Nuclear Engineering and Technology xxx (2017) 1–8

Available online at ScienceDirect

Nuclear Engineering and Technology

journal homepage: www.elsevier.com/locate/net

Original Article

Seismic Assessment and Performance of Nonstructural Components Affected by Structural Modeling

Jieun Hur [a,*], Eric Althoff [b], Halil Sezen [c], Richard Denning [d], and Tunc Aldemir [e]

[a] Ohio State University, 2070 Neil Avenue, Columbus, OH 43210, USA
[b] Ohio State University, 2070 Neil Avenue, Columbus, OH 43210, USA
[c] Ohio State University, 2070 Neil Avenue, Columbus, OH 43210, USA
[d] 2041 Hythe Road, Columbus, OH 43220, USA
[e] Ohio State University, 209 West 19th Avenue, Columbus, OH 43210, USA

ARTICLE INFO

Article history:
Received 20 December 2016
Received in revised form
16 January 2017
Accepted 17 January 2017
Available online xxx

Keywords:
Failure Probability
Nonstructural Component
Seismic Behavior
Structural Dynamic Analysis

ABSTRACT

Seismic probabilistic risk assessment (SPRA) requires a large number of simulations to evaluate the seismic vulnerability of structural and nonstructural components in nuclear power plants. The effect of structural modeling and analysis assumptions on dynamic analysis of 3D and simplified 2D stick models of auxiliary buildings and the attached nonstructural components is investigated. Dynamic characteristics and seismic performance of building models are also evaluated, as well as the computational accuracy of the models. The presented results provide a better understanding of the dynamic behavior and seismic performance of auxiliary buildings. The results also help to quantify the impact of uncertainties associated with modeling and analysis of simplified numerical models of structural and nonstructural components subjected to seismic shaking on the predicted seismic failure probabilities of these systems.

1. Introduction

The seismic probabilistic risk assessment (SPRA) integrates all elements such as structures, systems, and components in a nuclear power plant (NPP) and evaluates the safety of the entire plant under seismic events. Although the seismic performance of structures and nonstructural components are complicated and diverse, more simplified and effective structure, system, and component models are required for the massive computational loads in SPRA [1]. This study presents the quantification of variations induced by simplified and detailed structural models on the seismic performance of nonstructural components. Impacts of structural modeling strategy of auxiliary buildings will be investigated through estimation of epistemic uncertainties for the operational failure of nonstructural components (NSCs).

* Corresponding author.
http://dx.doi.org/10.1016/j.net.2017.01.004

In this study, the seismic performance of an auxiliary building is evaluated with simplified 2D and detailed 3D models. The 2D models are generated with simplified sticks, while the 3D models are developed with finite elements (FEs). For realistic plans of auxiliary buildings, the detailed 3D model includes both asymmetric mass distribution and stiffness of structures. For the simplification of the auxiliary building, a symmetric 3D model is also generated with uniformly distributed mass and symmetric stiffness, and its seismic performance is compared to that of the asymmetric 3D model. Using the modal and time history analyses, the dynamic characteristics of the 2D and 3D models are determined, and their seismic responses are estimated. Based on the dynamic analysis results from structural models, the seismic performance of the NSCs are evaluated by considering their operational and physical failure. Effects of modeling and analysis assumptions for each structural model on the performance of NSCs are summarized and analyzed in terms of their seismic failure probabilities, as well as their accuracy, time required for analysis, and modeling simplicity.

In this study, Section 2 describes the auxiliary building and its modeling procedures in 2D and 3D, and Section 3 presents a set of dynamic analysis results using the modal and time history analyses. The analysis results from different models are compared, and their difference and variations are quantified. In sum, Section 4 concludes this study.

2. Model description

2.1. Auxiliary building

2.1.1. General description of a realistic auxiliary building

Due to obvious security risks, structural plans for NPPs are not readily available. In that respect, a partial plan set of the decommissioned Connecticut Yankee NPP in Haddam, CT, USA was obtained from the Library of Congress (http://www.loc.gov/pictures/item/ct0714.sheet.00003a/). From this partial plan set, a set of modified structural plans was created to represent a typical NPP auxiliary building as shown in Fig. 1.

