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Pavement structures highways and expressways on the Lower Silesia area. State of the end 2018`s.

Abstract: The current increase in road traffic, an increase in the total weight of lorries and the load on individual vehicle axles, have resulted in the need for widespread use of pavements, which allow the transmission of increased loads. The article presents a qualitative and quantitative analysis of the pavement structure used on lower Silesia's highways and expressways and division into individual sections of classes A and S in the area of operation of the Wrocław branch of GDDKiA has been demonstrated

Keywords: highways, expressway, pavement structure.

Introduction

Currently, the length of the national road network in Poland is over 19,300 km. At the end of 2018, 3471.95 km of expressways remain in use, including 1638.450 km of motorways and 1833.500 km of expressways. The length of the whole network of national roads in Lower Silesia is 1309.433 km (1774.644 km in development per one carriageway), of which approximately 435 km are expressways.

Length of expressways

The length of highways in Lower Silesia amounts to 435.452 km, which is 12.54% of all highways in Poland. In the area of operation of the Wrocław branch of GDDKiA, 49% of the networks are class A and S.

All highways in Lower Silesia have a structure that allows the load to be transferred 115 kN/axis.

1. A network of national roads and fast traffic in Lower Silesia. (Source: GDDKiA Wrocław Branch.)

The length of highways in Lower Silesia

The total length of motorways in the area administered by GDDKiA Wrocław Branch is 222.278 km, which is 13.57% of all motorways in Poland. In Lower Silesia, there are: A-4 motorway with a length of 193,965 km, connecting the border with Germany in the west with the province border in the east; A-8 motorway with a length of 22.722 km, which is the motorway ring road of Wrocław (AOW); A-18 motorway with a length of 5.591 km between the Golnice junction (dk 18) and the Krzyżowa interchange (A-4).

The length of expressways in Lower Silesia

The total length of expressways in Lower Silesia is 213.174 km, which accounts for 11.63% of all expressways in Poland. In the area administered by GDDKiA Branch in Wrocław, there are: S-3 expressway with a length of 100.328 km, connecting the province's border in the north with Bolków in the south (ultimately with the border with the Czech Republic); S-5 expressway, 53,450 km long, connecting the province's border in the north with the Wrocław bypass of the Wrocław AOW; S-8 express road, 59.396 km long, which connects the Wrocław bypass (AOW) with the border of the voivodship (towards Warsaw)).

Surface constructions

The surface structure (surface) is a set of appropriately selected layers, the purpose of which is to distribute the stresses from the vehicle wheels to the ground surface of the pavement and

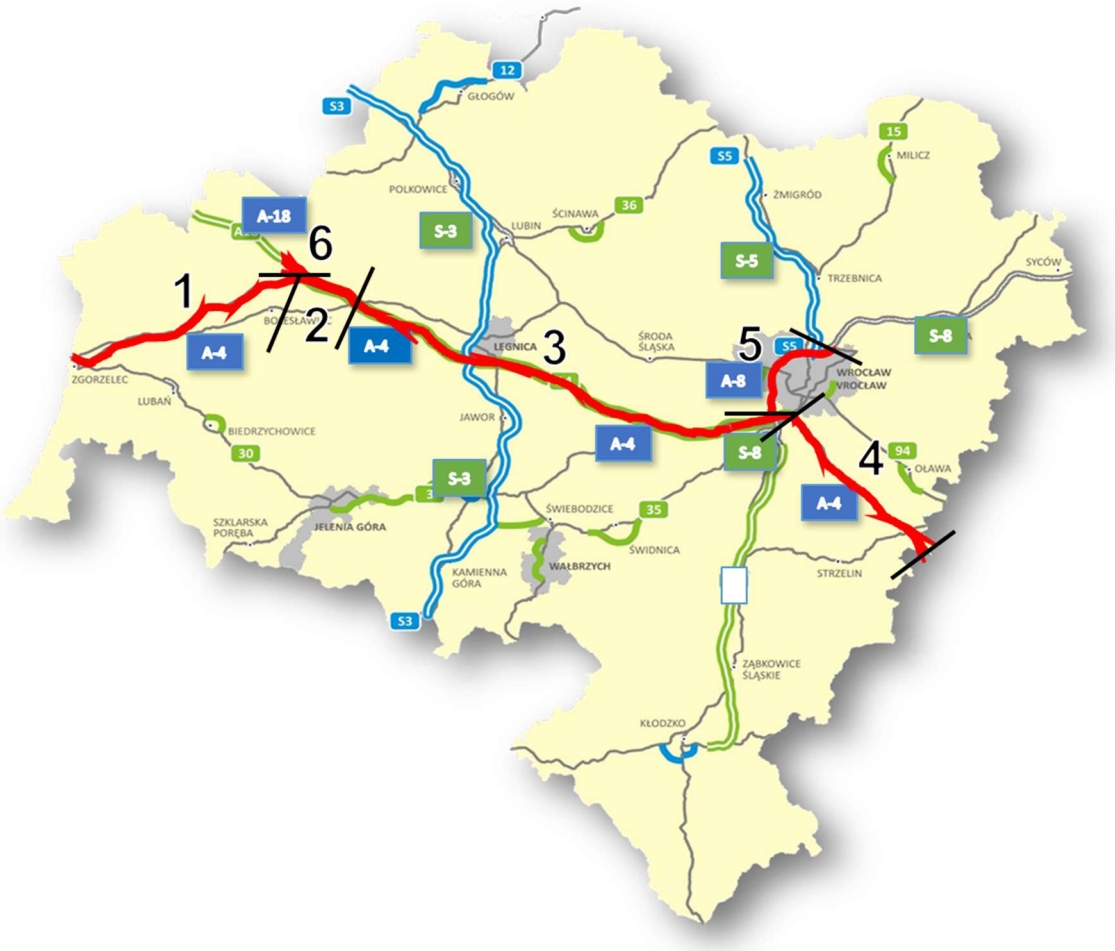
to ensure the safety and comfort of driving vehicles. The surface structure rests on the ground surface or on the layer of the improved substrate.

