Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 83 (1999)

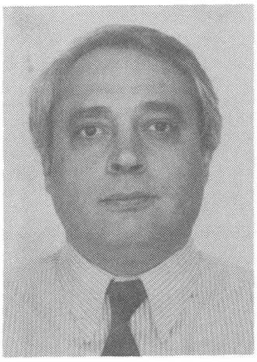
Artikel: Enhancing the fatigue life of Rio-Niterói Bridge's orthotropic steel deck

Autor: Battista, Ronaldo / Pfeil, Michèle

DOI: https://doi.org/10.5169/seals-62913

Enhancing the Fatigue Life of Rio-Niterói Bridge's Orthotropic Steel Deck

Ronaldo BATTISTA
Civil Eng., Professor
COPPE, Federal University
Rio de Janeiro, Brazil



Ronaldo Battista, born 1947, received his B.Eng. and M.Sc. from Federal University in Rio and his Ph.D. from University of London. He worked as a bridge designer and in 1980 joined COPPE Institute as a researcher and consulting engineer, becoming a professor in 1987.

Michèle PFEIL
Civil Eng., Adjoint Prof.
Federal University
Rio de Janeiro, Brazil

Michèle Pfeil, born in 1959, received her B.Eng. from the Catholic University in Rio and her M.Sc. and Ph.D. in structural engineering from COPPE Federal University. Her current field of research is aeroelastic problems in bridges.

Abstract

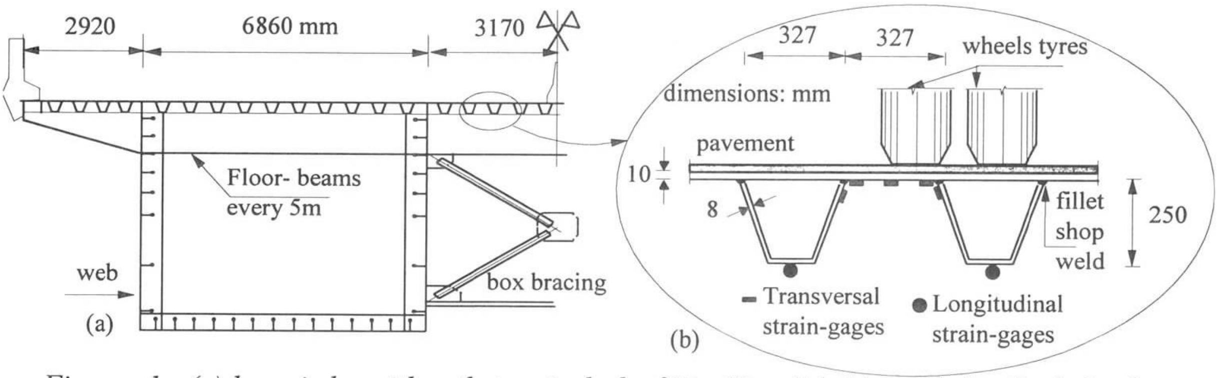
The thin-walled orthotropic deck of Rio-Niterói bridge, shown in Fig.1, has been under stochastic traffic loading frequently damaged by cracks in the fatigue-prone welded joints. Traffic on this bridge, brought into service in 1974, has raised to figures well beyond the initial estimates reaching now over one hundred thousand vehicles per day; almost 20% of these being heavy vehicles among which an increasing number of trucks with 3 and more axles.

To unveil the main causes of occurrence of observed cracks, it was carried out by a team of researchers and engineers with the COPPE's laboratory of structures a series experimental strain measurement campaigns: *in situ* as well as on a prototype scale model of the steel deck [1,2], i.e. a model in 1:1 geometric scale factor, shown in Photo 1. Refined numerical results from parametric studies, obtained with experimentally calibrated finite element models, were then used to better understanding the static and dynamic behaviours and sensitivity of this structure under heavy vehicle loading.

