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MANAGING COST AND TIME IN PROJECTS OF PUBLIC-USE FACILITIES BY USING THE S-CURVE

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Abstract

The paper presents the relation between the planned duration and costs for a project of reconstructing an overage public structure to become a public facility with social purpose. The aim of the paper was development of a management model for such projects so that they could be successfully carried out in terms of cost and time. The selected example presents the methodology of time and cost relation in the project. The selected tool for connecting the mentioned project parameters is the S-curve. The S-curve is obtained through the planning process in several steps which include creation of project WBS (work breakdown structure), cost estimate and progress chart (Gantt chart). The obtained S-curve is the basis which later serves as the indicator for project performance success. Aberrations from the planned values can be detected by comparisons, monitoring and control which enables duly reaction and undertaking specific correction measures. A quick information about key trends of the project and effects of specific decisions and measures on project cost and duration is obtained. The developed model can be applied to projects of reconstructing and reallocating public structures into public facilities with social purpose with similar technical and functional characteristics such as: size of the surface, number of floors, construction type, purpose and other.

Key words

Public facility with social purpose, reallocation, S-curve, successful project implementation

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1 INTRODUCTION

Pursuant to the Law on Space Planning of the Republic of Croatia (Official Gazette NN 153/13), public facilities are facilities intended to be used for services related to social activities. Social activities include education, educational system, science, culture, sport, health care system, social care system, state authorities and organizations, local and regional self-management authorities and organizations, associations of citizens and religious communities as well as other and similar services. It can be concluded from the definition that their structures are structures that serve people and are necessary for a modern society to function normally. Therefore, such projects are definitely required and necessary for modern users. When dealing with new structures, the interventions are usually large and expensive. One of the possible solutions is revitalization of vacant unused public structures which should be preserved from ruination and put into function, for example: revitalization of the abandoned hotel into dorm, closed factory into sports hall, commercial building into health center, etc. The most common source of financing such projects are public budget funds. However, PPP [1] model of financing public facilities has intensively been considered lately. Regardless of the source, money as well as all other resources must be used rationally. Rational use of resources is one of the main guidelines of economy which must be present in all aspects of human activities, public activities and construction industry included.

A successful implementation of the structure reallocation (change of use) project requires establishment of an efficient management system. Usually, main goals of planning and then control are prerequisites of a successful project management. Bases which are the result of planning are often indispensable and useful project management instruments. This paper puts the focus of interest on bases regarding cost and time. Since these two aspects of planning are related, they should be analyzed together. The relation is noticeable both at the level of a single activity and at the level of the whole project [2]. The costs reach their full amount only when the time cost is added [3].

The goal of this paper is to develop a project management model for reallocating public structures into public facilities so that they could be successfully performed regarding costs and time, which, along with meeting the quality criteria, is the main goal of each project. The methodology applied in the paper is based on the procedure of planning the reallocation project, all for the purpose of connecting the data about planned costs and time with a graph called the S-curve. Such presentation of cost and time relation in the later project stages is an effective tool which contributes to the successful implementation of the project.

2 COST AND TIME MANAGEMENT IN PUBLIC FACILITIES PROJECTS

A large number of projects in different fields fail to succeed in terms of satisfying the planned time and cost parameters. The aim of a successful management is to reduce overruns to a minimum or avoid them completely. The proposed cost and time management model applied in projects of reallocating public structures into public facilities consists of several related segments. Each segment of project management represents the development of a previous segment, which means that the results of a previous stage are used in the next one [4]. In the later project implementation stages these segments are the basis for monitoring, comparison and control of project cost and time stages. The segments of the model are shown in Fig. 1.

