APPLICATION OF CONSTRUCTION SCHEDULE FOR MONITORING AND CONTROL OF CIVIL ENGENEERING PROJECTS

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ABSTRACT

Construction schedule becomes part of positive practice of our construction. The construction of Building and Residential Complex Stepa Stepanovic has been used for conducting research among responsible contractors on certain aspects of schedule execution, problems during its executions and use in construction process. The results of the research show that there is lack of time and professional teams to produce detail construction schedule. Possiblities provided by the project management softwares are hugh and should be used in order to better assses the current state of construction and risks that accompany it.

Key words: *construction schedule, project planning software*

INTRODUCTION

Project of organization and construction technology in our country is not a legal requirement as it is in some other countries. It typically includes: technical description, work analysis with the adopted technology, the solution of internal and external transportation, resource plan (workforce plan, materials plan and machinery plan) which are obtained as the result of norming items, construction schedule, organizational scheme, site organization scheme with the layout and security measures and protection at work [1,2].

The part on which the investors, namely supervisors, insist is the construction schedule. International banks, foreign investors, such as European Agency for Reconstruction, the World Bank and the European Bank for Reconstruction and Development require that all civil engineering agreements are made according to the methodology of the International Association of Consulting Engineers - FIDIC (Fédération International Des Ingénieurs - Conseils). Preparation of a detailed time construction plan is required according to the clause 8.3 of the Red Book of the General Conditions of contracting of FIDIC [3].

CONSTRUCTION SCHEDULE IN LEGISLATION OF THE REPUBLIC OF SERBIA

In cases where the construction of objects in Serbia is not subject to the construction according to the FIDIC methodology, the question of development of construction schedule should be defined in the

framework of local laws, rulebooks, regulations and specific common practices. It is important to point out that the existing Law on planning and construction, as well as the draft of the Law on planning, designing and construction do not mention the issue of monitoring the execution of construction works through construction schedule [4,5].

Development of schedule becomes the obligation of contractors when signing the construction agreement in which the article according to which the contractor is required to develop a detailed schedule is included or when contracting parties that are in the process of building make commitment to follow specific common practices of civil engineering.

Specific common practices of civil engineering govern the rights and obligations between the contracting authority and the contractor on performing works on construction of objects. In Part II, paragraph 12, schedule is stated as a timetable of construction, as an integral part of the construction agreement [6].

Likewise, the Rulebook on the procedure of expert supervision during the construction of the object requires that the company or a person to whom the investor has entrusted professional supervision in accordance with Article 3, paragraph 8, cover with its expert supervision particularly, among other things, "regular monitoring of the dynamics of the construction of the object and compliance with the agreed terms."

It is expected that the supervisory authority, according to the Article 8 of the same Rulebook, among other things, acknowledges "remarks regarding the quality and dynamics of construction" in writing in the building log, during the professional supervision [7]. Problems arise when the schedule does not show the real situation on the site so the person who performs supervision can hardly make a clear comparison of executed and planned.

According to FIDIC, deadline for making construction schedule is 28 days and it runs from the date of receipt of notice of commencement of works (Section 8.1 of the General Conditions of contracting) [3]. Common practice in domestic projects where the investor and the contractor are not committed to building according to the FIDIC methodology is that the Construction agreement introduces the article that requires delivery of construction schedule within seven (7) days from the date of signing the agreement [3].

SOFTWARE PACKAGES FOR CREATING SCHEDULE

The concept of project management has found wide application in the world and successful project is almost unimaginable without adequate monitoring, and that is where the software support is of great importance. Modern civil engineering practices in the Republic of Serbia apply several software packages for creating construction schedule. The most commonly used is MS Project, but Primavera Project Planner, Gala and others are also frequently used.

MS Project is a product of Microsoft and an extension of the Microsoft Office package made for project management. MS Project works in the menu and toolbar environment familiar to many users of Office.

Primavera Systems is a name that include the entire spectrum of software packages that together provide a comprehensive solution for project management. It originates from 1983, and since 2008 is owned by Oracle Corporation.

To qualitatively and quantitatively develop a construction schedule, norming should be done in some of the software packages such as Module, Gala, Pharaon, and the like. After that, all entered data are exported into a software package Primavera Project Planner and MS Project, where activities are linked and optimization is performed [1,2].

