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A REVIEW ON SEISMIC VULNERABILITY ASSESSMENT OF RC BUILDING.

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Abstract:-
Earthquakes pose a significant threat to urban infrastructure, and the vulnerability of reinforced concrete (RC) buildings has been a focal point of research in seismic engineering. This review aims to provide a comprehensive overview of recent advancements in the seismic vulnerability assessment of RC buildings, focusing on key methodologies, challenges, and emerging trends. The review begins by outlining the fundamental principles of seismic vulnerability assessment, emphasizing the importance of understanding the dynamic behavior of RC structures under seismic loads. Various analytical and numerical approaches employed for assessing vulnerability are discussed, including deterministic and probabilistic methods, nonlinear static and dynamic analyses, and performance-based assessments. The paper explores the role of material properties, construction practices, and design parameters in influencing the seismic vulnerability of RC buildings. It delves into the significance of retrofitting and rehabilitation techniques in enhancing the seismic resilience of existing structures, emphasizing the need for cost-effective and sustainable solutions. Challenges and uncertainties associated with seismic vulnerability assessment are critically examined, such as the inherent variability in ground motion predictions, the complexity of structural response, and the evolving understanding of seismic hazards. The review highlights the ongoing efforts to incorporate advanced modeling techniques, such as finite element analysis and machine learning, to improve the accuracy and efficiency of vulnerability assessments. Furthermore, the paper discusses recent case studies and real-world applications, illustrating how seismic vulnerability assessments have informed risk mitigation strategies and influenced building codes and standards. The importance of interdisciplinary collaboration between structural engineers, geologists, and seismologists is emphasized to develop holistic approaches for assessing and mitigating seismic risks.

Keywords:-
Seismic vulnerability assessment, Reinforced concrete buildings, Earthquake risk, Performance-based assessment, Structural resilience.

INTRODUCTION

In the realm of civil engineering, the seismic vulnerability of reinforced concrete (RC) buildings is a major problem because of the necessity to increase the structures' resistance to pressures caused by earthquakes. Being erratic natural phenomena, earthquakes may have disastrous effects on populations, causing fatalities, property destruction, and economic upheaval. Urbanization and population increase have made RC structures more susceptible to seismic shocks, which has led to a major focus in research and engineering efforts. an outline of the significance and intricacy of RC building seismic risk assessments. Due to several factors such material qualities, building methods, and design considerations, reinforced concrete (RC) structures—which are commonly employed in construction because of their strength and versatility—are vulnerable to seismic pressures. Comprehending and measuring this susceptibility is essential for formulating efficacious tactics to alleviate seismic hazards and enhance the general stability of structures.
Because earthquakes are dynamic events, assessing vulnerability requires a complex approach. While deterministic methods were the mainstay of early seismic engineering procedures, the development of probabilistic and performance-based approaches has been made easier by advances in analytical and numerical tools. These contemporary approaches provide engineers a more thorough understanding of

how reinforced concrete buildings react to seismic stresses, allowing them to more precisely identify weaknesses and create earthquake-resistant building designs.
Rehabilitating and retrofitting old RC structures is essential to reducing their seismic risk. Retrofitting is fixing flaws found during vulnerability assessments by reinforcing or altering structures to function better during earthquakes. The significance of sustainable retrofitting techniques that not only improve earthquake resilience but also complement international initiatives for ecologically responsible building methods is emphasized in the introduction.
Moreover, the evaluation of seismic risk is a multidisciplinary field. To gain a comprehensive understanding of seismic risks and their consequences for reinforced concrete buildings, collaboration is essential between structural engineers, geologists, seismologists, and other relevant disciplines. This multidisciplinary method integrates geological and seismic insights into engineering assessments to provide a more thorough assessment of risks.
This emphasizes how urgent it is to solve RC buildings' seismic susceptibility in light of growing urbanization and seismic dangers. This study is to support ongoing efforts to create robust buildings that can survive the unexpected forces of earthquakes by examining the approaches, difficulties, and new developments in seismic vulnerability assessment.

