

Comparative study and mapping of vernacular and contemporary architecture of Kashmir region with a focused study of Srinagar city.

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ABSTRACT: Ancient Kashmir has been the hub of central Asia, due to the various trade activities in the ancient era; the region has adapted itself with beautiful architecture, which reached to them from time to time. The trade activities with the Mongols has shown its influence on the temples and monasteries. The settlement of Mughals have developed the environment friendly and beautiful architecture, which was enhanced with the passage of time. The seismicity of region has also influenced the evolution of building types of the region. The current study encompasses the types of different buildings in the district of Srinagar and also suggest some policies and methods to preserve the historical and cultural art of Kashmir. However, the focus is laid on different types of building architecture in Kashmir and the mapping of different building types of the district of Srinagar. The paper also focuses on the importance of Kashmiri architecture in accordance with the economic aspects which play a key-role in the low economic zones like Kashmir.

KEYWORDS: Kashmiri Architecture; Kashmir History; Seismicity; Taqq and Dhajji-Dewari.; GIS; Spatial Analysis

I. INTRODUCTION

Earthquake is a natural phenomenon which can occur any time anywhere, development of resistance techniques for making infrastructure earthquake prone has always been a realm of research in the scientific field. Several traditional techniques like vernacular architecture, taq system, etc have developed in Kashmir over the period of

time. Kashmir is a place where the seismic zone occupies the scale 5, thus making the valley earthquake prone as per the latest version of seismic zoning map of India given in the earthquake resistant design code of India [IS 1893 (Part 1) 2002]. The residents thus have developed a number of techniques to make their homes seismic resistant. The techniques include incorporation of different material in building, construction enforcement using wood and mud. Rural architecture including the vernacular one also proves to be a very effective method for seismic resistance. Winter cold is the most common natural factors which governs it. So the thick wall of brick, stone and mud plaster provide excellent protection against the cold weather. Kashmiris have been known as “Shastra Shilpa” which means architects. Famous historian Alexander Cunningham says that the Kashmiri architecture show the traces of Grecian art. Also, Francis young says that the architecture of temples in Kashmir have the influence of Egyptian architecture. The architecture of Kashmir is diverse in all aspects due to its geographical location and historical background. The Kashmir has always been the bridge between the Middle East and central Asian civilizations which has been reflected in the architecture. Dhajji-Dewari, Taq, Stone, Wood and mud building have been used for a long time in the valley for development of earthquake resistant building and to survive harsh winters. The techniques are very effective in the valley and thus have been incorporated in pre and post-modern infrastructure development particularly in the hilly areas. The process of implementing such techniques

have been improved over the time for better effectiveness. There are such techniques which have also proven to be useful in thermal reflection and chilling winters. Several such techniques exist wherein even under the severe seismic impact the buildings don't collapse at all and the enforcement techniques are not all completely rendered useless. The impact may however expose the weaknesses of the reinforcement but in no way expose them for complete destruction, the weaknesses may be repaired for as much terms as willed. Dhajji-Dewari, Taq and Mud have been explored for their effectiveness against the seismic impact and the amount of weaknesses are reported in the same. Areas of implementation have also been discussed and the most suitable of the same has been evaluated for better execution or wherever needed a hybrid model has been used by the local residents.

