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**A PROJECT REPORT**

ON

# SEISMIC VULNERABILITY STUDY OF ASSAM-TYPE GOVERNMENT SCHOOLS IN JORHAT TOWNSHIP AREA

*Submitted in Partial Fulfilment of the Requirements for*

*The Award of the Degree of*

**BACHELOR OF TECHNOLOGY (B.TECH)**

**IN**

**CIVIL ENGINEERING**

**Under**

**ASSAM SCIENCE AND TECHNOLOGY UNIVERSITY**

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# ABSTRACT

Assam and its adjoining region is known to be part of the seismically active region of the Alpine-Himalayan seismic belt. Assam, located in the northeastern part of India, is one of the most seismically active regions in the world, falling under Zone V, as per IS 1893(Part1):2002 the highest earthquake risk zone in the country. The earthquake caused loss of human lives and major damages specially to the buildings, infrastructures with death of livestock in the state. Jorhat, a prominent town in the State of Assam lies in the seismic zone V. Thus there is an urgent need to assess the seismic vulnerability in urban areas of Assam as an essential component of a comprehensive earthquake disaster risk management policy. This project comprises of seismic vulnerability study of Government schools in Jorhat township based on Rapid Visual Screening using Level I procedure. Detailed seismic vulnerability evaluation is a technically complex and expensive procedure and can only be performed on a limited number of buildings. It is therefore very important to use simpler procedures that can help to rapidly evaluate the vulnerability profile of different types of buildings. As per the classification of IS 1893:2002, the important lifeline buildings are schools, hospitals, fire stations, communication buildings, public buildings of importance, airports and runways etc. In our study, we prioritized the various school buildings, specifically the Assam-type schools in Jorhat township area.

The Rapid Visual Survey of the schools has been carried out as per the guidelines of IS 1893:2002 and National Policy for seismic vulnerability assessment of buildings, approved by Government of India. In order to carry out the RVS, various information like age of the building, compressive strength of walls and floor, etc were collected. The details collected during the RVS was compiled, based on which vulnerability assessment of the buildings has been done by adopting a suitable scoring system as per EMS-98 approved by IS 1893: 2002 (Part 1). Building with higher performance score perform better compared to lower performance score.

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# LIST OF SYMBOLS AND ABBREVIATIONS

| | |
|---|---|
| DDMA | District Disaster Management Authority |
| FEMA | Federal Emergency Management Agency |
| EMS-98 | European Macroseismic Scale 1998 |
| RVS | Rapid Visual Screening |
| DVA | Disaster Vulnerability Assessment |
| NDT | Non-Destructive Test |
| NDMA | National Disaster Management Authority |
| NBC | National Building Code |
| VS | Vulnerability Score |
| FS | Final Score |

# CHAPTER-1

# INTRODUCTION

## 1.1 GENERAL OVERVIEW

Seismic vulnerability is the possibility of a structure being damaged or deformed during an earthquake. This possibility can be because of several factors such as building materials, design or the environment. It is furthermore crucial in earthquake prone zones to know the cause of the seismic vulnerability and how it can be reduced for security of people and minimizing losses. Buildings which do not comply with seismic design codes are in more danger because they are prone to severe shaking without appropriate means to counteract them. In many developing regions including some parts of India, conventional methods of construction still exist. These methods do not use modern engineering practices and therefore have greater chances of the structures collapsing during seismic occurences . The aftermath can be horrific, particularly in schools that have a large population of children. Thus, there is an urgent need for such structures to be properly evaluated as well as consider various retrofitting options to improve the robustness of the structures. Moreover, very limited data are currently exist in our region about the building stock and about their seismic vulnerability. The housing data census collected every decade gives us information about the various building materials used in walls, flooring and other component parts of the buildings. In order to quantify about the seismic vulnerability of the existing life line buildings there is a scarcity about the information of those life line structures. Thus, there is an urgent need to investigate about the probable hazards and damage that might be caused during an earthquake.

## 1.2 ASSAM DISASTER MANAGEMENT PLAN, 2013 (ASDMA):

This state level disaster management plan assessed the vulnerability of critical infrastructure, including schools. The report highlighted that over 50% of school buildings in vulnerable districts like Jorhat are at risk due to poor construction standards, especially in flood affected zones. These findings highlight the urgent need for retrofitting and strengthening school buildings to withstand Assam's unpredictable environment. In such a high risk area, the importance of using sustainable materials and innovative construction techniques, such as prefabrication, cannot be overstated. Sustainable materials which are ecofriendly, durable and resilient have the potential to reduce the impact of earthquakes by enhancing the structural integrity of buildings. When combined with modern practices, the use of bamboo, laminated timber, precast concrete and other locally sourced alternatives can mitigate risks and promote sustainable development in assam. By embracing these approaches, it becomes possible to build earthquake resistant structures that are not only safe but also environment friendly, contributing to long term sustainability of the region.

## 1.3 SEISMIC VULNERABILITY OF JORHAT TOWNSHIP

Jorhat township, located in Assam, India, is situated in a region classified as a high seismic zone (Zone V). This classification indicates a significant risk of earthquakes that can lead to severe damage if buildings are not adequately designed or maintained. The architectural style prevalent in this region includes Assam-type schools, which are characterized by traditional construction techniques using locally sourced materials such as bamboo and thatch. While these materials are culturally significant and offer certain benefits, they also present unique challenges regarding seismic resilience. The historical context of Jorhat reveals that the region has experienced several earthquakes over the years. These seismic events have highlighted the vulnerabilities within existing school infrastructures, prompting calls for urgent assessments and interventions. Many Assam-type schools lack modern engineering features that enhance earthquake resistance, making them particularly susceptible to damage during seismic activities. In Jorhat district, the vulnerability of school buildings in the district is a major concern. According to Assam State Disaster Management Authority (ASDMA), 30% of schools in flood prone districts including Jorhat are at risk of being severely damaged. Some of the key reports highlighting the vulnerability of school buildings in Jorhat district are as follows:

The report, created by ISRO in collaboration with the Assam Government includes flood prone areas in Jorhat district. It identifies the extent of flood risk to structures, buildings including schools. Schools in low lying areas face seasonal flooding, leading to significant structural damage. As per **National School Safety Programme (NSSP) Report, Assam (ASDMA, 2013)** report surveyed schools across Assam, including Jorhat as part of a national initiative to evaluate school safety against disasters. Many of them have not been retrofitted to withstand the seismic activities that Assam is prone to, given that it is located in India's highest earthquake risk zone. The report found that many schools lack basic disaster preparedness features such as raised plinths for flood protection and retrofitting for earthquake resilience.

## 1.4 RAPID VISUAL SCREENING

Rapid Visual Screening, or RVS, is a standardised procedure used for the quick evaluation of structure vulnerability to seismic hazards. It assesses the possible vulnerability of structures based on visible attributes and structural characteristics without involving detailed engineering analysis. The susceptibility of a building to earthquake-induced forces is a reflection of seismic vulnerability that is measured by several visual indicators and structural features. The term "building typology" describes a classification of buildings by the structural system, materials, construction methods, and usage, such as reinforced concrete frames or unreinforced masonry. In RVS, the most commonly used metric is the performance score (PS), a number that reflects the seismic performance of a structure. It is expressed as the more vulnerable the structure, the lower the score. Structural systems are the building's primary load-resisting mechanisms, which include the shear walls, moment-resistant frames, or braced frames, and significantly affect the seismic behaviour. Non-structural components, such as infill walls, windows, and ceilings, do not contribute to structural integrity per se but may influence total seismic performance. The priority index, obtained from RVS, can be used to identify buildings that need urgent evaluation or retrofitting based on their risk profile. Seismic hazard levels classify the level of seismic risk in a region, which impacts expected ground motion parameters and RVS outcomes. Specific structural vulnerabilities, such as soft stories—building levels with reduced stiffness or strength—and pounding risk, where adjacent buildings may collide during an earthquake, are also critical in RVS assessments. Other factors that contribute to seismic risk include plan irregularities, such as re-entrant corners, and vertical irregularities, such as soft stories. Retrofitting is structural modification to improve seismic performance, often recommended after RVS findings. Damage states describe the levels of observed or potential damage in buildings, ranging from minor cosmetic cracks to collapse. Occupancy type, which categorizes the functional use of a building (residential, commercial, or educational) is one of the parameters that will be used when prioritising risk assessments. Lastly, Geographic Information Systems are usually incorporated into an RVS project to identify and analyze the spatial dispersion of the buildings surveyed with their vulnerabilities, which will help the decision-making process and utilization of resources.

Four levels of assessment can be undertaken to estimate the vulnerability of buildings to strong earthquake shaking, namely:

(1) Rapid Visual Screening (RVS),
(2) Detailed Visual Study (DVS),
(3) Simplified Quantitative Assessment (SQA)
(4) Detailed Quantitative Assessment (DQA).

As the name suggests, Rapid Visual Screening (RVS) is a quick method of earthquake assessment of buildings, and requires least time of all the four methods of assessment. The idea behind the development of this method is to minimize (and thereby save) the time, money and technical human resources required for assessment of large stock of existing buildings in the country. From the results of RVS (a final score), one can prioritize the building stock for the next three levels of assessment. Since this is an approximate method of assessment, many versions of RVS were proposed and practiced in different countries.

## 1.4.1 RVS Procedure

The Rapid Visual Screening (RVS) method is a systematic procedure designed for quickly assessing the seismic vulnerability of buildings without performing detailed structural calculations. It is typically implemented in the field, on-site, with the goal of identifying buildings that may require further, more detailed evaluations. Below is the step-by-step procedure for conducting RVS:

### *1.4.1.1 Site Visit and Data Collection:*

• Inspection for Defects: While collecting data, it is inspected the building for visible distress or damage, such as cracks, signs of seepage, or other issues that could affect the building's seismic performance.

• Assessment of Hazardous Conditions: Observing the surrounding environment for potential site specific hazards like landslides, flash floods, or fire risks that could affect the building during an earthquake.

***1.4.1.2 Filling Out the RVS Form:***

• Filling out the RVS form based on the information gathered during the site visit. This includes documenting the primary structural system, observed building defects, and relevant site conditions.

***1.4.1.3 Performance Scoring:***

• Seismic Hazard and Vulnerability Scores: Using the collected data, the school is assigned a numerical score that reflects:

• The scores are based on probability concepts, and they correspond to the seismic hazard in the area and the seismic performance expected from the building based on its shape and materials.

***1.4.1.4Data Analysis and Vulnerability Assessment:***

• The scores are used to assess the building's seismic vulnerability. This is done by comparing the scores to established vulnerability thresholds that categorise buildings into different risk levels (e.g., low, moderate, or high seismic risk) as per IS 1893:2002 Part 1.

• If a building falls into a high-risk category, it may require a more detailed evaluation, potentially involving structural calculations and further analysis.

***1.4.1.5Post-Inspection Analysis:***

• After the data is collected and the school's performance score is calculated, a compiled report summarising the building's seismic vulnerability is prepared.

• The results can be used for risk prioritisation, guiding decisions about which buildings need retrofitting or more comprehensive assessments.

## 1.5 ADVANTAGES OF RVS:

1. Cost-Effective: RVS is an economical method of assessing seismic vulnerability since it does not demand detailed engineering analysis or any specialized equipment.

2. Time-Efficient: The methodology allows the rapid assessment of a large number of buildings in a very short time frame, thus ideal for large-scale surveys.

3. Ease of Implementation: RVS is easy to conduct; it is based on observations and standardized scoring forms and does not require much technical expertise as in the case of detailed structural assessments.

4. Standardised Approach: Predefined forms and scoring systems ensure uniformity in data collection and assessment in different regions and building types.

5.Resource Prioritisation: RVS identifies the most vulnerable buildings, which guides decision-makers to prioritize structures for further evaluation, retrofitting, or resource allocation.

6.Supports Disaster Preparedness: RVS holds the ability to provide required data to be used on seismic risk reduction strategies for emergency response planning and, urban development policies.

7.Scalable for Different Regions: Both urban and rural areas hold applicability, making its use adaptable to various geographic contexts and socio-economic conditions of different regions.

8.Promotes Awareness: A process which increases awareness towards building owners, stakeholders as well as communities about possible seismic vulnerabilities and the worth of mitigating measures undertaken.

## 1.6. USES OF RVS

While the principal purpose of the RVS methods is to identify buildings potentially vulnerable to strong earthquake shaking, the results from RVS can be used for other purposes as well. The Rapid Visual Screening methodology serves several critical functions such as:

### 1.6.1Quick Assessment

RVS allows for rapid evaluation of large numbers of buildings without extensive engineering analysis or lengthy inspections, making it an efficient tool for preliminary assessments.

### 1.6.2Resource Allocation

By identifying vulnerable structures quickly, RVS helps local authorities prioritize funding and resources for retrofitting efforts or emergency preparedness initiatives.

### 1.6.3Emergency Preparedness

The information gathered through RVS informs disaster management strategies by identifying at-risk schools that may require evacuation plans or emergency drills tailored to their unique vulnerabilities.

### 1.6.4Community Awareness

RVS findings can raise awareness among local communities about seismic risks associated with school infrastructure, fostering a culture of preparedness and resilience.

### 1.6.5Initial Vulnerability assessment

RVS provides a quick and efficient means to assess the seismic vulnerability of buildings. It allows evaluators to identify structures that may require further detailed analysis, thereby prioritizing resources and efforts for more comprehensive assessments.

### 1.6.6Ranking of Buildings

The results from RVS can be used to rank buildings based on their seismic vulnerability. This ranking helps local authorities and organizations prioritize which buildings need immediate attention or retrofitting, ensuring that the most at-risk structures are addressed first.

### 1.6.7Integration with Geographic Information Systems (GIS):

The data collected through RVS can be integrated into GIS-based databases, which facilitates urban planning and disaster preparedness efforts. This integration allows for spatial analysis of vulnerabilities and helps in visualizing risk areas within a community.

### 1.6.8Guidance for Policy Development:

Findings from RVS assessments can inform policymakers about the current state of building safety within their jurisdictions. This information is crucial for developing regulations, building codes, and funding allocations for seismic retrofitting projects.

### 1.6.9Monitoring Changes Over Time:

RVS allows for the rapid reassessment of previously evaluated buildings as conditions change or new data becomes available. This ongoing monitoring helps track improvements or deteriorations in building safety over time.

**1.6.10Cost-Effective Screening:**

RVS is a cost-effective method for assessing large numbers of buildings without requiring extensive engineering analyses or resources. This efficiency makes it particularly useful for municipalities with limited budgets.

**1.6.11Foundation for Detailed Assessments:**

While RVS provides a preliminary assessment, it also lays the groundwork for more detailed evaluations when necessary. Buildings identified as high-risk can be subjected to comprehensive structural analyses to determine specific vulnerabilities and required interventions.

**1.6.12Support for Retrofitting Initiatives:**

The insights gained from RVS can guide retrofitting initiatives by identifying specific weaknesses in structures that need addressing, thus enhancing the overall safety and resilience of the built environment.

## 1.7. LIMITATIONS OF RVS

While RVS is a valuable tool for preliminary assessments, it does have limitations such as:

**1.7.1 Subjectivity in assessment**

The effectiveness of RVS can vary based on the inspector's experience and expertise, potentially leading to inconsistencies in evaluations across different inspectors or assessments.

**1.7.2 Surface-Level Assessment**

RVS primarily focuses on visible features; therefore, it may overlook hidden structural deficiencies that could compromise safety during an earthquake.

**1.7.3 Limited Detail**

The method provides a general overview rather than an exhaustive analysis; thus, it may necessitate follow-up detailed assessments for comprehensive understanding.

**1.7.4 Inability to Predict Performance**

While RVS can identify vulnerabilities, it cannot predict how a building will perform during an actual earthquake event due to many dynamic factors involved during such occurrences. In conclusion, understanding the seismic vulnerability of Assam-type schools in Jorhat township is essential for safeguarding students and staff against potential earthquake risks. By employing methodologies such as RVS and addressing identified vulnerabilities through targeted interventions, stakeholders can significantly enhance the resilience of educational infrastructure in this region while fostering a culture of preparedness within communities.

**1.7.5 Relies on Visual Observations**

RVS is based on the appearance of buildings, which neglects hidden structural defects and material degradation that can seriously impact seismic performance.

**1.7.6 Generalized scoring system**

The standardized scoring system used in RVS does not consider local specific seismic hazards, characteristics of buildings, or the variability in construction quality.

**1.7.7 Preliminary study:**

It is only an initial appraisal and not a substitute for in-depth engineering analysis as is the case for retrofitting or structural design.

**1.7.8 Lack of ability to identify retrofitting needs:**

RVS identifies vulnerable buildings but does not give detailed guidance on retrofitting measures or structural improvements required to enhance seismic performance.

**1.7.9 Dynamic soil structure system not considered:**

The methodology does not take into account the impact of soil conditions, such as liquefaction or site-specific amplification, that can affect a building's response to earthquakes.

**1.7.10 Not applicable for complex structures:**

Not applicable for complex structures: RVS is less effective for complex or high-rise structures where detailed analyses are required to assess their seismic vulnerabilities.

**1.7.11 Lack of historical Data**

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This method does not use historical damage data or past earthquake.

Despite its limitations, Rapid Visual Screening is a very important tool in assessing seismic vulnerability for decision making in disaster preparedness efforts. It is useful to identify high-risk buildings and prioritize resources to better prepare communities to be more resilient. The limitations, however, call for detailed structural evaluations that integrate RVS findings for a comprehensive risk mitigation process. By using RVS as a component of an integrated risk management approach, communities can be proactive in mitigating the effects of earthquakes, protecting lives and infrastructure.

## 1.8 OBJECTIVE OF THE STUDY

The objective of the study is to quickly identify schools that are potentially vulnerable to seismic events. It helps prioritize structures for detailed evaluation, guide resource allocation, and enhance community safety by reducing earthquake risks.

The primary objectives of this study are as follows**:**

1. To assess the seismic vulnerability of Assam-type school buildings in Jorhat township area.
2. To carry out Rapid Visual Screening and NDT test of these Assam type schools that could lead to potential failure during an earthquake.

   By achieving these objectives, the study aims to contribute to a safer learning environment for students and staff in Jorhat township.

## 1.9 SCOPE OF THE STUDY

The scope of this study encompasses a comprehensive assessment of the seismic vulnerability of Assam-type schools specifically within Jorhat township. The focus is on identifying critical weaknesses in these structures and evaluating their overall resilience against potential earthquake hazards.

The scope of the study are as follows:

1. This study is conducted in accordance with IS:1893:2002 Part-I.
2. To carry out Rapid Visual Screening of selected school buildings of Jorhat township.
3. To access the necessary data from this RVS study and conduct NDT tests to some selected schools.
4. To comment on the seismic vulnerability of selected schools of Jorhat township by adopting a scoring system.
5. Estimating potential damage scenarios and their implications for safety.

## 1.10 FUTURE SCOPE

1. This study is limited to government schools of Jorhat township area only.
2. The assessment through RVS in this study involves level –I procedure that involves only visual evaluation and limited additional information.
3. Detailed vulnerability assessment requires more complex computer analysis i.e level-III.

By concentrating on these areas, the study aims to generate valuable insights that can inform local authorities and educational administrators about necessary interventions to enhance safety.

# CHAPTER-2

# LITERATURE REVIEW

## 2.1 BACKGROUND

The seismic vulnerability of educational buildings has garnered significant attention in recent years, particularly in regions prone to seismic activity. Understanding the structural integrity and resilience of school buildings is crucial for ensuring the safety of students and staff during earthquakes. Various studies have employed methodologies such as Rapid Visual Screening (RVS) and detailed structural assessments to evaluate the seismic risks associated with educational infrastructures. For instance, a study conducted in Nepal assessed the seismic vulnerabilities of school buildings by collecting data from over 1,300 structures across multiple districts. The findings highlighted critical weaknesses in construction practices and materials, emphasizing the need for improved design standards to enhance safety in seismic zones.

In Assam, particularly in Jorhat township, Assam-type schools form a vital part of the educational landscape. These traditional structures, often built with locally sourced materials like bamboo and thatch, reflect the region's cultural heritage. However, their design may not adequately address the seismic risks posed by the area's geological conditions. As communities grow and urbanize, it becomes increasingly important to evaluate the seismic vulnerability of these schools using established methodologies like RVS. Identifying critical weaknesses in these buildings is essential for developing effective strategies to enhance their resilience. Despite the wealth of research on school building vulnerabilities worldwide, there remains a significant gap when it comes to Assam-type schools in India's northeastern states. While many studies have focused on modern structures or different geographical contexts, few have delved into the unique challenges faced by traditional buildings in high seismic hazard zones like Jorhat township. This gap underscores the need for targeted research that considers local construction practices and environmental factors affecting the safety of educational institutions. In conclusion, existing literature emphasizes the importance of assessing seismic vulnerability in schools as a means of safeguarding students and staff. By integrating localized assessment methodologies, we can develop effective strategies to enhance safety and resilience in regions like Jorhat township. This study aims to contribute to this critical dialogue by evaluating the specific vulnerabilities of Assam-type schools and offering actionable recommendations for improving their structural integrity against potential earthquake hazards. Through this work, we hope to foster a safe learning environment for future generations to come.

## 2.2 LITERATURE REVIEW

A concise summary of prior research work done in this field is provided below.

***Menoni Scira et al. (2002):*** The Author focuses on creating a model to assess the seismic vulnerability of lifelines by considering physical, functional, and organisational factors as interconnected. The tool developed measures the response capacity of lifelines during earthquakes. The concept of "systemic vulnerability" is central to the evaluation, meaning that not only direct physical damage but also the ripple effects from failures in other systems can be assessed. The tool was applied in Lombardy, Italy, and provided recommendations for prioritising actions to reduce the cascading effects of lifeline interruptions after an earthquake.

***Nojima N (2008):*** The Author introduces the vulnerability factor (V-factor), a simple index used to evaluate the seismic vulnerability of lifeline networks, such as water delivery systems. This index is based on factors like pipe diameter, material, and joint type, averaged across entire networks to assess their overall vulnerability during earthquakes. Applying this to Japan's water systems, the study shows a wide range of vulnerability levels across the country. Following the 1995 Kobe Earthquake, improvements were made, reducing pipe damage by 20-25% over a ten-year period when exposed to similar ground motion.

