TWO NEW DAUGAVA CROSSINGS IN RIGA

Ainars Paeglitis, Ph.D., Director of Inzenierbuve Ltd

Summary

Three fixed bridges for road traffic and one Railway Bridge connect the West and East Bank of Daugava River the Riga City nowadays. The traffic flaw intensity is close to the maximum capacity of existing road bridges. Considering the prosperous economic growth of the city in general and the expected further development of the port in particular, the present river crossings will not be sufficient to meet the expected traffic growth. Therefore, the Riga City Council decided to build two new Daugava River crossings.

Several corridor alternatives have been developed for northern and southern location. Crucial for these alignments is the integration into the existing street network in the City of Riga.

The corridor should be classified as a highway corridor with limited access and a design speed of 70 km/h. All intersections should, where possible, be grade separated.

Both at the West- and East bank of the river some alternative alignments were considered. For the crossings have been considered alternative structure types: fixed and moveable bridges, immersed and bored tunnels. The paper discusses the results of preliminary designs for both crossings.

1. Introduction

Swedish King Karl XII erected the first bridge from fastened boats over the Daugava River in Riga in 1701. So begin the development of 300-year history of the bridge construction over Daugava River in Riga. The last - Cable-stay Bridge, in consecutive order the last, is in maintenance since 1981.

The number of cars has considerably increased in Riga city during the last 10 years and exceeds 260 cars per 1000 inhabitants. The existing traffic lines on bridges – 7 in each direction, would not cover the increased traffic flaw.

The development plan of Riga city for 1995 – 2005 provided construction of several new crossings over Daugava River. The general decision about the new Daugava crossing north side from the existing cable-stay bridge Riga City council takes in1998. The City council after long discussions and studying processes in 2001 decided that the new crossing (northern crossing) will be located in the Spilvas street – Bukultu street corridor (1.Fig.). The idea about the second Daugava crossing -

Southern from Salu Bridge was initiated after Council elections in 2001 and decision was taken in relatively short time without serious preliminary studying process (Fig.1.).

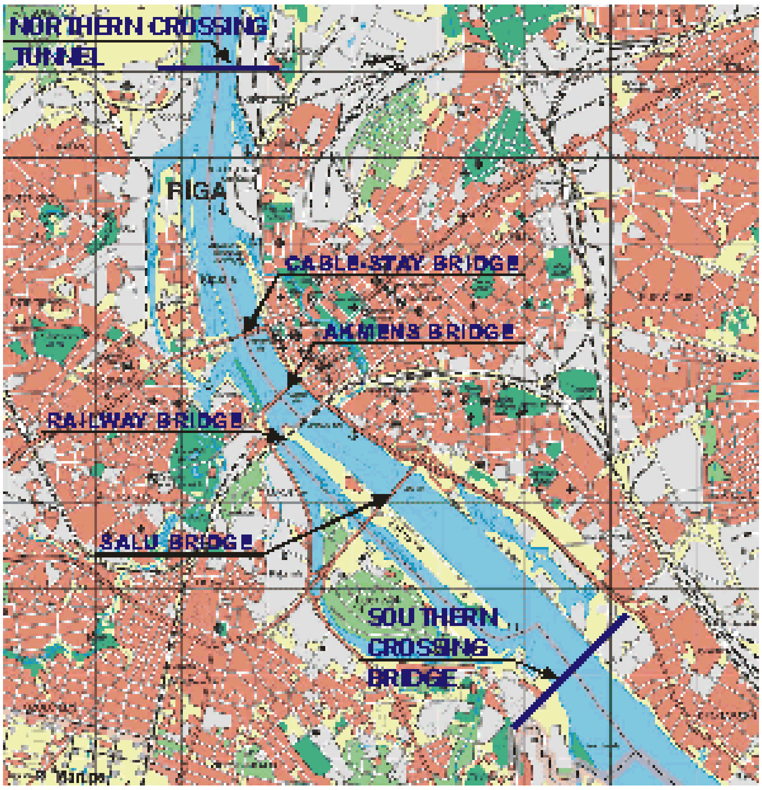

Fig.1. Principal crossings location scheme

Both proposed crossings would increase the number of traffic lines crossing Daugava river till 13 in both directions and considerably improve the traffic condition in Riga.