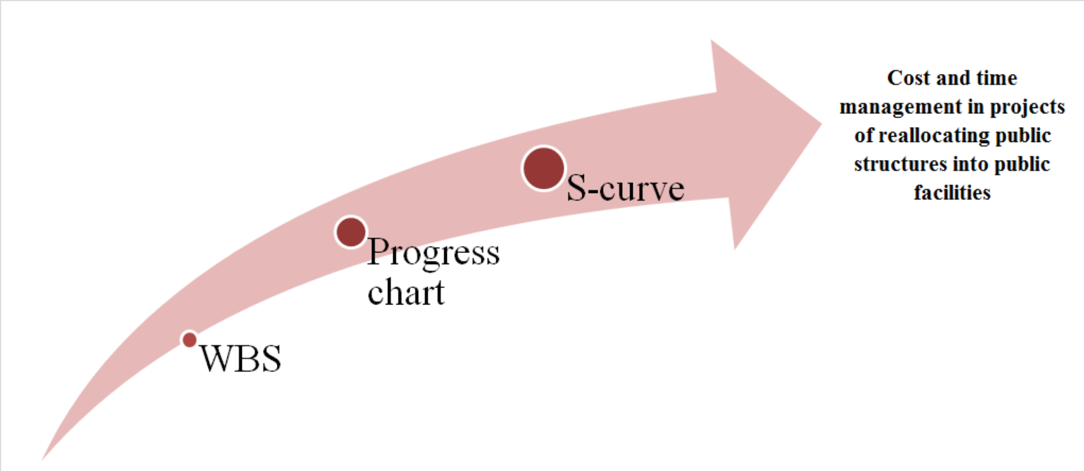

Fig. 1: Model of cost and time management in projects of reallocating public structures into public facilities

2.1 Work breakdown structure (WBS)

Work breakdown structure (WBS) is a logical decomposition of the unit into smaller parts. It represents a hierarchic structure which determines the entire project work and scope. The result of WBS technique application is an important planning segment which plays an important role in the further planning process. The main purpose of the WBS is to fully examine the project scope and provide an appropriate basis for planning the time, costs and other resources for the project. Moreover, this technique is also an aid in monitoring the project implementation development. The precision and integrity are main parameters for creating this diagram. If the process of creating the WBS is not done properly, it can result in numerous project changes, activity postponements, cost increases, that is, in endangering the final project implementation success [4].

The task of WBS is to coherently define the project downwards, to the segments which can be performed in an organized manner, that is, calculated, planned and assigned to authorized persons or departments in charge of their implementation and thus integrate efforts of different functions within the project structure [5]. The WBS distribution has an exceptional practical value in project planning because it enables the project to be divided to manageable segments, for each of which activities for their implementation must be determined according to the best management principle. Such diagrams offer the possibility of managing the implementation of each segment separately, from the lowest management level to the highest one, that is, to managing the project as a whole. It is important to keep in mind that each segment of the WBS is an integral part of the project. Activities are operations which must be undertaken to complete a specific segment of WBS. There is no unique way of creating the WBS for all projects. The creation steps should be the same and include the following: collection of data, selection of a method (types of WBS), determination of details and creation of a structure [2].

An example of a part of WBS for the project of public facility reallocation is shown in Fig. 2. The first level of WBS is the entire project which is then divided into smaller subprojects according to type of activity. The subprojects are then divided into activities. Fig. 2 also shows the examples of subprojects and activities which can occur in projects of reallocating the structures into public facilities.

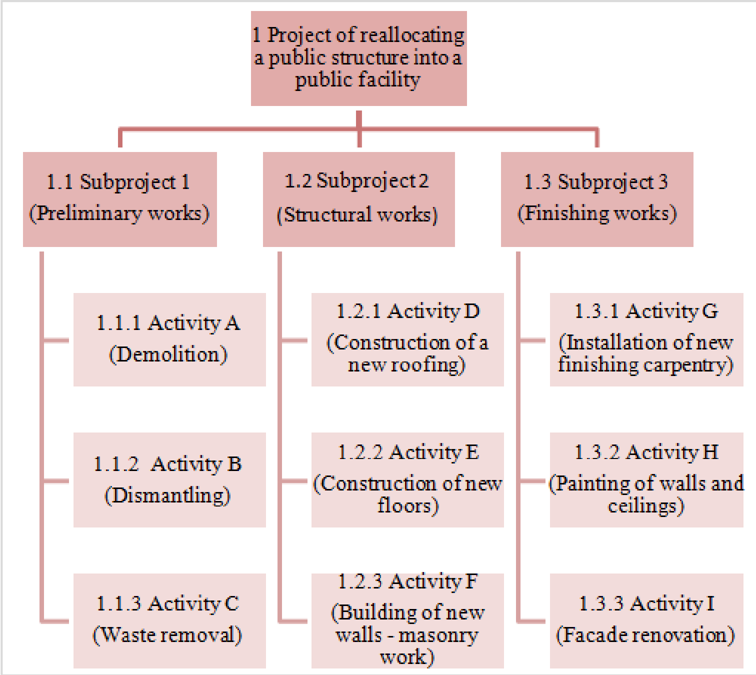

Fig. 2: An example of a part of WBS structure for a project of reallocating a public structure into a public facility

Based on such WBS, the next planning stage follows, which is creation of a progress chart for construction.

