The impact of the additional workload on the productivity in construction projects

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Abstract

Additional works are not rare in construction projects. Their occurrence is often not anticipated on time. Practice usually only considers the direct impact on the organizational and technological aspect of them when planning the project, although it is known that they reduce the productivity and motivation as well. These hidden effects can reduce the dynamics of labour and thereby cause additional problems to managing the project. Moreover, constraints typically increase or are constant on projects through project phases and thus are completely maladjusted to the new conditions of increasing workload. Conducted research includes detail analysis and simulation of performance of 3 business residential building projects in Croatia, considering the relationship between the workload, time pressure and the work productivity. The technical, organizational and human component is considered. The paper proves the occurrence of productivity reduction in the case of additional work, no matter if the additional work is required or is consequence of prior poor performance. Based on the research results, the paper give the recommendation for reduced productivity compensation, which has direct impact on cost, time and resources and should be taken into account when deciding on additional work, if the project success is the main objective of project activities.

Keywords: additional work, impact of additional workload, productivity

1. Introduction

The additional workload is usually the consequence of required additional work which is more practice than exception in construction projects. Disadvantages of project documentation, too late perceived needs and technology conditions and later investor's requests are some of the common reasons for additional works in construction projects. The research results all over the world prove that the each key project participant could be the initiator of additional work. In other words, client, consultant, contractor or any other can be responsible for rework orders (Arain and Low, 2006). Researchers confirmed that the client contributed most to rework (Hwang et al, 2013). Regardless the initiating participant, the negative impact of rework on project performance is in the focus of many researching in today's construction projects (Love et al, 2002; Palaneswaran et al, 2007; Thyssen et al, 2010). In this study, the term of additional workload means additional work or rework, despite of root cause and the contractual conditions and settings. In other words, regardless if it is consequence of accepted change or its time/cost or other constraint overrun that has to be overcome during the project performance, it is always the unpredictable event on which is necessary that project manager react. The research question is: Is there relationship between additional workload and the productivity in construction projects? If this relationship is significant, it has to be calculated in plan revising, whenever it includes additional work, which is not case in the practice. No doubt, this could be one of the drops in the bucket of reasons why 68-97% of projects don’t achieve their determined goals.
2. Background

The impact of additional work on construction projects is well recognized. It is one of the most common concerns in construction projects (Hwang et al, 2013). The researchers agree that it has significantly contributed to project cost and schedule overrun (Love and Edwards, 2005; Hwang et al, 2013). Rework, as one of the main manifestations, is a form of waste and is a non-value adding activity. (Love et al, 1999). It is believed that it appears in every project management dynamic model with varying degrees of complexity, especially after developing community of system dynamics in 1970s. (Lyneis and Ford, 2007). Each project that is to be modelled—a project is defined here as a series of tasks that have a specific objective, start and end dates, and funding limits. It is assumed to be comprised of a certain number of tasks or “original work to do”. The tasks can either be completed fully and correctly (i.e. they can become “work done”) or they can be mistakenly classified as completed fully and correctly (i.e. they can become “undiscovered rework”), until it is discovered that they were flawed and need to be redone (i.e. they can go from being “undiscovered rework” to “rework to do”). Thus the stocks or state variables of the system, as shown in Figure 1, are: original work to do, undiscovered rework, rework to do, and work done. The rates at which work is being completed correctly and incorrectly are affected by the value of original work to do and the workforce size, productivity, and error fraction. Similarly, the rate at which rework is discovered and reclassified as work to do is affected by the undiscovered rework and the time to discover rework, which can also be affected by the workforce size and productivity. In Figure 2, workforce size, productivity, error fraction, and time to discover rework are treated as constants (or parameters). However, in reality, the parameters in Figure 1 are state variables that are controllable by organizations and thus they represent the control authority of the organization over the states of work to do, undiscovered rework, and work done. (see figure 1).

