THE EFFECT OF FAULT PLANE ANGLE ON THE STRUCTURAL RESPONSE OF BURIED STEEL PIPELINE SUBJECTED TO FAULT MOVEMENT

Abdollah ROHANI HAJIAGHA
M.Sc. Hormozgan University, Bandar Abbas, Iran
sasanrohani@gmail.com

Abolfazl RIAHI NOURI
PhD Candidate, IIEES, Tehran, Iran
a.riyahi@iiees.ac.ir

Mohammad Ghasem VETR
Assistant Professor, IIEES, Tehran, Iran
vetr@iiees.ac.ir

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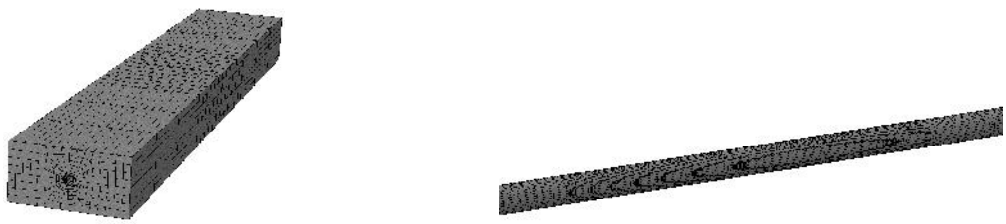
Analysis and design of buried pipelines is a complicated problem. The reason lies in the fact that it incorporates interaction between soil and pipeline as well as nonlinear behaviour of surrounding soil. In this study the effect of soil elastic and plastic characteristics on mechanical behaviour of pipeline is investigated. Fault displacement is imposed in various angles to longitudinal pipeline axis.

In order to simulate behaviour of buried pipeline in fault movement three-dimensional finite element procedure was implemented using ABAQUS software. Explicit and Standard solution procedures are carried out to provide the opportunity of comparing obtained results by means of both approaches. Three different angles which are considered for fault movement are 90, 60 and 30. Discretized geometry of typical model which consists of pipeline and surrounding soil is shown in Figure 1.



a b

Figure 1. (a) Soil discretization in the case of fault movement normal to longitudinal axis of pipeline (b) Pipeline

Four-node doubly-curved reduced-integration shell element is chosen for pipeline (S4R), whereas eight-node linear brick reduced-integration element is considered for surrounding soil. The model is divided in two parts: (a) Fixed part (b) Movable part, connected to each other by fault zone. As shown in Figure 1, finer mesh is employed for soil and pipeline near the fault. Owing to large displacements, Arbitrary Lagrangian-Eulerian (ALE) adaptive meshing scheme was used in the mesh near the fault (Vazouras et al., 2010) and (Srinivasa et al., 2011).

Two types of prevalent pipe's failure mode are tensile rupture owing to bending and tension, and wrinkling of the wall of pipe in account of bending and compression. The prime indication of tensile rupture is the maximum axial strain in the pipes wall. Newmark and Hall (1975) assumed that failure occurs when the average strain is greater than 4%. Figure 2a shows tensile rupture occurring in the pipe. Although, the tensile strain is less than 4%,the compression strain is about zero. This shows that by increasing the fault offset the amount of strain will rise and eventually tensile failure will occur. Figure 2(b and c) shows the rupture due to compression. As depicted in Figure 2c first wrinkling was turned up in the pipe, then strain near the wrinkling location rises to 4% (strain correspond to 70 cm fault offset), finally by increasing the fault movement, the wall of the pipe experiences a remarkable drop in the strain which is indication of compression failure.

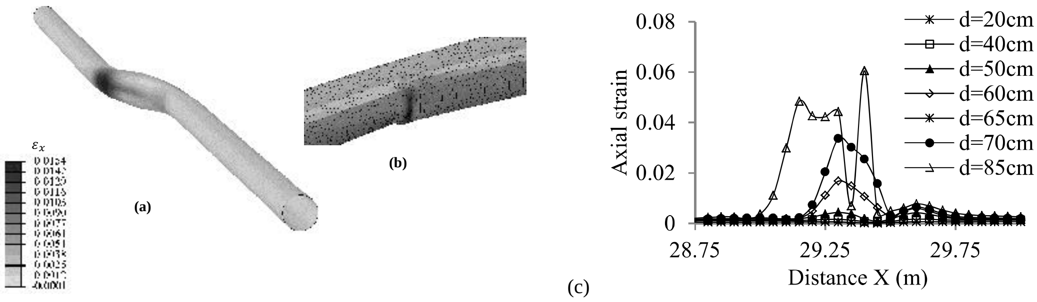


Figure 2. Types of failure mode (a) tensile rupture owing to bending and tension, fault angle= 60
(b)(c) Wrinkling formation and rupture due to bending and compression, fault angle= 90

A comparison between the results of numerical method and analytical approaches was done. For small offset, peak strain obtained numerically were compared to Newmark methods. Figure 3 represents that since Newmark method does not consider the bending strain in the pipe as well as the soil and pipe interaction in the case of specified unanchored length, the maximum axial strain in pipe surrounded by varied types of soil is identical.

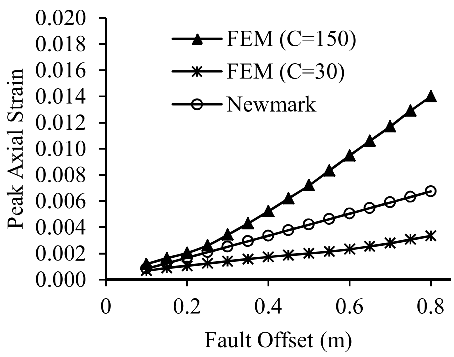


Figure 3. Peak pipe strain for small fault offset in different soil

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