Modernization Project for 1592D District Road Connecting Wierzbno with Polwica, Using High Modulus Asphalt Concrete AC WMS

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The paper presents a proposal for the modernization of a district road No. 1592D relation Polwica-Wierzbno. The aim of the modernization is to improve communication accessibility, increase traffic safety, ride comfort, and to adapt the surface to the current requirements. The technical condition of the road is insufficient, the surface is damaged, roadsides unsuitable and do not have adequate drainage. The degree of damage depends on many different factors. Over the last few years we have been observing significant growth of both transport and construction works. The main factor, influencing the condition of road pavements is high traffic, which results from agriculture development, and the same time more intensive participation of agricultural vehicles in slow-speed traffic, development of heavy good vehicles' traffic, development of local population and growth of passenger vehicles.

Keywords: district road, modernization, conceptual design.

1. INTRODUCTION

Over the last few years we have been observing significant growth of both transport and construction works. The main factor, influencing the condition of road pavements is high traffic, which results from:

- agriculture development, and the same time more intensive participation of agricultural vehicles in slow-speed traffic,
- development of heavy good vehicles' traffic,
- development of local population and growth of passenger vehicles.

Roads were built in the 20th century and today, considering the above mentioned growth of vehicles and the growth of traffic, they deteriorate very often. Additionally, weather and atmospheric conditions have big influence on roads condition. Rain has influence on roads condition too, it can deepen potholes and bumps. The number of roads which are in bad condition increases. Driving through such roads is not only uncomfortable, but also dangerous [13, 14, 15, 16], therefore they should be modernized.

The aim of roads modernization is [1]:

- improving communication accessibility
- increasing traffic safety and security
- increasing comfort
- adapting pavements to existing standards
- improving quality of life
- supporting regional development

Very often roads have big influence on local populace development, particularly in villages and little towns. Additionally, we can observe growing interest in sport and recreation. Sport activity results in higher number of bicycles on the roads. Therefore it is crucial to improve roads condition and to adapt them to existing standards.

Current situation of infrastructure is favourable for development of new technological solutions, new research methods or new technical projects. Together with standards also expectations and needs regarding pavements' quality and contractors grow. Nowadays, apart from functionality and durability, also economic and environmental factors are considered. New technologies can help to reduce level of noise, diminish costs, or extend usability time.

The aim of this paper is to present modernization project for 1592D district road connecting Wierzbno with Polwica with the use of

asphalt concrete, characterized by a high modulus of rigidity, type AC WMS.

2. LOCATION

The 1592D road is situated in Low Silesian voivodship in Olawa district and lies 10 km from the district city-Oława. It is located between Polwica and Wierzbno. It is a district road, classified as a service road.

There are several reasons of the planned modernization of the 1592D road:

- The road's conditions do not fulfil norm requirements. We can see damaged edges of the roadway, numerous cracks, ruts, holes. In addition, on its entire length the pavement is very rough, which affects the stability and drive quality. The pavement has been repaired only seasonally and only potholes have been repaired. Bitumen of various kinds has been used as repair material. As a result of these repairs in some parts of the road we can see a mosaic of three different bitumen types. Unfortunately, a significant part of the road is highly patched, which affects driving.
- The roadway width is not adjusted to the requirements. It is too narrow, hinders the movement of vehicles, especially in the era of developed truck transport or in the era of developing agriculture, and thus of high

Fig. 1. 1592D road localization [10,12].