1.1 Seismicity in the Kashmir valley:

Kashmir is the most challenged region for the natural disasters, it is located between the PirPanjal and the Zaskar thrusts, which makes the city more vulnerable to earthshaking. Srinagar and also North Kashmir appear to have been frequently and severely damaged by the earth shattering. There are multiple earthquakes which occurred in the valley however increased stresses in the NW-SE loop of the HAZARA KASHMIR SYNTAXIS (HKS) caused by Mw of 7.6 on Richter scale, which hits the Kashmir valley in 2005 which have caused to renew people's awareness of the risk (Gahalaut, 2006)(Parsons et al., 2006). The soil which are found in Srinagar and throughout the Kashmir are soft, loose soils which have a tendency to resist longer period of ground shaking properties of earthquake with epicentres distant from the site. In a plenty of cases the earthshaking last longer and accentuate damage building. Some of the severe earthquakes which have also been reported to have occurred in this region from the last 1000 years, most notable in 1501, 1555, 1669, 1736, 1779, 1824, 1828, and 1885 (Ahmad, Bhat and Bali, 2009). The isoseismic map of 1885 is shown in Figure.1(Brown, 2013) . Kashmir lies within a broad NW-SE trending belts of epicentres. The largest recorded in this zone were of richter magnitude 7.6 , the epicentre of which as in north Kashmir. Small earthquakes occur at a continuous rate in this region as a result of which the entire region is marked as very high risk damage risk zone V and high damage risk zone IV (Sharma, Kumar and Ghangas, 2013).

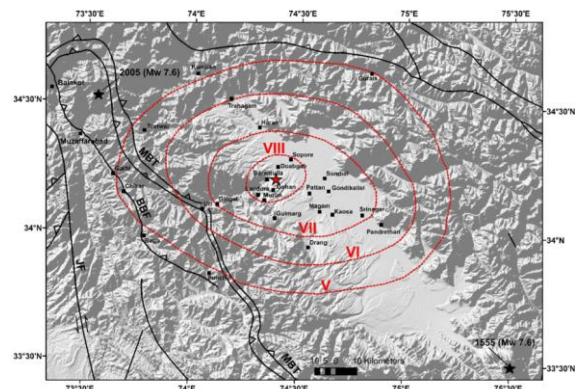


Figure 1: Isoseismic map of 1885 earthquake in Kashmir

With the delicate soils of the 2005 seismic tremor, one would have expected the harm to the more adaptable customary Taq and Dhajji-Dewari structures in Srinagar and Baramulla to be more regrettable than it was, however this is the place where the energy dissemination characteristics for both of these frameworks becomes an integral factor. The designs are versatile, yet not especially flexible. Their resounding reaction to ground movement is diminished because of the damping brought about by their inelastic conduct.

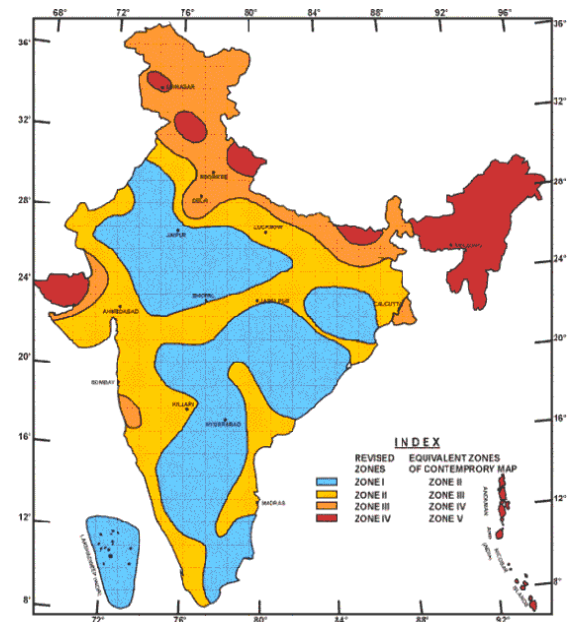


Figure 2: Seismic zoning map of India given in the earthquake resistant design code of India [IS 1893 (Part 1) 2002]

