



WEB APPLICATION FOR VULNERABILITY ASSESSMENT

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Abstract

In the aftermath of 2015 Gorkha Earthquake in Nepal the challenging task was to classify structural damage; for further consideration of the building for living purposes. Manual classification of such a large number of building stock is tedious job in terms of collecting and maintaining data, particularly from the point of view of using the same for further planning purposes. Hence a web based application will make the job simple and easy for the surveyor as they will fill the details from the application and get the damage state of the building and know whether or not the building is safe for living and maintain the record of their decision. The other important feature of this application is it also does the pre-earthquake assessment of the building; thus it evaluates the state of the building before an earthquake through which occupants will know whether it safe or not to live in a particular building and also the improvements required from overall safety point of view. In this paper, description of the web application is given with some case studies. Post-earthquake assessment is done for two types of buildings which is quite common i.e., Reinforced Concrete Building and Brick Masonry Building. Pre-earthquake assessment is done in three parts, first part is Detail Visual Assessment of building based on BMTPC form and second part is Simplified Quantitative Assessment and third one is Detail Qualitative Assessment.

Keywords: *Rapid Visual Screening; Web-application; Pre-earthquake assessment;*



1. Introduction

Many communities in earthquake prone regions of the country barely recognize the problem that safe housing is critical to their sustainable development. These communities need to be supported in reducing earthquake risk to their housing. Assessment of an existing building is much more difficult than designing a new building because construction of the structure is mostly not as per designer's specifications and a number of defects as well as uncertainties crop up during the construction and the quality of material deteriorates with time. It may also happen that building was initially built as per code provisions of that time but the seismic resistance requirements may have been revised in the later revisions of the code.^[1]

Rapid Visual Screening form is designed to calculate the damage without performing any structural calculations. Surveying of the structure is done to identify the structural load-resisting system and also to identify building attributes that modify the seismic performance expected for this lateral load-resisting system along with non-structural components.^[2]

Two steps are involved for evaluating the seismic resistance of an existing building^[3]. First procedure involves a rapid visual inspection to gather basic information about the building for identification of vulnerable elements of the building and after that detailed assessment of the building needs to be done by acquiring relevant data to know the deficiencies which would need treatment by retrofitting. Different types of building experience different levels of damage depend upon their structural characteristics^[4] and also depending upon the zone of that area in which building is located.

Result of RVS is used to^[5]:-

- Identify if a building requires further assessment for its seismic vulnerability.
- Assess the structural vulnerability of the building.
- Identify the retrofitting requirements for the building.

According to IS 1893:2002 (Part 1) India has been divided into 4 seismic hazard zones:-

- Zone II (Low seismic hazard upto MSK intensity VI or lower)
- Zone III (upto MSK Intensity VII)
- Zone IV (upto MSK Intensity VIII)
- Zone V (MSK Intensity IX or greater)

Recent earthquakes have clearly demonstrated that India has huge stock of vulnerable buildings like Bhuj earthquake of 26 January 2001 caused 14,000 casualties^[6]. Main reason for such huge casualties is lack of earthquake awareness and poor construction practices. Hence there is an urgent need for the development of rapid assessment tools for quick evaluation of large building stock to prioritize them for preliminary and detailed evaluations. Several organizations that have prepared RVS form for Indian conditions to evaluate seismic vulnerability of the building those are listed below.

- BMTPC (Building Materials and Technology Promotion Council)^[2]
- Bureau of Indian Standards^[3]

Objective of this paper is the development of web based tool for vulnerability assessment. This vulnerability assessment web based application is divided into four parts:-

- Simplified Visual Assessment
- Detailed Visual Assessment
- Simplified Quantitative Assessment
- Detailed Quantitative Assessment



1.1 Simplified Visual Assessment

Simplified Visual Assessment is done by RVS form for Reinforced Concrete structure and Brick Masonry structure as most of the houses in India are one of these. Purpose of this assessment is to identify whether or not the building is suitable for immediate occupancy after an event of earthquake. The RVS do not guarantee safety of the structure in a future event comparable to the main shock, but only addresses safety under existing gravity loads and small aftershocks expected in the post-earthquake period. The most critical question that the RVS addresses is whether or not the vertical load path in the building for gravity loads is intact or not. Based on the responses to questions on specific structural damage, a building is tagged GREEN implying that the building is usable, YELLOW implying that building needs to be assessed further and will be usable with necessary temporary interventions and RED tag implying that building is unusable in the immediate post-earthquake period. It should be noted that a RED tagged building does not imply its demolition it would require further detailed evaluation which may also lead to strategies for salvaging the structure.

