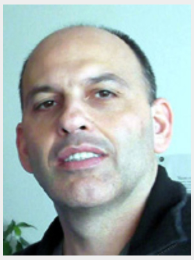
Addressing the identification of cost reductions in the design and construction process in new multi-family houses



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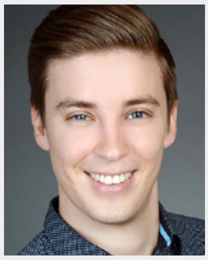

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Introduction

The Project CoNZEBs (Solution sets for the cost reduction of new Nearly Zero-Energy Buildings) is funded by the European Commission in the framework of the Horizon 2020 Program to identify, asses life cycle cost and analysis, and disseminate technological solutions able to reduce the construction costs of new nearly zero energy multi-family houses. Among the different activities, a work package was bound to identify potential cost reduction in the design and construction process (hereafter D&CP). This article presents the main outcomes of the activities, which were structured in the following phases:

- Identification of the current D&CP in the EU member states, with obvious focus on the project participant countries (Denmark, Germany, Italy, Slovenia);
- Identification of common boundary conditions and areas for possible cost reductions;
- Involvement of stakeholders through questionnaires and interviews to identify most promising approaches, methods and tools for D&CP;
- Provide exemplary solutions able to optimise and reduce costs in the overall process.

The full report "D3.1 Assessment and exemplary solutions for cost reduction in the design and construction process" will be public on the project website (www.conzebs.eu), where all the results of the activity will be available in detail.

Current costs in the design and construction process

Current costs in the design process for minimum requirements and nearly zero energy multi-family houses were analysed in participant countries, while a wide literature review was carried out to assess such costs in other member states. Design fees can be determined in three main ways: percentage of the building cost, predefined fixed fees, time charge based on hourly rates, depending on: the country, the size of the project, and its complexity.

Results in the participant countries were significantly different, in fact the share of design fees in respect to the overall construction project costs was identified as follows:

- Denmark 8–15%
- Germany 13% (median value)
- Italy 7–9%
- Slovenia 3–4%

It has to be noted that only in Italy, the survey evidenced an increase of design costs for nearly zero-energy buildings in respect to the minimum requirements ones; while no differences were detected in the other countries.

Analysing the construction process, it was found out that the area for cost reduction could be focused on the preliminaries (or indirect costs), which are costs not explicitly related to the specific items of measured work but mainly related to the construction site "life cycle" (i.e. plants, accommodation, temporary services, rents, transport, scaffolding, and insurances). Few data were available among the participant countries, in Italy a small survey proved shares in the 5–10% range; more data were collected at EU level, proving that preliminary accounts for 10–15% of total construction project.

In the next phase common boundary conditions and topical issues were screened: the main actors involved in the process, specific issue for the social housing, the construction site organisation and the worker skill, the compliance of work execution, supporting instruments. It was found out that very few data from the field are available for what concerns the impact of several measures in reducing costs in the D&CP.

Potential for cost reduction: the stakeholders' view

In order to better understand the feeling and the expectations of the main actors involved in the D&CP, two questionnaires were developed and sent around to related categories. The questionnaire for the designers and planners addressed the following main issues:

- Awareness about and experience with the design and planning of NZEBs.
- Method of calculating the costs for design and planning.
- Solutions to reduce design and planning costs or to reduce costs during the whole construction process (to be tailored at national level).
- Experience and impact of the long-term maintenance costs.

The questionnaire for the designers and planners addressed the following main issues:

- Awareness and experience of NZEBs.
- Adopted process to execute the construction works.
- Magnitude and causes for cost variations in respect to the planned costs.
- Internal process to reduce construction costs.
- Solutions to reduce overall construction costs (to be tailored at national level).

Also, the housing companies were involved in the survey. Alternative to the questionnaire, interviews with targeted actors were carried out.

Designers and planners detect in the integrated planning the most profitable instrument to reduce overall costs for the design and construction process

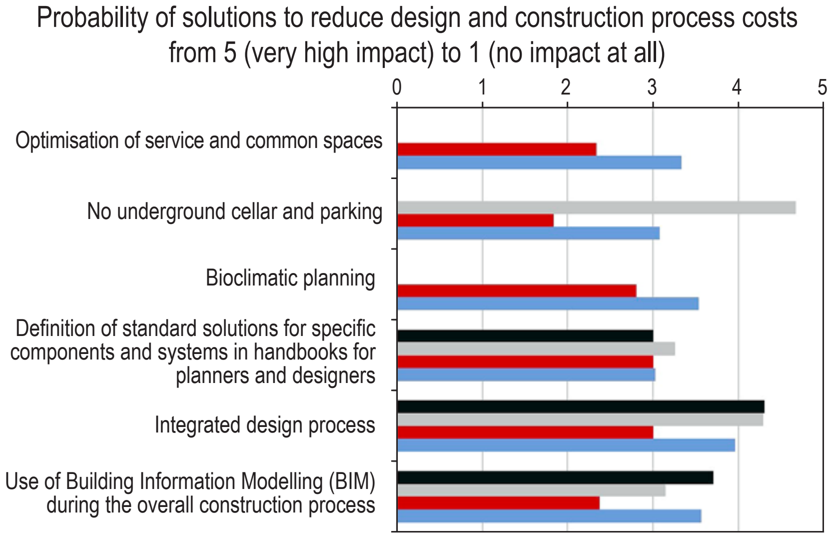

Figure 1. Answers of designers and planners about solutions to reduce D&CP costs. ■ Slovenia ■ Germany ■ Denmark ■ Italy

on average in the four countries, see **Figure 1**. In Germany the most voted solution is avoiding underground spaces for cellars and parking. Average values are scored for the other proposed solutions. BIM is seen as a potential area for cost reduction, especially in Italy and in Slovenia, while the optimisation of common area in multi-family houses is not considered significantly. External staircases and more compact building forms are considered as profitable solutions to optimise the construction costs in Germany.