Software for project management offer many possibilities [8]:

- a clear visual representation of the entire project, phases and individual activities;
- allocation of resources to the planned tasks;
- collaboration (information and documents exchange between groups of people engaged on the same project);
- system for tracking projects by certain elements, comparison and warning of possible or resulting deviations from the planned values;
- project portfolio management (analyzing and managing group of projects);
- document management (monitoring, analysis and archiving of various electronic versions of documents);
- "workflow system" (setting up workflows, rules that connect a series of tasks);
- reporting and analysis;
- network based (Intranet and Internet).

CASE STUDY - CONSTRUCTION OF RESIDENTIAL AND COMMERCIAL COMPLEX STEPA STEPANOVIC, VOŽDOVAC, BELGRADE

Project of massive residential construction in the area of the former military barracks Stepa Stepanovic in Belgrade covers an area of 42 hectares on which 44 buildings with a total of 4,616 apartments are built. It is important to note that the works involved more than 100 local civil engineering companies. Construction period was from 2010 to 2013. [9]

Mass construction, the use of the same technology for the construction of all objects and the same contractual terms provided the opportunity to conduct research on the practical aspects of the application of schedule in the construction of buildings with the emphasis on the problems faced by contractors and supervision [9].

Interview was conducted among the responsible contractors, i.e. agreement holders in case of consortiums, which were engaged in the construction of buildings in residential - commercial complex Stepa Stepanovic. Theme of the interview was the development of dynamic plans with closed questions. Care was taken that an interview does not contain redundant questions, that it has a logical flow and to interest respondents to give answers. The advantages of closed-form compared to the open is the possibility of usage of statistical procedures for processing, possibility of repetition of interviews, analysis of time changes in responses and avoidance any possible useless extreme answers [10].

The formulation of questions in the interview, Table 1, was performed in such a manner to allow a picturesque view of the current situation in the civil engineering of the Republic of Serbia in connection to the software application for planning and monitoring the implementation of civil engineering projects. As a basis we started from:

- practical professional experiences of the authors of this paper;
- solutions applied during the construction of the building 44 of the residential and commercial complex Stepa Stepanovic in Belgrade;
- theoretical research;
- previous research on the state of our building industry in terms of the modern approach to planning, administration and management of the implementation of civil engineering projects [11].

Row data, collected through the interview have been transformed in order to be statistically analyzed with software package IBM SPSS Statistics 20. Statistic data analysis comprised following steps: the

creation of structured data base with variable definition, data input, i.e. value input for each person interviewed, variable modification with alfanumeric codes and descriptive analysis.

Table 1. Representation of questions and answers provided in the interview

Question	Possible answers		
In the creation of schedule and static plans has been engaged an external person or the person who is directly involved in the project realization?	External person	A person who directly participates in realization	-
Have you personally been making any schedules for any project before this project?	Yes	No	-
You acquired necessary knowledge for the development of construction schedule on a	course	faculty	self training
What is your professional qualification?	high school	college	faculty
Have you normed positions before making schedule?	Yes	No	Partially
What project management software do you use?	MS Project	Primavera	Other
In your opinion, is 7 days enough to produce a quality schedule?	Yes	No	-
How many people in total were involved in the development of schedule?	1	2-3	More than 3
In your opinion, how much did the real dynamics differ from projected?	Not at all	A little bit	A lot
How many years of experience do you have in the development of construction schedule?	0-3	3-5	More than 5
Have you participated in the realization of any civil engineering project according to FIDIC methodology?	Yes	No	-

Results of interviews conducted for objects of the residential and commercial complex Stepa Stepanovic related to time limits and quality of developed construction schedule and the number of persons engaged in the development of the schedules are shown in Figure 1. It should be noted that 5% of the interviewed construction companies hire external people - professional associates for creating schedules instead of hiring engineers within their company who will participate in the construction of objects [10].
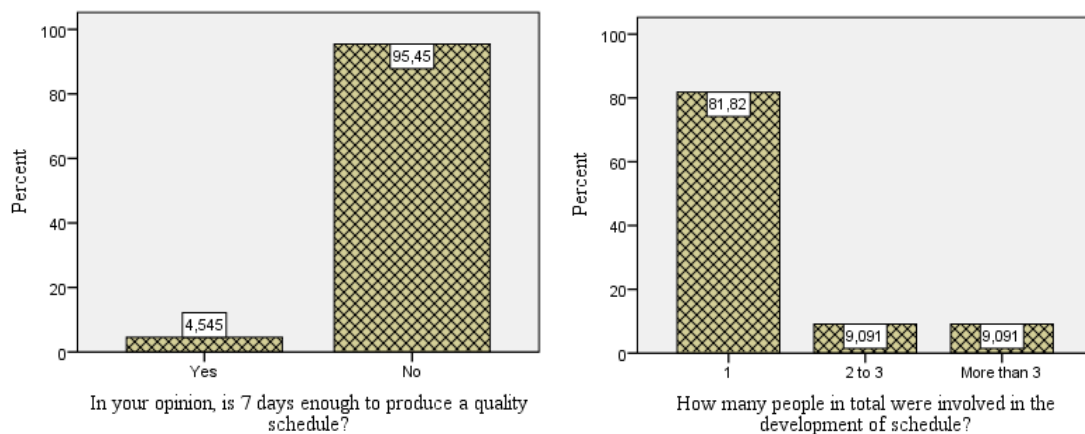

