Potential for Thermal Benefits in Low-cost Seismic Retrofitting Technology

Yasmin BHATTACHARYA[1] and Andrew CHARLESON[2]

[1] 東京大学大学院工学系研究科都市工学専攻
Department of Urban Engineering, Tokyo University, Japan

[2] School of Architecture, Victoria University of Wellington, New Zealand.

Vulnerability of low-income people to disasters is a worldwide problem. The inability to afford technologies that can provide improved seismic results in high casualty rates in seismic events. The authors investigate the potential of approaching seismic retrofitting technologies through an alternative outlook; not just as a safety component, but as a feature that can provide multiple benefits. This paper presents the ongoing investigation of low-cost seismic retrofitting technologies that could also enhance the thermal performance of houses. Three separate regions in India with the performance same level of seismic risk but differing climatic conditions have been selected for study in order to consider the varying thermal comfort requirements within the same required level of seismic resistance.

Keywords *: seismic retrofitting, thermal comfort, developing countries, low-cost technology, India*

1. Introduction

In developing countries, non-engineered construction is common in residential buildings. In fact, more than 90 percent of the population living in moderate to severe seismic zones of the developing world work and live in such buildings of simple construction built by themselves (Arya, 2000). However, while masonry construction can be financially beneficial, it is also seismically hazardous. The maximum number of fatalities in developing countries in earthquakes results from the collapse of these buildings, and historically, the low-income population has been most severely affected (Coburn & Spence, 2002).

Various low-cost retrofitting techniques have been researched and developed to make this consruction type safer in the event of an earthquake. However, as safety is an ethereal concept among the low-income population, and not so easily understood, and even more difficult to sell to a population with serious unmet needs in their everyday lives, there is a lack of implementation of these techniques (Meli & Alcocer, 2004).

Hence, it is necessary to link seismic vulnerability-reduction efforts to other efforts aimed at improving housing habitability, with the hope that it can be better sold if it is accompanied by tangible daily benefits (Meli & Alcocer, 2004). One such possible 'accompanied daily benefit' is thermal comfort.Therefore, the central challenge addressed by this study is the potential for integrating retrofitting techniques with passive thermal comfort strategies for low-income housing in developing countries (with a focus on India).

2. Methodology

The development of suitable integrative techniques however, is not solely a structural challenge. A thorough understanding of the population and their needs, the climate and geographical landscape, and most importantly, of the previous research regarding thermal comfort and seismic retrofitting for developing countries is essential. This has been achieved through a literature review, which provides the theoretical framework and identifies which seismic and thermal comfort strategies are appropriate for which type of constructions and climates, respectively. Following this, a research-by-design methodology is employed to formulate possible integrative solutions.

This study has four main objectives:

- Identify the challenges, opportunities and theoretical framework for housing the low-income population in India.
- Consider the level of thermal comfort in low-income housing and identify appropriate passive thermal comfort strategies for improvement.
- Consider the level of seismic resistance provided in non-engineered housing and identify appropriate retrofitting techniques for improvement.
- Explore the possibility of developing integrative techniques which combine seismic retrofitting techniques and passive thermal comfort strategies.

This research addresses four essential theoretical components of residential building design: safety, comfort, energy efficiency, and affordability. Safety and comfort are considered in terms of seismic provisions and thermal comfort, respectively. The integration of these two with an additional aspect of sustainability, owing to the low-cost and energy-efficient nature of the proposed techniques, produces affordable and durable housing systems which are also safe and comfortable.

3. Identification of Case Study Regions

The regions chosen in India for the study depend on two key features: 'seismicity' and 'climatic condition'. Each location chosen is based in Seismic zone IV (Indian Seismic Code IS 1893-2002) to keep the key requirements for the seismic resisting building structure constant. Zone IV is identified to be a 'high damage risk zone' and is equated to VIII of the MSK intensity scale which states that in the case of an earthquake, "most ordinary masonry constructions suffer heavy damage and most rural constructions are destroyed", emphasizing the need for improvement of seismic measures. The variable component is the climate which ranges between the extremes from hot and dry to the cold. This allows for the exploration of a wide range of integrative techniques that would be applicable to different climatic conditions. The common regions for the study (shown in the climatic and seismic zone maps in Figures 1 and 2) are Palanpur, Jammu and Sikkim.