2.2 Progress chart of construction work

The final goal of creating a timetable is creation of a realistic project plan which serves as the basis for monitoring the project time progress. The project is elaborated with a WBS and the activities required for completing the project are obtained. Before the progress chart is created, the duration of each activity must be defined, but the resource quantity and type in terms of manpower, equipment and materials must be determined even before that. Besides creating a basis for activity duration assessment, the assessment of required resources offers significant information for project cost assessment [4].

Before the progress chart is created, the activities must be properly determined and distributed and their relations must be defined. The progress chart is usually presented as a Gantt chart. The planned duration of the project is obtained based on the Gantt chart. Project costs must be added to the duration of the project. The planned project cost data is determined by calculation. The task of the planning is to determine the time dynamics of amounts of money which have been calculated in price analyses and entered into cost estimate items. During the planning stage, the focus is on planned price/costs, which means that they have been calculated before the work implementation. However, there is a possibility of deviating from the final or real value which can be determined only after the works in question have been completed [2].

After the cost estimate has been created, the cost can be assigned to the activities in the Gantt chart. Tab. 1 shows an example of time allocation of costs assigned to activities. The obtained data will be used for constructing a graph which connects project costs and time, that is, the S-curve.

Tab. 1: An example of movement of money on Gantt chart for a project of reallocating the public structure into a public facility

WBS code	Activity	Duration (in days)	Costs (m.u.)	1	2	3	4	5	6	7	8	9	10
1.	**Project of reallocating the public structure into a public facility**	**10**	**22**										
1.1.	Subproject 1	5	7										
1.1.1.	Activity A	2	2	1	1								
1.1.2.	Activity B	1	2			2							
1.1.3.	Activity C	3	3			1	1	1					
1.2.	Subproject 2	5	8										
1.2.1.	Activity D	3	3					1	1	1			
1.2.2.	Activity E	2	2				1	1					
1.2.3.	Activity F	2	1							0.5	0.5		
1.3.	Subproject 3	3	9										
1.3.1.	Activity G	1	2								2		
1.3.2.	Activity H	2	4									2	2
1.3.3.	Activity I	1	3										3
Daily costs				1	1	3	2	3	1	1.5	2.5	2	5
Cumulative costs				1	2	5	7	10	11	13	15	17	22
Weekly costs										13			22

2.3 Interconnection of time and money in the project – the S-curve

The interconnection of time and money in the project is indeed one of more important planning tasks. The cash flow is shown as a cumulative projection of money depending on time. The obtained curve is called the S-curve and it usually shows the cost-time relation in the project. S-curves are widely applied in project management and it is interesting that the records about their application date from 1928 [6].

Researches on curves are numerous and a number of authors who have been studying their application in construction projects can be listed. One of them is Boussbain who dealt with the analysis of the cash flow in projects [7], while e.g. Miskawi developed the S-curve equation for project control [8]. Tucker and Rahilly studied the model of cash flow in projects [9] as well as Radujković and Izetbegović who studied the selection of functional connections while conducting the research on S-curve trend [10], Ostojić-Škomrlj dealt with the S-curve prediction model in early construction project stages [3] and so on.

The most common resources whose summary value in time is shown with S-curve are the number of products, workers, costs… This paper puts the emphasis mostly on costs and thus the S-curve can be defined as a graphic presentation which represents a cumulative cash flow during a certain period, where time is shown on the abscissa and costs on the ordinate. When constructing the curve by points, time intervals are applied to the horizontal axis and the associated cost value, counted from the beginning to this very moment, to the vertical one [2]. Fig. 3 shows the example of an S-curve for projects of reallocating structures into public facilities based on cost shifting on the Gantt chart shown in Tab. 1.

