Crocodiles Protection: Impact for Chambal River Bridge Design

Serge Montens
Head of bridge division
Systra
Paris, France
smontens@systra.com

Serge Montens, born 1956, received his engineering degree at the Ecole Spéciale des Travaux Publics in 1978 in Paris.

André De Goyon
Foundation chief engineer
Systra
Paris, France
adegoyon@systra.com

André De Goyon, born 1961, graduated at Polytech Lille, Geotechnical and Civil

Yves Gauthier
Consultant
Systra
Paris, France
ygauthier@systra.com

Yves Gauthier, born 1947, got his Bridge engineering degree at the Ecole Centrale of Lyon in 1970.

Summary

This bridge, the first axial suspension cable-stayed bridge in India, had to meet some challenging requirements for the protection of crocodiles in the Chambal river.

In order not disturbing the crocodiles, modern and specific techniques had to be used for the design. Bed rock profile and deposit thickness below water were mainly determined by using satellite imagery. Geophysics using a resistivity method was implemented in order to assess the weathered zones on a large scale. A 3D model of the cliff at pier P5 was elaborated.The design of the noise barriers shape required wind tunnel tests, in order to limit vortex-shedding vibrations.

Keywords: Cable-stayed bridge, geotechnical investigation, wind tunnel test.

1. Introduction

The Chambal River cable-stayed bridge is situated in India on the Kota city bypass (Rajasthan province), on the NH-76 road running east to west. It crosses the Chambal River, which is home to a nature reserve and crocodile sanctuary.

In order to protect these crocodiles, drastic constraints were imposed for the bridge project:

- impossibility to install any pier in the river,
- impossibility to go on the river or to put any equipment in the river, even for investigations,
- necessity to protect the crocodiles from the highway noise.

These had a great impact on the design and construction of the bridge.

The river width is about 300 m. Due to the impossibility to put any pier in the river, the main span has to be 350 m. A cable-stayed bridge seamed adapted to this span and to the site. The bridge deck being not too high above the ground, it was economical to build several side piers in the side cable-stayed spans.

2. Topographical, geological and geophysical investigations

Due to the different restrictions of access to Chambal river for environmental reason, it was impossible to determine the river profile through common survey methods.

Satellite imagery supported by geological maps was useful to confirm the geology of the area, and to estimate the river bed profile. This investigation has also confirmed that there was no cavity below water level, which could extend below the pylon P5 foundations.

At Shivpuri bank, there is a very stiff cliff (P5 side). The impossibility to drill any borehole in the river at the foot of this cliff was very annoying, because it raised questions about the nature of the rock, and the possibility of a large sliding. So, a geophysical investigation was performed.

https://doi.org/10.2749/222137809796078793
Distributed by structurae

Although this type of investigation is not very common for a bridge project, it is useful to estimate the distribution of weathered zones in the rock mass, and also the open joints filled with materials.

Geophysics survey included cross-hole tests at pylons location and surface survey using the electrical method.

Cross hole tests have allowed to measure the velocity into the rock along the bore length. The tests have confirmed the presence of weak rock at 13 m depth. On the remaining height, the values were consistent and no drastic variation was observed. This test has also confirmed the absence of cavities or channels.

Surface geophysics survey has allowed developing a complete 3D model of rock resistivity. The geophysical investigation has concluded that the discovered weak zone (with low resistivity), do not extend up to the edge of the cliff and consequently do not affect the stability of the cliff.

After analysis of fractures families at each bank, a slope stability calculation was conducted considering global block stability without cohesion on sliding surfaces.

3. Noise protection

Noise barriers had to be provided on the part of the bridge which is directly above the river, in order to protect the crocodiles from the highway noise.

It is not common to have noise barriers on long span cable-stayed bridges. On some of them there are some wind barriers. Wind barriers without porosity would create some turbulence on the roadway. This is why wind barriers have generally a porosity of about 50 % in order to be more efficient. This porosity leads to decrease drag factor compared to a full barrier.

But for an efficient noise barrier, the porosity must evidently be 0 %. This full barrier is not efficient aerodynamically for the bridge behaviour. It increases the drag coefficient, and it can create some vortex shedding in torsion. Wind tunnel tests were performed by the CSTB (Scientific and Technical Centre for Construction) in Nantes (France).

During the first test, performed with a vertical noise barrier, some vortex shedding of high amplitude in vertical bending appeared for a mean wind speed of 15 m/s.

According to the design criteria, vortex shedding vibration amplitudes had to be limited for mean wind speeds lower than 20 m/s.

So, it was necessary to modify the noise barrier shape in order to meet the criteria.

Various alternates were then tested: ventilation at the base of the barrier, wide lateral symmetrical triangular cornices, flaps of limited size that are put on the corners beneath the deck, and some combinations of them.

None of them satisfied the criteria for vortex-shedding.

A noise barrier with a non symmetrical angular shape was finally tested. The vortex shedding critical speed was then above the 20 m/s limit.

The aero-elastic stability (flutter) was checked up to a 50 m/s mean wind speed.

The aerodynamic coefficients were then measured under uniform wind and turbulent wind, in construction stage and service stage.