Concerning contractors and construction companies, the most profitable solution is the efficient quality control in each phase of the process to avoid extra cost for rework, the latter being a critical issue emerged from the questionnaire results, see **Figure 2**. Also, industrialisation in construction components reach a high score. Some solutions, as BIM and skilled workers, show a strong dependence on the specific country in terms of cost reduction expectations. It was observed that potential solutions for cost reduction are more positively evaluated in Italy and Slovenia than Germany and Denmark, a situation that might also depend on how the market has already implemented cost efficiency measures in the different countries.

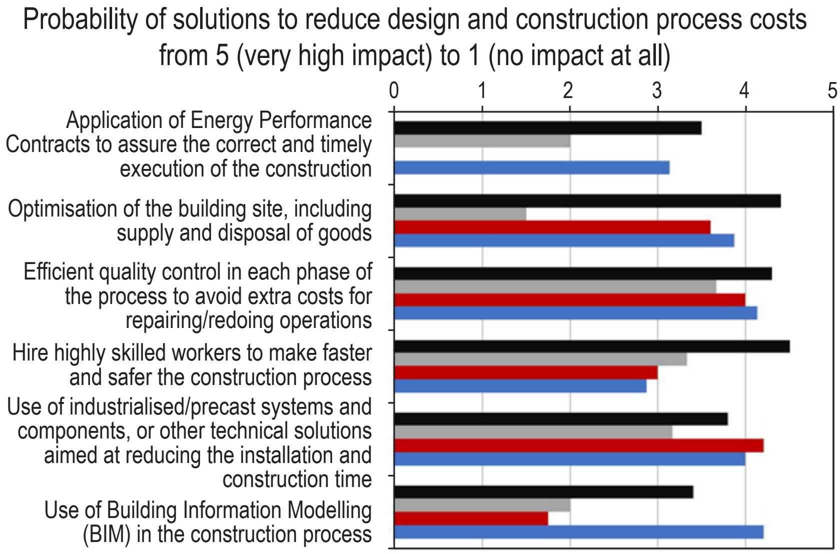

Figure 2. Answers of contractors and construction companies about solutions to reduce D&CP costs. ■ Slovenia ■ Germany ■ Denmark ■ Italy

Exemplary solutions for cost reduction in the design and construction process

Exemplary solutions were identified and analysed to show potential areas for cost reduction in the D&CP. It has to be underlined that they might not be of very general validity, since many factors can affect the final results; conversely, they show the potentialities for cost reduction, intrinsic in the overall process, which needs to be addressed by the involved actors in a holistic approach to the building construction project.

Impact of specific building envelope and energy system technologies

The investigated solutions demonstrate the cost effectiveness in terms of technology costs (material + labour), as well as the capacity of reducing the time for the execution of the works, with additional savings at construction site preliminaries.

The first example is the building facade made of large autoclaved aerated concrete (AAC) blocks, which allows completing the single layer facade in only one workflow with a thermal transmittance as low as to 0.15 W/m²K, instead of the two or three cycles needed with other envelope technologies. **Figure 3** shows construction works with AAC blocks. A comparison versus a reference clay brick layer plus an ETICS facade was carried out for an Italian multi-family house, showing 19% reduction costs and a significant 47% reduction of the construction time.

Another example, coming from Denmark, is the case for roof integrated PV systems: the underlying construction is the same as for other roof types, but the finishing layer is made of PV modules overlapping both by length and width the construction below, see **Figure 4**. This solar roof is easy and fast to mount in one simple workflow; it is obviously more expensive than a conventional roof but compared to the situation in which a traditional PV system has to be added, it leads to about 28% cost savings. Moreover, the construction time is reduced by 50%.

Figure 4. Exemplary application of PV integrated roof.

Figure 5. Example of multi-family house with external staircases.

Figure 3. Example of construction works using autoclaved aerated concrete blocks.

Impact of specific design solutions

These solutions proved that decisions taken during the design phase can positively affect the overall construction process cost, even though they may require small cost increase during the design and planning phase. A German study and application, as an example, proved the positive impact of external staircases in a multi-family house, with the concurrent reduction of the building external surface to heated volume ratio from 0.5 to 0.37 m^{-1}, and estimated 26% energy savings for space heating. Actualising the cost incurred at the construction time, the identified solution also leads to façade construction cost savings of 60 €/m² of living area. **Figure 5** shows a view of the building.

Impact of innovative project management systems

The focus was here on BIM (Building Information Modelling), generally defined as a digital planning and project monitoring method, based on a shared virtual dynamic building modelling, including a detailed database of continuously synchronised data. While this solution is still seen as not cost effective in relatively simple construction projects such as multi-family houses, a US study showed a high return of investments by BIM in a ten projects survey, with economic savings directly to the process in the 0–1.5% range (but one case with 14% savings). First data from the field in Europe were documented in two UK projects; here the economic benefit due to BIM were estimated to be 1.5 to 3%.

Conclusions

While most of the construction project costs are allocated for the construction phase (materials + labour) the performed activities evidenced areas for the cost reductions also in the design and construction process. Expectations and opinions of the involved actors differ from country to country depending on a specific priorities and maturity of the construction market. However, several strategies and solutions can be implemented with the general trend of moving the construction project from a traditional to an industry-like approach, where the accurately planning and management of all phases and the minimisation of the construction site lifetime will play a crucial role. ■

Acknowledgements

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