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Surveying and digital workflow in energy performance retrofit projects using prefabricated elements

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ABSTRACT

Due to the need for improving the energy efficiency of existing buildings, various methods for energy retrofitting are being developed. One such initiative is the TES Energy Façade project, a joint European academia and industry project under the umbrella of the WoodWisdom Net research platform. The project has developed a systematic approach for using prefabricated timber-framed elements that can be assembled in front of an existing façade. The TES approach requires a detailed and precise documentation of the as-built/as-maintained conditions of the existing façade. This paper discusses the approach for the surveying and documentation of a building's existing state and the need to establish a continuous digital chain that encompasses the various project stages from the survey to the site assembly of the elements. Technologies such as 3D laser scanning and BIM are efficient tools in the process but are not yet sufficiently developed to handle all of the challenges in renewal and retrofit projects.

1. Introduction

The improvement of the overall energy performance of existing buildings is currently a key component in the national energy efficiency policies because existing buildings are responsible for 40% of the energy consumption in the EU and US[1]. The residential sector accounts for the largest portion of the building sector energy use. Insulation retrofitting is one of the key strategies for conserving energy in existing buildings. The need for insulation is found in all of the main envelope constructions of a building, particularly in the external walls and roofs. Better insulation also reduces thermal bridges and provides proper air tightening, and thus reduces the energy loss as well as the heating and cooling costs.

The manufacturers of insulation material have developed various systems for insulation retrofits based on their products. The TES Energy Façade (2008–2010) research project addressed the insulation retrofit problem by studying the use of prefabricated, customized, timber-based elements mounted on existing external walls and roofs[2]. The prefabricated elements consist of a timber frame as a load bearing structure that contains the insulation, wind and moisture barriers, external and internal cladding and pre-assembled doors and windows. The elements are transported from the factory to the building site and mounted in front of the existing building envelope. Fig. 1 shows the TES process from the measurement to the mounting of the elements. Figs. 2, 3 and 4 show the prefabrication, the completed elements and the mounting.

Because the prefabricated timber-based elements are produced with strict tolerance requirements (typically ±5 mm), a major challenge for the TES method is adapting the prefabricated elements to the geometry of the existing structure. Outfitting an existing object with new, industrially-manufactured components in the TES method is related to challenges in many other industries that work with reverse engineering (RE). The process of RE is described by Abella et al. [3] as

> *the basic concept of producing a part based on an original or physical model without the use of an engineering drawing.*

Therefore, the methods for documentation of the as-built/as-maintained conditions of an existing structure are a major challenge for the TES method. Additionally, the project also addressed how the data from the documentation and surveying in the initial phase of a project could be reused throughout the project from the design via fabrication to the final mounting of the prefabricated elements on-site. This paper focuses on the portion of the TES project that deals with the survey and digital workflow.

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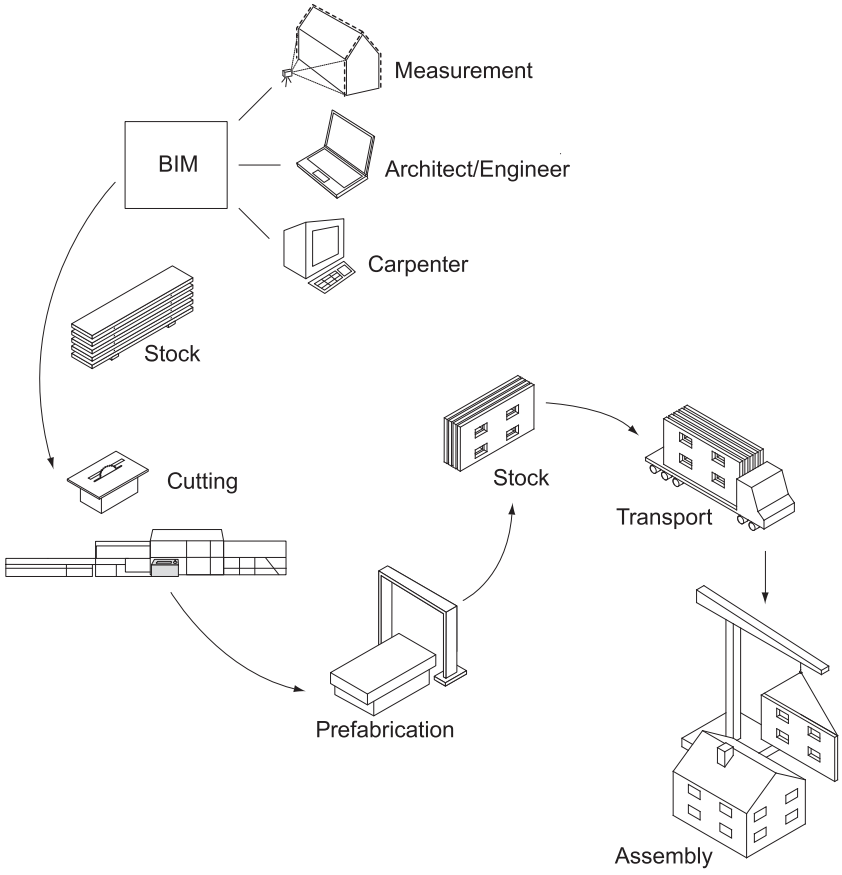

Fig. 1. Workflow in the TES process.

2. Survey in Retrofit Projects

Due to the lack of adequate documentation of the as-built/as-maintained conditions of existing buildings, renovation and refurbishment frequently suffer from estimation errors, inaccurate bids, design and fabrication mistakes, expensive field rework, etc. It is estimated that a 2% to 5% savings of the total project cost can be achieved with a better understanding of the existing conditions[4]. Thus, a complete building survey is the first crucial step in the TES process (Fig. 5).

Fig. 2. Prefabrication of the elements in the factory for the college of Buchloe, Germany.