INVESTIGATION ON THE EFFECT OF LATERAL SPREADING ON THE LONGITUDINALLY BURIED PIPELINES USING 1G SHAKING TABLE TESTS

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Buried pipelines may suffer different types of damages during and even shortly after earthquakes. Because of the importance of lifelines in human life their seismic behaviour should be carefully understood. Pipelines are one of the important types of lifelines. Among the different causes of damages to the buried pipelines, liquefaction of surrounding soil is a major source. Liquefaction and its consequences may play important role on the performance of buried pipelines. For instance lateral spreading of slopes that usually occurs in very gentle slopes could seriously damage the buried pipes. During any lateral spreading liquefied soil experiences very large deformations and movement and therefore could exert large forces to the pipelines. When the pipe is parallel to the slope movement, soil deformation can produce an axial strain along with the buried pipe. Also, because of the settlement of the surrounding, bending moment can make damage to the buried pipeline.

A research has been conducted for the favour and by support of Tehran Gas Company to prepare a regulation for design of buried pipeline in areas with high potentials of liquefaction. The current paper presents some results of experimental part of the mentioned research. This results have been used individually and also in combination with a comprehensive numerical study for understanding the effect of lateral spreading on buried pipelines. A series of physical modelling test using 1g shaking table has been conducted to for this purpose. Slope angels of 4%, 2.5%, 1.5% and 0% were used in model slopes. The model pipeline was buried in a thin unliquefiable layer that lied on a liquefiable one. Four accelerometers were placed in different depths of soil. Also some pore water pressure transducers have are placed inside the liquefiable layer for measuring the degree of liquefaction. By using high resolution LVDTs, the vertical and lateral displacement of the ground were measured. For measuring bending moment and axial force exerted to the pipeline, three sets of strain gauge were pasted on the surface of model pipe. They could record strains of the model pipe when it was subjected to any infinitesimal deformation caused by ground shaking.

The models were constructed inside a transparent box with dimension of 50 cm × 183 cm × 75 cm (in height). Also an aluminium pipe with 10 mm in diameter and 0.5 mm in thickness was the best choice for modelling a real pipeline with diameter of 14 inches based on the scaling law. A harmonic base shaking with was then applied to the model by using 1g shaking table apparatus of Tehran University. Response of the model was measure by 20 transducers during the shaking. Figure 1 shows one of the tests before and after the shaking. Moving down of the slope is clearly visible in this figure.

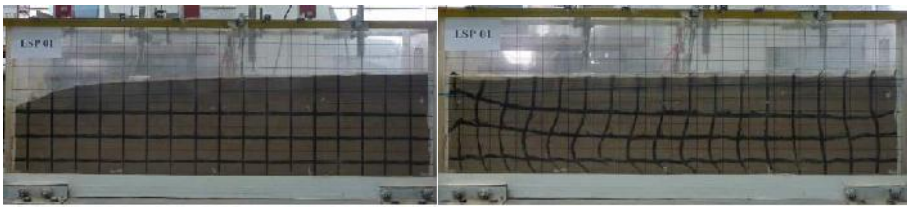

Figure 1. (Left) before shaking, (Right) after shaking

All the measured data were plotted individually and were used to understand the studied phenomena. Moreover this data were used to calibrate the numerical model that was prepared for this purpose. Recorded accelerations at different depths showed that liquefaction has occurred and the soil behaved like a liquid material. Remarkable decreasing of the shaking amplitude in the upper layers of the soil indicated loss of shear resistance due to the liquefaction. Recorded strains on the buried pipe showed that deformation of the pipe reduces when the liquefaction occurs. According to the measured pore water pressures, because of the low rate of water pressure dissipation, settlement could continue for minuets after the shaking. The settlement could increase the rate of damage into the model pipeline. The bending moment and axial strain has increased slightly by the increase of settlement. The measured axial strains showed that in some sections of the model pipe tension mode was predominant whereas in other parts compression mode obvious. This can occur in real cases because by the moving down of the slope, some section of the pipe in the upper side of the slope experiences tension and in the lower part experiences compression. Results show that the large deformation exerted to the pipeline is the most important parameter on the behaviour of pipeline against lateral spreading. An extensive attempt has been done to use all observed behaviour and all measured data to give a better image of the studied problem. As instance interaction of soil-pipe was explained by comparing collected data. Figure 2 shows the change of soil acceleration against the lateral displacement of the slope. It is obvious that the larger part of displacement has taken place in first cycles of the shaking. Accordingly larger part of deformation in the buried pipe has also occurred in this cycles.

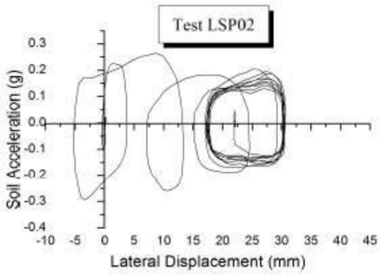

Figure 2. Measured acceleration in the surrounding soil versus lateral displacement

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