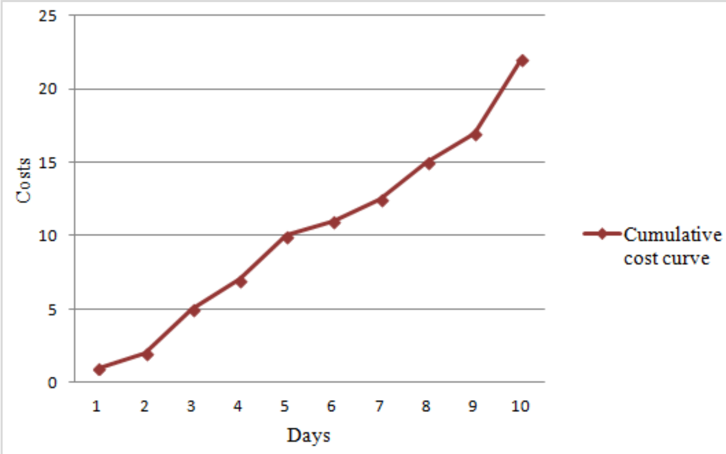

Fig. 3: An example of an S-curve for a project of reallocating a public structure into a public facility

During the cost and time control, two S-curves are usually applied in the project: one for the planned stage, and the other for the real execution of the plan. Such presentation of the project plan and its implementation provides a very precise image of trends and a quality insight into the stage of the each project part. Such presentation provides three important information: which stage we should be in (planned costs-time), which stage are we in (executed costs-time) and which stage should we move to (predicted costs-time). The prediction can be made after one-fourth or one-third of the total project duration time when the S-curve execution geometry is perceived and the curve is extended to the end with an imaginary line of a natural sequence. It is then possible to determine also the final result but under assumption that the same work is continued or some control and corrective measures are ordered which can change the execution trend. The curves of the planned stage and implementation are constructed in the same way but with different data shown in Tab. 2. These two curves may overlap; this happens when the project is fully executed according to the plan [2].

Tab. 2: An example of a planned stage and execution of the public facility reallocation project

	1	2	3	4	5	6	7	8	9	10
Daily planned costs	1	1	3	2	3	1	1.5	2.5	2	5
Cumulative planned costs	1	2	5	7	10	11	13	15	17	22
Daily executed costs	2	1	3	2	3					
Cumulative planned costs	2	3	6	8	11					

The result of this table is a graphic presentation of costs in time where planned and real costs shown in Fig. 4 can be easily followed. If there is a significant deviation from the planned, it is easily visually observed so that a timely reaction can lead to corrective measures can be taken such as: increasing the number of workers, work hours, machines, introducing two shifts, etc. [11].

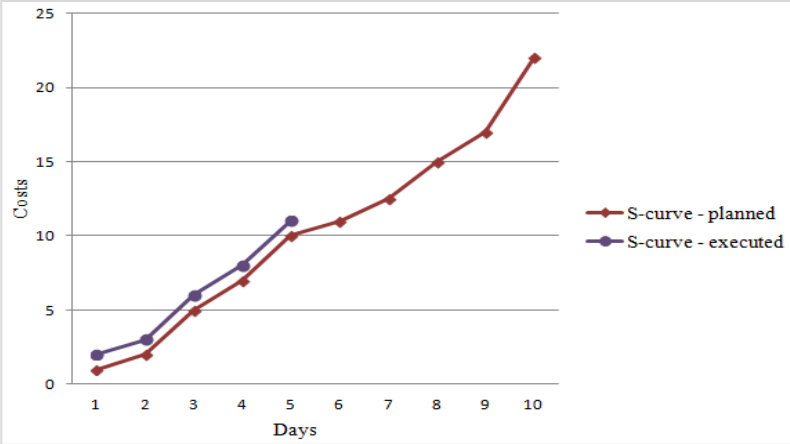

Fig. 4: S-curve for data from Tab. 2

The application of S-curve is wide and they are mostly applied at middle and higher management levels in time and financial control of work stages. They are especially applied by the project managers and managements wishing to obtain quick information about key project trends and effects of some decisions and measures on project duration and costs. S-curve is also applied for more complex analyses of project execution monitoring such as the Earned Value method [2]. Earned Value method is measuring project performance and progress from the viewpoint of achieving the scope, schedule and costs, and is integrating these parameters into a single system [12]. This method enables detection of earliest signs of problems related to the project and offers the swiftest method of obtaining information about how the project will end. It also enables recognition of potential project budget overrun, detection of possible risks and errors which can influence project success [13].

