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Road and Rail Infrastructure III

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BURIED FLEXIBLE CORRUGATED STEEL STRUCTURES – MODERN TECHNOLOGY IN CONSTRUCTION OF WILDLIFE CROSSINGS

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Abstract

Even though modern road network is the main prerequisite for sustainable economic development of every country, intensive road construction also has a negative influence on surrounding life and environment. With its unique characteristics, motorways presents large obstacle in landscape, intersecting the habitual migratory wildlife routes in their natural surroundings. One of the measures from adverse motorway impacts includes ensuring natural wildlife migrations across motorways. One of such measurements is construction of wildlife crossings which are well-established in the Croatian road planning process and relevant legislation. Therefore, it is created a favourable environment for the development and adoption of new technologies for their construction.
Buried Flexible Corrugated Steel Structures (BFCSS) presents modern construction technology for wildlife crossings with the variety of opportunities in term of spans and shapes. Technology of BFCSS for civil engineering infrastructure projects is well known in countries with developed steel industry and expensive labour. But in this part of Europe, south-eastern Europe, it has been unfairly neglected and just sporadically used. In order to promote new technology and achieve progress in the field of road construction, modern way of wildlife crossings construction will be presented.
In this paper, basic engineering properties so as the designing details and usage possibilities of BFCSS will be presented. Special emphasis will be given on practical experience of their use in the construction of wildlife crossings as well as on the use of long-span structures.

Keywords: Buried Flexible Corrugated Steel Structures, wildlife crossings, long-span structures, design details

1 Introduction

High-quality road network, especially the motorway network incorporated in the global transportation system is one of the basic conditions for the development of every country. At the same time, number of road users are in constant increase, so current road network is reaching even the most remote corners of the world. However, besides undisputable positive effects of road construction on global development, some negative impact have to be mentioned. Increasing built of motorways drastically affect the landscape, and it has high influence on human life and even higher on the animal and plant life. So the community attention to the environmental aspects of road construction is increasing.
There is a variety of measures implemented in road built for environmental protection. Some of protective measures from adverse road built are noise protection, drainage system, lan-

dscaping of the road area, protection of archaeological finds and measures for ensuring natural migration of animals across roads.
Habitat fragmentation has been recognized as one of the most significant factors contributing to the decline of biodiversity in Europe [1]. So, with its unique characteristics, motorways presents large obstacle in landscape, intersecting the habitual migratory wildlife routes in their natural surroundings. For that reason, it is very important to devote adequate attention during the design development stage for new motorway projects to provide suitable wild animals passageways. For that purpose, four types of structures have been conceived: green bridges, wildlife crossings and passageways, pipes and ground channels for small mammals and other vertebrates and amphibian tunnels [2].
Wildlife crossings are constructions that allow roads permeability for animals and safe crossing of wild animals at appropriate spatial intervals. By the Regulations on wildlife crossings [3], the construction of these structures is the obligation of roads investors and this specially (dedicated) built crossings have protection as natural values.
Construction of wildlife crossings are well-established in Croatian road planning process and relevant legislation. There are 80 wildlife crossings on 1250,7 km of motorways and semi-motorways in Croatia, which means one crossing on nearly every 16 km. One of them is presented in Fig. 1.

Figure 1 Wildlife crossing on Croatian motorway [2]

Therefore, it is created a favourable environment for the development and adoption of new technologies for their construction. Buried Flexible Corrugated Steel Structures (BFCSS) presents modern construction technology for wildlife crossings with the variety of opportunities in term of spans and shapes. So, basic engineering properties, designing details and usage possibilities of BFCSS are following.

2 Technology of Buried Flexible Corrugated Steel Structures

Animal passages are built as underpasses and overpasses. They can have various shapes and can be built in various technologies.
Since the introduction of BFCSS in XIX century this technology was gradually used in road construction. At the very beginning, there was galvanized steel pipes with round cross section, now referred to as corrugated steel pipes. The economy of these pipes led to a larger diameter, which are assembled on site from curved, corrugated plates. Corrugation of these plates was around 150x50mm, and they are now referred to as corrugated steel structures.
Nowadays this kind of structures are widely known and applied in many countries all over the world. They are mostly used as culverts or bridges for the roads and railway infrastructure, but they are also widely used for many other applications in the industrial, mine and other market sectors [4].
Today corrugated steel pipes are produced with corrugation of 68x13 mm, 76x25 mm, 120x20 mm, 125x26 mm and similar. Corrugated steel structures are manufactured with corrugation of 152x22 mm, 150x50 mm, 200x55mm and similar (fig. 2).

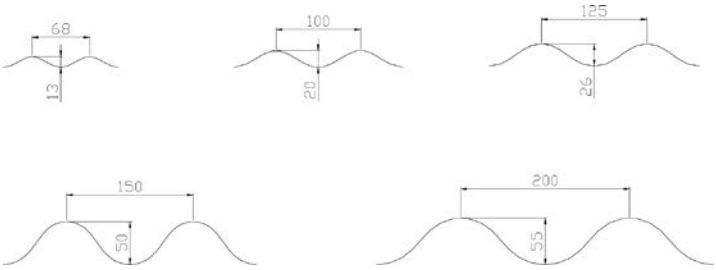

Figure 2 Typical shallow corrugation of BFCSS

Used us culverts or bridges under the road, maximum span that can be achieved with corrugation of 150x50 mm or 200x55 mm is about 12 m. They can be used with many different shapes showed in figure 3. Shape called box culvert (fig. 3i) can have a maximum span of 7,00 m.