![Figure 1. Rework cycle dynamic structure (Owens et al, 2011; Lyneis and Ford 2007)](image)

This is only one of the recognized models for additional work on projects. Every variable could have specific part of its behavioural, depending on type of the project, which also must be concerned. In the most cases in construction industry, additional work arises from changes, damages, defects, errors, omissions and other non-conformances (Palaneeswaran et al, 2007). It is proven that the cause of rework in a construction supply-chain is poor information flow and the absence of a quality focus (Love et al, 1999).

Concerning the participants in projects that contribute to the additional work, it is known that there are four project players responsible for rework orders, i.e. the client, consultant, contractor and others, and found that these project players were the sources of design change, design error, design omission, construction error and construction omission, which caused rework in construction projects (Hwang et al, 2009).
3. Methodology

Conducted research aims to find a relationship between workers’ productivity and the additional work that is being introduced in the project. It is about connecting workers’ productivity with project performance, which is not easy to do. Productivity involves a series of complex processes that workers perform.

If the legality could be found on the significant set of projects or on several projects of best practice, based on the average productivity of workers on projects that are analogue by its nature, then the conclusion could be performed.

Considering the average productivity of workers per day and performed activities, based on applied monitoring and control methods, the conducted research prove the relationship between additional work, motivation and time pressure in projects. The additional work is therefore defined as rework or set of unplanned activities that should be carried out within the previous determined plan. The workers’ productivity is measured by relative (%) difference between average workers’ productivity before, during and after applying the additional work on project.

A case study is chosen as the main research method, which allows a deep analysis of some of the best practice projects in Croatia.

It is very important to taking into account the various possible causes that have the identical effect as additional work, but still doesn’t derives from it and are not relevant for this research.

The figure 2 show the resume of additional work sources and analyze of it into three main components: organizational, technical and human component. The each component is further analysed into its parts. It is the framework for conducted research.

![Figure 2. The source and components of additional work on construction projects](image)

4. Case studies

The research included case studies of three construction projects in Croatia. The projects are chosen by criteria of Croatian construction industry best practice in the mean of applying project management procedures and methods as well as achieving the project management success. Two of them had private and one of them (Case study 2) had public investor. All of them are finished and achieved project management success.

It was very important to analyse all planned and performed information on projects and to ensure the research relevance for answering the research question.
4.1. Case study 1: Business building construction, Business Complex Radnička

The construction project which is observed here planned to last for 137 working days and had MS Project plan which was contracted. The monitoring and control system consisted of monitoring planned and realized amount of concrete (in m$^3$), gross area that was closed and ready for installers and other experts who follow the completion of construction structure (in m$^2$), as well as number of workers and performance in overall. After several weeks of realization within the planned one, the time delay occurred (at the first third of construction performance, see figure 1 and 2). It lasted until the number of workers had been increased for 77%. So there was additional work because of time pressure that had to be done. By the plan, during this time the workforce should increase for 40%. If we engage the increased (actual) number of workforce in the simulation of plan, it turns out that reaching the plan should come 10 days before it really happened. The results of analysis showed that the labour productivity, measured according to the average performance of workers, were about 10% weaker than at the period of realization according plan. Moreover, after the realization exceeded the planned performance, labour productivity slightly increased as well (for about 8%). Finally, the project was completed on time and achieved project management success.

![Figure 1](image1.png)  
**Figure 1.** The S-curve of planned and realized amount of concrete (case study 1) and closed gross area (BDP) in case study 1

![Figure 2](image2.png)  
**Figure 2.** The number of workers during the considering construction performance in case study 1

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4.2. Case study 2: Construction of Emergency medical services

The considering building has finished with construction phase on 2009. It has about 14,000 m2 and is consisted of eight floors. There is an emergency ambulance with reanimation, emergency alarming service for the whole city, patient injury clinic and medical educational centre with multi-storey garage for 170 ambulance vehicles. The Investor was the City of Zagreb.

There was an additional work for ensuring the stopping a possible rush of emergency vehicles under high speed, when exiting the multi-storey garage, in the case of failure of its breaks.

