Launched concrete viaduct of distinctive shape in a busy area

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Summary

One of the largest post-tensioned concrete viaducts built in Poland in the years 2000-2002 is described. The viaduct had to cross 12 railway tracks and a busy street. Due to the obstacles, 15 spans of different lengths (from 30.00 m to 52.00 m) were designed in each deck. The total length of structure is more than 600 m. The central part (430 m) of structure was launched, without any perturbation in car or train traffic. The remaining parts were cast in situ. The geometry of the launched parts was complicated - a circular arch on an inclined plane. Furthermore there are precast curved units assembled along the bridge below the cantilevered parts of the decks. This positively influences the appearance of the structure and creates a new feeling of bridge aesthetics in the city. Launching appears to be an effective method of construction in a busy area regardless complicated geometry of the deck. Aesthetic requirements were also fulfilled to the satisfaction of the client.

Keywords: concrete bridge, construction, aesthetics, launching, launching force

1. Introduction

The viaduct under consideration is situated along the Internal Ring Road of Wroclaw, Poland. The structural solution was chosen after a competition carried out in 1998. The winner was Mosty-Wroclaw, Design and Test Office. The client was ZDiK Wroclaw (municipal road authority), general contractor was Budimex-Dromex and specialized contractor – Fresyssinet Polska.
The structure consists of two parallel decks made of post-tensioned concrete. The side junctions, allow the traffic to flow from and to surrounding streets. The side junctions are connected monolithically to the main decks. Because of the specific layout of the railway tracks underneath, which are the main obstacle to this crossing, both parallel structures are 15-span continuous beams, but of different span lengths. (See Fig. 1 and Fig. 2). The axis of the structure is a superposition of two different curves in 3D space. The central part of the viaduct complies with the requirements of the longitudinal incremental launching method [1].

2. Description of the viaduct

The superstructures of the main decks are multi-span, one-cell box girders (see Fig. 1) with a layout suitable to the requirements of the road geometry. The girder depth equals 2.50 m along the axes of the webs. The thickness of the top slab is 0.25 m, the bottom slab is 0.20 m thick and the webs are all 0.65 m thick. The distance between webs is 7.00 m (between imaginary planes).
The superstructure is made of B60 concrete (cube strength), with a basalt aggregate and 6 % of silica fume. The total amount of B60 concrete exceeded 15200 m^3. There are 4 types of prestressing tendons on both decks:

- ‘centric’ prestressing tendons, to carry the loads appearing during launching,
- internal main tendons, in both webs, tensioned after final termination of the launching operations,
- external main tendons, composed of individually protected sheated strands,
- transversal prestressing of deck slab type of monostrand.

The supports of the structure are reinforced concrete abutments and double column piers. The diameter of the columns under the main decks is 2.00 m and the diameter of column under the side junctions is 1.50 m. There are drilled piles or footings underneath. The fixed bearings are located close to the side junctions on both the west and east side.
The cross section was adopted to the method of construction and the layout of prestressing tendons used. Close to the webs, the slabs (flanges) are thicker to make room for centric prestressing. The cross-section is uniform through all parallel decks, independent of the technology employed. Actually, there are some differences at the deviation points of external cables, anchorage places and over-pier thickening (support pilaster), Fig. 3.
The rounded cross-section of spans was secured with precast reinforced concrete elements, which were assembled onto the most recently produced section of the superstructure. The ribs of these precast elements act as struts for the cantilever part of deck, Fig. 4.

