TRANSFER OF KNOWLEDGE FOR SAVING HUMAN LIVES LIVING TRADITION: USE OF TRADITIONAL HORIZONTAL TIMBER BELTS AS ANTI-SEISMIC ELEMENTS

Lazar SUMANOV*, Macédoine / Macedonia

Introduction

In the Republic of Macedonia the tradition of transferring knowledge and experience from father to son, from master to young workers, is still alive. In the case of a family of artisans and skilled craftsmen, for example, if the father has a particular knowledge on how to make something as a receipt, this "secret" will be transferred only to the oldest son, and not to the others. This story will be repeated by the son, who will in turn transfer the knowledge only to his eldest son.

But when a question of saving human lives is involved, this is not the case. Everyone should know how to acquire knowledge and experience and transfer it to the next generation. The production of horizontal timber belts, when building one's own living and working area, constitutes a very important experience. That is the case in the Republic of Macedonia, one of the territories most prone and most vulnerable to earthquakes, located in the middle of the Balkan Peninsula in Europe.

Traditional structural anti-seismic elements

When discussing the materials used for the construction of structural elements and systems of built heritage in Macedonia, the widespread use of wood is a fact. It has also been used, *inter alia*, for building simple traditional structural elements, such as *horizontal timber belts.*

This structural element is composed of two or more parallel beams, placed horizontally within the wall, linked by smaller timber elements placed perpendicularly to their length. This element is always placed at the same level within perimeter and inner walls, the latter being constructed of sun-baked or fired bricks, stone or a combination of various natural or artificial components with earthen or lime mortar.

They are always placed at a particular distance from the ground, ranging between one and one and a half meters. This is certainly an invention of unknown builders who knew how to observe their creation and "record" all the characteristics, imperfections and irregularities during their structure's life. Why where these structural elements used?

a) All buildings in which these elements appear have masonry composite structural elements ranging from 0.6 to 2 meters in width. In Macedonian and Balkan territories, these are walls built with bricks (sun-baked or fired), stone and a lime mixture as bonding mortar.

b) This bonding element, mortar, which is absent in dry masonry and timber structures, is obtained by mixing the necessary components with a certain quantity of water. In this way a plastic mixture is obtained that is easy to incorporate but is characterized by slow hardening -by evaporation of water from the earthen mortar, or a chemical reaction of the lime paste when in contact with air.

c) It was very rarely that these walls rested on sound foundation elements. Weak foundations contributed to the irregular settling of the superstructure, sometimes even during construction.

d) In the course of construction, due to the thickness of the wall, its weight increased as it progressed in height. As a result, when constructing masonry upwards uninterruptedly, there was a large deformation of the wall profile due to the increased load upon the lower layers. This was due to the fact that the bonding material, particularly in the lower layers, did not reach the necessary hardness to support the permanently increasing loads.

e) For example, the Byzantine wall was not able to replicate the compactness and monolithism of Roman walls, although, in principle, it had the same morphology. Both have two faces and a middle core, but it is exactly the core that differentiates them. While Roman walls acquired monolithic properties by the use of *pozzolana* and constituted a compact and stable wall mass, Byzantine walls, with a lower-quality mortar, could never acquire such a degree of compactness and hardness.

To overcome the problems stated under d), the building method could be modified. The wall could be erected in layers/rows, always in the same direction, from right to left or from left to right, depending on whether the main master-builder (mason) was left-or right-handed.

After a row was finished, the following one was begun where the previous one had started in order to extend the latter's hardening time for the lime mortar (or mud mortar).

According to empirical knowledge and depending on the thickness of the walls, almost without exception in all Byzantine Churches and Ottoman structures in Macedonia, there is a horizontal layer composed of a single or a number of horizontal rows of bricks connecting the wall faces at a height of 1-1.5 m. Above these, horizontal wooden belts composed of two, three or more beams are placed at the same height in all perimeter walls, depending on the thickness of the treated walls.

Depending on the master builder's estimation, the building process stopped for a certain period of time to allow the binding material to harden until it was capable of supporting the following rows (load) without adverse deformations.

According to Evans, these elements were used in the architecture of Knossos, Crete (Fig. 1), in the second millennium BC. Their use can be traced from the beginning of the early Christian era until the present time. These elements have been used in architectural creations of any type, whether for religious or secular purposes. Based on the author's own research in Macedonia and the Balkans, there is evidence for the use of these elements.

In the three-nave basilica in Nicea, Turkey, dating from the fifth century AD, these elements are used in the wall between the naves. It is composed of three beams. (Fig. 2). The element used in the columns between the central and side naves has two beams.

In Constantinople, the masonry of the ramparts has a wooden belt with four parallel beams one meter from the ground, while in the upper rows we find three beams (Fig. 3). The wall is 1.6 metres thick, while the vertical distance between the rows is about 1.2 m. The ratio of the beams is 15-18 cm: 18-12 cm.

Another example can be mentioned regarding the continuity of use of this element. Namely, Isar fortress in Stip (Macedonia), dating to early medieval times. It can be seen in the details of the horizontal wooden belts in the first and second defensive walls. (Figs. 4-6).

In this case we see a system of three beams connected by massive perpendicular timber elements. Vertically, the distance ranges from 78 to 110 cm. (Fig. 5), which is certainly due to the great thickness of the wall: about two meters.
These wooden elements have been used in all Byzantine churches without exception. They are clearly seen in the Byzantine church of St. Atanasie in Prilep (Macedonia) (Fig. 7-8).