***Jain Sudhir K. et al. (2010):*** The study titled “A proposed Rapid Visual Screening procedure for seismic evaluation of R.C frame buildings in India” proposes a rapid visual testing (RVS) procedure for the seismic assessment of reinforced concrete (RC) frame buildings in India, based mainly on the damage observed during the 2001 Bhuj earthquake. The method aims to create a rapid and efficient earthquake assessment method. Vulnerabilities in large building piles that require more detailed evaluation or retrofitting. RVS focuses on identifying critical structures. The process is designed for on site pavement level inspections which take approximately 15-30 minutes per building. The assessment uses a rating system to assess key vulnerability parameters such as number of floors, presence of basements.

The proposed methodology draws on global RVS practices, including FEMA guidelines from the U.S. and systems used in Turkey, but adapts them to the specific construction practices, material use and urban layouts in India. The methodology involves scoring buildings based on observable factors that influence seismic performance, such as poor maintenance or asymmetrical designs. A scoring algorithm aggregates these vulnerabilities into an overall performance score, which is used to classify the building’s seismic risk.

***Naidu Radhikesh P. (2010):*** The study focuses on evaluating the seismic vulnerability and risk of the historic city centre of Coimbra, Portugal, emphasizing the fragility of traditional masonry buildings. The authors developed a comprehensive methodology integrating vulnerability index calculations, GIS-based mapping, and damage estimation models. Using detailed surveys of 679 buildings, they assessed structural characteristics, conservation status, and environmental factors influencing seismic performance. The analysis highlights that despite Coimbra's moderate seismic hazard, the historic buildings are highly vulnerable, with many falling into high-risk categories (vulnerability classes A and B). GIS tools allowed spatial mapping of risks, identifying areas most likely to experience severe damage and requiring urgent retrofitting. The research generated damage and loss scenarios for earthquake intensities VIII and IX on the EMS-98 scale, corresponding to historical seismic events in the region. These scenarios estimate significant physical damage, with potential collapse rates of up to 49% and homelessness affecting 82% of residents in extreme cases. The study underscores the need for proactive retrofitting strategies and risk mitigation measures, combining structural improvements with urban planning. The methodology developed is adaptable for other historic centre, offering a scalable tool for preserving heritage buildings while ensuring public safety.

***Mitra Keya (2010):*** The document describes a proposed Rapid Visual Screening (RVS) methodology designed for the seismic evaluation of RC-frame buildings in India. This method addresses the need to quickly assess the seismic vulnerability of a large number of buildings, particularly in urban areas, following events such as the 2001 Bhuj earthquake. The RVS procedure prioritizes buildings for detailed assessments based on factors such as structural vulnerabilities, maintenance quality, and observed damages. It utilizes a scoring system derived from field surveys and statistical analyses of vulnerability parameters. Key parameters include the presence of basements, number of stories, re-entrant corners, short columns, and open-story configurations. The model is validated using a sample of buildings in Ahmedabad, where damage grades from the Bhuj earthquake informed the development of vulnerability scores. A regression analysis calculates an Expected Performance Score (EPS) to predict building behaviour under seismic forces. This approach allows non-engineers to conduct surveys rapidly and prioritize buildings for further inspection. The methodology emphasizes adaptability to Indian conditions and highlights the influence of seismic zones, soil types, and building usage (residential vs. non-residential). It achieves 46% accuracy in predicting observed damage grades, with an 88% success rate within one error level. The study underscores the importance

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of expanding the data set and refining the model to improve accuracy, especially for diverse building typologies and seismic conditions.

***Faraji M et al. (2011):*** This approach focuses on the seismic risk of lifeline networks, which include potable water and electric power systems, underlining that their evaluation is complex because these systems reach a wide geographic area. The assessment of seismic risk of a single structure is quite different for lifelines, which require determining ground-motion intensities over many locations. The seismic performance of Bam city's lifeline systems has been evaluated by calculating damage estimates for a given earthquake scenario. Utility network data is collected in GIS format followed by seismic damage analysis, either using fragility curves or scenario-based ground motions. The post-seismic performance of the networks is evaluated based on these damage estimates, and their results provide insight for disaster management strategies. It also underlines the role of lifelines in modern urban areas, where the dependency is relatively high on critical infrastructures like supply of water, power, telecom and gas. It has been identified that Probabilistic Risk Analysis (PRA) forms a primary means to measure up the risk in such complex systems, providing a framework on the outcome and prioritizing areas of concerns. Overall, the study aims at giving a systematic method for assessing and managing seismic risks in lifeline networks, and this is important both to spur academic research in the sphere of disaster preparedness and to be applied directly in practical policy-making efforts.

***Pitilakis Kyriazis (2011):*** The Author summarises the outcomes of the European research project SYNER-G, which developed a framework for assessing seismic vulnerability and risk at urban and regional levels. The framework models the built environment into systems like buildings, transportation, utility networks, and critical facilities, evaluating how they interact and are affected by earthquakes. It integrates hazard analysis, component fragility, and socioeconomic impacts, using advanced simulation tools. The framework was applied in cities like Thessaloniki, Vienna, and regions in Italy. The project also produced various guidelines, reports, workshops, and publications to share its findings.

***Alam N (2012):*** The document is a comparative study of seismic vulnerability Assessment methods for buildings. The study also evaluates these methods using case Studies from Dhaka and Rangamati in Bangladesh, and Kelowna, Canada. The study Evaluates various seismic vulnerability assessment techniques for their applicability and Effectiveness, proposing a scoring system to rank them. Ease of use, scope, and site-specific adaptability. Building structural features and data Reliability. Damage grades and risk scopes. The AHP framework ranks methods based on Their performance in these criteria. Found 17% of buildings at high risk and 7% at severe Risk. 3% of buildings classified as high-risk due to relatively newer construction. 48% of Buildings were moderately vulnerable, with a concentration in the downtown area. The Hybrid method consistently performed well in all case studies, showing adaptability and detailed classifications useful for decision-makers. Vulnerability maps were created to Provide spatial risk insights, aiding targeted risk mitigation. The Hybrid method, along with The New Zealand and NRC Guidelines, offers the most comprehensive assessments. However, further studies are recommended for broader applicability.

***Pitilakis Kyriazis et al. (2013):*** In this paper, it develops an integrated methodology to assess seismic vulnerability and risk in urban systems, transportation and utility networks, and critical facilities. It investigates the physical and socio-economic impacts resulting from earthquakes, with vulnerability analyzed at regional and urban levels. The most critical feature of the methodology is the fully developed taxonomy that outlines the categorisation of the built environment into different components, such as buildings, transportation, and utility networks, each of which can further be divided into specific types of elements. This approach integrates seismic hazard assessments, vulnerability evaluation, and socio-economic consequences through a quantitative simulation framework accounting for uncertainties and interactions between different system components. Prototype software (OOFIMS) and associated tools are made available to support pre- and post-processing tasks. Applications in real cases validate the methodology, and an example case study conducted in Thessaloniki, Greece, demonstrates the usefulness and possible extent of application to systemic seismic vulnerability and risk analysis.

***Pitilakis Kyriazis and Argyroudis Sotiris (2014):*** The Author discusses the seismic vulnerability of lifelines, which are critical infrastructure systems that keep communities functioning. These systems, like water, gas, electricity, and transportation networks, are essential for the well-being of society and the economy. During strong earthquakes, damage to lifelines can cause severe disruptions and lead to major economic losses, with repair costs sometimes reaching 10-15% of their original construction cost. Lifelines are more complex than buildings because they cover large areas, are exposed to various hazards, and involve different types of materials and functions. They consist of links (such as pipelines and roads) and nodes (like tanks and substations). The vulnerability of lifelines is further complicated by how different components and systems depend on one another, meaning damage to one part can affect the performance of the entire network. Understanding these interdependencies is key to assessing and managing their seismic vulnerability.

***Asteris P.G. (2014):*** In this research paper, the author details the seismic vulnerability assessment of Historical masonry structural systems. It focuses on analyzing the behaviour of these Structures under seismic loading and proposes methodologies for their evaluation, Retrofitting, and protection. Specific case studies in Greece, Portugal, and Cyprus highlight The application of these methodologies and their outcomes. A step-by-step approach to assess historical masonry structures, including historical Documentation, material analysis, structural modeling, and failure assessment has been done in the paper. Challenges include irregularity in masonry composition and the need for experimental data. To establish mechanical characteristics. Methods include macro-modelling, simplified Micro-modeling, and detailed micro-modeling, each with specific advantages and Computational demands. Use of fragility curves to predict the likelihood of structural failure Under different seismic intensities, before and after interventions. Strategies include improving wall connectivity, reinforcing structural elements, and Employing innovative materials like FRPs and dampers. Analysis of a neoclassical masonry Building, with fragility reduced by 44% post-retrofit. Adobe masonry building with Retrofitting lowering heavy damage probability by 23%. Use of dampers in a Byzantine Church to achieve a 70% reduction in interstory drift.

***Rossi Fernando (2015):*** The document presents a Rapid Visual Screening (RVS) methodology tailored for evaluating the seismic vulnerability of reinforced concrete (RC) hospital buildings. It emphasizes the critical role of hospitals during earthquakes, requiring them to remain functional for patient care and disaster response. The methodology assesses vulnerabilities in structural and nonstructural components, as well as organizational preparedness, and combines these factors with seismic hazard and exposure to compute a comprehensive Safety Index (SI). Designed for large-scale applications, the RVS method is implemented through questionnaires and systematic surveys, enabling quick identification of high-risk buildings. The RVS approach was applied to two Italian hospitals in areas with different seismic risks and validated against detailed push-over analyses, which simulate structural responses under seismic loads. The results demonstrated good agreement between the simplified RVS indices and the outcomes of the advanced analyses, especially when hazard levels were assessed based on peak ground acceleration and assigned a weight of 40%. Furthermore, the method was tested on hospitals damaged during past earthquakes in Italy, providing realistic validation and reinforcing its reliability in reflecting observed damage trends. The study concludes that the proposed RVS methodology is a valuable tool for preliminary seismic risk mapping of critical facilities like hospitals. Its ability to identify high-priority structures for detailed assessments makes it an efficient solution for large-scale seismic risk evaluation. The results highlight the importance of accurate hazard evaluation, recommending adjustments to its influence in the SI to ensure reliable outcomes. This methodology provides a practical balance between precision and scalability for safeguarding essential healthcare infrastructure.

***Ningthoujam M.C et al. (2018):*** The research paper titled "Rapid Visual Screening Procedure of Existing Building Based on Statistical Analysis" proposes a new procedure for evaluating the seismic risk of buildings. More traditional RVS procedures suffer from a common problem of relying on personal estimation, which results in inconsistent evaluations of the risk incurred by structures. In order to overcome these shortcomings, the authors propose improved rapid visual screening (RVS) based on statistical evaluation of building structural system parameters and their performance rating, which allows structural assessments to be made more objectively and quantitatively. This approach can be used to perform classification according to vulnerability level by relating some factors such as age of building, height of building, construction materials and design features. Such a refined approach guarantees that essential structures that require retrofitting, repairs or demolition are accurately graded thereby enhancing the risk management of earthquake disasters. The authors advocate for a more systematic exposure of the sources and mechanisms of earthquake induced damage by combining modelling and performance based research so that the speed and accuracy of seismic risk evaluations can be enhanced. This model will be relevant for professionals as engineers, policy makers and city planners in the areas of disaster response and prevention.

***Joshi Girish Chandra et al. (2019):*** The Author focuses on study in the earthquake-prone Uttarakhand region of the Indian Himalayas found that many key public buildings, such as schools, hospitals, and police stations, are highly vulnerable to earthquakes. Specifically, around 71.86% of the surveyed local administration buildings, 64.58% schools, 62.08% Police stations, 56.25% Fire and Emergency Service stations and 52.86% hospitals together with 61.68% buildings are at risk. After an earthquake, more than half of these buildings would be unusable, hampering rescue efforts and emergency services. The study highlights poor quality of construction, lack of maintenance and non-compliance of safety standards as the main reasons for enhancing the vulnerability of the surveyed buildings.

***Sinha Ravi and Goyal Alok:*** The paper titled, "A National Policy for seismic vulnerability assessment of Buildings and Rapid Visual Screening of Buildings for Potential Seismic Hazards" deals with the formulation of national policy of seismic risk assessment of buildings in India. Considering the frequency of earthquakes in this country, the paper further stresses on the importance of having a well-planned disaster risk management framework. It recommends three major approaches in vulnerability assessment: Rapid visual screening (RVS). It is a scoring system which provides an evaluation scale for evaluating buildings in terms of their likely performance during and after seismic activity without technical design. Low performing buildings so determined are identified so that further assessment or mitigation of these systems can be done. The paper also emphasizes on the seismic zones in eastern India, most vulnerable building types and the need of employing these methods in urban centres where rapid development has outpaced the earthquake preparedness of many buildings.

***Mosoarcaa Marius (2019):*** The document collectively focus on assessing Seismic vulnerability, particularly for historic urban areas, using diverse methodologies Timisoara, Romania Evaluates seismic risks in historical buildings, proposing retrofitting Methods that balance structural integrity and cultural preservation. Coimbra, Portugal Maps risks using hybrid models and fragility curves, highlighting Vulnerabilities in unreinforced masonry and the need for urban risk reduction strategies. Global Methodology Review Covers 30 years of assessment evolution, detailing empirical (damage-based), analytical (simulation-based), hybrid, and rapid screening methods. Examples include HAZUS, DBELA, and RISK UE Key Takeaways Empirical methods excel in historical analysis; analytical approaches Predict future risks with precision. Hybrid models combine strengths for comprehensive Assessments. Retrofitting and urban planning must account for cultural heritage Preservation. Tools like fragility curves, vulnerability indexes, and capacity spectra are Central to modern methodologies.

***Harirchian Ehsan et al. (2020):*** The research paper delves into the use of Rapid visual screening method for assessing the earthquake safety of structures' performance. This method quickly assesses building damage in a qualitative manner in geographic regions that are expected to have medium or high seismic activities. In the paper, three widely adopted RVS methodologies, namely FEMA P-154 (USA), IITK-GSDMA (India), and EMPI (Turkey) are presented and metrics to evaluate the damage induced in reinforced concrete structures due to earthquake are developed.

In a case study carried out in Bingol, Turkey, after the earthquake of 2003, the authors checked what is the applicability of these RVS methods compared to reality in terms of estimated structural damage. According to the analysis, the most effective estimates of building damage in the Russian region can be provided by the ford IITK-GDSMA. Over the course of the investigation, FEMA P-154 method damages estimates were found to be excessive, minimizing the practicality of the method in real applications. As a takeaway from this research, it is worth noting the need for regional changes in RVS methods used for the assessment of buildings performance in seismic events.

***Dahal Pretam et al. (2022):*** The Author discusses the M6.9 earthquake that hit Sikkim on September 18, 2011, causing significant damage, especially in Gangtok and nearby areas. The damage was worse than expected due to poor construction practices, such as ignoring seismic codes, using low-quality materials, and poor workmanship. The survey aimed to study the impact of the earthquake and aftershocks on buildings, focusing on structural and geotechnical damage. The findings highlight the urgent need for a seismic vulnerability assessment of buildings in and around Gangtok. The paper presents this assessment using both rapid visual screening and detailed evaluation methods.

***Bektas Nurullah and Kegyes Orsolya (2024***): The paper discusses the development of a machine learning based Rapid Visual Screening (RVS) method for assessing the seismic safety of existing buildings, particularly in the context of the 2015 Gorkha earthquake in Nepal. Existing buildings often lack modern seismic design standards, making them vulnerable to earthquakes. Many buildings were constructed without adequate engineering considerations, leading to potential safety risks and economic losses during seismic events. The study utilizes data from post-earthquake building inspections to train nine machine learning algorithms, including Decision Tree Classifier, Random Forest, and Support Vector Machines. Advanced feature engineering techniques were employed to enhance the assessment capabilities by integrating parameters such as distance to the earthquake source and spectral acceleration. The developed RVS method achieved a test accuracy of 73%, significantly surpassing conventional methods which typically have less than 30% accuracy. The study highlights previous research that utilized post-earthquake data but notes their limitation in parameter selection and overall accuracy. The research emphasizes the need for improved RVS methods through machine learning to enhance urban resilience and safety. Future work should focus on refining parameter selection and developing universally applicable assessment methods for various building types. The study represents a significant advancement in using machine learning to improve seismic assessments, potentially leading to better preparedness and risk mitigation strategies for existing buildings.

## 2.3 SUMMARY

This chapter deals with the work done by various researchers in the field of vulnerability assessment through rapid visual screening of school buildings. This chapter delves into the contributions and findings of previous researchers highlighting potential seismic hazards of school buildings. By analyzing the previous studies, it aims to identify gaps, challenges and oppurtunities for future research, setting the foundation for a deeper exploration in the field of detailed vulnerability assessment in subsequent phases of the work to be carried out in the future.

# CHAPTER-3

# METHODOLOGY

## 3.1 GENERAL

The Rapid visual screening is designed to be implemented without performing any structural calculations. It requires a drawing of the structure and visual details after proper inspection of the site depending upon which scoring is done. The inspection, data collection and various decision making process occurs at the building site, which requires very less time (around 30minutes-1 hour duration). RVS methodologies can be implemented in both rural and urban areas, but it is not intended for structures other than buildings. The methodology outlines a comprehensive approach to assess the seismic vulnerability of Assam-type schools in Jorhat township. The assessment will involve multiple phases, each designed to gather relevant data, analyse vulnerabilities, and provide actionable recommendations aimed at improving safety for students and staff.

The detailed procedure of RVS in site was conducted as per the following steps –

1. External measurements of the building were taken preferably overall dimension post centre to centre distance whichever is easier.
2. All the internal measurements were taken and noted down.
3. Filling up of the RVS form following the guidelines of IS:1893:2002 part-I

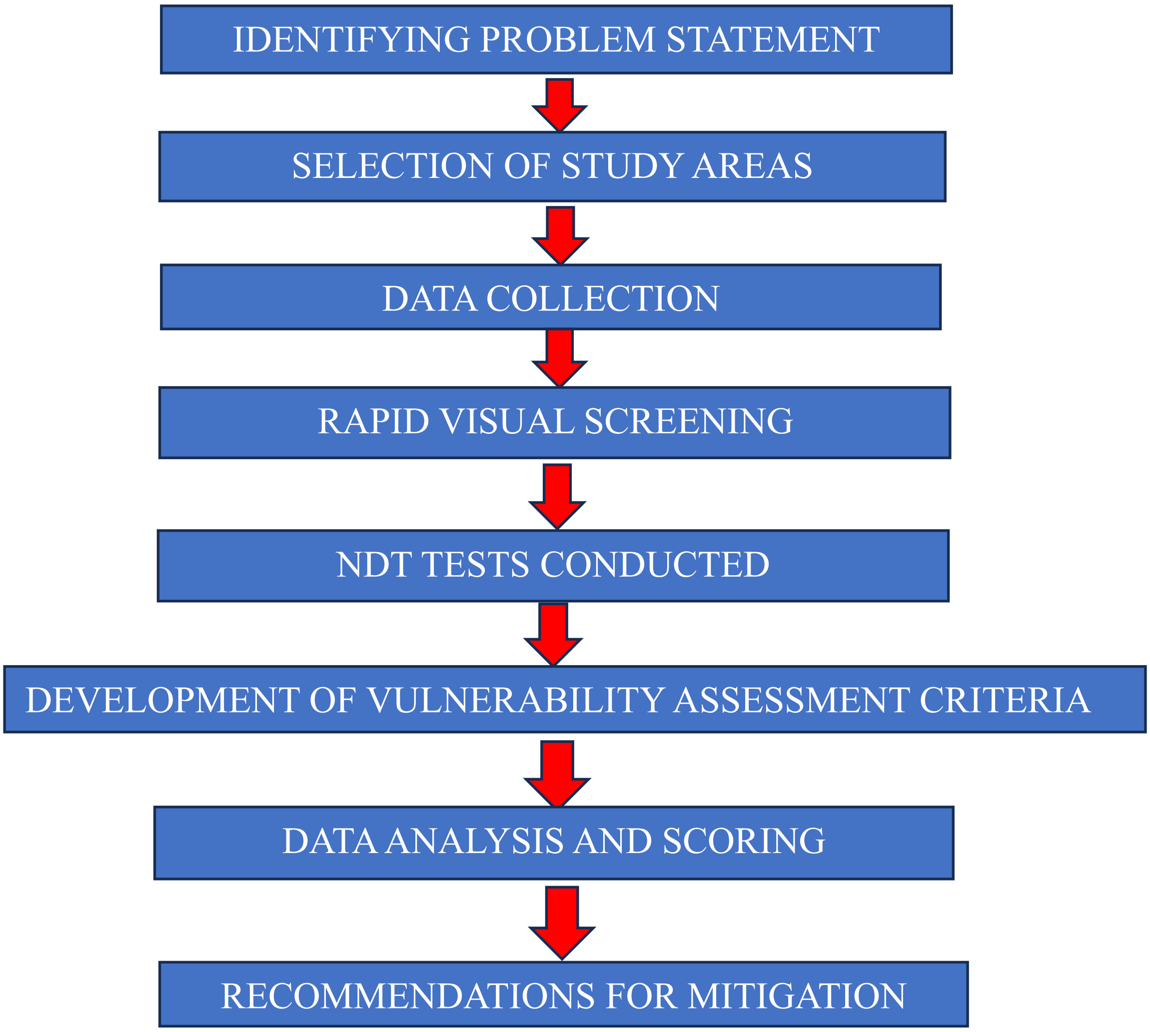
4. Observations are made if there are any defects like cracks in the structure, cracks in the building etc were also noted down.

5. The utmost important data that we have collected on site are age of the building, building material, shape irregularities etc. and was noted down in-site in RVS form.

6. All the data that was collected from the site was compiled and the final vulnerability Score of the building were calculated and depending upon this value the seismic vulnerability of the building was obtained.

The methodology consists of a step-by-step process that includes preliminary research, data collection, visual inspections, analysis, and community engagement. Our goal is to evaluate the structural integrity of Assam-type schools and identify critical vulnerabilities that may pose risks during seismic events. By following this structured approach, we hope to develop a deeper understanding of the resilience of educational infrastructure in Jorhat township, ensuring that these vital spaces remain safe during seismic events and vulnerabilities.

