

# Animal transitions on the section of the S17 expressway between junctions "Kurów West" and "Lublin Felin"

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**Abstract:** The article describes service parameters and effectiveness of the environmental elements of animal crossings on the S17 expressway. Animal transitions on the section of S17 expressway between junctions "Kurów West" and "Lublin Felin" were described. The requirements of environmental protection at the design stage and during the construction works were shown. Article gives an account of the works performed in order to protect the natural environment in areas adjacent to the route, and solutions provided to design objects and the basic functions of animal transitions. Paper summarizes the relevance of the applied solutions and their locations in the field.

**Keywords:** environmental protection, expressway S17, animals transitions.

## 1. Introduction

At the end of 2015, the bids for the design and construction of the last sections of the S17 expressway between the "Zakręć" and "Kurów West" junctions were opened. The said section of the S17 is, in the near future, to raise the class of national road No. 17 extending from Warsaw to the "Kurów West" junction to the class of an expressway. This route is divided into 7 sections and is to run, in the larger part, along the existing national road, going round several towns.

At the end of 2014, the last two sections of the major road investment named "The construction of the S17 expressway on the Kurów – Lublin – Piaski section" were opened to traffic. The construction of the nearly 67-km-long S17 expressway section started in 2010 and lasted four years. After opening, this section has practically taken over the traffic from the old national road No. 17. The expressway opens Lublin to new investments by providing comfortable transport conditions.

80% of National road No. 17, which used to be congested with traffic and which comes in first in the road hierarchy of the Lubelskie Voivodeship, has been moved beyond its former route. Building the expressway along a new route resulted in cutting across the migration corridors of wild animals and amphibians. In order not to create an artificial barrier, the type, number, and form of the designed civil engineering structures had to be adapted to those corridors.

This article discusses crossings for amphibians and for small, medium-sized, and large animals which were built within the structure of the S17 for the following purposes

- maintaining the continuity of the seasonal reproductive migration routes of terrestrial amphibians and invertebrates,
- maintaining the continuity of the habitats and migration routes of small mammals (mustelids, rodents, insectivores) and amphibious mammals (all species), which are also to serve medium-sized mammals living in burrows (mainly foxes),

- protecting access to the game-hunting and migration areas of large animals, all species of ungulates (including the elk), predatory mammals (including the wolf and the lynx), and medium-sized animals, simultaneously also allowing small animals and amphibians to use them.

## **2. The requirements of environmental protection**

In accordance with the Regulation of the Minister of Transport and the Maritime Economy of 30 May 2000 [1], wild animals should be ensured safe movement from one side of A-, S-, GP-, and G-class roads to the other in the areas of increased migration, especially in larger forest complexes and marsh terrains, as well as in other habitats of rare and endangered species that have been cut across by this road.

Directly along the constructed section of the S17 expressway, there are no national parks and Natura 2000 protected areas. However, in the proximity of the lines demarcating the investment (along the “Lublin Rudnik” – “Lublin Felin” sections), there is the “Bystrzyca Jakubowicka” Special-Protection Area classified as a Natura 2000 protected area. This area features several protected species of butterflies and plants. While designing and constructing the expressway, decisions concerning environmental protection [2, 3, 4, 5] and the provisions of the Environmental-Protection Act [6] were complied with. The protection of the environment was required during the construction of the S17 and will be required long after opening the road to traffic. The environmental protection requirements applied to water, air, noise, and animal protection (enabling the migration of animals and amphibians across the road), the protection of habitats, and the prevention of animal wanderings onto the road. The environmental laws applied to roadworks in the proximity of noise-protected areas and locations of construction bases. Works within the valuable habitats of protected species of plants and animals were limited to the minimum. In the course of the construction works, the lane was fenced off at both sides, protecting against uncontrolled interruptions of amphibians onto the construction site in the areas of marshy meadows and sections of migration routes.