Figure 1: Results of conducted research

When it comes to application of software packages in the schedule development, results show that the most commonly used software is MS Project, and that the experience in working in the software package is in most cases gained through the practice in the company, and not in official training courses or faculties as a part of modern education, Figure 2.
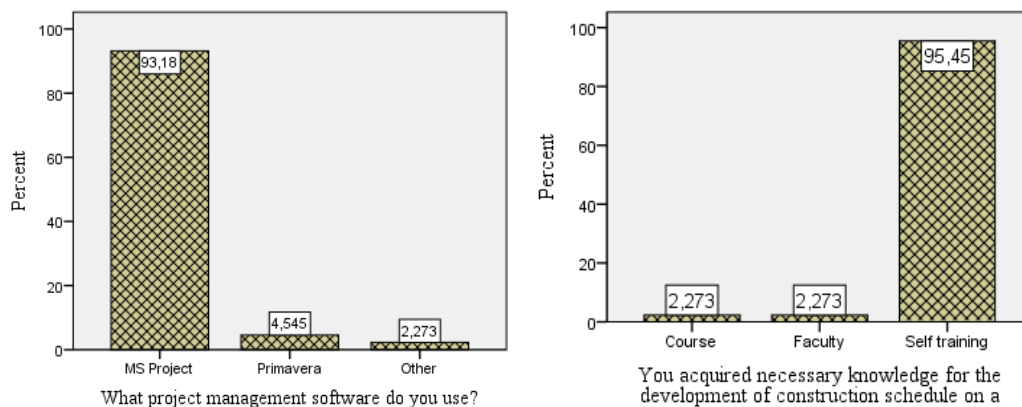

Figure 2: Results of conducted research

Previous studies in our civil engineering business in terms of the modern approach to planning, administration and management of the implementation of construction projects have shown a willingness of civil engineering companies to keep pace with the global trends and apply project management software.

Results of research conducted by a group of authors from the Faculty of Civil Engineering Management, Union University in Belgrade in 2010, which included 103 engineers, showed that only 61% of construction schedules for projects are made in some software package. Results of conducted interviews show that all schedules for the residential and commercial complex Stepa Stepanovic were made using software. In this sense we can determine significant progress [10,11].

MONITORING BUILDING DYNAMICS THROUGH RELATIONSHIP PLANNED-REALIZED

When it comes to the construction of residential and commercial complex Stepa Stepanovic we can speak of three kinds of schedules: general construction schedule, operational schedule, and so called overview.

After development of overall schedule before the start of the construction in time frame which is very short, contractors were required to develop and deliver operational schedule for the next month, during the construction at the end of the current month. This schedule should follow the general, already adopted plan, and to be more detailed. Practice has shown that there are large deviations in the planned activities of the general adopted scheduleand this operative schedule. General construction schedule was made in a short period of time with many empirically determined facts, while during the development of the operational schedules the contractor has more time, less activities, less material, equipment and people that should be entered into the plan, and based on the previously performed activities, duration can be estimated more realistic (in the case it is not normed) [9,12].

An overview is the construction schedule that compares planned and actual values: time, funding, resources, and other. It is prepared at the request of supervision only when it is assumed that the contractor is significantly late with performing works. The main indicator of the delay is Cash flow, i.e. deviation from the financial plan by month, which was an integral part of the master construction schedule [9].