2. Structures of the northern crossing

The alignments for the Spilves – Bukultu corridor cross the Daugava River at its narrowest part, i.e. 400 m. During the evaluation of the preliminary feasibility studies prepared by consulting companies Tebodin/Wittewen+Boss, three types of crossings structures were evaluated:

- high bridge
- immersed tunnel
- bored tunnel.

2.1 Bridge

The preliminary studies considered several bridge options. The main span structure for crossing of the navigation part was assumed 460 m and the height above the navigation channel was assumed 50 m (Fig.2.) and the pylon height - 250 m. The width of the bridge deck (consisting of pre-stressed concrete box girder) was assumed 23.6 m, providing 6 traffic lines.

The length of approach structures depend of the vertical slops assumed 3%. The total project length will be evaluated with 3630 m.

2.2 Immersed tunnel

Preliminary studies considered tunnel elements with two box structure, with 30 m width and 8 m height, proposed for 6 traffic lines (Fig.3). The deepest point in the tunnel will be - 24.30 m. The length of immersed section is 400 m and the length of cut and cover section is 2 x 434 m. The total project length by taking into account the 4.5% ramp slopes will be assumed 1469 m.

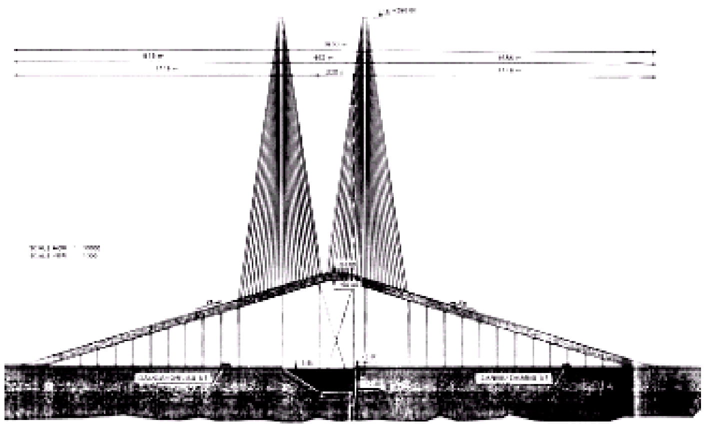

Fig.2. Principal scheme of the high bridge

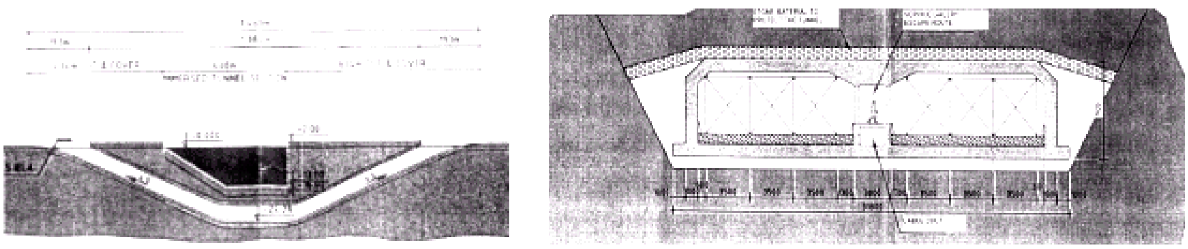

Fig.3. Principal scheme of immersed tunnel

2.3 Bored tunnel

Preliminary feasibility studies considered tunnel elements with two large diameter tubes (Fig.4), 15.4 m outer diameter (would be the largest in the world), proposed for 3 traffic lines. The deepest point in the tunnel will be – 36.70 m. The length of bored section will be assumed 860 m and the length of ramps 2 x 525 m. The total project length by taking into account the 4.5% ramp slopes will be assumed 1910 m.