1.2 Detailed Visual Assessment

Detail visual assessment is done using BMTPC form, the proposed method offers four novel aspects:-

- It offers a methodology for technical documentation of a house from seismic safety standpoint.
- It describes an IDEAL HOUSE of the typology in focus.
- It identifies deficiencies of an existing house from seismic safety standpoint.
- It focuses attention on seismic safety of non-structural elements of a house.
- It presents initiatives that should be undertaken to improve the ethos of ensuring earthquake safety of housing in India.

1.3 Simplified Quantitative Assessment

In simplified quantitative assessment, various photographs of the building is taken from the user along with the basic details to calculate irregularities present in the building which gets stored in database.

1.4 Detailed Quantitative Assessment

In detailed quantitative assessment time history analysis and response spectrum analysis of the building is done and the response is recorded and stored in database.

2. Methodology

Languages used for the development of this application is HTML (Hyper-text Markup Language), PHP (Hypertext Preprocessor), Bootstrap, CSS, JavaScript and MySQL. The application has two parts front-end and back-end. Front end is the User Interface part made using HTML, CSS, Bootstrap and JavaScript. Back-end is done using PHP and for storing the values in database MySQL is used. For high computational analysis MATLAB is used and connection to the matlab is done using PHP.

Simplified Visual Assessment	Simplified Detailed Assessment	Simplified Assessment	Quantitative
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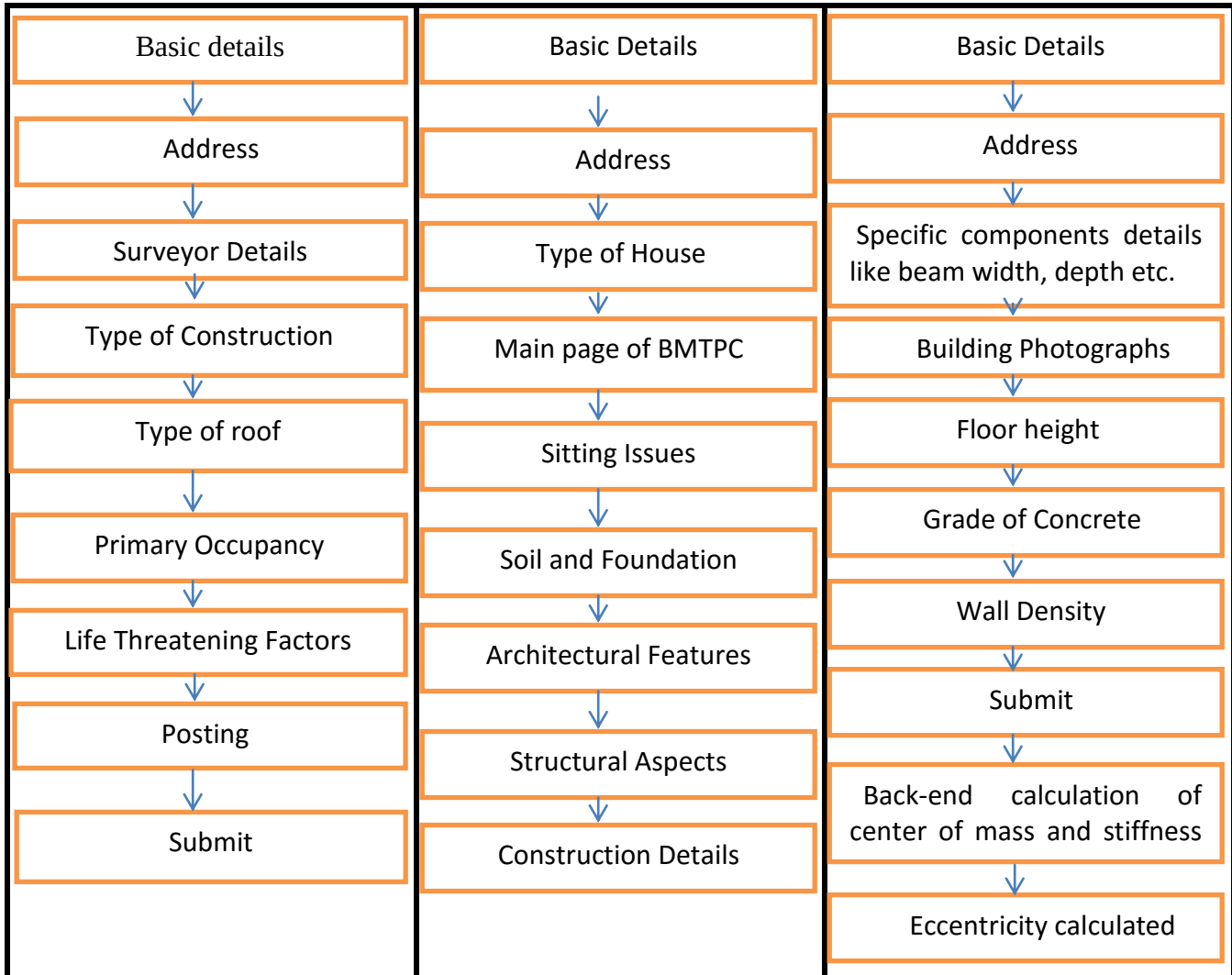


