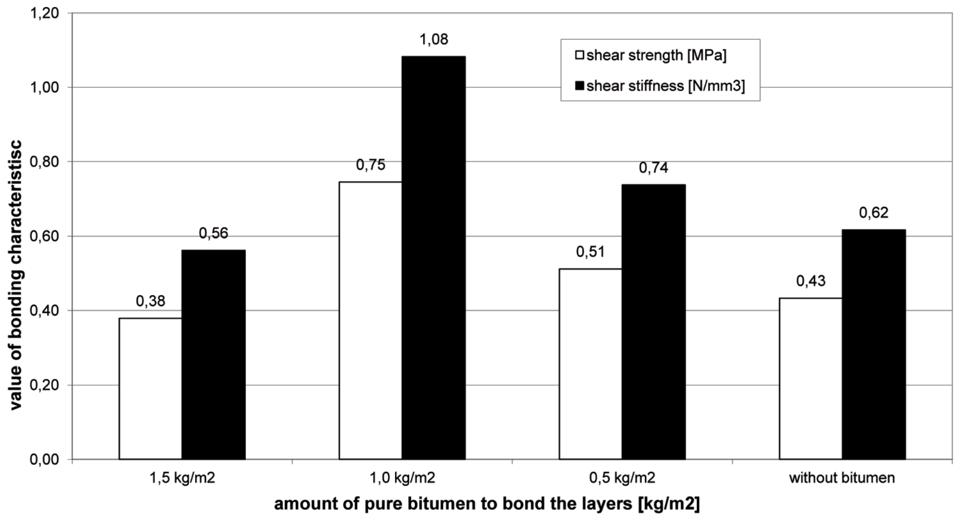


Fig. 8. Relations between interlayer bonding characteristics and amount of bitumen spreading for samples with nonwoven, T= 25°C
Rys. 8. Zależność charakterystyk związania międzywarstwowego od ilości skropienia dla próbek z BA 0/12,8 mm z geowłókniną GW, T = 25°C

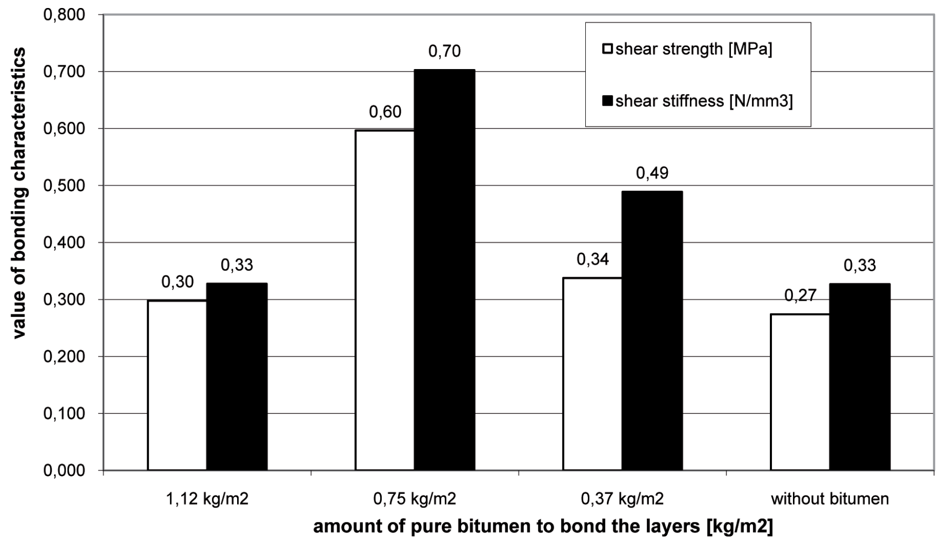


Fig. 9. Relations between interlayer bonding characteristics and amount of bitumen spreading for samples with glass geocomposite, T= 25°C

Rys. 9. Zależność charakterystyk związania międzywarstwowego od ilości skropienia dla próbek z BA 0/12,8 mm z geokompozytem szklanym, T = 25°C