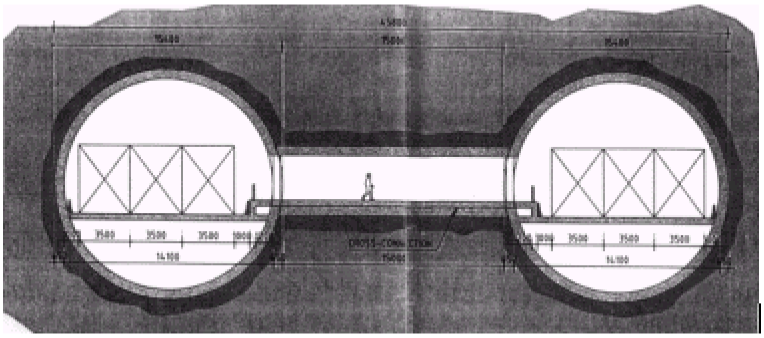

Fig.4. Principal scheme of the bored tunnel

Table.1. Summary of alignments for structural options

	Overall length (m)	Max. elevation difference (m)
Bridge	3630	+ 52.5
Immersed tunnel	1440	- 24.6
Bored tunnel	1940	- 37.7

2.4 Evaluation of alternatives

Based on preliminary feasibility studies is made the cost verification for proposed technical solutions. Input for the coast estimates are the unit costs as known by consulting companies Tebodin/Wittewen+Boss from recent comparable international projects (Table 2.).

Table.2. Summary of cost estimation

	Bridge (milo. EUR)	Immersed tunnel (milo. EUR)	Bored tunnel (milo. EUR)
Construction costs, main crossing	203.9	107.7	207.6
Construction costs, access roads	7.6	7.6	7.6
Contingencies and risks	25.4	17.3	32.3
Land costs	1.6	1.8	1.7
Compensation costs for port authorities	-	22	-
Subtotal	238.4	156.4	246.2
Engineering, desk studies and site investigations	10.6	5.8	10.8
Total costs	249.0	162.2	260.0

According to results of multi criteria analysis the immersed tunnel option was accepted for detailed design.

2.5 Preliminary design of accepted tunnel structures

The Riga City council awarded the consulting company TEC from the Netherlands for the preparation of the Basic Design for Public Discussion and the Employer's Requirements for a further tender on the design, build, finance, operate and transfer bases.

The main technical parameters of the tunnel, and ramps are presented in Fig.5 and Fig.6.

The cross-section of this tunnel consists of two boxes for a 2 x 3 traffic lanes and a central gallery. Each of the two road boxes is 13.2 m wide. The overall width of the tunnel is 31.4 m and height is 8.5 m. The central gallery between the two road boxes serves as emergency escape route and as cable and service duct.

The vertical traffic clearance should be at least 4.5 meters from the top of the road level. Above the traffic lines additional 0.4 meters is necessary for traffic signs, lightening and ventilations facilities.

The immersed section consists of 6 elements, each 129 m long. Each element consists of six 21.5 m long sections connected by expansion joint. The length of immersed part is 775 m and overall length of the tunnel is 1290 m.

The approach roads on the West bank have a length 4300 m and on the East bank of 2100 meters. This means that the total length on the northern crossing is 7690 m.

Time required to construct the immersed tunnel and its ramps would be about 3 years.

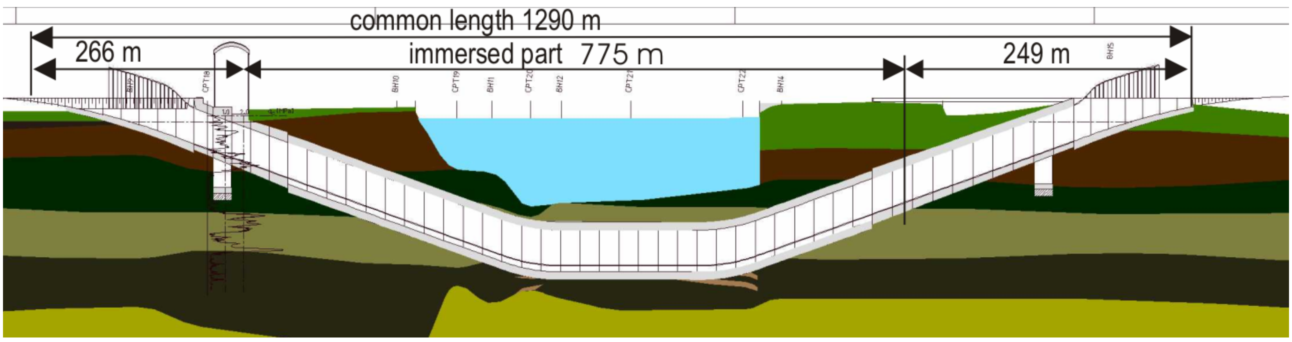

Fig.5. Scheme of immersed tunnel

The individual tunnel elements will be built in a separate location (the casting basin). The elements will be transported (floated) and immersed in a trench, which has been dredged in the riverbed and river banks (underwater slopes 1:6).

