

Analysis and evaluation of mass data for production planning and system configuration

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1. Introduction

The increasing rates of approved residential and non-residential buildings in timber construction in Germany reflect today's demand for timber buildings [1]. With the growing market, the field of application of timber construction is also expanding. Buildings are being planned and constructed with ever-increasing size and complexity.

The rising number of ever-larger timber construction projects lead to company expansions. Growth is particularly evident in companies with 20 or more employees. Both the number of companies of this size and the number of employees in these companies have increased by about 10% in 2021 [1].

To make work along the process chain as efficient as possible despite any changes, the development and optimization of production concepts and products are becoming more and more relevant for timber construction companies. The main goal here is to gain capacity by eliminating waste or by expanding resources.

In this context, the start-up holzbau.tech has been working on individual production planning and system configuration for timber construction companies. Data analysis plays a major role in this because it makes it possible to create customized concepts for specific requirements.

In this paper, the approach to production planning and the use of data for this purpose is presented. The focus is placed on the motivations and the benefits. The required programming process is only described superficially here.

2. Motivations for production planning and system configurations

More than 95% of timber construction companies in Germany have fewer than 20 employees. This illustrates that the timber construction industry is predominantly characterized by craftsmanship [1].

However, one major obstacle to capacity increase is the ongoing shortage of skilled workers. Business surveys conducted by Holzbau Deutschland have shown for years that the difficulty of finding workers is one of the top 5 obstacles to success for timber construction companies [1]. Therefore, to make companies sustainable and to be able to expand independently of personnel expansions, automation solutions should be implemented.

When converting to automated production, it is important to ensure that the upstream and downstream processes are also designed accordingly. This means, for example, that product designs that are too complex may not be efficiently manufactured by automation. If a company's products are too complex, they should be partially standardized so that they can be produced automatically by the technology used. This requires specific product development as well as system configuration.

As the level of automation increases, so does the relevance of end-to-end digitization. Data from construction planning must be created in such a way that it can be processed by machines and the materials and building elements can be produced automatically. The level of detail required here is higher than in manual productions.

Thus, if you follow the changes in the wood construction market and want to adapt your company and production to them, many necessary courses of action quickly arise. To always be future-oriented, a continuous improvement process should be introduced, and existing systems should be regularly questioned. This applies both to the processes of planning and production as well as to the technologies and systems used.

3. Today's common way of production planning and system configuration

Since every company usually differs from other companies in terms of products or processes, production planning should be carried out as individually as possible. First, the current state of the respective area of a company is analyzed to determine what needs to be optimized. In order to make effective changes, the goals should be clearly defined beforehand. But here is where the difficulty often arises. In many cases, the targets are defined by assumptions. For instance, production planning is usually based on information from a few reference elements. These are normally determined from an average. However, the problem is that these reference products can be outdated and often do not reflect the whole reality. More complex designs, for example, are often overlooked.

Another approach is to assume the worst case for production planning. A case in point is that the prefabricated walls in timber construction are usually a maximum of 13m long. With the thought of being able to cover all element lengths, planning is often done according to this maximum length without questioning whether this is really necessary and profitable (Figure 1). This unnecessarily takes up a lot of space in the production hall that could be used for other activities.

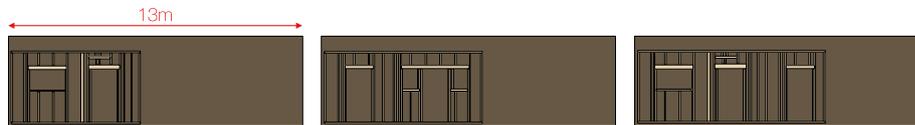


Figure 1: Negative example of producing mainly shorter elements on 13m-long tables

Thus, both approaches in planning do not meet the actual demand. It must be taken into account that both these approaches include exceptions. If these exceptions occur only very rarely, however, the concepts may be a hindrance to the actual demand.