Monitoring the project’s impact on the environment in terms of the effectiveness of planting and the ecological effectiveness of the measures taken to minimise the barrier influence of the road on animals (the accurateness of the locations of passages for animals and their parameters) is to last 4 years, and be performed once a year, starting from the second year to the opening of the road to traffic.

## **3. The basic functions of animal crossings and design solutions**

The crossings perform two basic ecological functions. They are creating the conditions which make it possible for those animals whose habitats are cut across by the road to move around; and which enable animals that move long distances to migrate, wander, and disperse [8]. In the case of the said section of the expressway, they constitute an important element in counteracting the barrier effect, created after the road was built along the new route and in the area of sparse building, where, previously, wild animals could move around freely.

The lie of the land and the location of the gradeline of the expressway resulted in the construction of only underpasses on the said sections. Within the expressway, there are both passages which perform the ecological function only and passages which combine the ecological and economic functions.

In order to ensure access to game hunting and migration areas of mainly large animals, ungulates, predators (e.g. the wolf), and medium-sized animals (the wild pig, the roe deer), the structures with the parameters presented in Tab. 1 were built along the S17 expressway. In the case of underpasses for large and medium-sized animals, the recommended values of horizontal clearance ( $b$ ) are  $\geq 15.0$  m and  $\geq 6.0$  m respectively. vertical clearance – ( $h$ )  $\geq 5.0$  m and  $\geq 3.5$  m. and the openness ratio (OR, width x height / length)  $\geq 1.5$  and  $\geq 0.7$  [8]. In accordance with the environmental approval [3], the parameters of crossings for medium-sized animals are  $b \geq 8.0$  m.  $h \geq 3.0$  m. and OR  $\geq 0.7$ . The structures presented in Tab. 1 can be also used by small animals and amphibians.

Table 1. A list of crossings parameters for large and medium-sized animals [13-17]

Section	Structure	Depiction	Obstacle	SW [m]	APW [m]	APH [m]	OR [-]
1	MS-02	PZDzd1	Wc, Ro	33.60	19.00	6.80	3.53
	MS-04	PZDzd2	Wc	21.76	17.48	5.60	2.83
	MD-04a	PZDzd2	Wc	21.80	17.60	5.40	12.34
	MS-05	PZDzd3	The Białka River	21.76	16.26	5.40	2.40
	MS-10	PZSzd1	The Białka River	21.80	16.80	3.00	1.46
	MS-14	PZSzd2	The Kurówka River	33.60	20.00	4.20	2.43
	PDŚZ	PZSzd3	Wc	15.82	9.42	6.50	0.92
	MS-16a	PZSzd4	Wc	17.62	13.82	7.20	1.38
	2	MS-02	PZSzd5	The Ciemięga River	29.70	20.20	4.45
PZSzd6		PZSzd6	Wc	14.50	9.60	3.80	0.90
PZSzd8		PZSzd8	dry Wc	11.50	11.50	5.00	1.23
3	WS-07	PZSzd9	Va, Ro	139.40	38.50	5.3-12.9	min 5.8
	PZSzd10A	PZSzd10	T	10.20	10.60	3.00	2.89
	PZSzd10B	PZSzd10	T	10.20	40.10	3.00	0.76
	PZSzd10C	PZSzd10	T	10.20	9.10	3.00	3.36
	PZSzd11A	PZSzd11	T	10.20	9.10	3.00	3.36
	PZSzd11B	PZSzd11	T	10.20	40.60	3.00	0.75
	PZSzd11C	PZSzd11	T	10.20	11.10	3.00	2.76
4	MS-16	PZDzd4	The Bystrzyca River	979.00	841.00	6.0-9.0	min. 4.69
	WS-20	PZSzd13	T, Ro, RRT	188.00	10.00	3.50	0.99

PZDzd – bottom crossing for large-sized animals, PZSzd – bottom crossing for medium-sized animals, SW – structure width, APW – zone width intended for animals, APH – height between the ground level and the bottom of span, OR – the openness ratio (the product of the height and width of a passage divided by the length, Wc – watercourse, Ro – road, Va – valley, T – terrain, RRT – railroad tracks

In addition to the above use, practically every crossing can be used more or less often by various species and groups of animals. In the proximity of the expressway, the following animals can be observed: the elk, the deer, the roe deer, the wild pig, the fox, the hare, small mammals, and amphibians.

