Seismic-Resistant Investigation of Multi-Storey Building by Response Spectrum Method

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The present article attempts to evaluate the earthquake resistance of a four-storey building frame. It also compares the performance of buildings with soft ground floors and different infill parameters, such as brick wall and shear wall. The Indian standard code (IS-code) of practice (IS: 1893, Part-1:2002) guidelines and methodology are used to analyze the problem. Response spectrum method, involving various modal participations, is employed to evaluate the nodal forces in the typical beam-column junctions. The frame members, infill walls and floors are tackled as rigid end joints, panel element, and diaphragms rigid in-plane, respectively. Linear elastic analysis is performed with individual floor mass and stiffness, taking into account the building as a multiple degrees of freedom system. The effect of damping and the soil criteria are also studied as per the provision of IS-code. The investigation concludes that the proper mass and stiffness distribution in multi-storied buildings will minimize the hazardous effects of seismic excitation. The mathematical model of the building finally recognized the hazardous features of Indian reinforced concrete buildings and recommends some measures to improve the seismic performance.

NOMENCLATURE

A	arbitrary constant
A_c	area of equivalent diagonal strut
$(A_h)_j$	design acceleration spectrum for the j^{th} mode
E_m	elastic modulus of infill masonry
$[F]$	force vector
K_i	i^{th} storey stiffness
$[K]$	stiffness matrix
K_w	stiffness of the infill wall
L_d	length of diagonal strut
$[M]$	mass matrix
p_j	modal participation factor for the j^{th} mode
Q_{ij}	design lateral force at the i^{th} floor and the j^{th} mode
V_{ij}	storey shear force at the i^{th} floor and the j^{th} mode
ν_i	peak storey shear force
W_i	weight of the i^{th} floor of the building
$[\ddot{X}]$	acceleration vector
$[X]$	displacement vector
$x(t)$	time variant displacement
ω	circular frequency of the vibration
(φ_{ij})	mode shape coefficient at the i^{th} floor and the j^{th} mode
φ_i	i^{th} eigenvalue or mode shape
θ	slope of the diagonal strut
Δ_i	storey drift at the i^{th} floor

1. INTRODUCTION

Earthquakes are a constant source of both fascination and horror. The deaths and loss of property during earthquakes are caused by the collapse of buildings. In the process of architectural design, it is a common practice to make major and minor adjustments to create habitable space formation. Rational studies and the knowledge regarding the performance of building structures during earthquake excitation show that maladjustments decrease the seismic-resistance capacity of the structure and lead to the collapse of the building. An integral seismic-resistant building system, in which all the components of the building's structure can effectively interact during the seismic action, is utterly necessary. Several studies and various recommendations from different building codes have been carried out to minimize the damage of the structures due to earthquakes. The Bhuj earthquake, which occurred in India in January 2001, left thousands of people dead or injured, was representative of an inadequacy in seismic-resistive structural system. On the other extreme, an earthquake near Olympia, Washington, had a comparable magnitude but resulted in only minor injuries that numbered in the hundreds. While there was extensive damage to structures during the Olympia earthquake, no devastation was reported.[1] The difference in outcomes from these two earthquakes can be attributed to the use of seismic-resistant design techniques.

An overall regularity in building configuration, mass, and the stiffness distribution are considered to be the basics feature of earthquake resistant buildings. The eleven-storey Manasi Apartments in Ahmedabad, India, collapsed due to the inverted pendulum effect during the 2001 earthquake. The weight of the swimming pool and reservoir a top the building contributed to the severity of the damage.[2] Mezzi et al. investigated the fundamental issue of the structural configuration of buildings with various load-resisting frames and peak ground acceleration.[3]