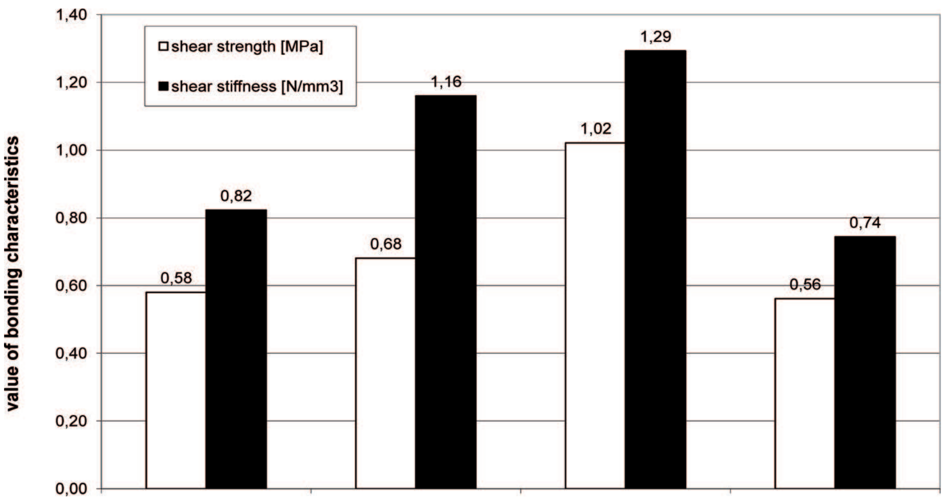


Fig. 10. Relations between interlayer bonding characteristics and amount of bitumen spreading for samples with polyester geocomposite, T= 25°C

Rys. 10. Zależność charakterystyk związania międzywarstwowego od ilości skropienia asfaltem dla próbek z geokompozytem poliestrowym, T = 25°C deviations inside all groups were the same. The Cochran test with the degree of confidence equal to 5% was applied. In all tested cases the degree of Cochran statistics was greater than 0.05, which enabled application of further tests. Otherwise, it would be recommended to apply the Box-Cox transformation.

Next test was performed to find out if there was any statistically significant difference between the averages of the variable. In all tested cases the differences between tested structures were significant at a given confidence level equal to 0.95. The ANOVA table was used for this purpose. To determine which interlayer systems differed significantly from one another, the analisis of multiply range tests with application of LSD (least square differences) option was used. Detailed tables of significant differences are reported in the work [18], whereas examples of graphical presentation of results are given in Figures 11-13 (on the vertical axe there is an amount of bitumen spreading for specimens). Results of the analysis of significance of differences for asphalt mixes specimens with different interlayers are presented in Tables 2-9.

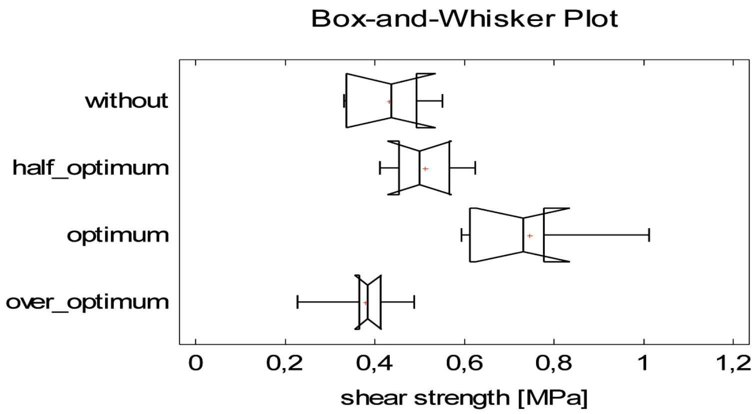


Fig. 11. Relations between shear strength and amount of bitumen used to glue the layers for specimens with polyester nonwoven, T= 25°C

Rys. 11. Zależność wytrzymałości na ścinanie od ilości skropienia asfaltem dla próbek z geowłókniną poliestrową, T = 25°C

