Pertaining Master's dissertation TVBK-5251
Division of Structural Engineering, Lund University of Technology
Pontus Christensson

# Analysis of Jointless Bridges due to Horizontal Actions and Soil-Structure Interaction

**The interaction between a bridge and the surrounding soil is a complex phenomenon where the boundary between soil and bridge may be modelled as spring supports. As a step to investigate the theory, two jointless bridges loaded by horizontal forces are studied. The surface between soil and structure is modelled as springs, and the results from the model is used to investigate if the spring boundary can be used to save both material and costs.**

Expansion joints, for example placed at the two ends of a bridge, allow the bridge to move horizontally for instance due to temperature movements or braking form vehicles. Bridges constructed without the use of expansion joints or bearings are called jointless bridges. Jointess bridges are mostly used in Sweden, Finland, England, the United States of America and Canada, but with slightly different appearances. One of the advantages of using a jointless bridge is the reduction of maintenance and life cycle costs, but the disadvantage is the fact that the jointless construction can give rise to difficult load situations. A structural element in focus in this type of bridge is the backwall (*sv. ändskärm*). The backwall is the wall between the soil and the bridge superstructure, figure 1.

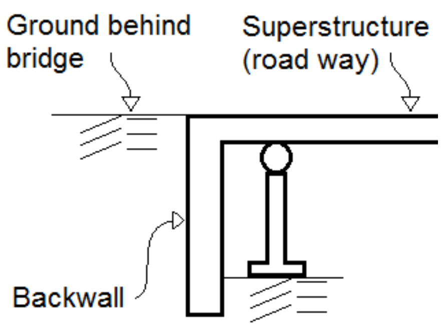


*Figure 1. An example of the composition of a bridge abutment including a backwall*

The theory is that use of a boundary condition as a spring bed will reduce the section forces, which in turn will reduce the amount of reinforcement. Reducing the reinforcement will allow to use less concrete. One of the biggest problems though, is the fact that the boundary conditions concerning the soil stiffness are very complex and hard to find. One way to verify the model is to perform measurements of actual structures, and update the computer model to behave like the measured data. Two types of jointless bridges, one with the backwall integrated with a pile foundation and one with the backwall separated with an intermediate column, is evaluated.

The method of work goes through calculations of the loads, restricted by the demands of the Swedish road administration, then setting up a three dimensional finite element model which is compared to the results from the measurement data. From the calculations it stands clear that the modelled stiffness becomes much larger than the measured. This is probably due to errors either in the model assumptions or the measurement data. The soil stiffness due to the braking force is much larger than the stiffness due to the temperature movement. This is because the braking load is a fast load, giving an impulse to the backfill soil. The impulse will only generate a small displacement. On the contrary, the temperature expansion is a slow and locked deformation, generating larger displacements and hence lower value of the stiffness. The soil cannot withstand the movement.

The springs between the backwall and the soil are capable of withstanding the loads with smaller magnitude, providing a so called spring support. For the much larger temperature movement however, the distribution of bending moment behaves more like a cantilevering beam. The difference in load cases is depicted in figure 2.

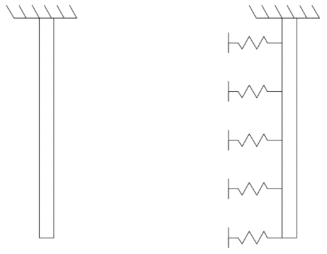


*Figure 2. (a) a cantilevering beam and (b) a cantilevering beam supported by an infinite number of springs.*

The variance in behaviour affects the distribution of bending moment, and reduces it in the top of the backwall for the loads with smaller magnitude. The difference in displacement between the two bridge types is most prominent at the bottom of the backwall, where the displacement of the fully integrated bridge is lower due to the effect of the pile. The results though are not fully comparable due to the deviation of the soil stiffness, but can give a hint that the use of spring support between soil and structure can be utilised to reduce structural dimensions.

## Conclusions

- The derivation of the soil stiffness due to the measurement data did not provide satisfactory results to prove that a method of finding the real response of the soil structure interaction is either possible or not
- The results point in a direction such as that the method could be made to work very efficiently with design of backwalls
- One explanation of the bad results can be for example bad simplifications or bad measurement data
- More measurements are needed to be able to provide satisfactory results, and capture the real behaviour of the bridge due to horizontal loading

*Pontus Christensson*