The rigid pavement structure consists of a topcoat made of cement concrete (dowel or not, anchored or not, reinforced or not), a slip layer, a base structure made of unbound compounds, bituminous concretes, compounds bound by hydraulic binders, an auxiliary foundation (source: Catalog Typical Structures of Rigid Surfaces, pp. 16-19).

The structure of the susceptible surface - the construction of the surface, in which the wear and binding layers are made of asphalt mixtures, and none of the foundation layers are made of materials bound with hydraulic binders. (source: Catalog of Typical Structures of Paving and Semi-rigid Surfaces, p. 15).On motorways used in Lower Silesia, there are both rigid pavement constructions and flexible pavement constructions. The subject pavement constructions were made of cement concrete as well as mineral-asphalt mixtures.

Highways with rigid construction

Motorways with a rigid pavement structure are A-4 section with a length of about 154 km (Jędrzychowice - Bielany Wrocławskie) and A-18 with a length of approx. 5.5 km (Golnice - Krzyżowa). The location of sections with a rigid structure is shown in Figure 2 (sections No. 1, 2, 3, 6).



2. Sections of highways in Lower Silesia. (Source: GDDKiA Wrocław Branch.)

Types of rigid constructions are presented in Tables 1 - 3.

Tab. 1. Construction of the A-4 motorway, section 1. (Source: GDDKiA Wrocław Branch.)

Thickness	Type of layer	Type of material
27 cm	driveway	Cement concrete B-40, compressive strength after 28 days R28 = 40 MPa, flexural strain at 5.5 MPa, 3,3 MPa stretching at splitting, 3% aeration, water absorption at 5%.
< 1 cm	dowel and anchored	Nonwovens, 500 g/m^2
18 cm	slip	Cement concrete compressive strength $R_m \geq 6 – 9$ MPa (Lean concrete)
15 cm	foundation	Crushed-stone aggregate mechanically stabilized – 0/31,5
20 cm	frost protection	Natural Aggregate Mechanically Stabilized - secondary deformation module (VSS pressure plate) $E_2 \geq 120$ MPa
	substrate	Native ground $E_2 \geq 60$ MPa

Tab. 2. The construction of the A-4 and A-18 motorway, sections 2 and 6. (Source: GDDKiA Wrocław Branch.)

Thickness	Type of layer	Type of material
7 cm	upper driveway	Cement concrete B-35, concrete mix 0/16, R_{28} = 35 MPa, aeration 4.5%, water absorption up to 5%.
19 cm	bottom driveway, doweled and anchored	Cement concrete B-35, concrete mix 0/32 (grit from crushed old concrete slabs), R_{28} = 35 MPa, aeration 4.5%, water absorption up to 5%.
15 cm/ 20 cm	foundation	Groundcement $R_7 \geq 4.0$ MPa, $R_{28} \geq 6.0$ MPa, freezing point 0.7
15 cm	frost protection	Unbound ground from the existing G1 and G2 road corps.
	substrate	Native ground

Tab. 3. The construction of the A-4 motorway, section 3. (Source: GDDKiA Wrocław Branch.)