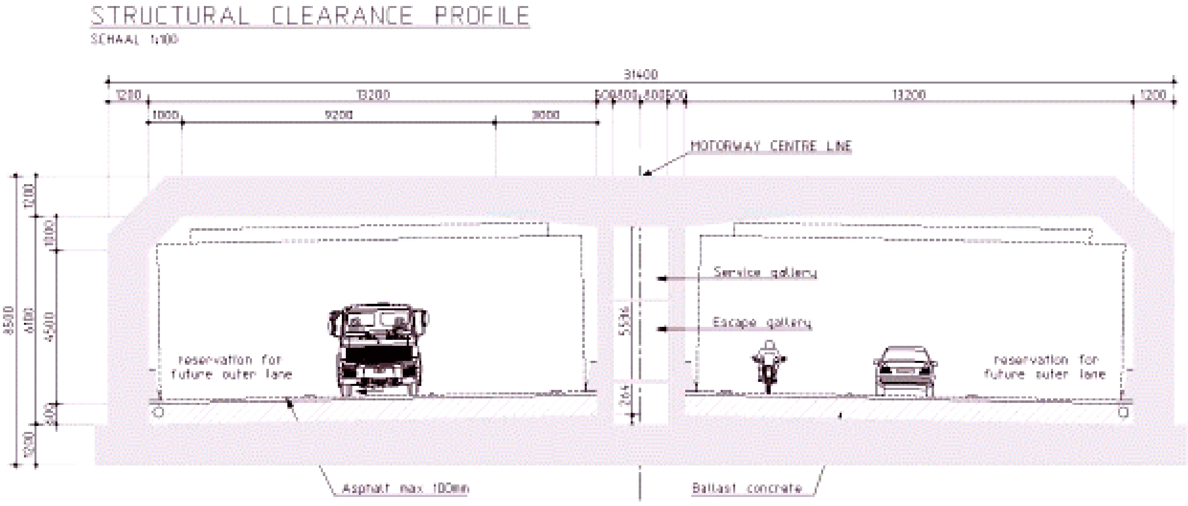

Fig. 6. Cross-section of immersed tunnel element

Based on the preliminary design is prepared the cost estimation (Table.3.). Cost estimation is based on unit cost from recent similar projects in the Netherlands. The calculations could not contain any reductions for Latvian conditions, because the main contractor for an immersed tunnel like this will be an international consortium. The costs did not include: taxes and compensation costs for disruption of Port activities.

Contractors costs (25%) include: construction management cost; general costs (overhead, office costs); profit and risk. Consultants and Clients costs (10%) include: project management; monitoring and supervision; permits; preparation of contract and tender documents; land acquisition etc.

Table.3. Final cost estimation for immersed tunnel

Section	Milo. EUR
Tunnel: Civil works	79.15
Tunnel: Casting basin	12.58
Tunnel: Mechanical and Electrical part	23.00
Approach roads and viaducts	17.40
Total:	132.13
Contractor's costs (25%)	33.03
Contractors design costs (5%)	8.26
Contingency (10%)	17.34
Land costs	2.0
Total construction:	190.76
Client and consultant's cost (10%)	19.08
Compensation cost	0
Total investment:	209.80

3. Structures of the southern crossing

The alignments for the Bauskas – Slavu streets corridor cross the Daugava River at 800 m wide place. The preliminary geotechnical assessment of riverbed shows a good soil conditions, dolomite were close to riverbed surface.

The Riga City Council tender commission during the tender in 2002, observed two principal proposals submitted by consulting companies "Tiltprojekts" and "Inzenierbuve", the choice was between concrete and steel structures.

3.1 Structures submitted by tenderers

"Tiltprojekts" presented two alternatives. The first one is composite steel-concrete continuous girder bridge with low pylons and stay cables (Fig.7.), similar to extradossed bridge, with span proportion: 49.5 + 77 + 5 x 110 + 77 + 49.5 m (Fig.8). The width of the bridge deck is assumed as 33 m, providing 6 traffic lines.