1.2 Architecture in Kashmir:

Rural buildings constructed in Kashmir are in a traditional way by the people (often referred to as a vernacular buildings) became an integral part of the local heritage. These buildings often reflect the strength of the community to house itself independent of any outside intervention. They are a manifestation of architectural systems optimised over time for a particular context with regard to climate, soil or the threat of natural disasters. Constructed from local materials with local skills and a deep understanding of local social and economic constraints, traditional architecture is in many aspects sustainable architecture. The urban areas of the valley have architecture that is distinct from all other areas. The main factor determining this architecture is the high density of development. This calls for vertical growth, resulting into three to four storey building in the valley. This architecture is quite common and prominent in its summer capital region. The very first view at Srinagar brings out its vernacular architecture. The soil of Kashmir is generally classified as clayey, loamy, rich and light peaty and low lying swamps and is of alluvial origin but quite fertile. In the semi-mountainous traits the soil is indeed coarse. The kandi traits have a stony soil and give a dry look even during the rainy season. The architecture of Kashmir can be broadly classified into four distinct types: Stone, Mud, Wooden and Vernacular architecture. Kashmir's rural architecture was mostly created by the local population using their abilities and locally accessible materials. It is also sometimes referred to as Kashmir's resilient architecture because of its ability to withstand earthquakes. Buildings in Kashmiri architecture have a distinctive design. One of the rural architecture examples is shown in Figure 3.

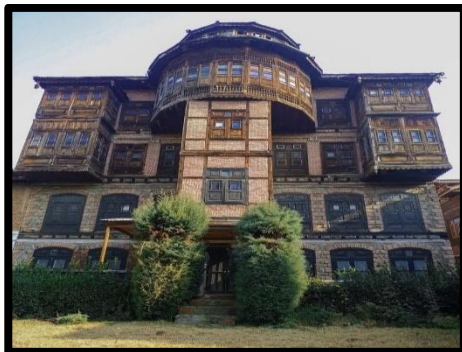


Figure 3: Rural Architecture of buildings in Kashmir

1.2.1 Stone architecture in Kashmir:

The stone architecture of Kashmir witnessed its peak in Buddhist-Hindu era that flourished in the first millennium A.D. However, this architecture can be only seen in form of temples and old monuments of historical importance or archeological designated places (Ahmad et al., 2017). This kind of structure is mostly seen in isolated areas, which are far away from the city. Some common examples of stone architecture include Parihaspur Stupa which is about 22 km's from Srinagar as shown in Figure 4. One of the greatest Kashmiri monarchs of all time, Lalit Aditya, chose the Parihasora stone building as the location for a new capital in the 8th century AD. The structures from the stone architecture are mostly cutout and from solid rocks in a particular shapes. These structures mostly have common things in them like fluted pillars, highly proportioned bases that distinguish them from the other architecture designs, Doric capitals etc. Although as of now, these structures are in dilapidated condition. As mentioned above, this architecture can be mostly observed in temples, which are not in good condition. The main reason behind that is the seismic activity of the region. The evidence from the photographs show that monolithic roofs are mostly absent in all of these kind of structures. As mentioned by legendary Moorcroft about the stone architecture, "It is scarcely possible to imagine that the state of ruin to which they have been reduced has been the work of time, or even of man, as their solidity is fully equal to that of the most massive monuments of Egypt. Earthquake must have been the cause of their overthrow." (Ahmad et al., 2015). About the seismic activity of 1885, Walter Lawrence says "it must be remembered that the temples of Pattan and palace of Srinagar suffered in 1885 earthquake" (Lawrence, 1895). So thus these structures add to the long list of lost glories from Kashmir's architectural legacy.