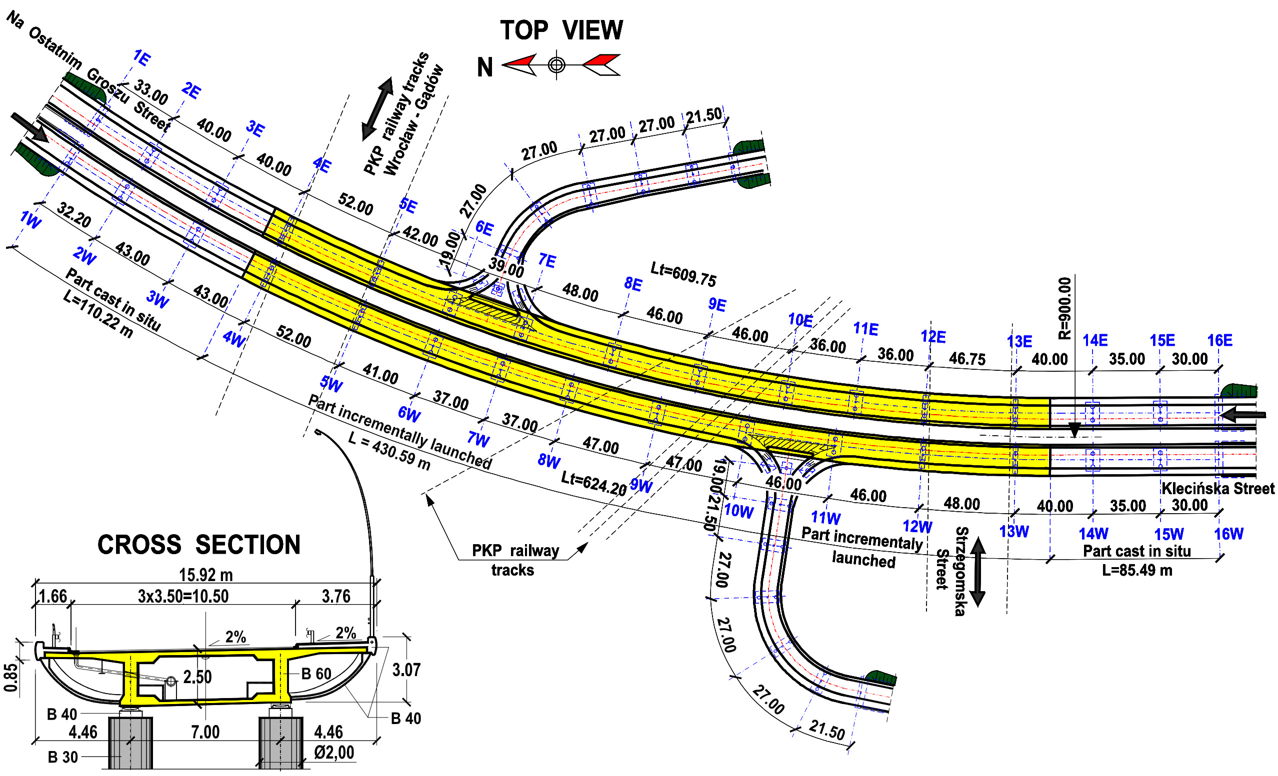

Fig. 1 The layout of the viaduct viewed from above. Launched parts are marked in yellow.

3. Construction

Two methods were employed here: longitudinal (incremental) launching and casting in situ span by span. Side junctions were cast in situ in three phases. Finally, closure parts were cast, and two independent superstructures were completed.
The process of launching was slightly different than normally observed at other Polish sites. Due to local circumstances and requirements, all fabrication plants were located not behind an abutment, but were situated between two piers (no. 13E/13W and no. 14E/14W) on the temporary embankment, strongly compacted (Fig. 5).