3 AN EXAMPLE OF A PROJECT OF REALLOCATING A PUBLIC STRUCTURE INTO A PUBLIC FACILITY

The applied methodology of planning the public facility project in order to manage costs and time in project has been applied to the planned project of reallocating the old city heating plant in Osijek, widely known as "Munjara" (Fig. 5, Fig. 6). Since Osijek would like to become the European Capital of Culture, there is a need for a technical museum, the capacity of which "Munjara" entirely meets. Thus, the idea of reallocating "Munjara" into the museum was born. As part of the conducted research, all important structural parts of the building were visited and photographed. Interviews were carried out with users of the building who, for the purpose of this research, have provided all the necessary descriptive documentation. Part of the relevant information about the building was gathered from the available printed and electronic sources.

Fig. 5: South view of "Munjara" building [14]

Fig. 6: East view of "Munjara" building [14]

"Munjara" building was built between two world wars and is one of the most valuable examples of modern architecture in Osijek. It was damaged in the II. World War and also later in the Croatian War of Independence but was never completely demolished, which speaks about the quality of its construction. Considering that until recently it was used as a reserve drive of Osijek heating plant which will soon be moved to another location, it is very well preserved and its reallocation does not require major investment. With its new function, this structure would be preserved from deterioration and its users could significantly enrich the regional cultural offering with their work and projects and a remarkable social and creative meeting point could be entered into the city map [15].

"Munjara" building was built as a two-nave building. Its ground plan dimensions are 38x33 m. It consists of two interconnected but functionally separate units and a chimney whose furnace is part of the larger nave. It covers 4 floors and has a total surface of about 3000 m². The rooms in the building are large, spacious and have a lot of light, which is typical for the architectural period of its construction. The building was constructed with a combination of concrete, reinforced concrete, steel and brick. The outer walls are 45-60 cm thick, with masonry consoles and the inner walls, such as e.g. furnace walls, are up to 90 cm thick. In the smaller nave and in west parts of the building traces of reinforced concrete in form of mezzanine constructions can be seen. Roof construction is steel latticework structure and the static system is a continuous beam across 6 spans. Regarding its age, purpose and numerous demolitions through history, the building is in a very good condition, which will reduce renovation costs.

The interventions which should be undertaken for reallocating the building into a museum include interior and exterior design and landscaping. The interior design includes works on installing new constructions such as: replacement of the roof girder, setting a new roof layer, renovation of floors, replacement of finishing carpentry, new furniture, and other. Exterior design includes demolition of buildings which are not part of the project, building of new traffic and pedestrian surfaces and horticulture [16].

After all the required data and documentation have been collected, planning of the reallocation began and a WBS, a progress chart and finally the S-curve which connects the planned costs and planned time in the project were created, all for the stage of work.

3.1 WBS of ''Munjara'' building reallocation project

The created WBS was oriented towards the structure, that is, the contents of the project were divided into physical units. It has been developed from the highest towards the lowest levels. The first WBS level is the whole project which is then divided according to the type of work to smaller subprojects, which are: preliminary works, demolition and dismantling, works of installing new constructions and finishing works, works on fittings, works on exterior design and, finally, works on equipping the museum. The lowest level of the WBS are activities. Project WBS is shown in Fig. 7 and Fig. 8.