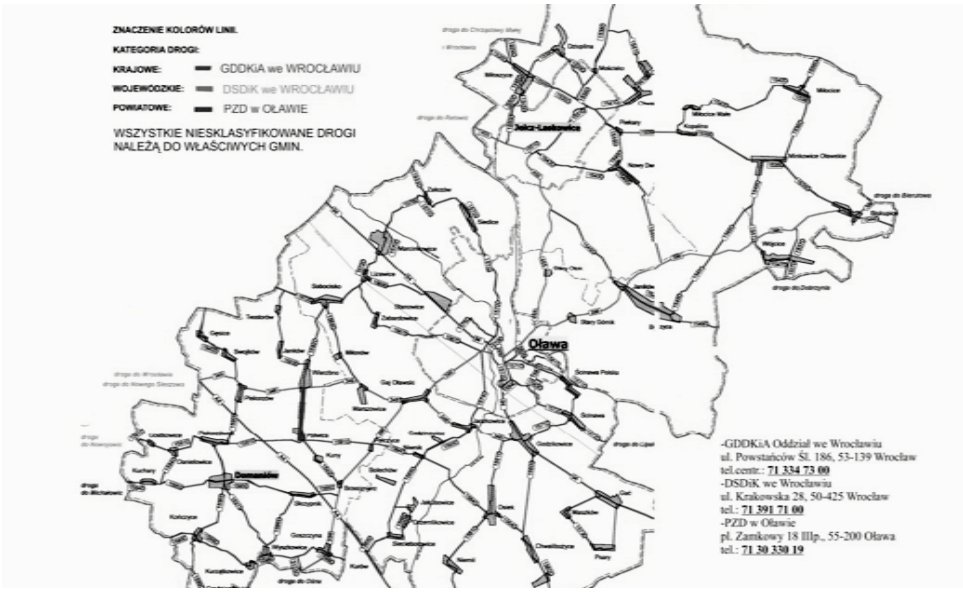

Fig. 2. District roads listing, the 1592D road is shown in red [11].

3. CURRENT CONDITION DESCRIPTION

The modernization project covers section outside built-up area, 1.4-km long. It is a single carriageway with lanes in two directions, on the whole length made of bitumen. The carriageway, 5-m wide, has ground roadsides, and the road prism is 9 m long. On both sides of the road there are potholes. On the whole length of the road there are no horizontal curves.

number of all kinds of agricultural machinery.

- Lack of hard roadside. The roadside is made of ground, completely overgrown with grass. Currently, it is uneven on the whole length, there are mainly holes, which result is many puddles during the rain. What is more, the level of the roadside is higher than the edge of the road. It makes rain water impossible to runoff into ditches. As the roadside is not sufficiently wide, both pedestrians and cyclers have to move on the roadway. The road is very narrow, therefore it is a potential danger. Justifying the road modernization plan, we should mention the vicinity of the A4 motorway, which is about 9 km away. The economic factor is relevant because local residents would benefit much more from the shorter route, saving both time and fuel. In addition, both Wierzbno and Polwica are small charming villages. They would probably attract investors interested in buying building plots. Peaceful surroundings, proximity to a large city and a highway, all this makes the location a very attractive place for development. However, one of the main criteria when buying plots is the condition of the access road, and it certainly can dissuade potential investors from purchasing. There is a small park in Polwica, nearby there are wooded areas and a fishpond. This fosters the development of alternative forms of communication, such as cycling. To support the hypothesis on the development of bicycle transportation a research was conducted. On 17th May, 2015 from 1 pm to 2 pm a number of bicycles was counted. During the period in question 32 bicycles were recorded.

Fig. 3. View of bicycles, photograph taken in the ongoing research [own photograph].

Therefore it is necessary to adapt technical conditions, in order to improve quality of life and to make the road more comfortable.

Fig. 4. View of repairs, made of different kinds of bitumen [Own photograph].

Fig. 5. View of damaged roadside [own photograph].

Fig. 6. View of unevenness of the pavement [Own photograph.

4. THE PROPOSED TECHNOLOGICAL SOLUTIONS WITH USE OF HIGH MODULUS ASPHALT CONCRETE AC TYPE WMS

Considering the above-mentioned development of transport, increasing traffic as well as higher number of the means of transport, road construction area has to face growing problems of Polish roads. The situation is favourable for the development of road paving technology, innovative solutions or research methods. Additionally, the expectations of contractors have increased. Socio-economic and ecological factors have to be considered also, together with such factors as road durability or comfort and safety of passengers. One of new technologies which can be an alternative to the standard design pavement is asphalt concrete of high modulus of rigidity AC type WMS. Road pavement is a system of layers of specific functions. The first layer of pavement is subjected to direct traffic and its aim is to provide safe and comfortable drive or ride for wheeled vehicles and to protect other layers from the weather. Tie layers and layers of foundation, in turn, constitute the capacity of the pavement structure. The concept of high modulus asphalt concrete AC WMS consists of combination of durable and resistant foundation with bonding layer, and then covering it with a thin wear layer. For concrete AC type WMS, unlike for ordinary asphalt concrete, harder bitumen is used, filler content is lower and aggregate is coarser. Dissemination of this technology is justified primarily by the fact that it is a perpetual, long-lived pavement technology, therefore only wear layer, which degrades under the influence of the movement of vehicles has to be replaced. Such renovation works take place once every 10 years, while reconstruction or repairs of the other layers of pavement are not necessary.

For the first time this blend was developed in France as EME (ENROBE and Eleve module - a blend of high modulus). In Poland, the first experimental section of the length of one kilometre was placed on a road near Poznan.

