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Understand the Local Seismic Culture through Ancient and Traditional Building

Zatir A, Mokhtari A, Foufa A, Zatir S.

University of Science and Technology Mohamed Boudiaf 31000 Oran

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ABSTRACT

A lot of monuments and constructions, built in traditional ways which survive for earthquakes, even in zones where the seismic risk is particularly important. This research, presents several examples of sismo-resistant traditional constructions, testifying a local seismic culture for every region listed respectively. By presenting examples exits of different civilizations, regions and different cultures, the study aims at demonstrating the solid know-how of the sismo-resistant vernacular architecture.

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INTRODUCTION

The local seismic culture is defined by "the capital of all the historical, scientific and technical knowledge of old buildings. It is to find methods that the affected population has invented over the centuries to protect themselves and their habitat against seismic events (Ferrigni, 2005).

Through the examples and the experiences presented, the remark which can be made, is that in the traditional built, two major principles in a way opposite, govern the constructions in earthquake-resistant. It is about the very big flexibility, whom answer very light constructions, like the Japanese wooden constructions, Turkish and even Chinese; that of the very big rigidity to which correspond constructions in masonry in particular stone, more or less heavy and massive, which we meet in particular in the Mediterranean Basin, and in the historic sanctuary of Machu Picchu.

In it is added sensible and well reflected techniques of construction, of which the use of the humble materials such as the earth and the adobe. The ancient communities were able to face the seismic risks, thanks to them know-how reflected in their intelligently designed constructions, testifying of a local seismic culture.

Local Seismic Culture In Japan:

The Japanese traditional constructions knew the use of plant materials such as: wood, straw, rice paper, thatches, reeds, barks of trees, bamboos, which are natural and flexible for the implementation. The wood is characterized by its report weight-resistance which is four times better than that of the reinforced concrete and one and a half time that of the metal.

The wooden structures offer a better flexibility and thus a better resistance (Pelletier, 1991). Bamboo is used to build the armatures of buildings because it is supple and solid (the flexibility of materials is necessary in case of earthquake).

Corresponding Author: Amira ZATIR, Department of Architecture, Faculty of Architecture and Civil Engineering, University of Science and Technology Mohamed Boudiaf. Oran, Algeria.
E-mail: amiraz83@live.fr

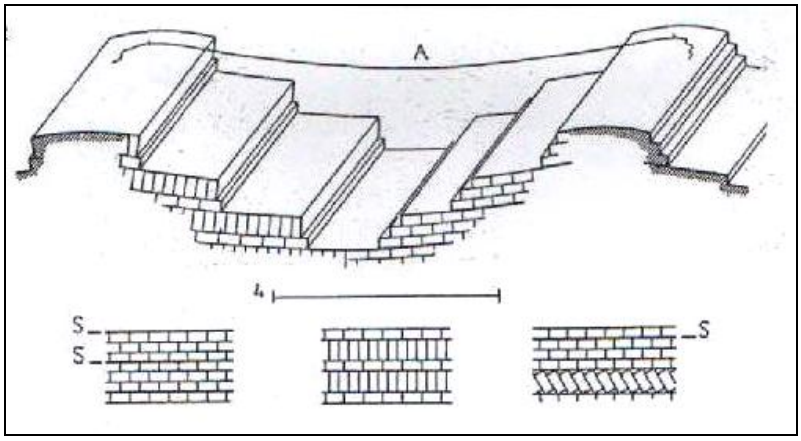

Fig. 1: Wavy beds of masonry (Choisy, 1996).

To Japanese, the assizes of masonry are rarely flat, their longitudinal profile is a curve turning its convexity to the ground; we saw in this shape a guarantee against earthquakes.

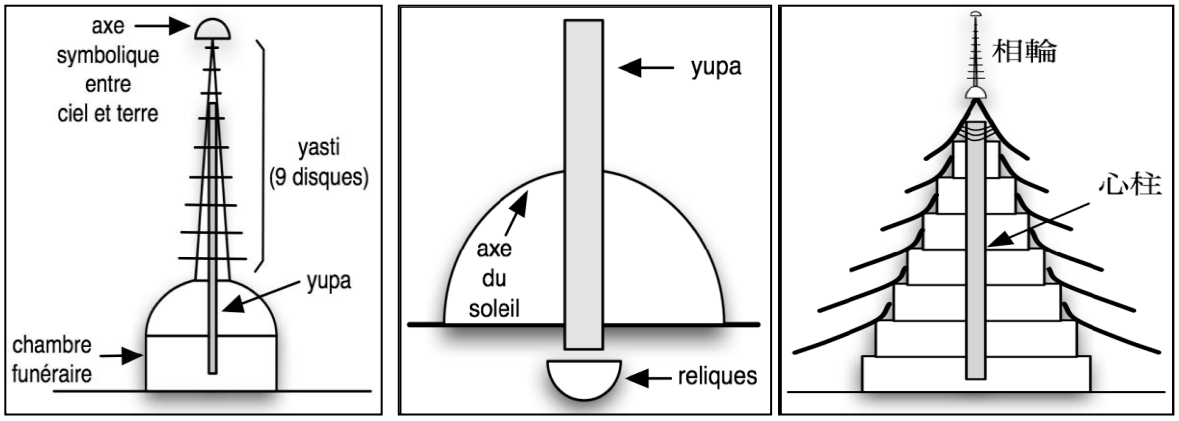

Fig. 2: Explanatory plans of pagodas.