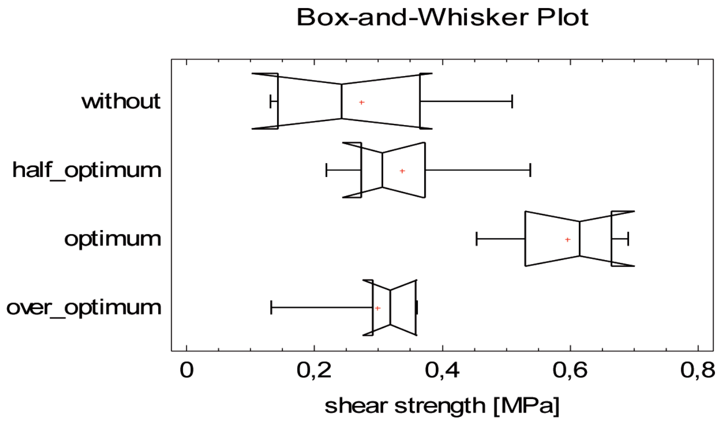


Fig. 12. Relations between shear strength and amount of bitumen used to glue the layers for samples with glass geocomposite, T= 25°C
Rys. 12. Zależność wytrzymałości na ścinanie od ilości skropienia asfaltem dla próbek z geokompozytem szklanym, T = 25°C

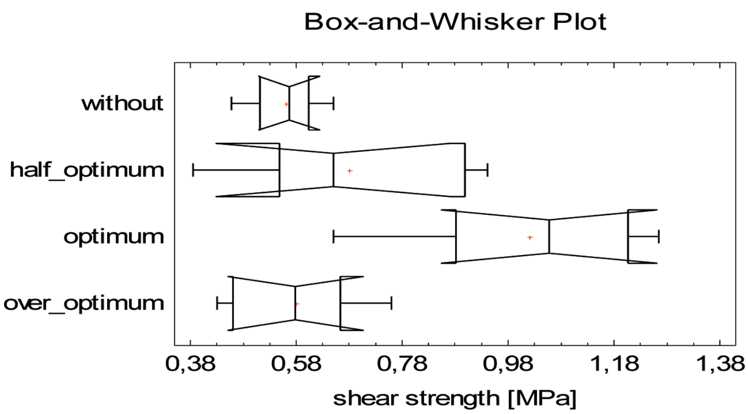


Fig. 13. Dependency between shear strength and amount of bitumen to glue the layers for samples with glass geocomposite, T= 25°C
Rys. 13. Zależność wytrzymałości na ścinanie od ilości skropienia asfaltem dla próbek z geokompozytem szklanym, T = 25°C

Table 2

Significance of statistical differences for samples with nonwoven, T=25°C.
Oszacowanie istotności różnic dla próbek z geowłókniną, T=25°C

Binder/ Layers	B 70Pen/ AC+AC	B 70Pen/ AC+SMA	E-65MP/ AC+AC	E-65MP/ AC+SMA	E-65/ AC+AC	E-65/ AC+SMA	E-70/ AC+AC	E-70/ AC+SMA
B 70Pen/AC+AC	–	**Y**	N	N	N	N	**Y**	**Y**
B 70Pen/AC+SMA	**Y**	–	**Y**	N	**Y**	**Y**	**Y**	**Y**
E-65MP/AC+AC	N	**Y**	–	**Y**	N	N	N	N
E-65MP/AC+SMA	N	N	**Y**	–	**Y**	N	**Y**	**Y**
E-65/ AC+AC	N	**Y**	N	**Y**	–	N	N	N
E-65/AC+SMA	N	**Y**	N	N	N	–	**Y**	N
E-70/AC+AC	**Y**	**Y**	N	**Y**	N	**Y**	–	N
E-70/AC+SMA	**Y**	**Y**	N	**Y**	N	N	N	–

Table 3

Significance of statistical differences for samples with polyester geocomposite, T=25°C.
Oszacowanie istotności różnic dla próbek z geokompozytem poliestrowym, T=25°C

