PHYSICAL MODELING OF RESPONSE OF BURIED PIPE WITH CONSTRAINTS TO REVERSE FAULTING

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The buried pipelines are inseparable section of current society and play a vital role in human's life. Permanent ground displacement (PGD) due to surface faulting is one of the major factors in defects of pipelines in recent earthquakes that might cause leakage of the materials inside the pipe such as oil and gas to surrounding area, leading to bioenvironmental hazards and economic threaten.

Different approaches have been performed to investigate the surface fault rupture hazard regarding continues pipelines such as experimental studies (Yoshizaki et al., 2003; O'Rourke et al., 2005; Sim et al., 2011; Rojhani et al., 2012; Jalali et al., 2017) numerical modeling (Takada et al., 2001; Ogawa et al., 2002; Joshi et al., 2011; Vazouras et al., 2012; Zhang et al., 2015) and analytical approaches (Newmark and Hall, 1975; Kenedy et al., 1977; Wang and Yeh, 1985; Karamitros et al., 2007, 2011). In this paper, based on some 1-g physical modeling tests, clear perspectives of response of buried pipe with elbows constraints to reverse faulting are presented. In the program of physical modeling tests of the present study, in addition to test on two free ends pipe, attempts have been made to perform tests on constrained pipes. The three tests performed by the reverse fault propagation simulator device in this study is presented in Table 1.

Table 1. Tests program.

Test NO.	Fault dip angle	Burial Depth (cm)	Description
1	60°	30	Without Constraint
2	60°	30	Roller Constraint in Foot Wall
3	60°	30	Roller Constraint in Hanging Wall

In Figure 1, the axial strain distribution for a no constrained pipe is shown in test 1 in the displacement of 20, 30 and 60 mm of the fault. According to the distribution of the axial strain for no constrained pipe it can be seen that the pipe tolerates tensile strain in hanging wall and compression strain in foot wall near the fault regions but in areas far from fault in each sides of the fault the pipe experiences compression strain that amount of these strains is higher in foot wall. In Figures 2 and 3, the distribution of the total axial and bending strain is shown for test 2 and test 3 in the displacement of 10 to 70 mm of the fault, respectively.

Based on these tests:

- When an unconstrained pipe subjected to reverse fault at the near-fault areas tolerate axial tensile stresses at the hanging wall and axial compressive strains at the foot wall, but in distant areas of the fault trace in each two sides of the fault the pipe experience the axial compressive strain.
- In the region of a reversed fault which the pipe is curved especially in the vicinity of the fault, the bending strains are much more than the axial strain and the behavior of the tube is due to the strain and flexural deformation of the

pipe but in other areas of the fault it is more distant or near the turning point of the deformed pipe the behavior of the pipe is under the influence of axial and flexure strains.

- In the event that the roller support is applied pipelines under reverse fault in foot wall side the curvature of the pipe is longer and less radius than that applied to the hanging wall.

Finally, it is shown which situation of constraints would threaten a buried pipe more and possibly lead to pipe damage, so in this regard should avoid it.

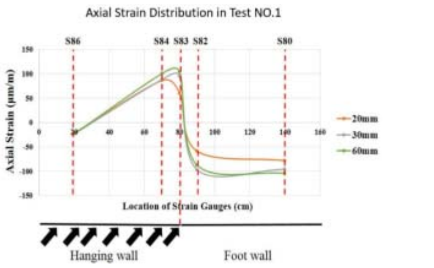

Figure 1. Distribution of axial strain for different fault displacement along the pipe in test 1.

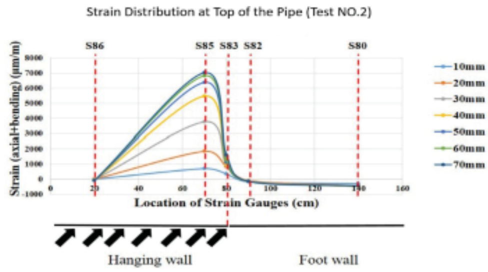

Figure 2. Strain distribution at the top of the pipe (Test 2).

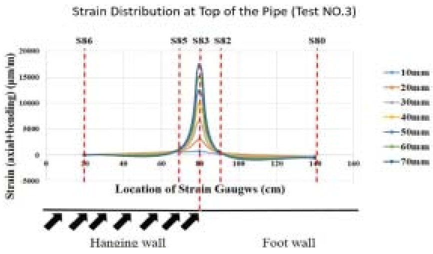

Figure 3. Strain distribution at the top of the pipe (Test 3).

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