Construction management of multi-storey residential timber buildings – assessment criteria's and their impact in the cost calculation

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1. Introductive abstract

The positive trend of multi-storey residential timber buildings recorded over the last years was mainly released by developments of new products such as cross laminated timber – CLT. However the arguments for timber in multi-storey buildings cannot be originated in the financial assessments and comparability to traditional building materials. Supplementary and in contrast to many considerations maintained in specific articles not based on research, timber offers the possibility of a cost-efficient but often miss-valued material. To proof and verify this predication a thoroughly analysis of a pre-investment study to be built in Graz, Austria includes an objective and comparable cost analysis as well as an investigation of further cost influencing arguments of an 8-storey residential timber building. To illustrate and generate verifiable data an all-encompassing cost calculation of the building was conducted followed by a comprehensive analysis by assuming diversifying building materials such as brick and concrete as well as an adaptable number of storeys. This assessment demonstrates that the production costs of a multi storey-timber building emerge a higher value of 6 to 7 % of the production costs of buildings built with traditional materials. However they can be converted easily into a financial benefit presuming an ideal ground plan design, consistent project implementation within the structural works as well as prefabrication of elements, optimized logistics followed by minimized construction time. Additionally verbal expressions and statements of these assessment criteria's were evaluated into depth and substantiated by generating evident graphs and tables in order to receive fundamental data for future projects.

2. Objectives of the investigated project

Todays large scale timber construction systems are very different to the traditional work of carpenters. This is mainly caused by technical developments of products in the last decade as well as size, complexity and application was extended significantly. Therefore analyses are required to ensure confidence and settlement within the building market. Although cross laminated timber (CLT) as a solid timber product experienced great success it was hardly examined regarding most economic aspects and construction management in general. In various articles it is often stated that timber is more expensive for structural components than concrete. This needs to be verified. The presented extensive cost calculation survey allows a neutral comparison of a large scale real-estate development to be built in Graz, Austria. Therefore one apartment block was analyzed systematically. To ensure a comparable and meaningful statement at the end the object was examined as eight-storey and three-storey building, each one calculated to be built in CLT and concrete resp. brick assuming the same building physics constraints.

The following figures and tables show the examined parameters with their substantial differences of both structural systems split into construction management and building economic aspects. This ensures a neutral financial assessment in future with cross company references based on input parameters with a large reliability to optimize the most critical financial aspects in order to originate timber as an alternative and appropriate building system.

3. Construction management – assessment criteria's

Currently the comparability of diverse building systems is mainly based on production costs per m² in most cases. Timber as structural material is often identified as more expensive. However various other impact factors as described below do give a different view. These criteria's consider timber at least as equivalent construction material regarding costs, scheduling and required site equipment.

Criteria prefabrication and installation

The graph below shows that the 8-storey building is only 4% more expensive regarding the production costs of structural works when built in timber.

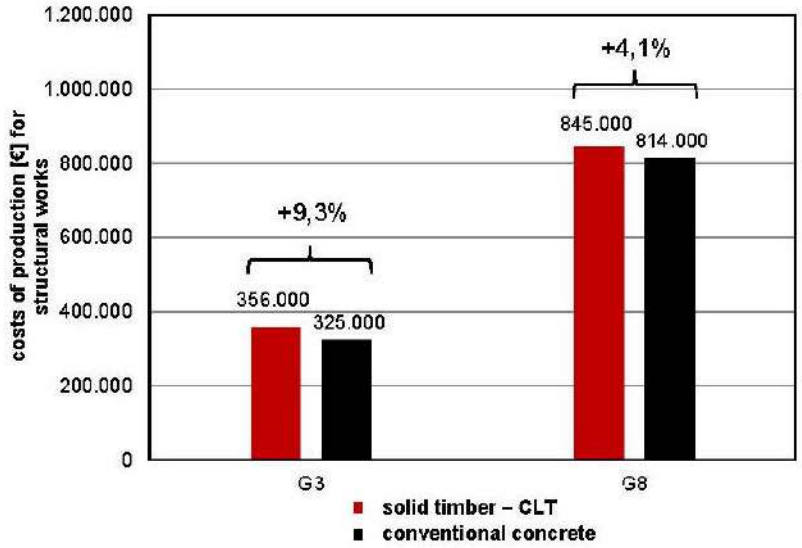

Figure 1. costs of production in € for structural works – comparison of solid timber – CLT to conventional concrete

Criteria finishing interior works

Following the restrictive fire safety requirements for timber structures in the Austrian regulations the costs for finishing interior works - especially plasterboard works - are exorbitant higher with 65 % than for structural concrete in the 8-storey building.