Fig1 (A)

Fig1 (B)

Fig1 (C)

First two fields are basic details and address which is common for all the type of assessment. Basic details include building name, contact number, state which gets stored in the database after the submission of the form and address entered by the user is converted to LAT-LONG by the use of GOOGLE MAP-API and also one map is shown highlighting the exact location this is done to know the seismic zone in which the building lies and this is also stored in database.

In the figure (1A) that shows Simplified Visual Assessment, all the details input by the user like surveyor details, type of roof etc. are stored in database. Now depending upon the life threatening factor selected by the user the red, yellow, green tag is shown to the user.

In the figure (1B) that shows Detailed Visual Assessment, according to the type of housing typology chosen by the user he is directed to the BMTPC form of that typology. Each typology is having four forms, 1. Life-Threatening Factors Related to the structural elements, 2. Life-Threatening Factors Related to the non-structural elements, 3. Economic Loss-Inducing factors related to the structural elements, 4. Economic Loss-Inducing

Factors Related To The non-structural elements. Depending upon the factors selected on each form assessment is done as per mentioned in the BMTPC form and the final value the net performance rating or Expected Performance Rating (EPR) of the building is calculated and shown to the user.

In the figure (1C) that shows Simplified Quantitative Assessment, Specific details of the building components like beam width and depth, column width and depth, storey height, number of storeys etc. is taken as input from the user and after the form submission these values are obtained in php and after the calculation eccentricity is calculated. Photos taken from the user is stored in the database and is used to refer if any of the inputs entered by the user is not correct.

In Detailed Quantitative Assessment Inputs taken from the user in this assessment is same as taken in simplified quantitative assessment but after submission of the form the mass matrix and stiffness matrix is calculated and then these matrices is converted in the format of matrices in MATLAB. In PHP connection to the Matlab is established and the matrices are sent to the matlab and time history and response spectrum analysis for the building is done and the results are stored in the database.

3. Development of Web Application



Fig 2- Home Page of the application

3.1 Simplified Visual Assessment

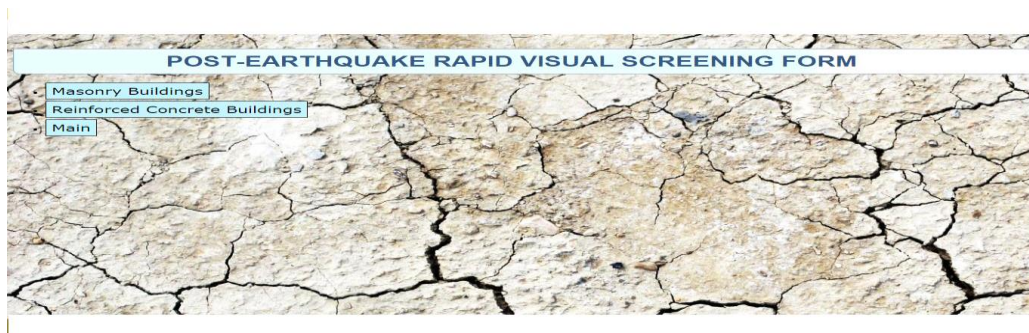


Fig 3- Main Page of Simplified Visual Assessment



The screenshot displays a web-based form titled 'RVS' (Rapid Visual Screening) for RCC (Reinforced Concrete). The form is organized into several sections:

- SURVEYER DETAILS:** Includes fields for Name, Surname, and a checkbox for 'Is a student?'. Below this is a table for 'TYPE OF CONSTRUCTION:' with columns for 'Type of construction' and 'No. of stories'. The table lists various construction types such as 'Reinforced concrete frame', 'Reinforced concrete frame with shear walls', etc.
- TYPE OF ROOF:** A dropdown menu to select the type of roof.
- PRIMARY OCCUPANCY:** A dropdown menu to select the primary occupancy of the building.
- LIFE THREATENING FACTORS:** A table with columns for 'Factor', 'Description', and 'Weight'. It lists various factors such as 'Proximity to fault', 'Proximity to liquefiable soils', etc.
- POSTING:** A section for posting the form, including a checkbox for 'Is the form posted?' and a 'Post' button.

