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FREQUENTLY OCCURRING LOSSES OF PRODUCTIVITY IN THE SHELL CONSTRUCTION PHASE

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In construction projects, losses of productivity often lead to additional costs and time delays. Suboptimal working conditions influence the labor productivity of workers and have an effect on the number of working hours required, for instance, to produce one cubic meter of reinforced concrete. Costs can be reduced and total productivity increased if the sources of potential losses of productivity are identified at the process planning stage or in early project phases. An expert survey conducted in 2014/2015 at Graz University of Technology, Austria, collected data on the losses of productivity that most frequently occurred in conjunction with reinforced concrete works in the shell construction phase. A standardized questionnaire was used for this survey. In addition, an interview was held with each of the experts to discuss the questionnaire in order to improve the quality of the survey and to gather important background information that prompted the responses provided by the experts. For this survey, reinforced concrete works were divided into ramp-up, main construction and final phases. Experts from Austria and Germany were able to select from a range of predefined losses of productivity and to specify other losses separately. This paper reports on the progress of the survey and refers to the related analytical methods. Furthermore, findings of the expert survey are represented in bar diagrams and interpreted. The survey revealed that the main construction phase was generally associated with the greatest potential for losses of productivity. Furthermore, most frequently stated losses of productivity varied depending on the specific construction phase. Future construction projects should particularly focus on the losses of productivity that were most frequently mentioned in the expert survey. The benefit of this approach is that it will provide the opportunity to implement early compensatory measures and to minimize the potential for losses of productivity.

Keywords: Expert survey, Reinforced concrete works, Ramp-up, Main construction, Final phase.

1 INTRODUCTION

In construction projects, losses of productivity often incur additional costs and construction time delays that give rise to disputes and legal proceedings as well as to the commissioning of expert opinions (Kummer 2015a).

To ensure a timely response to losses of productivity and to implement related compensatory measures, it is of particular interest to ascertain those losses of productivity that typically occur in the individual shell construction phases. An expert

survey was conducted by means of standardized questionnaires because site observations or analyses of final costing exercises are usually difficult to perform. This survey determined the losses of productivity that occurred most frequently in the individual shell construction phases (reinforced concrete works).

An idealized trapezoidal model that comprises ramp-up, main and final construction phases is assumed for the utilization of production factors. In the main construction phase, most resources, such as the maximum number of workers, are utilized on-site (see Figure 1 – idealized representation). This is also the period in which the highest output is achieved (Hofstadler 2014).

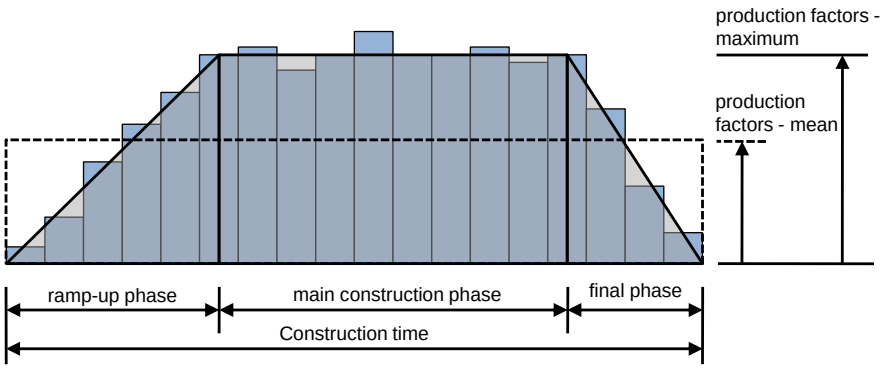

Figure 1. Development of production factors over construction time.

2 SELECTION OF EXPERTS

It is usually impossible to interview all experts in a given field, with the exception of a few, highly specialized disciplines. This is why sampling is necessary to arrive at conclusions as to the overall population on the basis of received responses. The selection of such experts relies on the following fundamental questions (Gorden 1969):

- Who is in possession of relevant information?
- Which of these experts are available?
- Whose willingness to provide information is the highest?
- Who is most likely in a position to provide accurate information?

In this context, experts are defined as individuals who possess specific knowledge in a clearly delineated field and who serve as a source of specific knowledge for the purpose of a survey (Gläser and Laudel 2010).