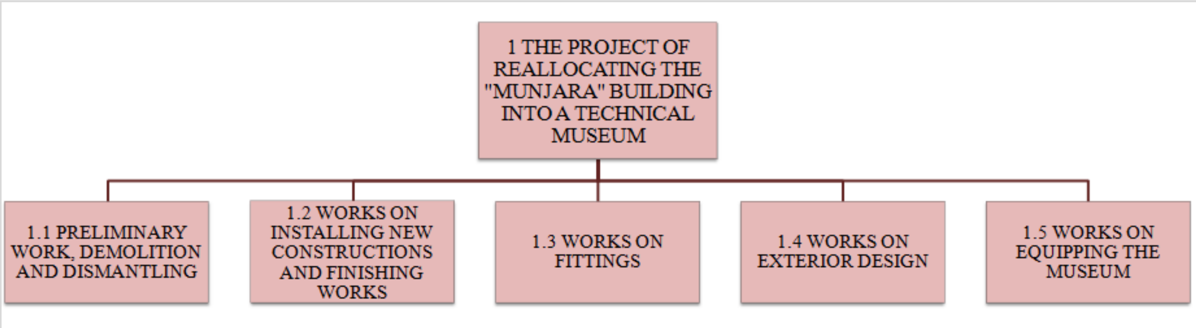

Fig. 7: WBS structure explained to the 2. level for the project of reallocating the "Munjara" building into a technical museum [14]