There was plan schedule in MS Project for the construction phase of project and monitoring and control system, which gave the weekly information about distinction of realization from planned ones. The realization was mainly followed planned schedule. There was slightly standstill because the required additional work demanded additional calculations and designing auxiliary steel structure, but the difference between planned and realized was only about 2%. From the time that this problem was recognized to the time that planned and realized had maximum deviation, the impact of this additional work increased this deviation to 5%. As the additional work was not in the initial plan, the plan had to be revised. At the time of revising the plan, which happened after finishing the whole preparation for building the auxiliary steel structure, the labour productivity, measured according to the average performance of workers, were about 8% weaker that at the period of realization according plan. After revising the plan, there was impossible to compare new productivity with earlier one because the reference point for comparing was the initial plan which has been changed. The project had one external time pressure requirement, which came from investors. It contained a request to shorten the construction phase period for 2 months. The key participants argued about it, especially contractor, but the importance and authority of investor is enabled that the project had achieved the new deadline, after the second revision of the plan. The contractor had to engage 15% more workers on the site, but the motivation was the award for earlier completion of work. The detailed analysis of performance and schedule was done for this situation. It appears that there was no decreasing productivity after shorting the deadline, which can be explained by motivation to get award of earlier completion of work.

4.3. Case study 3: Hotel Eden

Construction phase of Hotel Eden planned to last for 110 days. It consists of three parts: restaurant Oleandar, external swimming pool and wellness with additional facilities. In this project the plan was not designed in the detailed way. The monitoring and control system was applied after contracting the whole project and after the final plan approval.

The defects of plan were revealed very soon. The monitoring plan compared the planned and realized activities of main work groups, which were divided in the three main parts: restaurant Oleandar, external swimming pool and wellness with additional facilities. The work groups included earthworks, masonry, reinforced concrete works, electrical installations, and mechanical installations etc., for the each part of it. The greatest defects of the plan were done because the contractor put the start of activities towards the beginning of the project, so that they overlapped unrealistically. It caused the apparent delay in starting of the majority of group works, while activities were not even supposed to start practically. During the works the delay seemed to be decreased, while the plan was caught up the project realization. As the project was coming to the end, the delay was reduced. At the time of two weeks before planned end of the project, it was clear that the project would possibly be delayed for 2-3 days, which was acceptable for achieving the project’s success. Since the plan defects were noted at the beginning of the monitoring and control system applying, the project was monitored by two parallel systems: one by existing contract documentation and the other one by expert adjustment of existing plan, which complemented the measurable project parameters and gave the expert explanation of state of the project.

Without detailed analysis of plan, one could conclude that there is a time pressure and overrun in the early beginning of the project realization, which was not true.

Analysis of this project suggested that case study is the right research method for researching an impact of additional work on project success and that there are many preconditions that have to be clarify before any conclusions. This case study research resulted with list of concerning things to control the appropriateness of project choice.
5. Conclusions and future work

Exploring the impact of the additional workload to productivity is very challenging because the overlap with other similar issues in project management is significant. Precision, accuracy, reality and applicability of plan are limitation of research and the main reason why it is conducted only on 2 case studies. In other words, the quality of planning phase is crucial because it is impossible to make any conclusion if the plan has no listed properties (see 4.3.). Research has shown reduced performance productivity in applying additional work on projects (about 8-10 % weaker then at the time of realization according plan). The answer to the research question is: there is relationship between additional workload and productivity in the construction projects.

Creating a database with a large number of projects would provide more relevant results and enable wider conclusions. Moreover, further research could find the amount of organizational, technical and human component as parts of this impact. There was also increased productivity with reduced time pressure or extra motivation to complete the project, from which can be assumed that there is a relationship between motivation and productivity as well. Further researches include testing this relationship on greater number of projects before further conclusions.

For larger projects, a 10% decrease in productivity can certainly contribute to achieving the success of the project and this percentage should not be ignored. In other words, if additional work is applied in the project, the workers’ productivity should be calculated with 10% weaker than average or it could be compensate with more time needed than expected after revising the original one with new activities of additional work.

References