Along the said section of the expressway, a series of smaller passages for animals were built. These structures were constructed mainly in order to maintain the continuity of the habitats and migration routes of small insectivorous mammals, mustelids, rodents, and amphibious mammals. These passages are also there to serve smaller mammals living in burrows (mainly foxes) as well as amphibians and terrestrial invertebrates. Passages for small animals joined with culverts which are periodically or permanently filled with water were built in three forms. The first one involves steel shelves 50 cm wide, fixed on both

walls of the culvert (made of steel or reinforced concrete), with shelves covered with a layer of mineral soil. The second structure is a passage on the layer of ground covering the bottom of the passage. The third structure of the culvert is shelves made from gabions covered with a layer of hummus (fig. 1 and 2).



Fig. 1. The solution for animals crossing in the form of shelves with gabions in the facility PZM 33

Fig. 2. The solution for animals crossing in the form of shelves with gabions in the facility PZM 29

In accordance with the Passage Design Guide [8], the openness ratio of crossings for small animals should be no lower than 0.07. All passages for small animals constructed along the said section of S17 in the form of culverts meet this requirement. 34 groups of objects or single objects were built as passages for small animals (20 steel structures, 32 structures made of reinforced concrete, including two small-frame bridges). A listing of the parameters of passages for small animals is presented in Tab. 2.

Table 2. Summary of crossings for small animals with their parameters [13-17]

Type	Crossing number [items]	Width [m]	Height [m]	Passage area [m <sup>2</sup> ]	OR [-]	
					min	max
Steel	3	2.23	1.68	2.81	0.061	0.073
	2	2.76	2.05	4.29	0.099	0.100
	7	2.84	2.02	4.63	0.099	0.115
	5	2.96	2.16	5.06	0.067	0.098
	3	3.35	2.19	5.68	0.109	0.126
Reinforced concrete	8	2.00	1.50-2.00	3.00	0.081	0.429
	1	2.50	2.00	3.75	0.449	0.449
	5	2.50	2.50	5.00	0.106	0.602
	2	3.00	1.00	3.00	0.073	0.085
	5	3.00	2.00-3.00	4.50	0.099	0.652
	1	3.00	2.00	5.70	0.497	0.497
	2	3.00	3.00	7.50	0.159	0.181
	2	3.50	2.50	5.25	0.088	0.760
	3	4.50	1.50-2.50	6.75	0.092	0.416
	2	10.00	2.00	14.00	0.410	2.029

Examples of passage for large animals are shown in Fig. 3; medium in Fig. 4 - 6; small in Figs. 1, 2, 7, 8.



Fig. 3. Crossing for large animals PZDzd3 near the “Kurów Wschód” junction

Fig. 4. Crossing for medium-sized animals PZSzd5 in the Ciemięga River valley



Fig. 5. Crossing for medium-sized animals PZSzd6 near Sieprawice

Fig. 6. Crossing for medium-sized animals PZSzd11 within the North ring road of Lublin



Fig. 7. Group of crossings for small-sized animals PZM37

Fig. 8. Crossing for medium-sized animals PZSzd1 near the “Nałęczów” junction

The sections of the expressway were designed by several design companies, which resulted in some insignificant diversity of passage structures for small animals (Figs. 1, 2, 7, 8). Within Task 1 (“Kurów West” – “Jastków”), all 22 passages for small animals and amphibians were built as corrugated-iron structures. A few structures were constructed in the proximity of culverts under the expressways and on existing minor watercourses. Here animal passages were made from steel shelves covered with a layer of ground. Along Task 2 (“Jastków” – “Lublin Sławinek”), the structures of the passages for small animals were slightly differentiated. In those places where directly above the culvert, road pavements or small road embankments were placed, structures made of reinforced concrete were designed. In total, 5 structures made of reinforced concrete and 8 steel structures serving as