Thickness	Type of layer	Type of material
27 cm	driveway, doweled and anchored	Beton cementowy B-40, R_{28} = 40 MPa, rozciąganie przy zginaniu 5,5 MPa, nasiąkliwość do 5%.
< 1 cm	slip	Nonwovens
20 cm	foundation	Cement concrete $R_m \geq 6,0 – 9,0$ MPa (Lean concrete)
35 cm	frost protection	Crushed-stone aggregate mechanically stabilized
15 cm	improved substrate	The ground stabilized with cement R_m = 1.5 - 2.5 MPa - 0 / 31,5; $E_2 \geq$ 150 MPa
	substrate	Native ground

Highways with flexible structure

Motorways with a compliant pavement structure are A-4 section with a length of approx. 40 km (Bielany Wrocławskie - the border of the province) and A-8 with a length of approx. 22.7 km (Wrocław Południe - Wrocław Psie Pole). The location of sections with a susceptible structure has been placed on the drawing No. 2 (sections No. 4, 5). The types of susceptible structures are presented in tables 4 - 5.

Tab. 4. The construction of the A-4 motorway, section 4. (Source: GDDKiA Wrocław Branch.)

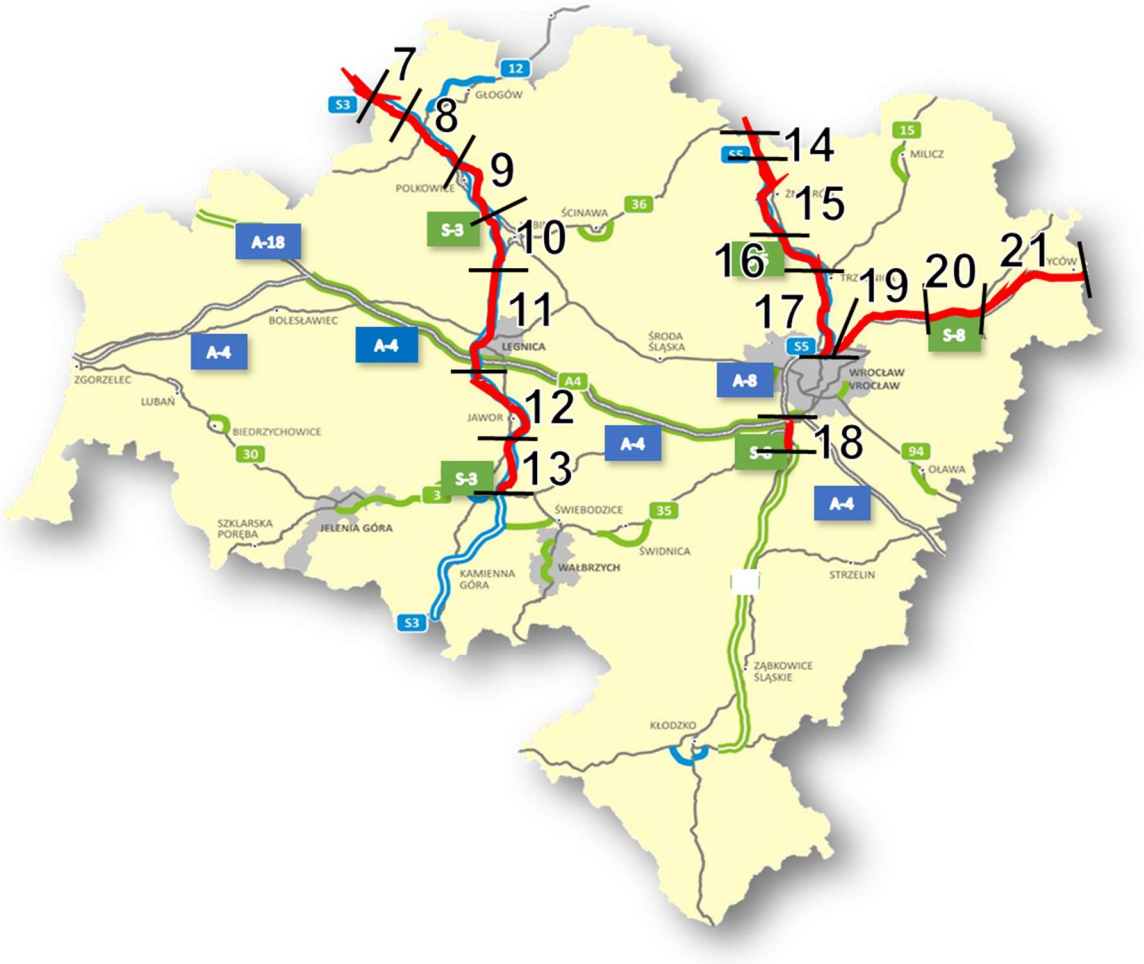
Thickness	Type of layer	Type of material
4 cm	wearing	Mineral - asphalt mix - SMA 11S (grit mastic)
8 cm	binding	Mineral-asphalt mix - ACWMS 16 W (asphalt concrete with a high stiffness modulus)
16 cm	foundation	Bitumen and asphalt mixture - BA 0/25 (AC 25 P) (asphalt concrete)
22 cm	unbound foundation	Aggregate mechanically stabilized – 0/31,5; $E_2 \geq 200$ MPa
20 cm	auxiliary foundation	Crushed-stone aggregate mechanically stabilized – 0/20; $E_2 \geq 160$ MPa
20 cm	frost protection	Unbound mixture, Californian load index CBR > 15%
	substrare	Native ground $E_2 \geq 60$ MPa

