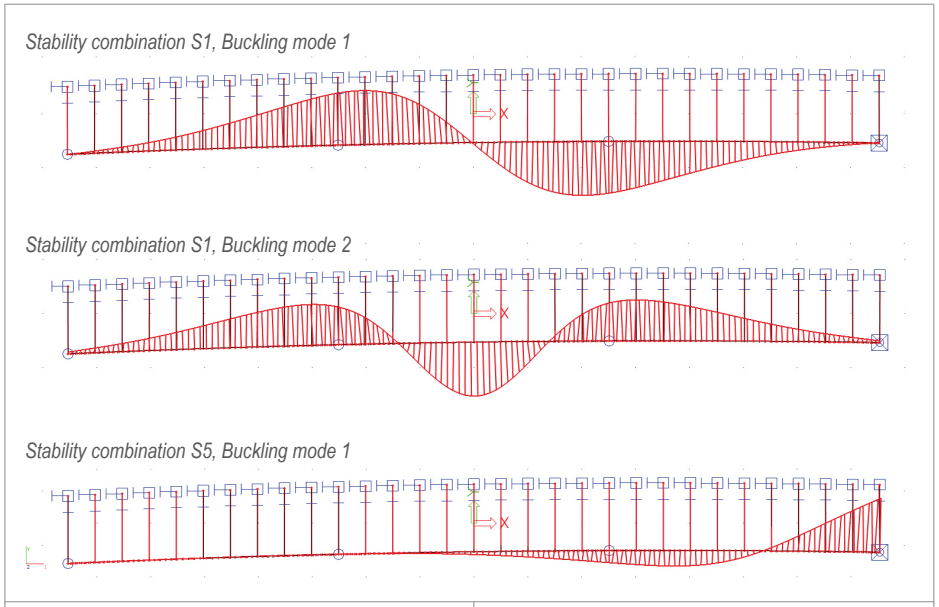
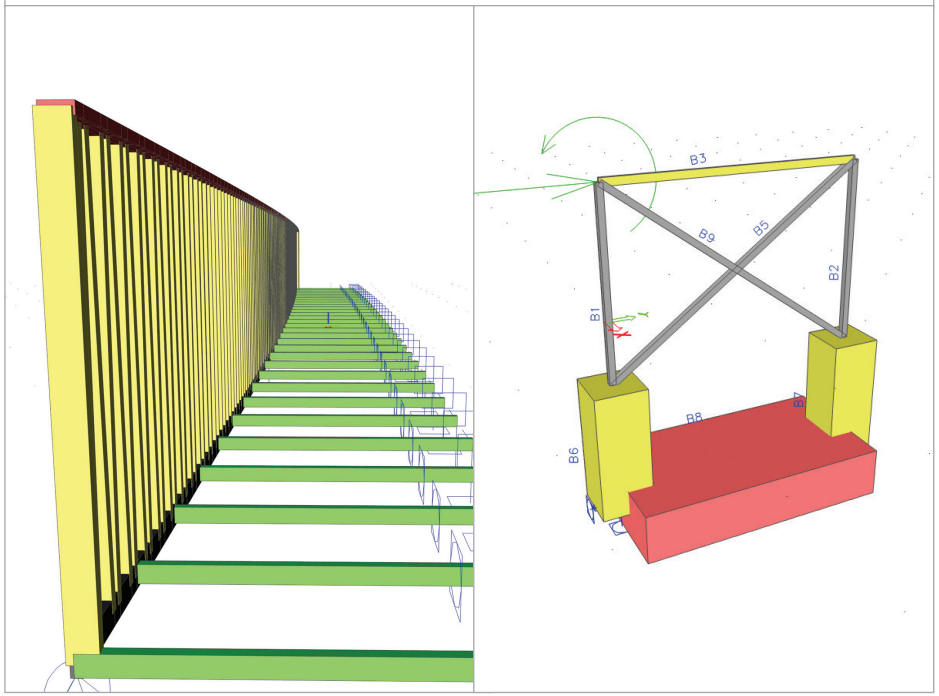
Footbridges of the “Smedenpoort” - Brugge, Belgium





Software: Scia Engineer

Programme
Architectural project and stability study.

