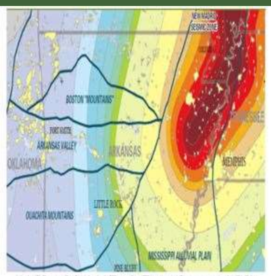
Seismic Ground Motion Data Analyses for North-East Arkansas (NEA)

Estimating the seismic site coefficients by performing site specific ground motion response analysis(SSGMRA) and developing liquefaction hazard maps.


(a) New Madrid Fault Zone (Source: AGS)

Highlight | Sep. 2020

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Northeast Arkansas (NEA) is very vulnerable in the event of major earthquakes because of its proximity to the New Madrid Seismic Zone (NMSZ). Besides, it has a deep deposition of soft soil down to bedrock ranging from 200 m~1000 m. This identical geologic condition has a significant impact on the estimation of seismic site coefficient. Code-based design procedures such as AASHTO (American Association of State Highway and Transportation Officials) do not account for this deep deposition of soft soil down to bedrock. The purpose of this study is to investigate the usefulness of performing site-specific ground motion response analyses (SSGMRA) over code-based approaches for the seismic design of transportation infrastructures such as bridges in Northeast Arkansas (NEA) as a means of reducing short-period design ground motions. Besides, liquefaction hazard analysis has been performed on 131 selected sites to develop liquidation hazard maps in terms of liquefaction potential index, vertical settlement, horizontal displacement, etc.

Background

New Madrid Seismic Zone has a history of producing a series of powerful earthquakes around the magnitude of 7.5 which were very devastating especially to the human. It has the potential of producing major earthquakes in the future also. NEA is very vulnerable due to its proximity to NMSZ and it has a deep deposition of soft soil, which plays a significant role during the period of major earthquakes. Code-based design procedures such as the AASHTO do not count this deep deposition of soft soil. Recently AROT (Arkansas Department of Transportation) has taken a plan to construct bridges for new highways as well as for the repairment of existing roadways. ARDOT usually follows the guideline of AASHTO for bridge construction. If code-based procedures are followed, this may lead to over-designing a structure for short period at significant cost and under designing a structure for long period at significant risk. To account for the impact of these identical geologic conditions, it is essential to perform SSGMRA. As a reason why, the AASHTO recommends performing SSGMRA in case of deep deposition of soft soil, large ground motions, etc.

Project Summary

The main objective of this study is to bring out the usefulness of performing SSGMRA over code-based design procedures such as AASHTO. Specific objectives are to (i) Gathering shear wave velocity profiles data from previous projects within Arkansas and Mississippi Embayment (ME) area, (ii) Collecting routine based geotechnical data (SPT, CPT), (iii) Collect and adjust appropriate time history data, (iv) Developing delineated design response spectra (DDRS) and estimating seismic site coefficients and (iv) Performing liquefaction hazard analysis and developing liquefaction hazard map for NEA.

Status Update

Shear wave velocity profiles (SWVP), CPT (cone penetration test SPT (standard penetration test) data have been collected from the previously completed projects within Arkansas and the ME area. These data are required for seismic hazard and liquefaction analysis. Target motions have been developed (return period 1000 years) for Five ARDOT bridge sites from the web-based USGS (the United States Geological Survey) tool called the uniform hazard tool. Deaggression analysis has been performed using this tool to determine the mean magnitude of the earthquake, M_w, and seismic source to site distance, r.

After that, time history data were collected from the US Nuclear Regulatory Commission Regulation (NUREG) database and ground motions were selected based upon the thumbs rule defined by *cox et al 2012*. The initially selected ground motions usually differ from target motions. Therefore it is required to perform matching of selected motions with the target one. Spectral matching was performed by using seismomathch 2020 software for adjusting ground motions. Then these ground motions were used as input ground motions in DEEPSOIL 7.0, a platform for performing 1D (dimensional) site response analysis by EQL (equivalent linear analysis) and NL (non-linear analysis) method. After that DDRS (delineated design response spectra) were developed to calculate the spectral acceleration or seismic site coefficients for five ARDOT bride sites. While developing DDRS, analyses results of both EQL and NL were accounted for (50%-50% weighted average). As a sample of the analysis results, the developed DDRS for Bay, Arkansas, ARDOT bridge site has been shown in Figure 1.

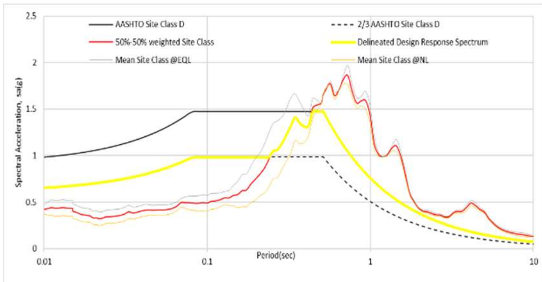

Figure 1. DDRS for Bay, ARDOT Bride Site

Seismic site coefficients i.e. PGA (peak ground acceleration 0.01 second) were estimated from the developed DDRS. This PGA and CPT/SPT/S_V (shear wave velocity) are required to perform liquefaction hazard analysis. Liquefaction analyses have been performed for 131 sites using CPT-IT (geologismiki) software. After performing the liquefaction analysis, GIS (Geographic information system) tool was used to develop liquefaction hazard maps. A liquefaction hazard map in terms of liquefaction potential index has been shown in Figure 2.

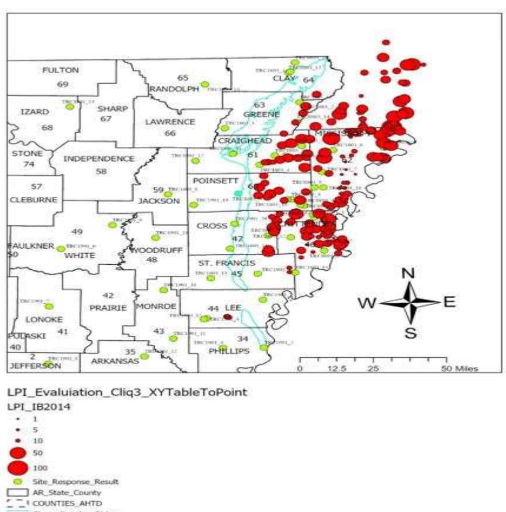

Figure 2. Liquefaction Potential Index for Different Locations in NEA.

Impacts

The findings of this study show that a significant reduction in spectral acceleration about 33% compared to that of AASHTO for a short period of time (<0.5 seconds). Hence, this study is expected to help the engineers to design bridges more efficiently and cost-effectively without field investigation for the selected bridge sites. Besides, the liquefaction hazard map will help the foundation engineers to design the foundation of bridges more effectively.

The main benefits of this study have been: (a) increase the usefulness of performed SSGMRA, (b) enhance training opportunity for students in the region, (c) help design officials to design bridges efficiently, and (d) create highly prepared transportation workforce. The deliverables of this project are: (1) a technical report containing seismic site coefficient data and guidelines for seismic hazard and liquefaction analysis and (2) dissemination of findings at conferences and symposia such as the 2020 Tran-SET Conference.

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

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