

Chapter 8.

REFLECTION.

8.2. Reflection on the research process and final product.

This part of reflection chapter will briefly summarise the main steps of the research project and my personal reflection on it.

Start phase. All quite on the western front.

The goal of this research was to find possible savings in modular hospital construction based on the benefits it provides. The choice of the topic for the research was based on my involvement in hospital design for significant period of time and theoretical potentials modular construction provides specifically in this building typology. The main research question rised in this research was formulated as to which extent are modular hospital construction more feasible comparing to conventional building techniques? The initial idea was to find two real cases from the companies, one for modular hospital project and another one for traditional hospital development. The comparison of these two cases, based on their briefs, set of interviews with involved parties and literature review, was intended to identify the exact savings in time and cost as well as the precise moments in construction schedule where these savings might take place.

Literature reivew phase. Modules in a nutshell.

Literature review phase started from the broad selection of the articles in academic libraries dedicated to modular construction. Soonly it became clear that the actual information such as real numbers, turnovers, volumes of production, construction technologies etc are not mentioned in these materials at all. Articles available in stock research filed mainly contain advertisement-based materials with a few details regarding actual savings and mostly suitable for the first call to particular company. As it was investigated later by me, this situation is based on quite closed nature of modular manufacturers since there is a few number of them in Europe and they do not reveal any information beside advertising booklets. In order to get the deeper knowledge in modular development I bought several books which describe design and construction modular process more precisely and in details. In parallel with academic reading I arranged a set of interviews with the parties involved in modular design and construction, thanks to my mentors Ruben Vrijhoef and Peter de Jong. It has become clear, then, that no one party is willing to share any precise and concrete information, even if you are a good student of TU Delft. They can demonstrate the module after completion in showroom, they can answer to some general questions (see [interviews in appendixes](#)), but they never ever ever will dive into manufacturing, construction and especially financial details. This is pitty to constant, but graduation within MBE and TU Delft do not guarantee any entries to the construction world. Although it highly depends on the selected topic, particular market situation and student personality, the actual involvement of the MBE faculty to the real construction sector is overestimated, in my point of view. Based on these reasons I switched my initial research plan from case study research to generic analysis of life cycle process of modular hospital and its aspects with divings into particular details in design, construction and use phases based on their availability. Thanks to my mentors I got a number of experts from architecture, module manufacturing and hospital management fields which answered to the number of questions of modular development (see [appendixes 15-19](#)). All their responses and comments are included in the body of the report. However, they were fluctuate to go into details regarding any numbers and real cases.

Final report development phase. Yes, I can.

Final report of this research are based on literature findings and interviews with experts mentioned in a previous paragraph. It touches the main parameters of hospital development and life cycle in three phases - design, construction and use. Every parameter of both construction methods is compared with each other and the conclusions regarding feasibility of modular construction in this particular step of building's life are made. Finally, the conclusion chapter summarizes all findings and describes the main savings in all phases. It is important to mention that findings in particular phase cannot be simply summarized since they are not equal to each other and represent different categori-

es sometimes. The results of the research are findings of possible savings in modular construction as a percentage comparing to conventional building methods (see conclusion chapter).

8.3. Time and costs savings are done. What about quality?

Two indicators investigated in this research were time and costs savings in modular construction. These two indicators were chosen specifically for this research in order to investigate quantitative savings in modular construction. Quality aspects, such as architectural, planning, spatial and aesthetic ones, were partially investigated during my Milan work, when I completed renovation project for general modular hospital. For these reasons quality aspects were not studied specifically, since it is separated and big topic for further research. Quality assessment has its own number of indicators and other measurements. Specific questionnaires need to be prepared to interview respondents. This topic can be considered for future investigation, based on monetary and time savings identified here.

At the same time, it is possible to conclude, based on current research, that quality increases take place in modular construction. These issues were partially explained in Construction phase, chapter 5. Main quality improvements are based on two factors. First one is indoor assembly process takes place in modular factory. It means that production process does not depend on weather conditions. Second one is fixed number of operations required to assemble a module. Lean management concept, explained in chapter 6, helps to minimize delays and overheads in supplies. McGraw & Hill annual report mentioned in part 7.4.4 confirms quality improvements in modular construction based on surveys of respondents (McGraw & Hill, Modularization in construction industry report, 2016). 15 % of respondents state high level of improvements, while another 50% report about medium impact on quality improvement. These two factors are basis for higher production conditions, absence of delays and higher quality of the final product.

8.4. Are the in-between scenarios in modular construction?

This research specifically explained 3d modular, or, volumetric construction benefits. This maximum scenario was chosen in order to investigate the limits and potentials of this construction method. Specific questions such as transportation of module to the site, dealing with installation of 3d module to the building, assembly of 3d frame, etc. are raised in this maximum scenario. The purpose of such maximum variant was to check the benefits of this method in front of more traditional ones, where some prefabricated elements are still used. Construction industry, in general, is quite conservative area, and innovations take place here infrequently. Modular construction, that is why, is one of these innovations. Despite relatively long history and a lot of attempts to build modular buildings in the past, modern industry is able to combine economy of scale with customizable layout, as it was shown in this research. The benefit of fully modular construction is complexity of environment and ability to control all processes on a higher level. Current use of prefabricated components in construction, however, does not emerge in qualitatively new features. It is possible to say that use of modular components in traditional construction eliminates some technological problems and reduces time for installation on site, but it is hardly possible to name these things by real changes in construction industry. Wiegerinck Architects, specialized in hospital construction, name 6 main types of prefab elements currently used in healthcare construction (Wiegerinck Architects, 2017). They are prefab facades, window frames, floor slabs, steel structures, bathroom pods and many small fitting parts. While these elements can save some time on construction site, based on their prefabricated character, they are still small part in a general traditional construction on-site process. Figure 8.2. represents all these components.