Fig.4

Fig 2 shows the main page of the application, by clicking on Simplified Visual Assessment we get access to the main page of SVA and these contain two forms one for RCC and another for Brick Masonry. Fig 4 shows RVS form for RCC and RVS form for Brick Masonry form is almost same.

3.2 Detailed Visual Assessment

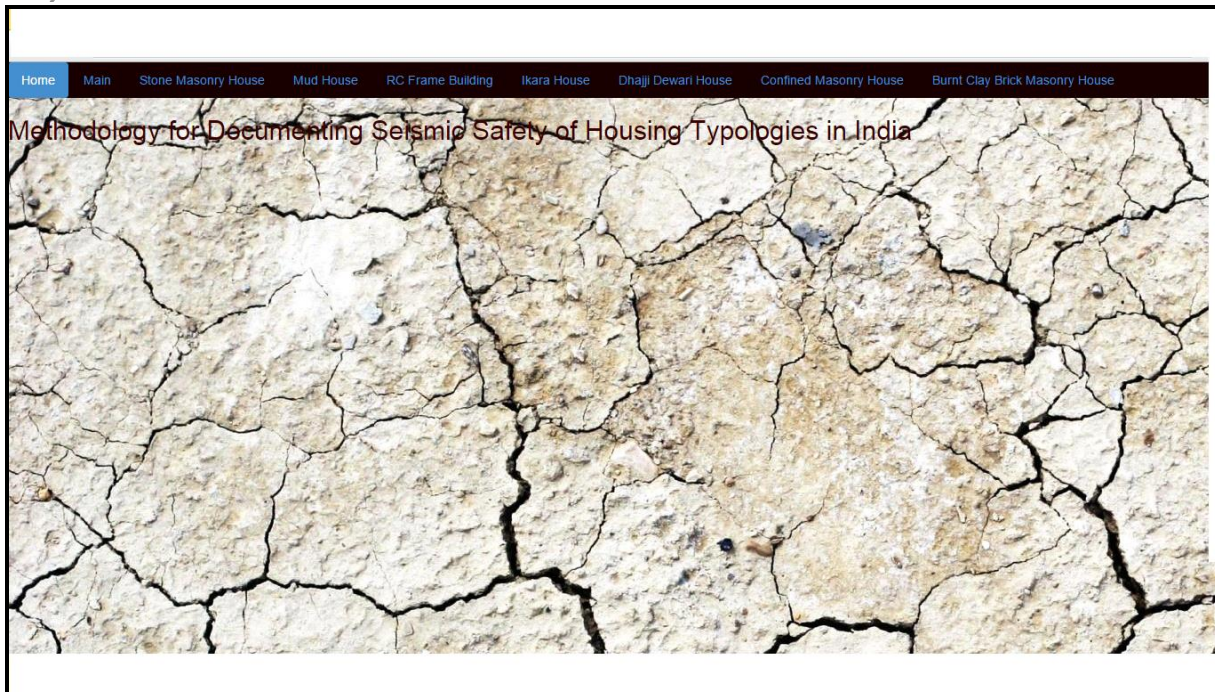


Fig. 5 – Main page of Detailed Visual Assessment

3.2.1 Four phases of BMTPC Form for Stone Masonry House

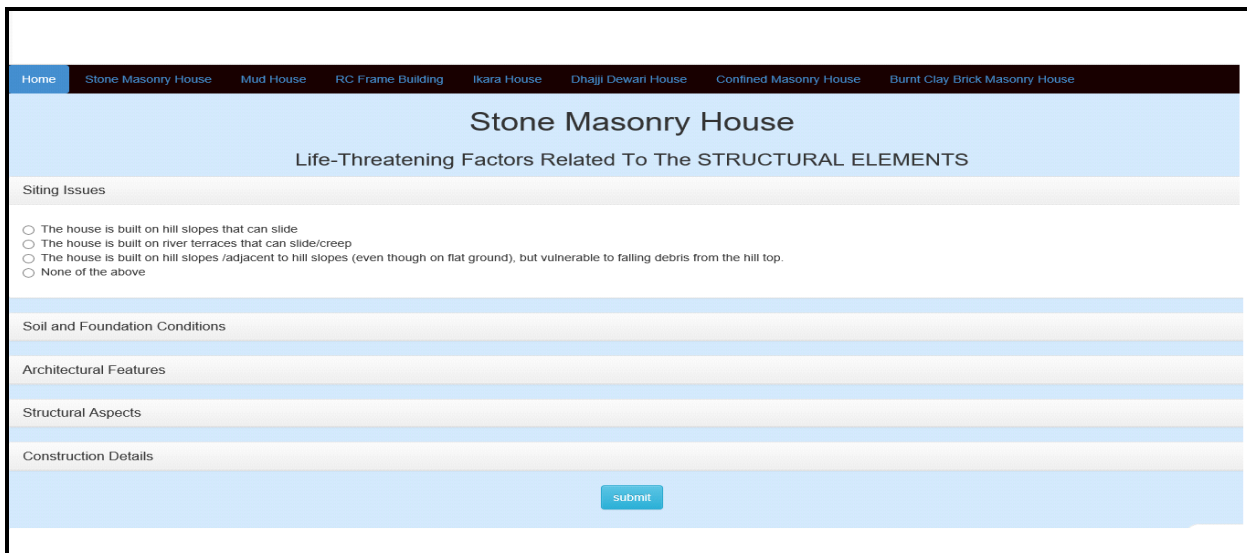


Fig.6- Life Threatening Factors related to Structural Elements (L(s))



Stone Masonry House

Life-Threatening Factors Related To The NON-STRUCTURAL ELEMENTS

Acceleration or Displacement Hazards

- ☐ A large object on the roof is unanchored
- ☐ The shelves inside the house are unanchored
- ☐ The lofts inside the house are unanchored.
- ☐ The objects on/in the lofts/shelves inside the house are unanchored
- ☐ The house has exposed wood used in the construction of the house (either as wall panels, roofs, lofts, or floors), thatch, husk, or exposed cloth in finishing of the house, at points close to locations of potential stove fire, electricity sparks or gas leakage fire that can result in a fire in the house during an earthquake
- ☐ The house has electricity wires held rigidly between the house and the street pole with no slack, that can result in short circuiting and fire during an earthquake
- ☐ The gas cylinders are not strapped to the wall, which can result in toppling of the cylinders, which in turn can lead to gas leakage and thereby fire during an earthquake
- ☐ None of the above

Lifelines

submit

← Previous

Next →

Fig.7 – Life Threatening Factors related to Non-Structural Elements (L(n))

Stone Masonry House

Economic Loss-Inducing Factors Related To The STRUCTURAL ELEMENTS