According to this definition, they possess knowledge and intellectual skills and competencies in a given field that clearly surpass the average level. Expert knowledge usually comprises exceedingly large amounts of information, including simplifications, lesser-known facts, rules of thumb and smart practices (heuristics) that enable efficient problem solving (in the relevant field) (Springer and Gabler 2014).

As part of a preselection process, a total of about 130 experts with experience in the fields of costing, process planning, construction, final costing and invoicing were

contacted in writing and asked to participate in the survey. These were individuals with the related expert knowledge and sufficient professional experience who were added to this "pool" of potentially competent and willing experts either due to the fact that they were personally acquainted with those conducting the survey or by establishing contacts through third parties.

In total, 27 experts from Germany and Austria were recruited for the survey. 26 responses were submitted to the question regarding losses of productivity that occur most frequently during the shell construction phase. The majority of respondents (approx. 63%) worked for large companies with more than 250 employees, about 26% worked for medium-sized businesses (50 to 249 employees), and about 11% came from small businesses (10 to 49 employees).

When selecting experts, one of the key criteria is their professional experience. Only this degree of experience will enable sound responses regarding the occurrence of losses of productivity. In the survey presented in this paper, experts had an average professional experience of 17.7 years; this experience ranged from 5 to 41 years.

Questions were designed and developed together with social researchers (sociologists) in several revision steps, applying the principles of simplicity, clarity, impartiality, and specificity.

On average, each respondent was interviewed for about 45 minutes either on the phone or in a face-to-face session to overcome ambiguities, collect missing information, or obtain background information and justifications of responses (Kummer 2015b).

3 ANALYSIS OF SURVEY

The expert survey determined the types of productivity losses that occurred in the individual project phases. Respondents were able to tick boxes to indicate the project phases in which predefined productivity losses (see Figure 2) occurred particularly frequently according to their experience. Multiple choices were permitted.

Results are represented and described as bar diagrams for each of the three shell construction phases (see Figure 1). Experts had the opportunity to specify other losses of productivity, including the following additional categories: losses upon handover during multi-shift operation, changes to plans, limited available storage space, unskilled workers, increased material utilization and extended periods of material provision.

Losses of productivity were reported to occur most frequently in the main construction phase (134 mentions), followed by the ramp-up phase (87 mentions). Respondents identified the lowest potential for losses of productivity in the final phase (69 mentions) (Kummer 2015b).

For the ramp-up phase (see Figure 2), a particularly large number of respondents indicated losses of productivity occurring due to exceedingly short lead times in the planning process and poor planning quality. This opinion was justified by the fact that, in most cases, the planning process had not yet been finalized upon commencement of the construction phase, and that plans were completed only shortly before the actual construction process began. The factor of "changes to plans" additionally mentioned by one of the respondents can also be grouped under the above-mentioned, most frequently occurring type of productivity loss identified in the survey.

