IMPACT: International Journal of Research in Engineering & Technology (IMPACT: IJRET)
ISSN(E): 2321-8843; ISSN(P): 2347-4599
Vol. 2, Issue 1, Jan 2014, 15-20

RESEARCH ON THE SEISMIC PERFORMANCE OF TRADITIONAL BUILDINGS

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ABSTRACT

It exists in several regions in the world, of numerous historic monuments, buildings and housing environment, built in traditional ways which survive for earthquakes, even in zones where the seismic risk is particularly raised. These constructions, stemming from vernacular architecture, allow, through their resistances in the time earthquakes, to identify the various sismo-resistant "local" techniques.

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.

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.

KEYWORDS: Construction, Earthquake, Resistance, Techniques, Traditional

INTRODUCTION

This work presents several examples of sismo-resistant vernacular constructions, testifying of a local seismic culture for every country 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.

EXAMPLE FROM CHINA

In china as in Japan, the manufacturing of the brick is made with perfection. " In the 3è century before J-C, while the European nations used only the brick believed on the beds of clay, whole pieces of the great wall were built or at least brick-built cooked, with some clay by way of mortar " [1].

Besides, the vernacular Chinese architecture distinguishes itself by the characteristic to use the wood as materials main thing for the construction of "wooden skeleton ".

The plan, usually, is a rectangular shape; with report of width in the length is 1/2, symmetric in two axes. Its mass and its rigidity are also distributed and symmetrically.

Thus, the point of the resultant strengths of action of earthquake meets almost the center of the strengths resulting from resistance, so avoiding the twisting of the construction.

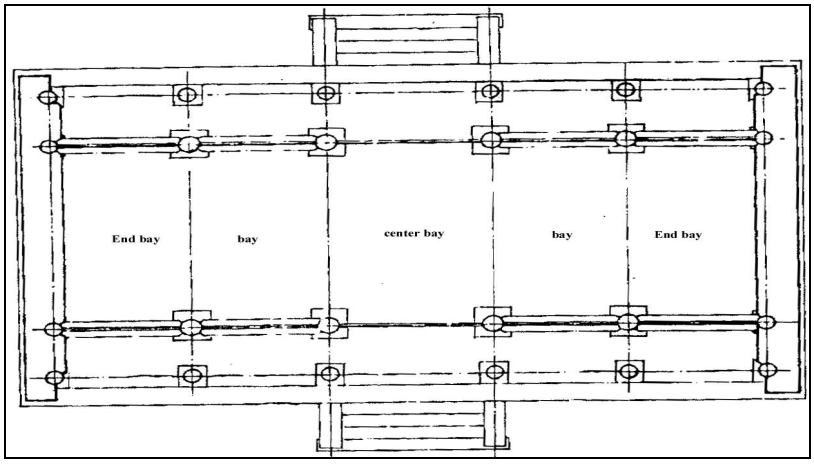

Figure 1: The Plan of the Traditional Construction of the Wooden Skeleton [2]

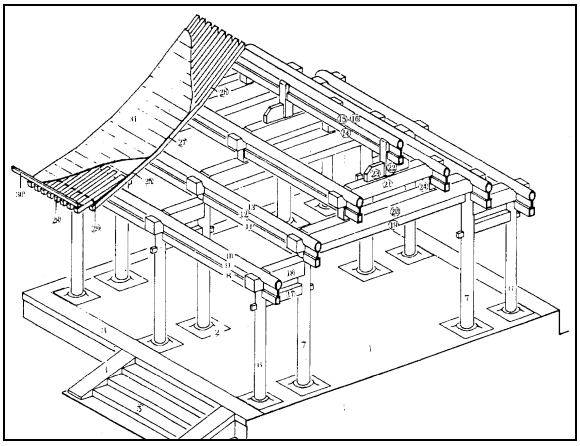

Figure 2: Basic Type of the Wooden Skeleton [2]

In the measure of the network of columns, the central bay is the biggest and by going towards the extremity, the bay becomes less wide. In the internal measures of the construction, we avoid putting the big rooms at the level of both extremities of the plan, because the seismic strengths put the construction in twisting.

Far from the center of mass, the additional power of the earthquake is bigger, and it can damage rooms and rooms in extremities [2].

EXAMPLE FROM JAPAN

The use of the Plant Materials

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" [3].

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).

The use of the Stone and the Brick

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.

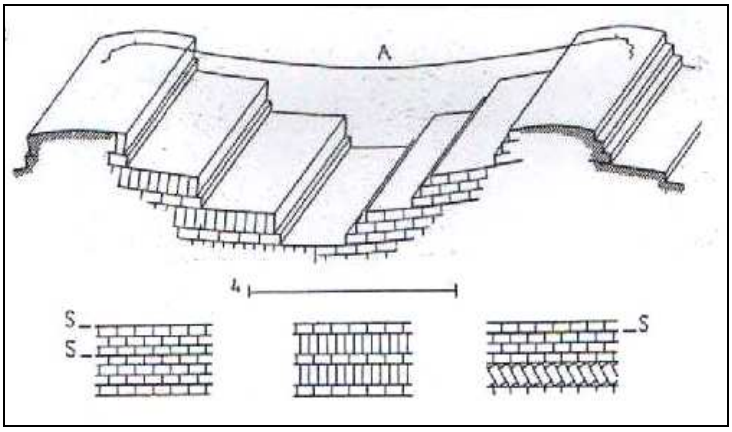

Figure 3: Wavy Beds of Masonry [1]

Pagodas, Example of the Sismo-Resistant Traditional Construction

"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.