Are the in-between scenarios?

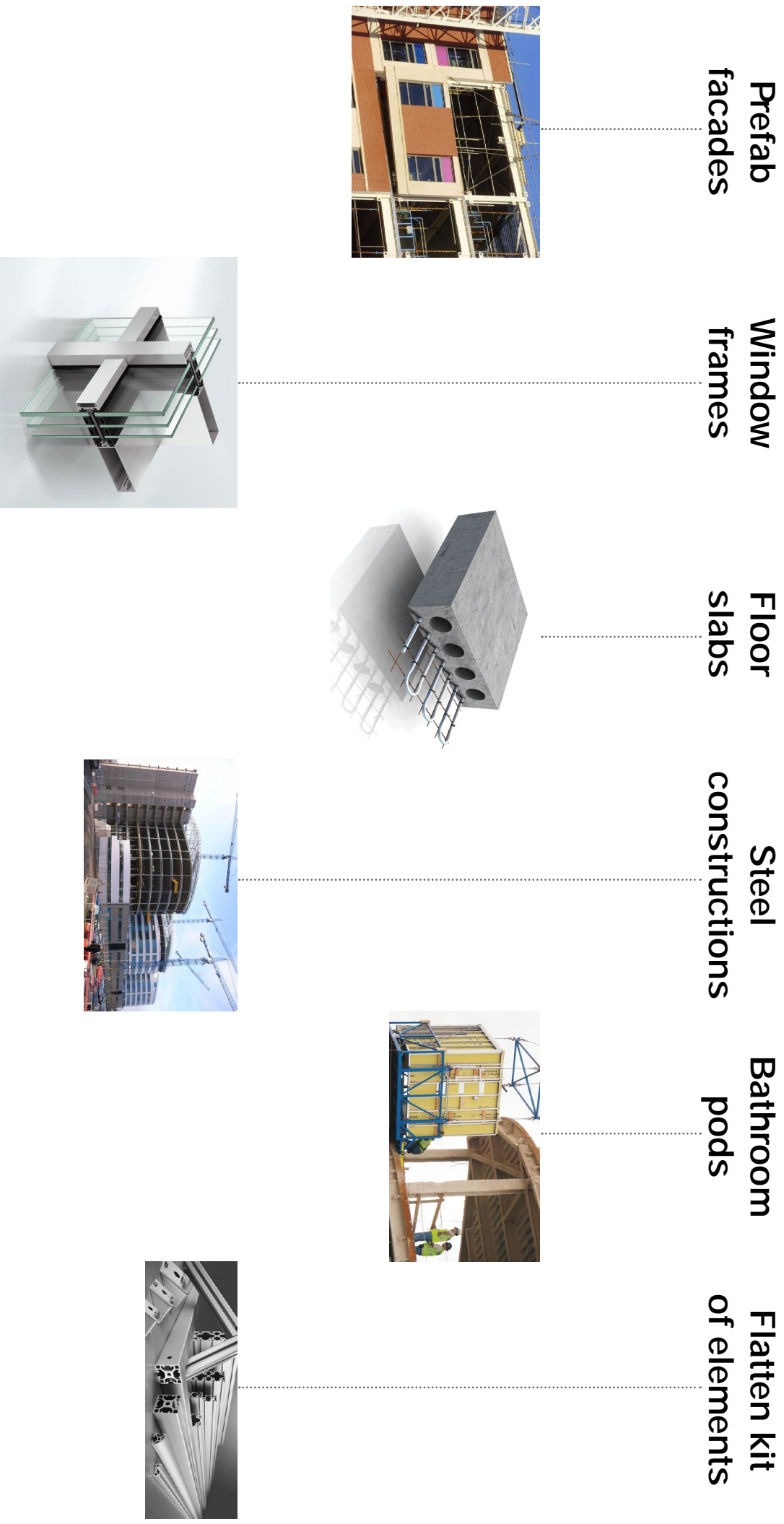


Figure 8.2. Prefab components used in traditional construction today (source: Author, 2017)

8.5. Recommendations for further research.

The real testing of benefits and limitations of modular construction in comparison with conventional one needs to be provided in a further research. Despite the fact that this report used some real numbers from case studies, interviews and literature sources and provided the comparison of the most important phases, operations and parameters, it does not provide the entire comparison of modular and traditional construction by a fixed similar set of parameters. This is based on unavailability of the full real case study for both modular and conventional construction. Further testing and deeper comparison with measuring of real time required for comparable operations is necessarily.

Another important direction of additional research is comparison of life cycle cost of different hospital departments in both conventional and modular construction. This report mainly concentrated on one type of the module and compared its life cycle cost with one square meter of normal construction. Understanding of different aspects of construction of different units (wards, surgery rooms, etc.) will allow to clearly understand economical effectiveness of combination of modular and traditional construction.

Another direction of further research is risk allocations on modular construction, partially mentioned in post-assessment chapter, already. Time savings are mostly based on earlier decisions made at the beginning of the process. However, the risks in this phase are higher based on higher number of decisions needs to be made. That is why risks need to be investigated additionally and their allocation in design, construction and use phases needs to be clarified.