Crack Analysis of Steel Water Pipelines

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Abstract: In this study, effect of circumferential cracks on small diameter steel water pipes were modeled using the finite element method. The bending capacity of the pipe was reduced due to crack propagation. The through-wall crack was more critical than partial crack on water pipes. Relationship between bending capacity and crack parameters of steel pipes have been developed.

1. Introduction:

Water pipelines of a city are usually made of asbestos cement, concrete, ductile iron, cast iron and PVC. Numbers of failures of water pipelines are being reported throughout the world. Causes of failures are very complex and diverse and can be related to age, pipe materials, construction and ground conditions. In most cases, failures are affected by two or more factors.

2. Objectives:

The objectives of this study are as follows: (1) identify the causes of water pipeline failures; and (2) investigate the effect of cracks on the water pipeline failure.

3. Failure Analysis:

Water pipeline failure modes include blowout holes, circumferential cracking, bell splitting, longitudinal cracking, bell shearing and spiral cracking. Corrosion plays an important role in the mode of blowout holes. When the pipe walls are thinned by corrosion to the point, the water pressure blows out the remaining, very thin walls. Circumferential cracking was reported to be the most common failure mode for small diameter gray cast iron pipes (Maker 2001). This was due to the bending forces applied to the pipe and the small moments of inertia of small diameter pipe. The bending forces could be produced by the non-uniform soil movement due to expansive soils. Baracos (1995) analyzed the pipe breakage data of cast iron and asbestos cement water mains in the city of Winnipeg, Canada and found the expansive soil movement amounted to be as much as 20 mm and could cause 0.5% of rotation at the tightened joints. It was noted that the movement in corrosion-weakened pipe caused flexural or joint failures. Effect of cracks in the pipes is being investigated by fracture experiments, analytical model and finite element modeling for 35-40 years. In the early years, the focus was on the axially cracked pipe specimens subjected to internal pressure. Recent studies are concerned on the behavior of circumferentially cracked pipe subjected to both pressure and bending loads.

4. FEM Modeling and Results:

Finite element method (FEM) was used to study the effect of cracking on water pipes. Corrosion was modeled by changing the thickness of pipe walls and the chemical processes. In this study, commercial software ANSYS was used to model the circumferential crack of the small diameter pipe. Four-point bending test was modeled to study the effect of cracks on the pipes. The quarter pipe with diameter of 2 inch was modeled because of symmetry. M is the output maximum moments and u is the output maximum deflections from ANSYS.

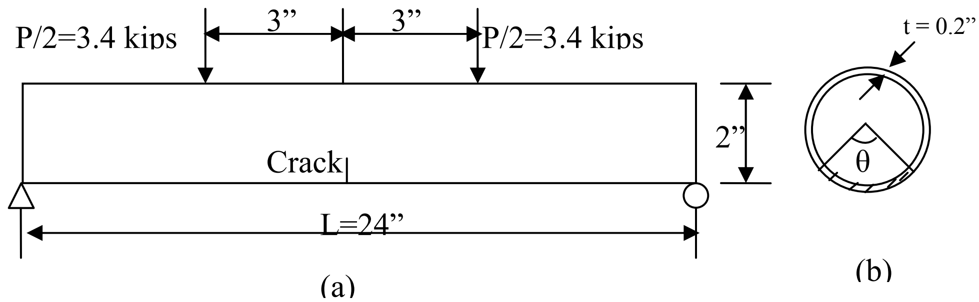
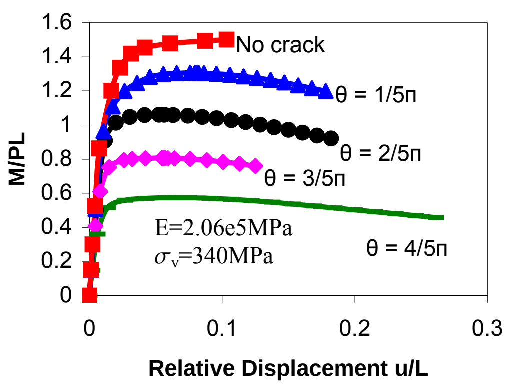


Figure 1 Analyses of pipes (a) Four-point Bending Condition (b) Cross-section



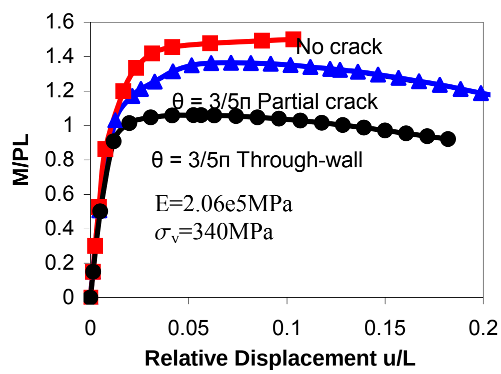


Figure 2 Through-wall Crack Analyses for Steel Pipe Figure 3 Partial Crack Analyses for Steel Pipe

5. Conclusion

The effect of circumferential cracks on the steel pipe behavior has been quantified. The bending capacity of the pipe was reduced due to the propagation of the circumferential crack. The bending capacity of the pipe was reduced much more by through-wall cracks than by partial cracks.

6. Acknowledgements:

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7. References:

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