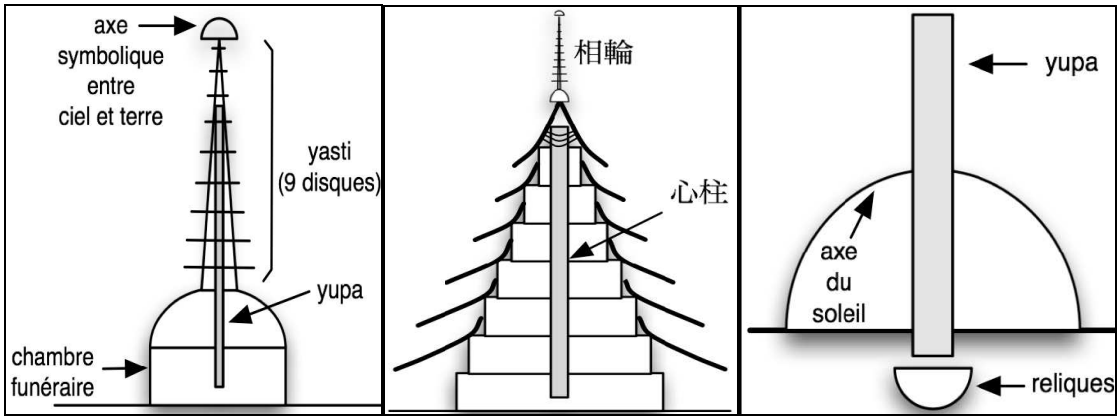

Figure 4: Explanatory Plans of Pagodas

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" [4].

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 bracing his neighbours mutually. There was a kind of collective resistance.

(a) **(b)**

(c)

Figure 5: (a) Resistance of Vaults, (b) Domes, and (c) Arcs [5]

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 [6].

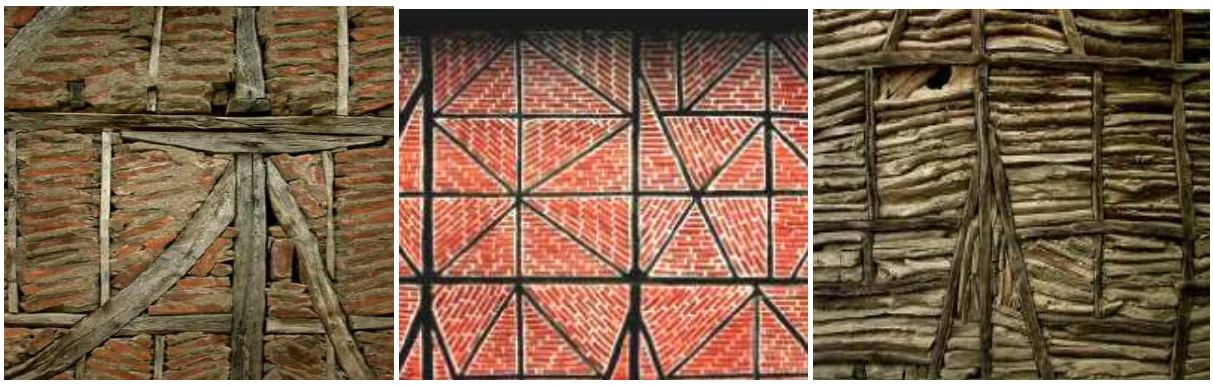

Figure 6: To the Left Hatil, Turkish Traditional Construction; in the Center Detail of the Variation Decorated with Construction Himis near Düzce; the Right Detail of the Wall Bagdadi to Golcuk [6]

PERFORMANCE OF ARCS AND DOMES IN THE TRADITIONAL CONSTRUCTION IN ORAN, ALGERIA, DURING THE EARTHQUAKE OF 1790

The system of arcs as well as the domes, showed a good performance counterpart the seismic strengths, during the earthquake which struck the city of Oran in Algeria, The met arcs surrounded the inside of patios, besides, the arc was used as link between two constructions, as discharging arch, and a passage bent in an alley, and on the other hand, presenting the ancient doors of the old town.

By trying to explain this good performance of arcs in front of earthquake of 1790, and even after this event, we can notice that these arcs reacted well in front of the compression [7]. Arcs create support points, allowing the transfer of the horizontal constraints in the ground. It is about discharging arches situated in the alleys of the Kasbah, binding two constructions. In that case, the resistance in front of seismic risks is good; these arcs are made by masonries of bricks.

Figure 7: Performance of Arcs in the Internal of the Kasbah of Oran [7]

Figure 8: Performance of Arcs and Dome of the Turkish *Hammam* in 1708, Situated in the Old Town of Oran, Algeria [7]

CONCLUSIONS

The objective of this research is to crystallize this 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 with regard to our era, the diverse constructive techniques, the difference between the specific modes of construction to every people and every region according to their cultural and religious traditions.

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