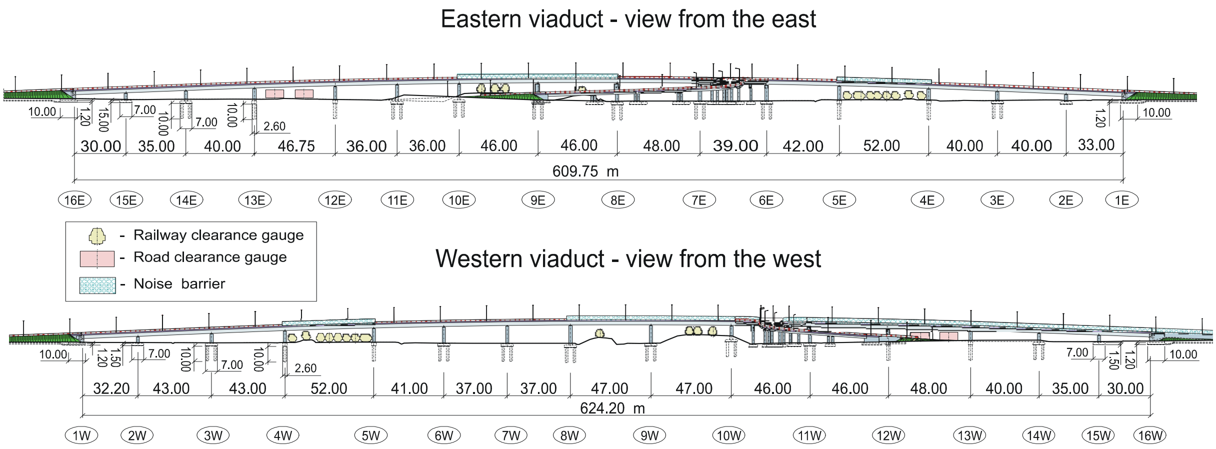

Fig. 2 Eastward and westward elevation of the structure

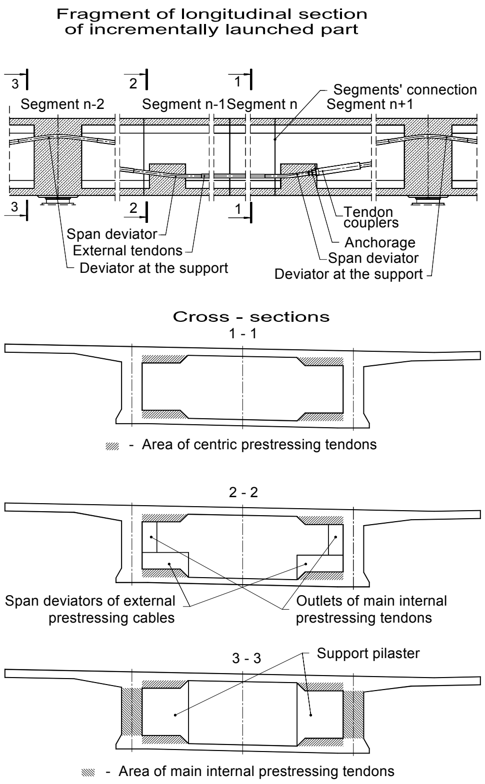

Fig. 3 Cross section along the structures

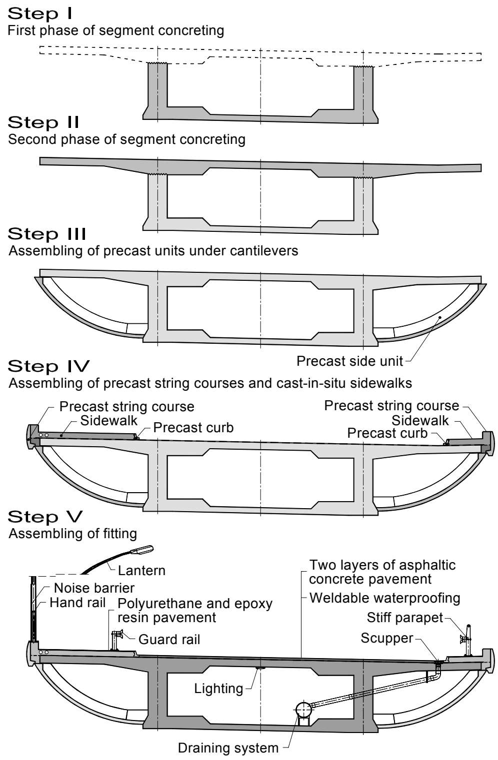

Fig. 4 Casting phases for a launched girder

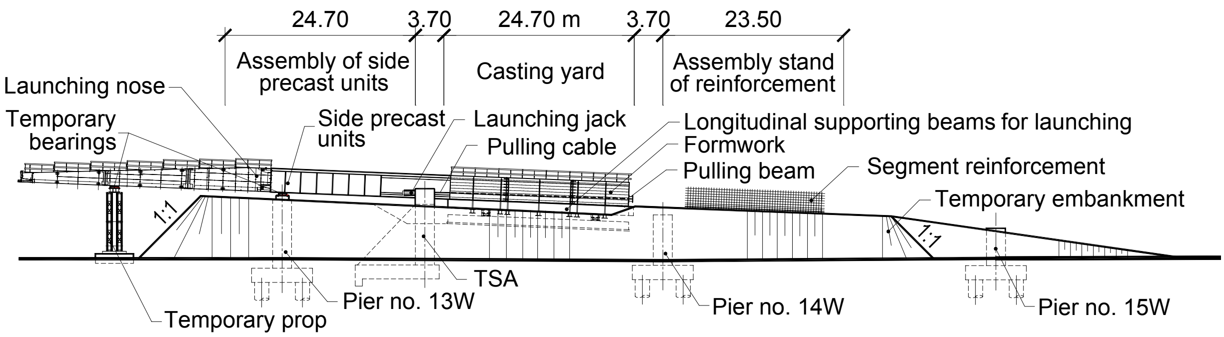

Fig. 5 Arrangement of fabrication yard

There are three zones in the fabrication yard (Fig 5):

- fabrication of reinforcement,
- casting of a segment in a form,
- assembly of precast elements.

The fabrication yard was equipped with the following facilities:

- steel formwork with some adjustment device,
- reinforced concrete longitudinal launching beams,
- TSA – temporary support, acting as a reaction element during launching,
- launching equipment: pulling beam, cables, jacks,
- breaking system to stop movement after each segment is launched.

The structure was launched with temporary supports and a 26.1 m launching nose. The longest span during launching was 33.5 m long (Fig. 6 and Fig. 7).
As the axis of the launching process is inclined uphill up to its middle point - crown, (the maximum slope to the yard is 4 %, average is 2 %), it was necessary to support the structure to avoid movement back to yard. A specific 'breaking' system was employed, with bolts inserted into holes in the rear of each segment.
At an advanced step of construction (17^{th} segment) the launching force reached about 7000 kN. The total mass at the launched part, at the last segment (no. 27), reached 12800 Mg.

Throughout the launching operations the following restrictions were observed:

- the axis of a launched part measured at its front and rear should not diverge from the theoretical position more than ± 3 mm,
- the deviation of the level of the last segment should not exceed ± 2 mm,
- the deviation of the level of any bearings should not exceed ± 6 mm.

The average time necessary to launch the length of one segment was 5 hours 30 minutes. The shortest time was 2 hours and 20 minutes.
