# A Review of Buried Pipelines Under Fault Action

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## Abstract

**This paper makes a systematic study on the development of buried pipeline under the action of site deformation dominated by fault. The research status of buried natural gas pipeline at home and abroad, as well as the research direction and progress of international frontier are summarized in detail from three aspects of theoretical analysis, numerical simulation and experimental research.**

## Keywords

**Fault, Buried pipelines, tensile, damage.**

## 1. Introduction

Urban underground pipe network is related to the operation of urban economy and every aspect of the lives of millions of people. If the buried pipeline is damaged due to force majeure, it will cause huge economic loss in a very short time due to its large pipe diameter and flow, and cause secondary disasters such as explosion. However, most of the damage of buried pipelines comes from the site deformation caused by earthquake, such as fault and uneven settlement. Since the 1970s, domestic and foreign scholars have done a lot of research on the damage of buried pipelines under earthquake response, and obtained the use and protection methods of buried pipelines, which has an important basis for the normal operation of buried pipelines under the service life of the design.

## 2. Study on Buried Pipeline in Town Under Fault Action

### 2.1. Theoretical Analysis and Research on Buried Pipeline

In the theoretical analysis of buried pipeline, the thin shell structure of pipeline is generally regarded as cable or beam, and then the theoretical analysis of the interaction between pipe and soil is simplified. The main theoretical research results are as follows:

In 1967, Newmark and Hall put forward two assumptions when studying buried pipelines: regardless of the inertia force of field deformation and the common movement of pipe and soil, and based on these two assumptions, they proposed the buried pipeline analysis method with small deformation between pipe and soil .

In 1991, when t. Arginine and bor-jen Leek studied the stretching and bending reactions of buried pipelines under the action of faults, they established the elastic semi-infinite space thin-walled beam model and analyzed the process of tensile failure of pipelines with the improved ruler method .

In 2007, Hao ting yue and Chen guiqing studied the interaction between buried pipe and surrounding soil, and proposed a method to determine the soil spring model by simulating the interaction between pipe and soil.

In 2011, jing liu et al. studied the buckling instability of large diameter underground pipelines through subsidence areas, separated the pipelines and surrounding soil from the semi-infinite soil medium, and established a new model of tube-soil interaction under subsidence.

In 2016, ding qingpeng et al. used the classical continuous foundation beam model to analyze the non-settlement buried pipeline, focused on the relationship between the deflection and deformation of the pipeline, deduced the motion equation of the pipeline, and obtained the deflection and deformation function.

In 2016, han yinshan et al. studied the applicability of three theoretical calculation methods under strike-slip fault action in four aspects: burial depth, soil type, crossing Angle and pipe type.

At present, the theoretical analysis model mainly consists of beam model and cable model. In the existing specifications of various countries, classic methods such as new mark-hall method and Kenne street method are mostly adopted. When the amount of fault dislocation is large, the deformation of pipeline and soil mass will enter into nonlinear state, so the assumption of theoretical analysis method is not applicable.

## 2.2. Numerical Simulation of Buried Pipeline

Numerical simulation analysis method is based on finite element method modeling, using numerical simulation software for numerical analysis, can simulate more complex engineering problems.

In 2001, Takada established the buried pipe shell model by using the finite element software, analyzed the buckling effect of buried pipes under the action of faults, and came to the conclusion that the buried pipes under the action of faults were mainly subjected to axial strain.

In 2006, Yang juntao used busieneske method to solve the additional load of pipeline under the action of faults, and made corresponding curve fitting of the obtained additional load, finally used the elastic foundation beam theory to solve the internal force and deformation of pipeline, and derived the corresponding expressions of two different boundaries.

In 2010, he shuo, Chen yanhua et al. used the ADINA finite element software to study the buried thermal pipeline through the fault area, and established the buried pipeline model based on the thermodynamic coupling effect.

In 2013, li haisheng et al. conducted numerical simulation of the mechanical properties of shallow buried gas pipeline under rock fall impact by using ANSYS finite element software, discussed the main influencing factors of the mechanical properties of gas pipeline with shallow buried depth, and obtained the mechanical rules of buried gas pipeline under rock fall impact.

In 2014, wang chunli established a new soil spring model for buried pipelines by using ADINA finite element software, based on which various mechanical properties of buried pipelines across faults were analyzed and studied.

In 2016, xue jinghong et al. established a shell element model to simulate buried pipelines by using ADINA finite element software, taking into account the influence of variable diameter position, soil type and pipeline wall thickness on pipelines, and drew some useful conclusions.

In 2017, quan kai et al. used ABAQUS software to study the deformation response of buried pipelines under the action of strike-slip faults, and concluded that the maximum deformation position of pipelines was 4 ~6m away from the fault level, and the internal pressure of pipelines could reduce the buckling deformation of pipelines to a certain extent.

In 2018, zhang jie et al. analyzed the mechanical behaviors and failure modes of non-pressure and pressure pipelines under different dislocation quantities in different strata by establishing a pipe-soil coupling three-dimensional numerical calculation model, and drew some useful conclusions.

## 2.3. Experimental Study on Buried Pipeline

In 1988, takada zhiro made a sandbox experimental device for buried pipelines based on the geometric similarity ratio of 1:16. The shear deformation of buried pipelines during soil liquefaction was studied on the vibration table with the sandbox device, and the value range of equivalent spring constant of simplified soil was determined through experiments.

In 2008, Jasmin et al. independently developed a loading device to conduct tests on the pressure, shear and bending at the joints of concrete pipes, and analyzed and studied the mechanical properties of the joints.

In 2013, zhang xu designed the components of the test device according to the actual situation under the uneven settlement of the pipeline and the stress conditions of the pipeline. The test results are obtained through the buried pressure loading of pipeline, and the test data are analyzed to draw the curve diagram of the internal force and settlement of pipeline with the change of hole size.

In 2015, tang aiping studied the strain characteristics of buried pipelines under large displacement of reverse fault through indoor simulation test, and discussed the influence of such factors as fault displacement and the included Angle between pipelines and faults on the mechanical response of pipelines.

In 2018, Yang chengwu considered the effect of buried conditions, tube-soil interaction and working pressure inside the pipe on the deformation of buried polyethylene pipe, and established the test model of reaction of buried polyethylene pipe under various loading conditions.

In 2019, fang mingzhong studied the influence of pipe diameter, main pipe spacing, branch position and soil mass on the mechanical properties of buried infusion pipeline network according to the self-designed experimental device.

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