passages for small animals and amphibians were built. In the case of Task 3 (“Lublin Sławinek” – “Lublin Rudnik”), 12 passages in the form of structures made of reinforced concrete from prefabricated elements for small animals and amphibians were constructed. Similar structures to those in Task 3 were intended as passages for small animals and amphibians in Task 4 (“Lublin Rudnik” – “Lublin Felin”). In total, 13 structures made of reinforced concrete were built from prefabricated elements. An additional passage for small animals is a bridge with a frame made of reinforced concrete with the dimensions of the opening 2,0 x 10,0 m.

In order to minimise the adverse influence of the expressway on amphibians, passages for amphibians were built. The structures took the form of steel culverts. Within the construction of the S17, 7 passages for amphibians within Task 1 (276x205 cm, OR 0,068 ÷ 0,098) and 4 within Task 2 (296x216 cm, OR 0,096 ÷ 0,120) were erected. Passages for amphibians also perform a supplementary function of passages for medium-sized and small animals.



Fig. 9. Traces of use by people of crossings for small-sized animals

Fig. 10. Visible signs of wheeled vehicles within the bottom crossing for medium-sized animals

#### 4. The relevance of the solutions

In 2015 two years had passed since the Task 1 section of the expressway [7] was opened to traffic and a year since the sections constructed within Tasks 2, 3, and 4 were opened to traffic. The period of their use allows a preliminary assessment of the effectiveness of the solutions implemented. The first analyses are already being made. Animals could already be getting used to the facilities meant for their protection when the construction was being delivered. Furthermore, this period, in the case of the sections from the “Jastków” junction to the “Lublin Felin” junction, for several reasons, has been extended by a year. A great unknown was how animals would react to the traffic near the expressway.

In analysing the appropriateness of the solutions implemented, a number of positive and negative aspects should be taken into account. As already discussed in Kowal’s publication [10], the location of the PZSzd8 passage of Task 2 (fig. 10) is a debatable issue. The structure was located directly in the proximity of farm buildings, which can significantly minimise its use by wild animals. The authors’ own observations show that the concerns were not groundless. It is difficult to notice trails of wild animals in the proximity of this passage, which does not mean that the object is not used by wild animals. The weakening of the basic function of the structure can be additionally influenced by its use by the locals. The structure is a perfect farm crossing. A similar situation applies to several passages for small animals, which perform the function of a crossing for local people (fig. 9).



A problem discussed in [10] was the relevance of placing street lamps in the proximity of and directly on the underpasses for animals (PZDzd1, PZDzd3, PZSzd1 – all along the “Kurów West” – “Jastków” section). Almost three years since the road was opened to traffic, it can be observed that the fauna, to some extent, has adapted to the new reality. In the proximity of the PZDzd3 structure (MS-05) and underneath it, there is a visible wild boar’s trail. Furthermore, the structure has probably become an interesting convenience for members of the game-hunting club of this area since a hunting look-out was placed 150 m north off the structure,. In the proximity of the PZSzd1 (MS-10) object, trails of roe deer have been observed (fig. 11).



Fig. 11. Animal traces within the crossing for medium-sized animals PZSzd1

Fig. 12. Animal traces within the group of crossings for small-sized animals PZM37