After the completion of launched and cast in situ parts, all the superstructure was prestressed together. The rest of the operations were conventional.

Fig. 6 The site

Fig. 7 Launching

4. Aesthetics

The aesthetics of the newly-built viaduct was of great importance from the beginning of design, as well as during the competition. It should be emphasised that this structure is situated over the route linking the city with the airport. The shape of spans in cross-section is distinctive and the colours chosen are pastel. A lot of details are also individually designed. A final impression can be gained from Figure 8.

Fig. 8 A few views of the completed structure

5. Research

During the launching process various types of research were performed and a lot of experience was gained. Some examples of research performed by Wroclaw University of Technology are listed below:

- the temperature distribution inside the structural elements due to the hardening heat of young concrete [2];
- the temperature distribution in the superstructure due to solar radiation;
- the dimension errors in the concrete elements, random characteristics of the properties of materials and prestressing forces;
- the values of launching forces (See Fig. 9) [3].
- a load test on the completed structure – static and dynamic loads.

The aim of this research was to verify the design assumptions and to develop further research.
The values of the launching force measured during launching, as well as the friction coefficient are shown in Figure 9. The superstructure was moved on sliding saddles with Teflon pads. A substantial difference in the force between the beginning moment of each segment launching and its following phases was observed. The biggest force was observed when launching the 17th segment

i.e. when the crown of axis was reached. In the following launching operations (following segments), the force was not bigger, in spite of an increase in the total moved mass.

