Study on Sustainable Timber Structures (Seismic Analysis)-Dajji-Dewari Houses in Kashmir-A Review

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Abstract— Earthquakes are the most destructive natural calamities which lead to a huge loss of life, property and economy. On 8 October, 2005, a magnitude 7.4 on righter scale earthquake took place the Kashmir valley (A Himalayan disputed region administered in parts by India and Pakistan), also the other areas affected were parts of India, Afghanistan and Pakistan. Around 90 thousand people died because of this earthquake, and an approximate 40 lakh people were left shelter less. The Kashmir earthquake took place at 9:25 am (IST) and was epicentered about 19 kilometers NE of Muzafarabad, which is the capital town of Pakistan-ruled Kashmir. Kashmir valley is situated at the fault line of the Indian

- To perform Response Spectrum Analysis Using IS 1893-2000 code for Zone-V on different timber framed wall (Dhajji-Dewari) models in SAP-2000.
- To perform Response Spectrum Analysis Using IS 1893-2000 code for Zone-V on a single story house with different configurations of timber framed (Dhajji-Dewari) walls (Box Type Structure Model) in SAP 2000.
- To perform Response Spectrum Analysis Using IS 1893-2000 code for Zone-V on a double story house with different configurations of timber framed (Dhajji-Dewari) walls (Box Type Structure Model) in SAP 2000.
- To determine Top Maximum Deflection in the models (both walls and houses).
- To determine Maximum Base Shear in the models (both walls and houses).
- To determine Time period of all the models.
- To determine the mechanism of the Dhajji-Dewari that make it seismic resistant.
- Comparison of results for Timber braced Dhajji-Dewari with conventional Lintel banded masonry box type houses.

Keywords: Sustainable Timber Structures, Houses in Kashmir

I. INTRODUCTION

A. General

Earthquakes are the most destructive natural calamities which lead to a huge loss of life, property and economy. On 8 October, 2005, a magnitude 7.4 on righter scale earthquake took place the Kashmir valley (A Himalayan disputed region administered in parts by India and Pakistan), also the other areas affected were parts of India, Afghanistan and Pakistan. Around 90 thousand people died because of this earthquake, and an approximate 40 lakh people were left shelter less. The Kashmir earthquake took place at 9:25 am (IST) and was epicentered about 19 kilometers NE of Muzafarabad, which is the capital town of Pakistan-ruled Kashmir. Kashmir valley is situated at the fault line of the Indian and Eurasian tectonic plates—the convergence of this Eurasian plate Indian plate caused the creation of the Great Himalayan Mountains— which makes the region prone to hazardous seismic earthquakes. The October 2005 quake was among one of the worst earthquakes to ever hit the area. It resulted in widespread destruction throughout the Kashmir regions, part of India-Ruled Kashmir; Pakistan-administered Kashmir; Pakistan's North-West Frontier Province; and northern areas of Pakistan. Damage to some extent was also reported from Afghanistan and north parts of India.

There are no ways to avert earthquakes but proper building design and use of construction practices based on research and in accordance with building code requirements can limit their effects. Every year millions of earthquakes occur throughout the world, but most of them we don't feel at all. They can hit anyplace; however, the chances of earthquakes massive enough to damage structures is high only in some geographic areas. Zone V and Zone IV make it to areas of high seismic hazard in India as per IS 1893-2000 code.

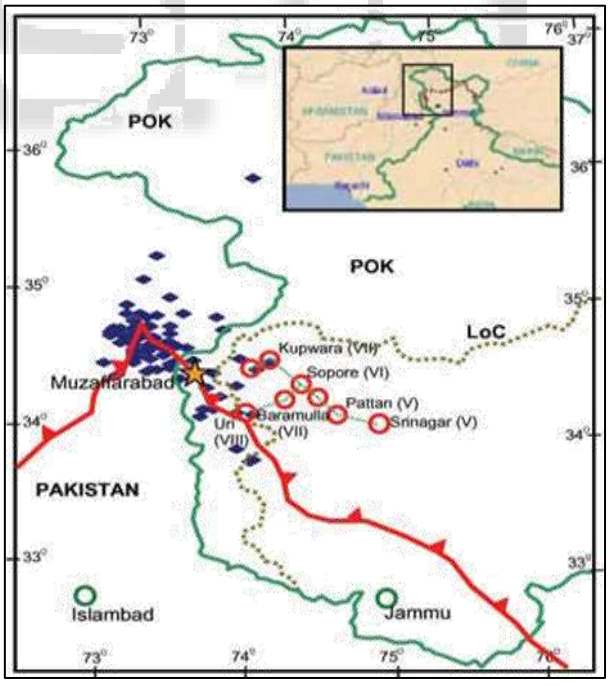

Fig 1.1: Epicenter Location of 7.4 magnitude Earthquake

The topography and landscape of the Kashmir region has resulted in land settlement and house forms that are of a different kind. A traditional way of life and building construction type is a result of this isolation and hence maximizes the use of locally available resources. This research discusses and analyses the house construction in terms of the above-mentioned way of life, but particularly in

