INTERNATIONAL INSTITUTE OF INFORMATION TECHNOLOGY
HYDERABAD

R&D SHOWCASE 2021
Technology, Social Impact

Seismic Analysis and Design Recommedation For Uran-Chakan-Shikrapur LPG Pipeline

OBJECTIVE

- The main objective of the project is to evaluate the safety of Uran-Chakan-Shikrapur LPG pipeline for seismic forces .
- Finite Element Analysis (FEA) is carried out to determine the safety of pipeline in terms of strains along the length of pipeline for PGD.

METHODOLOGY

- Analytical formulations as specified in IIITK-GSDMA guidelines for Seismic Design of Pipelines are used for following four cases:

a) Permanent Ground Deformation b) Buoyancy due to Liquefaction c) Fault Crossing d) Seismic Wave Propagation

The numerical calculation for Borehole (BH) 11 and 14 are shown in table 1. The pipeline is unsafe for PGD in transverse direction at BH-1, BH-2, BH-4, BH-5, BH-6 and BH-14. To make the pipeline safe following can be done:

1. The soil surrounding the pipeline should be loosened,
2. The soil properties of the above bore holes can be replaced or made equivalent to soil properties of safe bore holes locations.
3. The contact soil of pipeline in the specified regions should be replaced by filling sandy soil in the pipeline trench.

Buoyancy as per the IITK GSDMA guidelines pipe line for all bore holes is unsafe. The calculations done shows that the net upward force (Buoyancy) is lesser than that of net downward force (Self-weight of backfill soil and pipeline), which states that the pipeline is safe for buoyancy force. The same is verified by identifying the liquefaction zone at depths of soil strata using analytical formulation. From liquefaction study it has been observed that the zone of liquefaction does not occurs upto the burial depth of pipeline (Fig.2)

- The MATALB code for 3D FEM was developed for modelling of the buried continuous pipeline.. The governing FEM equation used is:
  Above nonlinear equation is solved using Arc-length method. Also, to accelerate the iteration process parallelization tool kit also utilized here. Numerical model, strain profile for bore holes are shown in figs .3.
- Finite element analysis using Beam on Nonlinear Winkler Foundation (BNWF) model, where the soil is represented by independent springs lumped at discrete locations of the pipe is also done using FEA package ANSYS. Properties of springs are calculated as per IITK-GSDMA guidelines. Fig.4 & 5 shows the numerical modeling of pipeline.

Table 1. Status of pipeline at BH-4 and BH-11 with safe or unsafe condition

BH No.	CASE	Max. Strain ($Tens_{long}$, $Tens_{trans}$)	Max. Strain ($Comp_{long}$, $Comp_{trans}$)	Allowable Strain (Tens.)	Allowable Strain (Comp.)	Safe / Unsafe
BH-4	I	0.0010 0.0723	5.3E-4 0.0708	0.03	0.0091	Safe Unsafe(T,C)
	II	4.7E+5	4.72E+5	0.03	0.0091	Unsafe
	III	0.0096	-	0.03	0.0091	Safe
	IV	0.0010	-	0.03	0.0091	Safe
BH-11	I	1.9E-5 0.0012	0.0015 3.1E-4	0.03	0.0091	Safe Safe
	II	2.9E+5	2.5E+5	0.03	0.0091	Unsafe
	III	0.0231	-	0.03	0.0091	Safe
	IV	0.0010	-	0.03	0.0091	Safe

(a) 1971 Sanfernando earthquake (b) 1999 Kocaeli earthquake (c) 2002 Denali earthquake

Fig 1. Failure of pipelines during past earthquake

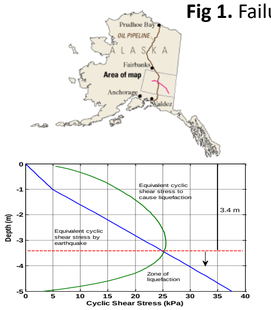

Fig 2. Zone of liqufaction for critical BH data

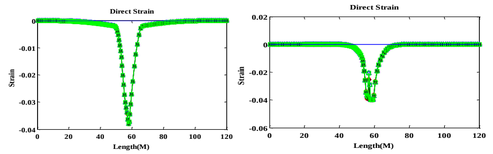

Fig 3. Strains along length of pipeline for BH-4 and along all BH

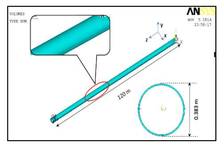

Fig 4. Numerical modeling of pipe in ANSYS

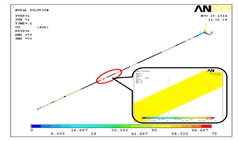

Fig 5. Numerical modeling of pipe in ANSYS

CONCLUSIONS

- The pipeline is unsafe for PGD for a 3.75 time factor of safety with respect to MCE of particular region. Pipeline is safe for other case, except for buoyancy, which is also found to be safe from the zone of liquefaction study (Fig.2).
- Alternative solution to make pipelines safe with 3.75 time factor of safety had been provided.
- FEA done with (BNWF) and Soil mesh finite element model shows the pipeline is safe for PGD along the longitudinal and transverse direction, which was unsafe in analytical solutions.