PROBLEMS INVOLVED IN REPAIRING TIMBER CHURCH BUILDINGS IN NORTHERN RUSSIA

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SUMMARY
The paper discusses the problems involved in the renovation of historic timber church buildings. The details of the repair of a 300-year-old timber Orthodox church on the Kizhi Island in northern Russia are presented.

Keywords: Historic buildings, Timber, Renovation

In Eastern Christian culture, especially in the northern zone, church buildings, e.g. Orthodox churches, would be made of timber. Their load-bearing structures had the form of framework walls on a stone foundation. Typically underesinated unimpregnated pinewood or spruce logs would be used for this purpose. The buildings were usually rectangular or octagonal. Sometimes, for architectonic reasons, the shape of the plan would change along the building’s height: an octagonal framework would be rested on a rectangular framework. Such a load-bearing structure would be topped with a dome in the form of a single onion or many onions. The onions would be tipped with iron or wooden crosses. Their sheathing would usually be made from aspen wood slates resistant to the action of atmospheric precipitation. Moreover, after many years of being in service aspen wood changes it colour to steel blue, which enhances the aesthetic qualities of the building. After many years of being in service in the severe climatic conditions of northern Russia, the buildings undergo degradation and suffer damage, manifesting itself in the following symptoms:
– longitudinal surface cracking of the wooden elements caused by moisture shrinkage,
– fungal decay of the wood,
– loosening of the nodal carpentry joints,
– excessive horizontal and vertical deformations of the whole structural system.

Fig. 1 Onion dome toppled due to loss of stability of supporting structural members

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The above kinds of damage are especially critical for the condition of the dome, being most heavily loaded with snow or wind. In the case of uneven settlement of the building’s framework structure, the dome leans out of the perpendicular. In the extreme case, when the main structural members supporting the dome lose their load capacity, the latter may topple (Fig. 1). The most representative timber building built with this structural design is the Orthodox church erected on the Kizhi Island in northern Russia 300 years ago (Fig. 2). The church was built from timber without the use of steel connectors. The building is of great world historical value, as evidenced by the fact that it is under UNESCO protection.

![Fig. 2 Orthodox church on Kizhi Island in northern Russia](image)

The characteristic feature of this Orthodox church is its atypical dome, consisting of 22 little onion domes tipped with crosses (Fig. 3). The load-bearing structure of the little onion domes is made up of solid wood ribs with planking and then aspen slate sheathing fixed to them. Because of their wear the slates are replaced every 25-30 years.

![Fig. 3 View of onion-shaped little domes of Orthodox church](image)
The evidence of the building’s durability is the fact that until the middle of the 20th century this Orthodox church had not undergone any series repairs. However, due to the lack of proper maintenance, and because of improper use, in the course of the first half of the 20th century the church suffered series damage, mainly as a result of the excessive and uneven settlement of the load-bearing framework structure. Therefore, an attempt was made to brace the whole load-bearing system with an inner steel skeleton. In addition, the most rotten framework logs were replaced with new ones and the remaining logs were tapped and impregnated. As experience showed, the measures turned out to be ineffective. Because of the strict UNESCO requirements, in the last decade comprehensive measures have been taken to save this monument. Nevertheless, at the moment there are still no proper repair solutions which would guarantee the reliability and durability of the building for a few hundred years. The various offered repair solutions usually have a declarative character, but have no scientific basis. The problem also consists in this, that according to the restoration requirements it is necessary to observe the principle of authenticity [1]. This does not apply only to the shape and the structural solutions of the building, but also to the materials used (only 30% of the materials are allowed to be replaced).

One of the most radical repair proposals which is currently being implemented is Norwegian lifting, consisting in introducing a steel skeleton into the building. The former at certain levels is joined with the framework system. Thus, along its height the building is divided into six imaginary storeys, denoted by different colours in Fig. 4.

Fig. 4 Schematic of Orthodox church repair using Norwegian lifting method
In the first stage, the whole church body is lifted above the imaginary lower storey by means of hydraulic jacks resting on the foundation. Then this storey is completely disassembled. In a specially built building all the storey’s structural elements (the wooden logs and the connectors) are subjected to comprehensive renovation: mycological [2] and strength tests, decay removal, tapping, impregnation and so on. The structural elements or their parts no longer serviceable are replaced with new ones made of wood seasoned for a period of 3-5 years. During this time, a major repair of the foundations is being carried out. When it is completed and the wooden elements have been renovated, they are reassembled. In the next stage, the suspended body of the building is mounted on the repaired lower storey. The next stage in the repair consists in lifting the church’s whole body situated above the second imaginary storey by means of the hydraulic jacks. Freed of load, this storey is subjected to disassembly and the same renovation procedures as the first imaginary storey. This repair procedure is repeated until the last, i.e. the top, part of the church is repaired.

It should be noted that this method had been used for a long time by the builders of framework buildings, including dwelling houses, located in areas with prevailing humid climatic conditions. Because of the heavy dampness of the lower bond beams of the framework structure (due to excessive capillary rise through the foundations, to rainfall or to the thawing of the snow cover) it was necessary to replace the lower bond beams every 20-25 years. In order to facilitate the replacement, there had to be a possibility of prising the higher situated part of the building. For this purpose, as the building was being erected slightly inclined timber columns, resting at the bottom on the foundation and at the top fitted into sockets cut out in the beams marking the building’s first storey (Fig. 5), would be installed along the perimeter of the building. If the bond beams had to be replaced with new ones, wedges would be driven between the columns and the foundation whereby the upper part of the building would be lifted.

In the course of many years’ observation of the Orthodox church on the Kizhi Island it was found that the principal onion dome leaned out of the perpendicular by 0.5 m. The main cause of the displacements is the uneven deformation of the framework walls on which the dome rests. The walls are subjected to bending under concentrated load and their flexural rigidity is defined as the sum of the flexural rigidities of the individual logs. In order to increase this rigidity, the authors proposed to integrate the logs by means of special screws with a quick sharp thread. First pilot holes, with a diameter 4 mm smaller than the screw diameter, are bored in the logs. Once the screws are screwed in, the logs become integrated whereby the wall under bending behaves as a composite structure (Fig. 6).
Because of the complexity involved in repairing such building structures, the repairs should be made under the supervision of research units specializing in timber constructions. Moreover, any repair propositions should be subject to a discussion among competent internationally-known specialists [3, 4]. A situation when buildings of great historical value are experimented on in order to verify various unfounded repair propositions should not be allowed.

REFERENCES


