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COMPARATIVE EXPERIMENTAL STUDY ON SEISMIC RETROFIT OF EXISTING GAS RISERS

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Distribution system for this lifeline consists of several critical components including pipelines, valves, stations, pumps, distribution lines and finally the risers. Riser as the last element at costumer location has the most uncertainty in seismic vulnerability because its performance under earthquake load highly depends on characteristics of the customer building and its seismic behavior which cannot easily have considered in seismic design of the riser. This paper presents the results of an extensive experimental and numerical investigation on seismic behavior and retrofit of riser system. Several tests have been conducted on full scale risers with real conditions to assess the performance of existing risers in different load scenarios. After finding the weak points and failure modes, several retrofit countermeasures have been implemented to find the best solutions for upgrading the seismic performance of the system considering the assessment and modification on all minor and major components of the connections. The results have been developed numerically to obtain the details of stress and deformation distribution using calibrated models. Finally, the best solutions as innovative countermeasures have been presented. Gas riser system has been used in many large cities including the capital and several other seismic prone areas. The damage histories show that the existing system has a high vulnerability and requires appropriate countermeasures (Gross, 1985). In the capital city of Tehran itself there are more than one million risers with different sizes and more than ten million residents. Similar condition exists in other large cities in Iran. This fact raises the importance of finding an appropriate retrofit solution for the issue.

The riser steel pipe and its welded joints have shown ductile behavior during past earthquakes. The threatened steel joints have also shown good performance but with less ductility compared to welds. This joints are located under the Mitter stop valve, under and top of the regulator and at the meter location. However, the weakest point of the system is the Insulator unit on top of the Mitter stop valve which connect it to the regulator with a short steel pipe. This insulator unit is made from plastic to provide electric current insulation from corrosion protection system (MGL, 2010).

All buried metallic pipe must be properly coated and have a cathodic protection system designed to protect the pipe in its entirety. Newly constructed metallic pipelines must be coated before installation and must have a cathodic protection system installed and placed in operation in its entirety within one year after construction of the pipeline (ANSI/ASME B31.1, 2018). Cathodic protection requirements do not apply to electrically isolated, metal alloy fittings in plastic pipelines if the alloyage of the fitting provides corrosion control, and if corrosion pitting will not cause leakage (Elster, 2011).

The experimental study has been conducted based on failure mode evaluation under three loading condition including lateral, transversal and torsional displacement exerted at the location of bend of connection of regulator outlet pipe to the building piping system. The load has been applied under a displacement control protocol using hydraulic jack and a LVDT displacement sensor.

As shown in Figure 1, the failure of the riser starts from the connection of the mitter stop valve to the upper pipe where the polymer insulating unit exists. The failure starts with gas leakage from the insulation and ends to the total insulation unit breakout. Figures 2 and 3 show the verification tests of some alternatives discussed in the paper.

Figure 1. Failure process of the riser under lateral displacement.

Figure 2. Sample test performed by steel clamp.

Figure 3. Results of the test for retrofit alternative by using flexible pipe between the stop valve and the regulator.

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