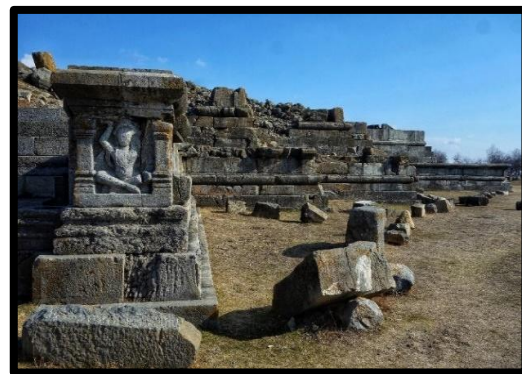


Figure 4: Stone architecture in Parihaspora, Kashmir

1.2.2 Mud architecture in Kashmir:

A number of building systems in various parts of Kashmir have developed over time to accommodate local climatic and cultural factors, including the impact of earthquake. Earthquake-resistant construction are not new to Kashmir, for that matter the community of nomad people had in built disaster resilience. Like, KUCCHA houses (mud sheds) belonging to those which are in the Gujjar or bakarwal community. They can be made and disassembled easily, and the material can be up cycled many times. Gujjar mud house are situated in the lap of the mountains and forests in Kashmir. The building have depended completely upon mud, stone, dried grass and log for roofing as well as walling. Winter is cold which is common in Kashmir. Thick walls of stone and wood with mud plaster provide excellent protection against this, as does a thick mud-timber roof. Traditional flat mud roof on timber structure with stone masonry. Typical mud house located at Doodhpathri Budgam is shown in Figure 5.



Figure 5: Mud architecture in Budgam, Kashmir

1.2.3 Wooden Architecture

The wooden architecture came into Kashmir with the advent of Islam (1400) B.C (Brown, 2013). Wooden structures consisted of horizontal planks of trees, which may or may not be carved. However, the vertical columns consisted of tree trunks. One of the best examples of wooden architectures are the wooden bridges in Srinagar and Baramulla along the Jhelum River. Most of the structures include piers, which is generated after the accumulation of wooden logs alternatively placed at right angles with each other, which add to its strength for bearing the continuous flow of water. Srinagar city consists of Shah-i-Hamdan mosque that is the clear example of wooden architecture as shown in Figure 6,7. Sultan Sikandar Butikshikan commissioned it in 1395.



Figure 6 : Wooden architecture in Srinagar, Kashmir

This structure consisted of cubical wooden structure with a hall and pyramid roof mostly in tiers. The lower part of the structure is made up of wooden logs mostly carved in square and laid alternatively. Since Kashmir is considered as one of the seismic active zones of the world, therefore wood architecture found its importance. Second, the wood is available in abundance therefore, it became economically sustainable. The Madani mosque of Srinagar is one of the oldest examples of wooden architecture of Kashmir. This architecture has a wooden pyramids supported by long columns of tree trunks curved beautifully. The ceiling is designed with khatamband as that of Shah-i-Hamdan mosque. From the decoration point of view, Akhtar reported the lattice type work on the wood which enhanced the beauty on the doors, walls, ventilators and partitions (Dar, no date).



Figure 7: Wooden architecture in Srinagar, Kashmir

1.2.4 Vernacular Architecture

Vernacular architecture can be defined as the architecture which is based on local settlers needs, construction material and the local cultural tradition. It has a easy maintenance which can done by the common people and also it can constructed by the common peoples without the help of an Engineer. It tends to evolve over time to reflect the environmental, cultural, technological, economic, and historical context in which it exists (Ahmad et al., 2017). The two most common wailing systems observed are Taq and Dhajji-dewari and it is found in Kashmir from the beginning of the 19th century. The material for the construction of these two systems can be found locally and it is easily available. Taq construction and Dhajji-Dewari construction are fine examples of vernacular architecture to climate response in Kashmir. Majority of these two constructions are mostly seen in Downtown Srinagar. As Kashmir lies in a seismic zone area and it is always prone to earthquakes. So all the houses in the valley are constructed with measures to prevent it from damages. Structure is an integral part of architecture and both structure and architecture should be addressed to, simultaneously. The normal practice is to incorporate the structural design into an already developed architectural concept. Due to the special circumstance of the earthquake, an integrated approach to structure and architecture was envisaged (Shah and Tayyibji, 2008).