## 3.2.FLOWCHART




### 3.3 METHODOLOGY PROCEDURE

The project is divided into several main phases, each with specific objectives and activities:

**3.3.1Identifying problem statement**: We began by conducting a literature review to understand existing methodologies for assessing seismic vulnerability in educational buildings. This helped us gather background information on Assam-type schools and learn from previous studies.

**3.3.2Selection of Study Sites:** Next, we identified and selected a representative sample of Assam-type schools in Jorhat township for vulnerability assessment. We compiled a diverse list of schools based on various criteria, such as age of the school, number of students in the schools , local construction materials used etc.

**3.3.3Development of Assessment Criteria:** We established clear criteria for evaluating the seismic vulnerability of selected schools. This involves creating a checklist based on recognized standards as well as local construction practices to ensure relevance.

**3.3.4Data Collection:** Visual inspections and collection of data on each school's structural condition. A standardized surveys was carried out to gather qualitative and quantitative information regarding building materials, present features of the schools and possible hazards.

**3.3.5Data Collection Techniques:** To ensure a thorough assessment, we employed various data collection techniques:

- Visual Inspections: We conducted visual inspection of the various Assam type government schools in the vicinity of Jorhat township area.
- Data collection: Necessary data like wall details, type of construction, floor details, foundation type, structural cracks were noted down.
- Surveys: Standardized surveys conducted across the schools to gather information about building conditions, age of the schools and occupancy patterns.
- Photographic Documentation: Photographs were taken during the inspections to visually document structural conditions and any identified vulnerabilities associated.

- Compilation of information collected: The various data and information collected during the field visit to the schools were compiled to get a clear picture of the vulnerability of these schools to seismic activities.
- Assigning vulnerability score to the schools: By adopting a suitable formula, vulnerability scores were assigned to the schools in accordance with IS 1893:2002 and National Policy for seismic vulnerability assessment of buildings and seismic hazards

### 3.4 SCORING CRITERIA

For final scoring of the schools, we have adopted a suitable formula by following guidelines of IS 1893:2002 and National Policy for seismic vulnerability assessment of buildings. We have used the following tables for grade and vulnerability classification.

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**Table 1: Vulnerability classification (As per IS 1893:2002 National policy for seismic vulnerability assessment of buildings)**

<table>
<tr><th rowspan="2">Material</th><th rowspan="2">Type of Load-Bearing Structure</th><th rowspan="2">Sub-Types</th><th colspan="6">Vulnerability Class</th></tr>
<tr><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th></tr>
<tr><td rowspan="14">Masonry</td><td rowspan="2">Stone Masonry Walls</td><td>Rubble stone (field stone) in mud/lime mortar or without mortar</td><td>O</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Massive stone masonry (in lime/cement mortar)</td><td>|-</td><td>-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td rowspan="4">Earthen/Mud/ Adobe/Rammed Earthen Walls</td><td>Mud walls</td><td>O</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Mud walls with horizontal wood elements</td><td>|-</td><td>O</td><td>-|</td><td></td><td></td><td></td></tr>
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<tr><td>Unreinforced brick masonry in mud mortar with vertical posts</td><td>|-</td><td>O</td><td>-</td><td>-|</td><td></td><td></td></tr>
<tr><td>Unreinforced brick masonry in lime mortar</td><td>|-</td><td>O</td><td>-</td><td>-|</td><td></td><td></td></tr>
<tr><td>Unreinforced brick masonry with reinforced concrete floor</td><td></td><td>|-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td>Unreinforced brick masonry in cement mortar with lintel bands (various floor/roof systems)</td><td></td><td>|-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td>Confined brick/block masonry with concrete posts/tie columns and beams</td><td></td><td></td><td>|-</td><td>O</td><td>-|</td><td></td></tr>
<tr><td rowspan="2">Concrete block masonry</td><td>Unreinforced, in lime/cement mortar (various floor/roof systems)</td><td></td><td>|-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td>Reinforced, in cement mortar (various floor/roof systems)</td><td></td><td></td><td>|-</td><td>O</td><td>-|</td><td></td></tr>
</table>

Here O = Most likely vulnerability class, |- = lower range, -| = upper range

A=High Vulnerability

B=Moderate Vulnerability

C=Intermediate Vulnerability

D= Average Vulnerability

E=Low Vulnerability

F=Very low Vulnerability

**Table 2: Classification of damage to buildings. (As per IS 1893:2002 National policy for seismic vulnerability assessment of buildings)**

| **Classification of damage to masonry buildings** |
|---|
| **Grade 1: Negligible to slight damage**<br>**(No structural damage, slight non-structural damage)**<br>Hair-line cracks in very few walls.<br>Fall of small pieces of plaster only.<br>Fall of loose stones from upper parts of buildings in very few cases. |
| **Grade 2: Moderate damage**<br>**(Slight structural damage, moderate non-structural damage)**<br>Cracks in many walls.<br>Fall of fairly large pieces of plaster.<br>Partial collapse of chimneys |
| **Grade 3: Substantial to heavy damage (moderate structural damage, heavy non-structural damage)**<br>Large and extensive cracks in most walls.<br>Roof tiles detach. Chimneys fracture at the roof line; failure of individual non-structural elements (partitions, gable walls etc.). |
| **Grade 4: Very heavy damage (heavy structural damage, very heavy non-structural damage)** Serious failure of walls (gaps in walls); partial structural failure of roofs and floors. |
| **Grade 5: Destruction (very heavy structural damage)**<br>Total or near total collapse of the building. |

**Table 3: Damage Potential (As per IS 1893:2002 and National policy for seismic vulnerability assessment of buildings)**

| RVS Score | Damage Potential |
|---|---|
| S < 0.3 | High probability of Grade 5 damage; Very high probability of Grade 4 damage |
| 0.3 < S < 0.7 | High probability of Grade 4 damage; Very high probability of Grade 3 damage |
| 0.7 < S < 2.0 | High probability of Grade 3 damage; Very high probability of Grade 2 damage |
| 2.0 < S < 3.0 | High probability of Grade 2 damage; Very high probability of Grade 1 damage |
| S > 3.0 | Probability of Grade 1 damage |

**Table 4. Scoring criteria for Assam type building (As per IS 1893:2002 and National policy for Seismic vulnerability assessment of buildings)**

| Parameter | Description | Value range |
|---|---|---|
| Z | Zone Factor (based on seismic zone ) | Zone II = 1.0<br>Zone III = 1.5<br>Zone IV = 2.0<br>Zone V = 3.0 |

| | | |
|---|---|---|
| I | Importance Factor(based on school type) | Assam type LP Schools =1.0<br>Higher Secondary schools =1.5<br>Facilities Available=2.0 |
| R | Response Reduction Factor (based on design) | Well shaped =1<br>Average shaped=2<br>Poorly shaped =3 |
| Score formula | Total Seismic | Score =Z + I – R |

## Scoring Formula :

Final Score, S= Z + I – R

Score = Total seismic safety score

Z =Zone Factor (1 to 3 based on seismic zones )

I = Importance Factor(1 to 2 based on school type)

R= Response Reduction factor (1 to 3 based on structural design)

## Scoring Interpretation

**Table 5: Scoring Interpretation (By following the guidelines of National policy for seismic vulnerability assessment of buildings)**

| Score Range | Grade |
|---|---|
| 4 – 5 | Excellent (A) |
| 3 | Good (B) |

| Score Range | Grade |
|---|---|
| 2 | Fair (C) |
| 0 – 1 | Poor (D) |

This table allows for seismic vulnerability assessment while adhering to relevant guidelines.

## 3.5 SUMMARY

RVS is an economical method of assessing seismic vulnerability since it does not demand detailed engineering analysis or any specialized equipment. The methodology allows the rapid assessment of a large number of buildings in a very short time frame, thus ideal for large-scale surveys. RVS is easy to conduct; it is based on observations and standardized scoring forms and does not require much technical expertise as in the case of detailed structural assessments. This study is based on rapid visual screening of various Assam type schools in Jorhat township area through visual inspection to assess the probable risk hazards of these schools during an earthquake. The project work is carried out through a scientifically proven method and in accordance with IS 1893:2002 Part 1. The detailed analysis of structural components requires more complex evaluation. In this study we are confined with Level -I procedure.

# CHAPTER-4

# RESULTS AND OBSERVATIONS

## 4.1 INTRODUCTION

This chapter deals with the survey that has been carried out in various Assam type schools of Jorhat township area through Rapid Visual Screening. The findings about the seismic vulnerability of these schools has been assessed in tabular form. The results of the RVS give a comprehensive review of the structural vulnerability of the buildings surveyed. It will point out the percentages of buildings classified as high-risk, moderate-risk, and low-risk according to set standards. The analysis will point out some of the critical vulnerabilities, such as structural deficiencies, irregularities in shapes, material degradation that can worsen the impact of some hazards, such as earthquakes. The conclusion highlights the potential of RVS as an efficient and time-saving tool to rank buildings that need thorough assessments or urgent interventions.

It also underlines the role of RVS in decision-making for risk mitigation, urban planning, and policy development. Recommendations are made for improving the RVS process and vulnerabilities identified to make the built environment safer.

## 4.2 FIELD STUDY OF RAPID VISUAL SCREENING

For our study, we have conducted Rapid Visual Screening (RVS) on 20 Assam type Government schools located in Jorhat township area. The list of the schools are

1. Jorhat Engineering Collegiate L.P School
2. 216 No. Garmur Duliagaon L.P School Housing Type: Assam type
3. Murmuriya Bagisa L.P School
4. 12 No. Garmur L.P School
5. Baghjhan Gorfolia L.P School
6. Magolukhat L.P School
7. Cintamoni Adarsha L.P School
8. Gayon Gaon L.P School, Dhakorgorah
9. Belguri Tribal High School
10. Jorhat Adarsha Sanjukta Vidyalaya
11. Jorhat Adarsha School
12. Jorhat Model Composite School
13. Kumar Chandranarayan Sinha L.P School
14. Balya Bhawan School
15. Borigaon Public High School
16. 83 No. Borigaon L.P School
17. 83 No. Nokari L.P School
18. Rebakanta Boruah Public High School
19. Sarujini Devi H.S Girls School
20. Maheshwar Hazarika Suwarini Sishu Niketan

## 4.3 SCHOOLS VISITED

We have visited the following Schools for our field study of assessing the seismic vulnerability of Assam-type Government Schools of Jorhat Township area. We have prepared Rapid Visual Screening General Form as per the guidelines of IS 1893: 2002 (Part-1) and National Policy for Seismic Vulnerability Assessment of buildings. The Schools are as given below:

## SCHOOL NUMBER 1

Name of the School: Jorhat Engineering Collegiate L.P School, Jorhat


Figure 1.1:Front View


Figure 1.2:Side View

1. ADDRESS OF THE BUILDING: Jorhat Engineering College Road, Jorhat, Assam
2. DISTRICT: Jorhat
3. AREA: URBAN: ☑ RURAL: ☐
4. AGE OF THE BUILDING:52 Years
5. NUMBER OF STUDENTS: 43
6. BUILDING ELEMENTS
   a. Number of doors: 6
      Door Size: 1.2 m×2.1m
   b. Number of Windows: 10
      Window size: 1.2m×1.1m
   c. Ramps: Number of Ramps: 1
7. EXPOSURE TO HAZARD TYPES:
   a. EARTHQUAKE ☑
   b. LANDSLIDE ☐
   c. FIRE ☑
   d. FLOOD ☐
8. BASIC DETAILS OF THE BUILDING:
9. a. TYPOLOGY OF THE BUILDING:
   ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐

   b. BUILDING CODE COMPLIANCE:

   ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

   c.TYPE OF CONSTRUCTION:

   BRICK MASONRY ☑ STONE MASONRY ☐ R.C FRAME ☐ MUD WALL ☐
10. FLOOR DETAILS:
    a. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE
11. WALL DETAILS:
    a. WALL MATERIAL:
    CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE ☐

14. FOUNDATION TYPE: Shallow foundation
15. CONSTRUCTION QUALITY:
    GOOD ☐ FAIR ☑ POOR ☐
16. IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?
    YES ☑ NO ☐

17. OTHER DEFICIENT PARAMETERS:

a. WATER SEEPAGE: YES ☑ NO ☐

b.WATER LOGGING: YES ☐ NO ☑

c. DAMPNESS: YES ☑ NO ☐

d. CORROSION: YES ☑ NO ☐

<u>SCORING CRITERIA</u>

The above table allows for seismic vulnerability assessment while adhering to relevant guidelines.

Score(As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)

Score, S = Z+I-R
Where Z= Zone Factor(1 to 3 based on seismic zone)
I(Influence factor) = 1
Here, Z= 3(For seismic Zone V)
R(Response Reduction Factor) = 2
Final score, S=3+1-2
Final Score, S= 2

1. SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES: 2

2. VULNERABILITY CLASSIFICATION:

CLASS A (High vulnerability) ☐

CLASS B(Moderate vulnerability) ☐

CLASS C(Intermediate vulnerability) ☐

CLASS D ( Average vulnerability) ☑

CLASS E (Low vulnerability) ☐

CLASS F (Very Low vulnerability) ☐

<table>
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<tr><td rowspan="6">Burnt clay brick/block masonry walls</td><td>Unreinforced brick masonry in mud mortar</td><td>|-</td><td>O</td><td>-|</td><td></td><td></td><td></td></tr>
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<tr><td>Unreinforced brick masonry in lime mortar</td><td>|-</td><td>O</td><td>-</td><td>-|</td><td></td><td></td></tr>
<tr><td>Unreinforced brick masonry with reinforced concrete floor</td><td></td><td>|-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td>Unreinforced brick masonry in cement mortar with lintel bands (various floor/roof systems)</td><td></td><td>|-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td>Confined brick/block masonry with concrete posts/tie columns and beams</td><td></td><td></td><td>|-</td><td>O</td><td>-|</td><td></td></tr>
<tr><td rowspan="2">Concrete block masonry</td><td>Unreinforced, in lime/cement mortar (various floor/roof systems)</td><td></td><td>|-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td>Reinforced, in cement mortar (various floor/roof systems)</td><td></td><td></td><td>|-</td><td>O</td><td>-|</td><td></td></tr>
</table>

TABLE 1.1 VULNERABILITY CLASSIFICATION

Here O = Most likely vulnerability class, |- = lower range, -| = upper range

| RVS Score | Damage Potential |
|---|---|
| S < 0.3 | High probability of Grade 5 damage; Very high probability of Grade 4 damage |
| 0.3 < S < 0.7 | High probability of Grade 4 damage; Very high probability of Grade 3 damage |
| 0.7 < S < 2.0 | High probability of Grade 3 damage; Very high probability of Grade 2 damage |
| 2.0 < S < 3.0 | High probability of Grade 2 damage; Very high probability of Grade 1 damage |
| S > 3.0 | Probability of Grade 1 damage |

Table 1.2: Damage Potential

| Parameter | Description | Value range |
|---|---|---|
| Z | Zone Factor (based on seismic zone ) | Zone II = 1.0<br>Zone III = 1.5<br>Zone IV = 2.0<br>Zone V = 3.0 |
| I | Importance Factor(based on school type) | Assam type L.P Schools =1.0<br>Higher Secondary Schools =1.5<br>Faculties =2.0 |
| R | Response Reduction Factor (based on design) | Well Shaped =1<br>Average Shaped =2<br>Poorly Shaped =3 |
| Score formula | Total Seismic | Score =Z + I - R |

Table 1.3. Scoring criteria for Assam type building as per IS 1893:2002 and National policy for Seismic vulnerability classification

Scoring Interpretation

| Score Range | Grade |
|---|---|
| 4 – 5 | Excellent (A) |
| 3 | Good (B) |
| 2 | Fair (C) |
| 0 – 1 | Poor (D) |

Table 1.4: Scoring Interpretation

This table allows for seismic vulnerability assessment while adhering to relevant guidelines

| Sl No | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in N/mm$^2$ |
|---|---|---|---|---|
| 1. | Post-1 | 22,23,25,24,23,22 | 23.16 | **13.1** |
| 2. | Post-2 | 20,22,22,26,24,22 | 22.66 | **12.5** |
| 3. | Post-3 | 21,22,20,22,20,22 | 21.16 | **11.9** |
| 4. | Post-4 | 22,24,26,28,22,20 | 23.66 | **14.2** |
| 5. | Post-5 | 22,25,24,23,22,24 | 23.33 | **12.1** |
| 6. | Post-6 | 22,24,25,25,26,28 | 25 | **16** |
| 7. | Wall | 30,32,27,28,32,28 | 29.5 | **23** |

Table 1.5: NDT Test Results

3.POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible) ☐
b. GRADE 2 (Slight) ☑
c. GRADE 3 (Moderate) ☐
d. GRADE 4 (Severe) ☐
e. GRADE 5 (Total collapse) ☐

## 4.COMMENTS AND OBSERVATIONS:

a. The building has undergone a rebound hammer test, revealing compressive strength values for the columns ranging between 11.9 MPa and 16 MPa. These values are inadequate for seismic resistance, especially in a region prone to earthquakes.

b. The walls exhibit a compressive strength of 23 MPa, which, while relatively higher than the columns, does not offset the overall structural weaknesses observed in the building.

c. A score of 2 signifies that the Assam-type school falls into the fair category, meaning it fulfills some basic seismic safety requirements but requires further enhancements to improve its structural resilience.

d. The rebound hammer test score of 2 indicates a structural condition corresponding to Grade 2 damage as per the EMS-98 scale, signifying moderate damage. This highlights that the building has deficiencies that compromise its ability to withstand seismic forces effectively.

e. The structure falls under Class D, indicating a high degree of vulnerability due to its construction typology. The presence of dampness further exacerbates structural deterioration, reducing the material's load-bearing capacity and increasing susceptibility to seismic damage.

f. The observed dampness in walls and posts suggests water infiltration, which can weaken materials, cause corrosion of reinforcement (if present), and exacerbate structural vulnerabilities during seismic activity.

## SCHOOL NUMBER 2

Name of the School: 260 No Dulia Gaon L.P School, Jorhat


Figure 2.1:Front View


Figure 2.2: Crack on wall

1.ADDRESS OF THE BUILDING: Dulia Gaon, Jorhat, Assam

2.DISTRICT: JORHAT

3.DENSITY: URBAN: ☑ RURAL: ☐

4.AGE OF THE BUILDING:49 Years

5. NUMBER OF STUDENTS: 38

6.BUILDING ELEMENTS

a. Number of doors: 5
   Door Size: 1.12 m×2.09 m
b. Number of Windows: 6
   Window size: 1.1m×1.05m
c. Ramps: Number of Ramps: 1

7. EXPOSURE TO HAZARD TYPES:

a. EARTHQUAKE ☑
b. LANDSLIDE ☐
c. FIRE ☑
d. FLOOD ☐

8.BASIC DETAILS OF THE BUILDING:

a. TYPOLOGY OF THE BUILDING:

ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐

b. BUILDING CODE COMPLIANCE:

ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

c.TYPE OF CONSTRUCTION:

BRICK MASONRY ☑ STONE MASONRY ☐ R.C FRAME ☐ MUD WALL ☐

9.FLOOR DETAILS:

a.PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE

10.WALL DETAILS:

a.WALL MATERIAL:

CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE ☐

11. FOUNDATION TYPE: Shallow foundation

12. CONSTRUCTION QUALITY:

GOOD ☐ FAIR ☑ POOR ☐

13. IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

YES ☑ NO ☐

14. OTHER DEFICIENT PARAMETERS:

a.WATER SEEPAGE: YES ☐ NO ☑

b.WATER LOGGING: YES ☐ NO ☑

c. DAMPNESS: YES ☐ NO ☑

d. CORROSION: YES ☑ NO ☐

<u>SCORING CRITERIA</u>

The table allows for seismic vulnerability assessment while adhering to relevant guidelines.

