Upheaval Buckling of Buried Pipelines

Name: Shengsheng Fan

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Supervisor: Prof. Svein Sævik

Co- Supervisor: Tornes Knut and Helland Lars-Rune (JP KENNY Norge)

The main purpose of this thesis was to develop a MATLAB program based on Terndrup-Pedersen' analytical method for upheaval buckling analysis and verify the analytical model by comparing with FE analysis using software SIMLA. In addition, an elastic-plastic pipe model was built in SIMLA to investigate the plastic behavior of pipeline and its effect on the pipeline design.

All simulations of the analytical model and FE model are based on the use of MATLAB and SIMLA.A brief introduction to the program, which consists of the input data, solver and output data, is included. A brief description of methods applied in SIMLA and nonlinear finite element analysis is included. The thesis also contains a chapter describes the relevant concepts of upheaval buckling, like effective axial force, buckle force. A summary of needed data and procedure for the analytical method is given.

A group of cases with imperfection level δ_P varying from 0.1m to 0.6m and burial depth H varying from 0.4m to 1.6m has been defined and analyzed in both analytical model and FE model. Elastic-plastic material is also considered in the FE model to investigate the plastic behavior of the pipeline.

By comparing the results of analytical and elastic FE model, it is clearly verified the analytical model proposed by Terndrup-Pedersen will always give results that will be consistent with results of FE modeling in SIMLA. The MATLAB program developed is able to implement the analytical method and give very good results for design. However, it should be noted that the analytical model will always give conservative results compared with the results given by FE model.

The results clearly indicate the allowable operating temperature and buckle force will decrease significantly as the imperfection level increases, on the contrary the maximum bending moment will increase as the imperfection level increases. It is also evident to see the allowable operating temperature and buckle force will increase as the burial depth increase, while the maximum bending moment increase a little bit and is nearly a constant for given imperfection level.

It is also noted that the deviation of the analytical and FE results are dependent on the imperfection level for given soil conditions. The analytical model tends to give results close to FE model for large imperfection levels, say 0.3m or larger in the thesis, while the deviation may be larger for small imperfection level, say 0.2m or smaller. It is affected by the difference in the modeling of soil/pipe model in two models. The penetration of pipe into the seabed in the FE model may result a difference. In addition, it is found that the burial depth will have little effect on the deviation between the analytical and FE model.

Finally, it is also found the elastic-plastic properties of the pipe will affect the design temperature and buckle force to some extent. The results given by the elastic pipe model will always give conservative results for design. Therefore it is wise to take the elastic-plastic material properties into consideration.