Binder/ Layers	B 70Pen/ AC+AC	B 70Pen/ AC+SMA	E-65MP/ AC+AC	E-65MP/ AC+SMA	E-65/ AC+AC	E-65/ AC+SMA	E-70/ AC+AC	E-70/ AC+SMA
B 70Pen/AC+AC	–	**Y**	**Y**	N	N	N	**Y**	N
B 70Pen/AC+SMA	**Y**	–	**Y**	N	N	N	**Y**	N
E-65MP/AC+AC	**Y**	**Y**	–	**Y**	N	**Y**	N	**Y**
E-65MP/AC+SMA	N	N	**Y**	–	N	N	**Y**	N
E-65/ AC+AC	N	N	N	N	–	N	N	N
E-65/AC+SMA	N	N	**Y**	N	N	–	N	N
E-70/AC+AC	**Y**	**Y**	N	**Y**	N	N	–	**Y**
E-70/AC+SMA	N	N	**Y**	N	N	N	**Y**	–

Table 4

Significance of statistical differences for samples with glass geocomposite, T=25°C.
Oszacowanie istotności różnic dla próbek z geokompozytem szklanym, T=25°C

Binder/ layers	B 70Pen/ AC+AC	B 70Pen/ AC+SMA	E-65MP/ AC+AC	E-65MP/ AC+SMA	E-65/ AC+AC	E-65/ AC+SMA	E-70/ AC+AC	E-70/ AC+SMA
B 70Pen/AC+AC	–	N	N	N	N	N	N	N
B 70Pen/AC+SMA	N	–	N	N	N	N	N	N
E-65MP/AC+AC	N	N	–	N	N	N	N	N
E-65MP/AC+SMA	N	N	N	–	N	N	N	N
E-65/ AC+AC	N	N	N	N	–	N	N	N
E-65/AC+SMA	N	N	N	N	N	–	N	N
E-70/AC+AC	N	N	N	N	N	N	–	N
E-70/AC+SMA	N	N	N	N	N	N	N	–

Table 5

Significance of statistical differences for samples with various interlayer glued with 70Pen bitumen, T=25°C.
Oszacowanie istotności różnic dla próbek z różnymi warstwami pośrednimi sklejonymi asfaltem 70Pen, T=25°C

Layers	AC+SMA	AC+AC	AC+PN +SMA	AC+ PN+AC	AC+PG+ SMA	AC+ PG+AC	AC+ GG+SMA	AC+ GG+AC
AC+SMA	–	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
AC+AC	**Y**	–	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
AC+PN+SMA	**Y**	**Y**	–	N	Y	N	N	N
AC+PN+AC	**Y**	**Y**	N	–	**Y**	**Y**	N	N
AC+PG+SMA	**Y**	**Y**	**Y**	**Y**	–	N	**Y**	**Y**
AC+PG+AC	**Y**	**Y**	N	**Y**	N	–	**Y**	N
AC+GG+SMA	**Y**	**Y**	N	N	**Y**	**Y**	–	N
AC+GG+AC	**Y**	**Y**	N	N	Y	N	N	–

Table 6

Significance of differences for samples with various interlayer bonded with modify emulsion K1-65MP, T=25°C.
Oszacowanie istotności różnic dla próbek z różnymi warstwami pośrednimi sklejonymi emulsją K1-65MP, T=25°C

Layers	AC+SMA	AC+AC	AC+PN +SMA	AC+ PN+AC	AC+PG+ SMA	AC+ PG+AC	AC+ GG+SMA	AC+ GG+AC
AC+SMA	–	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
AC+AC	**Y**	–	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
AC+PN+SMA	**Y**	**Y**	–	N	N	N	N	N
AC+PN+AC	**Y**	**Y**	N	–	**Y**	N	N	N
AC+PG+SMA	**Y**	**Y**	N	**Y**	–	**Y**	**Y**	**Y**
AC+PG+AC	**Y**	**Y**	N	N	**Y**	–	N	N
AC+GG+SMA	**Y**	**Y**	N	N	**Y**	N	–	N
AC+GG+AC	**Y**	**Y**	N	N	**Y**	N	N	–