Score(As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)

Score, S = Z+I-R

I(Influence factor) = 1

Where Z= Zone Factor(1 to 3 based on seismic zone)

Here, Z=3(For seismic Zone V)

R(Response Reduction Factor) = 2
Final score, S=3+1-2
S=2

1. SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES
   SCORE: 2

2.VULNERABILITY CLASSIFICATION:

CLASS A (High vulnerability) ☐

CLASS B(Moderate vulnerability) ☐

CLASS C(Intermediate vulnerability) ☐

CLASS D ( Average vulnerability) ☑

CLASS E (Low vulnerability) ☐

CLASS F (Very Low vulnerability) ☐

| **Material** | **Type of Load-Bearing Structure** | **Sub-Types** | **Vulnerability Class** | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E | F |
| Masonary | Stone Masonry Walls | Rubble stone (field stone) in mud/lime mortar or without mortar | O | | | | | |
| | | Massive stone masonry (in lime/cement mortar) | \|- | - | O | -\| | | |
| | Earthen/Mud/ Adobe/Rammed Earthen Walls | Mud walls | O | | | | | |
| | | Mud walls with horizontal wood elements | \|- | O | -\| | | | |
| | | Adobe block walls | O | -\| | | | | |
| | | Rammed earth construction | O | -\| | | | | |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Burnt clay brick/block masonry walls | Unreinforced brick masonry in mud mortar | \|- | O | -\| | | | |
| | | Unreinforced brick masonry in mud mortar with vertical posts | \|- | O | - | -\| | | |
| | | Unreinforced brick masonry in lime mortar | \|- | O | - | -\| | | |
| | | Unreinforced brick masonry with reinforced concrete floor | | \|- | O | -\| | | |
| | | Unreinforced brick masonry in cement mortar with lintel bands (various floor/roof systems) | | \|- | O | -\| | | |
| | | Confined brick/block masonry with concrete posts/tie columns and beams | | | \|- | O | -\| | |
| | Concrete block masonry | Unreinforced, in lime/cement mortar (various floor/roof systems) | | \|- | O | -\| | | |
| | | Reinforced, in cement mortar (various floor/roof systems) | | | \|- | O | -\| | |

Table 2.1: Vulnerability classification

Here O = Most likely vulnerability class, |- = lower range, -| = upper range

| RVS Score | Damage Potential |
|---|---|
| S < 0.3 | High probability of Grade 5 damage; Very high probability of Grade 4 damage |
| 0.3 < S < 0.7 | High probability of Grade 4 damage; Very high probability of Grade 3 damage |
| 0.7 < S < 2.0 | High probability of Grade 3 damage; Very high probability of Grade 2 damage |
| 2.0 < S < 3.0 | High probability of Grade 2 damage; Very high probability of Grade 1 damage |
| S > 3.0 | Probability of Grade 1 damage |

Table 2.2: Damage Potential

| Parameter | Description | Value range |
|---|---|---|
| Z | Zone Factor (based on seismic zone ) | Zone II = 1.0<br>Zone III = 1.5<br>Zone IV = 2.0<br>Zone V = 3.0 |
| I | Importance Factor(based on school type) | Assam type L.P. Schools =1.0<br>Higher Secondary Schools=1.5<br>Faculties =2.0 |
| R | Response Reduction Factor (based on design) | Well shaped =1<br>Average shaped =2<br>Poorly shaped =3 |
| Score formula | Total Seismic | Score =Z + I - R |

Table 2.3. Scoring criteria for Assam type building as per IS 1893:2002 and National policy for Seismic vulnerability classification

Scoring Interpretation

| **Score Range** | **Grade** |
|---|---|
| 4 - 5 | Excellent (A) |
| 3 | Good (B) |

| Score Range | Grade |
|---|---|
| 2 | Fair (C) |
| 0 - 1 | Poor (D) |

Table 2.4: Scoring Interpretation

| Sl No | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in $N/mm^2$ |
|---|---|---|---|---|
| 1. | Post-1 | 24,28,25,22,20,21 | 23.33 | **12.1** |
| 2. | Post-2 | 24,22,20,28,25,26 | 24.16 | **14.25** |
| 3. | Post-3 | 23,28,24,22,20,26 | 24 | **14** |
| 4. | Post-4 | 22,22,21,22,23,25 | 21.50 | **11** |
| 5. | Post-5 | 22,25,24,28,26,26 | 25.16 | **16.1** |
| 6. | Post-6 | 22,24,25,25,26,28 | 25 | **16** |
| 7. | Wall | 30,36,34,38,28,32 | 33 | **28** |

Table 2.5 NDT Test Results

## 3. POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible) ☐
b. GRADE 2 (Slight) ☑
c. GRADE 3 (Moderate) ☐
d. GRADE 4 (Severe) ☐

e. GRADE 5 (Total collapse) ☐

## 4.COMMENTS AND OBSERVATIONS:

a. The building has undergone a rebound hammer test, indicating compressive strength values for the columns ranging from 11 MPa to 16.1 MPa. These values fall below the recommended standards for earthquake-resistant structures, highlighting a significant vulnerability to seismic forces.

b. The walls exhibit a compressive strength of 28 MPa, which is comparatively higher than the columns. However, the presence of cracks compromises their structural integrity and performance during seismic events.

c. A score of 2 signifies that the Assam-type school falls into the fair category, meaning it fulfills some basic seismic safety requirements but requires further enhancements to improve its structural resilience.

d.The building is classified as Grade 2 damage according to the EMS-98 scale, reflecting moderate damage. This damage level suggests the structure is at considerable risk during earthquakes and may not adequately resist significant seismic forces.

e. The structure is categorized under Class D, indicating a high degree of vulnerability due to its construction typology. The presence of cracks in the walls further weakens the building, reducing its ability to distribute loads effectively and increasing the likelihood of collapse during seismic activity.

f. As a non-engineered structure, the building lacks critical design features that improve earthquake resilience, such as proper reinforcement, load path continuity, and seismic-resistant detailing. This absence exacerbates its seismic vulnerability.

g.Immediate retrofitting measures are necessary to improve the structural safety of the building. These measures should include repairing cracks in the walls, implementing design strategies that enhance earthquake resilience. Additionally, routine maintenance and monitoring are essential to address emerging vulnerabilities and prolong the building's lifespan.

## SCHOOL NUMBER 3

Name of the school: Murmuriya Bagisa L.P School, Jorhat


Figure 3.1:Front View


Figure 3.2:Side View


Figure 3.3:Crack on the door


Figure 3.4:Crack on wall

1. ADDRESS OF THE BUILDING: Murmuriya Bagisa Road,Jorhat,Assam

2. DISTRICT: Jorhat
3. DENSITY: URBAN: ☑ RURAL: ☐

4.AGE OF THE BUILDING:54 Years

5.NUMBER OF STUDENTS:50

6.BUILDING ELEMENTS

a. Number of doors: 7
   Door Size: 1.2 m×2.1 m
b. Number of Windows: 12
   Window size: 1.2m×1.1m
c. Ramps: Number of Ramps: 1

7.EXPOSURE TO HAZARD TYPES:

a. EARTHQUAKE ☑
b. LANDSLIDE ☐
c. FIRE ☑
d. FLOOD ☐

8.BASIC DETAILS OF THE BUILDING:

a. TYPOLOGY OF THE BUILDING:

ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐ STEEL BUILDING ☐

b. BUILDING CODE COMPLIANCE:

ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

c. TYPE OF CONSTRUCTION:

BRICK MASONRY ☑ STONE MASONRY ☐

9.FLOOR DETAILS:

a. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE

10.WALL DETAILS:

a. WALL MATERIAL:

CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED ☐

11. FOUNDATION TYPE: Shallow foundation

12. CONSTRUCTION QUALITY:

GOOD ☐ FAIR ☐ POOR ☑

13. IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

YES ☑ NO ☐

14. OTHER DEFICIENT PARAMETERS:
    - a.WATER SEEPAGE: YES ☐ NO ☑
    - b.WATER LOGGING: YES ☐ NO ☑
    - c. DAMPNESS: YES ☐ NO ☑
    - d. CORROSION: YES ☑ NO ☐

<u>SCORING CRITERIA</u>

Score (As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)

Score, S = Z+I-R

I(Influence factor) = 1

Where Z= Zone Factor(1 to 3 based on seismic zone)

Here, Z= 3(For seismic Zone V)

R(Response Reduction Factor) = 3

Final score, S=3+1-3

S = 1

1.SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES: 1

2.VULNERABILITY CLASSIFICATION:

CLASS A (High vulnerability) ☐

CLASS B(Moderate vulnerability) ☑

CLASS C(Intermediate vulnerability) ☐

CLASS D ( Average vulnerability) ☐

CLASS E (Low vulnerability) ☐

CLASS F (Very Low vulnerability) ☐

| Material | Type of Load-Bearing Structure | Sub-Types | Vulnerability Class | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E | F |
| Masonary | Stone Masonry Walls | Rubble stone (field stone) in mud/lime mortar or without mortar | O | | | | | |
| | | Massive stone masonry (in lime/cement mortar) | \|- | - | O | -\| | | |
| | Earthen/Mud/ Adobe/Rammed Earthen Walls | Mud walls | O | | | | | |
| | | Mud walls with horizontal wood elements | \|- | O | -\| | | | |
| | | Adobe block walls | O | -\| | | | | |
| | | Rammed earth construction | O | -\| | | | | |
| | Burnt clay brick/block masonry walls | Unreinforced brick masonry in mud mortar | \|- | O | -\| | | | |
| | | Unreinforced brick masonry in mud mortar with vertical posts | \|- | O | - | -\| | | |
| | | Unreinforced brick masonry in lime mortar | \|- | O | - | -\| | | |
| | | Unreinforced brick masonry with reinforced concrete floor | | \|- | O | -\| | | |
| | | Unreinforced brick masonry in cement mortar with lintel bands (various floor/roof systems) | | \|- | O | -\| | | |
| | | Confined brick/block masonry with concrete posts/tie columns and beams | | | \|- | O | -\| | |
| | Concrete block masonry | Unreinforced, in lime/cement mortar (various floor/roof systems) | | \|- | O | -\| | | |
| | | Reinforced, in cement mortar (various floor/roof systems) | | | \|- | O | -\| | |

Table 3.1: Vulnerability classification

Here O = Most likely vulnerability class, |- = lower range, -| = upper range

| RVS Score | Damage Potential |
|---|---|
| S < 0.3 | High probability of Grade 5 damage; Very high probability of Grade 4 damage |
| 0.3 < S < 0.7 | High probability of Grade 4 damage; Very high probability of Grade 3 damage |
| 0.7 < S < 2.0 | High probability of Grade 3 damage; Very high probability of Grade 2 damage |
| 2.0 < S < 3.0 | High probability of Grade 2 damage; Very high probability of Grade 1 damage |
| S > 3.0 | Probability of Grade 1 damage |

Table 3.2: Damage Potential

| Parameter | Description | Value range |
|---|---|---|
| Z | Zone Factor (based on seismic zone ) | Zone II = 1.0<br>Zone III = 1.5<br>Zone IV = 2.0<br>Zone V = 3.0 |
| I | Importance Factor(based on school type) | Assam type L.P. Schools =1.0<br>Higher Secondary Schools =1.5<br>Faculties =2.0 |
| R | Response Reduction Factor (based on design) | Well shaped =1<br>Average shaped =2<br>Poorly shaped =3 |
| Score formula | Total Seismic | Score =Z + I - R |

Table 3.3 Scoring criteria for Assam type building as per IS 1893:2002 and National policy for Seismic vulnerability classification

Scoring Interpretation

| Score Range | Grade |
|---|---|
| 4 – 5 | Excellent (A) |
| 3 | Good (B) |
| 2 | Fair (C) |
| 0 – 1 | Poor (D) |

Table 3.4: Scoring Interpretation

| Sl No | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in $N/mm^2$ |
|---|---|---|---|---|
| 1. | Post-1 | 24, 24,23,22,27,23 | 23.83 | **13.9** |
| 2. | Post-2 | 24,22,23,25,28,23 | 24.17 | **14.2** |
| 3. | Post-3 | 23,22, 26,22,24,25 | 23.67 | **13.8** |
| 4. | Post-4 | 23,22,24,24,24,22 | 23.17 | **13.5** |
| 5. | Post-5 | 24,25,24,25,26,24 | 20.50 | **11.2** |
| 6. | Post-6 | 22,23,24,24,22,24 | 23.17 | **13.5** |
| 7. | Wall | 26,24,28,26,24,26 | 25.5 | **16.1** |

Table 3.5 NDT Test Results

3.POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible) ☐
b. GRADE 2 (Slight) ☐
c. GRADE 3 (Moderate) ☐
d. GRADE 4 (Severe) ☑
e. GRADE 5 (Total collapse) ☐

## 4.COMMENTS AND OBSERVATIONS:

a. The building has undergone a rebound hammer test, revealing compressive strength values for the columns ranging from 11.2 MPa to 14.2 MPa. These values are critically low and indicate significant vulnerability to seismic forces, particularly in regions prone to earthquakes.

b. The walls exhibit a compressive strength of 16.1 MPa, which is inadequate for ensuring structural stability under seismic loads. This deficiency further compromises the building's overall earthquake resistance.

c.A score of 1 indicates that the Assam-type school is in the poor category, suggesting that it fails to meet essential seismic safety standards, and significant improvements are urgently required to ensure its structural integrity.

d. The structure is classified as Grade 4 damage according to the EMS-98 scale, indicating heavy damage with major structural and non-structural deficiencies. This level of damage suggests the building is at extreme risk during seismic events and may collapse under significant lateral forces.

e. The building falls under Class B, signifying that while it may have some engineered features, its overall design and construction are insufficient to withstand seismic forces effectively.

f.The rebound hammer test score of 1 reflects poor structural condition, confirming the need for urgent intervention to address both structural and material inadequacies.

## SCHOOL NO 4

Name of the school: 12 NO. Garmur L.P School, Jorhat


Figure- 4.1: Front View


Figure-4.2: Side View

1. ADDRESS OF THE BUILDING: Garmur, Jorhat- 7,Assam
2. DISTRICT: Jorhat
3. DENSITY: ☐ URBAN: ☑ RURAL: ☐

4.AGE OF THE BUILDING:47 Years

5.NUMBER OF STUDENTS:74

6.BUILDING ELEMENTS

a. Number of doors: 6
   Door Size: 1.15 m×2.08 m
b. Number of Windows: 12
   Window size: 1.13m×1.06m
c. Ramps: Number of Ramps: 1

7.EXPOSURE TO HAZARD TYPES:

a. EARTHQUAKE ☑
b. LANDSLIDE ☐
c. FIRE ☑
d. FLOOD ☐

8.BASIC DETAILS OF THE BUILDING:

a. TYPOLOGY OF THE BUILDING:

ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐ STEEL BUILDING ☐

b. BUILDING CODE COMPLIANCE:

ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

c. TYPE OF CONSTRUCTION:

BRICK MASONRY ☑ STONE MASONRY ☐ R.C FRAME ☐ MUD WALL

9.FLOOR DETAILS:

a. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE

10.WALL DETAILS:

a. WALL MATERIAL:

CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE ☐

11. FOUNDATION TYPE: Shallow foundation

12. CONSTRUCTION QUALITY:

GOOD ☑ FAIR ☐ POOR ☐

13. IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

YES ☑ NO ☐

14. OTHER DEFICIENT PARAMETERS:

a.WATER SEEPAGE: YES ☐ NO ☑

b.WATER LOGGING: YES ☐ NO ☑

c. DAMPNESS: YES ☐ NO ☑

d. CORROSION: YES ☑ NO ☐

## SCORING CRITERIA

The table shown below allows for assigning the scores to the schools.

Score (As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)

Score, S = Z+I-R
I(Influence factor) = 1
Z= Zone Factor(1 to 3 based on seismic zone)
Here, Z= 3(For seismic Zone V)
R(Response Reduction Factor) = 2
Final score, S=3+1-2
S=2

1. SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES
   SCORE : 2

2. VULNERABILITY CLASSIFICATION:

   CLASS A (High vulnerability) ☐

   CLASS B(Moderate vulnerability) ☐

   CLASS C(Intermediate vulnerability) ☐

   CLASS D ( Average vulnerability) ☑

   CLASS E (Low vulnerability) ☐

   CLASS F (Very Low vulnerability) ☐

| Material | Type of Load-Bearing Structure | Sub-Types | Vulnerability Class | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E | F |
| Masonary | Stone Masonry Walls | Rubble stone (field stone) in mud/lime mortar or without mortar | O | | | | | |
| | | Massive stone masonry (in lime/cement mortar) | \|- | - | O | -\| | | |
| | Earthen/Mud/ Adobe/Rammed Earthen Walls | Mud walls | O | | | | | |
| | | Mud walls with horizontal wood elements | \|- | O | -\| | | | |
| | | Adobe block walls | O | -\| | | | | |
| | | Rammed earth construction | O | -\| | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Burnt clay brick/block masonry walls | Unreinforced brick masonry in mud mortar | \|- | O | -\| | | | |
| | | Unreinforced brick masonry in mud mortar with vertical posts | \|- | O | - | -\| | | |
| | | Unreinforced brick masonry in lime mortar | \|- | O | - | -\| | | |
| | | Unreinforced brick masonry with reinforced concrete floor | | \|- | O | -\| | | |
| | | Unreinforced brick masonry in cement mortar with lintel bands (various floor/roof systems) | | \|- | O | -\| | | |
| | | Confined brick/block masonry with concrete posts/tie columns and beams | | | \|- | O | -\| | |
| | Concrete block masonry | Unreinforced, in lime/cement mortar (various floor/roof systems) | | \|- | O | -\| | | |
| | | Reinforced, in cement mortar (various floor/roof systems) | | | \|- | O | -\| | |

Table 4.1: Vulnerability classification

Here O = Most likely vulnerability class, |- = lower range, -| = upper range

| RVS Score | Damage Potential |
|---|---|
| S < 0.3 | High probability of Grade 5 damage; Very high probability of Grade 4 damage |
| 0.3 < S < 0.7 | High probability of Grade 4 damage; Very high probability of Grade 3 damage |
| 0.7 < S < 2.0 | High probability of Grade 3 damage; Very high probability of Grade 2 damage |
| 2.0 < S < 3.0 | High probability of Grade 2 damage; Very high probability of Grade 1 damage |

| | |
|---|---|
| S > 3.0 | Probability of Grade 1 damage |

Table 4.2: Damage Potential

| Parameter | Description | Value range |
|---|---|---|
| Z | Zone Factor (based on seismic zone ) | Zone II = 1.0<br>Zone III = 1.5<br>Zone IV = 2.0<br>Zone V = 3.0 |
| I | Importance Factor(based on school type) | Assam type L.P. Schools =1.0<br>Higher Secondary Schools=1.5<br>Faculties =2.0 |
| R | Response Reduction Factor (based on design) | Well shaped =1<br>Average shaped =2<br>Poorly shaped =3 |
| Score formula | Total Seismic | Score =Z + I - R |

Table 4.3 Scoring criteria for Assam type building as per IS 1893:2002 and National policy for Seismic vulnerability classification

Scoring Interpretation

| **Score Range** | **Grade** |
|---|---|
| 4 - 5 | Excellent (A) |
| 3 | Good (B) |

| Score Range | Grade |
|---|---|
| 2 | Fair (C) |
| 0 - 1 | Poor (D) |

Table 4.4: Scoring Interpretation

| Sl No | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in $N/mm^2$ |
|---|---|---|---|---|
| 1. | Post-1 | 23,26,28,24,20,22 | 23.83 | **13.85** |
| 2. | Post-2 | 20,22,22,21,20,20 | 20.83 | **11.15** |
| 3. | Post-3 | 20,21,21,20,23,22 | 21.16 | **11.5** |
| 4. | Post-4 | 22,22,21,20,23,20 | 21.33 | **11.6** |
| 5. | Post-5 | 22,21,20,22,22,21 | 21.33 | **11.6** |
| 6. | Wall | 20,22,22,21,20,21 | 21 | **11.2** |
| 8. | Floor | 21,20,20,21,22,20 | 20.67 | **16** |

Table 4.5: Results of NDT Test

3.POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible) ☐
b. GRADE 2 (Slight) ☑
c. GRADE 3 (Moderate) ☐
d. GRADE 4 (Severe) ☐

e. GRADE 5 (Total collapse) ☐

## 4.COMMENTS AND OBSERVATIONS:

a. The school is an Assam-type, non-engineered structure, inherently vulnerable to seismic activity due to its construction typology and lack of design considerations for earthquake resistance.

b. The building has a damage grade of 2 according to the EMS-98 scale, indicating moderate damage. This suggests that the structure is at significant risk during seismic events and may not withstand substantial earthquake forces effectively.

c. A score of 2 signifies that the Assam-type school falls into the fair category, meaning it fulfills some basic seismic safety requirements but requires further enhancements to improve its structural resilience.

d. The rebound hammer test shows compressive strength values of 11.5 MPa to 13.85 MPa for the columns and 11.2 MPa for the walls. These values are critically low, particularly for buildings in seismic zones, and highlight the need for stronger materials to resist lateral forces generated by earthquakes.

e. Slight cracks observed in the walls further compromise the structural integrity of the building, reducing its capacity to withstand seismic forces and increasing the risk of progressive damage during an earthquake.

f. The structure falls under Class D, which indicates a high degree of vulnerability due to the lack of engineered design and reinforcement features. This category underscores the potential for severe damage or collapse during a significant seismic event.

# SCHOOL NUMBER 5

Name of the school : Baghjan Ghorfolia L.P School, Jorhat


Figure 5.1 Front View


Figure 5.2: Side View

1. ADDRESS OF THE BUILDING: Baghjan Ghorfolia Gaon,Jorhat,Assam

2. DISTRICT: JORHAT
3. DENSITY: URBAN: ☐ RURAL: ☑

4.AGE OF THE BUILDING:62 Years

5.NUMBER OF STUDENTS:58

6.BUILDING ELEMENTS

a. Number of doors: 5
   Door Size: 1.2 m×2.1 m
b. Number of Windows: 10
   Window size: 1.14m×0.86m
c. Ramps: Number of Ramps: 1

7.EXPOSURE TO HAZARD TYPES:

a. EARTHQUAKE ☑
b. LANDSLIDE ☐
c. FIRE ☑
d. FLOOD ☑

8.BASIC DETAILS OF THE BUILDING:

a. TYPOLOGY OF THE BUILDING:

ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐

b. BUILDING CODE COMPLIANCE:

ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

c.TYPE OF CONSTRUCTION:

BRICK MASONRY ☑ STONE MASONRY ☐ R.C FRAME ☐ MUD WALL ☐

9.FLOOR DETAILS:

a. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE

10.WALL DETAILS:

a. WALL MATERIAL:

CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE

11. FOUNDATION TYPE: Shallow foundation

12. CONSTRUCTION QUALITY:

GOOD ☐ FAIR ☑ POOR ☐

13. IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

YES ☑ NO ☐

14. OTHER DEFICIENT PARAMETERS:
a. WATER SEEPAGE: YES ☑ NO ☐
b. WATER LOGGING: YES ☐ NO ☑
c. DAMPNESS: YES ☐ NO ☑
d. CORROSION: YES ☑ NO ☐

## SCORING CRITERIA

The below table allows for seismic vulnerability assessment while adhering to relevant guidelines.