The continuous use of these elements was not disrupted even after the fall of Macedonia under Ottoman rule. The walls of Ottoman religious and secular buildings and structures have the same characteristics as two-faced Byzantine walls. They are different only in respect to their outline and the finishing of openings (doors and windows).

These elements are still inside the walls and consist of two or three beams. There are numerous examples in Skopje (capital city of Macedonia), notable among which are the remains of Dukandjik Mosque (Fig. 9) and the ruins of the Turkish Bath next to the Kursumli An (Inn) complex. (Fig. 10).

The same element is also used in the construction of individual residential structures both in towns and rural settlements. In Macedonia, in each structure composed of massive bearing walls, regardless of the material used (sun-baked bricks or stone), this element is found, but now visible on the wall surface. The horizontal wooden beams are found in the wall plane, both in the facade and the interior. This is the case of nineteenth- and twentieth-century structures. It must be pointed out that this element is still used nowadays, in the beginning of the 21st century, in individual rural structures of sun-baked bricks (in villages in the central and western parts of Macedonia, dominantly).

A further example of this construction method may be drawn from the traditional building heritage of Macedonia- just a few examples out of many. In the case of buildings in the village of Maloviste (Bitola region, Macedonia), horizontal belts within stone and lime mortar masonry, are placed at approximately the same vertical distance, and have well endured the ravages of time (Fig. 11). The same holds for structures in the village of Kicinica (Mavrovo-Gostivar region, Macedonia), the difference being that the vertical distance is somewhat shorter than that in the aforementioned structures. (Fig. 12). In both cases, these horizontal belts are used in stone and lime mortar masonry.

There are two other examples in which this element is used in both stone and sun-baked brick walls with mud mortar in the same structure. In both cases, the lower wall section is built of stone masonry with lime mortar. This principle, without exception, is recognizable over the whole territory of Macedonia, regardless of the function (use) of the structures (residential, public, economic, etc.). Therefore, there is always a sound and dry foundation particularly for walls of sun-baked bricks (adobe). This is a key preventive element against moisture. This is the case of a structure in the village of Gornjani (Skopje region) (Fig. 13) and a house in the village of Cucer (Skopje region) (Fig. 14).

During the author's research in the city of Struga (Ohrid Lake region, Macedonia,) it was noticed that buildings have walls of stone with lime mortar as foundation elements at the basement and raised ground floor levels, while walls at the upper floors are built of sun-baked bricks (adobe) with mud mortar. What renders this building unique is that reinforced concrete structures are used instead of timber floor and ceiling structures. As a substitute of wooden horizontal belts, a reinforced concrete belt course is used (Fig. 15). The explanation given by the owner was that he felt safer in this structure. While he was staying in Skopje after the catastrophic earthquake of 1963, he observed that all structures had reinforced concrete belt courses instead of timber ones.

Therefore, he thought that the structure would be safer if a reinforced concrete belt course was incorporated into it. By doing so, the owner made a terrible mistake. He did not increase the safety of the structure, but exactly the opposite. This will lead to severe damage under each future earthquake, turning into an expensive and fatal experience for the owner.

What makes us particularly happy is the fact that the tradition of use of these wooden structural elements still continues in Macedonia. Examples of this are found in structures in the village of Djepiste (Fig. 16) and the village of Otisani (both in Debar region, Macedonia), where another tradition is still alive. Namely, the construction of residential rural structures by using sun-baked (adobe) bricks in mud mortar as the main support elements.

Following the example of the structure in Struga, we find the elements of horizontal belt courses (now reinforced concrete) in newly-built structures in Skopje.(Fig. 17) This element has an identical position in the wall, at the same height as the base of the window, as in the aforementioned examples.

Conclusions

Transferred knowledge for the use of wooden horizontal belts in structures in Macedonia is still alive, with the hope that it will continue in the future. Also, the author takes the opportunity, by writing and presenting this paper, to transfer his own knowledge on this matter to the next generation, as the "sacred" duty of all builders-master masons and architects around the world.

NB All photos, except Fig 1, were taken by the author.

ABSTRACT

From the beginning of human history one of the most important goals was to safeguard human lives by using, at first, natural and then built artificial shelters. Throughout the millennia those shelters have been erected using natural and artificial building materials. Methods and procedures have been permanently improved. Such structures, of various kinds, have been tested constantly by man-made or natural disasters. Only the best building examples survive the test of time and disasters. Know-how regarding these examples has been transferred from the past until today, and we still have, in the Republic of Macedonia, which is a very earthquake-prone area, the production of very simple and useful structures using the very same traditional natural and artificial local materials applying ancient methods to build a home/shelter/space for living and for the production of various goods. This is in effect a living tradition that has the intention of continuing.

***Lazar SUMANOV**

Education: Grad. Eng. Architect; Advisor Conservator; Ph.D. (York, UK)
Present position: President of ICOMOS Macedonia National Committee; Free-lance Architect Advisor conservator
Recent posts and duties: Elected member of ICCROM Council (1997-2001); -Member of the Macedonian National Commission for UNESCO; -Member of the Steering Committee of the World Bank project in Macedonia "Community, Development and Culture"; -Supervisor of the reconstruction of the Church of St. Athanasios in the village of Lesok (destroyed during the armed conflict in 2001 in Macedonia); -Chairman of the Urgent Regional Workshop on Cultural Heritage in the Event of Armed Conflict-Macedonia Case.

TRANSFER OF KNOWLEDGE FOR SAVING HUMAN LIVES LIVING TRADITION USE OF TRADITIONAL HORIZONTAL TIMBER BELTS AS ANTI-SEISMIC ELEMENTS

Lazar SUMANOV*, Macédoine / Macedonia