Tab. 5. Construction of the A-8 motorway, section 5. (Source: GDDKiA Wrocław Branch.)

Thickness	Type of layer	Type of material
4 cm	wearing	Mineral - asphalt mix – SMA 11 S
8 cm	binding	Mineral - asphalt mix – ACWMS 16 W
18 cm	foundation	Mineral - asphalt mix – ACWMS 16 P
22 cm	unbound foundation	Crushed-stone aggregate mechanically stabilized – 0/31,5; $E_2 \geq 180$ MPa
25 cm	frost protection	Unbound mixture, CBR > 40%, $E_2 \geq 150$ MPa
	substrate	Native ground $E_2 \geq 40$ MPa

Constructions of express road surfaces

On expressways used in the area administered by GDDKiA Wrocław Branch, there are only vulnerable pavement constructions, all of which have been made of asphalt mixtures. The location of sections of expressways with a susceptible structure has been placed on drawing No. 3.



3. Sections of express roads in Lower Silesia. (Source: GDDKiA Wrocław Branch)

Express roads with a pavement structure with classic asphalt concrete

Sections of expressways whose susceptible pavement structure contains binding layers and foundations are made of asphalt concrete (asphalt mixtures) are presented on drawing 3. These are sections of roads S-3 No. 9 and No. 12 and S-8 No. 20. Types susceptible structures are presented in Tables 6 - 8.

Tab. 6. Construction of the S-3 expressway, section 9. (Source: GDDKiA Wrocław Branch.)

Thickness	Type of layer	Type of material
4 cm	wearing	Mineral - asphalt mix - SMA 11 S
10 cm	binding	Mineral-asphalt mix - AC 16 W (asphalt concrete)
16 cm	foundation	Mineral - asphalt mix - AC 22 P
15 cm	unbound foundation	Crushed-stone aggregate mechanically stabilized – 0/31,5; $E_2 \geq 180$ MPa
14 cm	technological (auxiliary foundation)	Mix $C_{90/3}$ unbound, CBR > 35%,
20-35 cm	frost protection	Unbound mix, CBR > 35%, $E_2 \geq 140$ MPa
50 cm	upper layer of embankment / excavation	Ground G1, $E_2 \geq 100$ MPa
	substarte	Native ground

Tab. 7. Construction of the S-3 expressway, section 12. (Source: GDDKiA Wrocław Branch.)

Thickness	Type of layer	Type of material
4 cm	wearing	Mineral - asphalt mix – SMA 11 S
8 cm	binding	Mineral - asphalt mix – AC 16 W
18 cm	foundation	Mineral - asphalt mix – AC 22 P
20 cm	unbound foundation	Crushed-stone aggregate mechanically stabilized – 0/31,5; $E_2 \geq 180$ MPa
30 cm	upper layer of embankment / excavation	Ground G1, or Ground stabilized with cement, $E_2 \geq 80$ MPa
	substrate	Native ground

Tab. 8. Construction of the S-8 expressway, section no. 20. (Source: GDDKiA Wrocław Branch.)

