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FIRST MAJOR IMPROVEMENTS TO THE TWO-CURVE DUCTILE FRACTURE ARREST MODEL – EFFECT OF DIFFERENT SOIL TYPES ON DUCTILE FRACTURE ARREST, AND SEPARATING ELASTIC AND PLASTIC CONTRIBUTIONS TO THE CRACK-DRIVING FORCE

Summary

The objective of the proposed program is to make the first major improvements to the most commonly used ductile fracture arrest criterion. There are two tasks in this effort.

The first task is to improve the accuracy of the Two-Curve Ductile Fracture Model to be able to account for different types of soil backfills, i.e., sand, clay, etc. To make this improvement, a series of intermediate-diameter (6 to 12-inch) pipe burst tests with different soil types, compaction, and moisture content will be conducted at the Emc^2 burst test site in the Mojave Desert in California.

The second task involves making an improvement to the crack-driving force equations in the Two-Curve Method so that there will be elastic and plastic contribution to the crack-driving force. Experimental results have shown that the arrest toughness value determined from the Two-Curve Ductile Fracture Model should be continually increased as the grade of the pipe is increased. A significant portion of this empirical correction comes for the elastic energy being higher than was accounted for in the current Two-Curve Ductile Fracture Model. Making this improvement will allow for safer future pipeline design with higher-grade steels.

Progress as of March 2004

One of the most difficult parts of this program is to find the pipe material to be tested. This is because smaller diameter pipe was desired, and the smaller the pipe size, the lower the Charpy energy needed to guarantee a ductile propagating crack. In the proposed experiments, it is essential to conduct the tests so that a steady-state ductile fracture propagates in the test soil, as well as the reference backfill (air).

Current day steel-making practice is much better in the 1980's. API pipe purchased in the past (high sulfur content) for similar tests is not available in North America, Japan, or Europe. Importing pipe from 3rd world countries and getting the mechanical properties we wanted is not likely. Consequently, we examined alternative pipe/tubular products. Down-hole tubular goods, such as N80 casing, were a possibility, but discussions with Lone Star Steel Company were not encouraging.

The alternative that appears to be successful is using 1026 DOM (drawn over a mandrel) mechanical tubing. This tubing is heavily cold-worked so the yield strength is high and the Charpy energy should be low. Three samples of this tubing product have been obtained for testing. Charpy tests will be conducted to verify that the energy is sufficient to allow steady-state ductile fracture propagation. If the energy is sufficient, this material will be used in the pipe experiments.