Another issue brought up for discussion was the colour of the anticorrosive of the concrete structures [10, 11]. The application of the light yellow colour on the walls of bridgeheads and wings and the orange colour on the surfaces of cornices probably did not negatively affect wildlife use. Currently, the authors do not have their own photographic resources demonstrating the use of the structures by specific species of animals depending on the time of day. However, in the course of guarantee construction works in the period from September to October 2015, construction workers making alterations at the MS-02 (PZSzd5) structure on the “Jastków” – “Lublin Sławinek” section observed, several times, crossings of roe deer and foxes under the structure in daylight. The PZSzd5 structure is a bridge over the Ciemięga River combined with a passage for medium-sized animals. Its parameters do not prevent large animals from using it. During the construction of this bridge in 2013, next to the structure, an adult elk wandered onto the embankment of the road. Later a similar crossing was not observed. However, in the course of the said guarantee works, on a sunny day, one of the workers took a picture of a young elk coming near the structure, although it did not go over it. It is possible, however, that the object will also serve as a passage for this species.

The traces of roe deer trails were also noted by the authors in the group of passages for small animals PZM37 (fig. 12). This is interesting because the dimensions of the diameter in these structures are 3.0 m horizontally and 1.5 m and 2.0 m vertically. The openness ratio in these structures is 0.59 for the structure with the smaller diameter, and 0.181 for the other one.

## 5. Summary

The investment consisting of the construction of an expressway is a considerable challenge, both for the contracting party, which in the case of expressways is the General

Directorate for National Roads and Motorways, the Lublin division, and for the designers and contractors. Determining an optimum route, including communication with localities adjacent to the national road, and making it possible for animals to cross the barrier that is the expressway, constitute challenging tasks. The year 2016 will see the stage of designing the route, junctions, and engineering objects on other sections of the S17 expressway from the “Kurów West” junction to the “Zakręt” junction. There are interesting new solutions to look forward to.

The construction of the S17(12) expressway on the section from “Kurów West” to “Piaski West” has contributed to the improvement in the life comfort and road-traffic safety within the localities situated along the old national road No. 17, which were omitted as the new route was built. The assessment of the actual impact of the construction of the expressway on the number of road incidents and accidents will be possible in the coming years.

The designers saw to it that environmentally friendly solutions for road elements and adjacent areas were introduced in order to interfere with the natural environment in the proximity of new roads to the least extent possible. The cost of all elements required by environmental protection laws used on the said section of S17 had a significant share in the total cost of the investment (up to 27% [10]). However, people, animals, plants, water, and air have to be protected against the adverse effects of building and operating roads of this type. It should be remembered that maintaining a balance in the natural environment, including the care for clear water and air, as well as amphibians, small, medium and large animals, eventually affects the conditions people live in. By observing and analysing the already constructed environment protection structures, good, reliable, and cost-effective solutions should be sought so that they can be used in future investments.

Performing the final assessment of the effectiveness of environmental protection structures in the form of passages for animals on the said section of S17 it must be said that, despite the former doubts as to their usefulness, the majority of those structures are used in accordance with their intended use. The assessment of utility should not be based solely on the number of animals going through a passage over a specific period of time. There is reason for optimism because, with high probability, the structures on which animals have been already observed will become a new “natural” element along the routes of wildlife passage in the near future. Observations should continue and optimum solutions should be sought in order to employ effective solutions in the future. Moreover, each bridge structure serving as a passage for animals could be appropriately equipped in the future, becoming a point of control for the natural environment, about which the authors have already written in [11].

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# **Przejścia dla zwierząt na odcinku S17 między węzłami „Kurów Zachód” a „Lublin Felin”**

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**Streszczenie:** W artykule opisano parametry i efektywność elementów ochrony środowiska drogi ekspresowej S17 w formie przejść dla zwierząt. Przedstawione zostały obiekty inżynierskie na odcinku od węzła „Kurów Zachód” do węzła – „Lublin Felin”. Opisano wymagania ochrony środowiska na etapie projektowania oraz podczas realizacji budowy. Zaprezentowano rozwiązania konstrukcyjne obiektów oraz podstawowe funkcje tych przejść. Podsumowano trafność zastosowanych rozwiązań obiektów i ich lokalizacji w terenie.

**Słowa kluczowe:** ochrona środowiska, droga ekspresowa S17, przejścia dla zwierząt.