1. INTRODUCTION

1.1 General overview

Reinforced concrete (RC) buildings are mostly used recently in the construction industry. Masonry is also used as popular and economical materials in the RC buildings. Recently, the most common structural system for residential, commercial, and office buildings consists of multi-level framed structures with masonry infills. Therefore, it is important to determine the earthquake behavior of RC structures with masonry infills under seismic load. The masonry panels are generally not considered in the analysis and design process and it is treated as an architectural component. Nevertheless, the presence of masonry infill walls has a significant impact on the seismic response of a reinforced concrete frame building as it increases structural strength and stiffness. The design of masonry infills with improved earthquake resistance presents a challenge for structural Engineers. The importance of the infill-frame interaction increases especially under the impact of earthquakes.

In the recent era, the seismic load acting on the structure is mostly higher than the considered design load. Many of the seismic design codes give the guidelines to account nonlinearity in structure by using response reduction factor (R-factor). The response reduction factor is the seismic design tool which shows the level of inelasticity in the structure. The R-factor also identified as a "response modification factor" or "behavior factor" in other country codes. In earthquake phenomena, the structures are generally designed by using linear static or dynamic method to resist the dynamic loads; the response reduction factor plays an important role to reduce the elastic behavior to the inelastic behavior of the structure. The other country codes and guidelines provide the '*R*' values for the different structures. However, the code (IS 1893 Part-1:2016) does not give any specific explanation on different issues like structural configurations, irregularities, openings in masonry infills, etc. So there is need to study the seismic design parameters of existing RC structures with masonry infill.

A natural disaster namely an earthquake comes at any time, so the quality of the construction should be good enough. Seismic evaluation and retrofit of structure is the best option to avoid the loss of life and infrastructure. Most of the constructions are not able to sustain the seismic loads due to their design and construction deficiency and inherent structural planning. So, there is a need to go for a retrofitting option. Retrofitting can be defined as the process of modification of an existing structure to improve its overall performance. These retrofitting strategies are especially needed in earthquake-prone areas. In the present study, a systematic approach for the seismic evaluation of RC structure contains three methods, *viz.*, Earthquake Disaster Risk Index (EDRI) method, Quadrants assessment method, and material strain limit approach. Earthquake Disaster Risk Index (EDRI) method is utilized for the preliminary survey of RC structures in the field (Koyna-Warna region). The Quadrants assessment method and material strain limit approach are utilized for the detailed assessment of RC structures.

1.2 Research Need

Past evidences have shown that the structures in India are more vulnerable due to earthquakes. The RC building construction trends are increasing day by day. In current construction practice, buildings are designed & seismically evaluate based on the linear methods only, but the nonlinearity of the structure is more important in the seismic area and it is incorporated by a response reduction factor (R-factor). Thus, it is essential to evaluate the existing RC buildings with masonry infills by using nonlinear static analysis in earthquake prone areas and retrofit them based on the deficiencies in the structure. Also, there is a need to study the seismic design parameters, *viz.*, ductility, overstrength factor, and response reduction factor, etc. because, the code (IS 1893 Part-1:2016) does not provide the value of response reduction factors for RC infilled frames. Thus, it is essential to study the real behaviors of RC buildings with masonry infill through nonlinear analysis and suggest the circumstances which affect the response of the structure.

1.3 Past Earthquake in India

India has experienced several devastating earthquakes in the past, resulting in a large number of deaths and severe property damage. In the last few decades, a dramatic increase in the losses caused by natural catastrophes has been observed in India. India has had a number of the world's greatest earthquakes in the last century. In fact, more than 60 percent of the areas in the country are prone to damaging earthquakes (Pradeep Kumar and Murty, 2014). The country has witnessed several major earthquakes affecting the areas as seen from Table 1.1 (Jain, 2016). The main reasons for such huge casualties are low earthquake awareness and poor construction practices. Based on the history of seismic activities in past 100 years and related scientific studies, the Indian Meteorological Department (IMD) and the Bureau of Indian Standards (BIS) have classified the country into four seismic risk zones with the possible Modified Mercalli Intensity (MMI).

Table 1.1 Major Earthquakes in India

Year	Location	Magnitude in Richter Scale
1900	Coimbatore	6
1905	Kangra, Himachal Pradesh	8
1934	Bihar- Nepal Border	8.3
1935	Quetta	7.7
1941	Andaman Islands	7.7
1950	Assam-Tibet	8.6
1956	Anjar, Gujarat	6.1
1967	Koyna, Maharashtra	6.5
1970	Bharuch, Gujarat	5.2
1988	Bihar-Nepal Border	6.6
1991	Uttarkashi, Uttarakhand	6.4
1993	Killari (Latur), Maharashtra	6.2
1997	Jabalpur, Madhya Pradesh	6.0
1999	Chamoli, Uttarakhand	6.6
2001	Bhuj, Gujarat	7.7
2002	North Andaman (Diglipur)	6.8
2004	Sumatra	9.4
2005	Kashmir	7.6
2011	Sikkim	6.9
2016	Myanmar	6.7
2018	Assam	5.3
2021	Assam	6.0

1.4 Scope of Work

The study offers a wide scope of knowledge on earthquake disasters in the Koyna-warna region, Maharashtra. As per the survey report, low and moderate earthquake events have been occurring persistently for the last 50 years. Also, the villagers said that, the Koyna-Warna area had been experiencing earthquakes for several times in every six months. So the study focuses on this particular earthquake prone area, i.e., Koyna-warna region for the earthquake preparedness, which may reduce the loss of life and infrastructure. There are various ways of preparedness such as capacity building, and constructing earthquake resistant structure. Out of that "earthquake resistant structure" is the one way for earthquake preparedness. For that purpose, seismic evaluation and retrofit methodology can be used to check the capacity of the buildings and make them more earthquake resistive to sustain future earthquakes. Thus, the research provides a great scope for seismic evaluation and retrofit of existing RC building in the earthquake prone areas in order to focus on respective disaster planning and decision making. This study aims to evaluate the seismic performance of existing RC buildings with masonry infill in seismically active area and suggest retrofit solutions based on their deficiencies.