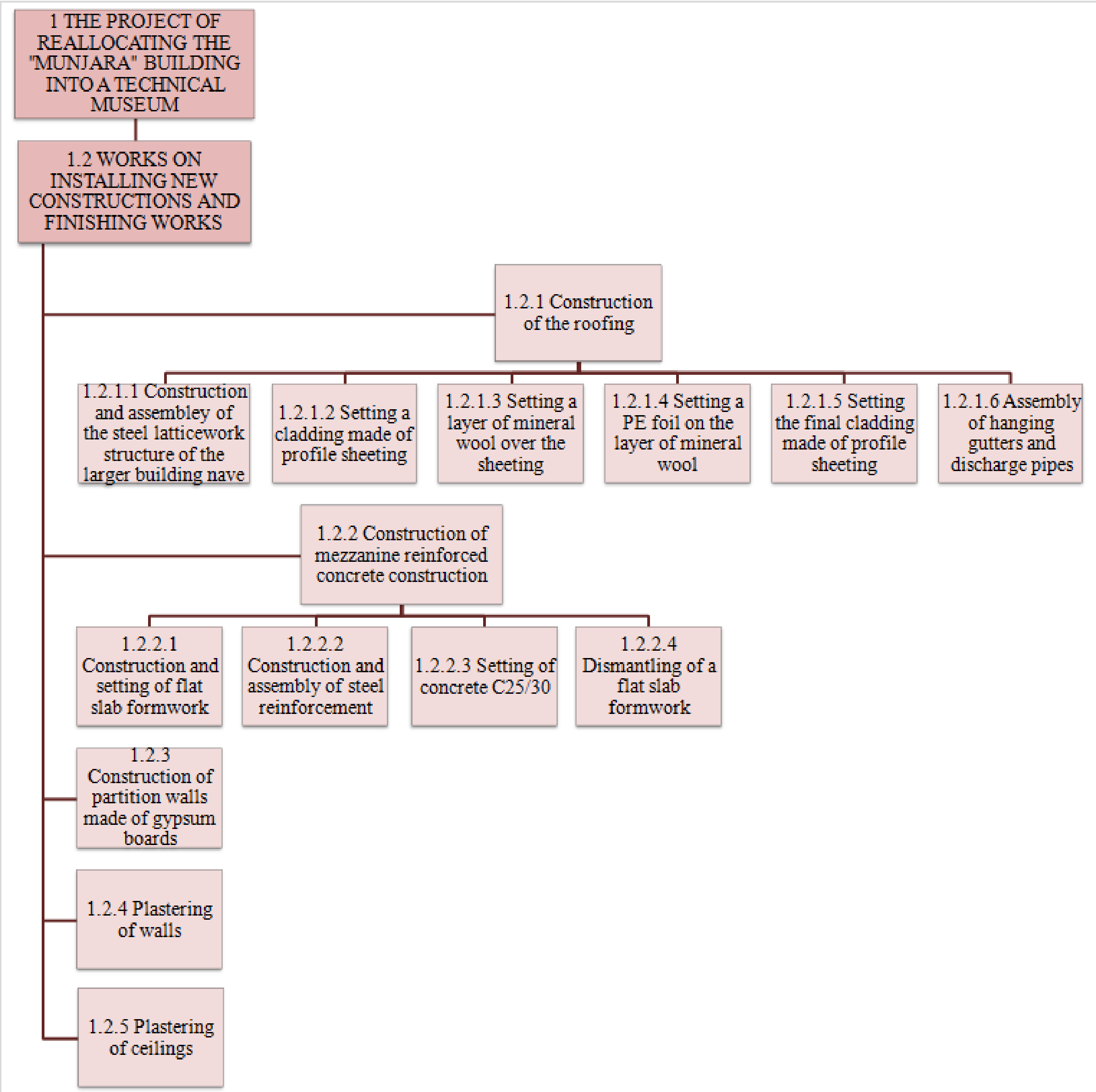

Fig. 8: Part of the WBS structure for the project of reallocating the "Munjara" building into a technical museum [14]

3.2 Gantt chart for the project of reallocating the ‘‘Munjara’’ building into a technical museum

The created progress chart is in Gantt chart form (Fig. 9). A workweek consists of 6 work days, Sunday excluded. Daily working time is 9 hours. The plan includes 78 activities which are interrelated with time relations: FS – end-beginning, SS – beginning-beginning, FF – end-end. The total project duration time is 433 work days. Before the Gantt chart was created, the duration of activities and the necessary number of resources were determined.

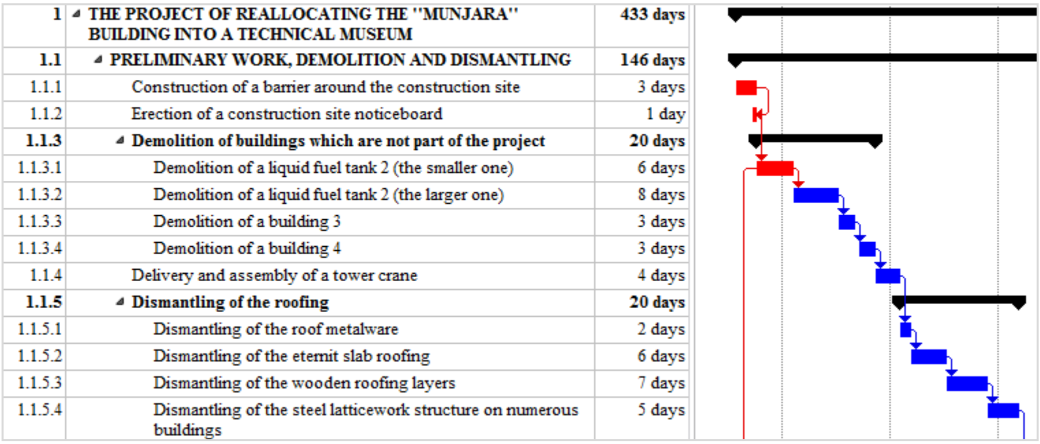

Fig. 9: Part of a Gantt chart for the project of reallocating the ‘‘Munjara’’ building into a technical museum [14]

3.3 The S-curve for the project of reallocating the ‘‘Munjara’’ building into a technical museum

After the cost estimate was made, costs were assigned to the activities and cash flow on Gantt chart was obtained based on which the S-curve was constructed. The same graph also shows the bar chart of costs in order to obtain a better insight into the cost change according to time (Fig. 10). The data on costs in the bar chart were obtained by projecting the cost data over activities in the Gantt chart. By checking the number of costs for each activity, day by day on the Gantt chart time scale and adding them along each day, data on total planned cost amount for each day is obtained [2]. The time unit in the presented cash flow is one trimester. All costs are expressed in Kuna.

