Engineering solutions for Golden Horn Bay Bridge with V-shaped pylons

Igor KOLJUSHEV
Managing Director
Institute Giprostroymost
Saint Petersburg, Russia
office@gpsm.ru

Igor Koljushev, born 1958, received his bridge engineering degree from the Petersburg State Transport University, Russia

Roman GUZEEV
Head of structural analysis department
Institute Giprostroymost
Saint Petersburg, Russia
roman.guzeev@gpsm.ru

Dr. Roman Guzeev, born 1976, received his Ph.D. degree from the Voronezh State University of Architecture and Civil Engineering, Russia

Dmitry MASLOV
Leading Structural Engineer
Institute Giprostroymost
Saint Petersburg, Russia
dims@gpsm.ru

Dmitry Maslov, born 1977, received his bridge engineering degree from the Petersburg State Transport University, Russia

Summary

The cable supported Golden Horn Bay Crossing in Vladivostok city has 737 m length main span. The bridge has two V-shaped pylons with only one truss composite cross beam. The bridge is exposed to severe environmental actions such as gust wind with high wind velocities and earthquake hazard. In order to ensure engineering solutions various experimental and analytical investigations were carried out. The bridge is equipped with shock-transmitter devices which allow to improve bridge performance under environmental actions.

Keywords: Cable-stayed bridge, shock-transmitter, wind tunnel, CFD analysis, earthquake, pylon

1. Introduction

The Golden Horn Bay Crossing is a very important project for the East Russia region. The Golden Horn Bay Crossing is a cable-stayed bridge in Vladivostok, Russia, which forms part of a new network of routes connecting the city airport and national highway M-60 Ussury with Russky Island. The bridge inauguration ceremony took place in August 2012.

The main challenges for the bridge design come from ship navigation requirement, urban conditions at the site and environmental conditions.

2. General design decisions

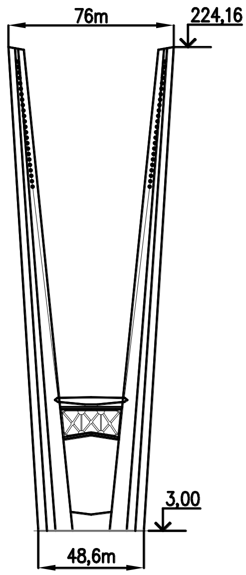

Fig. 1: The V-shaped pylon

The main difference from the typical cable stayed bridges is the 224 m height V-shaped pylons (Fig. 1). Each leg is balanced by self weight and eccentrically applied cable-stay forces. The optimal leg inclination was determined at the preliminary design stage. The V-shaped pylon considerably simplifies the deck anchorage joint and reduces its size as well The pylon leg bending moment at the level of the cross beam produced by the weight of the deck which is suspended on the stays is 600 MNm. But the combination of the pylon self weight and cable forces make up only 80 MNm.

The rest of the piers and the deck form a frame system. Both the abutment and the first pier have free bearings in longitudinal direction. The second pier has fixed pin bearings. The third long slender pier is rigidly connected to the deck.

The bridge deck has streamlined cross section. There are two service ways. The width of the deck allows to carry 6 traffic lanes (3 in either direction), according to the Russian traffic codes. The side span is a prestressed concrete deck while the central span is a steel box girder.

The bridge site is located in the region with very high wind velocities. According to meteorological data, the wind velocity with the return

https://doi.org/10.2749/222137813808626803

period of 100 years is 38,2 m/s at the level of 10m above the sea. On the other hand, the bridge site is exposed to the earthquake hazards, with design PGA of 0,18g.

Eight shock-transmission units were designed for the bridge – four for each tower – to transmit the longitudinal dynamic loads from the deck to the tower.

3. Experimental investigation

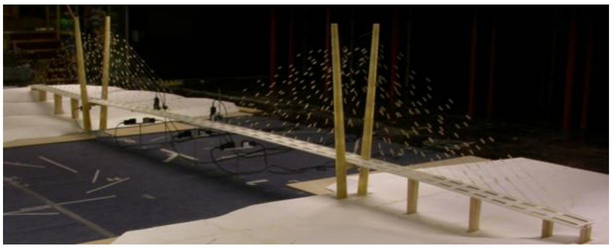

Fig. 2: The full bridge model

The shape of the bridge deck is designed as a monobox girder in order to reduce aeroelastic forces, provide aerodynamic stability and carry 6 lanes.

The Section model test was performed on the scale of 1:70. The vortex shedding vibrations almost vanished in atmospheric turbulence. Coupled flutter was found at the wind velocity of 144 m/s which is much higher than the In order to investigate the pylon and wind interaction, wind tunnel test was carried out for pylon construction phase on the scale of 1:175. The decision made was validated in the full-bridge model tests. Tests were performed for cantilever construction stage and bridge in-service on the scale of 1:175 (Fig. 2).

4. Structural analysis

The bridge buffeting response analysis was based on the random vibration theory in the frequency domain using modal superposition method. Bridge and structure interaction was modeled considering aerodynamic stiffness and damping [1]. The flutter derivatives were determined by numerical discrete vortex method and by section wind tunnel tests. The numerical results are in satisfactory agreement with the experimental data.

Table 1: Buffeting response for 0 deg wind angle incidence

	Deck			Pylon	
Response	Across bridge Dy,m	Vertical Dz,m	Torsional Rx, mrd	Across bridge Dy,m	Along bridge Dx,m
Mean	0,291	0,272	1,504	0,382	0,080
Peak	0,285	1,010	13,615	0,397	0,238
Max	0,576	1,282	15,119	0,779	0,318

The seismic analysis was performed as a response spectrum and time history analysis, and the response spectrum analysis was based on the response spectrum curve according to the project specification. On the other hand, the time history analysis was performed. Two different methods were used to determine the ground accelerogram; the first used seismological data, the second involved the development of an artificial accelerogram generation algorithm using special software. The seismic time-history analysis takes into account the time lag caused by seismic wave propagation.

The bridge design procedure also includes: optimization of the cable prestressing; creep and shrinkage analysis; construction sequence analyses; cable lose analysis; analysis support of the cable tensioning on the construction site.

5. Conclusion

Advanced construction technology, computer analysis capability and experimental study helped improve the engineering design of the bridge. Nowadays the project is implemented and construction is completed. The bridge in service improving city life and has become a remarkable architectural landmark.

6. References

- Strøman E., *Theory of Bridge Aerodynamic*, Springer, Berlin Heidelberg New York, 2006, p. 239.