Score(As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)

Score, S = Z+I-R
I(Influence factor) = 1
Where Z= Zone Factor(1 to 3 based on seismic zone)
Here, Z=3(For seismic Zone V)
R(Response Reduction Factor) = 3
Final score, S=3+1-3
S=1

1. SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES
   SCORE: 1

2. VULNERABILITY CLASSIFICATION:

   CLASS A (High vulnerability) ☐

   CLASS B(Moderate vulnerability) ☐

   CLASS C(Intermediate vulnerability) ☑

   CLASS D ( Average vulnerability) ☐

   CLASS E (Low vulnerability) ☐

   CLASS F (Very Low vulnerability) ☐

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<table>
<tr><th rowspan="2">Material</th><th rowspan="2">Type of Load-Bearing Structure</th><th rowspan="2">Sub-Types</th><th colspan="6">Vulnerability Class</th></tr>
<tr><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th></tr>
<tr><td rowspan="13">Masonary</td><td rowspan="2">Stone Masonry Walls</td><td>Rubble stone (field stone) in mud/lime mortar or without mortar</td><td>O</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Massive stone masonry (in lime/cement mortar)</td><td>|-</td><td>-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td rowspan="4">Earthen/Mud/ Adobe/Rammed Earthen Walls</td><td>Mud walls</td><td>O</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Mud walls with horizontal wood elements</td><td>|-</td><td>O</td><td>-|</td><td></td><td></td><td></td></tr>
<tr><td>Adobe block walls</td><td>O</td><td>-|</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Rammed earth construction</td><td>O</td><td>-|</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="6">Burnt clay brick/block masonry walls</td><td>Unreinforced brick masonry in mud mortar</td><td>|-</td><td>O</td><td>-|</td><td></td><td></td><td></td></tr>
<tr><td>Unreinforced brick masonry in mud mortar with vertical posts</td><td>|-</td><td>O</td><td>-</td><td>-|</td><td></td><td></td></tr>
<tr><td>Unreinforced brick masonry in lime mortar</td><td>|-</td><td>O</td><td>-</td><td>-|</td><td></td><td></td></tr>
<tr><td>Unreinforced brick masonry with reinforced concrete floor</td><td></td><td>|-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td>Unreinforced brick masonry in cement mortar with lintel bands (various floor/roof systems)</td><td></td><td>|-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td>Confined brick/block masonry with concrete posts/tie columns and beams</td><td></td><td></td><td>|-</td><td>O</td><td>-|</td><td></td></tr>
<tr><td>Concrete block masonry</td><td>Unreinforced, in lime/cement mortar (various floor/roof systems)</td><td></td><td>|-</td><td>O</td><td>-|</td><td></td><td></td></tr>
</table>

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Reinforced, in cement mortar (various floor/roof systems) | | | \|- | O | -\| | |

Table 5.1: Vulnerability classification

Here O = Most likely vulnerability class, |- = lower range, -| = upper range

| RVS Score | Damage Potential |
|---|---|
| S < 0.3 | High probability of Grade 5 damage; Very high probability of Grade 4 damage |
| 0.3 < S < 0.7 | High probability of Grade 4 damage; Very high probability of Grade 3 damage |
| 0.7 < S < 2.0 | High probability of Grade 3 damage; Very high probability of Grade 2 damage |
| 2.0 < S < 3.0 | High probability of Grade 2 damage; Very high probability of Grade 1 damage |
| S > 3.0 | Probability of Grade 1 damage |

Table 5.2: Damage Potential

| Parameter | Description | Value range |
|---|---|---|
| Z | Zone Factor (based on seismic zone ) | Zone II = 1.0<br>Zone III = 1.5<br>Zone IV = 2.0<br>Zone V = 3.0 |
| I | Importance Factor(based on school type) | Assam type L.P. Schools =1.0<br>Higher Secondary Schools=1.5<br>Critical Faculties =2.0 |
| R | Response Reduction Factor (based on design) | Well shaped =1<br>Average shaped =2<br>Poorly shaped =3 |

| | | |
|---|---|---|
| Score formula | Total Seismic | Score =Z + I - R |

Table 5.3 Scoring criteria for Assam type building as per IS 1893:2002 and National policy for Seismic vulnerability classification

Scoring Interpretation

| **Score Range** | **Grade** |
|---|---|
| 4 - 5 | Excellent (A) |
| 3 | Good (B) |
| 2 | Fair (C) |
| 0 - 1 | Poor (D) |

Table 5.4: Scoring Interpretation

| **Sl No** | **Testing Structures** | **No. of Rebound Hammer** | **Average of No. of Rebound Hammer** | **Equivalent Compressive Strength in $N/mm^2$** |
|---|---|---|---|---|
| 1. | Post-1 | 21,23,20,22,20,22 | 21.33 | **11.9** |
| 2. | Post-2 | 20,22,22,21,20,20 | 20.83 | **11** |

| | | | | |
|---|---|---|---|---|
| 3. | Post-3 | 20,21,21,20,23,22 | 21.16 | **11.5** |
| 4. | Post-4 | 22,22,21,20,23,20 | 21.33 | **11.9** |
| 5. | Post-5 | 22,21,20,22,22,21 | 21.33 | **11.9** |
| 6. | Wall | 20,22,22,21,20,21 | 21 | **11.7** |

Table 5.5 NDT TEST RESULTS

3.POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible) ☐
b. GRADE 2 (Slight) ☐
c. GRADE 3 (Moderate) ☑
d. GRADE 4 (Severe) ☐
e. GRADE 5 (Total collapse) ☐

## 4.COMMENTS AND OBSERVATIONS:

a. The building is an Assam-type, non-engineered structure, making it inherently vulnerable to seismic activity due to its construction typology and the lack of proper design considerations for earthquake resistance.

b. With a damage grade of 3 according to the EMS-98 scale, the building is categorized as having substantial damage. This indicates significant structural deficiencies, placing it at high risk of severe damage or collapse during seismic events.

c.A score of 1 signifies that the Assam-type school is in the poor category, indicating a failure to meet critical seismic safety standards and highlighting the urgent need for substantial structural improvements.

d. The rebound hammer test shows compressive strength values of 11 MPa to 11.9 MPa for the columns and 11.7 MPa for the walls. These values are critically low and insufficient for withstanding the lateral forces generated by earthquakes, particularly in seismic-prone zones.

e. Slight cracks observed in the posts of the building further weaken its structural integrity, increasing the likelihood of progressive damage under seismic loading.

f. The structure is classified under Class C, indicating moderate vulnerability. While it may exhibit some resilience, the observed weaknesses and lack of engineered reinforcement significantly increase the building's susceptibility to seismic forces.

## SCHOOL NUMBER 6

Name of the school : Magolukhat M.E School, Jorhat


Fig 6.1:Front View


Fig6.2:Front View


Fig 6.3: Performing Rebound Hammer Test

Figure 6.4: Crack on the Post

1.ADDRESS OF THE BUILDING: Mogolughat, Jorhat,Assam
2.DISTRICT: JORHAT
2. AREA: URBAN: ☑ RURAL: ☐
4.AGE OF THE BUILDING:65 Years

5.NUMBER OF STUDENTS:85

6.BUILDING ELEMENTS

a. Number of doors: 8
   Door Size: 1.01 m×1.79 m

b. Number of Windows: 14
   Window size: 1.15m×0.82m

c. Ramps: Number of Ramps: 1

7.EXPOSURE TO HAZARD TYPES:

a. EARTHQUAKE ☑
b. LANDSLIDE ☐
c. FIRE ☑
d. FLOOD ☑

8.BASIC DETAILS OF THE BUILDING:

a. TYPOLOGY OF THE BUILDING:

ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐ STEEL BUILDING ☐

b. BUILDING CODE COMPLIANCE:

ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

c.TYPE OF CONSTRUCTION:

BRICK MASONRY ☑ STONE MASONRY ☐ EARTHEN/MUD WALLS ☐

BURNT CLAY BRICKS/BLOCK MASONRY WALLS ☐

CONCRETE BLOCK MASONRY ☐

9.FLOOR DETAILS:

a. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE

10.WALL DETAILS:

a. WALL MATERIAL:
CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE ☐

11.FOUNDATION TYPE: Shallow foundation

12. CONSTRUCTION QUALITY:

GOOD ☐ FAIR ☑ POOR ☐

13.IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

YES ☑ NO ☐

14. OTHER DEFICIENT PARAMETERS:

a.WATER SEEPAGE: YES ☐ NO ☑

b.WATER LOGGING: YES ☐ NO ☑

c. DAMPNESS: YES ☐ NO ☑

d. CORROSION: YES ☑ NO ☐

## SCORING CRITERIA

Score(As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)

Score, S = Z+I-R

Where Z= Zone Factor(1 to 3 based on seismic zone)

I(Influence factor) = 1

Here, Z= 3(For seismic Zone V)

R(Response Reduction Factor) = 2

Final score, S=3+1-2

Final Score, S= 2

1. SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES SCORE: 2

2. VULNERABILITY CLASSIFICATION:

CLASS A (High vulnerability) ☐

CLASS B(Moderate vulnerability) ☐

CLASS C(Intermediate vulnerability) ☐

CLASS D ( Average vulnerability) ☑

CLASS E (Low vulnerability) ☐

CLASS F (Very Low vulnerability) ☐

| **Material** | **Type of Load-Bearing Structure** | **Sub-Types** | **Vulnerability Class** | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E | F |
| | Stone Masonry Walls | Rubble stone (field stone) in mud/lime mortar or without mortar | O | | | | | |
| | | Massive stone masonry (in lime/cement mortar) | \|- | - | O | -\| | | |
| Masonary | Earthen/Mud/ | Mud walls | O | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Adobe/Rammed Earthen Walls | Mud walls with horizontal wood elements | \|- | O | -\| | | | |
| | | Adobe block walls | O | -\| | | | | |
| | | Rammed earth construction | O | -\| | | | | |
| | Burnt clay brick/block masonry walls | Unreinforced brick masonry in mud mortar | \|- | O | -\| | | | |
| | | Unreinforced brick masonry in mud mortar with vertical posts | \|- | O | - | -\| | | |
| | | Unreinforced brick masonry in lime mortar | \|- | O | - | -\| | | |
| | | Unreinforced brick masonry with reinforced concrete floor | | \|- | O | -\| | | |
| | | Unreinforced brick masonry in cement mortar with lintel bands (various floor/roof systems) | | \|- | O | -\| | | |
| | | Confined brick/block masonry with concrete posts/tie columns and beams | | | \|- | O | -\| | |
| | Concrete block masonry | Unreinforced, in lime/cement mortar (various floor/roof systems) | | \|- | O | -\| | | |
| | | Reinforced, in cement mortar (various floor/roof systems) | | | \|- | O | -\| | |

Table 6.1: Vulnerability classification

Here O = Most likely vulnerability class, |- = lower range, -| = upper range

| RVS Score | Damage Potential |
|---|---|
| S < 0.3 | High probability of Grade 5 damage; Very high probability of Grade 4 damage |
| 0.3 < S < 0.7 | High probability of Grade 4 damage; Very high probability of Grade 3 damage |

| | |
|---|---|
| $0.7 < S < 2.0$ | High probability of Grade 3 damage; Very high probability of Grade 2 damage |
| $2.0 < S < 3.0$ | High probability of Grade 2 damage; Very high probability of Grade 1 damage |
| $S > 3.0$ | Probability of Grade 1 damage |

Table 6.2: Damage Potential

| Parameter | Description | Value range |
|---|---|---|
| Z | Zone Factor (based on seismic zone ) | Zone II = 1.0<br>Zone III = 1.5<br>Zone IV = 2.0<br>Zone V = 3.0 |
| I | Importance Factor(based on school type) | Assam type L.P. Schools =1.0<br>Higher Secondary Schools =1.5<br>Faculties =2.0 |
| R | Response Reduction Factor (based on design) | Well shaped =1<br>Average shaped =2<br>Poorly shaped =3 |
| Score formula | Total Seismic | Score =Z + I - R |

Table 6.3. Scoring criteria for Assam type building as per IS 1893:2002 and National policy for Seismic vulnerability classification.

## Scoring Interpretation

| **Score Range** | **Grade** |
|---|---|
| 4 - 5 | Excellent (A) |
| 3 | Good (B) |
| 2 | Fair (C) |
| 0 - 1 | Poor (D) |

Table 6.4: Scoring Interpretation

| **Sl No** | **Testing Structures** | **No. of Rebound Hammer** | **Average of No. of Rebound Hammer** | **Equivalent Compressive Strength in N/mm²** |
|---|---|---|---|---|
| 1. | Post-1 | 24,23,28,26,27,25 | 25.5 | **16.25** |
| 2. | Post-2 | 24,22,22,28,25,26 | 24.5 | **16** |
| 3. | Post-3 | 24,26,27,28,24,24 | 25.5 | **16.25** |
| 4. | Post-4 | 22,22,20,21,23,25 | 22.16 | **11.9** |
| 5. | Post-5 | 22,25,24,23,22,24 | 23.33 | **13.9** |
| 6. | Post-6 | 22,24,25,25,26,28 | 25 | **16** |
| 7. | Wall | 30,32,34,30,28,30 | 30.66 | **24** |

Table 6.5: NDT Test Results

3.POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible) ☐
b. GRADE 2 (Slight) ☑
c. GRADE 3 (Moderate) ☐
d. GRADE 4 (Severe) ☐
e. GRADE 5 (Total collapse) ☐

## 4.COMMENTS AND OBSERVATIONS:

a. The building is an Assam-type, non-engineered structure, which makes it inherently vulnerable to seismic activity due to its construction typology and the absence of design considerations for earthquake resistance.

b. With a damage grade of 2 according to the EMS-98 scale, the building is categorized as having moderate damage. This suggests that the structure is at risk during seismic events and may not effectively withstand significant earthquake forces.

c. A score of 2 indicates that the Assam-type school is categorized as fair, reflecting that it meets basic seismic safety requirements but still needs additional improvements to strengthen its structural resilience.

d.The rebound hammer test indicates compressive strength values of 11.9 MPa to 16.25 MPa for the columns and 24 MPa for the walls. While the wall strength is relatively higher, the column strength is insufficient for ensuring adequate stability under seismic loading.

e.The building is classified under Class D, indicating high vulnerability to seismic activity due to its lack of engineered reinforcement and structural detailing.

f.The presence of very slight cracks, although minor, is an early indicator of stress within the structure. Over time, these cracks could propagate and further compromise the building's ability to resist seismic forces.

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## SCHOOL NUMBER 7

Name of the school: Chintamoni Adarsha Sishu Niketon, Dagaon


Figure 7.1: Front View


Figure 7. 2: Boundary Wall

1.ADDRESS OF THE BUILDING: Dhakorgarah, Jorhat, Assam

2.DISTRICT: JORHAT

3.DENSITY: URBAN: ☐ RURAL: ☑

4.AGE OF THE BUILDING:36 Years

5. NUMBER OF STUDENTS:90

6.BUILDING ELEMENTS

a. Number of doors: 13
Door Size: 1.2 m×1.81m

b. Number of Windows: 30
Window size: 1.05m×0.79m

c. Ramps: Number of Ramps: 1

7.EXPOSURE TO HAZARD TYPES:

a. EARTHQUAKE ☑
b. LANDSLIDE ☐
c. FIRE ☑
d. FLOOD ☑

8.a. TYPOLOGY OF THE BUILDING:

ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐

b. BUILDING CODE COMPLIANCE:

ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

c.TYPE OF CONSTRUCTION:

BRICK MASONRY ☑ STONE MASONRY ☐ R.C FRAME ☐ MUD WALL ☐

9.FLOOR DETAILS:

a. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE

10.WALL DETAILS:

a. WALL MATERIAL:

CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE ☐

11. FOUNDATION TYPE: Shallow foundation

12. CONSTRUCTION QUALITY:

GOOD ☑ FAIR ☐ POOR ☐

13. IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?
YES ☑ NO ☐

14. OTHER DEFICIENT PARAMETERS:
a. WATER SEEPAGE: YES ☐ NO ☑
b. WATER LOGGING: YES ☐ NO ☑
c. DAMPNESS: YES ☐ NO ☑
d. CORROSION: YES ☑ NO ☐

SCORING CRITERIA

Score(As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)
Score, S = Z+I-R
Where Z= Zone Factor(1 to 3 based on seismic zone)
I(Influence factor) = 1
Here, Z= 3(For seismic Zone V)
R(Response Reduction Factor) = 1
Final score, S=3+1-1
Final Score, S= 3

1. SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES SCORE: 3

2. VULNERABILITY CLASSIFICATION:

CLASS A (High vulnerability) ☐

CLASS B(Moderate vulnerability) ☐

CLASS C(Intermediate vulnerability) ☐

CLASS D ( Average vulnerability) ☐

CLASS E (Low vulnerability) ☑

CLASS F (Very Low vulnerability) ☐

| Sl No | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in N/mm² |
|---|---|---|---|---|
| 1. | Post-1 | 24,22,28,22,20,22 | 23 | **13** |
| 2. | Post-2 | 24,22,22,23,20,22 | 22.12 | **12** |
| 3. | Post-3 | 23,22,23,22,21,20 | 21.83 | **12.25** |
| 4. | Post-4 | 22,22,21,22,20,22 | 21.50 | **12.2** |
| 5. | Post-5 | 22,22,21,23,28,25 | 23.5 | **14** |
| 6. | Post-6 | 24,22,22,23,24,28 | 23.8 | **14.25** |
| 7. | Post-7 | 20,22,20,20,20,23 | 20.83 | **10.5** |
| 8. | Post-8 | 20,20,20,22,24,24 | 21.66 | **12.22** |
| 9. | Post-9 | 20,20,22,24,24,24 | 22.33 | **12.1** |
| 10. | Wall | 30,36,32,26,28,32 | 30.66 | **24** |

Table 7.1: NDT Test Results

## 3.POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible) ☐
b. GRADE 2 (Slight) ☑
c. GRADE 3 (Moderate) ☐
d. GRADE 4 (Severe) ☐
e. GRADE 5 (Total collapse) ☐

## 4.COMMENTS AND OBSERVATIONS:

a. The building is an Assam-type, non-engineered structure, inherently vulnerable to seismic activity due to its construction typology and lack of specific design considerations for earthquake resistance.

b. With a damage grade of 2 according to the EMS-98 scale, the building exhibits moderate damage, indicating that it is at significant risk during seismic events and may not withstand strong earthquake forces effectively.

c. A score of 3 indicates that the Assam-type school is in the good category, suggesting that it meets most seismic safety standards, though minor improvements could further enhance its structural integrity.

d.The rebound hammer test reveals compressive strength values of 10.5 MPa to 14.25 MPa for the columns and 24 MPa for the walls. While the walls demonstrate adequate strength, the columns have critically low compressive strength, making them insufficient for resisting lateral forces during an earthquake.

e. The building is classified under Class E, which signifies a very high degree of vulnerability. Structures in this category typically lack engineered reinforcement and show significant deficiencies that compromise their seismic resilience.

f.The high vulnerability of the building is exacerbated by the inadequacy of its columns, which are critical load-bearing elements. This weakness makes the structure prone to severe damage or potential collapse under seismic forces.

**SCHOOL NUMBER 8**

Name of the school:615 No. Gayon Gaon L.P School, Jorhat


Figure 8.1: Front View

Fig 8.2: Crack on wall



Figure 8.3: Side View

Fig 8.4: Ramp

1.ADDRESS OF THE BUILDING: Dhakorgarah,Jorhat,Assam

2.DISTRICT: JORHAT

3.DENSITY: URBAN: ☐ RURAL: ☑

4.AGE OF THE BUILDING:58 Years

5.NUMBER OF STUDENTS: 48

6.BUILDING ELEMENTS

a. Number of doors: 4
Door Size: 1.017 m×1.75 m

b. Number of Windows: 8
Window size: 1.133m×0.83m

c. Ramps: Number of Ramps: 2

7.EXPOSURE TO HAZARD TYPES:

a. EARTHQUAKE ☑
b. LANDSLIDE ☐
c. FIRE ☑

d. FLOOD ☑

8.BASIC DETAILS OF THE BUILDING:

a. TYPOLOGY OF THE BUILDING:

ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐

b. BUILDING CODE COMPLIANCE:

ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

c.TYPE OF CONSTRUCTION:

BRICK MASONRY ☑ STONE MASONRY ☐ R.C FRAME ☐ MUD WALL ☐

9.FLOOR DETAILS:

a. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE

10.WALL DETAILS:

a. WALL MATERIAL:

CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE ☐

11. FOUNDATION TYPE: Shallow foundation

12. CONSTRUCTION QUALITY:

GOOD ☐ FAIR ☐ POOR ☑

13. IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

YES ☑ NO ☐

14. OTHER DEFICIENT PARAMETERS:

a.WATER SEEPAGE: YES ☑ NO ☐

b.WATER LOGGING: YES ☐ NO ☑

c. DAMPNESS: YES ☑ NO ☐

d. CORROSION: YES ☑ NO ☐

## SCORING CRITERIA

Score(As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)

Score, S = Z+I-R

Where Z= Zone Factor(1 to 3 based on seismic zone)

I(Influence factor) = 1

Here, Z=3(For seismic Zone V)

R(Response Reduction Factor) = 3

Final score, S=3+1-3

Final score, S=1

1. SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES: 1

2. VULNERABILITY CLASSIFICATION:

- CLASS A (High vulnerability) ☐
- CLASS B(Moderate vulnerability) ☑
- CLASS C(Intermediate vulnerability) ☐
- CLASS D ( Average vulnerability) ☐
- CLASS E (Low vulnerability) ☐
- CLASS F (Very Low vulnerability) ☐

| Sl No | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in N/mm$^2$ |
|---|---|---|---|---|
| 1. | Post-1 | 23,26,28,24,20,22 | 23.83 | **15** |
| 2. | Post-2 | 20,22,22,21,20,20 | 20.83 | **12** |
| 3. | Post-3 | 20,21,21,20,23,22 | 21.16 | **12.25** |
| 4. | Wall | 22,22,21,20,23,20 | 21.33 | **12.5** |
| 5. | Wall | 22,21,20,22,22,21 | 21.33 | **12.5** |
| 6. | Wall | 20,22,22,21,20,21 | 21 | **11.9** |

Table 8.1: NDT Test Results

3.POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible) ☐
b. GRADE 2 (Slight) ☐
c. GRADE 3 (Moderate) ☐
d. GRADE 4 (Severe) ☑
e. GRADE 5 (Total collapse) ☐

## 4.COMMENTS AND OBSERVATIONS:

a. The building is an Assam-type, non-engineered structure, inherently vulnerable to seismic activity due to its construction typology and lack of design considerations for earthquake resistance.

b. With a damage grade of 4 according to the EMS 98 scale, the building is categorized as having severe damage. This indicates a high level of structural compromise, suggesting the building is at critical risk during seismic events and may collapse under strong earthquake forces.

c. A score of 1 signifies that the Assam-type school is categorized as poor, reflecting its inability to meet essential seismic safety standards and emphasizing the need for immediate and significant structural improvements.

d. The rebound hammer test shows compressive strength values of 12 MPa to 15 MPa for the columns and 11.9 MPa for the walls. These values are inadequate for providing the required resistance to lateral forces generated by earthquakes, particularly in areas with high seismic activity.

e. The building is classified under Class B, which signifies moderate seismic vulnerability. However, the presence of numerous cracks in both the walls and the posts further weakens the structure, making it highly susceptible to progressive failure during seismic events.

f. The extensive cracking in the structural elements compromises the integrity and load-bearing capacity of the building. This condition poses an immediate safety hazard, especially for occupants during seismic activity.

g. Urgent retrofitting measures are required to address the structural deficiencies. These measures should include sealing and reinforcing the cracks in the walls and posts, enhancing the compressive strength of the structural elements, and introducing earthquake-resilient features such as proper reinforcement and load distribution mechanisms. Regular monitoring and maintenance are also crucial to ensure the long-term safety of the building.

