PERFORMANCE –BASED SEISMIC RESPONSE OF BURIED STEEL PIPELINES

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Performance-Based Earthquake Engineering (PBEE) attempts to improve seismic risk through assessment and design methods that are more informative than current approaches. However, little work has been performed investigating the seismic response of buried steel pipelines within a performance-based framework. In this study the seismic demands of buried steel pipelines are investigated in a performance-based context. Several nonlinear dynamic analyses of four buried steel pipe models with different D/t, H/D ratios and different soil properties and different pressures, performed under a suite of far-field earthquake ground motion records were scaled to several intensity levels to investigate the behavior of buried pipeline from elastic response to failure. Several scalar ground motion intensity measures (IMs) are used to investigate their correlation with engineering demand parameter (EDP) which is measured in terms of peak axial compressive strain in critical section. Using regression analysis it is found that velocity-based IMs are the most efficient in evaluating the buried pipe response.

To investigate the effects of different material and geometrical properties, four buried pipeline of API 5L Grade X65 models with different pipe and soil properties are considered. To simulate soil-pipeline interaction effects in axial, transverse and vertical directions bilinear force displacement curves (elastic-perfectly plastic) representation of soil are employed based on suggestions of the American Lifeline Alliance (2001). The FE code ANSYS was used in the analyses. The buried pipeline and the surrounding soil are modeled using SHELL181 and COMBIN39 elements, respectively. To simulate soil-pipeline interaction effects, each node of the model was connected to three spring-dashpots.

Before deciding which ground motion IMs correlate well with seismic demand on buried pipes the first question to be answered is: how is the seismic demand measured? The peak axial compression strain at the critical section would seem the most obvious candidate to use for EDP of buried pipe, as it directly relates to occurrence of damage. It is necessary to examine a wide range of potential IMs for determining the best IM for prediction of the buried pipe response. Therefore a total of 16 different IMs are considered and summarized in Table1. Definitions of all IMS can be found in Riddell (2007). In this paper, a one-parameter log-log linear regression of peak axial compressive strain on IM is utilized in assessing the efficiency of each alternative IM. The approach of assessing the efficiency of IMs can be found in Shome and Cornell (1999). Figure 1 illustrates the obtained pipe peak compressive axial strains from nonlinear dynamic analyses of model 1 for two intensity measures, PGA and velocity spectrum VSI, respectively. The plots indicate the efficiency of these IMs. It is apparent that there is a reduced dispersion in the relationship between strain and VSI (σ=0.71) as compared to that of strain and PGD (σ=0.77). In this article dispersion refers to the standard deviation of the natural logarithm of the values.

Table 1. Intensity Measures used in the analyses

No.	Intensity measure(IM)
1	Peak ground acceleration, PGA
2	Peak ground velocity, PGV
3	Peak ground displacement, PGD
4	PGV2/PGA
5	RMS acceleration, RMSa
6	RMS velocity, RMSv
7	RMS displacement, RMSd
8	Arias intensity, Ia
9	Cumulative absolute velocity, CAV
10	Acceleration spectrum intensity, ASI
11	Velocity spectrum intensity, VSI
12	Sustained maximum acceleration, SMA
13	Sustained maximum velocity, SMV
14	Spectral acceleration, Sa(T_1, 5%)
15	Spectral velocity, Sv(T_1, 5%)
16	Spectral displacement, Sd(T_1, 5%)

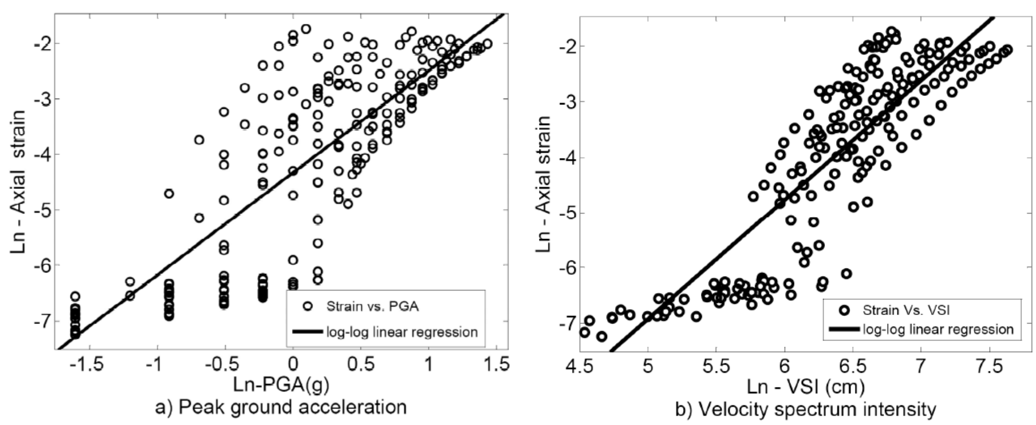

Figure 1. Comparison of EDP-IM scatter plots for the nonlinear dynamic analyses of model 1

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