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INCREASING TIME-SCHEDULING EFFICIENCY IN THE BUILDING PROCESS

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ABSTRACT

The submitted paper deals with time scheduling. It concentrates on scheduling the building process and extends it by providing a way to set priorities. The priorities are evaluated from two points of view: the point of view of the building owner or investor and the point of view of the building contractor. These priorities are next used in the initiation of the relations among the scheduled activities. The utilization of priorities can contribute to preventing mistakes in creating the schedule. It could also facilitate schedule updates with changes. The contribution only contains the most important ideas for the exploitation of prioritization in the scheduling. A detailed description is included.

KEY WORDS

- scheduling,
- schedule,
- building-up process,
- building owner,
- building contractor,
- priority.

INTRODUCTION

Time, costs and quality are the basic project parameters. The subject of the construction process is a building. To keep these mostly contracted parameters is the assumption for the successful completion of the project – the building. The assumption of the time parameter is to meet the construction deadline in connection with scheduling the building process. The majority of building companies finish their construction outside the scheduled budget, deadline and quality, because they do not seriously prepare their plans. The plans, especially time plans, do not reflect the requirements, conditions, and constraints of all the construction participants and the specific building. This situation is unacceptable for the investors and building owners. For those reasons the importance of exploiting dynamic schedules in building practice is highlighted along with proposing new procedures for streamlining and developing the time schedules. In the text below, what the investor and contractor's

priorities are and the basic parameters of the project are described. It also includes how these priorities can be expressed and how they can influence the building process.

THE BUILDING OWNER'S PRIORITIES AND THE BUILDING CONTRACTOR'S PRIORITIES

The current schedules done now in the building industry neither reflect the building owner's priorities nor the building contractor's priorities. Priorities express requirements and conditions and also the constraints of both of the most important construction participants. At first these priorities have to be defined; then they need to be evaluated; then they can be used in the process of creating a schedule. If someone would like to take into consideration the construction participants' priorities by scheduling, he needs to implement the basic parameters that define all the relevant characteristics of the

Tab. 1 *The basic parameters and the criteria.*

The basic parameter	The criterion	The symbol
Costs	Amount of costs	C
Time	The observance of the beginning and ending terms of the building process	T
The quality of the building process	The acceptability of any change in the building process's specifications without an impact on the final quality of the building	Q
Scope of the building	The acceptability of any change in the scope in connection with the scheduled beginning of the appropriate building process	S

project – the building. These basic parameters were chosen in the paper and are also the basic parameters of a project globally:

- Costs – (C)
- Time – (T)
- The quality of the building process – (Q)
- Scope of the building – (S)

It is possible to evaluate each of the basic parameters. A criterion on the basis of this evaluation can be assigned every parameter. Every building project can be evaluated by the following criteria:

- **Costs – C** – express the necessity of adequate financial sources for the realization of the building project. The amount of the costs is determined for both the above-cited participants. Neither of them would like to exceed the budgeted cost and lose their profit. For that reason *“The amount cost”* will be the criterion for this parameter.
- **Time – T** – every production process and also the building process and any activities take place over time. This means each one of them has a beginning and an end. *“The observance of the beginning and ending terms of the building process”* is chosen as the criterion for this parameter.
- **The quality of the building process – Q** – represents the sum of the observance of a material's quality and the observance of the relevant building methods. A lot of changes occur during the realization of a construction. In many cases the material specifications are changed and also the technological rules are consequently modified, but the quality of the building process must remain untouched. *“The acceptability of any changes in the building process' specifications without an impact on the final quality of the construction processes”* is chosen as the criterion for this parameter.
- **Scope of the building – S** – the parameter which means the architectural and technical drawing and documents that include “what will be constructed”. It is the most important input for creating the time schedule. Many changes in the scope are initiated during the building process. But it is relevant when changes appear during the realization. The lead time should be

adequate for the amount of any changes in order to keep the contracted terms. *“The acceptability of the change of the scope in connection with the scheduled beginning of the appropriate building process”* is chosen as the criterion for this parameter.

Despite any changes the final deadline should be kept.

A summary of the chosen parameters and criteria is in table 1.

The importance of the priority of any criterion can be expressed through its weight. The weight will be indicated as the “Degree of the acceptability of change” of any criterion for every basic parameter in this case.

The weight of any criterion can only be evaluated after a detailed analysis of the requirements, conditions and constraints of any building. We will use the term “weight vector” when referring to all the weights, which expresses the priority of all criteria.

The most important construction participants are the owner and the contractor. For that reason the weight vector will be determined for both of them. The weight vector expressing the building owner's priorities will be **“the weight vector of the project”** and its symbol is w_p . It takes into consideration that one criterion is either more or less important than another, including the personal preferences of the building owner or investor. The symbols of the weights for any criterion that are included in “the weight vector of the project” are in table 2.