## SCHOOL NUMBER 9

Name of the school: Balguri Tribal School,Jorhat

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Figure 9.1:Front View

Figure 9.2: Steps



Figure 9.3: Roof

Figure 9.4: Side View

1. ADDRESS OF THE BUILDING: Charighoria, Jorhat, Assam

2. DISTRICT: JORHAT
3. DENSITY: URBAN: ☐ RURAL: ☑
4. AGE OF THE BUILDING: 61 Years

5. BUILDING ELEMENTS

   a. Number of doors: 10
      Door Size: 1.011 m×1.77 m

   b. Number of Windows: 24
      Window size: 1.142m×0.81m

   c. Ramps: Number of Ramps: 1

6. NUMBER OF STUDENTS: 66

7 .EXPOSURE TO HAZARD TYPES:

   a. EARTHQUAKE ☑
   b. LANDSLIDE ☐
   c. FIRE ☑
   d. FLOOD ☑

8. BASIC DETAILS OF THE BUILDING:

   a. TYPOLOGY OF THE BUILDING:

      ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐

   b. BUILDING CODE COMPLIANCE:

      ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

   c. TYPE OF CONSTRUCTION:

      BRICK MASONRY ☑ STONE MASONRY ☐ R.C FRAME ☐ MUD WALL ☐

9. FLOOR DETAILS:

   a. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE

10.WALL DETAILS:

   a. WALL MATERIAL:
   CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE ☐

11. FOUNDATION TYPE: Shallow foundation
12. CONSTRUCTION QUALITY:

   GOOD ☐ FAIR ☑ POOR ☐

13. IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

   YES ☑ NO ☐

14. OTHER DEFICIENT PARAMETERS:

a. WATER SEEPAGE: YES ☑ NO ☐

b. WATER LOGGING: YES ☐ NO ☑

c. DAMPNESS: YES ☑ NO ☐

d. CORROSION: YES ☑ NO ☐

## SCORING CRITERIA

Score(As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)
Score, S = Z+I-R
I(Influence factor) = 1
Where Z= Zone Factor(1 to 3 based on seismic zone)
Here, Z=3(For seismic Zone V)
R(Response Reduction Factor) = 1
Final score, S=3+1-1
S=3

1. SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES: 3

2. VULNERABILITY CLASSIFICATION:

CLASS A (High vulnerability) ☐

CLASS B(Moderate vulnerability) ☐

CLASS C(Intermediate vulnerability) ☐

CLASS D ( Average vulnerability) ☑

CLASS E (Low vulnerability) ☐

CLASS F (Very Low vulnerability) ☐

| Sl No | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in $N/mm^2$ |
|---|---|---|---|---|
| 1. | Post-1 | 21,22,20,22,20,22 | 21.16 | 12 |
| 2. | Post-2 | 28,26,26,28,24,26 | 26.33 | 16 |
| 3. | Wall | 23,22,23,22,21,20 | 21.83 | 12.25 |
| 4. | Wall | 22,22,21,22,20,22 | 21.50 | 12.2 |
| 5. | Wall | 22,22,21,23,28,25 | 23.5 | 13 |
| 6. | Wall | 24,22,22,23,24,28 | 23.8 | 13.25 |

Table 9.1: NDT Test Results

## 3.POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible) ☐
b. GRADE 2 (Slight) ☑
c. GRADE 3 (Moderate) ☐
d. GRADE 4 (Severe) ☐
e. GRADE 5 (Total collapse) ☐

## 4.COMMENTS AND OBSERVATIONS:

a. The building is an Assam-type, non-engineered structure, inherently vulnerable to seismic activity due to its construction typology and lack of design considerations for earthquake resistance.

b. With a damage grade of 2 according to the EMS 98 scale, the building is categorized as having moderate damage. While the building is still structurally stable, it remains at risk during seismic events and may not withstand significant earthquake forces effectively.

c. A score of 3 signifies that the Assam-type school is categorized as good, indicating compliance with most seismic safety standards, with only minor enhancements needed to further improve its structural integrity.

d. The rebound hammer test shows compressive strength values of 12 MPa to 16 MPa for the columns and 13.25 MPa for the walls. Although these values are somewhat within the acceptable range for seismic zones, they are still on the lower side, making the building vulnerable to lateral forces generated by earthquakes.

e. The building consists of two parts: one that has been newly constructed and another with very slight cracks. The presence of cracks in the older part indicates that the structure may be deteriorating over time, and while the newly constructed portion may offer better resilience, the overall stability of the entire building could be compromised without proper reinforcement.

f. The slight cracking in the older portion of the building may worsen during seismic events, potentially affecting the load-bearing capacity of the structure. It is essential to address these cracks to prevent further damage and maintain the structural integrity of the building.

g. Immediate retrofitting measures are necessary, particularly for the older section of the building. This may involve reinforcing the walls and columns, addressing the cracks, and ensuring proper construction techniques and materials are used to bring the building up to current seismic safety standards. Enhancing drainage systems and ensuring proper load distribution throughout the building will also improve its earthquake resilience.

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## SCHOOL NUMBER 10

Name of the school: Jorhat Adarsha Sanjukta Vidyalaya, Jorhat



Fig 10.1: Side View

Fig 10.2 : Rebound Hammer Test


Fig 10.3 : Damage on wall    Fig 10.4 : Front View

1. ADDRESS OF THE BUILDING: Mithapukhuri, Jorhat, Assam
2. DISTRICT: Jorhat
3. AREA: URBAN: ☑ RURAL: ☐
4. AGE OF THE BUILDING: 56 years
5. NUMBER OF STUDENTS: 32
6. BUILDING ELEMENTS
    a. Number of doors: 5
       Door Size: 1.15 m× 2.05m
    b. Number of Windows: 9
       Window size: 1.3m×1.07m
    c. Ramps: Number of Ramps: 2
7. EXPOSURE TO HAZARD TYPES:
    a. EARTHQUAKE ☑
    b. LANDSLIDE ☐
    c. FIRE ☑
    d. FLOOD ☑
8. BASIC DETAILS OF THE BUILDING
    a. TYPOLOGY OF THE BUILDING:
       ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐ STEEL BUILDING ☐
    b. BUILDING CODE COMPLIANCE:
       ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑
    c. TYPE OF CONSTRUCTION:
       BRICK MASONRY ☑ STONE MASONRY ☐ EARTHEN/MUD WALLS ☐
       BURNT CLAY BRICKS/BLOCK MASONRY WALLS ☐
       CONCRETE BLOCK MASONRY ☐
9. FLOOR DETAILS:
    a. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE
10. WALL DETAILS:
    a. WALL MATERIAL:
       CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE ☐

11`. FOUNDATION TYPE: Shallow foundation

12. CONSTRUCTION QUALITY:

GOOD ☐ FAIR ☐ POOR ☑

13. IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

YES ☑ NO ☐

14. OTHER DEFICIENT PARAMETERS:

a. WATER SEEPAGE: YES ☐ NO ☑
b. WATER LOGGING: YES ☐ NO ☑
c. DAMPNESS: YES ☑ NO ☐
d. CORROSION: YES ☑ NO ☐

## SCORING CRITERIA

Score(As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)

Score, S = Z+I-R

I(Influence factor) = 1

Where Z= Zone Factor(1 to 3 based on seismic zone)

Here, Z=3(For seismic Zone V)

R(Response Reduction Factor) = 2

Final score, S=3+1-2

S=2

1.SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTE SCORE : 2

2.VULNERABILITY CLASSIFICATION:

CLASS A (High vulnerability) ☐

CLASS B(Moderate vulnerability) ☐

CLASS C(Intermediate vulnerability) ☑

CLASS D ( Average vulnerability) ☐

CLASS E (Low vulnerability) ☐

CLASS F (Very Low vulnerability) ☐

| Sl.No. | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in N/mm$^2$ |
|---|---|---|---|---|
| 1. | Wall | 34,26,25,24,28,27,26,34,28,25,26,30 | 27.75 | 19 |
| 2. | Post-1 | 24,20,26,22,23 | 23 | 13.7 |
| 3. | Post-2 | 32,30,26,28,27 | 28.6 | 21 |
| 4. | Post-3 | 33,28,26,30,32 | 29.8 | 23 |
| 5 | Post-4 | 30,24,28,26,30 | 27.6 | 19.3 |

Table 10.1: NDT Test Results

3.POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible damage) ☐
b. GRADE 2 (Moderate damage) ☐
c. GRADE 3 (Substantial damage) ☑
d. GRADE 4 (Very heavy ) ☐
e. GRADE 5 (Destruction) ☐

## 4.COMMENTS AND OBSERVATIONS:

a. The assessment of the building shows that it receives a grade level of 3 according to EMS 98 indicating substantial vulnerability to seismic events.

b. A score of 2 indicates that the Assam-type school is in the fair category, suggesting that while it meets some basic seismic safety standards, improvements are necessary to enhance its structural integrity.

c. Large and extensive cracks in most walls are observed , and a grade level of 3 suggests that the non structural elements are at risk of failure like partition, gable walls etc.

d. It suggests that while the building may withstand moderate seismic forces, it is at risk of significant damage during severe earthquakes.

e. From the NDT test, compressive strength of wall was obtained as 19 MPa, which indicates that while they are capable of bearing standard loads, they are potentially vulnerable under extreme conditions.

f. The compressive strength of the columns ranged from 14 to 23 MPa, revealing variability in strength, which could compromise overall stability, highlighting the need for rigorous assessment and potential reinforcement.

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**SCHOOL NUMBER 11**

Name of the school : Jorhat Adarsha School, Jorhat


Fig 11.1: Front View

Fig 11.2:Side View



Fig 11.3: Classroom

Fig 11.4:Crack on floor

1. ADDRESS OF THE BUILDING: Mithapukhuri Road, Jorhat, Assam

2.DISTRICT: Jorhat

3.DENSITY :URBAN: ☑ RURAL: ☐

4.AGE OF THE BUILDING: 48 years

5.NUMBER OF STUDENTS: 42

6.BUILDING ELEMENTS

Number of doors: 6

Door Size: 1.09m×2.03m

Number of Windows: 12

Window size: 1.2m×1.1m

Ramps: Number of Ramps: 2

7.EXPOSURE TO HAZARD TYPES:

a. EARTHQUAKE ☑

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b. LANDSLIDE ☐

c. FIRE ☑

d. FLOOD ☑

8.BASIC DETAILS OF THE BUILDING:

a. TYPOLOGY OF THE BUILDING:

ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐ STEEL BUILDING ☐

b. BUILDING CODE COMPLIANCE:

ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

c.TYPE OF CONSTRUCTION:

BRICK MASONRY ☑ STONE MASONRY ☐ EARTHEN/MUD WALLS ☐

BURNT CLAY BRICKS/BLOCK MASONRY WALLS ☐

CONCRETE BLOCK MASONRY ☐

9.FLOOR DETAILS:

a.PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE

10.WALL DETAILS:

a.WALL MATERIAL:

CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE ☐

11.FOUNDATION TYPE: Shallow foundation

12.CONSTRUCTION QUALITY:

GOOD ☐ FAIR ☑ POOR ☐

13.IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

YES ☑ NO ☐

14.OTHER DEFICIENT PARAMETERS:

a.WATER SEEPAGE: YES ☐ NO ☑

b.WATER LOGGING: YES ☑ NO ☐

c.DAMPNESS: YES ☑ NO ☐

d.CORROSION: YES ☑ NO ☐

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SCORING CRITERIA

Score(As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)

Score, S = Z+I-R

Where Z= Zone Factor(1 to 3 based on seismic zone)

I(Influence factor) = 1

Here, Z= 3(For seismic Zone V)

R(Response Reduction Factor) = 2

Final score, S=3+1-2

Final Score, S= 2

1.SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES SCORE : 2

2. VULNERABILITY CLASSIFICATION:

- CLASS A (High vulnerability) ☐
- CLASS B(Moderate vulnerability) ☐
- CLASS C(Intermediate vulnerability) ☐
- CLASS D ( Average vulnerability) ☑
- CLASS E (Low vulnerability) ☐
- CLASS F (Very Low vulnerability) ☐

| Sl.No. | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in $N/mm^2$ |
|---|---|---|---|---|
| 1. | Wall | 32,26,32,28,25,28,24,18,20,28 | 26.1 | 17.5 |
| 2. | Post-1 | 20,22,26,24,21 | 22.6 | 13 |
| 3. | Post-2 | 24,20,20,22,23 | 21.8 | 11.8 |

| | | | | |
|---|---|---|---|---|
| 4. | Post-3 | 26,24,22,25,20 | 23.4 | 13.8 |
| 5 | Floor | 24,22,18,22,20 | 21.2 | 16 |

Table 11.1: NDT Test Results

3. POTENTIAL DAMAGE LEVEL:
   a. GRADE 1 (Negligible damage) ☐
   b. GRADE 2 (Moderate damage) ☑
   c. GRADE 3 (Substantial damage) ☐
   d. GRADE 4 (Very heavy) ☐
   e. GRADE 5 (Destruction) ☐

## 4.COMMENTS AND OBSERVATIONS :

a. The school is an Assam-type, non-engineered structure, inherently vulnerable to seismic activity due to its construction typology and lack of design considerations for earthquake resistance b.With a damage grade of 2 according to the EMS 98 scale, the building is categorized as having moderate damage, indicating that it is at risk during seismic events and may not withstand significant earthquake forces effectively.

c.The school receives a score of 1, indicating that the school is in the poor category, reflecting severe seismic vulnerabilities and inadequate structural safety measures.

d.The compressive strength of the columns (14-17 $N/mm^2$) and floor (11 $N/mm^2$) is inadequate for withstanding the lateral forces generated by an earthquake. This is particularly concerning as buildings in seismic zones require higher strength materials to ensure safety.

e. The school's foundation may be compromised due to water logging issues, which can lead to soil erosion or liquefaction during an earthquake. This increases the risk of settling or tilting, further endangering structural stability.

f.As a non-engineered building, the school lacks design features that enhance earthquake resilience, such as proper load distribution and reinforcement techniques. This absence significantly increases its vulnerability during seismic events.

## SCHOOL NUMBER 12

Name of the school : Jorhat Model Composite School, Jorhat


Fig 12.1: Front View


Fig 12.2 : Crack on floor


Fig 12.3 : Crack on post


Fig 12.4 : Crack on ramp

1. ADDRESS OF THE BUILDING: Mithapukhuri Road, Jorhat, Assam

2. DISTRICT: Jorhat

3. AREA: URBAN: ☑ RURAL: ☐

4. AGE OF THE BUILDING: 42 years

5. NUMBER OF STUDENTS: 45

6. BUILDING ELEMENTS

a. Number of doors: 6
   Door Size: 1.1m× 2.06m

b. Number of Windows: 10
   Window size: 1.15m×1.05m

c. Ramps: Number of Ramps: 1

7. EXPOSURE TO HAZARD TYPES:

a. EARTHQUAKE ☑
b. LANDSLIDE ☐
c. FIRE ☐
d. FLOOD ☑

8.BASIC DETAILS OF THE BUILDING

a. TYPOLOGY OF THE BUILDING:

ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐ STEEL BUILDING ☐

b. BUILDING CODE COMPLIANCE:
   ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

c. TYPE OF CONSTRUCTION:
   BRICK MASONRY ☑ STONE MASONRY ☐ EARTHEN/MUD WALLS ☐

   BURNT CLAY BRICKS/BLOCK MASONRY WALLS ☐

   CONCRETE BLOCK MASONRY ☐

9. FLOOR DETAILS:

a. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE

10. WALL DETAILS:

a. WALL MATERIAL:
   CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE ☐

11. FOUNDATION TYPE: Shallow foundation

12. CONSTRUCTION QUALITY:

GOOD ☐ FAIR ☑ POOR ☐

13. IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

YES ☑ NO ☐

14.OTHER DEFICIENT PARAMETERS:

a.WATER SEEPAGE: YES ☐ NO ☑

b.WATER LOGGING: YES ☑ NO ☐

c.DAMPNESS: YES ☐ NO ☑

d.CORROSION: YES ☑ NO ☐

## SCORING CRITERIA

Score( As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)

Score, S = Z+I-R

Where Z= Zone Factor(1 to 3 based on seismic zone)

Here, Z = 3( For seismic Zone V)

I( Influence factor) = 1

R(Response Reduction Factor) = 3

Final score, S = 3+1-3

S = 1

1.SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES SCORE : 1

2.VULNERABILITY CLASSIFICATION:

CLASS A (High vulnerability) ☐

CLASS B(Moderate vulnerability) ☑

CLASS C(Intermediate vulnerability) ☐

CLASS D ( Average vulnerability) ☐

CLASS E (Low vulnerability) ☐

CLASS F (Very Low vulnerability) ☐

| Sl.No. | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in $N/mm^2$ |
|---|---|---|---|---|
| 1. | Wall | 24,22,32,26,22,28,26,27,30,29,28,30 | 27 | 18.5 |
| 2. | Post-1 | 24,26,28,20,22 | 24 | 14.5 |
| 3. | Post-2 | 23,20,25,22,24 | 22.8 | 13.5 |
| 4. | Post-3 | 28,26,24,27,22 | 25.4 | 17 |
| 5 | Post-4 | 24,22,23,24,26 | 23.8 | 14 |
| 6. | Post-5 | 28,26,24,28,22 | 25.6 | 17.2 |
| 7. | Floor | 20,22,18,20,22 | 20.4 | 10.5 |

Table 12.1: NDT Test Results

3.POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible damage) ☐
b. GRADE 2 (Moderate damage) ☐
c. GRADE 3 (Substantial damage) ☐
d. GRADE 4 (Very heavy) ☑
e. GRADE 5 (Destruction) ☐

## 4.COMMENTS AND OBSERVATIONS:

a.The school is an Assam-type, non-engineered structure, inherently vulnerable to seismic activity due to its construction typology and lack of design considerations for earthquake resistance

b. With a damage grade of 4 according to the EMS 98 scale, the building is categorized as having very heavy damage, indicating that it is at risk during seismic events and may not withstand significant earthquake forces effectively.

c.The school receives a score of 1, indicating that the school is in the poor category, reflecting severe seismic vulnerabilities and inadequate structural safety measures.

d.The compressive strength of the columns (14-17 $N/mm^2$) and floor (11 $N/mm^2$) is inadequate for withstanding the lateral forces generated by an earthquake. This is particularly concerning as buildings in seismic zones require higher strength materials to ensure safety.

e.The school's foundation may be compromised due to water logging issues, which can lead to soil erosion or liquefaction during an earthquake. This increases the risk of settling or tilting, further endangering structural stability.

f.As a non-engineered building, the school lacks design features that enhance earthquake resilience, such as proper load distribution and reinforcement techniques. This absence significantly increases its vulnerability during seismic events.

g.Given the current state of the building, immediate retrofitting measures are essential. This could involve reinforcing walls and columns, improving drainage systems to address water logging, and enhancing overall structural integrity to mitigate seismic risks.