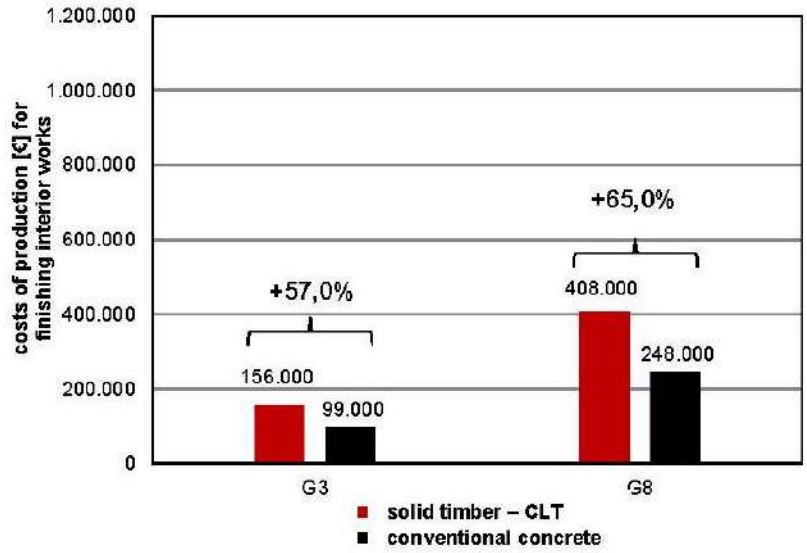

Figure 2. costs of production in € for finishing interior works – comparison of solid timber – CLT to conventional concrete

Criteria building site equipment

Referring to the prefabrication grade of CLT the site installation costs are significantly lower in a timber structure as the time on site is shorter.

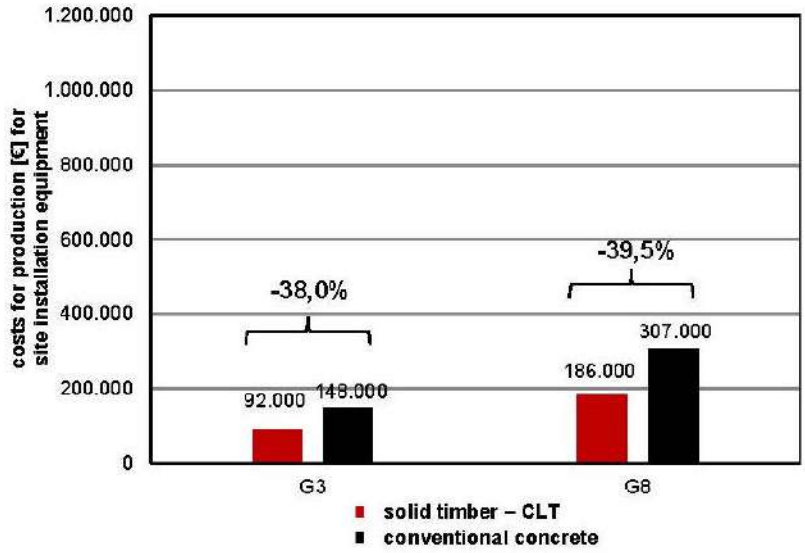

Figure 3. costs of production in € for site installation equipment – comparison of solid timber – CLT to conventional concrete

4. Building economics – assessment criteria's

The following criteria's introduce timber as structural material not based on the main factor costs per m² for the installation but by the determination of assisting values which can be converted into costs per m² easily giving advantages to timber.

Criteria usable area

Following the slender thickness of wall elements in timber structures by keeping the same outer alignment the 8-storey timber building generates 67 m² more usable area.

project		gross storey area [m²]	net living area [m²]	degree of utilization	balance net living area [m²]	balance structural costs [€]	income by selling [€]	income by over 30 years [€]
G 8	T	3,084	2,315	0.75	+ 67	+ 99,176	+ 173,600	+ 277,400
	C		2,248	0.73				
G 3	T	1,100	814	0.74	+ 23	+ 37,407	+ 59,600	+ 95,200
	C		791	0.72				
G8… 8-storey building G3… 3-storey building		T… Timber structure C… Concrete structure			renting expenses… 11.50 €/m² selling expenses… 2,591 € /m²			

Figure 4. comparison of usable area - net living area and their possible incoming relation

Criteria enclosed volume and transport

The self-weight of timber is about 20% of the concrete mass. This fact and the slenderness of elements enables 7-times less transport for the 8-storey timber building, 10-times less for the 3-storey one.