"The pagoda says itself tô or sotôba (which comes from the sanscrit stûpa). All the stûpas is built around a column, "yupa", below which we buried an important dead man ". The yupa is suspended in the middle of the building and is retained by chains to the structure of the pagoda which surrounds it. So, in case of earthquake, It allows to stabilize the group by creating a counterweight, what explains that we find ancient pagoda in Japan: they resisted the insults of time.

Performance of Arcs, Vaults And Domes In The Traditional Construction Iranian In Bam:

The region of Bam, almost desert, where there was no bamboo or no wood, it was thus frequent to meet series of walls and vaults in earth. The main material of construction was the adobe, bricks of raw earth.

The only earth, because it has no strong resistance in the tension, is not an excellent material against the big earthquakes. But it possesses deformability certain in compression and cutting. What makes a material interesting for the earthquake-resistant (Tournon, 2004). Arcs, vaults and domes were the most important elements in the vernacular constructions in Iran till the beginning of the 20th century. It was frequent to meet series of walls and vaults in earth, attached the some to the others in the grouped housing environments, every unity contreventant his neighbours mutually. There was a kind of collective resistance.

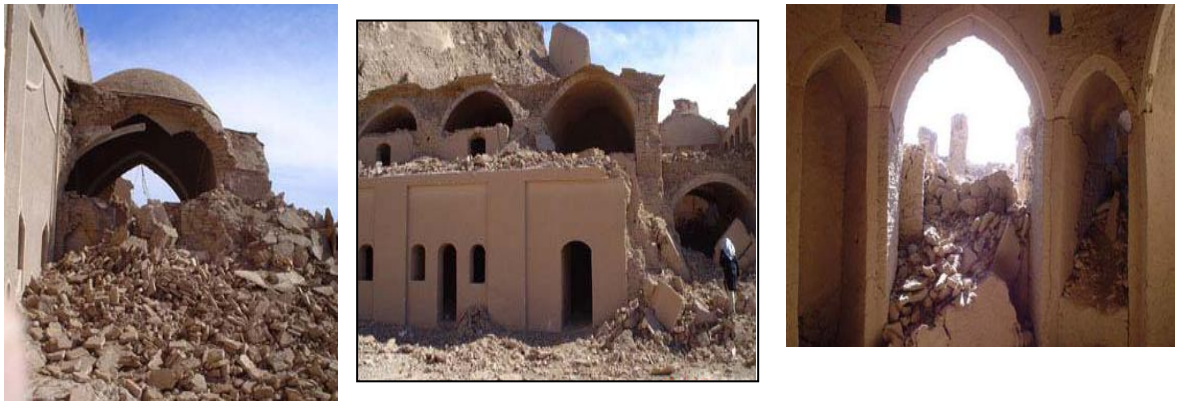

Fig. 3: Performance of arcs, vaults and domes the 2003 bam earthquake (Mahdi, 2004)

Performance of The Type of Construction: Hatil, Himis And Bagdadi, In Turkey:

A characteristic of the practices of Ottoman traditional construction is the use of the wood in the masonry of the walls of lacing-up. The use of the horizontal pieces of wood 'hatil' integrated into bearing walls in masonry and the insertion of the masonry between columns, beams and posts of a wooden skeleton 'Himis'. Another known type under the name of 'Bagdadi' is spread enough. The construction Bagdadi, is characterized by the use of short raw pieces of wood for the filling instead of the masonry.

These were generally put inside and the outside to form a solid wall. By using what must have been largely of the old wood which could not be used for the structural elements, house Bagdadi is light, resisting earthquakes (Gülkan and Langenbach, 2004).