Monitoring the realization of construction projects through the software package is an important step in the management of civil engineering projects that was skipped on the aforementioned complex. In

practical terms when using the software package MS Project, this would mean that for each position the actual date of commencement and completion of the works is entered, that the percent of completion of works on a weekly or, even better, on daily basis is entered.

With one look at the Tracking Gantt chart supervision would know the exact progress of the construction and whether the project is late. In Figure 3 and on example of the plastering of the VI floor it can be seen [12]:

- by master construction schedule plastering is scheduled to begin on February 11th and to last 34 days (column Baseline Start)
- plastering began on April 21st (column Actual Start)
- at the moment an overview was done, 90% of plastering was done (column % Complete)
- Finish Variance column shows that the delay in this item is 50 days
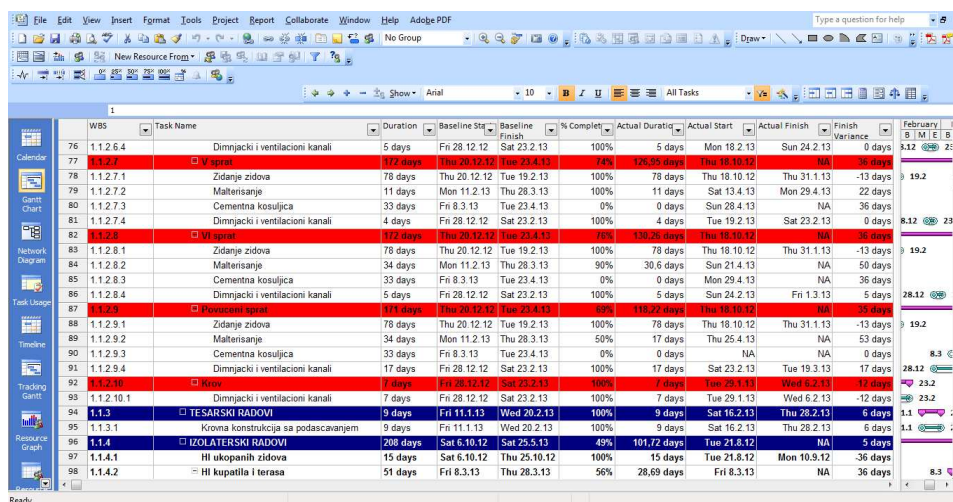

Figure 3. Tracking Gantt

It is important to point that the software package MS Project offers multiple views of the same data. Previously described screen in its right part which is shown in Figure 4 graphically represents all that is numerically given on the left side of the screen. Activities are represented by the horizontal bars that are filled to the percentage in which the activity is completed.

It should be noted that the Tracking Gantt in Figure 4 shows the activity only with a percentage of position completeness, assuming that each of them started exactly when planned, according to the master construction schedule. Such Gantt chart was made as a overview of state on one of the objects in residential and commercial complex Stepa Stepanovic, so that the investor could evaluate the progress of the works. Since Gantt chart has not been updated with data related to the actual start and completion of each activity, the only form of monitoring is the percentage of completeness of the position [9].
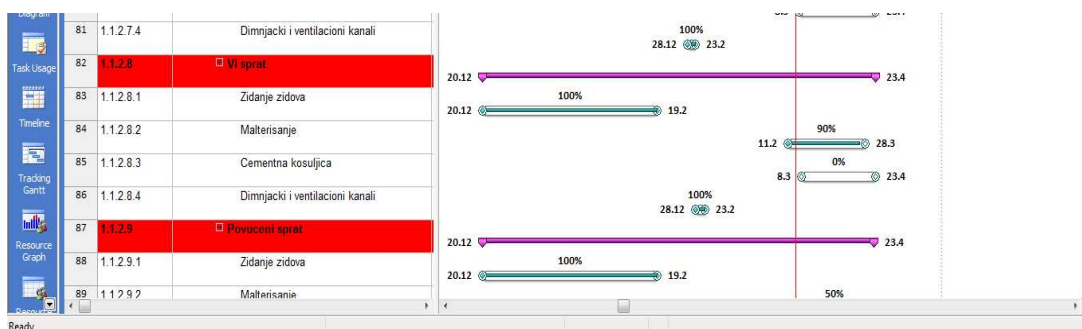

Figure 4. Activity Gantt Chart

An example of good practice is when the implementation of the project is also monitored during realization by entering relevant data in the form of the actual date of commencement and completion of activities and than it is possible to perceive in more detail the current status of the project and the risk of delay [12].

