DYNAMIC ANALYSIS OF BURIED PIPELINES UNDER BLAST LOADING BY DIFFERENTIAL QUADRATURE METHOD

Parvin RISMANI
M.Sc. Student, Persian Gulf University, Bushehr, Iran
parvin.rsmn@gmail.com

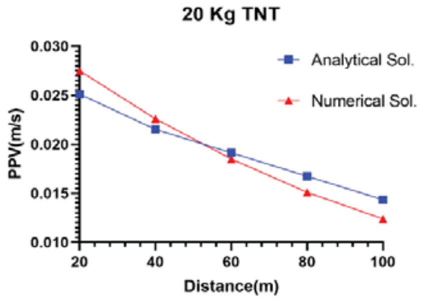
Alireza FIOUZ
Faculty of Civil Engineering, Persian Gulf University, Bushehr, Iran
fiouz@pgu.ac.ir

Amin KESHAVARZ
Faculty of Civil Engineering, Persian Gulf University, Bushehr, Iran
keshavarz@pgu.ac.ir

Keywords: Pipeline, Buried pipeline, Blast load, DQ method, Dynamic analysis

Lifeline categories are classified into three groups of totally buried, semi-buried and on-surface pipelines. Because of preserving the visual beauty and using soil as a protecting layer, totally buried pipelines are more noticeable. In addition to the failure of service, lifelines destruction caused many problems, such as environmental pollution, firing, and wasting of national resources. These pipelines are influenced by liquefaction, landslide, fault, and earthquakes. The pipe's failure is based on three different criteria, including stress, strain, and peak particle velocity (PPV) (Abedi, 2016). The motion equation of pipelines is simulated by a beam on an elastic foundation. Nourzade et al. (2011) investigated the static analysis of buried pipes without considering the time factor, which is an important parameter in the explosive discussion. Abedi et al. (2016) deduced the dynamic equation of buried pipelines under explosion and used peak particle velocity to show the results. Researchers use numerical and analytical methods to solve the equation. The use of numerical methods due to their accuracy in answering and the lack of complexity of analytical solutions is welcomed by researchers. In numerical method dimension of equation meshed. Chosen points and the relationship between them will determine the accuracy of the answer, which means the finer mesh, the more accurate result will be, but finer mesh would require impractical computational resources (the computational time and memory storage requirements). Some types of numerical methods are finite elements and finite difference and differential quadrature. In this article, differential quadrature (DQ) has been used to solve the equation. Differential quadrature method approximate a derivation of f(x) with respect to *x* as a weighted linear sum of the function values at all discrete points, including the two end points (Wang, 2016). This method has high precision by lower mesh than required in other ways that cause fast enough by involving all points of the network to achieve answer (Wang, 2016). To compute the results, a program has been written in Matlab. Results show that differential quadrature can solve the problem with significant precision in comparison with the analytical solution as shown in Figure 1. Furthermore, the effects of different parameters such as distance, charge f TNT, mass and material of pipe on PPV (Peak Particle Velocity) have been searched Figure 1. Results show steel pipeline has better performance than polyethylene and as the weight of pipeline increase the peak particle velocity decrease (Table 1).

$$
\begin{aligned}
&\mathrm{EI}\frac{d^4v}{dx^4}+\mathrm{M}\frac{d^2v}{dt^2}+K_fV=w_n(x.t)\\
&\mathrm{w_n(x.t)}=\pi\frac{D}{2}P_sH\left(t-\frac{\sqrt{x^2+d^2}}{c}\right)e^{-at}e^{(a-\beta)\frac{\sqrt{x^2+d^2}}{c}}\frac{d}{\sqrt{x^2+d^2}}
\end{aligned}
\tag{1}
$$



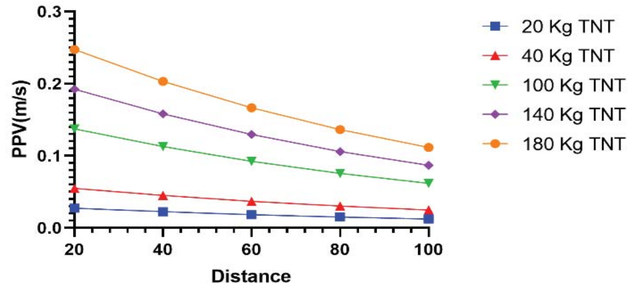


Figure 1. Effect of charge and Distance on PPV.

Figure 2. Comparison PPV between anaytical solution and DQM.

Table 1. Comparison PPV between steel pipes and polyethylene pipes.

	Polyethylene Pipeline				Steel Pipeline			
Module of elasticity (Pa)	$2.6*10^8$				$2.02*10^{11}$			
diameter (mm)	500	400	250	200	500	400	250	200
thickness (mm)	15.3	36.3	6.1	18.2	15.9	36.53	6.1	18.2
mass (Kg/m)	23.4	41.3	4.83	10.4	183.22	322.83	20	90.35
PPV-Buried (m/s)	0.0282	0.0292	0.0200	0.0190	0.0118	0.0162	0.0264	0.0200

REFERENCES

Abedi, A.S. (2016). A*nalytical, Numerical, and Field Study of the Dynamic Response of Buried Pipeline under Blast Wave*. Ph.D. Thesis, Shiraz University, Shiraz, Iran.

Abedi, A.S., Hataf, N., and Ghahramani, A. (2016). Analytical solution of the dynamic response of buried pipelines under blast wave. *Int. J. Rock Mech. Min. Sci.*

Nourzadeh, D., Khorshid, S., Takada, S., and Bargi, K. (2011). Analytical proposal to damage assessment of buried continuous pipelines during external blast loading. *Int. J. Comput. Math. Sci.*, *59*(27), 126–130.

Shu, C. (2000). *Differential Quadrature and Its Application in Engineering*.

Wang, X. (2016). *Differential Quadrature and Differential Quadrature Based Element Methods*.