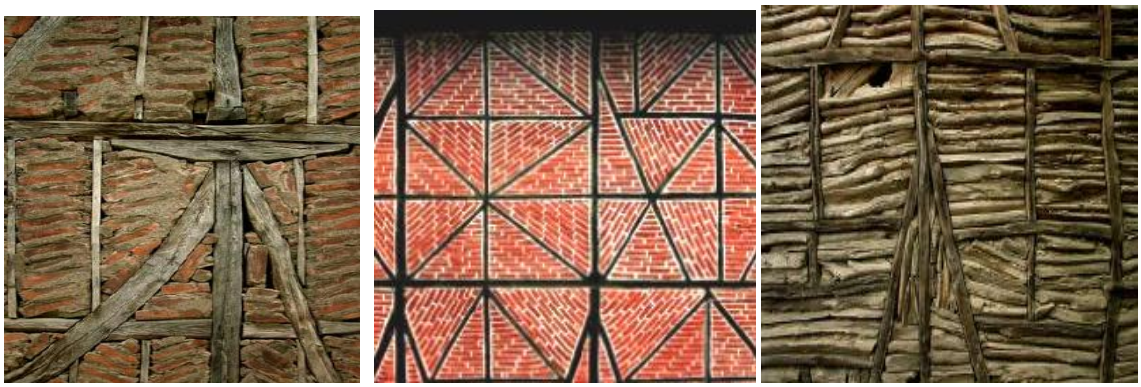

Fig. 4: to the left Hatil, Turkish traditional construction; in the center detail of the variation decorated with construction Himis near Düzce; the right detail of the wall Bagdadi to Golcuk (Gülkan and Langenbach, 2004).

Presence of The Local Seismic Culture In The Mediterranean Basin Regions:

Many countries in the Mediterranean region are known for their high geomorphological and tectonic settings, which therefore highlights the seismic risk. These areas are located west of the Alps, where the intersection between the Eurasian plate and the African, Arabian and Indian causes a complex system of collision plates.

These areas were always exposed to intense seismic activity, which has led to many disastrous consequences in terms of human lives and damage more or less important architectural heritage of buildings, tall buildings, centers historical and the environment as a whole -natural and built environment- (De Tommasi,).

Earthquakes have historically been interpreted with great imagination and so apocalyptic. Human understanding was even considered inappropriate because of the lack of a scientific approach in the pre-modern culture. However, there was a certain philosophy of prevention among builders since antiquity, even ignoring the causes of earthquakes and their predictions, especially, this telluric phenomenon does not occur at frequent intervals.

Seismic-resistant solutions and technical passive:

In Italy, in the fourth century Bebore J.C. and in the Greek colonies of *Metapontum* and *Paestum*, builders constructed building foundations in trenches dug into the rock, then filled with sand. In northern Syria, the second century before J.C. masonry constructions were equipped with a wooden structure. After the earthquake that destroyed Pompeii and part of the city of Naples in the year of 63, a seismic regulation preventing the construction of buildings over two storeys was imposed, distributed and transmitted to the Renaissance (De Tommasi,).

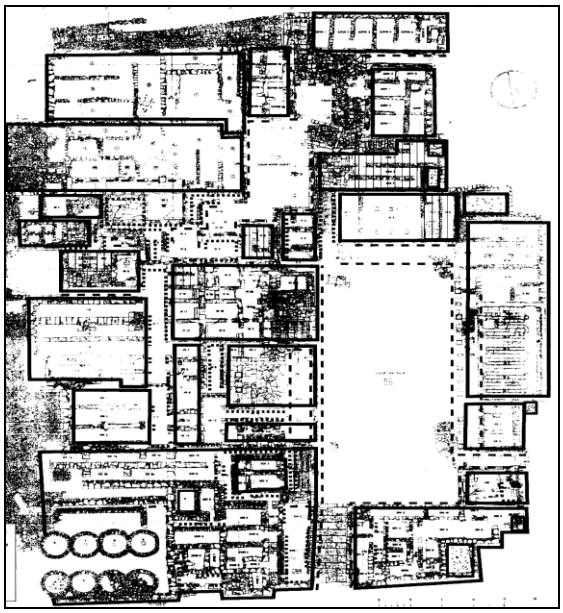

Fig. 5: Plan of the Palace of Malia, with the division into dynamic islands, Crete (POURSOULIS, 2000).

Archaeological and historical research, could give a clear idea about the seismic activity of Crete, and reveal Seismic-resistant qualities of the proto-Minoan architecture. The techniques used in the construction of these buildings, including the plane symmetrical split into several islands of buildings isolated from each other by joints separations reveal a seismic value consistent with current rules.

In the Mediterranean, the most common stone wall; in the most common situation, it is thick and built with mortar (Meda, Euromed Heritage, 2002).

It is this scenario that correspond Minoan buildings. Building techniques, rare, do occur only in areas weakened either by the lightness of the construction materials used, inner walls of brick or block of earth and stone, or by the weight of the superstructure, when 'there is an imposing upper floor, stairs leaning against a wall light (POURSOULIS, 2000).

In France and Italy, there are examples of earthquake-resistant traditional methods, whose aim was the reinforcement of the frame. Vernacular buildings in villages, previously affected by earthquakes, we can see that a certain know-how and local seismic cultural existed.

