Emergency Repair of the Bridge from Prefabricated Posttensioned Beams

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Abstract. In the '70s and' 80s of the last century, bridge constructions with prefabricated pretensioned concrete beams were commonly built in Poland. Objects made of these beams are characterized by low durability of about 40 years. This is mainly due to the very low quality of joint concrete. This problem is particularly evident in the case of objects made of type I beams. In this type of bridges, we see rapid destruction of the slabs. The case of failure of an object made of WBS type concrete beams is shown. The way of repair and increase of load capacity is presented.

1. Introduction

In the '70s and' 80s of the last century, bridge constructions with prefabricated prestressed concrete and cable concrete beams were commonly built in Poland. Beam elements made under controlled conditions in casting yard with a good quality concrete show good quality. Despite this, objects made of these beams are characterized by low durability of approx. 40 years to 50 years [1, 2]. This is mainly due to the very low quality of the joint concrete made on site (the strength of concrete made on site was in the order of 15 MPa to 25 MPa) and the lack of tight expansion joints. Also, the low-quality insulation materials used at that time were often quickly damaged, which led to the penetration of water with de-icing agents deep into the concrete of the platform slab. In addition, the tendency to optimize solutions also affected the insufficient durability of this type of structures. The used thickness of the deck slab (from 15 cm) did not have sufficient rigidity. This affects the acceleration of fatigue damage, mainly of bridge plates.

This problem is particularly evident in the case of objects made of type I beams. In solutions made using this type of beams, the platform slab has a relatively large span. In addition, all the above-mentioned factors overlapped in such facilities - concrete slabs of very low quality, small thickness of the bridge slab, very low transverse rigidity. The combination of these factors leads to very rapid destruction of the platform slabs. Destructive processes are accelerated by the penetration of water into concrete through leaking expansion joints and often damaged insulation of the slab.

The article presents the case of failure of the platform bridge slab made of type I beams and the actions taken to remove the failure to restore traffic on the viaduct.

2. Characteristics of the object

The viaduct is located above two-way expressway with three lanes in each direction. The expressway is characterized by very high traffic of over 100,000 vehicles a day. Any obstructions on the road -
even temporary closing of one lane causes traffic jams. The viaduct leads over the local road, which is an important transport connection for the city's inhabitants divided into two parts by express road. The road on the viaduct has a roadway and double-sided walkways – figure 1, figure 2).

![Figure 1. Cross section of the viaduct before reconstruction](image1)

![Figure 2. Side view of the viaduct](image2)

The object is a concrete, two-span, free-support with a beam-slab structure. The superstructure consists of six prefabricated concrete beams of the type "WBS" (beams with cross-section I) with a height of 1.60 m, and an axial spacing of 2.20 m. The theoretical span of the spans is 29.00 m. The beams are connected by a bridge slab, support and span crossbeams (two support and three span
crossbeams). The deck is a reinforced concrete slab 16 cm thick with shaped cornices. The viaduct supports are two abutments and a reinforced concrete pillar.

"WBS" beams used in the viaduct are cable concrete beams. Due to the length, they were made in segments joined at the construction site and then posttensioned.

3. **Characteristics of the technical condition and description of the failure**

Object damages are typical for objects from this period. First of all, advanced corrosion of concrete and loss of protective properties of concrete of supports were found – figure 3, figure 4. Cracks caused by corrosion and localized corrosion of reinforcing bars were visible. In the case of beams of the superstructure, stains, deposits and impurities were found. Despite these damages, the condition of the beams was good – figure 5. The worst condition was found in the case of the platform slab and crossbeams. There was practically disintegration of the concrete of the crossbeams on the abutments – figure 6, and the bridge slab of one span – figure 7. Damage to the insulation contributed to the destruction of the slab. In the span in which the plate was not damaged (its condition was sufficient), the scope of leaks was much smaller – figure 5. This indicated that the insulation was not completely destroyed. In the span with a damaged slab, the condition of the bottom of the slab indicates complete destruction of the insulation.

![Figure 3. Abutment](image-url)
Figure 4. Pillar

Figure 5. Slab - first span
Figure 6. Crossbeam on the abutment

Figure 7. Slab - a span in which a failure occurred
During inspections, attention was paid to the poor condition of the object. Unfortunately, the lack of funds decided to postpone the removal of irregularities. Unfortunately, the shift resulted in a failure. The failure occurred during an current repair of the pavement on the object. During the thickening of the bituminous mass in the place of the pavement defect, a hole was created in the bridge slab – figure 8.

![Figure 8. Place of failure](image)

4. **Analysis of the condition of the structure**
After the failure, the condition of the structure was analyzed to determine how to proceed. Assessment of the condition of the structure showed that the object after a failure cannot be used due to the condition of the slab. A general renovation or reconstruction of the viaduct is required. As part of the reconstruction, it is possible to partially use the supports and the prefabricated beams of the superstructure. The time needed to prepare such an investment is long and the costs of the investment itself are large. Due to the important communication function of the viaduct, it was necessary to restore traffic as soon as possible. At the same time, there was a shortage of funds for the entire investment. Therefore, it was decided that a limited renovation will be carried out, which will temporarily restore traffic on the object and at the same time will be within the financial capabilities of the owner. It is also to be the first stage of reconstruction of the viaduct - the amount of work lost should be minimized as much as possible.

5. **Program and scope of renovation**
When determining the scope of work, the following assumptions were made:
- renovation / repair of only damaged span (undamaged span slab can still perform its function);
- leaving existing WBS beams;
- road technical parameters corresponding to the technical class Z of public roads;
- road grades unchanged;
- overall width of superstructure unchanged.

At the same time, it was assumed that the load capacity of the object should be increased as much as possible.

It was decided that as part of the renovation, the entire damaged span slab and equipment (expansion joints, insulation, surfaces, etc.) would be replaced. In addition, surface repairs of beams and left parts of crossbeams will be carried out in this span – figure 9. It was assumed that the remaining works will be carried out in the second stage of work after the preparation of full project documentation and providing financial resources.

There was no freedom in shaping the slab. A smaller problem was the need to maintain the width of the span. Fortunately, the existing width was sufficient to provide all cross-sectional elements required by regulations [3]. The bigger problem was the need to keep the existing gauge and grade line. This did not allow free forming of the slab. Therefore, in order to increase the load-bearing capacity of the object, the top surface of the slab was raised to the maximum using the minimum thickness required by regulations [3]. To further increase the load-bearing capacity of the object, it was decided to use a temporary support for the time of concreting the slab [4]. Due to the expressway under the object with very high traffic volume, it was possible to support it in one cross section only – figure 10. In addition, additional joining connectors were used to transfer created additional delamination forces – figure 11. As a result of these operations, class C load according to the standard [5] was obtained. Due to the load capacity of the undamaged span, it was decided that the obtained load capacity at this stage is sufficient, and further increase of the load capacity will be possible in the second stage of renovation, e.g. by applying additional external compression.

![Figure 9. Cross-section of a damaged span after renovation](image-url)
6. Conclusions

Bridge structures made of prefabricated beams built in the 70's and 80's have very low durability. This is due to the low quality of works performed at the construction site. The beam elements themselves have very good properties and are used in reconstruction. It is also possible to increase the load capacity of such structures by properly shaping the slabs, using temporary supports and concreting staging. Composite materials or external compression can also be used. It is also often used to change static shame of such structures. Despite the good properties of prefabricated elements, the decision to replace these elements is increasingly being made during the reconstruction of bridges.

References

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