Table 7

Significance of differences for samples with various interlayer bonded with emulsion K1-65, T=25°C.
Oszacowanie istotności różnic dla próbek z różnymi warstwami pośrednimi sklejonymi emulsją K1-65, T=25°C

Layers	AC+SMA	AC+AC	AC+PN +SMA	AC+ PN+AC	AC+PG+ SMA	AC+ PG+AC	AC+ GG+SMA	AC+ GG+AC
AC+SMA	–	N	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
AC+AC	N	–	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
AC+PN+SMA	**Y**	**Y**	–	N	**Y**	**Y**	N	N
AC+PN+AC	**Y**	**Y**	N	–	**Y**	**Y**	N	N
AC+PG+SMA	**Y**	**Y**	**Y**	**Y**	–	N	N	**Y**
AC+PG+AC	**Y**	**Y**	**Y**	**Y**	N	–	N	N
AC+GG+SMA	**Y**	**Y**	N	N	N	N	–	N
AC+GG+AC	**Y**	**Y**	N	N	**Y**	N	N	–

Table 8

Significance of differences for samples with various interlayer glued with emulsion K1-65, T=25°C.
Oszacowanie istotności różnic dla próbek z różnymi warstwami pośrednimi sklejonymi emulsją K1-65, T=25°C

Layers	AC+SMA	AC+AC	AC+PN +SMA	AC+ PN+AC	AC+PG+ SMA	AC+ PG+AC	AC+ GG+SMA	AC+ GG+AC
AC+SMA	–	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
AC+AC	**Y**	–	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
AC+PN+SMA	**Y**	**Y**	–	N	**Y**	**Y**	**Y**	N
AC+PN+AC	**Y**	**Y**	N	–	**Y**	**Y**	**Y**	**Y**
AC+PG+SMA	**Y**	**Y**	**Y**	**Y**	–	**Y**	**Y**	**Y**
AC+PG+AC	**Y**	**Y**	**Y**	**Y**	**Y**	–	N	N
AC+GG+SMA	**Y**	**Y**	**Y**	**Y**	**Y**	N	–	N
AC+GG+AC	**Y**	**Y**	N	**Y**	**Y**	N	N	–

where: **Y – differences are significant**
N – differences are not significant

Table 9

Significance of differences for all binders together, T=25°C.
Oszacowanie istotności różnic dla wszystkich lepiszczy łącznie, T=25°C

Layers	AC+SMA	AC+AC	AC+PN +SMA	AC+ PN+AC	AC+PG+ SMA	AC+ PG+AC	AC+ GG+SMA	AC+ GG+AC
AC+SMA	**X**	**0.75**	**1**	**1**	**1**	**1**	**1**	**1**
AC+AC	**0.75**	**X**	**1**	**1**	**1**	**1**	**1**	**1**
AC+PN+SMA	**1**	**1**	**X**	**0.25**	**0.75**	**0.50**	**0.50**	**0.25**
AC+PN+AC	**1**	**1**	**0.25**	**X**	**1**	**0.75**	**0.25**	**025**
AC+PG+SMA	**1**	**1**	**0.75**	**1**	**X**	**0.75**	**0.75**	**1**
AC+PG+AC	**1**	**1**	**0.50**	**0.75**	**0.75**	**X**	**0.25**	**0.25**
AC+GG+SMA	**1**	**1**	**0.50**	**0.25**	**0.75**	**0.25**	**X**	**0**
AC+GG+AC	**1**	**1**	**0.25**	**0.25**	**1**	**0.25**	**0**	**X**

where: 1 – significant difference exist for all tested binders
0.75 – significant difference exist for 3 from 4 tested binders
0.50 – significant difference exist for 2 from 4 tested binders
0.25 – significant difference exist for 1 from 4 tested binders
0 – significant difference for tested binders not exist