The weight vector of a project finally equals $w_p = [w_{p(C)}, w_{p(T)}, w_{p(Q)}, w_{p(S)}]$.

The weight vector of project - w_p is valid for the whole building project, and it is identical for all the activities. When we change the weights of one criterion, we can receive another variant of the time schedule, which can help us choose an optimal schedule, including the building owner's requirements.

The building owner's priorities have already been defined. Now we need to determine the building contractor's priorities. These priorities will reflect the building contractor's opportunities, capabilities and experience for the realization of the construction.

Every project, especially building, includes many activities that have to be accomplished for the achievement of the objective – the building. So the time schedule of a building project consists

Tab. 2 *The symbols of the weights forming the weight vector of a project.*

The criterion	The symbol of the criterion	The symbol of the weight
Amount of costs	C	$w_{P(C)}$
The observance of the beginning and ending terms of the building process	T	$w_{P(T)}$
The acceptability of any change in the building process's specifications without an impact on the final quality of the building	Q	$w_{P(Q)}$
The acceptability of any change in the scope in connection with the scheduled beginning of the appropriate building process	S	$w_{P(S)}$

Tab. 3 *The weight symbols forming the weight vector of activity A_i .*

The criterion	The symbol of the criterion	The symbol of the weight of the criterion of activity A_i
Amount of costs	C	$w_{Ai(C)}$
The observance of the beginning and ending terms of the building process	T	$w_{Ai(T)}$
The acceptability of any change in the building process's specifications without an impact on the final quality of the building	Q	$w_{Ai(Q)}$
The acceptability of any change in the scope in connection with the scheduled beginning of the appropriate building process	S	$w_{Ai(S)}$

of activities and the relations between them. To determine the priorities of the building contractor, the same criteria were chosen for determining the building owner's priorities. In contrast to the building owner's priorities, the building contractor's priorities are evaluated for every activity that has to be accomplished. The weights express how every activity is deliberated upon from the building contractor's point of view and how he is capable of realizing it. We will also use the weight vector when referring to all the weights of every activity. This weight vector was denominated as the "**weight vector of an activity** – w_A ". The weight symbols for any criterion that is included in "the weight vector of an activity" are in table 3.

The weight vector of activity A_i finally equals $w_{PAi} = [w_{Ai(C)}, w_{Ai(T)}, w_{Ai(Q)}, w_{Ai(S)}]$.

The scale of measurement can be pre-defined to express a sufficient ratio of the importance among all the criteria. A range from 1 to 5 was chosen to evaluate the importance of the weights. Every number from the range represents a verbal expression as follows:

- 1 – Unlimited acceptable change of a criterion
- 2 – Limited acceptable change of a criterion – until 50% over the plan
- 3 – Limited acceptable change of a criterion – until 10% over the plan
- 4 – Unwanted change of a criterion
- 5 – Unacceptable change of a criterion

This evaluation of the weights tells us how ready the building owner or building contractor is to admit a change in any criterion.

FINAL PRIORITIES OF THE CHOSEN CRITERIA

The final priorities will be received after multiplying the weight vector of the project - w_P by the weight vector of the activity – w_{Ai} . In principle every activity has to be multiplied by the weight vector of the project and its form is:

$$w_P \cdot w_{Ai} = [w_{P(C)} \cdot w_{Ai(C)}, w_{P(T)} \cdot w_{Ai(T)}, w_{P(Q)} \cdot w_{Ai(Q)}, w_{P(S)} \cdot w_{Ai(S)}] \quad (1)$$

The four numerical data are the result of this product – one value for every criterion.

ANALYSIS OF THE WEIGHT VECTORS' PRODUCT

The weight of any criterion can receive a value from 1 to 5 for both weight vectors. By the mutual multiplication of the values for one criterion from both the weight vectors it is possible to reach the combination of numbers included in table No. 4. There are all the potential combinations of weights for criterion "T" in this table.

Tab. 4 The potential combinations of the weight vectors' product.

Product $w_{P(T)} \times w_{Ai(T)}$		The value of the weight from the vector of project - $w_{P(T)}$				
		1	2	3	4	5
The value of the weight from the vector of the activity - $w_{Ai(T)}$	1	1	2	3	4	5
	2	2	4	6	8	10
	3	3	6	9	12	15
	4	4	8	12	16	20
	5	5	10	15	20	25

A B C D E F

The interpretation of the table No. 4:

The table is divided into several coloured fields. Every field represents a certain number or numbers that are the result of the weight vectors' product. The interpretation of every coloured field is as follows:

A and B – represent the values of a weight with a low priority both from the building owner and the building contractor's point of view. Activities with these values can be well optimised. The light green fields can be better optimised from the building owner's point of view. The dark green fields can be better optimised from the building contractor's point of view. This means the building contractor has a free hand in scheduling these activities to keep all the principles of building technology.