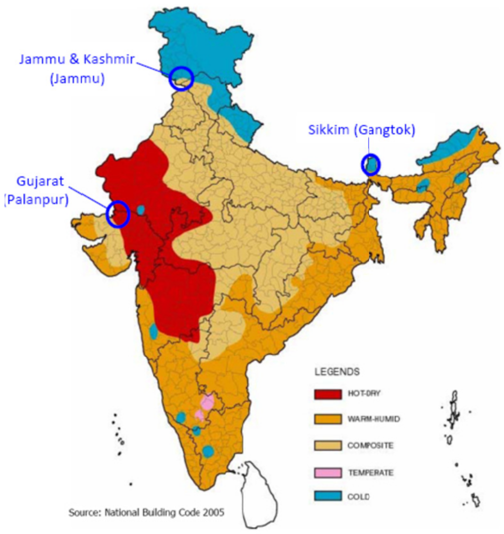

Figure 1: Climatic Zone Map (HPCB, 2010)

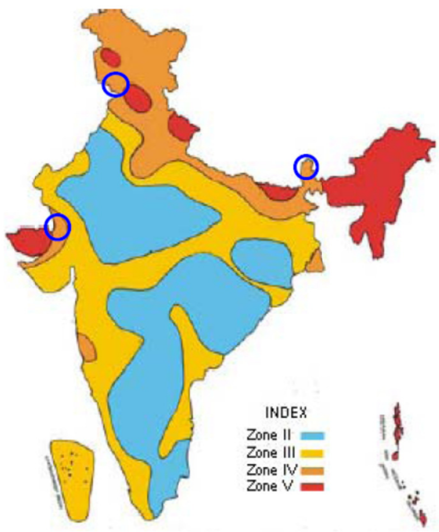

Figure 2: Climatic Zone Map (ISR, 2007)

(1) Climatic Profiles of the Regions

Climatic data, such as temperature and humidity values, were attained for each region which reiterated the above climatic classifications. Hence, the climatic profiles for each region are mentioned as thus:

- Palanpur (in Gujarat) = Hot-dry (with fluctuating humidity)
- Jammu (in Jammu & Kashmir) = Composite (with fluctuating humidity)
- Gangtok (in Sikkim) = Cold (with high humidity)

(2) Typical Housing Types

Based on the 2001 Indian Census housing data, the typical rural housing types (as these are almost always only inhabited by the low-income population) found in the regions of Gujarat, Jammu & Kashmir and Sikkim were identified. Based on the analysis of most the commonly used wall materials in the selected regions, the following three main construction types were identified: Fired/unfired brick; Adobe; and Stone. All of these are non-engineered constructions and therefore have high vulnerability during earthquakes.

4. Thermal Comfort Integration

Following thermal comfort analysis of each of the regions and a thorough review of the available seismic reftrofitting technologies for non-engineered construction, the best type of passive strategy for each month in each of the regions can be identified. Currently, work is in progress in this area, and it is hoped that the process will give a clear indication regarding which thermal comfort strategies will have the maximum use and therefore a higher integrative potential.

Basic passive strategies that could be considered are: natural ventilation, thermal mass, radiant systems, evaporative cooling, earth cooling, passive solar heat gain, insulation, shading, and colour. Some strategies can have a high integrative potential with the seismic retrofitting technique mentioned above, though some are not directly related to the structural aspect meaning that these strategies would only have limited scope for integration. Further research needs to be carried out in order to validate this and propose the possible integrative solutions.

5. Conclusion

This study looks at the possibilities for integrating passive thermal comfort features with existing seismic retrofitting techniques for non-engineered houses. First, seismic strengthening techniques that are appropriate for non-engineered residential construction are identified. Following this, a climatic design process is proposed. Finally, the integration of thermal comfort features with seismic retrofitting techniques can be investigated. There is a considerable amount of research that still needs to be done in order to understand the criteria for integration and develop the appropriate systems which shall provide the double benefit of safety and comfort.

6. References

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