Thickness	Type of layer	Type of material
4 cm	wearing	Mineral - asphalt mix – SMA 0/12,8 S
9 cm	binding	Mineral - asphalt mix – BA (AC) 0/20 W
18 cm	foundation	Mineral - asphalt mix – BA (AC) 0/25 P
20 cm	unbound foundation	Crushed-stone aggregate mechanically stabilized – 0/31,5; $E_2 \geq 180$ MPa
12 cm	improved substrate	Ground stabilized with cement, $R_m = 2,5$ MPa
15 cm	improved substrate	Ground stabilized with cement, $R_m = 1,5$ MPa

	substrate	Native ground

Express roads with a pavement structure with asphalt concrete with a high stiffness module

Sections of expressways, which susceptible pavement structure contains foundation and binding layers made of asphalt concrete with a high stiffness modulus (asphalt mixtures), are presented in Figures 3. These are sections of the S-3 road No. 7, 8, 10, 11, 13; sections of the S-5 road No. 14, 15, 16, 17; sections of the S-8 road No. 18, 19, 21. The types of susceptible structures are presented in Tables 9 - 16.

Tab. 9. Construction of the S-3 expressway, sections No. 7 and No. 8. (Source: GDDKiA Wrocław Branch.)

Thickness	Type of layer	Type of material
4 cm	wearing	Mineral - asphalt mix – SMA 11 S
10 cm	binding	Mineral - asphalt mix – ACWMS 16 W
13 cm	foundation	Mineral - asphalt mix – ACWMS 22 P
20 cm	unbound foundation	Crushed-stone aggregate mechanically stabilized – 0/31,5; $E_2 \geq 180$ MPa
15 cm	frost protection	Unbound mix, CBR > 40%
10 cm	technology	Ground stabilized with cement, $C_{1,5/2,0}$
50 cm	upper layer of embankment / excavation	Ground G1
	substrate	Native ground

Tab. 10. Construction of the S-3 expressway, section 10. (Source: GDDKiA Wrocław Branch.)

Thickness	Type of layer	Type of material
4 cm	wearing	Mineral - asphalt mix – SMA 11 S
10 cm	binding	Mineral - asphalt mix – ACWMS 16 W (lepiszcze 20/30)
12 cm	foundation	Mineral - asphalt mix – ACWMS 16 P (lepiszcze 20/30)
20 cm	unbound foundation	Crushed-stone aggregate mechanically stabilized – 0/31,5; $E_2 \geq 180$ MPa
15 cm	frost protection	Mix $C_{90/3}$ unbound CBR > 35%, $E_2 \geq 140$ MPa
10 cm	technology	Mix $C_{90/3}$, CBR > 40%
50 cm	upper layer of embankment / excavation	Grunt G1 or Ground stabilized with cement, $E_2 \geq 120$ MPa
	substrate	Native ground

Tab. 11. Construction of the S-3 expressway, section No. 11. (Source: GDDKiA Wrocław Branch.)

Thickness	Type of layer	Type of material
4 cm	wearing	Mineral - asphalt mix – SMA 11 S
8 cm	binding	Mineral - asphalt mix – ACWMS 16 W
15 cm	foundation	Mineral - asphalt mix – ACWMS 22 P (lepiszcze 20/30)
20 cm	unbound foundation	Crushed-stone aggregate mechanically stabilized – 0/31,5; $E_2 \geq 180$ MPa
15 cm	frost protection	Unbound mix, CBR > 35%, $E_2 \geq 150$ MPa
25 cm	upper layer of embankment / excavation	Ground G1, ground stabilized with cement $R_m = 2,5$ MPa, $E_2 \geq 100$ MPa
	substrate	Native ground

Tab. 12. Construction of the S-3 expressway, section 13. (Source: GDDKiA Wrocław Branch.)

Thickness	Type of layer	Type of material
4 cm	wearing	Mineral - asphalt mix – SMA 11 S
11 cm	binding	Mineral - asphalt mix – ACWMS 16 W
12 cm	foundation	Mineral - asphalt mix – ACWMS 16 P
20 cm	unbound foundation	Crushed-stone aggregate mechanically stabilized – 0/31,5; $E_2 \geq 180$ MPa
10 cm	strengthening	Mix 0/31,5 ($C_{90/3}$), unbound; CBR ≥ 60%, $E_2 \geq 140$ MPa
25 cm	upper layer of embankment / excavation	Grround G1, or ground stabilized with cement, $E_2 \geq 80$ MPa
	substrate	Native ground

Tab. 13. Construction of the S-5 expressway, section No. 14. (Source: GDDKiA Wrocław Branch.)