4. Approach for realistic planning: data analysis

For a better reflection of reality in production planning and to focus on the truly relevant requirements, attention should be paid to data. The Economist called data «The world's most valuable resource» on its cover of the May 2017 issue. By analyzing data, well-founded conclusions can be drawn about previous projects. Data evaluation provides information about the actual consumption of resources, such as the processing times required, or the materials used. Calculated costs can be compared with actual costs.

In addition to conclusions that data analyses reveal retroactively, inferences for the future can also be recognized. Products of past projects can be examined, whereby it can be recognized, for example, whether designs are error-prone or ineffectively manufactured with the current production methods. E.g., If there are a lot of production stops because of a certain product design or because of some construction details, an optimization would be reasonable. Another example is the configuration of a new machine. The requirements can be identified based on the data analysis of the previously produced parts and thus a precise system configuration can be developed. Among other things, this means that machines are not unnecessarily oversized and are equipped with all the capabilities that are really needed.



Figure 2: Example optimized table length based on product analysis through data

4.1. Today's impediments for timber construction companies

While the benefits of data analytics for production planning are clear, experience shows that the approach is hardly practiced in the timber construction industry. What is stopping timber construction companies from collecting and analyzing the data they create?

A common response from companies is that they simply have no data to analyze. However, this is not correct. They just lack the understanding of what useful data is and what

it can reveal when analyzed. Therefore, the first step to using data analytics is to recognize what data is needed, generated, and used already.

Every company has data and information in the form of invoices, purchase orders or self-created charts. These can, for example, provide information about how much raw material was procured.

Beyond that, a large amount of data is generated in the planning department of timber construction companies. After all, of all the construction methods, timber construction is the one with the highest proportion of self-planning by an executing company. This is due to the prefabrication of building elements for which the manufacturing companies need their own workshop planning. Thus, they have been producing their own 3D models for decades [2].

So while data is generated in any case in timber construction, it is not used further beyond production. To change this and enable the analysis of numerous data sets, the first prerequisite is their accumulation and storage instead of leaving them unused.

4.2. What to do to enable data analysis

As described above, the first step towards data analysis is to gain an understanding of the data itself. To do this, it is best to catalog them first (Figure 3). This means getting an overview of where data is generated and needed, both on computers and on machines. Once an overview of the data has been obtained, it must be backed up first, if it has not already been done, in order to avoid data loss. Depending on the digitization of the company, this can work in conjunction with an existing ERP (Enterprise Resource Planning) system, cloud systems or similar platforms.

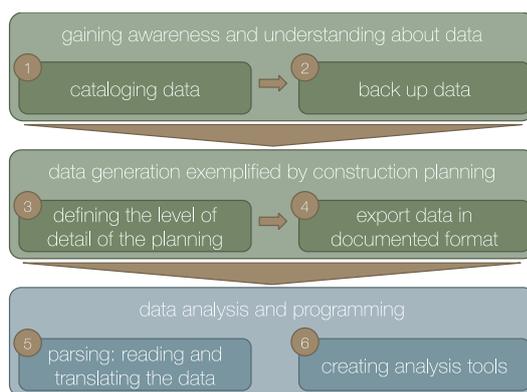


Figure 3: Simplified process for data analysis

Having established the awareness of the value that created data brings, attention should be paid to the quality of its creation. The most important area here is the construction planning. The plans provide the most information about the products and production. Depending on the degree of prefabrication and automation of the company, plans are already drawn up in greater or lesser detail. In principle, the more information that is created about an element, the more insight the data and its analysis will provide in retrospect. It is therefore important to define the level of detail of the plans and to maintain it consistently. The fact that the plans should also be created as

error-free as possible is just as important for the data analysis as for the production itself. After the data has been created in the form of manufacturing plans, it must be exported in a format that can be further processed by data analysts. It is referred to as a documented format. This means that a defined interface description exists for the output information, which describes the meaning of the individual data. An example is the universal data format BTL. It is not only supported by timber construction CAD and machine software, but a wide range of software solutions can also read and write the format [3]. But even a simple export as an Excel spreadsheet can be used for evaluation.

