Beams

Introduction

This document describes the implementation of beam structural support element in RS3. Beams are 3D elements representation of columnar support which are relatively thin along certain axes. Hence, beams are formulated as one-dimensional elements (line).

3D Beam Components

3D beam components are line structures that exhibit flexural rigidity about the two axes of the cross-sectional area of the beam. Therefore, in simple beam elements which are formulated as lines, two dimensions for the cross section should be defined.

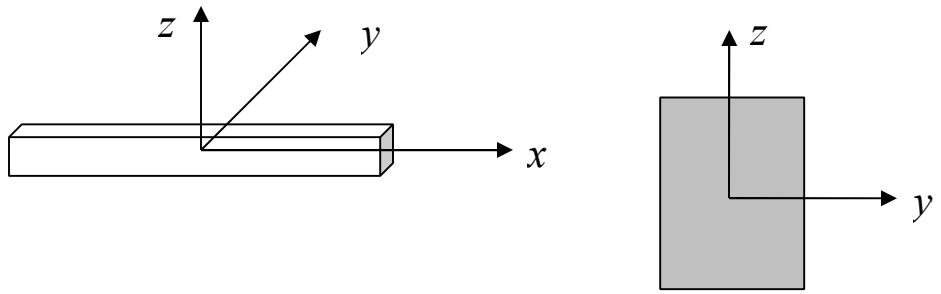

Figure 1 Geometry of a 3D Beam Element

These geometric properties are sometimes expressed in terms of moment of inertia about the two axes, I_{yy} and I_{zz}. Examples of 3D beams in underground excavation are the support beam elements in $RS3$.

NOTE: the XYZ axes used to define the beam in Figure 1 are LOCAL axes used for the beam calculations, and should not be confused with the global XYZ axes of your RS3 model.

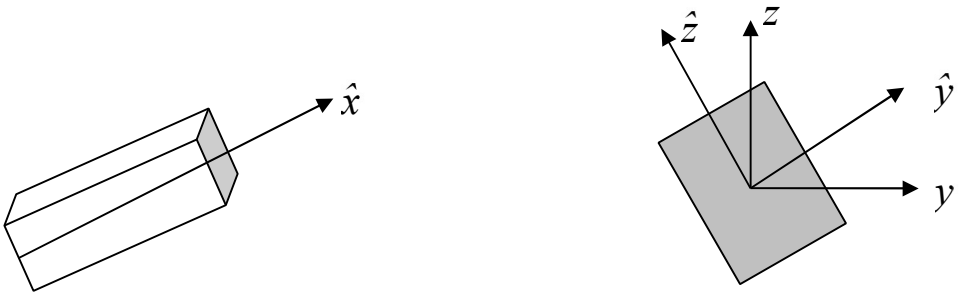

Figure 2 Geometry of a 3D Beam Element

Finite Element Formulation of 3D Beam Element in RS3

Beam elements are formulated as line components. Beam formulation can be based on the assumption of Bernoulli or Timoshenko beams (Cook et al, 2002). The former disregards the contribution of shear stresses, while the latter considers shear stresses on the cross-sectional area of a beam.

Linear (L2) and Quadrilateral (L3) beam elements Formulation

These elements represent the extensional behavior along the x axis as well as the bending about x2 and x3. The relevant stress and moment components are represented in Figure 3.

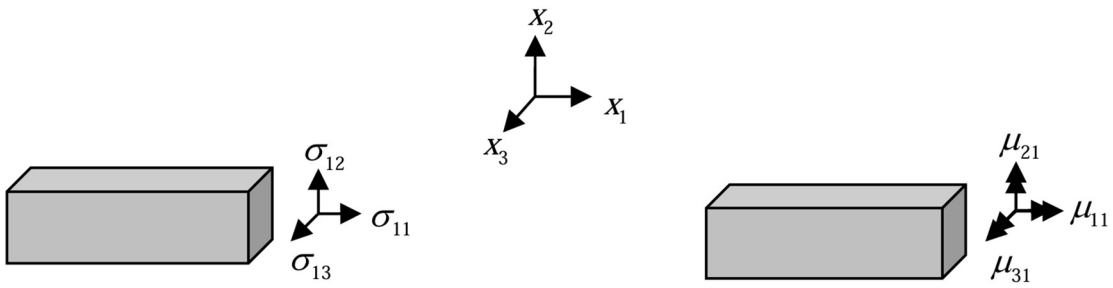

Figure 3 3D representation of stress and couple-stress in a beam component

In $RS3$, moments index 1=x, index2=y and index 3=z.

The beam components are therefore, bending moments about x and y, which in the current input file are myx and mzx, torsional moment mxx, two transverse shear loads sxz and sxy and one membrane force sxx.

Beam Plasticity

Beam plasticity is conceptually based on the layered approach. But in beams interaction of two bending moments in creation of tension and compression zones must be considered. It is assumed that the beam is divided into a number of regions as depicted in the Figure 4.

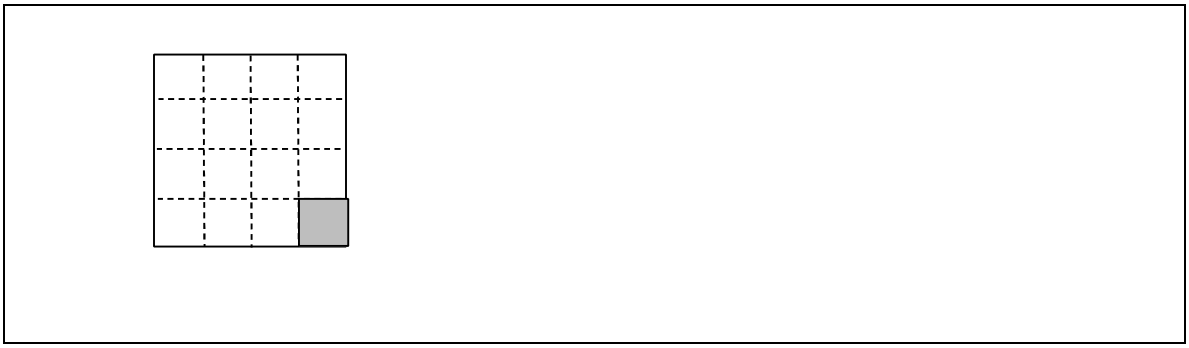

Figure 4 Division of a beam profile into a number of regions

The axial force is the result of membrane stress, axial stress caused by moment about y and axial stress caused by moment about z in each region. The algorithm loop will go through the whole profile.