1.2.4.1 Taq System

The first system referred to as Taq system. It consists of brick masonry interlaced with heavy timber bands supported on large masonry piers made of baked bricks. The taq type of construction has a large number of windows ("Taq" means window), one in each gap between the piers. The roofs are two and four-sided. The pier can be made of stone and the infill walls of brick. Timber runners at each level tie the walls. The infill walls have timber embedded in them to increase their elasticity. Taq timber construction is a combination of wood and unreinforced masonry laid on weak mortar which gives the building the required flexibility and uses traditional architecture and material. Taq construction is a bearing wall masonry, it's usually configured with a modular layout of masonry piers and window bays tied together with ladder like construction of horizontal timber embedded in the masonry at each floor level. These horizontal "ladder bands" are located at the base of the structure to the modular layout of the piers and window bays, i.e, a five-taq house is five bays wide.

The masonry above the foundation (das or dassa) and at each floor level and at the window lintel level. Taq refers piers (tshun) are almost 40-60cm and the bays are approximately 90-120cm in width. Because the modular pier and bat design and the timber-laced load-bearing masonry pier and wall system go together, the name has come to identify the structural system. Taq system does not consist of complete frames instead has larger timber runners resting along the load bearing masonry walls with floor beam and runners from the cross walls. Taq designates a timber laced masonry building. Example shown in Figure 8.



Figure 8: Taq architecture in Srinagar, Kashmir

1.2.4.2 Dhajji-Dewari

Dhajji-Dewari is a traditional architecture found both in Kashmir and Pakistan administered Kashmir. This construction technique wasn't much recognised before the 2005 Kashmir earthquake. The ENVIS Center for Human Settlements estimates that Dhajji Dewari has been in existence for more than 200 years. As suggested by the name, the structure resembles a patchwork built of different patterns; in Indian Standard Codes, it is also referred to as brick nogged wood frame construction. Both Taq and Dhajji-Dewari of Kashmir are similar to hatin and himis construction of Turkey (Ahmad et al., 2017). Dhajji-Dewari refers to the timber frame and infill consisting of baked or unbaked bricks. The timber frames in the Dhajji-Dewari walls are generally well laid out with system of diagonal bracings that provide a distinct path to the ground for the stresses caused by lateral seismic forces. The term Dhajji-Dewari is thought to be derived from the Persian word meaning "patchwork quilt wall" and is a traditional building type found in Kashmir. These structures are typically double or triple storey building. Dhajji derives its name from quilting, i.e. which is made from recycled materials and scraps of cloth, making it both sustainable and regional building construction method with a capability of making different low-strength materials to function as a

single system. The Dhajji-Dewari style of construction combines masonry and wood. The wall and hence the structure won't completely collapse if one panel were to fail. Thus, making Dhajji-Dewari houses more resilient to earthquakes. Greater safety against out of plane collapse is provided by small brick panels surrounded by timber pieces. (Shah and Tayyibji, 2008).



Figure 9: Dhajji-Dewari architecture in Srinagar, Kashmir

1.2.5 Load bearing brick masonry structures

Load bearing brick masonry structures are the most common kind of building in Kashmir nowadays. To give these structures tensile strength, reinforcement is used during construction. Because bricks are torn apart at the mortar joints, normal brick masonry cannot bear tensile pressures; in these cases, steel flats, steel bars, or expanded bars are used to reinforce the brick masonry. Reinforced brickworks are typically utilized in lintels, retaining walls, seismic zones, and walls constructed on land that is prone to significant soil settlement. Bricks can absorb more heat because of their high thermal density. The bricks retain heat throughout the day and release it at night. In essence, you have the ideal option for keeping your house cozy in the winter and cool in the summer. Days require less heat than nights do, which is where the thermal insulation property comes into play. Because of their thinness relative to their height and length, masonry walls are thin. By acting as a box with the roof at the top and the base at the bottom, these walls may be easily made to respond well to seismic shaking. Therefore, making it the most favourite option of building construction in the Kashmir valley. In these structures, the whole load is supported by masonry

wall and the transfer of loads occurs from masonry walls to foundation.