Paying attention to the quality of the data and its output format is essential for smooth data analysis. «Data science is the easy part. Getting the right data, and getting the data ready for analysis, is much more difficult» [4]. The 2016 Data Science Report found that 60% of Data Scientists' work time is spent «cleaning and organizing data» [5]. To minimize the effort here, the quality, level of detail and file format should be as constant as possible.

Countless data can then be fed into a software, which begins parsing and translating the previously somewhat abstract data in an intelligible way. From the translated data, innumerable evaluations and analyses can be created with a wide variety of considerations and objectives.

5. Examples from practice

For profitable solutions and concepts that are elaborated on the basis of data analyses, clear objectives should be defined. In this way, the analyses, evaluations, and simulations are designed precisely to meet the need. The following are some practical examples of how holzbau.tech has used data analytics in the context of production planning.

5.1. Simulation automated blowing of loose insulation

In this example, numerous walls of a company were analyzed using their data. Predefined parameters were used to specify which compartments could be insulated automatically and which could not. The result can be seen as an example in Figure 4. The analysis revealed a proportion of the structural compartments that the intended technology would not be able to process. With this knowledge, planned systems can be optimally redesigned so that the automated processes become possible. Alternatively, as it also makes sense here, the construction design can be changed so that non-automatable areas are avoided and thus machine stops do not occur because of this.

If only individual reference walls were considered instead of a mass data analysis, this would most likely result in a different proportion and sources of error would remain undetected.

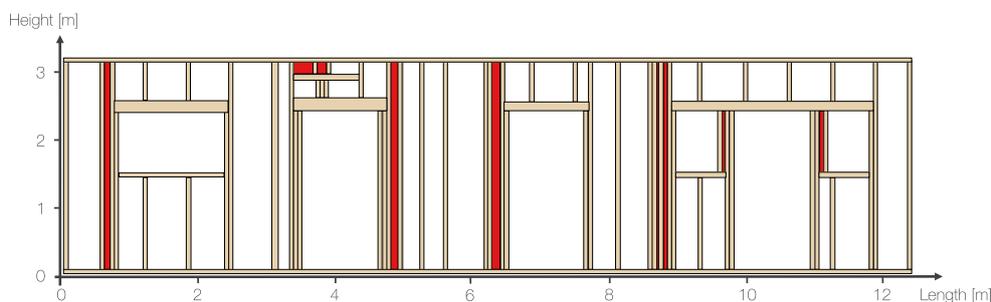


Figure 4: Example element: analysis by holzbau.tech, which spaces cannot be insulated automatically (red)

5.2. Waste analysis when machining 13m timber

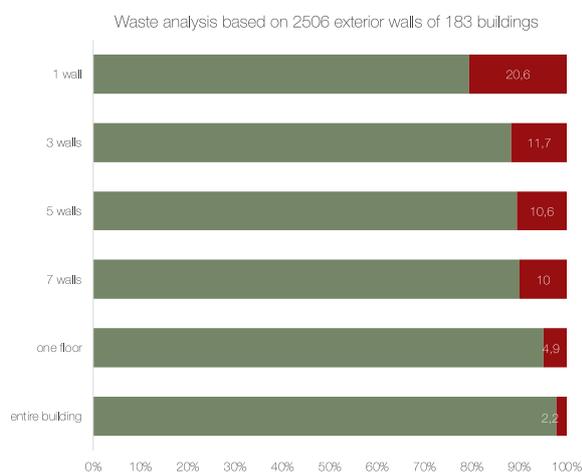


Figure 5: Waste analysis when machining 13m timber

Most timber construction companies process 13m long raw timber for the individual components of the elements. In order to generate as little waste as possible, the parts for one element are usually not cut individually, but combined in batches of several elements. In this way, the different timber parts are distributed more optimally among the long raw timbers and the timber is better utilized. The analysis carried out here (Figure 5) shows the effects of the batch size on the waste. It can be seen that the more parts are combined in one batch, the less waste is generated.

