Joint Networks

This document provides a summary of the Baecher, Veneziano and Voronoi joint network models used in *Phase2*.

Poisson Point Process

The Poisson point process is a method very commonly used to define random locations for joints in two-dimensional and three-dimensional space. This process assumes that the locations of joints are independent of each other, and that these locations obey uniform random distributions along the coordinate axes.

Poisson Line Process

A Poisson line process simply assumes that a joint of infinite extent passes through each joint location generated by a Poisson point process.

Joint Intensity Measures

Joint intensity measures describe the degree of jointing that occurs within a volume of rock mass. There are five measures for joint intensity in two dimensions. These are:

1. The number of joint traces per unit area of the trace plane
2. The sum of joint trace lengths per unit area of the trace plane
3. The sum of joint trace lengths per square root of the trace plane area
4. The sum of squared joint trace lengths per unit area, and
5. The square of the sum of joint lengths per unit area.

The last three measures are dimensionless.

Length Persistence

Coplanar joints are separated from each other by intact rock material (rock bridges). In a two-dimensional trace plane, the ratio of joint length to the sum of joint length and rock bridge length is known as length persistence.

Baecher Model

The Baecher model (Baecher et al., 1978) is a flexible algorithm that can generate intricate joint networks. In this model, joints are assumed to have finite trace lengths, which follow some statistical distribution. The centres of the joints are located in space according to a Poisson point process. The orientations of joints in a Baecher network can either vary according to an orientation distribution or be constant. The number of joints generated in a Baecher network is controlled by a joint intensity measure.

In order to avoid boundary effects for a specified model region, the Baecher algorithm first enlarges the region before generating joints. After generating the joints according to the required joint intensity measure, the algorithm then clips the network with the original bounding region. Joints of the Baecher network generally terminate in intact rock.

Veneziano Model

In a two-dimensional trace plane, the Veneziano model is based on a Poisson line process. It however adapts the Poisson process to generate joints of finite length. The process for creating a Veneziano joint network consists of:

1. Generating infinite joint lines, each of which passes through a point located according to a Poisson point process (points distributed in the trace plane according to a uniform distribution). The orientations of the lines may be constant or vary according to some orientation distribution, and
2. Dividing each joint line into segments of random lengths. These lengths correspond to a specified statistical distribution. (In the original Veneziano formulation, lengths were assumed to have an exponential distribution. *Phase2* relaxes this condition and allows users to specify other statistical distributions.)

A portion of these segments are classified as joints and the remainder as intact rock bridges. The proportion of joints to intact rock bridges is determined by the length persistence parameter.

As a result of the use of joint lines as the first step in generating joints, joints in a Veneziano network tend to be coplanar. (Coplanar joints are joints that are all located in the same plane.) This tendency towards coplanarity differentiates the Veneziano model from the Baecher model in which joints tend to be independent segments.

Voronoi Joint Network Model

Two-dimensional Voronoi tessellation is a process that randomly subdivides a plane into non-overlapping convex polygons. A Voronoi joint network consists of joints that are defined by the bounding segments of these polygons.

Voronoi tessellation starts with a Poisson point process, which defines "seeds" or "generators". The Voronoi cell corresponding to each seed is the planar region closer to the seed than to any other seed. The bounding segments of this region are lines that are equidistant to the seed and adjacent generator.

Seeds generated through a Poisson point process are generally not evenly distributed in space. Some points may lie very close to each other, while others are far apart. As a result, it may be desirable to make the distribution of seeds more regular. When this is done, the resulting Voronoi cells become more regular in shape.

Phase2 allows users to either define the density of Voronoi seeds or the average length of the sides of Voronoi polygons. The Voronoi network is recommended for broken rock masses in which there are no preferred jointing directions.

References

1. Baecher, G.B., Lanney, N.A. and H.H. Einstein. 1978. Statistical Description of Rock Properties and Sampling. Proceedings of the 18th U.S. Symposium on Rock Mechanics, 5C1-8.
2. Dershowitz, W. 1985. Rock Joint Systems. Ph.D. Thesis, Massachusetts Institute of Technology, Cambridge, MA.