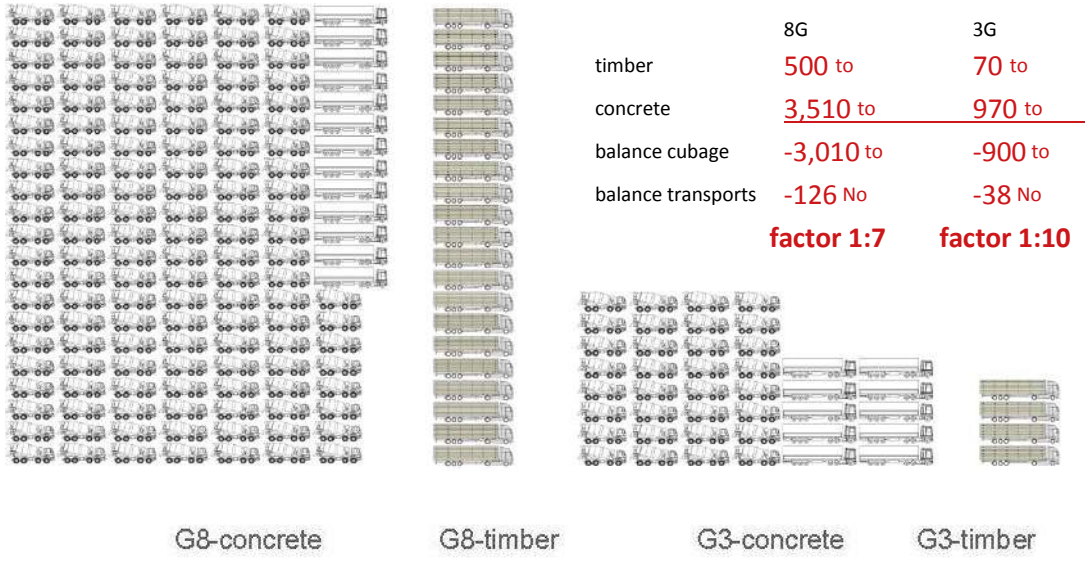

Figure 5. comparison of transports according to the structural works

Criteria site logistics

Timber elements are usually delivered just-in time and therefore the area required for storage on site is less than when built in concrete. This factor produces therefore less costs for rent of storage space.

Criteria construction time

The prefabrication of timber elements offers a great advantage regarding timeline. The 8-storey timber building requires 9 weeks less construction time.

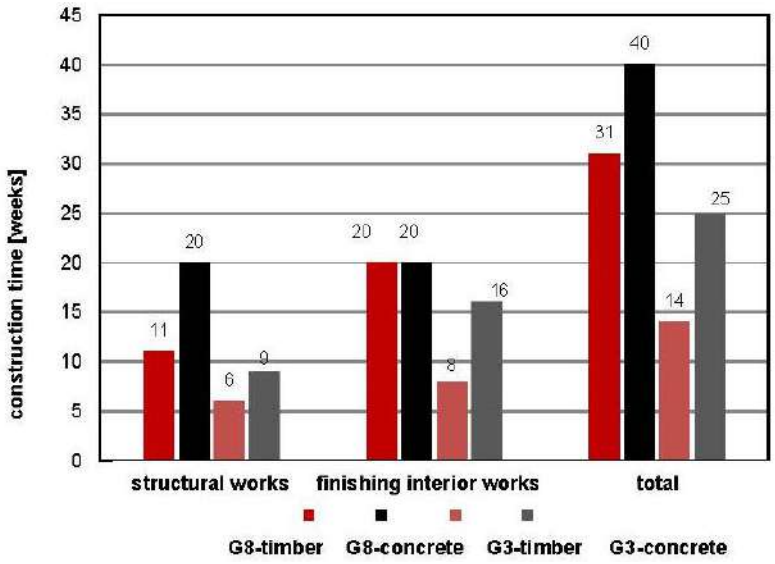

Figure 6. comparison of required construction time corresponding to the different building stages

5. Impact of criteria's – investigated performance values

All criteria's mentioned before show that once the additional factors are introduced in the evaluation of a timber structure compared to its concrete equivalent especially solid timber as structural material has big advantages, also cost wise.