LITERATURE REVIEW

Ningthoujam and Nanda [1], employed statistical regression analysis on a record of 396 damaged structures inspected during the 2016 Manipur earthquake to determine a link between outcome variables. Examined were many Rapid Visual Screening techniques from the United States, India, New Zealand, Europe, Greece, Italy, Turkey, Japan, and Canada. A review of the documentation was done to confirm the casual parameters of the building damage distribution during the seismic activity, taking into account both structural and construction flaws, such as soft storeys, substantial overhangs, floating columns, re-entrant corners, state of maintenance and building materials, eccentric staircase location in relation to the plan, type of soil, number of stories, and building age. A new RVS sheet was proposed based on statistical regression analysis. It was observed that the different damage grades predicted by the suggested sheet agree 64.65% with the actual building damage.
Albayrak et. al. [2], 1643 structures in the northern section of Eskisehir, Turkey, were surveyed in-situ, and a sidewalk survey was used to evaluate the buildings' seismic stability. Zone II was determined to include the city. The street surveying technique created by Sucuoğlu served as the foundation for the seismic risk assessment process used for RC structures. The building's age, number of stories, soft story, short column, heavy overhangs, visual construction quality, and local soil conditions were the characteristics used for the assessment. Following the survey, each building's Earthquake Risk Score (ERS) was determined. The buildings were divided into three types of hazards: low risk, moderate risk, and high risk, based on ERS assessment. According to the findings, 218 of the buildings overall were classified as high risk and were advised to undergo a more thorough assessment.
Rautela et. al. [3], conducted a quick visual assessment of the Himalaya's two main tourist destinations, Mussoorie and Nainital in Uttarakhand, India. According to the seismic zoning chart of India, both of these locations are located in seismic zone IV. To adapt the FEMA 154/ATC-21 survey sheet to the circumstances of India for various seismic zones, a modification was made to it. To evaluate the losses caused by a seismic activity, the European Macroseismic Scale (EMS-98) parameters of grade categorization of likely seismic damage were applied. Sixty-six structures were evaluated, of which fourteen percent in Nainital and eighteen percent in Mussoorie showed a significant risk of seismic damage.
Arya and Agarwal [4], suggested a quick visual screening form for RC building seismic vulnerability assessments throughout all Indian seismic zones. Based on building type, damageability grade, and seismic intensity as recorded in previous earthquakes, the evaluation recommendations were developed. We talked about the specifics of IS 1893-2002, including the zone factor, importance factor, irregularities, soil type, etc.

Sarmah and Das [5], conducted RVS for a structure that was already in Guwahati, Assam. A total of one hundred randomly chosen buildings—residential, commercial, religious, etc.—were included in the sample. Based on India's seismicity, the city is located in seismic zone V. Taking into consideration the population density and typology, the RVS was carried out on five wards within the city. The other factors, such as the city's geoprofile, the climate, and its seismic past, were also taken into account. The structures were adapted in accordance with FEMA rules, and the RVS processes created by Jain et al.[10] were employed. In order to help the public authorities prioritize which buildings should get suitable remedial actions, such as retrofitting or replacement, the research provided a rapid and comprehensive overview of the stock of existing structures.

Shah et. al. [6], conducted Rapid Visual Screening on more than 1000 residential buildings built over two distinct historical periods in Jeddah, Saudi Arabia, in order to assess the distinction between older and new structures. The city is rapidly increasing. Based on information on structures and people from the municipality office, two areas were chosen. As-Salamah, a developing and developed area, was represented by one of the areas, while Al-Balad, a traditionally ancient territory, was represented by the second. The RC buildings for these two districts were the subject of a FEMA 155 investigation. The data made it possible to conduct a more thorough seismic study of currently constructed structures.

Ramly et. al.[7], evaluated the seismic susceptibility of the existing structures in Bukit Tinggi, Pahang, Malaysia, using a fast visual screening approach. For the RVS methods and building score, several building inventories were taken into consideration, following FEMA 154 (2000). In Bukit Tinggi, 1166 buildings in total were inspected. Of them, 26% of the structures required additional expert evaluation, while the remaining 74% of buildings were determined to be safe from ground motion. The findings showed that the principal structural lateral load resisting system (building types) element had the biggest influence to the structures' final score.