The main advantages of high modulus asphalt concrete are:

- Obtaining perpetual pavement (30 - 40 years)
- Ensuring load capacity
- Rutting and fatigue resistance
- Resistance to deformation or to thermal cracking
- Reducing the cost of construction and operation and
- Reduction of the thickness of layers of 5-6 cm
- Use of lesser quality aggregates

Table 1. Materials for concrete asphalt of high modulus of rigidity for foundation and bounding layers [17].

Material	Trafficcategory KR3÷7	
Asphalt-mineral aggregate, D dimension	16	22
Asphaltgranulate, U dimension	22,4	31,5
Asphaltbinders	20/30[b)],PMB 10/40-65, PMB 25/55-60, PMB 25/55-80, MG 20/30-64/74, MG 35/50-57/69	
Mineralaggregates	Tabele 4,5,6,6a[c)],7,8,9,10,11,WT-1 2014	

[a)] recommended breaking temperature according to Fraas for asphalts:
- modified and multimode not higher than -10 °C
- 20/30 not higher than -5 °C

[b)] approved for use in zone I and II by the Polish climate Fig. 1. Not approved for winter the layer with asphalt 20/30, not covered additional layer of asphalt which should consist of mma with another type of asphalt than 20/30 and used properly.

[c)] it is not approved, that aggregate of constant cohesion constitute 100% of designed mineral mixture.

5. SUGGESTION OF THE ROAD MODERNIZATION

Road No. 1592D will meet all technical requirements in accordance with the Regulation of the Ministry of Transport and Maritime Economy of 2 March 1999, on the technical conditions of public roads and their location, that have to be fulfilled [Acts. Laws No. 43, item. 430) [3]:

- Technical Class: Z (Cumulative)
- Road: single carriageway, two-way
- Outside the built-up area
- Design speed: 60 km/h
- Prism of the road: 10.5 m
- Roadway width 5.5 m
- Width of lanes: 2,75 m
- Number of traffic lanes: one in each direction
- Hardened roadside width: 2 m
- Width of the roadside: 0.5 m

Table 2. The required properties of mineral- asphalt mixture for asphalt concrete of high modulus for foundation layers KR3 ÷ 7 [17].

Property	Density conditions according to pn-en 13108-20	The method and conditions for the examination	Dimension of blend	
			Ac wms 16	Ac wms 22
Content of freespace	C.1.3, compaction, 2x75 of blows	PN-EN 12697-8,pkt 4	$V_{min\ 2,0}$ $V_{max\ 4,0}$	$V_{min\ 2,0}$ $V_{max\ 4,0}$
Watersusceptibility	C.1.1, compaction , 2x35 of blows	PN-EN 12697-12, storing in 40°C with one cycle of freezing [b], examining in 25°C	$Itsr_{80}$	$Itsr_{80}$
*permanent deformation resistance [a,c]	C.1.20, rolling P_{98}-p_{100},	PN-EN 12697-22 method b in air, pn-en 13108-20,d.1.6, 60°C	$Wts_{air0,10}$ $Prd_{air5,0}$	$Wts_{air0,10}$ $Prd_{air5,0}$
*mixture dimension [c]	C.1.20, rolling P_{98}-p_{100},	PN-EN 12697-22, large apparatus,60°C, 30 000 cycles, thickness of the plate 100 mm	$P_{7,5}$	$P_{7,5}$
Rigidity[mpa][c]	C.1.20, rolling P_{98}-p_{100},	PN-EN 12697-26, 4pb-pr, temperature 10°C, frequency 10hz	$S_{max\ 17\ 000}$	$S_{max\ 17\ 000}$
			$S_{min\ 11\ 000}$	$S_{min\ 11\ 000}$
Fatigue restistance, cateory not lower than[c]	C.1.20, rolling P_{98}-p_{100},	PN-EN 12697-24, 4pb-pr, temperature 10°C, frequency 10hz	ε_{6-130}	ε_{6-130}

[a] thickness of the plate: ac wms 16-60 mm, ac wms 22-60 mm
[b] the standardized test procedure of the sensitivity to the action of water with one cycle of freezing was given in the enclosure 1
[c] procedure of short-term conditioning mma before thickening test samples they gave in the enclosure 2
* permanent deformation resistance- one should choose one of methods

Table 3. The required properties of mineral- asphalt mixture for asphalt concrete of high modulus for bounding layers KR3 ÷ 7 [17].

