Towards a simplified model for considering the second order effects on slender concrete piers of bridges

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Summary

The concrete slender piers of tall bridges were often calculated using a model that did not usually take into account the contribution of the deck to reduce the movement and the rotation of the top of the pier.The paper presents the results of a lot of 2^{nd} order calculations made on some different bridges. Mechanical and geometrical non linearities were considered for calculating the buckling of slender piers and the distribution of the effects of the loads of the deck on each pier. The goal of the investigation, that is presented ion this paper, was to define a “simplified model” of the slender pier that takes into account the connection of the deck to the pier when calculating the buckling of the pier as a single element, fixed at the bottom.

Keywords: *Slender pier, buckling, concrete pier, second order, push over,*

1. Abstract

When designing bridges of spans longer than 50-60 m, it is usual to get piers that are more than 40 m tall and sometimes they get 90-10 m high. These piers are usually made of reinforced concrete; often, the cross section is a hollow section, being the thickness of the walls 30-40 cm. Consequently, the resulting slenderness of the piers are λ=60-90 (being $\lambda = L_k/i$), and so, the piers are “slender piers”, where second order effects must be considered.

Traditionally, these piers have been calculated using some assumptions that, sometimes, were not very reliable:

- The piers were supposed to be fixed at the bottom and free at the top, supposing the deck does not collaborate to prevent the top of the pier to move or to rotate.
- The calculations of the effects of the loads of the deck on each pier (vertical axial forces, bending moments and shear forces) were calculated using a first order analysis.
- The distribution of the forces from the deck to the substructure (abutments and piers) was made with no consideration of the loss of stiffness of the piers due to the cracking of the concrete.
- The instability of each pier was calculated using a “single pier model” but considering the mechanical non linearity of the concrete.

Now, in the 21^{st} century, calculation of structures involves a extensive usage of computers and so, it is possible to use a complete model of the structure for dimensioning the substructure. The author has prepared a 3D parametric model for calculating some different bridges. The model takes into account all the possible non linearities to be considered on the calculation: non linearity of the concrete and of the reinfoircing steel, cracking and tension stiffening of the concrete, imperfections and geometrical non linearities ...

The results of the different calculations were analysed trying in order to produce a “simplified model” that takes into account the connection of the deck to the pier when calculating the buckling of the pier as a single element, fixed at the bottom.