The Geo Engineering Centre

Depth Beyond Knowledge™

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RESEARCH SUMMARY

STEEL AND FIBREGLASS PIPES SUBJECTED TO LATERAL GROUND MOVEMENT

STEEL AND FIBERGLASS PIPES TESTED UNDER LATERAL GROUND MOVEMENTS

PIPES TESTED AT DIFFERENT BURIAL DEPTHS

THREE DIMENSIONAL RESPONSE MONITORED USING POTENTIOMETERS AND STRAIN GAGES

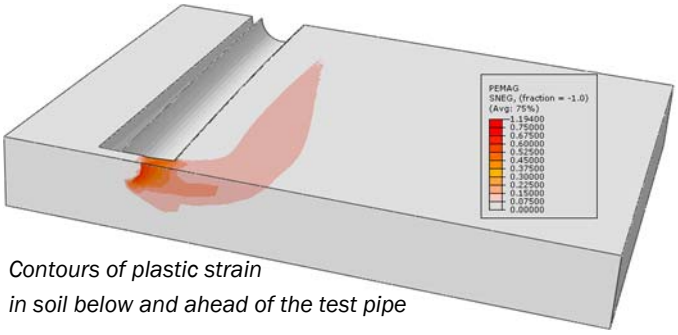
THREE DIMENSIONAL FINITE ELEMENT ANALYSIS DEVELOPED USING ABAQUS

CALCULATIONS REFLECTED THREE DIMENSIONAL BENDING

PULLING FORCE ESTIMATES ADJUSTED USING MODIFIED INDUSTRY PROTOCOL

Oil and gas transmission pipelines can be subjected to lateral ground movements when passing along slopes that experience slow or rapid down-slope soil movements. Pipelines need to be designed for the lateral forces that then develop. This includes conventional steel pipes that are the normal choice for high pressure pipes, and the fibreglass pipes now being selected for their corrosion resistance. Mohamed Almahakeri designed and conducted lateral loading experiments on 100mm diameter steel and fibreglass pipes of equivalent pressure rating. The tests were designed to evaluate a segment of pipe spanning between two points of zero moment towards the boundaries of a zone of moving ground. These provided measurements of the lateral loads that develop, as well as the longitudinal bending deformations and axial strains along the pipeline. Some longitudinal bending occurred in the steel pipeline, but was substantially higher in the fibreglass pipe which is considerably more flexible.

Finite element modeling was then undertaken using ABAQUS, where the nonlinear phenomena controlling the behaviour are considered, such as shear failure and dilation of the dense coarse-grained soil, large deformations at the soil-pipe interface, and separation of the pipe from the soil. The three dimensional analysis captures the progressive development of shear failure along the pipe, as the soil moves further past the ends of the pipe, and mobilizes the strength and stiffness of the soil at that location well before the pipe midsection. The analysis also models the effects of the orientation of the glass fibres, and the effect of burial depth on lateral soil loading and pipe resistance to failure in flexure.



Contours of plastic strain in soil below and ahead of the test pipe

HIGHLIGHTS

- **4 papers published or accepted to date with more being submitted**
- **Awarded the Michael E Argent Graduate award of the North American Society of Trenchless Technology**
- **Now employed as consultant in Indiana, USA, specializing in nonlinear computer analysis**

USE OF CORROSION RESISTANT FIBERGLASS PIPES FOR OIL AND GAS TRANSPORT

Fibreglass pipes can be designed to resist the high pressures that arise in oil or gas transmission pipelines, and they avoid the corrosion problems associated with use of steel pipelines. Fiberglass design includes specification of fibre orientation relative to the pipe axis. However, the much greater flexibility of the fiberglass pipes prompted this investigation of longitudinal bending under the influence of moving ground, and changes the tolerance level to lateral bending before pipes need to be excavated and straightened.

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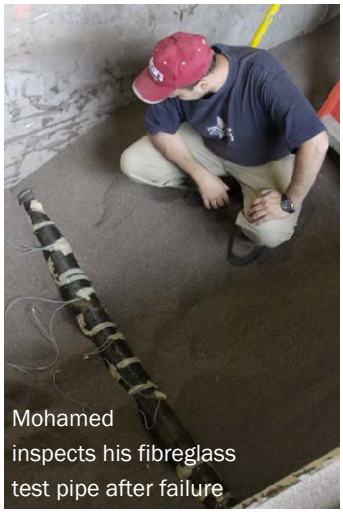

Mohamed inspects his fibreglass test pipe after failure