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ScienceDirect

Energy Procedia 96 (2016) 202 – 211

Energy Procedia

SBE16 Tallinn and Helsinki Conference; Build Green and Renovate Deep, 5-7 October 2016, Tallinn and Helsinki

Lean production of cost optimal wooden nZEB

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Abstract

The paper studies lean construction as a co-operational way of working to achieve nZEB targets and good indoor climate and to find new innovative combinations of building solutions. Main target of this paper is to assess energy efficiency, resource efficiency and economics of lean wooden nZEB compared to traditional wooden apartments. The results are based on lean construction literature survey, interviews and two case studies. According to a case calculation lean production of cost optimal wooden nZEB causes only about 115 €/m² additional investment cost compared to construction, which only fulfils the minimum requirements as defined by building regulations. Annual savings in energy cost is about 8 €/m² as present value. The annual life cycle cost is about 5 €/m² as present value for the calculation period of 30 years. Also resale value and user-value (aesthetic value, thermal comfort, high quality of inner climate and good adjustable lightning) are a little higher compared to the traditional building. Calculations show that the total productivity of lean construction is about 20 % better than of basic construction in both assessment cases.

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Peer-review under responsibility of the organizing committee of the SBE16 Tallinn and Helsinki Conference.

Keywords: lean production; labour productivity; investment cost; life cycle economics; nearly Zero Energy Buildings (nZEB)

1. Introduction

The energy Performance of Buildings Directive [1] requires all new buildings to be nearly zero energy buildings by the end of 2020 (in public sector by the end of 2018). The national regulations are based on cost optimization within calculation period of 30 years in the case of apartment buildings. Also resource efficiency and user-values should increase.

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Peer-review under responsibility of the organizing committee of the SBE16 Tallinn and Helsinki Conference.
doi:10.1016/j.egypro.2016.09.122

Our hypothesis is that lean production of wooden nearly zero energy buildings (nZEBs) is a favorable method to fulfil these targets. Then lean construction is a way to design production systems to minimize waste of materials, time and effort in order to generate the maximum possible amount of value, which is defined as the whole series of activities that create and build value at every step [2]. The validity of this was studied and verified within European project "Innovative[1] lean processes and co-operation models for whole value chain (Fig. 1.) of urban timber buildings" (LeanWood).

Lean construction is essentially based on client-driven process where the client sets the target-values [3]. Both designers and clients share the responsibility for revealing and refining concerns, for making new assessments of what is value, and for selecting how that value is produced through the design process [3].

Lean construction is a primary way to prevent large amounts of information losses at the interface of planning, factory production and construction. Compared to common on-site construction prefabricated timber solutions require a higher effort for planning and decision making in early project stages; this is a preconditions also for successful nZEB construction.

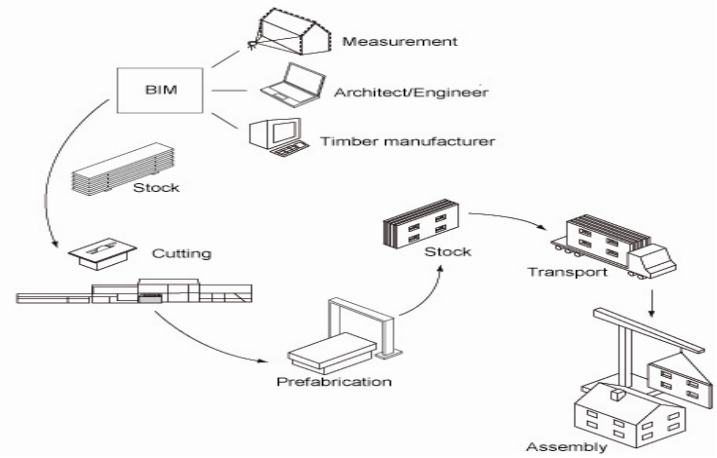

Fig. 1. Workflow from Design to Assembly with good logistic management and utilizing Building Information Model (BIM).

2. Targets and methods

The main target of this paper is to assess economics, energy efficiency, environmental effects and user-satisfaction of lean wooden nZEB compared to traditional wooden apartments. In addition, the study assesses differences in work productivity between prefabricated apartment modules and prefabricated timber elements. The specific targets were to assess:

- the carbon footprint and wastes of lean nZEB wood construction
- the investment cost, energy cost and life cycle cost of lean nZEB wood construction and
- users' satisfaction with regard to indoor air climate, acoustics and thermal comfort.

The results are based on lean construction literature survey, interviews and two case studies (Table 1). Two real building cases were studied. The other case (A) was constructed by prefabricated, large timber elements and the other one (case B) with prefabricated apartment modules (Fig. 2.). Case study A made it possible to study the results against our hypothesis and make conclusions. Both case projects are located in the capital region of Finland. Case A is located in the city of Vantaa. It is a single building, with its first floor made of concrete and the other six floors made with timber elements. Case B, is located in Helsinki. It comprises of four separate buildings, each with concrete first floor and other, four to six floors, made with timber modules. Case B made it possible to analyse the productivity effects of use of prefabricated apartment modules.

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