Experimental studies on CSRDM specimen to validate the use of Ritz vectors for the response evaluation of structures subjected to multi-support excitation

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HIGHLIGHTS

• Ritz vector is used for the first time to analyze multi-support excitation problem.
• Efficiency of Ritz vector over Eigen vector is studied.
• Effect of spatial variation of ground motion in the responses are analyzed.
• Experimental testing on CSRDM rod for multi-support excitation has been carried out.
• The numerical formulation and their results have been compared with experimental results.

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ABSTRACT

The control and safety rod drive mechanism is a classic example of a multiply supported and differentially excited structure as it receives varying inputs at each of its supports as they are connected at different parts of a building. The responses of such systems are conventionally computed using pseudo-static method in which the dynamic component is evaluated by time history analysis, response spectrum method or modal analysis. In the present work the dynamic components are evaluated by using Ritz vectors and are compared with the conventional methods namely time history analysis and modal analysis. The usage of Ritz vectors as an alternative for conventional modal vectors has been validated through an experiment conducted on a control and safety rod drive mechanism (CSRDM) subjected to differential input motion. The validation of the code developed for this purpose is carried out for a bridge structure.

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1. Introduction

Conventional earthquake analysis of structure for seismic forces assumes that the ground motions between various supports are identical in space and are represented by response spectrum, time histories, power spectral density functions etc. In the case of long span structures such as bridges, tunnels etc. the effect of spatial variability in the earthquake motion has to be considered to determine the true behavior of the structure. The main reasons for the change in the spectral properties are due to (1) the systematic time shifts in the arrival of the seismic waves at the supports called as the wave passage effect, (2) the loss in coherency due to the difference in the manner of superposition of the waves arriving from different sources and also due to the reflections and refractions the wave encounters as it passes through the various heterogeneous layers of the earth crust, called as incoherence effect, (3) the change in the frequency content of the wave as it passes through the various layers of the soil called as local soil effect.

By virtue of its functionality, a CSRDM specimen is supported at three locations at different elevations of a nuclear reactor. The impedance expression at each of this location is not unique, both in terms of magnitude as well as phase. This results in varying input excitation to each support location of CSRDM specimen, though the input acting on the reactor structure is same.

In early stage, most of the studies investigated only the wave passage effect on the response of structural systems simulated using relatively simple finite element models (e.g. Bogdanoff et al., 1965; Masri, 1976). Seismic ground motions were generated using