With this knowledge, productions can adjust their wood cutting accordingly. For the downstream process, this means sorting the parts of a batch after it has been machined for their particular element, so that the assembly process for the elements gets the right parts at the right time. In process development, therefore, it is not only the cutting process that has to be considered, but also the downstream sorting process and the respective effort involved.

5.3. Analysis of the wall dimensions

Figure 6 shows the analysis of well over 2000 walls and displays the distribution of the dimensions. Usually, one quickly focuses only on the average. However, if one wants to create a production layout with new workstations, for example, the big picture should be considered. To return to the above example of the 13m-long tables, we look in particular at the rear part of the evaluation. We can see that the distribution of dimensions decreases significantly after 9m length. Consequently, when planning new tables, it becomes evident that they do not necessarily have to be 13m long. Most walls can be made on shorter tables. One possible course of action would therefore be to design the production layout for predominantly smaller walls. The few walls that are longer can then be produced on a custom processing table. In this way, significant space can be saved and used more sensibly.

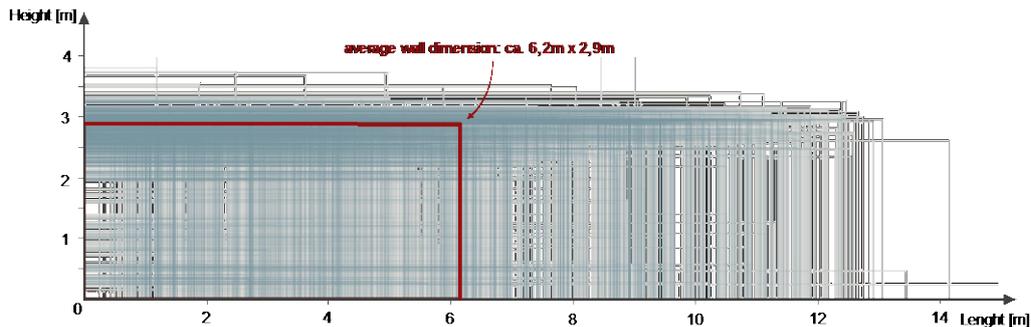


Figure 6: Analysis of the wall dimensions

5.4. Software tools to enable professionals to analyze data

The examples described above were made by IT experts on the basis of previously clearly defined objectives. However, the IT partners often lack the necessary expertise to recognize or understand errors or inconsistencies in the evaluations. This often results in long consultations and revisions. To avoid this waste in the processes, the approach of creating software tools for experts makes sense. This can be, for example, an online tool that is programmed specifically for a customer and addresses the specific issues. The data required for evaluation is implemented there and can be analyzed in a user-friendly manner. Optimally, the deciding experts can then use this tool and set parameters as desired to identify different effects. For instance, if a potential sales price has an impact on the overall profitability of a project, different values can be entered and different results can be compared (Figure 7).

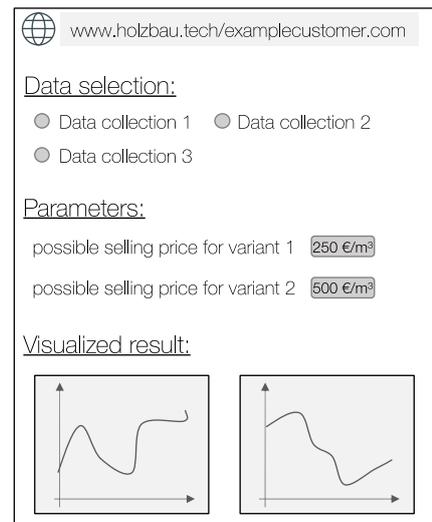


Figure 7: Example of a software tool

6. Conclusion

In conclusion, the use of data holds huge potential for the timber construction industry. It is important that the understanding for data analysis is created and that timber construction companies realize that they have these possibilities and how they can take advantage of them.

7. Sources

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