

## Quantifying Wire Stresses in Main Cables Using Neutron Diffraction

### Adrian BRÜGGER

Associate Research Scientist  
Adjunct Assistant Professor

Columbia University

New York, USA

[brugger@civil.columbia.edu](mailto:brugger@civil.columbia.edu)

Director of the Carleton Laboratory;  
research interests in suspension bridge  
cable mechanics and friction using non-  
contact neutron diffraction methods

### Bjørn CLAUSEN

Instrument Scientist

Los Alamos National Laboratory

Los Alamos, USA

[clausen@lanl.gov](mailto:clausen@lanl.gov)

Research interests in determining  
structure-property relationship of  
materials and composites via  
constitutive modelling and experimental  
validation using neutrons and x-rays

### Raimondo BETTI

Professor

Columbia University

New York, USA

[beti@civil.columbia.edu](mailto:beti@civil.columbia.edu)

Research interests in structural health  
monitoring, system identification,  
damage detection, and corrosion of  
structures

### İsmail Cevdet NOYAN

Professor

Columbia University

New York, USA

[icn2@columbia.edu](mailto:icn2@columbia.edu)

Research interests in characterization  
and modelling of mechanical and  
micromechanical deformation; residual  
stress analysis; x-ray and neutron  
diffraction, microdiffraction analysis

**Contact:** [brugger@civil.columbia.edu](mailto:brugger@civil.columbia.edu)

## 1 Abstract

Effective maintenance strategies for suspension bridges rely on a fundamental understanding of the internal mechanics of its failure-critical members, most importantly the main cables. While experimentally quantifying the development length – the distance over which a broken wire in a cable regains service stress through load transfer from surrounding wires – we found that this quantity depends heavily on the amount of local confinement force (e.g. clamping and compaction) acting on said wire. Both academics and engineering practitioners commonly use prescribed mean-field stress distributions to estimate internal cable stresses, assuming an equivalence of this discrete multi-body system to a homogeneous steel monolith. Using the SMARTS beamline at Los Alamos National Laboratory, we test this assumption by reporting direct measurements of axial stresses within each individual wire of parallel wire strands. The strands are constrained by a clamp modeled after a cable band and measurements are made around a clamp for various clamping loads while the strand is under tension. The results reveal that effective confinement of a cable section is one of the most critical variables driving the safety factor of a bridge cable.

**Keywords:** suspension bridge, main cable, fracture, friction, neutron diffraction, development length