Siting Issues

Slope of the ground

- ☐ The house is on sloped ground with access to house at two/three levels, i.e., ground, middle floor, and roof
- ☐ The house is connected to the sloped ground and there is no gap between the building and the natural slope of the site
- ☐ None of the above

Soil and Foundation Conditions

Architectural Features

Structural Aspects

Construction Details

← Previous

Next →

Fig 8 - Economic Loss-Inducing Factors related to Structural Elements (E(s))

Stone Masonry House	
Economic Loss-Inducing Factors Related To The NON-STRUCTURAL ELEMENTS	
Acceleration or Displacement Hazards	
Shelves	
☐ Not anchored to structural system ☐ Contents not strapped ☐ None of the Above	
Items on lofts	
☐ Not anchored to structural system ☐ None of the Above	
Hangings from roof/floor and from walls	
☐ Heavy weight and unstrapped ☐ None of the Above	
Gas cylinders and geysers	
☐ Unsecured to the wall ☐ None of the Above	

Fig 9 - Economic Loss-Inducing Factors related to Non-Structural Elements (E(n))

By clicking on Detailed Visual Assessment we get access the main page of BMTPC form and upon the selecting the respective Housing typology its corresponding form gets open. Fig 6, Fig 7, Fig 8, and Fig 9 shows the four forms for Stone Masonry House and after that EPR of the building is calculated and shown to the user.

Similarly all the form is built using all the housing typologies:-

- Mud House
- RC Frame Building
- Ikara House
- Dhajji Dewari House
- Confined Masonry House
- Burnt Clay Brick Masonry House

3.3 Simplified Quantitative Assessment

Fig 10 below is the web page for simplified quantitative assessment all the input is taken from the user and then irregularity of the building is calculated at the backend using PHP and shown to the user.