terms of available local materials and the distribution of these materials through developed construction techniques into a structural system that is flexible and has the potential for seismic resistance. Key construction technique like the 'DHAJJI-DEWARI' will be analyzed in detail, while understanding its role within an overall construction system and as compared to the conventional more brittle masonry houses.

Fig. 1.2: Shows Dhajji-Dewari surviving October 2005 Kashmir Earthquake

Fig. 1.3: Typical Dhajji-Dewari Kashmir house

Fig. 1.4: Collapse of masonry walls while the Dhajji-Dewari portion stand without any damage.

B. Seismic Zoning

The economical design of earthquake resistant building or other structures is highly dependent on a research-based assessment of dependable data of past earthquake intensities of a particular region. However, we are still not able to predict the time and place of the occurrence of earthquakes, and their intensities and what characteristic ground motions they will possess. The simple method of assessment is to use research based seismic map, in which all regions are divided according to their vulnerability to high-risk earthquakes and zonal intensity factors. This map serves as a useful tool for the implementation of code provisions on seismic resistant design. The present IS1893-2002 recommended seismic zone map of India shows the country divided into 4 different zones (II, III, IV& V), each zone is associated with some risk factor of that area, which depends upon the local hazard and past earthquake data. Each of these zones is described in terms of the value of its highest ground acceleration, also known as designed ground acceleration associated with each zone is a factor which enters into the expression for determining the total base shear and is known as zone factor. Kashmir region lies mostly in earthquake zone V and is hence frequented by earthquakes.

C. Some Important Terms

1) EARTHQUAKE: A tremor of the crust surface of the Earth, sometimes intense and hazardous, which results from shock waves generated by the movement of rock masses deep inside the Earth, mostly near boundaries of tectonic fault plates.
2) RESPONSE SPECTRUM: It is a plot of the maximum response amplitude (displacement, velocity or acceleration) versus time period of many linear SDOF oscillators to a given component of characteristic ground movement.
3) In traditional building construction, we have another form of timber-framed masonry referred to as Taq system of construction and has been practiced at large scale as well. In this system large timber members are used as horizontal girders incorporated within the heavy brick masonry walls, making the building to resist lateral forces satisfactorily. In this project various structural models of Dhajji-Dewari with timber elements in different configurations have been analyzed using response spectrum based seismic analysis and their respective base shears and displacements have been studied and compared with the new more brittle DHAJJI DEWARI: is a timber framed masonry wall which constitutes of burnt half brick masonry confined within timber members to form a panel, combination of these panels results in a continuous wall built up of timber and masonry. The name Dhajji-Dewari is derived from a Persian word meaning "patch-work quilt wall". The frame of each panel consists of vertical as well as cross members that subdivide the infill brick masonry into small panels, imparts strength and prevents the masonry wall from out-of-plane failures.
4) BRICK INFILLS: Brick infill refers to Brick masonry used to fill the opening in a structural frame, known as the bounding frame. The bounding frame of timber comprises of the columns and upper and lower beam that surround the masonry infill and provide structural support.

D. Purpose of the work

- To bring back highly sustainable resource i.e.; timber-blue pine, back into construction.
- To formulate construction guidelines for efficient earthquake resistant Dhajji-Dewari house.
- Incorporation of modern techniques into this traditional construction practice.
- To cut out on modern materials like cement which affect the ecological balance of nature.
- To rebuild the confidence of people in this traditional Dhajji-Dewarisystem, so that this economical construction practices is not lost to expensive and inefficient modern practices.

