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Learning from the past to protect the future: Armature Crosswalls

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Abstract

It seems counter-intuitive to assert that simple, unsophisticated, non-engineered, timber and masonry structures that now seem so archaic as to be more easily associated with the medieval rather than modern world might be safer in large earthquakes than new structures of reinforced concrete, but such has proven to be the case in a number of recent earthquakes. Indeed, in many different regions of the world, the earthquake record for contemporary structures of reinforced concrete (RC) frequently has been abysmal, while certain types of traditional masonry structures with timber-lacing have survived earthquakes that have felled their concrete neighbors.

Before the advent of the strong materials of reinforced concrete and steel, many societies had developed an approach to seismic resistance based on flexibility rather than strength that is only slowly being re-learned in the present. This paper will explore what can be learned from these historical construction practices, by describing the concept for "Armature Crosswalls," a construction technology inspired by Turkish and Kashmiri traditional construction but designed for use in reinforced concrete infill-wall buildings. The value of this approach for heritage conservation is that when people understand historic structures not only as archaic and obsolete building systems, but also as repositories of generations of thought and knowledge of how to live well on local resources, societies can begin to rediscover the value of these traditions once again by seeing them in a new light – one that, at its most fundamental level, can save lives.

Keywords: Traditional construction; Reinforced concrete; RC; Masonry; Timber; Earthquake; Heritage; Infill-frame; Turkey; Portugal; Kashmir

1. Introduction

The superior performance of many traditional timber and masonry buildings over newer ones of reinforced concrete during recent earthquakes in Turkey, India (Gujarat and Kashmir) and Pakistan raises fundamental questions about the assumptions made over many decades that simple, unsophisticated, non-engineered, timber and masonry structures (seemly more medieval than modern) are less safe in large earthquakes than newer structures of reinforced concrete (RC). Despite the frequently abysmal record of contemporary RC structures under seismic loading, certain types of traditional masonry structures with timber-lacing have survived the same earthquakes with only minor damage. This gives rise to the question of whether one can employ aspects of traditional technology Fig. 1 to enhance the seismic performance of modern constructions.

As described below, the concept of "Armature Crosswalls" is derived from *hımış* (in Turkey) and *dhajji dewari* (in Kashmir) as an alternative to the otherwise nearly ubiquitous conventional infill masonry in RC moment frames. Although experimental evidence is still preliminary, and issues of scalability from small experiments and low-rise traditional buildings to multi-story RC buildings have yet to be rigorously addressed, a re-examination of traditional structural systems may furnish an example of how a reinvention of an indigenous building technique may simultaneously provide guidance for safe modern construction using local materials and skills, and encourage the preservation of cultural heritage. Exploring this premise is designed to help facilitate a paradigm shift to one where the goals of historic preservation are not necessarily viewed as incompatible with seismic safety. Yet, to do this may require a fundamental rethinking of current analysis and analytical tools to encompass the use of masonry as an interactive part of the primary lateral-force structural system of modern frame structures.

2. Background

Before the advent of strong materials such as RC and steel, masonry was predominant for construction in most

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Fig. 1. This long abandoned and unmaintained 2.5 story *hımış* house in Gölcük survived the 1999 earthquake with little additional damage, despite the widespread collapse of the surrounding RC structures.

Fig. 2. Partially collapsed RC frame with infill masonry apartment block, Gölcük, Turkey, 1999.

Fig. 3. Partially demolished *taq* construction (Srinagar, Kashmir, 2006) showing timber lacing laid into the wall. Timber bands at floor level and at the window lintel levels.

parts of the world, but, with the judicious use of timber, a moderate degree of flexibility could be achieved. With regional variations, traditional construction with timber-laced masonry and masonry-infilled timber frames can be found in many earthquake-prone areas. The recent large Turkish Marmara earthquakes in 1999, in which tens of thousands died in collapsed new RC buildings – Fig. 2, provide juxtaposed cases against which to study the behavior of traditional structures. While poor design and bad construction are reasonable explanations for many RC collapses, arguably a system that depends for basic life-safety on a level of quality control that is rarely achieved is unwise.

By contrast, the traditional buildings that survived the earthquake were not engineered, and lacked both steel and concrete. No plans for them were ever inspected, because none were ever drawn. They were only rarely erected by anyone who could remotely be characterized as a professionally trained designer or builder, nor could many of them be characterized as having been carefully constructed. On the contrary, they were constructed with a minimum of tools, with locally acquired materials, and employed only a minimum of nails and fasteners. Often the timber was not even milled, being only cut and debarked and sometimes put together with only a single nail, before being infilled with brick or rubble stone in mud or weak lime mortar. Thus, arguably the traditional buildings which survived inherently possess the type of construction deficiencies usually identified as reasons why the modern buildings fell down. As such, the argument that engineering design and strong materials can consistently provide seismic protection must be questioned, especially where construction quality control is unreliable [6].