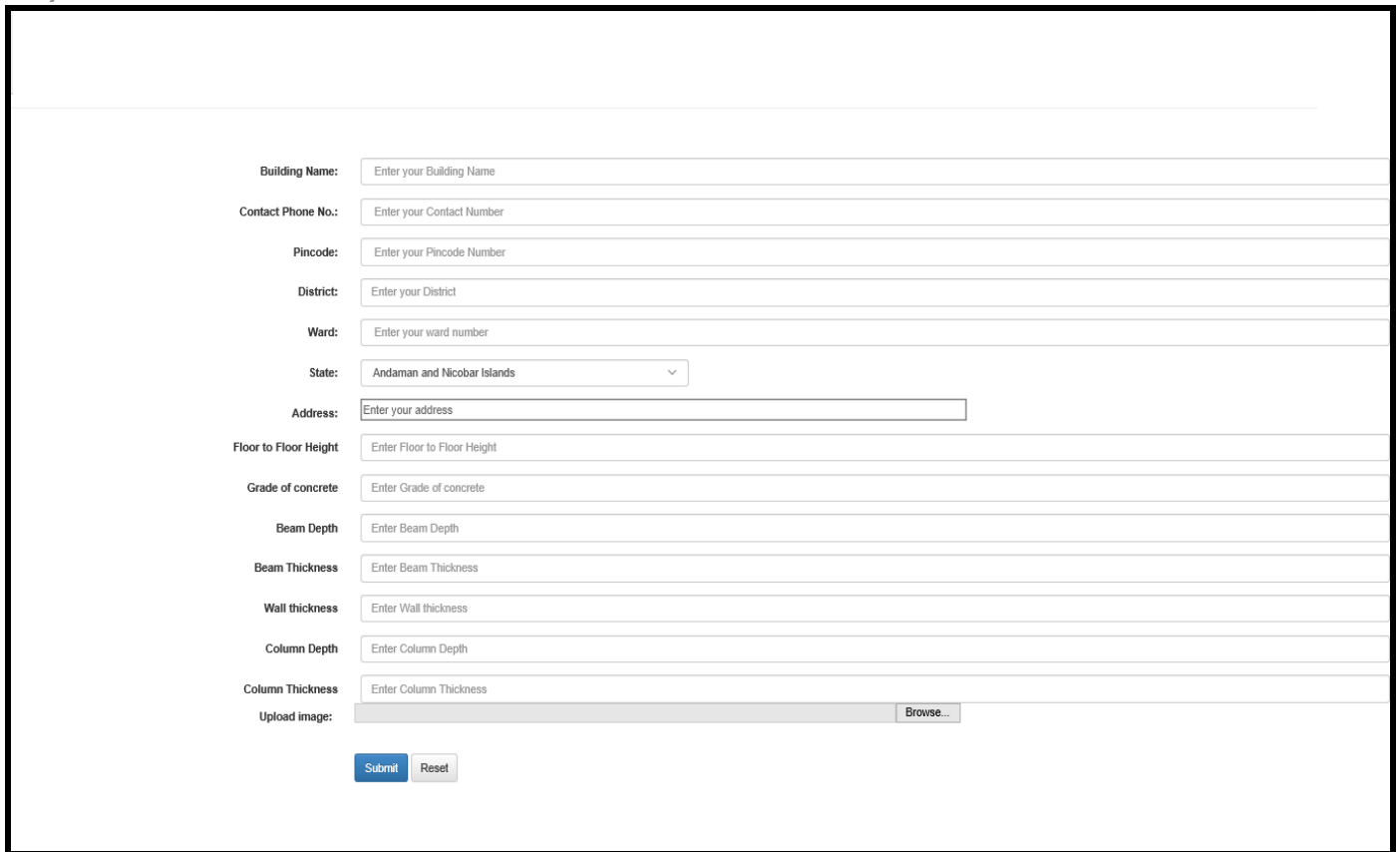


Fig 10- Main page of Simplified Quantitative Assessment

4. Summary and Conclusion

This application provides easy and interactive UI (user interface) so that user don't have to do any kind of mathematical calculations as this is be done in the backend calculation using programming languages. After complete work this web application will be open to all. The major advantage over the use of this application is all the data gets stored at one place which can be easily retrieved from anywhere. We can also use data for doing statistical analysis of each region using computational power.

5. Future Work

The last part of this application is Detailed Quantitative Assessment which is yet to be developed and is the immediate target and developing an android application for the first two types of assessment.

6. References

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