Estimating Joint Stiffness

In the *RS2* Define Joint Properties dialog, one of the required parameters is the Joint Stiffness (normal and shear stiffness).

Joint stiffness is not an easily measured or well known parameter. Methods of estimating joint stiffness have been derived. Two possible methods are presented below. One method is based on the properties of the joint infilling material, the other is based on the deformation properties of the rock mass and the intact rock.

Stiffness Estimated from Rock Mass Properties

The normal and shear stiffness of joints can be estimated from rock mass modulus, intact rock modulus and joint spacing. If we assume that the deformability of a rock mass is due to the deformability of the intact rock and the deformability of the joints in the rock mass, then we can write Equation 1.

$$\frac{1}{E_m} = \frac{1}{E_i} + \frac{1}{k_n L} \qquad \text{Eqn.1}$$

where E_m = rock mass modulus, E_i = intact rock modulus, k_n = joint normal stiffness, L = mean joint spacing.

This assumes a single joint set with an average spacing L, oriented perpendicularly to the direction of loading. This can be re-arranged to give Equation 2, the joint normal stiffness [Barton 1972].

$$k_n = \frac{E_i E_m}{L(E_i - E_m)} \qquad \text{Eqn.2}$$

The same reasoning can be used to derive an expression for the joint shear stiffness.

$$k_s = \frac{G_i G_m}{L(G_i - G_m)} \qquad \text{Eqn.3}$$

where G_m = rock mass shear modulus, G_i = intact rock shear modulus, k_s = joint shear stiffness, L = mean joint spacing.

Stiffness Estimated from Joint Infill Properties

Another approach to estimating joint stiffness, assumes that a joint has an infill material with known elastic properties. The stiffness of a joint can be estimated from the thickness and modulus of the infilling material by the following equations:

$$k_n = E_0/h \qquad \text{Eqn.4}$$

$$k_s = G_0/h \qquad \text{Eqn.5}$$

where:

k_n = joint normal stiffness

k_s = joint shear stiffness

E_0 = Young's modulus of infill material

G_0 = shear modulus of infill material

h = joint thickness or aperture

NOTE:

It is difficult to estimate joint stiffness when lacking parameters. Approximating joint stiffness will be considered under the circumstances. See the Joint Stiffness Approximation section (on RS2 Knowledge Base – Joints page) for detail method and references.