# 5 Pull-Out Tests for Cable Bolt

## 5.1 Problem Description

This problem concerns the cable pull tests under constant radial stiffness. The results of field tests were performed in limestone. The pull-out strength of a bolt is function both of the frictional resistance by expansion of the bolt and the mechanical interlock between the bolt and asperities (extrusions) in the borehole. The pull-out force required can thus be expressed as:

$$F_{pull} = \min(R_f, S)$$

where $R_f$ is the total frictional resistance and $S$ is the shear strength of all asperities in direct contact with the bolt. ***RS3*** does not make this distinction; the bolt-rock interface is assumed to have a single stiffness and pull-out strength. Refer to Hyett et al and Moosavi 1996 on bond strength of cable bolts for more details on experimental data and numerical results for this study.

Figure 5-1 shows a rock mass with embedment length of cable 250 mm as modeled in ***RS3***. The bolt and rock properties are summarized in Table 5-1. The bolt is defined with joint shear under bolt model setting.

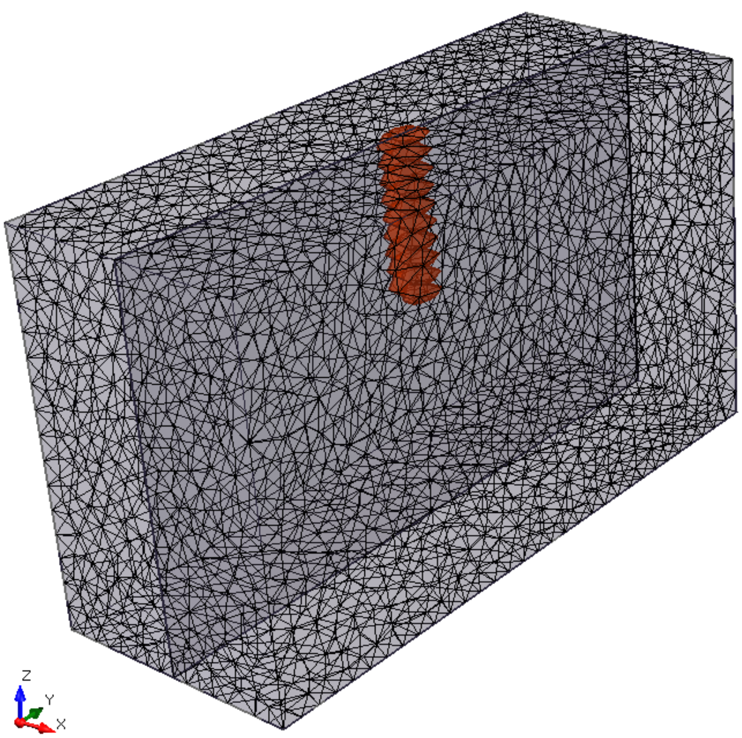


**Figure 5-1: Plain strand cable rock bolt as modeled in *RS3***

**Table 5-1 Limestone properties**

| Parameter | Value |
|---|---|
| Young's modulus (*E*) | 23747 MPa |
| Poisson ratio | 0.2 |
| Friction angle | 35 |
| Cohesion strength | 10.5 |

**Table 5-2 Bolt Properties**

| Parameter | Value |
|---|---|
| Borehole Diameter | 48 mm |
| Cable Diameter | 19 mm |
| Cable Modulus (*E*) | 98600 MPa |
| Cable Peak | 100 MN |
| Water Cement Ratio | 0.3 |
| Residual Cable Peak | 100 MN |

The model shown in Figure 5-1 is made up of an elastic host material containing 250 mm bolt, to which various pull-out forces (10 kN to 120 kN) were applied.

## 5.2 Results

Figure 5-2 shows the load displacement response for pull tests at three surface localities (Hyett et al). These experimental data points are labeled in the graphs as upper and lower bound to indicate the range of experimental results, where limestone as the confining medium. The model created by Moosavi and ***RS3*** results are also plotted to compare between obtained field results and the corresponding simulation for both of the models.

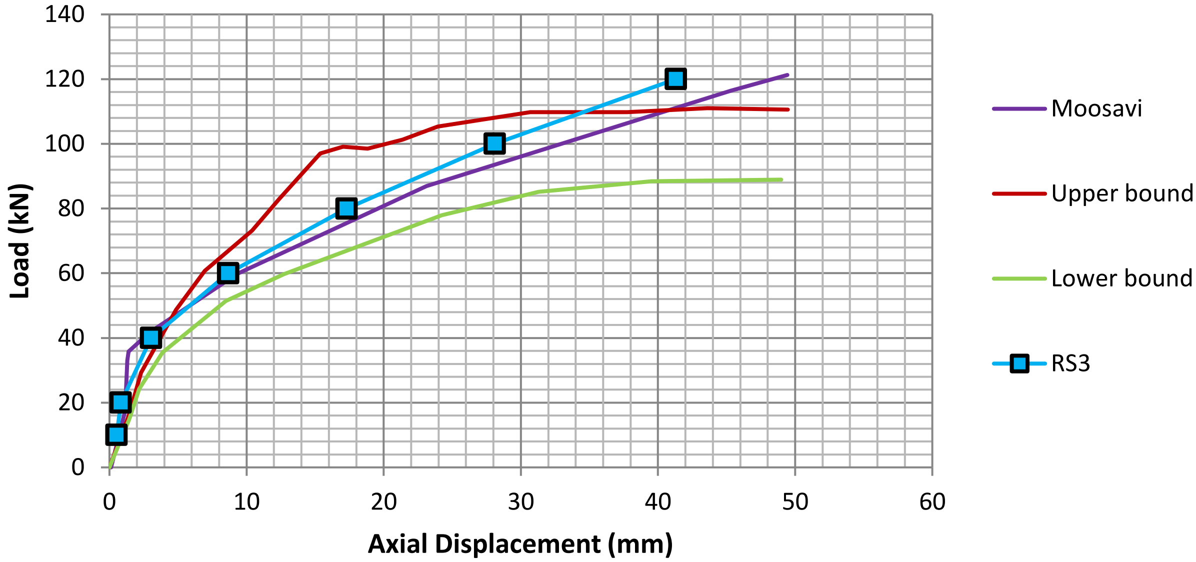


**Figure 5-2: Elastic force-displacement behavior of single cable with limestone**

Figure 5-2 show that ***RS3*** results are in close agreement with Moosavi simulation results.

## 5.3 References


1. Hyett et al. (1992) "The Effect of Rock Mass Confinement on the Bond Strength of Fully Grouted Cable Botls" *Int. J. Rock Mech. Min. Sci. & Geomech. Abstr*, vol 29. No.5. pp. 503-524, 1992.
2. Moosavi Mahdi. (1996) "Load Distribution Along Fully Grouted Cable Bolts based on Constitutive Models obtained from a Modified Hoek Cell" *Queen's University, Ontario.*


## 5.4 Data Files

The input data files can be found in the ***RS3*** installation folder. Refer to Table 5-3 for the contents of each data file.

**Table 5-3: Input data files for pull-out tests for cable bolts**

| *File* | *Pull-Out Forces* |
|---|---|
| **V005 10KN.rs3model** | 10 kN |
| **V005 20KN.rs3model** | 20 kN |
| **V005 40KN.rs3model** | 40 kN |
| **V005 60KN.rs3model** | 60 kN |
| **V005 80KN.rs3model** | 80 kN |
| **V005 100KN.rs3model** | 100 kN |
| **V005 120KN.rs3model** | 120 kN |