The height of composite pylons is 11.5 m; the pylons are fixed in girder structure. Each pylon has 9 stay cables on each side. Each cable consists from 36 tendons (d=15.2 mm). The average bridge concrete deck height is 250 mm.

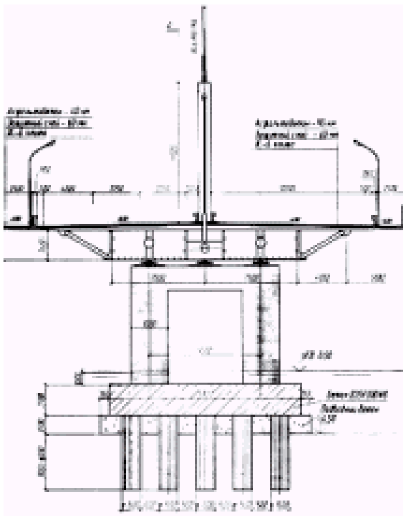

Fig.7. Cross-section of span structure

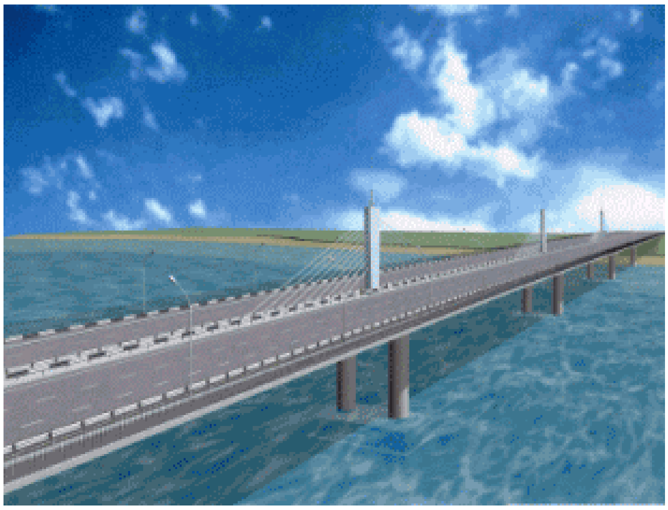

Fig.8. Visualization of proposed composite extradossed bridge

The span will be installed from the elements on one of the banks and then pushed into place. Each peer will be filled with the sliding saddles and guiding devices.

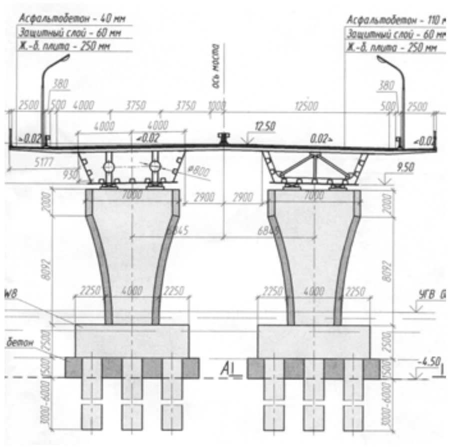

Fig.9. Cross-section of girder bridge

The second alternative is composite steel-concrete continuous girder bridge (Fig.9.), with span proportion: 42 + 63 + 7 x 84 + 63 + 42 m (Fig.10). The width of the bridge deck is assumed as 32 m, providing 6 traffic lines.

The average bridge deck height is 250 mm.

The construction method will be the same as described above.

"Inzenierbuve" proposed two twin bridge system types of pre-stressed concrete. The proposed bridge structures are projected from high performance concrete.

The first alternative is proposed as extradosed bridge, consisting of T-shape frames with pylons and cables for supporting span structure and middle girders between the ends of cantilevers. The span structure in frames is proposed from pre-stressed prefabricated segments but the middle part - from composite structure - spatial steel frame with concrete slab.

The span proportion is chosen as following: 130 + 3 x 195 + 130 m (Fig.10) with the total length of 845 m. Both, 11.5 m wide carriageways is proposed for 3 traffic lines and sidewalks for pedestrians and bikeway.

