DEVELOPMENT OF A DAMAGE ASSESSMENT MATRIX FOR LOAD-BEARING MASONRY HOUSES

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Masonry houses are common types of buildings constructed using materials like bricks, stones, or concrete blocks. They are popular due to their durability and aesthetic appeal. However, as masonry structures age, they become vulnerable to various forms of crack damage that can potentially compromise their structural integrity and the safety and comfort of their occupants. While numerous studies have examined the condition assessment of buildings, they primarily rely on visual inspection conducted by inspectors who often base their evaluations on personal experience, biases, and risk attitudes. Recognizing the absence of a standardized method for assessing wall crack damages, this research study was aimed at developing a crack damage assessment matrix specifically focusing on single-story, load-bearing masonry houses. A database surrounding over 270 instances of cracks in approximately 60 houses from the Higurankgoda area in Sri Lanka, is considered to determine the key factors influencing the damage severity and safety of the house. Severity considerations include crack length, width, and number of cracks in the wall, while safety factors encompass crack severity level, separation level of the crack, surface condition of the cracked wall, crack location, crack direction, and structural degradations. To construct a data-driven prioritization matrix, the study employs the Analytical Hierarchy Process (AHP) and a probability-based approach, utilizing real-world data to assign reliable weightage to each parameter. This research determines the influence weightage of each parameter on overall safety and stability. The calculated weightage results indicate that the parameter with the highest impact is from the structural degradations, while the parameter with the lowest impact is from the crack direction. This matrix facilitates a Risk Level Index (RLI) to assess the overall impact of individual cracks and a systematic approach is proposed to determine the overall risk level of the house. The systematic approach illustrates the risk level for the house when it has varying numbers of wall cracks based on the generated RLI value and the number of cracks in each influence category. Fifteen single-story load-bearing masonry houses were selected for the testing and verification of the developed matrix, and the outcomes of the matrix were compared with the already assigned risk levels by experts for each house. The proposed matrix was tested and validated with more than 80% accuracy level. This prioritization matrix will empower engineers, and homeowners to efficiently prioritize repair efforts and allocate resources based on potential risk. The proposed approach integrates advanced analytical techniques with practical insights to enhance decision-making in addressing wall crack damages in masonry houses.

Keywords: Analytical hierarchy process, Damage assessment, Masonry cracks, Severity and safety

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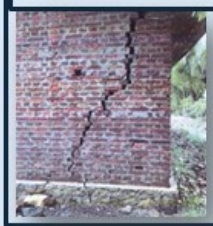
Introduction



This research addresses the challenge of crack damage in single-story load-bearing masonry houses. It aims to:

- Identify and quantify key parameters influencing crack damage
- Develop a damage assessment matrix for assessing the overall safety impact of crack damages
- Case study: 270 instances of cracks around 60 houses

Research Methodology

Field Investigation	• Understanding the current condition, and primary information on the damages
Data Collection	• Crack damages in single storey masonry houses
Preparation of the Database	• Categorized based on selected variables
Data Analysis	• Using statistical techniques and analytical tools
Development of Risk Prioritization Matrix	• Variable identification & Assigning weightages • Development of the matrix • Framework to assess the risk level • Validation of the model

Results

$$\begin{pmatrix} RLI_1 \\ RLI_2 \\ RLI_3 \\ . \\ . \\ . \\ RLI_n \end{pmatrix} = \begin{pmatrix} F_{11} & F_{21} & F_{31} & F_{41} & F_{51} & F_{61} \\ F_{12} & F_{22} & F_{32} & F_{42} & F_{52} & F_{62} \\ F_{13} & F_{23} & F_{33} & F_{43} & F_{53} & F_{63} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ F_{1n} & F_{2n} & F_{3n} & F_{4n} & F_{5n} & F_{6n} \end{pmatrix} \begin{pmatrix} 0.0561 \\ 0.0952 \\ 0.1654 \\ 0.1455 \\ 0.3078 \\ 0.2298 \end{pmatrix}$$

Data-driven matrix was developed to rank crack damages

Determination of the overall risk level of the entire house

In the matrix, each row represents a single wall crack, and the entire matrix encompasses all wall cracks within a single house. Here, F_{1i}, F_{2i}, F_{3i}, F_{4i}, F_{5i}, and F_{6i} denote the cell scores assigned to the influenced level of crack direction, surface condition of the cracked wall, separation level of the crack, crack location, signs of immediate collapse, and crack sensitivity, respectively.

Risk Level Index(RLI) Range	Influence level	Notation
RLI <= 1.6	Very Low	C_{VL}
1.6 < RLI <= 2.5	Moderately Low	C_{ML}
2.5 < RLI <= 3.4	Moderately High	C_{MH}
RLI > 3.4	Very High	C_{VH}

Risk level classification of cracks with RLI