C – represents the value of a weight with an average priority. Activities with this value can be assigned to any coloured field. Activities can be optimised average.

D – represents the values of a weight with a high priority from the building owner's point of view. This means the building contractor has to consider these priorities by creating the schedule, and so he has to optimize.

E – represents the values of a weight with a high priority from the building contractor's point of view. The impact is that he does not have to considerate the building owner's priority as such, and he can realise the activity as he is capable of complying with the contractual conditions.

F – represents the values of the weight with the highest priority. This means that every activity with these values is important from the points of view, of both the building owner and building contractor. If the product is equal to 25, the criterion will not accept the change with this value. The activity cannot be optimised, and it is usually on the critical path in the schedule.

ATTRIBUTE OF CRITICALITY AND OF DETERMINATION FINAL PRIORITIES

Following table No. 4 it is possible to assign a criticality attribute to every number. The critical attribute verbally expresses how every activity appears from a realization point of view after the application of both the building owner and the building contractor's priorities. We can determine if the activity is or is not problematical or critical. The chosen attribute of criticality for every potential combination is in table No. 5 below.

Tab. 5 Criticality attributes.

Attributes of criticality				
Low (BO, BC)	Low (BO)	Middle (BO)	High (BO)	Critical (BO)
Low (BC)	Small (BO, BC)	Middle (BO)	High (BO)	Critical (BO)
Middle (BC)	Middle (BC)	Middle	High (BO)	Critical (BO)
High (BC)	High (BC)	High (BC)	High (BO, BC)	Critical – High (BO, BC)
Critical (BC)	Critical (BC)	Critical (BC)	Critical – High (BC, BO)	Critical (BO, BC)

BO – building owner, BC – building contractor

The final priorities can be obtained on the basis of table No. 5. But we only have verbally defined priorities. If we want to calculate the final priorities, it is necessary to transform this verbal valuation to numerical data. Table No. 5 has 25 fields (5 x 5). Different numbers from 1 to 25 have to be assigned to every field for the uniquely determined final priorities. It is in ascending order, which means the higher the number, the higher the priority. There are the uniquely determined final priorities for every criticality attribute in table No. 6:

This order was achieved by comparing the criticality attributes and the values obtained from the weight vectors' product using these rules:

- Key point – The building owner always have the higher priority because the building contractor performs the building owner's requirements,
- It is not the only priority; it has its constraints (technology, possibility of realization), where the building contractor's priorities are higher,

Tab. 6 *The final priorities.*

The final priorities				
1	3	6	10	15
2	5	9	14	17
4	8	13	20	21
7	12	19	23	24
11	16	18	22	25

Tab. 7 *The symbols of the final priorities for every criterion of the “i” activity.*

The criterion	The symbol of the final priority of “i” activity - A_i
Amount of costs	$P_{Ai(C)}$
The observance of the beginning and ending terms of the building process	$P_{Ai(T)}$
The acceptability of any change in the building process’ specifications without an impact on the final quality of the building	$P_{Ai(Q)}$
The acceptability of any change in the scope in connection with the scheduled beginning of the appropriate building process	$P_{Ai(S)}$

- The key activities are those activities where the building owner’s priorities and the building contractor’s priorities are identical. Symbols denoting the final priorities of “i” activity for any criterion are in table No. 7 below:

And, at last, the final priority of the “i” activity with the symbol P_{Ai} will be the sum of the final priorities for all the criteria of the “i” activity.

$$P_{Ai} = P_{Ai(C)} + P_{Ai(T)} + P_{Ai(Q)} + P_{Ai(S)} \quad (2)$$

It is not difficult to calculate the final priority for one activity. The building process consists of hundreds of activities. Then the calculation of the final priorities for all the activities would be time consuming. For that reason the “tool for the calculation of the final priorities” was made in Microsoft Excel with VBA Macro. This tool calculates the final priorities after inputting the weight vector of the project and the weight vector of the activity for all the activities; in addition, it enables export to the Microsoft Project (the application for scheduling and management of every project).

CONCLUSION

Using priorities for creating a schedule for the building process can help to identify which activities will be critical or problematic, although they are not on a critical path after application of network analysis methods. The proposed method of prioritization can also be used for change requests and for implementing any changes to the basic time schedule. The abovementioned tool for calculating the final priorities is possible to use for scheduling because it enables exploitation by most building companies that work with Microsoft Project software. In this way we can prevent unsuccessful realizations in the building process, which means not observing the terms, condition of the contract, money, etc.

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