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Analysis on the mechanical properties of historical brick masonry after machinery demolition

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HIGHLIGHTS

- Bricks and mortar pieces collected from the demolition plot, were classified separately.
- Masonry wall sections obtained from demolition debris were tested under compressive and shear loads.
- Wall sections had higher compressive strength and initial shear strength than specified values for new buildings.
- The cracks after triplet shear test indicated interface failures.
- Optimal condition for reuse of wall pieces was identified.

GRAPHICAL ABSTRACT

The process of the study: Investigation into the properties of debris, Laboratory tests.

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ABSTRACT

The demolition process of a historical brick masonry building in St. Petersburg, Russia was observed as a case study and research was conducted on the possibility of reusing the resultant debris, which was composed of high quality brick masonry, as new building material. Therefore, samples from the demolition debris, i.e. brick, mortar and wall pieces were collected and tested for their mechanical properties, according to Russian standards, when available, and according to International Standards for the rest. The results for the compression test of brick and mortar separately as well as wall prisms indicated that their strength was still higher than standard limits, therefore, these wall pieces could be reused under appropriate conditions. Additionally, the bed mortar was tested under shear loads in order to understand if the jointing was still reliable or not. Eurococe 6 (Eurocode 6: Design of masonry structures – Part 1–1: General Rules for Reinforced and Unreinforced Masonry Structures, (2005)) defines a reference table for comparison, which showed that the shear resistance obtained from the wall prisms was also reliable.

1. Introduction to the reclaiming project

This paper is based on information gathered from a case study regarding a demolition project and tests conducted on the physical properties of the demolition debris collected from the site (Fig. 1). The focus of the study was on the end-of-life scenarios of masonry

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buildings and hence the possible disposal and reuse options for masonry wall components. Details regarding the case building and its demolition process, as well as the laboratory tests conducted on small quantities of debris samples are presented in the following sections.

1.1. End-of-life for masonry construction

Owing to their durability and prevalence throughout the ages, there exists a vast stock of masonry buildings in the world, yet, some of them are being demolished and disposed of. Apart from their deterioration and age, the reasons behind the demolition of such buildings appear to be: changes in building bye-laws or redundancies of buildings; which sometimes are carried out to clear the plots for new and mostly taller buildings [8]. On the other hand, buildings struck by disasters especially earthquakes have to be demolished also as they are no longer safe for habitation.

A study on the deconstruction of Earthquake-damaged buildings in Turkey illustrates that, although slightly damaged buildings can be strengthened for safe occupancy some are severely damaged and cannot be rehabilitated. Such buildings underwent partial deconstruction, whenever it was possible to reclaim building materials or components from them. The researcher attracts attention to the impact of deconstruction method on the recovery rates and the quality of the construction materials and recommends top-down technique i.e. deconstructing the building story by story, starting from its roof. On the other hand, when demolition is selected as the method of disposal it results in further damage on the recoverable material and the resultant debris mix is almost impossible to sort out [9].

Another option is partial demolition of old masonry buildings and refurbishment of the remaining parts. For instance, "façade retention" is a common approach to conserving the historical characteristics of an area by keeping the old façade intact and demolishing the spaces behind. The new building is then constructed behind the original façade[1] [1].

Whichever approach is selected for the end-of-life scenario, huge amounts of masonry makes up the demolition waste. On the other end, since these buildings are not always demolished due to wear and tear, the condition of masonry walls after partial or complete demolition may still be of a good quality that may be conducive to their use elsewhere.

One method for the reuse of masonry components is the salvage of good quality bricks (Fig. 2). This method is mostly favored owing to the vintage look of the bricks that can be integrated into the modern architectural designs. Regardless of the design intention, this is indeed a useful way to prevent valuable material from being dumped as waste and thus contribute to environmental and economic sustainability.

In addition to the reclaimed single bricks, using wall pieces as recovered masonry wall sections is a possible scenario as illustrated in the Cubo House project. This project was an addition and alteration intervention in an existing dwelling where some parts of the building were demolished and many components were reused. Within this context, one old masonry wall of the building was cut carefully into rectangular pieces and the sections were reused on the new elevation (Fig. 3). This approach not only helped to salvage the old materials but also carried the historical style of the building to its current design with a new understanding [17].

In view of these examples of different recovery scales, from brick units to wall sections, masonry wall debris can be re-assessed as a secondary source of construction material that offers alternative design solutions depending on the inherent potential of the waste material.

1.2. The case study building

To assess the condition of the rubble and the potential of reusing the masonry material, the demolition process of a historical brick masonry building was observed and a few samples were obtained to conduct the further tests. Although the demolition process itself, which uses considerable force, was the main parameter effecting the final state of the material, the condition and characteristics of the building throughout its service life were also a very important parameter. Information on the location, history, change in functions, material of the building as well as its construction have been presented in the following section.

1.2.1. The building and its location

The building was located on Pirogovskaya Quay 11, on the banks of Neva River in Vyborg District near Lenin Square, which is close to the central business district of St. Petersburg, in Russia. It is surrounded by small scale production plants as well as offices and housing blocks. Construction on this plot was started in 1853 and buildings were added over time; however the exact date of construction of the case study building is not known. During its lifetime, it was used for many different purposes; from storage to production to a photography studio [7]. After its demolition, the structure will be replaced by a modern hotel building.

The building was a three story high block with solid brick envelope and a gable steel roof (Fig. 4). Although the external walls were almost identical for the entire building, the construction techniques of the slabs, beams and columns differed from story to story. Use of different materials and techniques together in a single building was a common practice in many historical buildings in Russia especially in ones damaged buildings during the war, as well as the newly built ones belonging to the post-revolution and post-war era of economic crisis. Besides documentation of its architectural aspects, demolition process of the building was also observed and is presented in the following section.

1.2.2. Demolition process

The waste management regulations in Russia obligate the detection of material types and expected amounts in rubble prior to starting the demolition work. While the disposal methods are followed according to type of material, as per the State laws [18]. Hence the demolishing firm has to submit information on types, approximate amounts of materials and planned disposal methods to the authorities. The company that had undertaken the demolition job of the case study area, designed the process as selective demolition. This method included the separation and sale of metals to recycling factory, temporary use of rubble as ground cover for leveling and draining the site during construction work; and lastly, removing the rotten wood in order to protect other materials from decay also.

The fenestration and metal roof were dismantled and then the structure was demolished with hydraulic pulverizer and a bucket type excavator was used to carry the broken pieces and dump them in sorted piles. Consequently, large wall sections, small crushed wall fragments and timber pieces were accumulated on the plot; whereas metal waste was frequently transported to the recycling factory. The rubble was to be used as hard core for repairs of worn-out roads, according to the regulations Russian Federation [18] while the larger pieces of masonry wall sections seemed appropriate for reuse (Fig. 4). For this reason, such samples were collected and their mechanical properties were tested.

[1] Heritage and value is beyond the context of this study.