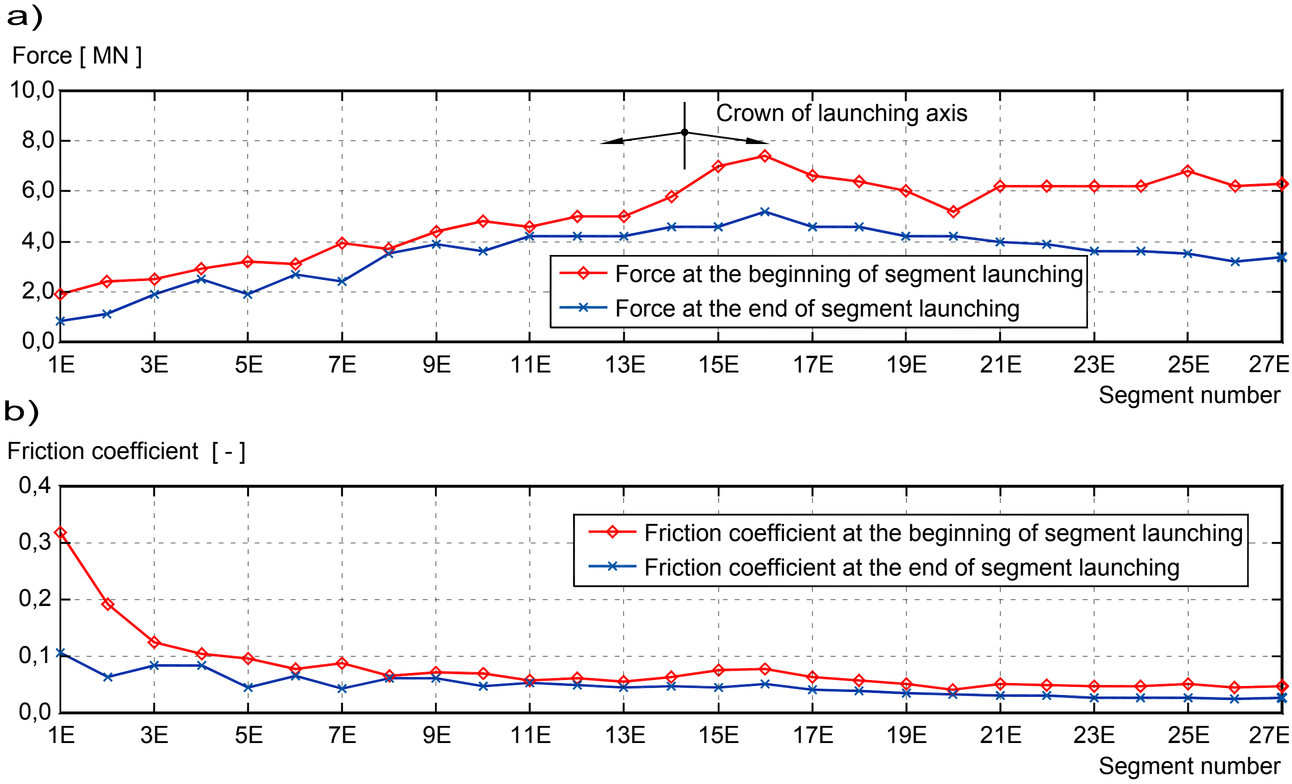

Fig. 9 a) Values of the launching forces, b) Values of the average friction coefficient – East deck

6. Conclusion

The method of longitudinal launching occurred effective in this specific circumstances, where a lot of transport facilities present a spread obstacle. Two segments per week were launched (from double yard) and total number of 54 segments were produced. No problems with the flow of car nor train traffic appeared throughout the entire construction period.

References

[1] Incremental launching as a solution in extreme situations. *Freyssinet Magazine*. No 216, January/April 2003, pp. 20 ÷ 21

[2] HELOWICZ A., Concrete hardening temperature distribution in the massive bridge elements. *Inzynieria i Budownictwo* no 3-4/2002, pp. 204 ÷ 207, (in Polish)

[3] BARCIK W., HILDEBRAND M., WOJCICKI M., Traction forces emerged when longitudinal launching method of bridge construction is applied. *Inzynieria i Budownictwo* no 10/2003, pp. 560 ÷ 563, (in Polish)