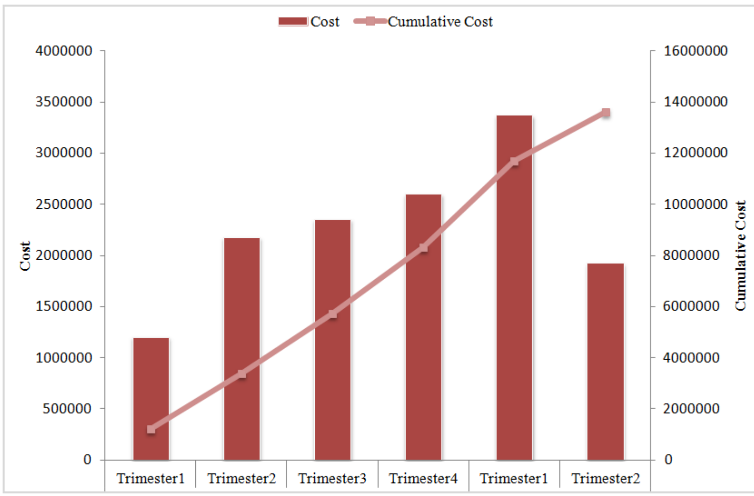

Fig. 10: Cash flow in the project of reallocating the ‘‘Munjara’’ building into a technical museum [14]

After the stage of project documentation development, that is, final design development was completed, data on realized costs is obtained. By comparing the planned and realized costs, a graphic presentation of costs in time is created, from which the planned and realized costs can be easily followed (Fig. 11).

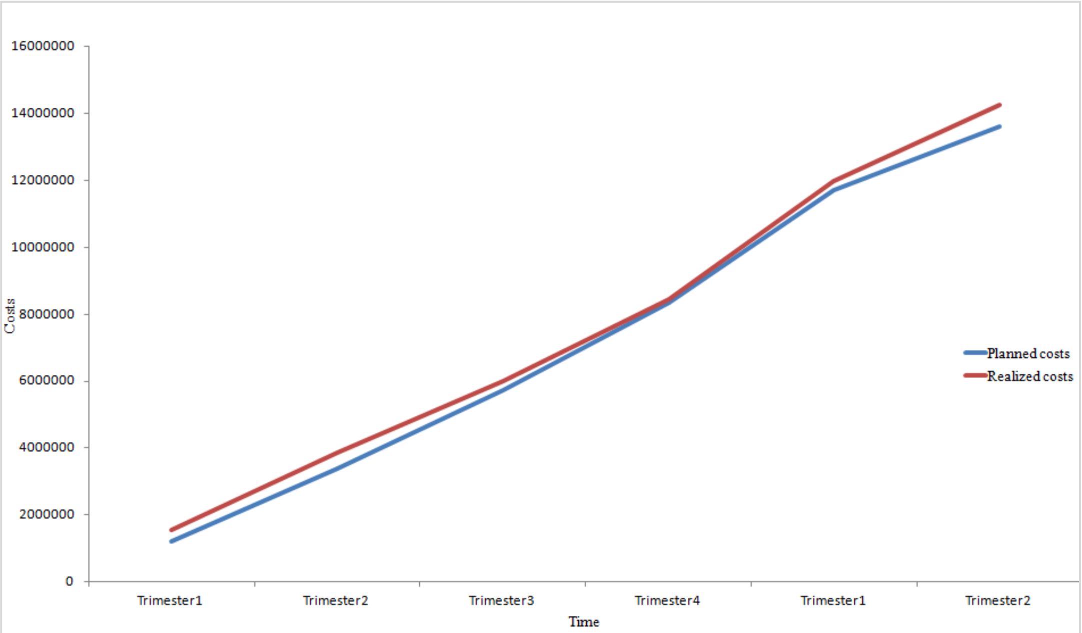

Fig. 11: Comparison of planned and realized costs for the project of reallocating the ''Munjara'' building into a technical museum [14]

Deviations of costs and time are visually easily noted and a timely reaction can lead to corrective measures such as: increasing the number of workers, work hours, machines, introducing two shifts, etc

4 CONCLUSION

Time and cost management is the basis of a quality project management. These parameters enable a constant monitoring of single activities, parts of projects and project as a whole.

This paper presents a model of cost and time management based on the S-curve in projects of reallocating public structures into public facilities. The application of the proposed model is shown on a concrete example of reallocating the "Munjara" building in Osijek into the Technical museum. The S-curve was chosen as a tool of management in the mentioned projects because it is simple to apply, easy to understand and enables quick information about cost and time trends in the project. By monitoring, comparing and control, any deviation from the planned is quickly identified and a timely reaction can lead to undertaking corrective measures.

The successful execution of the project implies the realization of planned costs and planned construction deadline along with meeting the quality requirements, to all of which the application of the S-curve greatly contributes.

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