Property	Density conditions according to pn-en 13108-20	The method and conditions for the examination	Dimension of blend	
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Content of freespace	C.1.3, compaction, 2x75 of blows	PN-EN 12697-8, pkt 4	$V_{min\ 2,0}$ $V_{max\ 4,0}$	$V_{min\ 2,0}$ $V_{max\ 4,0}$
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*mixture dimension [c]	C.1.20, rolling P_{98}-P_{100},	PN-EN 12697-22, large apparatus,60°C, 30 000 cycles, thickness of the plate 100 mm	$P_{7,5}$	$P_{7,5}$
Rigidity [mpa][c]	C.1.20, rolling P_{98}-P_{100},	PN-EN 12697-26, 4pb-pr, temperature 10°C, frequency 10hz	$S_{max\ 17\ 000}$	$S_{max\ 17\ 000}$
			$S_{min\ 14\ 000}$	$S_{min\ 14\ 000}$
resistance to low-temperature chaps	C.1.20, rolling P_{98}-P_{100},	PN-EN 12697-46, pkt 8.2,	to quote the value	to quote the value
Fatigue restistance, cateory not lower than [c]	C.1.20, rolling P_{98}-P_{100},	PN-EN 12697-24, 4pb-pr, temperature 10°C, frequency 10hz	ε_{6-130}	ε_{6-130}

[a] thickness of the plate: ac wms 16-60 mm, ac wms 22-60 mm
[b] the standardized test procedure of the sensitivity to the action of water with one cycle of freezing was given in the enclosure 1
[c] procedure of short-term conditioning mma before thickening test samples they gave in the enclosure 2
* permanent deformation resistance- one should choose one of methods

- Herring-bone cross-section of the carriageway cross fall: 2.0%
- Trapezoidal ditch on both sides of the road
- Width of the ditch bottom: 0.40 m
- Inclination of the slope and counterscarp of the ditch: 1: 1.5

The route of the proposed road consists entirely of a straight section with a length of 1.4 km.

According to the project, the roadway is to be 5.50 m wide. Two lanes 2.75 m wide, one for each direction of movement, and the cross-section herring-bone, falling from the centre line, towards the edge amounting to 2.0%, are also designed. Roadway on both sides will be limited with paved roadside, 2 m wide.

Based on the data available from the District Roads Management in Oława it has been assumed

that the road traffic category 1592D is classified as KR3, while bearing capacity group for water conditions and low-frost susceptible and doubtful soils is classified as a group G2.

Basing on *the Catalogue of typical design of flexible and semi-rigid pavements* [8] pavement structures have been chosen, which correspond to established technical characteristics and water-ground conditions.

Wearing course of mineral - asphalt mix SMA8 - 4cm

A binding layer of asphalt concrete AC WMS 16 - 5cm

The essential foundation layer of asphalt concrete AC WMS 22- 7 cm

The essential foundation layer of mixture unbounded to the aggregate $C_{90/3}$ - 20 cm

Frost-protection layer with unbounded mixture or from the non-swelling soil - 28 cm.

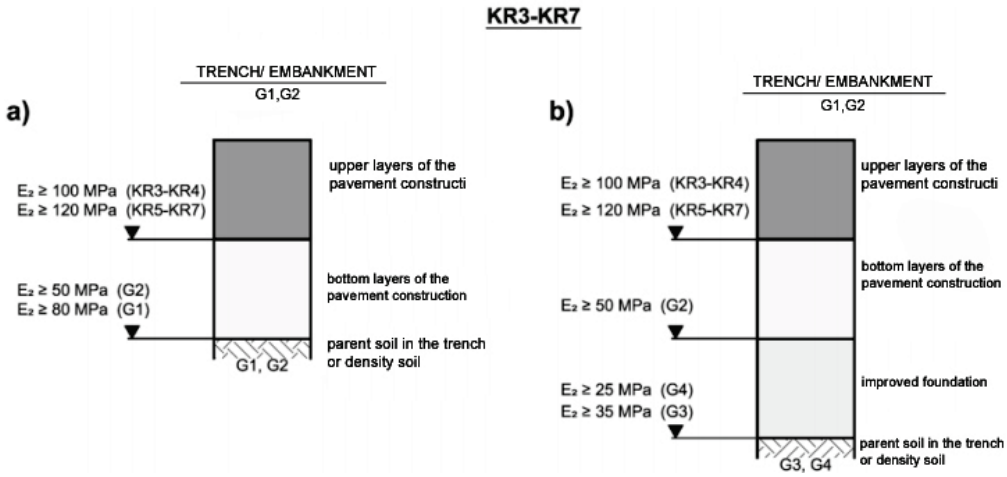

Fig. 7. The scheme of the surface construction layers for the KR3-KR7 category, in reference to the carrying capacity of the bed [8].

Table. 4. [8] typical solution of bottom layers of pavement construction for KR3 and KR4 (E2 ≥ 100 MPa) traffic category.

