

**Effect of Nonlinear Soil Modeling on Ground  
Response at Macau**

By

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**Master of Science in Civil Engineering**



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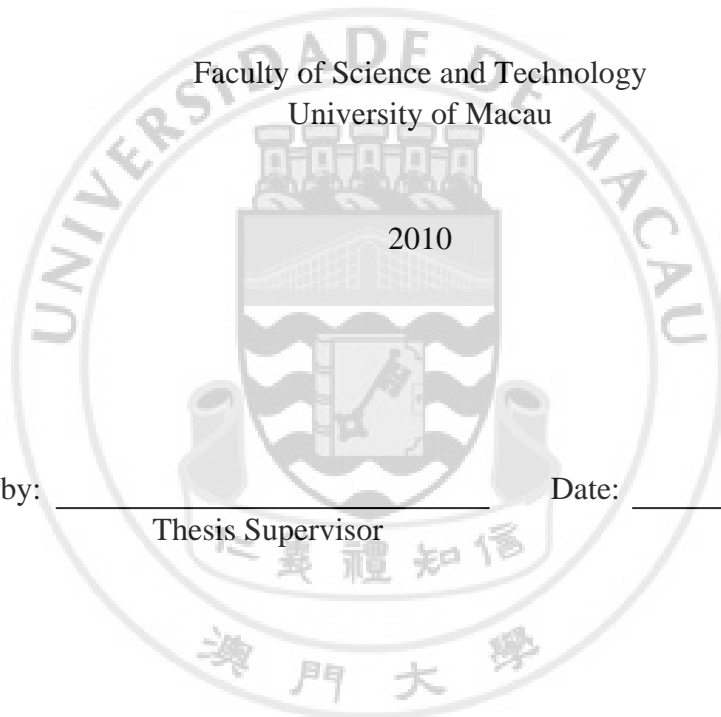
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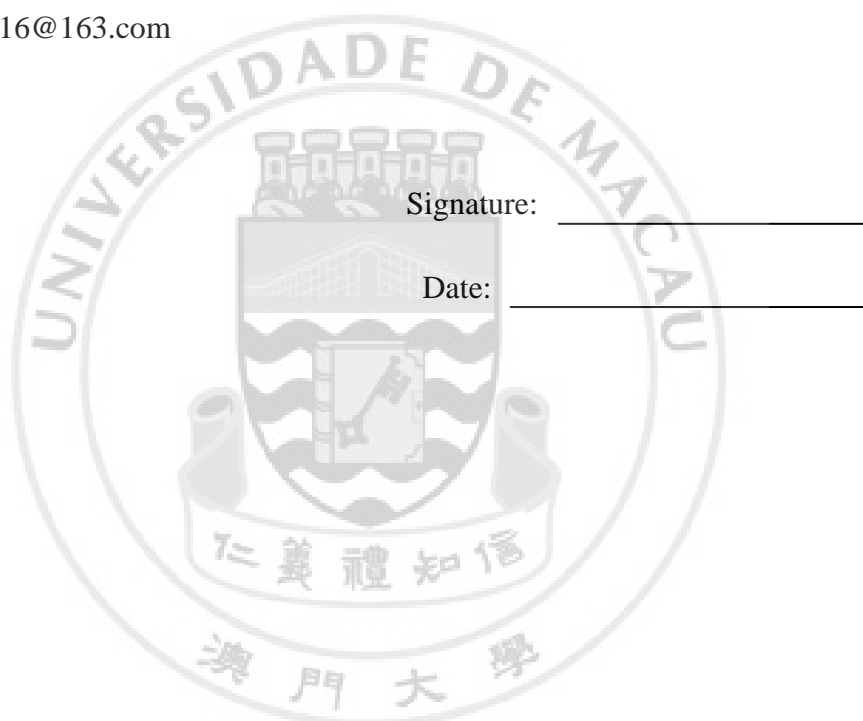
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Abstract

## Effect of Nonlinear Soil Modeling on Ground Response

at Macau

by Zhou Jianmei

Thesis Supervisor: Dr.Lok Man Hoi

The study is part of a larger project for the investigation of seismic ground response at Macau. Previous tasks including site investigation and measurement of shear wave velocity of local soils were carried out in recent years. A series of ground response analyses consisting thousands of cases using equivalent linear procedure was conducted using the data obtained from the investigation. In particular, the current study is aimed to investigate the effects of nonlinear soil modelling on the seismic ground response at Macau

To obtain linear and nonlinear site response spectra during seismic loading, site response analyses for some representative sites were performed using the one-dimensional equivalent linear (PROSHAKE) and the fully nonlinear (D-MOD2000) seismic site response codes. The model parameters for nonlinear analysis were estimated based on the modulus degradation and damping curves used for the different soils in Macao as input for the equivalent linear method.

$V_{s30}$ , which is defined as the ratio of 30m to the travel time of a vertically propagating shear wave between a depth of 30m and the ground surface, was used in this study for classification. The idealized cases were classified based on this classification into three site classes. The comparisons were made for each site class between linear and nonlinear analysis.

From the comparison of results obtained in this study, the shape of response spectra from both equivalent linear and nonlinear analyses is similar to each other for lower input maximum horizontal acceleration less than 0.3g, while the comparison for input

maximum horizontal acceleration of higher than 0.3g, the shapes of response spectra from linear and nonlinear programs start to deviate from each other. Therefore, the nonlinear analysis is necessary when the input motion holds large magnitude.

The finding also shows that at low to moderate acceleration levels, acceleration at all soil sites are likely to be higher than rock site. However for stiff and soft deposit case, especially at deep stiff and soft deposit soil sites, maximum horizontal acceleration tends to be less than rock site at high level of earthquake, such as  $a_{\max} > 0.5g$  from both linear and nonlinear analysis.

The comparison between GB50011-2001 and calculated response spectra were made and the modification on design response spectra were recommended for local sites.



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