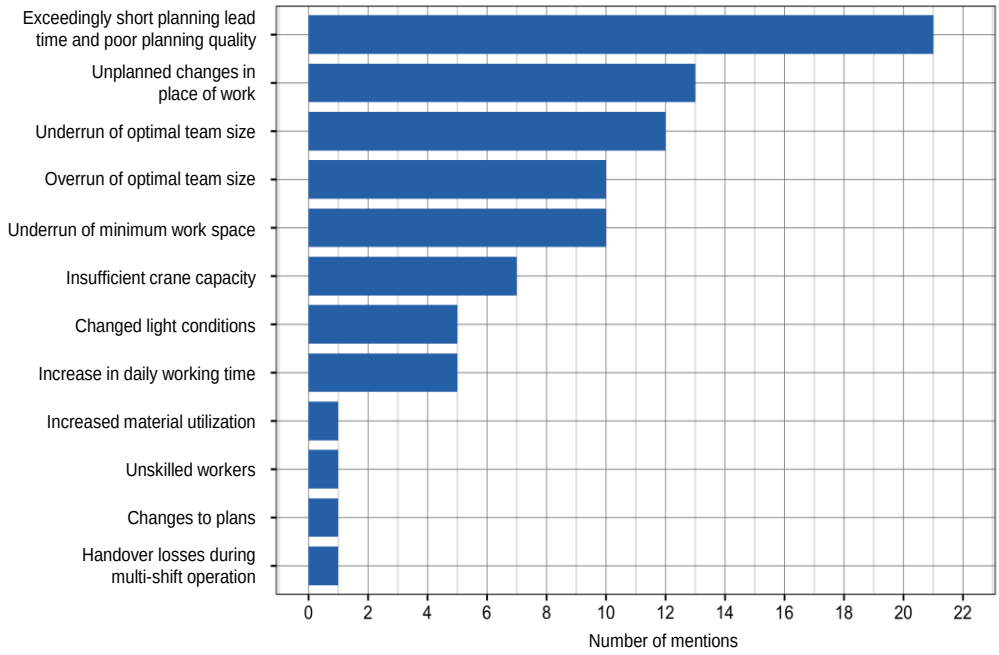

Figure 2. Losses of productivity – ramp-up phase (total number of mentions: 87).

Furthermore, unplanned changes in the place of work were frequently mentioned as a reason because on-site processes and workflows often need to be aligned with each other at the initial stage, and employees may also have to perform residual work on other construction sites, which prevents them from being available for an entire day or week on the affected site. Changed lighting conditions were mentioned relatively rarely as a cause of loss of productivity in the ramp-up phase because extended daily working times are rather infrequent at this stage. According to the experts, the same applied to insufficient crane capacity, which is a relatively rare phenomenon in the ramp-up phase because the maximum number of workers has not been reached and the amount of resources used in this phase is smaller than at the main construction stage.

Figure 3 shows the number of mentions of losses of productivity that occurred during the main construction phase. Overall, this diagram revealed a marked increase in the number of mentions compared to the ramp-up phase. This phase was considered to be associated with the highest potential for losses of productivity.

In this phase, the most frequently mentioned losses of productivity were increases in daily working time, changed lighting conditions, and insufficient crane capacity. Moreover, the experts identified exceedingly short planning lead times and poor planning quality as one of the other key factors that promoted losses of productivity in the main construction phase (as previously stated for the ramp-up phase).

Less significant factors that led to productivity losses in the main construction phase included unplanned changes in the place of work and underrun of the optimal team size. Since this phase is likely to be associated with the maximum number of workers present on-site, overruns of the optimal team size or underruns of the minimum work space are more likely to occur at this stage.

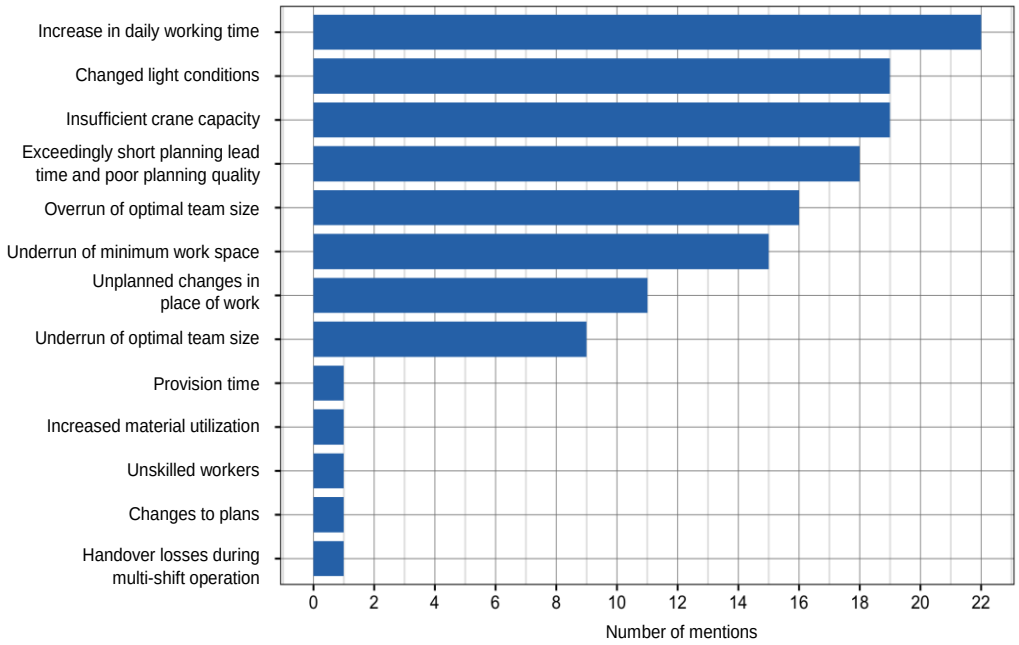

Figure 3. Losses of productivity – main construction phase (total number of mentions: 134).