Figure 5 shows that the position of plastering of the VI floor should have begun in accordance with the master schedule on 02/11 and lasts until 03/28 (black bar), and a real start of plastering was 03/25 (blue bar).
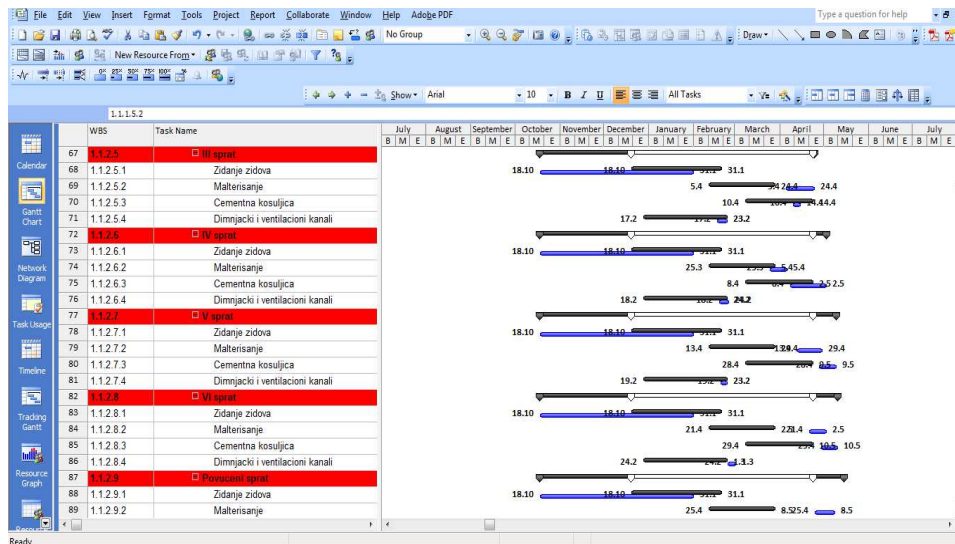

Figure 5. Tracking Gantt - good practice example [12]

Another certain sign that the project is in delay is the delay of items that are on the critical path. The critical path is the series of activities that start from the first event in the network diagram and go to the last event, have the longest duration of all paths in the network, there is no time reserve and it defines the duration of the entire project [13]. When any position that is on the critical path is not completed in planed term, every day of delay on that position directly moves the final deadline for completion of works for that same time.

CONCEQUENCES OF DELAYS IN CONSTRUCTION WORKS

The consequences of delays in construction works are not only time movements in the completion date, but also the loss of material and financial resources. Consequences are experienced by all of the investors, from constructors to future users of these objects.

Consequences should primarily include losses of a financial nature, loss of time for work execution, loss of material resources, which include various damage of resources that are not yet build in or the occurrence of errors in the derived position of works, and other losses which are essentially determined by the shape, intensity and circumstances, as well as the occurrence of some unexpected events. For example, loss of investor confidence is often more important than many material losses, because as a result this may have a denial of some privileges, without which, in the continuation of the project, other changes may occur and worsen the conditions of realization of works [9].

It is important to emphasize that risk exists in all projects, regardless of their complexity, length, size or place of performance. Even when a contractor prepares the realization of a project well, and prepares a construction schedule that is based on a detailed knowledge of the technology of all works, norms for each position of works and available resources of the company, there are still processes that can not be influenced and that may affect the realization of a segment of the project, or an entire project.

CONCLUSION

In order for a construction schedule to be of high quality and in everything in line with the real potentials of contractors, it is needed for all positions from the estimate calculation to be normed and based on the available resources of the company, to get time needed for the preparation of each position. Previous practice has shown that the contractor is not able to norm all positions with regard to the short time frame that is left for the development of schedules, rather than to empirically determine the duration of each position. This problem can be overcame by extending the term stated in the agreement from 7 to 28 days for development of construction time plan. Such practice exists in the world, and FIDIC introduced this term as a contractual obligation.

Results of the conducted research show that in the development of construction schedule for the construction of buildings in the Republic of Serbia mostly only one person was involved. Development of schedule should be subject to teamwork of more engineers from different fields.

Further research will be focused on interviewing supervising engineers within the same civil engineering projects of building of residential and commercial complex Stepa Stepanovic to gain a view from the perspective of investors and a comprehensive picture of the application of construction schedule in the monitoring and control of civil engineering projects.

(Received January 2015, accepted March 2015)

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