The Connecticut Yankee NPP auxiliary building was a reinforced concrete building with two stories above ground level and a partial basement. As with most buildings, the structural components (such as walls, slabs, beams, and columns) of this auxiliary building had diverse dimensional and structural properties varying throughout its footprint. As typical NPP auxiliary buildings are likely to have some heavy equipment, the structural plan set created for this paper was

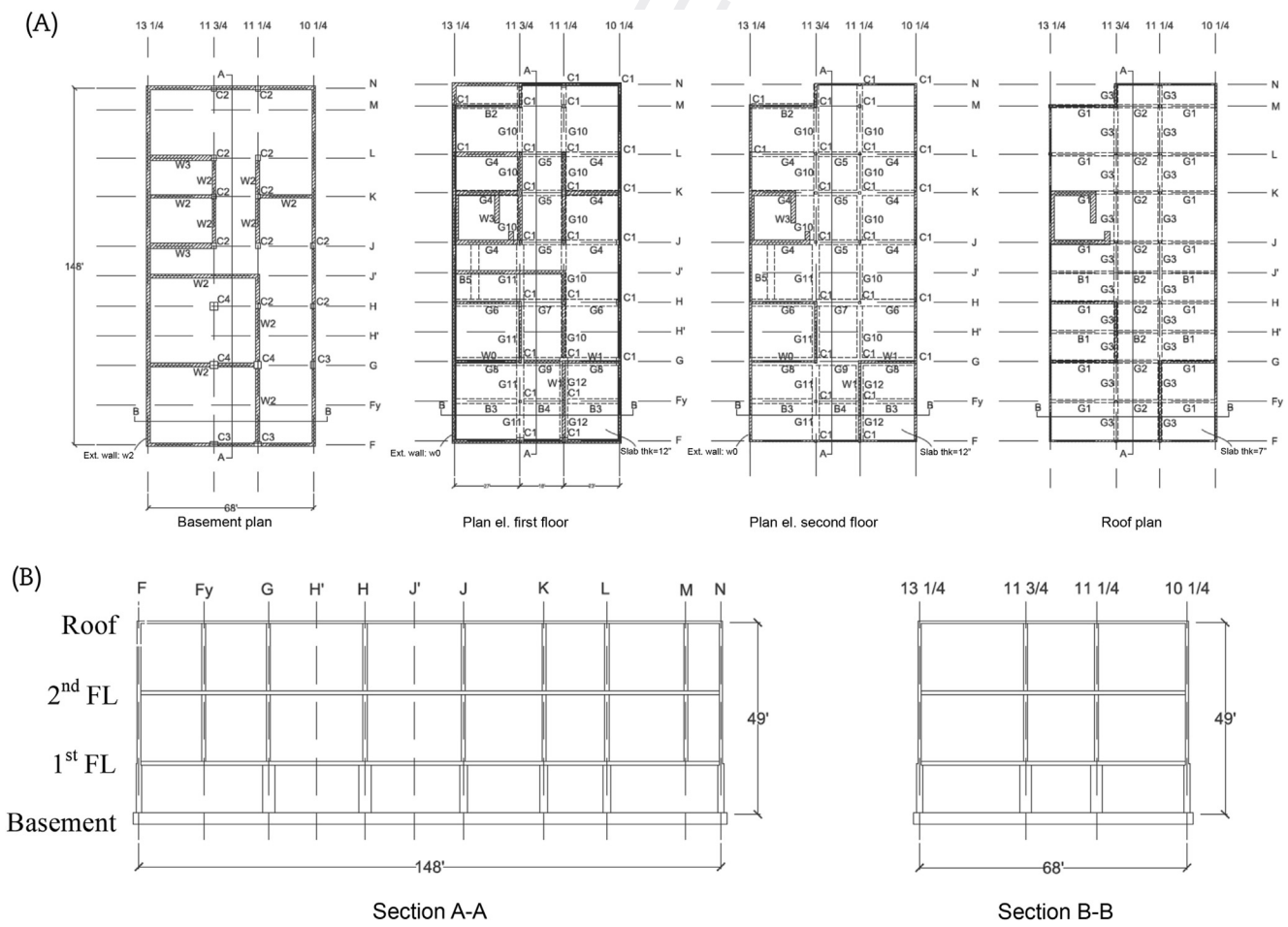

Fig. 1 – Modified structural plans of Connecticut Yankee nuclear power plant auxiliary building. (A) Plan drawing of each level. (B) Elevation drawing of each side. FL, floor.

Please cite this article in press as: J. Hur et al., Seismic Assessment and Performance of Nonstructural Components Affected by Structural Modeling, Nuclear Engineering and Technology (2017), http://dx.doi.org/10.1016/j.net.2017.01.004