GRUPA NOŚNOŚCI PODŁOŻA	TYP 5	TYP 6	TYP 7 (nie stosuje się, gdy wymagana jest warstwa odsączająca)	TYP 8	TYP 9
G4	100 MPa PP 15 WM 20 — 50 MPa WUP 25 — 25 MPa	100 MPa PP 18 — 50 MPa WUP 40 — 25 MPa	100 MPa WM 22 — 50 MPa WUP 25 — 25 MPa	100 MPa WM 28 — 50 MPa WUP 25 — 25 MPa	100 MPa PP 24 — 50 MPa WUP 40 — 25 MPa
G3	100 MPa PP 15 WM 20 — 50 MPa WUP 20 — 35 MPa	100 MPa PP 18 — 50 MPa WUP 25 — 35 MPa	100 MPa WM 22 — 50 MPa WUP 20 — 35 MPa	100 MPa WM 28 — 50 MPa WUP 20 — 35 MPa	100 MPa PP 24 — 50 MPa WUP 25 — 35 MPa
G2	100 MPa PP 15 WM 20 — 50 MPa	100 MPa PP 18 — 50 MPa	100 MPa WM 22 — 50 MPa	100 MPa WM 28 — 50 MPa	100 MPa PP 24 — 50 MPa
G1	100 MPa PP 15 — 80 MPa	100 MPa PP 15 — 80 MPa	100 MPa WM* 18 — 80 MPa	100 MPa WM* 22 — 80 MPa	100 MPa PP 15 — 80 MPa

subbase of mixture bounded with hydraulic binder or soil stabilized with hydraulic binder

subbase of mixture non-bounded with CBR60%

anti-frost layer of non-bounded mixture or non-swelling soil (natural or anthropogenic) with CBR 35%, when necessary, anti-frost layer plays a role of drainage layer of k 8m/24 hours

anti-frost layer of mixture bounded with hydraulic binder or soil stabilized with hydraulic binder

layer of improved base of soil stabilized with hydraulic binder or with lime

layer of improved subbste of mixture non-bounded or non-swelling soil (natural or anthropogenic) with CBR 35%, when necessary, anti-frost layer plays a role of drainage layer of k 8m/24 hours

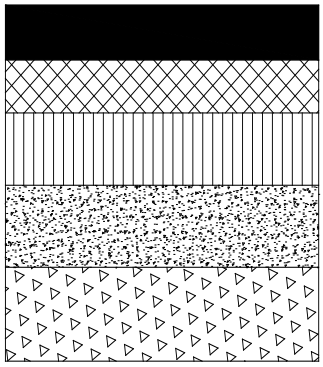

Fig. 8. Construction of the chosen pavement. [Own elaboration].

The designed pavement structure must meet standards in terms of thickness on the frost resistance in Poland [5,6].

Fig. 9. Depth of ground freezing in Poland according to [2,4,8].

Depth of the designed construction of the pavement is:

h=4 + 5 + 7 + 20+28= 64 cm.

For 1592D road the depth of ground freezing is h_z = 0,8m. for G2 soil and traffic category KR3 the minimal depth of the construction should be bigger that 0.40 m. The condition is therefore fulfilled.

6. FINAL REMARKS

The aim of the paper was proposition of 1592D district road modernization. The section of the road, from Polwica till Wierzbno, is situated outside built-up area. Technical condition of the road is not satisfying, the pavement is damaged, there are numerous bumps, holes, crevices and cracks on the whole length of the section of the road in question. Moreover, the roadway is too narrow when it comes to existing norms and requirements. Roadsides are not adapted to pedestrian and bicycle traffic, there is no proper drainage. All these factors have crucial influence on quality and comfort of drive or ride, regardless means of transport.

Considering the level of degradation of the road pavement, characteristics of damages and specificity of vehicles on the road, a technology of high modulus asphalt concrete has been suggested. This type of asphalt concrete has high modulus for rigidity. It is resistible to fatigue and to damages caused by trucks. Moreover it is perpetual asphalt. Mixture of the high modulus asphalt concrete are more and more often used in Poland, as they are more resistant to permanent deformation. Pavement made in technology of high modulus asphalt concrete fulfils the requirements of contemporary needs, when it comes to durability and to permanence, or from the point of view of economics. Tiring renovation works are conducted only on the wearing course, which diminish losses in terms of time and money, from the point of view of transport or agriculture.

After the modernization of the road, it will be more accessible from the point of view of communication, drive comfort and adaptability of the pavement to the requirements. New quality of the road will improve the communication network in the region, and it can be an impulse for local populace development.

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