Steel Arches

Out-of-plane stability

RESEARCH SCHOOL
INTEGRAL DESIGN OF STRUCTURES

Speerpunt BOUW


Gateshead Millenium bridge, Newcastle UK, Cocks, Carmichael, Whitford


York Millenium bridge, York UK Wilkinson Eyre Architects

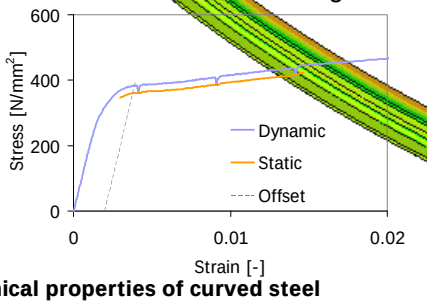

Campo Volatin, Bilbao, Spain, Santiago Calatrava

Subject

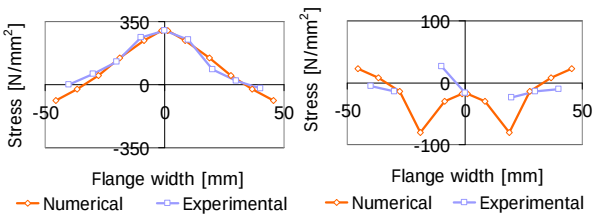
Arches are structures which are curved in elevation and carry their main loads by means of compression and bending. Their application is in bridges and large span roofs of buildings.

Goal

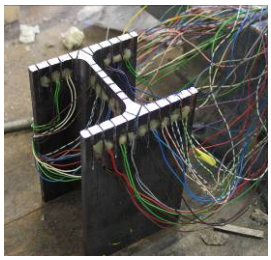
The objective of the research is to gain new knowledge on the out-of-plane behavior of freestanding steel arches and to derive design rules on the basis of this knowledge.



Mechanical properties of curved steel



Residual stress measurements of curved steel



Cold bent specimen HE 100A (left) and residual stress measurements (right)

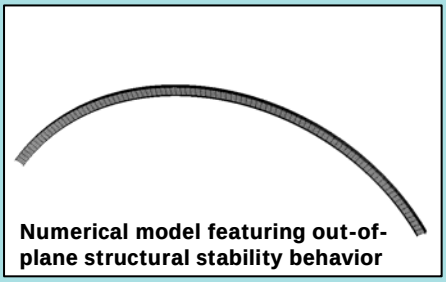
Apart from the initial crookedness and twist, the bending process in terms of residual stress, hardening and cross-sectional imperfections has an effect on the arch behavior which has to be quantified to determine the degree to which these aspects need to be taken into account.
By means of a numerical and experimental approach it is aimed to gain insight in the influence of the bending process.

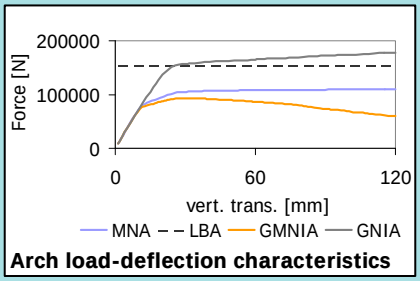
(Expected) Results

Thus far the following results have been achieved:

- Analytical expression of the in-plane plastic capacity of steel arches.
- Numerical model composed of solid elements simulating the roller bending process to a certain extent.
- Residual stress measurements on steel sections.


Tensile test
250 kN Schenck testing machine


Numerical model featuring out-of-plane structural stability behavior



Arch load-deflection characteristics

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3TU.

TU/e Technische Universiteit Eindhoven University of Technology

M2i Materials innovation institute

bouwen met staal

Steel Arches
Out-of-plane stability

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Subject

The main application for arches is in bridges and large span roofs of buildings. Bridges and buildings may be built with single freestanding arch-ribs for which out-of-plane stability is the dominant design criterion. For these structures, the behavior is not fully understood and design rules against inelastic lateral buckling are not available.

Goals

It is the objective of this research to gain insight into the out-of-plane stability behavior of freestanding arches and to develop design rules for these structures.

Research Question

How can the structural stability behavior of steel arches and its influencing factors be quantified and translated into design rules?

Strategy

The effect of the roller bending process (altered mechanical properties, residual stresses and cross-sectional properties) and initial crookedness and twist on the structural behavior of steel arches needs to be studied to determine the degree to which these issues need to be taken into account. Subsequently a parameter study is executed to study the out-of-plane stability behavior of arches and to derive a design rule.

Expected Results

New design rules for the out-of-plane stability of hot-rolled wide flange steel arches which reflect the structural behavior and take into account the effect of the roller bending process.

Preferred Partners Applications / Sponsors

The research is funded by the Materials Innovation Institute (M2i) and Bouwen met Staal.

Prime Publication (selection)

Spoorenberg, R.C., Snijder, H.H., Hoenderkamp J.C.D. & Bakker, M.C.M. (2009)
Residual stresses in cold bent HE 100A steel arches. Nordic *Steel Construction Conference (pp. 414-422)*. Stockholm: SBI Swedish Institute of Steel Construction.

Spoorenberg R.C., Snijder, H.H., Hoenderkamp J.C.D. and Bakker, M.C.M. (2008)
Cold forming hot-rolled wide flange beams into arches. Preliminary finite element simulations. In R. Ofner, D. Beg, J. Fink, R. Greiner, H. Unterweger (Eds.), *5th European Conference on Steel and Composite* Structures*. Volume B. (pp. 1837-1842).* Brussels: ECCS European Convention for Constructional Steelwork.

Research Period

May 2007 – May 2011