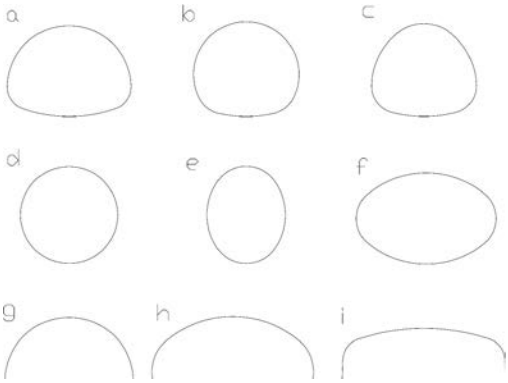

Figure 3 The most popular shapes of BFCSS

In the mid of 80's of the twentieth century deep-corrugated plates were introduced, with a pitch between 380 and 400 mm, and rise between 140 and 150 mm (fig.4), they initiated a new generation of corrugated steel structures. This kind of structure are called SuperCor, DeepCor, BridgeCor, StrenCor.

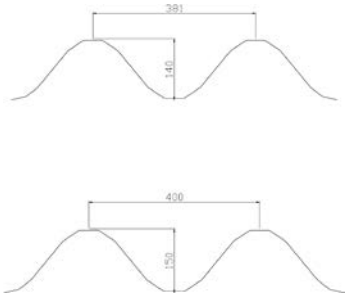

Figure 4 Deep corrugation

The advantage of deep corrugation is that, with a small increase in the volume of steel, the flexural rigidity is increased about nine times with comparison to shallow corrugation 200x55 mm. Thanks to that it is possible to make BFCSS with greater span up to 24 m, called super-span or long-span. It was possible to achieve bigger span also because of reinforcement ribs patented in 1994.

Figure 5 Animal overpass in Trzebaw (2002) (span of 17,68m) and above railway, Rzepin (2008); Poland

Figure 6 Animal overpass: motorway A2, Poland; constructed in 2006 and 2013.

Figure 7 Animal overpasses above highway, Banff; Canada (2009) and South Korea (2010)

Figure 8 Animal overpasses, Tallinn, Estonia 2013

A new dynamic development of BFCSS will not be possible without in situ and laboratory tests and development of design method. One of the newest design method including new innovations and trends is Sundquist–Petterson method described in [5].
New generation of deep corrugated BFCSS gives a possibility to design and install structures that can be used as bridges breaking next technological barriers for road and railway infrastructure and civil engineering. There are many of such structures already built or designed and those which are waiting for realization used like viaducts, and especially ecological animal crossings over new motorway net in the center of Europe [6].
Advantages of constructing of animal crossing with the use of BFCSS versus traditional technologies are lower cost, faster construction, minimum disruption to traffic and nice fit into the landscape. Important environmental factor is a use of soil as a structural element. Very often local soil can be used for backfilling.
BFCSS can be efficiently used to build animal crossing over roads. Quick construction and minimum disturbance to surrounding limit negative influence of works on environment and save cost due to minimum disturbance of the traffic. Use of natural materials (sand, gravel, stone, wood) enhances environmental effect. Financial effectiveness and aesthetic look support the idea of common use of those technology for construction of animal crossing over and under roads. Figures 5- 8 show examples of such animal overpasses.

3 Croatian experience with Buried Flexible Corrugated Steel Structures

Some of the first experiences with corrugated steel structures in Croatia were the use of corrugated steel pipes for the construction of culverts. In [7], one of such kind of an example is presented. In Croatia and Balkan's region BFCSS are only used for some several years, and there are structures in the road network with the use of this technology also as animal crossing.
In May 2009, animal underpass in km 5+030,00 of Adriatic Highway – ISTRIAN "Y" was constructed. It's the passage of wild and domestic animals with the light opening passages 4x4m. To fulfill this requirement, corrugated steel structures with span 5,97m and height 5,49m was used, with corrugation 200x55 mm. Total length 46,44 m. In September 2009 another animal underpass in km 43+849,02 of Adriatic Highway – ISTRIAN "Y" was constructed by use of profile with span 4,49 m and height 3,97 m. Total length 39,32 m.
Both structures were constructed in two phases. In a first phase around 65% of the total length of underpasses were built under first highway line, and in the second phase second parts of structures were installed later. In Fig. 9 Phase II and finished animal underpass is presented.

Figure 9 Installation of animal underpass – phase II and animal underpass in km 5+030,00 of Adriatic Highway – ISTRIAN "Y"

Based on the above examples, we can say that Croatia has made the first step towards adopting a technology of BFCSS and use it for animal crossing. Beyond these examples, there are many small culverts in Croatia with use of BFCSS. There are many ready designs that are waiting for realization.

4 Conclusion

Even though, technology of BFCSS for civil engineering infrastructure projects is well known in countries with developed steel industry and expensive labour, in Croatia and generally in south-eastern Europe, it has been unfairly neglected and just sporadically used. Construction of wildlife crossings are well-established in Croatian road planning process and relevant legislation so favourable environment for the development and adoption of new technologies for their construction is created. In order to promote new technology and achieve progress in the field of road construction, modern way of wildlife crossings construction is presented in this paper.

Some of the basic aadvantages of BFCSS use in construction of animal crossing are lower cost (average 30-40% cheaper than traditional solutions), faster construction (execution is several times faster as compared to concrete structures), minimum disruption to traffic and nice fit into the landscape. Also, use of natural materials (sand, gravel, stone, wood) enhances its positive environmental effect.

However, it could be concluded that so far, this technology is not fully utilized in Croatian territory. There is no deep corrugation structure built in Croatia yet.

Taking into consideration advantages given by BFCSS, especially for its application in animal crossings construction and positive experience from its usage in other European countries might result in a greater application of steel culverts in Croatian civil engineering practice.

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