Impact – construction management criteria's

Incorporating all criteria's of the construction management sector and by applying them to the main decision criteria for an investor - the rentable net living area - the following graph shows the cost development of the timber structure compared to the concrete one. The site installation costs are less, the costs for the structural work are almost the same and the costs for the finishing interior works, especially for fulfilling the high fire safety regulations at the moment, are substantially higher for the timber building.

However for the entire costs the timber building is only 4 % more expensive not assessing the fact of a green building and its positive values referring to life cycle costs and carbon footprint.

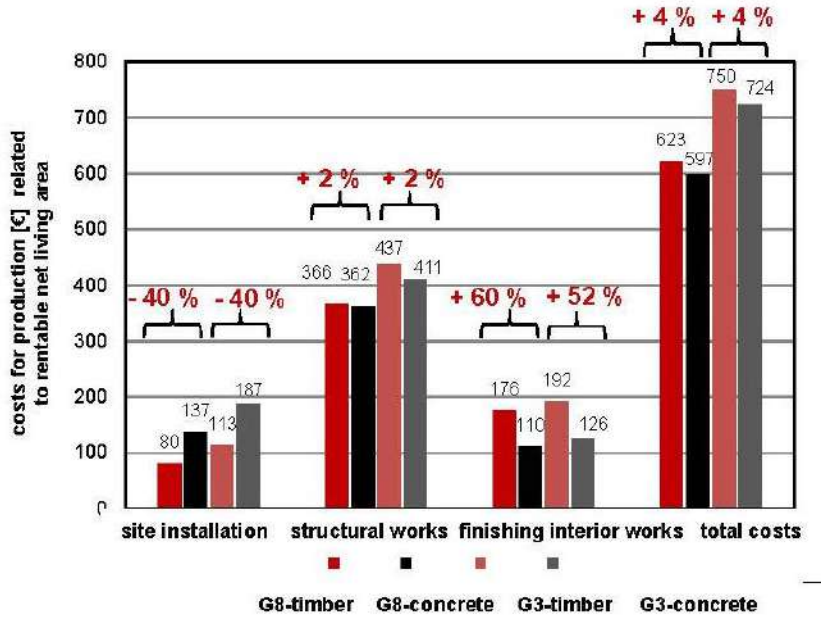

Figure 7. comparison of costs for production related rentable net living area corresponding to the different building stages

Impact – building economic criteria's

Referring to the investigation of the 8-storey and the 3-storey structure the following statements distinguishes the timber building system:

- up to 3 % more net living area in comparison to the concrete structure.
- up to 80 resp. 90 % less self-weight of the timber structure
- up to 40 resp. 50 % less construction time overall.

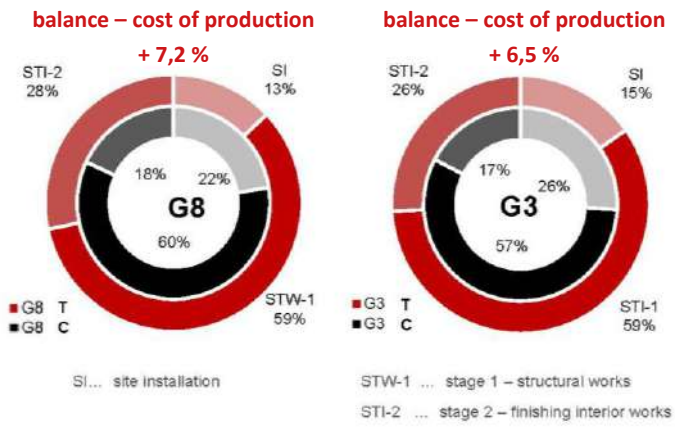

Figure 8. percentages of the entire costs corresponding to the different building stages

6. Potentials of timber construction

The high potential of timber construction is located in the short period of installation required on site. Additionally site installation equipment is less corresponding with smaller areas for temporary storage. Apart from non-influence able weather conditions the installation time is affected by the grade of prefabrication, lifting facilities as well as the installation performance of the team on site. However these evident arguments are not commonly used as they are hardly quantifiable and rate able. Cost facts and time influencing circumstances are difficult to be split between the collaborating companies. Although timber has a high potential as integral building system especially when implementing turnkey strategies. To extend the successful way more effort is required not only in the technical sector but more than ever in the construction management and building economic segment to allow the ecologically friendly material to become a widely used building system.

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