Thickness	Type of layer	Type of material
4 cm	Wearing	Mineral - asphalt mix – SMA 11 S
8 cm	binding	Mineral - asphalt mix – ACWMS 16 W
16 cm	foundation	Mineral - asphalt mix – ACWMS 16 P
22 cm	unbound foundation	Crushed-stone aggregate mechanically stabilized – 0/31,5; $E_2 \geq 180$ MPa
20 cm	frost protection	Mix 0/31,5 unbound; CBR > 30%, $E_2 \geq 120$ MPa
20 cm	improved substrate	Ground stabilized with cement, $R_m = 5,0$ MPa
30 cm	upper layer of embankment / excavation	GroundG1, $E_2 \geq 100$ MPa
	substrate	Native ground

Tab.14. Construction of the S-5 express road, section 15. (Source: GDDKiA Wrocław Branch.)

Thickness	Type of layer	Type of material
4 cm	wearing	Mineral - asphalt mix – SMA 11 S
8 cm	binding	Mineral - asphalt mix – ACWMS 16 W
14 cm	foundation	Mineral - asphalt mix – ACWMS 16 P
20 cm	unbound foundation	Crushed-stone aggregate mechanically stabilized – 0/31,5; $E_2 \geq 180$ MPa
15 cm	improved substrate	Ground stabilized with cement, $R_m = 2,5$ MPa ($C_{1,5/2}$)
35 cm	upper layer of embankment / excavation	Ground G1, $E_2 \geq 80$ MPa
	substrate	Native ground

Tab. 15. Construction of the S-5 expressway, section 16 and 17. (Source: GDDKiA Wrocław Branch.)

Thickness	Type of layer	Type of material
4 cm	wearing	Mineral - asphalt mix – SMA 11 S
11 cm	binding	Mineral - asphalt mix – ACWMS 16 W
11 cm	foundation	Mineral - asphalt mix – ACWMS 16 P
20 cm	unbound foundation	Crushed-stone aggregate mechanically stabilized – 0/31,5; $E_2 \geq 180$ MPa
30 cm	frost protection	Unbound mix, CBR > 35%, $E_2 \geq 140$ MPa
30 cm	upper layer of embankment /	Ground G1, or Ground stabilized with cement, $E_2 \geq 60$ MPa

	excavation	
	substrate	Native ground

Tab. 16. The construction of the S-8 expressway, sections 18, 19, 21. (Source: GDDKiA Wrocław Branch.)

Thickness	Type of layer	Type of material
4 cm	wearing	Mineral - asphalt mix – SMA 11 S
8 cm	binding	Mineral - asphalt mix – ACWMS 16 W (lepiszcze 20/30)
18 cm	foundation	Mineral - asphalt mix – ACWMS 16 P (lepiszcze 20/30)
22 cm	unbound foundation	Crushed-stone aggregate mechanically stabilized – 0/31,5; $E_2 \geq 180$ MPa
25 cm	frost-protection /	Unbound mix, CBR > 40%, $E_2 \geq 140$ MPa
15-25 cm	filtering	Ground stabilized with cement, $R_m = 2,5$ MPa
	improved substrate	Native ground

Summary

The enormous increase in road traffic, the increase in the total weight of lorries and the load on individual vehicle axles, have resulted in the need for extensive use of pavements, which allow the transfer of increased loads (Szydło A., p. 25). At the same time, the requirements regarding the exploitation characteristics of the surface, the length of service and the fatigue life of the pavement increased.

The length of highways in Lower Silesia with a structure that allows the load to be transferred 115 kN/axle, totals 435.452 km. This accounts for 6.6% of all national roads - 115 kN/axle in Poland. It is also 33.26% of national roads in the area administered by GDDKiA Branch in Wrocław.

4. Structures of class A and S road surfaces in Lower Silesia. (Source: GDDKiA Wrocław Branch.)

In Lower Silesia, 159,043 km of class A and S roads have a rigid pavement structure, and on the length of 276.409 km of expressways, the susceptible surface dominates (source: GDDKiA Wrocław Branch). Motorways and express roads with rigid construction (red color) and with a flexible construction (black color) are shown in Figure 4.

Lower Silesia as a border region is an important element of transport routes in Poland and in Europe. It borders with Germany in the west and the Czech Republic in the south.

The network of national roads, including high-speed roads - class A and S roads, despite the large variety of pavement construction, is appropriately prepared for fast, comfortable and safe conduct of heavy transit traffic and local traffic.

Source materials

[1] GDDKiA Oddział we Wrocławiu. Wydział Technologii – Laboratorium Drogowe. Archiwum podręczne.
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