One important advantage of this slender structure is its low weight combined with great longitudinal bending stiffness. On the other hand, low transversal stiffness (see Fig.2) also brings higher sensitivity of local stresses to a series of relevant random and interdependent factors which appear in both static and dynamic problems of contact pressures resulting from the interaction between the vehicles' pneumatic tyres, the flexible asphaltic pavement and the slender steel orthotropic deck. Random stresses variations are then sensitive to all these concurrent factors and may cause precocious fatigue cracks in welded details, due to a complex and evolutive cycle of causes and effects. An attenuating effect is brought in by comparisons between today's and past measurements taken around 20 years ago which show that traffic loading is less adverse today than it was in the past, as far as localized stresses ranges and consequent fatigue life are concerned. First reported cracks occurred for a service time interval which could be closely predicted by taking the stresses histograms from past measurements and applying the Miner-Palgren rule and appropriate S-N curves for calculating cumulative damage.

With a better insight into the focused problems new solutions could be envisaged to attenuate the degree of sensitivity to so many random factors as well as to enhance the ulterior fatigue life of the slender steel deck and the service life of the pavement. From the obtained results it becomes clear that the very slender orthotropic steel deck lacks transversal bending stiffness and proper damping in all multiple and clustered frequencies vibration modes that leads to precocious fatigue of welded joints and of the adhesive layer of the asphaltic pavement on the steel deck.

A rational solution which fulfills lacking properties has been found by transforming the deck into a sandwich structure composed by a RC slab on top of a layer of visco-elastic material adhered to the steel plate. The performance of this composite structure, in which the RC slab may become itself the proper pavement was assessed with experimental tests performed on the prototype scale model. Redistribution of stresses resulting from the composite stiffness properties led to a substantial reduction of values in both longitudinal and transverse bending stresses. Visco-damping properties of the sandwich structure, with modal damping factors ranging from 3% to 7%, resulted similar to that displayed by the steel structure with a flexible asphaltic pavement having weight and thickness equivalent to the RC slab.



Figures 1 - (a) box girder with orthotropic deck of Rio-Niterói bridge. (b) detail of slenders trapezoidal ribs and deck plate, also showing typical instrumentation with strain-gages.

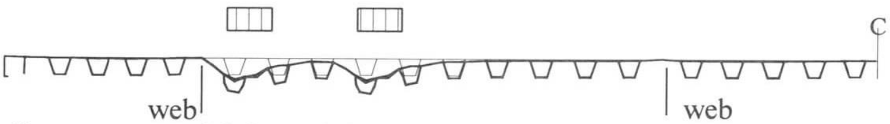


Figure 2 - Cross section of deformed deck under wheels loading (3D FEM model).

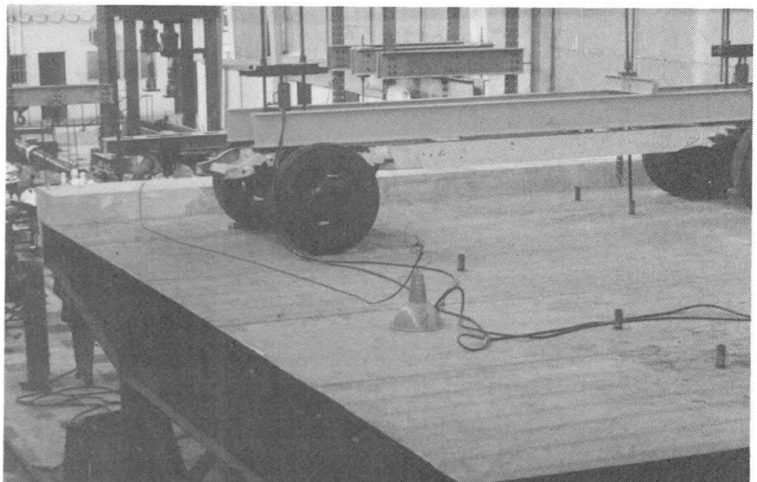


Photo 1 – View of the prototype scale model of the deck at COPPE's Laboratory of Strucutures.

References

1. Battista, R.C. et al., *Global analysis of the structural behaviour of the central spans of Rio-Niteroi bridge* (in portuguese), Ponte SA Contract report, 5 vols., COPPETEC ET-150747, Rio de Janeiro, RJ, 1997.
2. Battista, R.C. et al., *Experimental tests on a prototype scale model of the slender steel orthotropic deck of Rio-Niteroi bridge* (in portuguese), Ponte SA Contract report, COPPETEC ET-150771, Rio de Janeiro, RJ, 1998.