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Emergency Rehabilitation of the Zárate-Brazo Largo Bridges, Argentina

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Abstract

In November 1996 a cable ruptured on the Guazú Bridge across the Paraná River in Argentina, one of the two almost identical Zárate-Brazo Largo Bridges. COWI was immediately after retained as consultant by the bridge owner Direccíon Nacional de Vialidad in order to ensure and document the safety of the bridges and to investigate the causes of the cable failure.

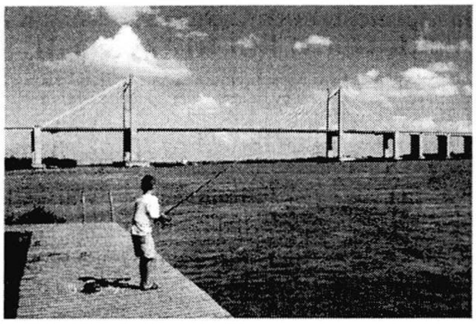

Fig. 1 Guazú Bridge across Paraná

The two cable stayed bridges are both 550 m long with a main span of 330 m. The bridges carry a 4 lane highway and a single railway track placed eccentrically. The bridges were opened to roadway traffic in 1977 and railway traffic in 1978. During the service life of the bridge there had been no prior indication of the critical situation of the cables.

The cables consist of non-galvanised high-strength parallel wires protected by cement grout and a PE-pipe. The cable anchorage's are of the HiAm type.

Possible causes for the cable rupture

The evaluations revealed that a combination of corrosion and fatigue damage caused the failure of one cable, see Fig. 2, and large damages to a number of other cables. The corrosion was due to insufficient performance of the corrosion protection of the original cables. The cement grout, which was supposed to be the main active corrosion protection, was insufficient in the anchorage zone due to the presence of a non-protecting epoxy tar.

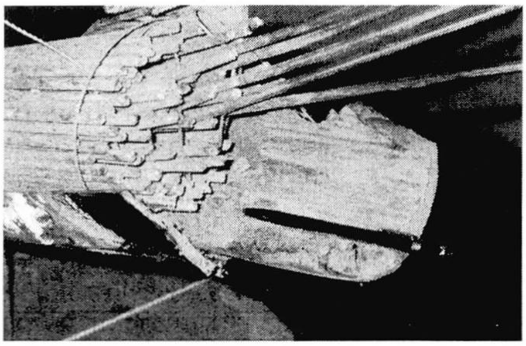

Fig. 2 Ruptured cable

The fatigue damage has been severe due to larger traffic loads than accounted for in the original design, but not least due to large amplitude cable vibrations. These amplitudes of the vibrations have been in the order of up to 1 m, which theoretically causes stress ranges well above the endurance limit of the wires. The corrosion has furthermore increased the fatigue stresses locally due to stress concentration.

Emergency Rehabilitation

The emergency rehabilitation of the bridges included:

- Evaluation of the present condition of the bridges through inspection, non-destructive and destructive testing
- Evaluation of the present load conditions by measuring the permanent cable forces by a vibration method and establish the characteristic traffic load (rail and road) on the basis of information on the present traffic
- Evaluation of partial safety factors by means of reliability based methods
- Evaluation of the required temporary strengthening and of the most urgently required cable replacements
- Evaluation of required traffic restrictions in order to ensure adequate safety at all times

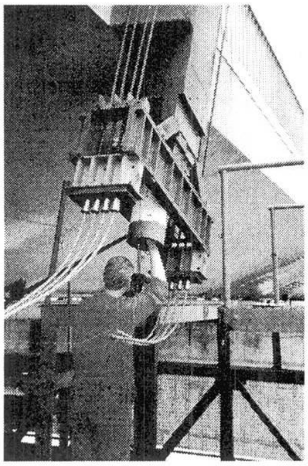

Fig. 3 Ultrasonic inspection of original cable. Temporary strengthening also shown.

A Rehabilitation Design Basis using reliability methods was established on the basis of the investigations carried out. This enabled a rational planning of the rehabilitation and a stringent evaluation of the allowable traffic on the bridges during the various phases of the emergency rehabilitation.

The present condition of the cables were investigated through ultrasonic inspection as shown in Fig. 3. The investigations revealed that a number of cables were deteriorated with up to 62% damage of the original cable cross section. The material properties of the wires were established from tensile and fatigue tests carried out on specimens from the cables replaced first. The tests revealed that the tensile strength of the tested wires were below the original design values and that severe fatigue damage had taken place. The wires did no longer have an endurance limit.

The establishment of characteristic traffic loads revealed that the actual traffic load on the bridges is much larger than the bridges originally were designed for.

A total of 13 cables were replaced during the emergency rehabilitation. The existing cables have been removed by cutting of the individual wires as seen in Fig. 4. It has been recommended to provide temporary wind ropes between the cables in order to limit the large amplitude cable vibrations. Furthermore, installation of guide deviators has been recommended in order to reduce the bending stresses in the anchorage zone.

A complete rehabilitation of the bridges is expected to be carried out during 1999/2000.

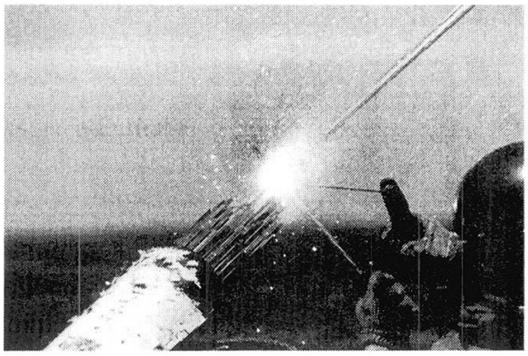

Fig. 4 Removal of existing cable by cutting of individual wires