Wahyuni et. al. [8], using FEMA 154 (2000) survey sheets to conduct a quick visual screening survey in Surabaya City, Indonesia. GPS technology was employed to find the examination's data. Following a pilot survey, the Android platform was used to create the RViSITS smartphone application, which is based on the FEMA 154 code and provides fast visual screening. Numerical assessments were carried out on four structures based on Indonesian code using SAP 2000 in order to validate the smartphone application. Out of 4 structures, three were validated Ok by the comparison of numerical results with RVS findings of smartphone application.

Nanda and Majhi [9], carried out a survey on quick visual screening for seismic evaluation of emerging nations like India. RVS employed data collecting forms based on FEMA 154/ATC-21 for three seismic hazard conditions: low, moderate, and high. The Indian campus of NIT Durgapur was subjected to the RVS approach. RVS score was computed utilizing Score modifiers based on building characteristics and Basic Score based on building type. According to EMS98, damage was categorized into five classes, ranging from Grade 1 to Grade 5. According to FEMA 154 (2000), a cutoff score of two was recommended. When the building's seismic risk is more than 0.7, it necessitates a thorough assessment and retrofitting.

Jain et. al. [10], reviewed the many quick visual screening techniques that are available globally. Methodologies from the USA, Turkey, Canada, Japan, New Zealand, and other countries were examined, along with RVS techniques. Students from CEPT University investigated the damage to structures in Ahmadabad. Out of these 3,720 buildings, 101 RC-frame structures were shortlisted based on their placement throughout the city, a process known as Phase I. To confirm the findings, the students inspected an additional 169 buildings, which they dubbed Phase II. For analytical purposes, a third sample of 270 buildings consisting of Phase I and Phase II structures was taken into consideration. The third sample was subjected to a statistical regression analysis in order to assess the buildings' Expected Performance Score (EPS) based on a quick visual survey. For the third Sample, it was observed that 46% of the buildings were predicted accurately by the approach.

Sinha and Goyal [11], explored a number of significant historical earthquakes in India. We spoke about the Detailed Vulnerability Assessment (DVA), Simplified Vulnerability Assessment (SVA), and

Rapid Visual Screening (RVS) procedures. The application of RVS findings has been examined, and the seismicity of India as per IS 1893-2002 has been deliberated. The RVS process was established and recommended in accordance with FEMA 154/ATC-21. One may compute the RVS score using such information. Five damage classes can be used to classify damage grades in accordance with EMS-98.

Patil and Swami [12], conducted a quick visual inspection of Chiplun City in order to evaluate the current buildings' seismic sensitivity. A total of forty buildings, including load-bearing and RCC structures, were surveyed using the FEMA 154 RVS sheet with certain modifications to account for Indian conditions. For each of the 40 buildings, the RVS Score was determined. Out of 40 structures, 23 (or 57% of them) had a Score of more than 2. Out of 40 structures, 17 (43%) had a score below 2. To calibrate RVS data, a thorough investigation of 17 structures with a score of less than two was recommended.

Arya and Agarwal [13], suggested a quick visual screening sheet for masonry buildings' seismic hazard assessment throughout all seismic zones. Based on building type, damageability grade, and code-based seismic intensity as noted in previous earthquakes, the screening was conducted. We talked about the specifics of IS 1893-2002, including the zone factor, importance factor, irregularities, soil type, etc. Based on the criteria of the European Macroseismic Scale (EMS-98), all buildings were categorized into class A to type F. According to EMS-98, damage grades from G1 to G5 were contemplated.

Mukhopadhyay and Dutta [14], explored the methods for developing a quick visual screening process for structures in the Indian seismic zones III and IV that are not engineered or partially engineered. We looked both the FEMA-described quick visual screening technique and the Arya and Agarwal-recommended RVS processes for masonry buildings. And structures were categorized appropriately. The performance of reinforced and unreinforced masonry connections was compared using a shaking table experiment, and the results showed that the reinforced junction could sustain 2.4 times higher ground acceleration. A novel RVS approach was suggested and cross-checked by the surveyed building. Two distinct structures were chosen: an undamaged hillside dwelling composed of a timber-bamboo combination (North Sikkim) and a substantially damaged mud building (West Bengal). The computed Score aligned with the results obtained from the damage assessment.

Lizundia et. al. [15], presented several improvements to the FEMA 154 and FEMA 155 fast visual screening technique. The optional level 2 form, located on the second page of the data collection form provided in the third edition, allows for a more thorough examination of the facility. A number of statements on the Level 2 form are used to gather additional specific information about the building.