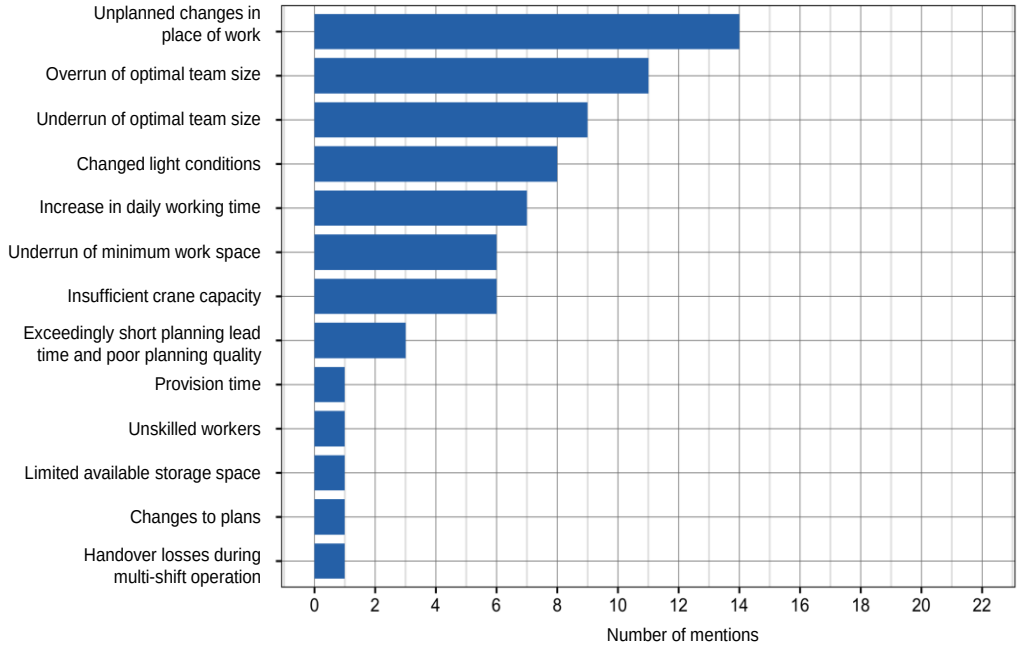

Figure 4. Losses of productivity – final phase (total number of mentions: 69).

Overall, the number of mentions of expected losses of productivity became smaller again in the final phase compared to the main construction phase (see Figure 4), and generally decreased to a level below the ramp-up phase.

In the final phase, the most frequently mentioned loss of productivity resulted from unplanned changes in the place of work. Experts justified this statement by workers often either having to perform residual work in several different places when the project is nearing completion or working on other construction sites already. Respondents stated that overruns and, similarly, underruns of the optimal team size may occur at this stage. Underruns should be expected whenever the completion date is not at risk and workers are removed from the construction site for this reason. Overruns should be expected whenever the final project phase is under high time pressure, and work intensity increases accordingly to comply with the scheduled completion date. In the final phase, experts rarely indicated losses of productivity due to short planning lead times and poor planning quality because, at this stage, the detailed design exercise will usually have been completed, and related plans are available early enough in the process.

4 SUMMARY

This paper identified the specific shell construction phase in which losses of productivity are most likely to occur. The main construction phase is generally associated with the highest potential for losses of productivity. This is where the number of mentions was the highest across all cited causes of losses of productivity. Experts justified this observation by the fact that the maximum amount of resources is utilized on-site at this stage, which may result in mutual obstructions between trades and longer working times as well as insufficient equipment capacity. Future construction projects should particularly focus on the losses of productivity that were most frequently mentioned in the expert survey. Its results should primarily raise awareness of frequently occurring losses of productivity among all parties involved in the construction process to prevent such losses in future and to increase productivity during the shell construction process.

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