## SCHOOL NUMBER 13

Name of the school: Kumar Chandranarayan Sinha L.P School, Jorhat



Fig 13.1: Front View

Fig 13.2:Roof Truss

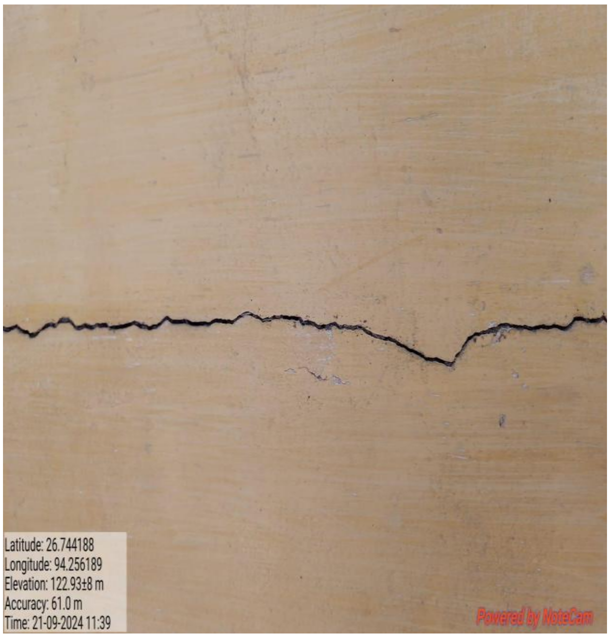

Fig 13.3 : Crack on wall

Fig 13.4 : Crack on wall

1.ADDRESS OF THE BUILDING: Mithapukhuri, Jorhat, Assam

2.DISTRICT: Jorhat

3.AREA: URBAN: ☑ RURAL: ☐

4.AGE OF THE BUILDING: 51 years

5.NUMBER OF STUDENTS: 47

6.BUILDING ELEMENTS

a. Number of doors: 6
   Door Size: 1.08m× 2.07m

b. Number of Windows: 10
   Window size: 1.12m×1.08m

c. Ramps: Number of Ramps: 2

7.EXPOSURE TO HAZARD TYPES:

a. EARTHQUAKE ☑

b. LANDSLIDE ☐

c. FIRE ☑

d. FLOOD ☑

8.BASIC DETAILS OF THE BUILDING:

a. TYPOLOGY OF THE BUILDING:

ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐ STEEL BUILDING ☐

b. BUILDING CODE COMPLIANCE:

ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

c.TYPE OF CONSTRUCTION:

BRICK MASONRY ☑ STONE MASONRY ☐ EARTHEN/MUD WALLS ☐

BURNT CLAY BRICKS/BLOCK MASONRY WALLS ☐

CONCRETE BLOCK MASONRY ☐

9.FLOOR DETAILS:

a. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE

10.WALL DETAILS:

a. WALL MATERIAL:
CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE ☐

11.FOUNDATION TYPE: Shallow foundation

12.CONSTRUCTION QUALITY:

GOOD ☐ FAIR ☐ POOR ☑

13.IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

YES ☑ NO ☐

14.OTHER DEFICIENT PARAMETERS:

a. WATER SEEPAGE: YES ☐ NO ☑

b. WATER LOGGING: YES ☐ NO ☑

c. DAMPNESS: YES ☐ NO ☑

d. CORROSION: YES ☑ NO ☐

## SCORING CRITERIA

Score(As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)

Score, S = Z+I-R

Where Z= Zone Factor(1 to 3 based on seismic zone)

I(Influence factor) = 1

Here, Z= 3(For seismic Zone V)

R(Response Reduction Factor) = 3

Final score, S=3+1-3

Final Score, S= 1

1.SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES SCORE: 1

2.VULNERABILITY CLASSIFICATION:

CLASS A (High vulnerability) ☐

CLASS B(Moderate vulnerability) ☑

CLASS C(Intermediate vulnerability) ☐

CLASS D ( Average vulnerability) ☐

CLASS E (Low vulnerability) ☐

CLASS F (Very Low vulnerability) ☐

| Sl.No | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in $N/mm^2$ |
|---|---|---|---|---|
| 1. | Wall | 26,22,24,20,22,28,26,20,28,25,24,21 | 23.8 | 14.4 |
| 2. | Post-1 | 24,26,22,20,24 | 23.2 | 13.7 |
| 3. | Post-2 | 23,20,24,21,26 | 22.8 | 13 |

| | | | | |
|---|---|---|---|---|
| 4. | Post-3 | 24,20,25,21,27 | 23.4 | 13.9 |
| 5. | Floor | 22,26,24,23,20 | 23 | 18 |

Table 13.5: NDT Test Results

3.POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible damage) ☐
b. GRADE 2 (Moderate damage) ☐
c. GRADE 3 (Substantial damage) ☐
d. GRADE 4 (Very heavy) ☑
e. GRADE 5 (Destruction) ☐

## 4.COMMENTS AND OBSERVATIONS:

a. The building receives a grade of 4, indicating substantial damage and intermediate vulnerability to seismic events.

b. Here, thatch roofs are present which are typically lightweight and their reduced mass means they exert less force on supporting walls and columns but they are highly vulnerable to fire, water damage, and decay, reducing their long-term durability.

c. A score of 1 signifies that the Assam-type school is categorized as poor, reflecting its inability to meet essential seismic safety standards and emphasizing the need for immediate and significant structural improvements.

d. Significant cracks in the corners of doors and floor and horizontal cracks were observed, reducing the overall capacity of the elements to withstand seismic loads.

e. The compressive strength of walls was measured at 14.4 MPa, which is below the standard load-bearing capacity for extreme seismic conditions, indicating high vulnerability.

f. The compressive strength of columns ranged from 13 MPa to 13.9 MPa, signifying low and uniform weakness, signifying the vulnerability of the building to seismic activities.

g. Immediate retrofitting measures should be considered to improve structural integrity, such as reinforcing walls and posts, adding shear walls, and addressing any water logging issues that may affect foundation stability.

## SCHOOL NUMBER 14

Name of the school: Balya Bhawan School, Jorhat



Fig 14.1: Front View

Fig 14.2: Crack on wall



Fig 14.3: Half wall

Fig 14.4: Crack on half wall

1. ADDRESS OF THE BUILDING: Old Circuit House Road, Atilagaon, Jorhat, Assam
2. DISTRICT: Jorhat
3. AREA: URBAN: ☑ RURAL: ☐
4. AGE OF THE BUILDING: 74 years
5. NUMBER OF STUDENTS: 72
6. BUILDING ELEMENTS
   a. Number of doors: 6
      Door Size: 1.009m× 2.08m
   b. Number of Windows: 11
      Window size: 1.13m×1.07m
   c. Ramps: Number of Ramps: 1
7. EXPOSURE TO HAZARD TYPES:
   a. EARTHQUAKE ☑
   b. LANDSLIDE ☐
   c. FIRE ☑
   d. FLOOD ☑
8. BASIC DETAILS OF THE BUILDING:
   a. TYPOLOGY OF THE BUILDING:

ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☑ STEEL BUILDING ☐

b. BUILDING CODE COMPLIANCE:

ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

c.TYPE OF CONSTRUCTION:

BRICK MASONRY ☐ STONE MASONRY ☐ EARTHEN/MUD WALLS ☑

BURNT CLAY BRICKS/BLOCK MASONRY WALLS ☑ CONCRETE BLOCK MASONRY ☐

9. FLOOR DETAILS:
   a. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE
10. WALL DETAILS:
   a. WALL MATERIAL:

CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE ☐

11. FOUNDATION TYPE: Shallow foundation

12. CONSTRUCTION QUALITY:

GOOD ☐ FAIR ☑ POOR ☐

13.IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

YES ☑ NO ☐

14.OTHER DEFICIENT PARAMETERS:

a. WATER SEEPAGE: YES ☐ NO ☑
b. WATER LOGGING: YES ☐ NO ☑
c. DAMPNESS: YES ☑ NO ☐
d. CORROSION: YES ☐ NO ☑

## SCORING CRITERIA

Where Z= Zone Factor(1 to 3 based on seismic zone)

I(Influence factor) = 1

Here, Z= 3(For seismic Zone V)

R(Response Reduction Factor) = 2

Final score, S=3+1-2

Final Score, S= 2

1. SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES SCORE : 2

2. VULNERABILITY CLASSIFICATION:

CLASS A (High vulnerability) ☐

CLASS B(Moderate vulnerability) ☐

CLASS C(Intermediate vulnerability) ☐

CLASS D ( Average vulnerability) ☑

CLASS E (Low vulnerability) ☐

CLASS F (Very Low vulnerability) ☐

| Sl.No | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in $N/mm^2$ |
|---|---|---|---|---|
| 1. | Wall | 24,26,30,28,26,18,22,24,27,24,26,28 | 25.2 | 16.4 |
| 2. | Post-1 | 36,34,30,28,32 | 32 | 26.4 |
| 3. | Post-2 | 28,26,22,24,25 | 25 | 16 |
| 4. | Post-3 | 30,28,27,24,28 | 27.4 | 19 |
| 5. | Post-4 | 20,26,28,24,22 | 24 | 14.6 |
| 6. | Post-5 | 24,28,27,30,26 | 27 | 18.6 |
| 7 | Floor | 18,22,20,21,20 | 20.2 | 10.1 |

Table 14.1: NDT Test Results

3.POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible damage) ☐
b. GRADE 2 (Moderate damage) ☑
c. GRADE 3 (Substantial damage) ☐
d. GRADE 4 (Very heavy) ☐
e. GRADE 5 (Destruction) ☐

## 4.COMMENTS AND OBSERVATIONS:

a.It has been assigned Grade 2 level damage as large gaps in walls and extensive cracks were observed, indicating that both structural and non-structural elements are at severe risk of failure, such as walls, partitions, etc.

b.It thus reflects significant deficiencies in seismic performance, suggesting that the structure is unlikely to withstand even moderate seismic forces without considerable damage.

c.A score of 2 indicates that the Assam-type school is categorized as fair, reflecting that it meets basic seismic safety requirements but still needs additional improvements to strengthen its structural resilience.

d.By NDT test, the compressive strength of walls was measured at 16.4 MPa, which is generally considered moderate for masonry walls, indicating the walls can support standard loads but may fail under extreme seismic forces.

e.The compressive strength of columns ranged between 14.6 MPa and 26.4 MPa, indicating variable strength across columns. The lower range of 14.6 MPa suggests weaknesses that could severely compromise overall stability.

f.Retrofitting measures like grout injection in the cracks of the walls and concrete jacketing, i.e. encasing existing columns with reinforced concrete can help in this aspect.

**<u>SCHOOL NUMBER 15</u>**

Name of the school: Borigaon Public High School, Jorhat


Fig 15.1: Front View

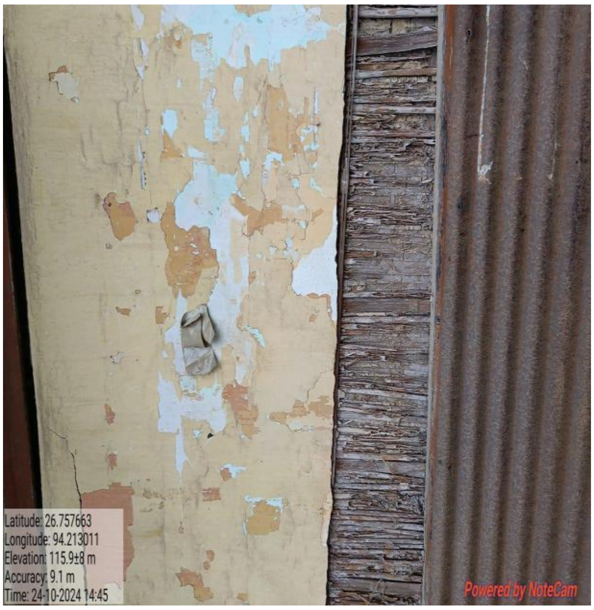


Fig 15.2 : Damage on wall

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Fig 15.3 : Dampness on wall


Fig 15.4 : Thatched panel walls

1. ADDRESS OF THE BUILDING: Borigaon, Nimati Path, Jorhat, Assam
2. DISTRICT: Jorhat
3. AREA: URBAN: ☑ RURAL: ☐
4. AGE OF THE BUILDING: 55 years
5. NUMBER OF STUDENTS: 55
6. BUILDING ELEMENTS
   a. Number of doors: 8
      Door Size: 1.1m× 2.09m
   b. Number of Windows: 15
      Window size: 1.11m×1.09m
   c. Ramps: Number of Ramps: 2
7. EXPOSURE TO HAZARD TYPES:
   a. EARTHQUAKE ☑
   b. LANDSLIDE ☐
   c. FIRE ☑
   d. FLOOD ☑
8. a. TYPOLOGY OF THE BUILDING:
   ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐ STEEL BUILDING ☐
   b. BUILDING CODE COMPLIANCE:

ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

c.TYPE OF CONSTRUCTION:

BRICK MASONRY ☑ STONE MASONRY ☐ EARTHEN/MUD WALLS ☐

BURNT CLAY BRICKS/BLOCK MASONRY WALLS ☐

CONCRETE BLOCK MASONRY ☐

9. FLOOR DETAILS:

a. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE

10. WALL DETAILS:

a. WALL MATERIAL:

CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE ☐

1. FOUNDATION TYPE: Shallow foundation

15. CONSTRUCTION QUALITY:

GOOD ☐ FAIR ☑ POOR ☐

16.IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

YES ☑ NO ☐

17.OTHER DEFICIENT PARAMETERS:

a. WATER SEEPAGE: YES ☑ NO ☐
b. WATER LOGGING: YES ☑ NO ☐
c. DAMPNESS: YES ☑ NO ☐
d. CORROSION: YES ☐ NO ☑

SCORING CRITERIA

Score, S = Z+I-R

Where Z= Zone Factor(1 to 3 based on seismic zone)

I(Influence factor) = 1

Here, Z= 3(For seismic Zone V)

R(Response Reduction Factor) = 3

Final score, S=3+1-3

Final Score, S=1

1. SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES SCORE : 1

2. VULNERABILITY CLASSIFICATION:

CLASS A (High vulnerability) ☐

CLASS B(Moderate vulnerability) ☑

CLASS C(Intermediate vulnerability) ☐

CLASS D ( Average vulnerability) ☐

CLASS E (Low vulnerability) ☐

CLASS F (Very Low vulnerability) ☐

| Sl.No | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in $N/mm^2$ |
|---|---|---|---|---|
| 1. | Wall | 32,30,28,26,22,26,30,26,28,24,26,30 | 27.3 | 18.9 |
| 2. | Post-1 | 24,22,23,26,28 | 24.6 | 15 |
| 3. | Post-2 | 22,24,28,23,21 | 23.6 | 12.2 |
| 4. | Post-3 | 28,25,27,24,22 | 25.2 | 16.1 |
| 5. | Post-4 | 30,27,28,25,26 | 27.2 | 19 |

| | | | | |
|---|---|---|---|---|
| 6. | Post-5 | 24,28,26,30,24 | 26.4 | 18 |
| 5. | Floor | 22,24,20,25,20 | 22.2 | 17 |

Table 15.1: NDT Test Results

3.POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible damage) ☐
b. GRADE 2 (Moderate damage) ☐
c. GRADE 3 (Substantial damage) ☐
d. GRADE 4 (Very heavy) ☑
e. GRADE 5 (Damage) ☐

## 4.COMMENTS AND OBSERVATIONS:

a.In this structure, ikora walls are present with a wooden frame that holds thinner panels. The wooden or plywood section shows layers separating, indicating water seepage or termite damage.

b.The discoloured and flaking paint of the walls suggest prolonged exposure to moisture or humidity. The wooden or plywood section in the walls show layers separating, indicating water seepage or termite damage.

c.A score of 1 signifies that the Assam-type school is categorized as poor, reflecting its inability to meet essential seismic safety standards and emphasizing the need for immediate and significant structural improvements.

d.The adjoining corrugated surface hints at the use of traditional roofing or wall cladding materials.

e.Observable structural cracks in the walls and floors, along with dampness and salt deposits, suggest ongoing deterioration. These issues can weaken the structural integrity and increase the likelihood of failure during an earthquake.

f. NDT test results show that the equivalent compressive strength of walls is 19 $N/mm^2$, while posts range from 12.2 to 19 $N/mm^2$, and the floor strength is 17 $N/mm^2$. The variability in post strength raises concerns about their ability to effectively support lateral loads during seismic activity.

g.The building has received a damage grade of 2 on the EMS 98 scale, indicating that while it has moderate damage, it is still at risk for further deterioration during seismic events, which could compromise the safety of students and staff.

h. Being 55 years old, the building may have experienced material fatigue and degradation over time. This aging process can lead to reduced structural performance and increased susceptibility to seismic forces.

i.Implementing retrofitting measures should be prioritized to improve the building's earthquake resilience. This may include reinforcing walls and posts, addressing moisture issues, and ensuring proper drainage to prevent further deterioration.

## SCHOOL NUMBER 16

Name of the school: 83 No. Borigaon L.P. School, Jorhat


Fig 16.1: Front View


Fig 16.2: Crack on floor

Fig 16.3: Post

Fig 16.4: Crack on post

1. ADDRESS OF THE BUILDING: Borigaon, Nimati Path, Jorhat, Assam
2. DISTRICT: Jorhat

3. AREA: URBAN: ☑ RURAL: ☐
4. AGE OF THE BUILDING: 41 years
5. NUMBER OF STUDENTS: 38
6. BUILDING ELEMENTS
    a. Number of doors: 8
       Door Size: 1.09m× 2.06m
    b. Number of Windows: 14
       Window size: 1.10m×1.08m
    c. Ramps: Number of Ramps: 2
7. EXPOSURE TO HAZARD TYPES:
    a. EARTHQUAKE ☑
    b. LANDSLIDE ☐
    c. FIRE ☑
    d. FLOOD ☑
8. a. TYPOLOGY OF THE BUILDING:
   ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐ STEEL BUILDING ☐
   b. BUILDING CODE COMPLIANCE:
      ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑
   c. TYPE OF CONSTRUCTION:
      BRICK MASONRY ☐ STONE MASONRY ☐ EARTHEN/MUD WALLS ☐
      BURNT CLAY BRICKS/BLOCK MASONRY WALLS ☑
      CONCRETE BLOCK MASONRY ☐
9. FLOOR DETAILS:
    a. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE
10. WALL DETAILS:
    a. WALL MATERIAL:

CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE ☐

11. FOUNDATION TYPE: Shallow foundation
12. CONSTRUCTION QUALITY:
    GOOD ☐ FAIR ☑ POOR ☐
13. IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?
    YES ☐ NO ☑
14. OTHER DEFICIENT PARAMETERS:
    a. WATER SEEPAGE: YES ☐ NO ☑
    b. WATER LOGGING: YES ☐ NO ☑
    c. DAMPNESS: YES ☐ NO ☑
    d. CORROSION: YES ☐ NO ☑

## SCORING CRITERIA

Score(As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)

Score, S = Z+I-R

Where Z= Zone Factor(1 to 3 based on seismic zone)

I(Influence factor) = 1

Here, Z= 3(For seismic Zone V)

R(Response Reduction Factor) = 1

Final score, S=3+1-1

Final Score, S= 3

1. SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES SCORE : 3

2. VULNERABILITY CLASSIFICATION:

CLASS A (High vulnerability) ☐

CLASS B(Moderate vulnerability) ☐

CLASS C(Intermediate vulnerability) ☐

CLASS D ( Average vulnerability) ☐

CLASS E (Low vulnerability) ☑

CLASS F (Very Low vulnerability) ☐

| Sl.No | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in $N/mm^2$ |
|---|---|---|---|---|
| 1. | Wall | 30,34,28,36,34,26,24,27,29,25,22,28 | 28.5 | 21 |
| 2. | Post-1 | 32,30,24,28,26 | 28 | 20 |
| 3. | Post-2 | 26,28,22,24,23 | 24.6 | 15 |
| 4. | Post-3 | 30,32,28,26,25 | 28.2 | 20.2 |
| 5. | Post-4 | 28,25,27,22,24 | 25.2 | 16.1 |
| 5. | Floor | 24,18,22,20,20 | 20.8 | 10.5 |

Table 16.5: NDT Test Results

3.POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible damage) ☐
b. GRADE 2 (Moderate damage) ☑
c. GRADE 3 (Substantial damage) ☐
d. GRADE 4 (Very heavy) ☐
e. GRADE 5 (Destruction) ☐

## 4.COMMENTS AND OBSERVATIONS:

a.This school exhibits a relatively low seismic vulnerability due to its current structural condition and the absence of visible cracks.

b. Receiving a damage grade of 2 on the EMS 98 scale indicates that the building has negligible damage, suggesting it is in good condition and poses a lower risk during seismic events compared to buildings with higher damage grades.

c.A score of 3 indicates that the Assam-type school is in the good category, suggesting that it meets most seismic safety standards, though minor improvements could further enhance its structural integrity.

d.The NDT test results show that the equivalent compressive strength of the walls is 21 $N/mm^2$, with posts ranging from 16.1 to 20.2 $N/mm^2$, and the floor strength at 10.5 $N/mm^2$. While the wall and post strengths are adequate for seismic resistance, the floor strength is relatively lower and may require attention.

e. The lack of structural cracks in the walls and floors is a positive indicator of the building's integrity. This suggests that it has maintained its structural performance well over the years, reducing immediate seismic concerns.

f. While the school is currently in good condition, proactive measures should be taken to mitigate potential vulnerabilities that could arise from aging materials or unforeseen environmental factors.

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## SCHOOL NO 17

Name of the school: 83 No. Nokari Adarsha L.P School School, Jorhat


Fig. 17.1:Front View


Fig.17.2: Side View


Fig.17.3: Crack on floor


Fig.17.4: Crack on ramp

1. ADDRESS OF THE BUILDING: Borigaon, Nimati Path, Jorhat, Assam

2. DISTRICT: Jorhat

3. AREA: URBAN: ☑ RURAL: ☐

4. AGE OF THE BUILDING: 135 Years

5. NUMBER OF STUDENTS: 80

6. BUILDING ELEMENTS:

   a. Number of doors: 6
      Door Size: 1.15 m×2.00m

   b. Number of Windows: 14
      Window size: 1.2m×0.86m

   c. Ramps: Number of Ramps: 1

7. EXPOSURE TO HAZARD TYPES:

   a. EARTHQUAKE ☑

   b. LANDSLIDE ☐

c. FIRE ☐

d. FLOOD ☑

8. BASIC DETAILS OF THE BUILDING:

a.TYPOLOGY OF THE BUILDING:

ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐ STEEL BUILDING ☐

b. BUILDING CODE COMPLIANCE:

ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

c. TYPE OF CONSTRUCTION:

BRICK MASONRY ☑ STONE MASONRY ☐ EARTHEN/MUD WALLS ☐

BURNT CLAY BRICKS/BLOCK MASONRY WALLS ☐

CONCRETE BLOCK MASONRY ☐

9. FLOOR DETAILS:

a.PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE

10. WALL DETAILS:

a. WALL MATERIAL:

CONCRETE ☑ BURNT BRICK ☐ DRESSED STONE ☐ UNDRESSED

STONE ☐

11. FOUNDATION TYPE: Shallow foundation

12. CONSTRUCTION QUALITY:

GOOD ☐ FAIR ☑ POOR ☐

13. IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

YES ☑ NO ☐

14. OTHER DEFICIENT PARAMETERS:

a. WATER SEEPAGE: YES ☐ NO ☑

b. WATER LOGGING: YES ☐ NO ☑

c. DAMPNESS: YES ☐ NO ☑

d. CORROSION: YES ☑ NO ☐

SCORING CRITERIA

Score(As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)

Score, S = Z+I-R

Where Z= Zone Factor(1 to 3 based on seismic zone)

I(Influence factor) = 1

Here, Z= 3(For seismic Zone V)

R(Response Reduction Factor) = 2

Final score, S=3+1-2

Final Score, S= 2

1. SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES SCORE : 2

2. VULNERABILITY CLASSIFICATION:

CLASS A (High vulnerability) ☐

CLASS B(Moderate vulnerability) ☐

CLASS C(Intermediate vulnerability) ☐

CLASS D ( Average vulnerability) ☑

CLASS E (Low vulnerability) ☐

CLASS F (Very Low vulnerability) ☐

| Sl.No | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in $N/mm^2$ |
|---|---|---|---|---|
| 1. | Wall | 32,28,25,27,30,28,24,30,26,27,30,24 | 27.5 | 19.5 |
| 2. | Post-1 | 30,28,26,22,24 | 26 | 17 |
| 3. | Post-2 | 27,26,30,23,26 | 26.6 | 17.8 |
| 4. | Post-3 | 24,22,27,28,24 | 25 | 16 |
| 5. | Post-4 | 26,28,22,27,24 | 25.4 | 16.6 |
| 5. | Floor | 20,22,24,20,22 | 21.6 | 11.5 |

Table 17.1: NDT Test Results

3. POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible) ☐

b. GRADE 2 (Slight) ☑

c. GRADE 3 (Moderate) ☐

d. GRADE 4 (Severe) ☐

e. GRADE 5 (Total collapse) ☐

## 4. COMMENTS AND OBSERVATIONS:

a. The building is an Assam-type, non-engineered structure, inherently vulnerable to seismic activity due to its construction typology and lack of design considerations for earthquake resistance.

b. With a damage grade of 2 according to the EMS 98 scale, the building is categorized as having moderate damage. This indicates that it is at significant risk during seismic events and may not withstand substantial earthquake forces effectively.

c. A score of 2 indicates that the Assam-type school is categorized as fair, reflecting that it meets basic seismic safety requirements but still needs additional improvements to strengthen its structural resilience.

d.The compressive strength of the columns (16-17.8 MPa) and walls (19.5 MPa) is insufficient for withstanding the lateral forces generated by an earthquake. Buildings in seismic zones require materials with higher strength to ensure safety.

e. The building's structural safety score is 0.6, reflecting a poor resistance to seismic forces and highlighting the urgent need for intervention to address the risk of collapse or severe damage.

f. As a non-engineered building, it lacks essential design features that enhance earthquake resilience, such as adequate load distribution, reinforcement techniques, and appropriate structural detailing. This significantly increases its vulnerability to seismic events.

g. The foundation of the building may be compromised, especially if subjected to water logging, which can lead to soil instability such as erosion or liquefaction during an earthquake. This increases the risk of differential settlement or tilting, further endangering the structure.