II. OBJECTIVES

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III. LITERATURE REVIEW

Mohammad Akeeb Dar and Sajad Ahmad (2014), published a paper in International Journal of Civil and Structural Engineering Research Vol. 2, Issue 2, pp: (86-92), month: October 2014-march 2015. The paper published as Traditional Earthquake Resistant Systems of Kashmir discusses about the traditional systems like Taq and Dajji-Dewari built historically in Kashmir valley, their architectural significance and how economically these timber framed structures behaved satisfactorily in an event of an earthquake. Various representations give us an idea about the structural configuration of these systems.

Durgesh C Rai and C.V.R Murthy (2005), published a paper in Current Science Journalvol.9, No. 8, April 2006 issue. The publication is titled as the 2005 Kashmir (muzzaffarabad) earthquake and its effects on the existing buildings and the areas which were more affected The M_w 7.4 October 8 earthquake was a major earthquake which struck Muzzafarabad and parts of Jammu and Kashmir. This publication initially gives a brief about the role played by the active thrust generated due to the convergence of Eurasian plate into the Indian tectonic plate and how this Himalayan range generating subduction zone was responsible for this major earthquake shaking three countries. The team Durgesh C Rai and C.V.R Murthy carried out a Reconnaissance survey of the Indian controlled Kashmir part of affected region. They visited the Srinagar city, major northern towns Baramulla, Sopore and Uri. Also, the border areas of Kupwara and Tangdhar. They assessed the damage to the buildings and housing structures. In the paper they mention how they were surprised by the collapse of Rubble stone masonry walls even due to much lesser shaking. Along the Highways they visited various major civil engineering projects like dams and hydroelectric projects. They assessed various housing areas which are largely load bearing type masonry structures, usually laced with timber. The floors diaphragms were usually flexible. These typical structures locally referred to as Dhajii-Dewari amazed the surveyors as they had performed really well against the earthquake forces. These typical box type houses were simple masonry structures which had a simple patchwork of masonry confinedby small vertical and horizontal timber members. They say that there was no collapse even the regions of intense shaking.

K.M.OHicyilmaz, T.Wilcock, C.Izatt, J.da-Silva and R. Langenbach (2012) published a paper titled Analytical seismic performance of DhajjiDewari buildings. In this research the Authors studied the Dhajji-dewari houses which were built in great numbers after October 2005 earthquake. As there was little or no research-based data available to back the great seismic resistance claim. They aimed to analytically model the building to study the behavior of such houses. In this research seismic Analysis was carried out to a box type timber framed structure to understand its behavior and performance during a massive earthquake

The timber members and the brick infill were modeled accurately by giving the respective properties. They carried out Response Spectrum analysis and Push-over Analysis on the building to assess the overall performance.

The paper concludes that Analysis results show that Dhajji-Dewari can be modeled in FEM software to study their behavior. From, Analysis results it was established that Dhajji-Dewari house can resist earthquake forces safely even in high seismic regions. It was also concluded that Dhajji-Dewari wall behaves as confined masonry, and here timber members act as confinement members. This confinement keeps the masonry together and Seismic energy gets dissipated through friction between the masonry panels and the timber frame and within the yielding of the connections. It was also concluded that increased levels of overburden acting on the masonry increases the energy absorption capacity of the assembly.

V.R.Shah and Riyaz Tayyibji(2008) presented a paper at world conference on Earthquake Engineering. The paper presented as The Kashmir house, its seismic Adequacy and the question of social sustainability discusses about the development of construction practices by incorporating locally available material into a structural system that is flexible and has the potential of seismic resistance. The TAQ and Dhajji-Dewari systems were

studied in detail and their overall role in construction was studied. A case study was carried out to discuss the limitations of modern methods of structural analysis, and extensions required for a better understanding of traditional structures and construction. It also discusses the need to regain the confidence in traditional construction techniques, with their ability to respond to a seismic resistance while simultaneously responding to other issues such as local availability of material, climate etc. The paper brings out the inclusive way in which traditional buildings deal with issues of structure, rather than viewing them in isolation.

The paper concludes that the formulation of ideal model for scientific analysis needs to be prepared which is capable of being analyzed using known mathematical relationship also the codes and engineering methods are designed to ensure predictable behavior and therefore advocate simple and regular configuration closer to idealized models and at last it states that the method fails totake into account contradictory, complex or unqualifiable characteristics of the combined action of wood and brick.

Ultimately, the main difficulty it states is that most analytical methods are based on the assumption that the structure is elastic. These fail to take into account the higher order of deformability and energy dissipation of traditional construction. The response of inelastic structures will be different from that of elastic structure and the seismic forces attracted are lower in the former than in the latter.

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