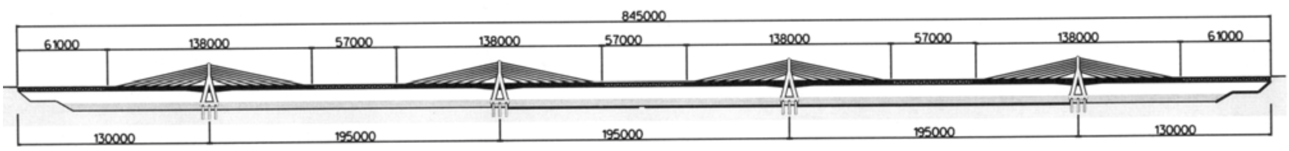

Fig.10. Elevation of proposed "extradosed" structure

Near the piers is proposed 4 m high segments, bet at the end of frames the height of segments is decreased till 2.5 m. The segment length is 2.5 m. Eight external tendons 27 strands 15.2 mm in diameter are proposed for placing inside the box girder.

The vertical stiffness of the span cantilevers ensured by stay-cables, supported on small pylons (Fig.11). Seven cables comprising each from 8 till 2 tendons of 27 strand 15.2 mm in diameter supported each cantilever. The stay cables of extradosed bridge are functionally comparable to external post-tensioning cables.

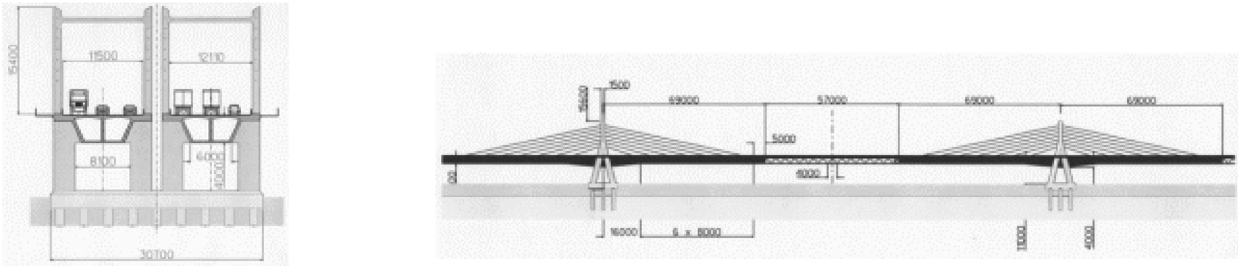

Fig.11. Cross-section and elevation of span structure

The girder located between the frame cantilevers has a fixed connection to the one of the cantilever ends, but the other end has bearing that allowed thermal displacements, but did not made hinge. Such structure will be considered as continuous in full span length.

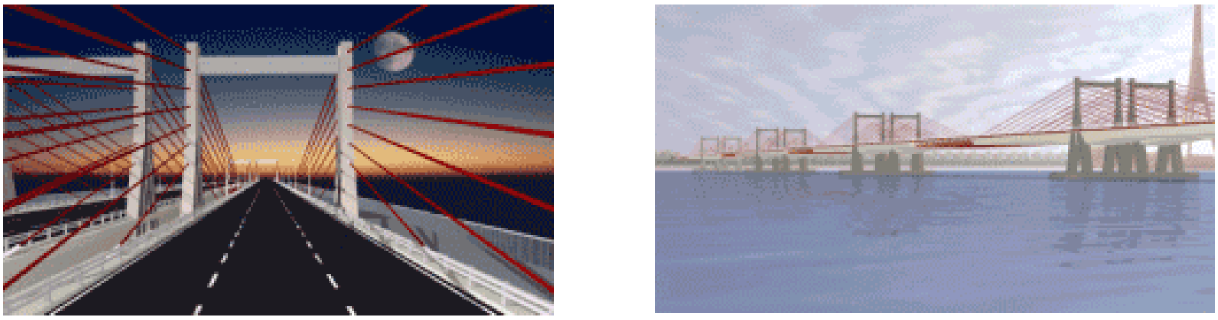

Fig.12. Visual impression of proposed “extradosed” bridge structure

The <u>second alternative</u> solution was proposed as the “classical” continuous box girder bridge from pre-stressed prefabricated segments (Fig.13.). The span proportion is chosen as follow: 60 + 9 x 80 + 60 m, with the total length of 840 m. Both, 11.5 m wide carriageways is proposed for 3 traffic lines and sidewalks for pedestrians and bikeway (Fig.14.).