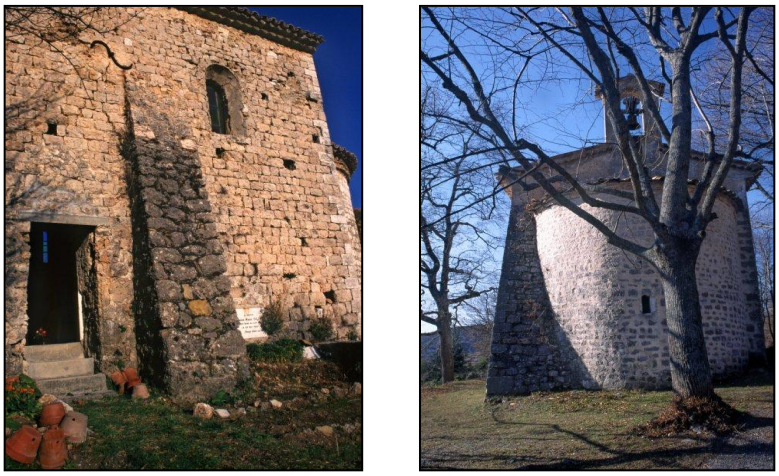

Fig. 6: The parish church (left) and the chapel of Notre-Dame du Peuple (right) from the village of *Bézaudun*, France, have been strengthened by buttresses after the earthquake of 1887. (Laurenti, 2002)

The reinforcement **(Fig.6),** a reinforcing member is an existing structure and usually, it is added on an older masonry. Sometimes the counter is run in conjunction with the construction of the building, premeditated and deliberate act to reinforce this construction, most often in the corners. By its mass, the foothills also lower the center of gravity of a building.

Fig. 7: Examples of arcs of reinforcement in the resort of *Diano Castello* in *Liguria*, Italy. (Laurenti, 2002).

Reinforcement arcs or arcs of contrast **(Fig.7),** an alley or a narrow passage between two buildings, are elements of break in the continuity of a linear façade. Stone masonry arches with relative flexibility allow transmission of horizontal stresses in the floor.

Earthquake Traditional Construction Techniques In El Salvador In Central America:

It is a country where earthquakes are frequent, the example below presents a draft earthquake-resistant traditional construction Adobe, carried by ordinary builders trained by architect **Wilfredo Carazas** (architect specializing in buildings ground).

The construction principle:

The main objective of this project is to prevent the house collapses due to an earthquake. People build adobe brick or adobe. The points that are the strength of the earthquake-resistant building are: (Vincesoiz, 2007)

- The shape of the house (the square being the most earthquake-resistant)
- The square bricks adobe (sun-dried brick of earth)
- The addition of buttresses
- Addition of a frame in the walls in the ground,
- Chaining all the walls of the house, both horizontally and vertically.

The construction consists of several square modules, it can then be expanded by adding modules existing symmetries and by chaining together.

Fig. 8: phases of construction of the house (Vincesoiz, 2007).

The result:

In December 2006, another earthquake, lower than 2001 but still important, shook El Salvador. The houses have resisted, and none collapsed. In six years, many families have benefited from the project continues and grows.

The Local Seismic Culture In The Andean Site "Machu Picchu" In Peru:

Peru is a country prone to earthquakes; it is located on a seismic fault, which causes each year, a number of earthquakes whose intensity remains low. Amid the seismic context, Peru contains a historic site dating back to the Inca civilization. This is historic Machu Picchu is a site that offers a representative example of a local seismic Culture.

Building materials in Machu Picchu:

Most of the buildings in Machu Picchu use the classic Inca architectural style; the walls are built of dry stones. The Incas did not use mortar on their sites but that of Machu Picchu, the majority of walls and buildings consist of disjoint very irregular stones, and filled with earth between them.

Fig. 9: Detail of a stone wall with close fitting to Machu Picchu.

Architecture Features:

Machu Picchu is a city that has withstood earthquakes over time; including its buildings and walls, show many subtle details that might prevent them from collapsing during an earthquake. The verticality of the walls was not respected by the Incas, as the walls are sloped inward parts, such as buildings with a slightly larger area at the bottom than the top. Furthermore, the openings (doors and windows), are trapezoidal.

Fig. 10: Doors and windows as a trapeze in Machu Picchu.

Conclusion:

The objective of this research is to crystallize the ancestral know-how, to reconstitute it to pull the key of this Sismo-resistant traditional architecture. Demonstrate that this sismo-resistant traditional architecture is far from being a supernatural coincidence, by finding all around the world vernacular constructions which resisted earthquakes through time, in spite of the distances which separated regions, diversity of the used materials even if they are considered simple. The examples presented in this study demonstrate the presence of a local seismic culture nourishes and transmitted through repetitive experiences and the existence of a solid knowledge

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