10(a)



10(b)

Figure 10(a) & 10(b): Typical examples of Load bearing masonry structures in Kashmir

1.2.6 RCC Framed Structures

Reinforced Cement Concrete (RCC) is a flexible composite and one of Kashmir's most popular building materials for contemporary structures. Members made of concrete and steel bars, such as beams, boards, columns, and roof trusses. Traditional cement concrete is combined with reinforcements to create reinforced concrete. This combination uses the tensile strength of steel and the compressive strength of concrete at the same time to resist a variety of loading. The word "reinforced" is used because the steel strengthens the concrete and gives it additional reinforcement. It is a Popular building materials because it is robust, simple to work with, adaptable, versatile, long-lasting, and reasonably priced. Since the 1950s, structural dynamics has gradually become the core of the analysis and design of earthquake-resistant structures. In the beginning, linear models with viscous damping were introduced, but soon, steps were made toward models of inelastic behaviour with hysteretic damping, aiming at a more realistic approach to the response of structures to strong seismic motions, which cause damage. RCC

Structures that are constructed in Kashmir valley are generally made of Commercial or Institutional Purposes. In RCC framed structure, the whole load is supported on beam and slab; and the load of beam and slab is transferred through columns to footing.



Figure 11: Typical example of RCC Framed Structures

II. STUDY

The study involved the identification of all the building types in one of the district areas of Kashmir region i.e. Srinagar. All the data was collected by physical survey of the area wherever possible and for mapping of inaccessible areas, google earth software was used. Further, the identified areas were plotted and further analysis was done on Q-GIS. In our study, it was observed that Srinagar encompasses a total area of 250 sqkms. Also, out of this identified total area of Srinagar, the majority of the buildings are of Brick Cement Masonary followed by RCC Framed Structures and a small portion of the buildings are of Vernacular and Other Types. The area obtained for different building types after analysing the data in Q-GIS is tabulated in Table 1 below. The focus on use of load bearing walls without taking into account the rich history of Kashmir will lead to catastrophic results if an earthquake of higher magnitude strikes the valley. After taking into account the safety of structures, the RCC Framed Structures behave the best and Stone/Mud S behave the worst.

S.No	Building Type	AREA (in sqkms)	Percentage of Total Area	Comparatively Ductility Rank	Comparatively Strength Rank	Overall Rank
1	Dhajji&Taq	1.5 to 2.0	1-1.5%	1	3	2
2	Reinforced Concrete	30 to 35	22-25%	2	1	1
3	Brick Cement Masonary	105 to 110	74-76%	3	2	3
4	Stone/Wooden/Mud (Other Types)	1.0 to 1.5	0.07-1%	4	4	4