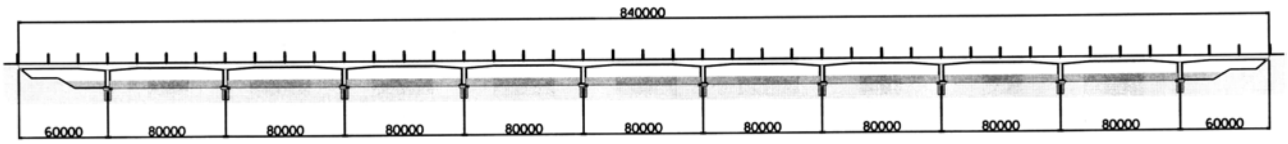

Fig.13. Elevation of continuous box girder bridge

The segments height varies from 4.0 m in sections on piers till 2.5 in the middle part of the span. The segment length is 2.5 m. Inside the box girders 16 external tendons with 27 strands 15.2 mm in diameter is placed.

The girders will be constructured by the free cantilevering method, using prefabricated segments.

Fig.14. Cross section and visual impression of continuous box girder bridge

Based on proposed alternatives is made the cost verification for proposed technical solutions. Input for the coast estimates are the unit costs from recent comparable projects (Table 4.).

Table. 4. Cost estimation of alternatives used by tenderers

Alternative	Cost, Milj. Ls.
Composite cable stay bridge	19.84
Composite girder bridge	17.03
Pre-stressed concrete extradosed bridge	29.87
Pre-stressed concrete box girder bridge	23.65

The Riga City council has selected the consulting company “Tiltprojekts” for the preparation of the Basic Design for Public Discussion and the Employer's Requirements for a further tender on the design and build bases.

3.2 Preliminary design of accepted bridge structure

After some discussions and architectural improvements was accepted composite cable-stay bridge with low pylons and span proportion: 49.5 + 77 + 5 x 110 + 77 + 49.5 m (Fig.15).

Fig.15. Elevation of composite cable-stay bridge with low pylons

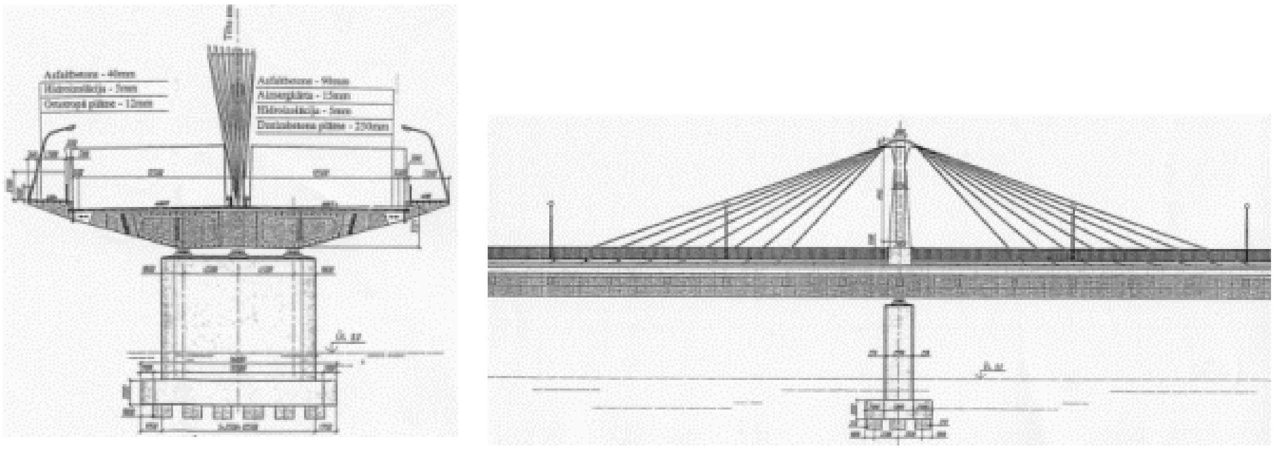

Fig.16. Cross section and elevation of accepted bridge structure

The pylon structure after architectural improvements have obtained curious view and could serve as bad example of cooperation between architects and bridge engineers.

The architectural impressions of proposed bridge structure are given in Fig.17.

Fig.17. The architectural impression of proposed bridge structure

Based on the preliminary design the bridge cost will be evaluated with 27 milj. Lats.