Concluding Remark

A study of the numerous fast visual screening methods and their advancements, taking into account different building criteria for both foreign and Indian buildings, is provided by the literature review. While the full assessment methods have also been researched with the suggested pushover analysis and hinges creation, the preliminary assessment is carried out by the survey, which identifies buildings for further evaluation based on the grade awarded. However, the city of Nagpur has not yet had its seismic susceptibility evaluated. Thus, this study's primary goal is to determine how vulnerable the city's existing structures are to various levels of susceptibility.

References

1. Ningthoujam, M. C., and Radhikesh P. Nanda. "Rapid visual screening procedure of existing building based on statistical analysis." International journal of disaster risk reduction 28 (2018): 720-730.

2. Albayrak, Uğur, Mehmet Canbaz, and Gülçağ Albayrak. "A rapid seismic risk assessment method for existing building stock in urban areas." Procedia engineering 118 (2015): 1242-1249.

3. Rautela, Piyoosh, et al. "Seismic vulnerability of Nainital and Mussoorie, two major Lesser Himalayan tourist destinations of India." International journal of disaster risk reduction 13 (2015): 400-408
4. Anand S. Arya, Ankush Agarwal “Rapid Visual Screening of RCC Buildings”. NATIONAL DISASTER MANAGEMENT DIVISION Ministry of Home Affairs, North Block, New Delhi
5. Sarmah, Tanaya, and Sutapa Das. "Earthquake Vulnerability Assessment for RCC Buildings of Guwahati City using Rapid Visual Screening." Procedia engineering 212 (2018): 214-221.
6. Shah, Md Faiz, et al. "Case Study Using Rapid Visual Screening Method to Determine the Vulnerability of Buildings in Two Districts of Jeddah, Saudi Arabia 15th Int." Symp. On New Technologies for Urban Safety of Mega Cities in Asia. 2016.
7. N. Ramly1, M. Ghafar2, M. Alel3 and A. Adnan, “Rapid Visual Screening Method for Seismic Vulnerability Assessment of Existing Buildings in Bukit Tinggi, Pahang, Malaysia” International Journal of Structural Analysis & Design (2014):2372-4102
8. Wahyuni, Endah, et al. "Assessment of Vulnerable Buildings Due to Earthquake Loading Using Rapid Visual Screening Smartphone Application." International Journal on Advanced Science, Engineering and Information Technology 8.2 (2018): 567-572.
9. Nanda, Radhikesh P., and Deepti Ranjan Majhi. "Rapid seismic vulnerability assessment of building stocks for developing countries." KSCE Journal of Civil Engineering 18.7 (2014): 2218-2226.
10. Jain, Sudhir K., et al. "A proposed rapid visual screening procedure for seismic evaluation of RC-frame buildings in India." Earthquake Spectra 26.3 (2010): 709-729.
11. Sinha, Ravi, and Alok Goyal. "A national policy for seismic vulnerability assessment of buildings and procedure for rapid visual screening of buildings for potential seismic vulnerability." Report to Disaster Management Division, Ministry of Home Affairs, Government of India, Hindistan (2004).
12. V.S. Patil, Mr Swami S.M. “Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Case Study of Chiplun City” International research journal of engineering & technology 07 (2017): 2395-0056.
13. Anand S. Arya, Ankush Agarwal “Rapid Visual Screening of masonry Buildings”. NATIONAL DISASTER MANAGEMENT DIVISION Ministry of Home Affairs, North Block, New Delhi.
14. Mukhopadhyay, Parthasarathi, and Sekhar Chandra Dutta. "Rapid visual screening of earthquake-susceptible buildings." Proceedings of the Institution of Civil Engineers Municipal Engineer. Vol. 170. No. 2. Thomas Telford Ltd, 2016.
15. Lizundia, B., Durphy, S., Griffin, M., Holmes, W., Hortacsu, A., Kehoe, B., ... & Welliver, B. (2015). Update of FEMA P-154: Rapid Visual Screening for Potential Seismic Hazards. In Improving the Seismic Performance of Existing Buildings and Other Structures 2015 (pp. 775-786).