Context
The Smedenpoort (“The Gateway of the Blacksmiths”), one of the four remaining heritage-listed gateways of the City of Bruges, and built in the 13th century, became a bottleneck. The gateway was too narrow to allow for a fluid traffic of cars, pedestrians and cyclists. The City of Bruges decided, under the supervision of the Commission for Monuments and Landscapes, to add new footbridges on both sides of the existing heritage monument.

Project description
The two footbridges have a width of 2.5 m. The overall lengths are 62.6 m for the southern footbridge and 57.2 m for the northern footbridge, with the radius being 253.5 m. Except for the position of the abutments and bracings, the two bridges are identical. The effective spans are reduced to 5 m between each supporting column, which corresponds with the spans of the existing bridge across the fortification canal.

The new footbridges had to respect the strong historic presence of the surroundings. The path has been conceived as an element that embraces the existing bridge and gateway, offering respect to the old monument.

The structure is constructed with weathering steel and the walking surface is made of prefabricated concrete tiles. The use of steel bars instead of hollow sections and the used details refer to handcraft.
The structural elements have a reduced dimension due to the large number of supports and the structural use of the railing. This results in a filigree structural design, with the railing a mix of a Warren truss and a Vierendeel truss. The pattern of the vertical bars of the railing is developed according to the internal forces in the truss, optimising the material use. The horizontal stiffness is provided by the bridge deck forming an arched lattice, with the concrete tile work as compression struts.

Structural analysis
For the bridge calculation, the choice was to split the three-dimensional structure into two-dimensional pieces, on the one hand to simplify the modelling, and on the other hand to maximise the direct insight into the results. This split was made possible by the structural concept and the connection between the different elements.

A first model consisted of three spans of the structural railing. In addition to this, models were made for an individual column, the abutments with bracings, the cross-beam and the concrete tile. To enable the checking for instability of the structural railing, the first 2D-model was extended to 3D with half of the crossbeams and other supporting conditions applied. Finally, another 2D-model to check the horizontal stability of the bridge deck structure was made with the bridge deck consisting of cross-beams and concrete tiles.

Modelling with different small calculation models allows for a good insight but requires a good exchange of reaction forces and supporting conditions. The ‘Productivity toolbox’ functionality proved to be very useful for this project. Calculation results (such as internal forces) for the different models were exported in numerical values, so that they could be combined to make a global envelope or imported afterwards as loads in the other models. ‘General Cross Section’ was used to model the steel handle with the reservation for the integrated Led-line.

Due to the slenderness of the whole structure, the railing had to be checked for buckling and the bridge deck (an arch in the horizontal plan) for pedestrian-induced vibrations. Therefore, the stability was analysed with the ‘Stability analysis’ functionality. A modal analysis was carried out using the ‘Dynamics’ functionality. A good estimation of the supporting stiffnesses was essential.

Ney & Partners

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Ney & Partners is a structural engineering consultancy, established in Brussels. Since its creation in 1997, the office has worked with a pro-active view on the art of engineering through the integration of the different civil works disciplines.

This integration and optimisation of structural elements aims to overcome the classic hierarchic assembly of constructive solutions. Innovative bridges, roof structures and works of art developed by our office most clearly express this vision.

The construction project quality lies in the synthesis of specific design constraints. The structural aspect is of primary importance to this synthesis. From the very beginning of the design process, Ney & Partners conducts constant research for advanced engineering integration. In doing so, our position as an engineering consultancy goes beyond the standardised dimensioning of predefined technical solutions. Ney & Partners currently employs more than 45 civil engineers, architects and draughtsmen.

Project information

Owner	City of Bruges
Architect	Ney & Partners
General Contractor	Depret nv
Engineering Office	Ney & Partners
Location	Brugge, Belgium
Construction Period	06/2011 to 07/2012

Short description | **Footbridges of the "Smedenpoort"**

With total lengths of 62.5 m and 57.2 m, respectively, the footbridges at the Smedenpoort in Bruges provide a safe passage for pedestrians embracing the listed gateway. Weathering steel is used for the main structure; concrete tiles form a bridge deck that is 2 m wide. To minimise the dimensions of the structural elements and maximise the transparency of the structure, the railing and bridge deck become structural and the spans are reduced. The position and dimension of the railing bars is determined by a pattern. Each 5 m section of the bridge is supported by a small column. The footbridges embrace the gateway with their curved trajectory and, at night, with light-emitting diodes integrated into the handrail of the outer railing.