5. Analysis of shearing tests result

5.1. Specimens without geosynthetics

- Samples compacted as a single layer gave shear strength by 1,5-2 times higher than layered samples, and this grew up along with the increase of gradation of asphalt mixes.
- In the case of two layered samples without spreading the bitumen in interlayer, shear strength and shear stiffness were lower for asphalt mixes including lower amount of bitumen, due to the lack of adhesion.
- Application of bitumen tack coat between asphalt concrete layers without geosynthetics increased shear strength by about 70%, while the use of bitumen modified emulsions lifted shear strength by about 35%; in the case of application of ordinary bitumen emulsions no significant differences were reported.
- Application of bitumen tack coat between AC and SMA did not increase shear strength, while an application of ordinary bitumen emulsions decreased the shear strength. It showed that in the case of application of SMA wearing coarse on the AC layer, an application of tack coat was not necessary.
- Application of SAMI (Stress Absorbing Membrane Interlayer) essentially (2-3 times) decreased the shear strength, which might have a significant influence on fatigue properties in this solution.

5.2. Specimens with polyester nonwoven

- Samples made of AC+SMA gave higher shear strength than AC+AC in all cases, and in most cases it made a significant difference. It showed that using of interlayer limited the influence of surface contact texture but increased the viscous contact.
- Bitumen as a binder bonding layers gave the best results, for the optimum amount of bitumen shear strength equal to 0.45 MPa for specimens AC+AC, and 0.55 MPa for specimens AC+SMA. The samples with tack coat amount decreased by half, decreased the shear strength by 35-45%, and in the case without spreading shear strength it was lower by about 70%, but in the case of tack coat amount below optimum shear strength it fell down by 80%.
- Specimens with modified bitumen emulsion spreading gave smaller shear strength than hot bitumen spreading, but the differences were not significant. In the case of application of ordinary bitumen emulsions as a tack coat, shear strength decreased significantly.
- Specimens with polyester nonwoven gave shear strength lower than those with polyester geocomposite, but similar to specimens with glass geocomposite or SAMI.

5.3. Specimens with polyester geocomposite

- Specimens with polyester geocomposite achieved the highest shear strength in comparison to other geosynthetics, and in most cases the differences were statistically significant. It might be caused by the adhesive agent the polyester geocomposite is coated with.
- Samples made with AC+SMA gave higher shear strength than AC+AC in all cases, and in most cases the difference was significant.
- Similarly to specimens with nonwoven, the highest shear strength was reported for samples bonded by hot bitumen, then for modified bitumen emulsion, but the differences were not significant. In the case of application of ordinary bitumen emulsions as a tack coat, shear strength decreased significantly.
- Specimens with tack coat which was decreased or increased in comparison to optimum spreading, decreased shear strength by 70%.

5.4. Specimens with glass geocomposite

- Because for all the binders used to bond glass geocomposite the results of shear strength were worse than for polyester geocomposite, and similar to polyester nonwoven, the stiffness of geosynthetics was concluded to have no influence on shear strength in geosynthetic interlayer.
- For specimens with glass geocomposite with various type of bitumen no significant differences were observed.
- The best shear strength was noted for specimens with the amount of bitumen equal to 0,75 kg/m^2 (the optimum bitumen amount), and both increasing or decreasing of bitumen spreading by half decreased shear strength by about 50%.

5.5. Specimens at temperature of -2°C

- Specimens tested at temperature of –2°C gave significant increase of shear strength (4.5 – 8.7–times), but the ranking of shear strength was the same as at temperature +25°C.
- Type of asphalt mixes had no significant influence on shear strength.
- The highest increase of shear strength at temperature of -2°C in comparison to temperature +25°C was noted for polyester nonwoven, rather than for glass geocomposite and polyester geocomposite. The lowest increase of shear strength was noted for samples without geosynthetics, where the amount of bitumen applied to interlayer bonding was lower than in the case of application of geosynthetics.