Table 1 : Results of analysing building data in Q-GIS

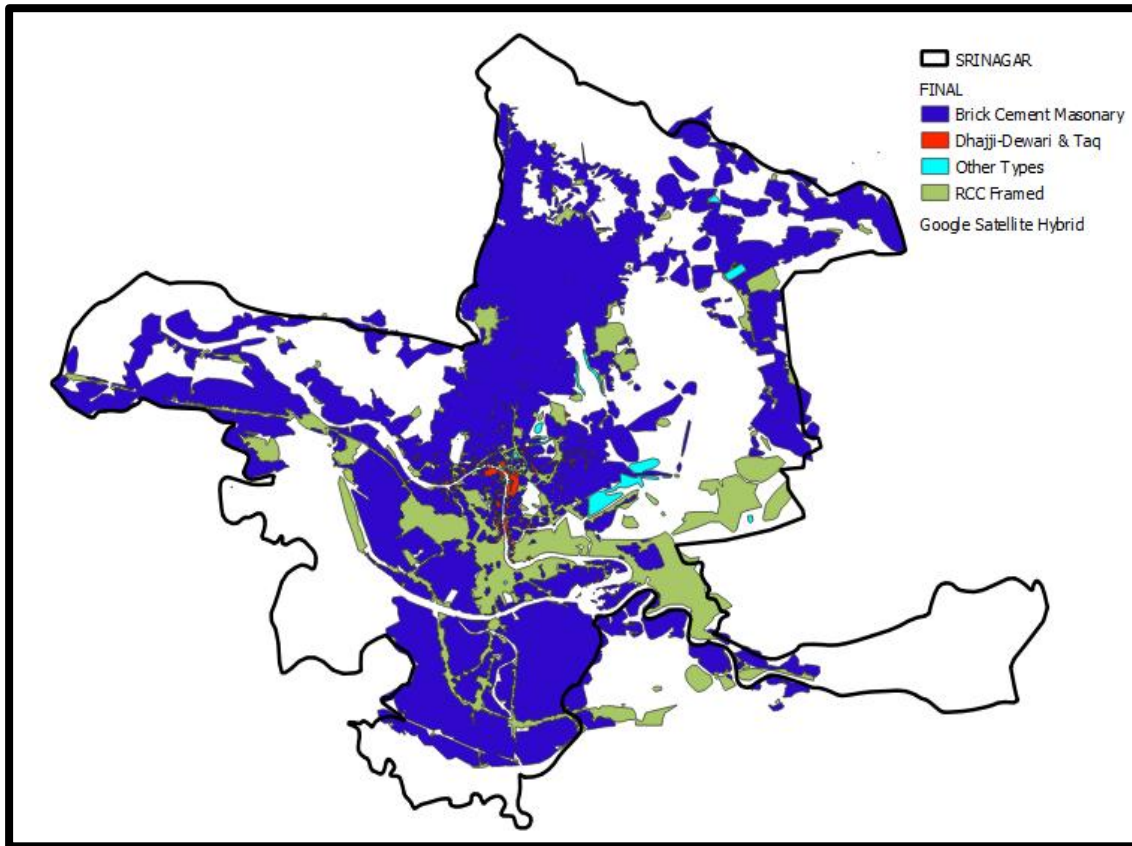


Figure 5: Map obtained after surveying different building types of district Srinagar, Kashmir

III. CONCLUSION

From the early centuries, the Kashmir has been a place for extra-ordinary architecture. The Mosques, Monasteries, temples and shrines have kept their mark on architectural history. The flower carving on the wooden ceilings and walls, so called “Khatamband” is the remarkable piece of Kashmiri architecture which was migrated from the then Persia which got mixed with the traditional architectures like Dhajji-Dewari and Taq system. From the seismic point of view, Kashmir comes under zone 5, therefore more emphasis is to be laid on earthquake resistant features of the structure. In our study it was found that the Load Bearing Brick Cement Structures are the most prevalent building type in Srinagar while the traditional techniques like Dhajji-dewari and Taq system have been restricted to the old city areas only. The Dhajji-dewari and Taq system have survived most of the brutal earthquakes of the early centuries while the stone architecture didn’t survive. Thus the current need is to put the emphasis on the two vernacular traditional architectural techniques to sustain the frequent earthquakes and preserve the history of Kashmir region. These old houses comprising of vernacular architecture are in a

dilapidated condition, which needs to be taken care of. Recently the Srinagar city was marked for UNESCO creative city, which gives it a sort of hallmark. The agencies like INTACH have Asian bank and World Bank assisted projects and their prime focus is on renovation of historical places but the residential old architecture is not included in these restoration schemes. Residential architecture can boost the local economy. The history of Kashmiri architecture can be preserved as that of the streets of Germany, Italy and France. Also, some ways of merging this Dhajji-dewari and Taq system with the existing contemporary architecture could be looked into so that the safety of the region improves and the buildings of the region perform in a better way in case of an earthquake in future.

IV. AUTHOR CONTRIBUTION:

The authors confirm contribution to the paper as follows: study, conception and design: Burhan Ahmad Wani & Yasir Reshi; data collection: Yasir Reshi; mapping, analysis and interpretation of results in Q-GIS: Burhan Ahmad Wani & Ayman Bashir; draft manuscript preparation: Dr. V.K. Dogra, Burhan Ahmad

Wani, Yasir Reshi & Ayman Bashir. All authors reviewed the results and approved the final version of the manuscript.

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