## SCHOOL NUMBER 18

Name of the school: Rebakanta Boruah Public High School, Jorhat


Fig 18.1: Roof


Fig 18.2: Front View


Fig 18.3 : Crack on post


Fig 18.4: Side view

1. ADDRESS OF THE BUILDING: Kenduguri, Jorhat, Assam
2. DISTRICT: Jorhat
3. AREA: URBAN: ☑ RURAL: ☐
4. AGE OF THE BUILDING: 122 years
5. NUMBER OF STUDENTS: 73
6. BUILDING ELEMENTS
   a. Number of doors: 12
      Door Size: 1.12 m× 2.09m
   b. Number of Windows: 21
      Window size: 1.2m×1.5m
   c. Ramps: Number of Ramps: 2

7. EXPOSURE TO HAZARD TYPES:

   a. EARTHQUAKE ☑

   b. LANDSLIDE ☐

   c. FIRE ☑

   d. FLOOD ☑

8. a. TYPOLOGY OF THE BUILDING:

   ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐ STEEL BUILDING ☐

   b. BUILDING CODE COMPLIANCE:
      ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

   c. TYPE OF CONSTRUCTION:
      BRICK MASONRY ☑ STONE MASONRY ☐ EARTHEN/MUD WALLS ☐

      BURNT CLAY BRICKS/BLOCK MASONRY WALLS ☐

      CONCRETE BLOCK MASONRY ☐

9. FLOOR DETAILS:

   a. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE

10. WALL DETAILS:

   a. WALL MATERIAL:

   CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE ☐

11. FOUNDATION TYPE: Shallow foundation

12. CONSTRUCTION QUALITY:

   GOOD ☐ FAIR ☐ POOR ☑

13. IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

YES ☑ NO ☐

14. OTHER DEFICIENT PARAMETERS:

d. WATER SEEPAGE: YES ☐ NO ☑
e. WATER LOGGING: YES ☑ NO ☐
f. DAMPNESS: YES ☑ NO ☐
g. CORROSION: YES ☑ NO ☐

## SCORING CRITERIA

Score(As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)

Score, S = Z+I-R

Where Z= Zone Factor(1 to 3 based on seismic zone)

I(Influence factor) = 1

Here, Z= 3(For seismic Zone V)

R(Response Reduction Factor) = 2

Final score, S=3+1-2

Final Score, S= 2

1.SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES SCORE: 2

2.VULNERABILITY CLASSIFICATION:

CLASS A (High vulnerability) ☐

CLASS B(Moderate vulnerability) ☐

CLASS C(Intermediate vulnerability) ☑

CLASS D ( Average vulnerability) ☐

CLASS E (Low vulnerability) ☐

CLASS F (Very Low vulnerability) ☐

| Sl.No. | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in $N/mm^2$ |
|---|---|---|---|---|
| 1. | Wall | 26,20,22,20,24,25,28,24,27,30,22,26 | 24.5 | 15.6 |
| 2. | Post-1 | 26,24,20,23,27 | 24 | 15 |
| 3. | Post-2 | 28,26,22,24,27 | 25.4 | 16.6 |
| 4. | Post-3 | 20,22,25,26,24 | 23.4 | 13.9 |
| 5. | Post-4 | 30,28,26,27,30 | 28.2 | 20.9 |
| 5. | Floor | 22,24,20,22,26 | 22.8 | 13 |

Table 18.1: NDT Test Results

3.POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible) ☐
b. GRADE 2 (Slight) ☐
c. GRADE 3 (Moderate) ☑
d. GRADE 4 (Severe) ☐
e. GRADE 5 (Total collapse) ☐

## 4.COMMENTS AND OBSERVATIONS:

a.The building receives a grade level of 2 as many cracks in the walls and fall of large pieces of plaster were observed, showing moderate vulnerability to seismic events.

b.Significant cracks in the posts indicate that the material has lost its original strength, making it less capable of bearing loads during an earthquake. These are more likely to crack further under seismic forces, potentially causing parts of the structure to break away.

c.A score of 2 indicates that the Assam-type school is categorized as fair, reflecting that it meets basic seismic safety requirements but still needs additional improvements to strengthen its structural resilience.

d.The compressive strength of the walls was recorded as 15.6 MPa, suggesting a substantial vulnerability during seismic events and compressive strength of the columns ranged between 13.9 MPa and 20.9 MPa, revealing significant variability. The weaker columns at the lower range could compromise the building’s stability during a seismic event.

e.Salt deposits on walls have been observed which weaken the structure by causing surface degradation and discoloration, while damp walls promote mold growth, reduce durability, and harm indoor air quality.

f.Retrofitting and reinforcement of both walls and columns are strongly recommended to enhance the building’s resilience and ensure safety during seismic activity.

## SCHOOL NUMBER 19

Name of the school: Sarujini Devi H.S Girls School, Jorhat


Fig 19.1: Front View

Fig 19.2: Damage on post

Fig 19.3: Ikora thatched wall

Fig 19.4: Crack on wall

1. ADDRESS OF THE BUILDING: Kenduguri, Jorhat, Assam
2. DISTRICT: Jorhat
3. AREA: URBAN: ☑ RURAL: ☐
4. AGE OF THE BUILDING: 73 years
5. NUMBER OF STUDENTS: 75
6. BUILDING ELEMENTS
    a. Number of doors: 10
       Door Size: 1.1m× 2.09m
    b. Number of Windows: 18
       Window size: 1.18m×1.4m
    c. Ramps: Number of Ramps: 4
7. EXPOSURE TO HAZARD TYPES:
    a.EARTHQUAKE ☑
    b.LANDSLIDE ☐
    c.FIRE ☑
    d.FLOOD ☑
8. BASIC DETAILS OF THE BUILDING
    a. TYPOLOGY OF THE BUILDING:

ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☑ STEEL BUILDING ☐

b. BUILDING CODE COMPLIANCE:

ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

c. TYPE OF CONSTRUCTION:

BRICK MASONRY ☑ STONE MASONRY ☐ EARTHEN/MUD WALLS ☐

BURNT CLAY BRICKS/BLOCK MASONRY WALLS ☐

CONCRETE BLOCK MASONRY ☐

9. FLOOR DETAILS:
   a. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE

10. WALL DETAILS:
    b. WALL MATERIAL:

CONCRETE ☐ BURNT BRICK ☑ DRESSED STONE ☐ UNDRESSED STONE ☐

11. FOUNDATION TYPE: Shallow foundation

12. CONSTRUCTION QUALITY:

GOOD ☐ FAIR ☐ POOR ☑

13. IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

YES ☑ NO ☐

14. OTHER DEFICIENT PARAMETERS:
    a. WATER SEEPAGE: YES ☑ NO ☐
    b. WATER LOGGING: YES ☐ NO ☑
    c. DAMPNESS: YES ☑ NO ☐
    d. CORROSION: YES ☑ NO ☐

## SCORING CRITERIA

Score(As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)

Score, S = Z+I-R

Where Z= Zone Factor(1 to 3 based on seismic zone)

I(Influence factor) = 1.5

Here, Z= 3(For seismic Zone V)

R(Response Reduction Factor) = 3

Final score, S=3+1.5-3

Final Score, S= 1.5

1.SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES: 1.5

2.VULNERABILITY CLASSIFICATION:

CLASS A (High vulnerability) ☐

CLASS B(Moderate vulnerability) ☑

CLASS C(Intermediate vulnerability) ☐

CLASS D ( Average vulnerability) ☐

CLASS E (Low vulnerability) ☐

CLASS F (Very Low vulnerability) ☐

| Sl.No | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in $N/mm^2$ |
|---|---|---|---|---|
| 1. | Wall | 22,26,20,18,22,25,28,24,30,29,27,32 | 25.2 | 16.4 |
| 2. | Post-1 | 30,27,28,24,26, | 27 | 18.8 |
| 3. | Post-2 | 32,28,27,24,28 | 27.8 | 19.8 |
| 4. | Post-3 | 28,29,27,25,24 | 26.6 | 18 |
| 5. | Post-4 | 28,32,30,29,28 | 29.4 | 22.5 |
| 5. | Floor | 26,24,22,20,21 | 22.6 | 17.5 |

Table 19.1: NDT Test Results

3.POTENTIAL DAMAGE LEVEL:

- a.GRADE 1 (Negligible) ☐
- b.GRADE 2 (Slight) ☐
- c.GRADE 3 (Moderate) ☐
- d.GRADE 4 (Severe) ☑
- e.GRADE 5 (Total collapse) ☐

## 4.COMMENTS AND OBSERVATIONS:

a.The building receives a grade level of 3 according to EMS-98 adopted by IS 1893:2002 (Part 1) indicating an intermediate or substantial vulnerability to seismic events.

b. This school represents a pure Assam type structure with Ikora thatched walls which are lightweight, posing advantages in seismic prone regions like Assam. The flexibility of Ikora allows the walls to sway with seismic forces, the porous nature of the materials used allows for moisture regulation, preventing dampness.

c. A score of 1.5 signifies that the Assam-type school is categorized as poor, reflecting its inability to meet essential seismic safety standards and emphasizing the need for immediate and significant structural improvements.

d. However, when subjected to strong shaking, these walls may not provide adequate support due to their limited load bearing capacity.

e. In this school, the wooden posts exhibit reduced strength and load bearing capacity as they are susceptible to various environmental factors such as rot and decay, increasing the risk of failure during earthquakes.

f. The compressive strength of walls is 17 MPa, indicating a moderate level of strength, which is generally acceptable for traditional masonry structures and compressive strength of columns varying from 18 to 23 MPa, indicating that some columns are more robust than others.

g. Thus, While the building can withstand typical loads, its performance during earthquakes could be compromised due to relatively low compressive strength of walls and variability in column strengths.

## SCHOOL NO 20

Name of the school: Mahashwar Hazarika Suwarini Sishu Niketon, Jorhat


Fig 20.1: Front View


Fig 20.2: Crack on wall


Fig 20.3: Crack on floor


Fig 20.4: Crack on wall

1. ADDRESS OF THE BUILDING: Aalmukhiya Gaon, Jorhat, Assam

2. DISTRICT: Jorhat

3.AREA: URBAN: ☑ RURAL: ☐

4. AGE OF THE BUILDING:36 Years

5. NUMBER OF STUDENTS: 32

6. BUILDING ELEMENTS

a. Number of doors: 13
   Door Size: 1.2 m×1.81m
b. Number of Windows: 30
   Window size: 1.05m×0.79m
c. Ramps: Number of Ramps: 1

7. EXPOSURE TO HAZARD TYPES:

a. EARTHQUAKE ☑

b. LANDSLIDE ☐

c. FIRE ☐

d. FLOOD ☑

8. a. TYPOLOGY OF THE BUILDING:

ASSAM TYPE ☑ RCC ☐ HALF BRICK WALL ☐ STEEL BUILDING ☐

b. BUILDING CODE COMPLIANCE:

ENGINEERED BUILDING ☐ NON-ENGINEERED BUILDING ☑

c. TYPE OF CONSTRUCTION:

BRICK MASONRY ☑ STONE MASONRY ☐ EARTHEN/MUD WALLS ☐

BURNT CLAY BRICKS/BLOCK MASONRY WALLS ☐

CONCRETE BLOCK MASONRY ☐

9. FLOOR DETAILS:

b. PREDOMINANT MATERIAL OF THE FLOOR: MORTAR CONCRETE

10. WALL DETAILS:

b. WALL MATERIAL:

CONCRETE ☑ BURNT BRICK ☐ DRESSED STONE ☐ UNDRESSED STONE ☐

11. FOUNDATION TYPE: Shallow foundation

12. CONSTRUCTION QUALITY:

GOOD ☐ FAIR ☐ POOR ☑

13. IS THERE ANY STRUCTURAL CRACK AVAILABLE IN THE BUILDING?

YES ☑ NO ☐

14. OTHER DEFICIENT PARAMETERS:

a. WATER SEEPAGE: YES ☑ NO ☐

b. WATER LOGGING: YES ☐ NO ☑

c. DAMPNESS: YES ☑ NO ☐

d. CORROSION: YES ☑ NO ☐

SCORING CRITERIA

Score(As per IS 1893:2002 guidelines and National Policy for seismic vulnerability assessment of buildings)

Score, S = Z+I-R

Where Z= Zone Factor(1 to 3 based on seismic zone)

I(Influence factor) = 1

Here, Z= 3(For seismic Zone V)

R(Response Reduction Factor) = 2

Final score, S=3+1-2

Final Score, S= 2

1. SCORE BASED ON STRUCTURAL SYSTEM AND ATTRIBUTES SCORE : 2

2. VULNERABILITY CLASSIFICATION:

CLASS A (High vulnerability) ☐

CLASS B(Moderate vulnerability) ☐

CLASS C(Intermediate vulnerability) ☑

CLASS D ( Average vulnerability) ☐

CLASS E (Low vulnerability) ☐

CLASS F (Very Low vulnerability) ☐

| Sl.No | Testing Structures | No. of Rebound Hammer | Average of No. of Rebound Hammer | Equivalent Compressive Strength in $N/mm^2$ |
|---|---|---|---|---|
| 1. | Wall | 28,30,26,32,27,24,29,25,23,22,28,25 | 26.5 | 18 |
| 2. | Post-1 | 26,24,27,22,20 | 23.8 | 14.2 |
| 3. | Post-2 | 30,28,29,24,27 | 27.6 | 19.3 |
| 4. | Post-3 | 22,25,27,24,26 | 24.8 | 15.3 |
| 5. | Post-4 | 24,25,28,27,32 | 27.2 | 18.9 |
| 5. | Floor | 18,22,26,24,26 | 22.8 | 15.5 |

Table 20.1: NDT Test Results

3. POTENTIAL DAMAGE LEVEL:

a. GRADE 1 (Negligible) ☐

b. GRADE 2 (Slight) ☐

c. GRADE 3 (Moderate) ☑

d. GRADE 4 (Severe) ☐

e. GRADE 5 (Total collapse) ☐

## 4. COMMENTS AND OBSERVATIONS:

a. The building is an Assam-type, non-engineered structure, which is inherently vulnerable to seismic activity due to its construction typology and lack of design considerations for earthquake resistance.

b. With a damage grade of 3 according to the EMS 98 scale, the building is categorized as having substantial to heavy damage. This level of damage indicates a high risk during seismic events and a significant likelihood of collapse under strong earthquake forces.

c. A score of 2 indicates that the Assam-type school is categorized as fair, reflecting that it meets basic seismic safety requirements but still needs additional improvements to strengthen its structural resilience.

d. Visible cracks and dampness in the walls and posts suggest weakened structural elements. These issues further compromise the building's ability to withstand lateral forces generated by seismic activity.

e. The compressive strength of the columns (14.2-19.3 MPa) and walls (18 MPa) is inadequate for a structure located in a seismic zone. The material strength does not meet the requirements for resisting earthquake forces, exacerbating the building's vulnerability.

f. As a non-engineered building, it lacks essential design features such as adequate load transfer mechanisms and proper reinforcement, which are crucial for improving earthquake resilience. This deficiency increases the potential for failure during seismic events.

g. The foundation may be further compromised by the presence of dampness, which can lead to long-term deterioration, soil instability, and a higher risk of differential settlement or tilting.

h. Given the critical state of the building, urgent retrofitting measures are imperative. These should include repairing and strengthening the cracked and damp walls and posts, reinforcing structural elements such as columns and beams, and implementing earthquake-resilient design features. Additionally, improving drainage systems to mitigate dampness and addressing underlying structural deficiencies are essential to ensure safety and stability.

## 4.4 SUMMARY

The assessment of Assam-type schools revealed significant structural vulnerabilities due to their advanced age, with most buildings ranging from 50 to 135 years old and classified primarily as having moderate damage potential (Grade 2), while some exhibited higher damage levels (Grades 3 and 4). Vulnerability scores indicated that the majority fell into the fair category (score of 2), but several schools were rated in the poor category (score of 1).Some of the schools also scored 3 indicating that the schools are in the good category ,suggesting that they meet most seismic safety standards, highlighting an urgent need for retrofitting or reconstruction. One school also scored 1.5, reflecting its inability to meet essential seismic safety standard. Non-destructive testing results showed that the compressive strength of structural elements such as posts and floors was relatively weak, compromising their ability to withstand seismic forces. These findings underscore the critical need for immediate interventions to enhance seismic resilience and ensure the safety of students and staff.

In terms of vulnerability scores, the majority of schools fell into the **fair category (score of 2)**, suggesting that while they are still usable, they require significant improvements to enhance safety. However, several schools were rated in the **poor category (score of 1)**, which indicates a critical need for immediate intervention to prevent potential structural failure. Non-destructive testing results further revealed that the **compressive strength of key structural elements**, including posts and floors, was relatively weak in many cases, compromising their ability to withstand seismic forces effectively.

# CHAPTER-5

# CONCLUSION

## 5.1GENERAL

The current project work is based on rapid visual screening of Assam type school buildings in Jorhat township area. The study emphasises on Level -I procedure of Rapid Visual Screening as per IS 1893: 2002. A total of Twenty nos. of school are being surveyed through RVS method. The findings and conclusion of this study are as follows:

The assessed Assam-type schools range from **50 to 135 years old**, indicating their historical and cultural significance. However, their age raises critical concerns regarding structural integrity, as older buildings may not meet contemporary seismic safety standards. The aging infrastructure necessitates a thorough evaluation of their ability to withstand seismic events, given the increasing frequency of such occurrences in the region.

The majority of the schools are classified under **Grade 2 (moderate damage)** according to the EMS-98 classification system, suggesting that while they may still be functional, they exhibit signs of distress that could worsen during an earthquake. Some schools are categorized as **Grade 3 (substantial damage)**, indicating a higher risk of failure under seismic loads. A few schools even fall into **Grade 4 (very heavy damage)**, which signifies critical structural issues that could lead to catastrophic failure. This variation in damage potential underscores the urgent need for targeted interventions to address vulnerabilities.

The vulnerability classification of these schools varies significantly, with most falling into **Class D (average vulnerability)** and some rated as low as **Class E (low vulnerability)**. A select few are classified as **Class B (moderate vulnerability)**, indicating that while some structures may possess better resilience, many remain at considerable risk during seismic events. This classification highlights the need for a tailored approach to retrofitting based on individual school assessments.

The overall vulnerability scores reveal that most schools score a **2**, placing them in the **fair category**, which suggests that while they may be usable, they require improvements to enhance safety. In contrast, a subset of schools score **1**, which falls in the **poor category**, indicating a critical need for immediate action to prevent potential structural failure. This disparity emphasizes the varying levels of risk across different institutions and the necessity for prioritizing interventions based on vulnerability scores.

Non-destructive testing (NDT) results indicate that the **compressive strength of posts and floors is relatively weak** in many of these schools. This weakness compromises their structural integrity and ability to endure seismic forces effectively. The findings suggest that materials used in construction may have deteriorated over time or were not originally suited for seismic resilience, necessitating a comprehensive evaluation and potential replacement or reinforcement of these materials.

Given the findings from the vulnerability assessments and material strength tests, there is an urgent need for comprehensive retrofitting or reconstruction of these Assam-type schools. Implementing modern engineering practices and materials can significantly enhance their seismic resilience and ensure the safety of students and staff. Stakeholders must prioritize funding and resources for these interventions to mitigate risks associated with potential earthquakes.

## 5.2 LIMITATIONS OF THE STUDY

1. **Lack of Comprehensive Data**: One significant limitation of this study is the **lack of comprehensive data** on critical factors such as **soil liquefaction potential**. Soil conditions play a crucial role in determining a building's seismic vulnerability, and the absence of this data could lead to an incomplete assessment of the risks associated with each school.
2. **Insufficient Geotechnical Investigations**: The study did not include detailed geotechnical investigations, which are essential for understanding the subsurface conditions. Without this information, it is challenging to evaluate how different soil types might react during seismic events, potentially underestimating the risk of ground failure.
3. **Limited structural Data:** The assessment relied on available structural data, which may not have captured all relevant aspects of each building's design and construction. For example, information regarding the quality of materials used, construction practices, and any modifications made over the years was not comprehensively documented, limiting the depth of the analysis.
4. **Variability in Building practices:** The study acknowledges that building practices may vary significantly across different regions and even among schools within the same area. This variability can lead to inconsistencies in vulnerability assessments and complicate comparisons between schools.
5. **Subjectivity in Assessments:** Some aspects of the vulnerability assessment were based on subjective interpretations, particularly in evaluating damage potential and structural

conditions. This subjectivity may introduce bias and affect the reliability of the findings.

6. **Temporal Data Limitations:** The study did not account for changes in building codes or construction practices over time, which could influence current vulnerability levels. Historical data on past seismic events and their impacts on similar structures were also limited, hindering a comprehensive understanding of risk.

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