6. Final conlusions

On the basis of the shearing tests results and their statistical analysis, the following conclusions were formulated:

1. Obtained results were fully confirmed by the German research presented on 9^{th} International conference of geosynthetics 2010 [21], where the importance of the correct amount of bitumen emulsion for appropriate bonding, as well as the influence of geosynthetics type on interlayer shear strength, was analyzed.
2. In the author's tests, for the specimens without geosynthetics, the shear strength in the surface contact decreased by 1,5-2 times in comparison to the single layer specimens, supported to shearing. It depended on the gradation of aggregate mixtures, the types and the amount of bitumen used for interlayer bonding.
3. Application of geosynthetics in asphalt layers at the optimal amount of emulsion gave the decrease of 2-3 times of interlayer bonding parameters in comparison to the without geosynthetics. At the other amount of emulsion the decrease was a bit greater.
4. Shear strength in geosynthetics interlayer area was strongly related to the temperature, in the case of the increase of temperature from -2˚C to +25˚C, shear strength decreased 4-9 times, depending on the types of geosynthetics. The greatest decrease was noted in the case of use of nonwoven; it might be the effect of the highest amount of bitumen in interlayer.
5. In the case of nonwoven, shear strength and shear stiffness mainly depended on the type and the amount of bitumen, the best result was achieved for hot bitumen and the bitumen emulsion modified by elastomer. In the case of geocomposites, shear strength and shear stiffness also depended on mechanical parameters of the material of which geosynthetics were made of (polyester, glass), as well as on additional activities during geosynthetics production, e.g. impregnation of geosynthetics by means of an adhesive agent.
6. To saturate and bond geosynthetics, an application of hot binder (pure bitumen) was most effective, whereas in the case of bitumen emulsions the best conditions of interlayer bonding occured for bitumen emulsions modified with elastomer.
7. Application of geosynthetics, that were initially impregnated by bitumen or another adhesive agent, improved the bonding between geosynthetics and asphalt layers.

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BADANIA POŁĄCZEŃ MIĘDZYWARSTWOWYCH W WARSTWACH ASFALTOWYCH Z GEOSYNTETYKIEM

S t r e s z c z e n i e

Problem związania międzywarstwowego jest jednym z poważniejszych problemów wykonawczych w budowie nawierzchni asfaltowych, zwłaszcza w sytuacji zastosowania geosyntetyków, które są bardzo wrażliwe na błędy aplikacji. Brak zapewnienia dobrego połączenia warstw skutkuje zmniejszeniem trwałości całej konstrukcji nawierzchni. Problemem badawczym jest więc określenie jak spadek połączenia warstw wpływa na trwałość zmęczeniową konstrukcji nawierzchni. Badania takie zostały wykonane w ramach 2 grantów badawczych, natomiast niniejszy artykuł prezentuje tylko część dotyczącą badań połączeń międzywarstwowych. Badania te zostały wykonane metodą ścinania opracowaną na Politechnice Krakowskiej, w dwóch wybranych temperaturach tj. -2°C i +25°C. Jako czynniki determinujące sczepność międzywarstwową przebadano wpływy rodzaju geosyntetyku, rodzaju lepiszcza stosowanego do połączenia warstw, rodzaju mieszanki mineralno-asfaltowej a także ilości lepiszcza stosowanej do skropienia międzywarstwowego. Istotność wpływów poszczególnych czynników na parametry związania międzywarstwowego określono z wykorzystaniem metod statystycznych z zastosowaniem programu Statgraphics Plus v.5.1. Stwierdzono pozytywny wpływ zastosowania geosyntetyków wstępnie impregnowanych środkiem adhezyjnym, jako lepiszcze do nasycania i przyklejania geosyntetyku najbardziej efektywny okazał się asfalt na gorąco bądź emulsja modyfikowana, stosowanie emulsji niemodyfikowanych dało gorsze rezultaty. Bardzo istotny okazał się wpływ ilości lepiszcza stosowanego do nasycania i przyklejania geosyntetyków. Wykazano, że dla każdego rodzaju warstwy pośredniej istnieje optymalna ilość skropienia międzywarstwowego, przy której wytrzymałość na ścinanie i sztywność ścinania jest największa. Zarówno zwiększenie jak i zmniejszenie tej ilości lepiszcza powoduje spadek parametrów związania międzywarstwowego. W aspekcie praktycznym wyniki te pokazują konieczność indywidualnego doboru rodzaju i ilości lepiszcza do skropienia międzywarstwowego dla konkretnego rodzaju geosyntetyku oraz warstw mineralno-asfaltowych, w których będzie ułożony.

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