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APPLICATION OF NETWORK PLANNING TECHNIQUE IN BUILDING CONSTRUCTION

Abstract

The "plan" for the completion of any building is represented by a number of linked plans. Planning is the production of budgets, schedules, and other detailed specifications of the steps to be followed and the constraints to be obeyed in project execution. No matter the type of the project there is always a need for a plan. Construction projects are very complex in nature, so proper planning can ensure that things happen successfully.

Modern planning can be implemented in every project stage with logical updating as the project advances. Construction planning can be oriented towards time and costs. These parameters are mutually related, and they should give a general or detailed view of the length of the construction, cash flow and in some cases the risks that may occur. The planning can be done with detailed review of the design with communication with the Investor and Contractor. Nowadays project scheduling and planning is usually done with software solutions which result in Gant charts, network diagrams, linear plans, etc.

This paper shows time planning of parallel construction of three buildings, as part of a hotel complex, in Republic of North Macedonia using MS Project. The general purpose and goal of the analysis conducted in this paper is to show that adequate planning can significantly improve the overall construction process, resulting in lowering the total duration of the project, while respecting of the major milestones, smaller investment costs and better insight during the whole construction process.

Keywords

Network planning; parallel construction; MS Project; building; technology of construction.

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1. INTRODUCTION

Planning is more than an aid to the successful completion of the project, it is an essential part of the project. All those responsible for the management of construction work, client, designer, contractor and subcontractors, need to plan. Each party within a project will be working to a different schedule that reflects their own requirements [1]. Proper planning can eliminate uncertainties in the project which are connected to the schedule, cost, environment, performance and client [2].

Efficient and high-quality project management and construction planning implies the use of quality planning and management methods, among which network models and Gant charts occupy a significant place [7, 8, 11].

Timely forecasting and planning allows a better division of work tasks, more rational application of construction machines, better use of working time and resources, increase in productivity and economy, reduction of losses in production, etc [4, 5, 6].

The construction time has multiple effects on the total cost of the civil engineering structures. Regular monitoring and control of the dynamics of construction by taking adequate measures to maintain the planned dynamics can significantly affect the investment cost of the construction, which increases the saving of financial resources during the construction, and at the same time increases return on investment in exploitation [4, 5, 6].

Therefore, in this paper a time planning and scheduling has been shown applied for the construction of three buildings, as part of a hotel complex located in the Republic of North Macedonia, with the application of MS Project. A method of parallel construction has been proposed in order to reduce the total construction time, while respecting the real local conditions, demands and requests given from the Investor, adopted organization and technology of construction and overall risks and uncertainties that might occur during the construction period.

2. DESCRIPTION OF THE TECHNICAL SOLUTION

The building complex located in Republic of North Macedonia is designed from three blocks with basement, ground floor and 4 additional floors. All three blocks are planned as independent buildings connected with the same basement which is underground parking.

The entrance to the construction site is located on the eastern side, from where you can access an internal one-way street. The internal thoroughfare provides vehicular access to the three blocks and two ramps, one of which is for the entrance and one for the exit of cars in the basement, where the parking lots will be located. Parking lots are also located in the building plot at ground level, a total of 63 parking spaces.

Figure 1. Horizontal layout of the three blocks

Block 1 is located on the southwest side of the plot. The entrance to the building is located on the west side. On the ground floor, the hotel contents (hall, lobby, reception, info desk, cafeteria, restaurant, kitchen, warehouse, 3 conference rooms, administration and sanitary facilities) rooms in the function of the hotel, which will serve the three blocks, are provided. Apartments (hotel rooms) are located on the floors. There are 13 apartments on each floor. Block 2 is located on the south-eastern side, which houses a total of 64 apartments. The entrance to the building is located on the east side. There are 12 apartments on the ground floor, and 13 apartments each on the first, second, third and fourth floors. Block 3 is located on the north side, which houses a total of 64 apartments. The entrance to block 3 is located on the south side of the building. There are 12 apartments on the ground floor, and 13 apartments each on the first, second, third and fourth floors. All three blocks are accessible for people with special needs. In accordance with the regulations, a total of 9 apartments are provided for people with special needs.

The structural system of the building is skeletal reinforced concrete, with reinforced concrete, columns, beams, floor slabs and foundation slab. All load-bearing concrete elements will be constructed with MB30 concrete, and the planned reinforcement is RA 400/500-2. The facade masonry is from ceramic blocks d=20cm with thermal isolation, and the internal walls with ceramic block d=12cm. The layout of the basement is 8347 m^2, two block are 1524 m^2 and the last block 1220 m^2. The treatment of the walls will be done according to the purpose of the rooms, so that the living and resting rooms will be plastered on both sides in two layers and treated with white color, while the bathrooms and toilets will be treated with ceramic tiles. The roof is a flat slab. Above the roof slab are the elevator houses for the two elevators, which are located within the roof silhouette and the stairwell with exit to the roof for cleaning and maintenance. The exterior appearance of the buildings is identical, clean modernist with accented bay windows. Flat surfaces, large window openings and large balcony doors for access to the terraces dominate. The semicircular parts of the buildings have a structural facade. The buildings will be dominated by greenery, that is, there will be gardens on the terraces. The terraces will have glass fences. The electrical, plumbing and sewage installations are adapted to the purpose of the building for its smooth functioning. The facility will provide heating and cooling of the rooms with inverter air conditioners. All apartments have separate heating and cooling with inverter air conditioners. Connection for electric power supply from the existing electric city power supply network. Water supply and sewage connection from the existing street network. Connection of a PTT installation from an existing city network.

3. PLANNING OF THE BULDING CONSTRUCTION

In order to propose the most suitable and adequate construction plan, several different options were analyzed in detail. The methodology of the analysis and research consisted of: deep and thorough research of all the relevant literature (theoretical and expert) regarding the construction planning, analysis of different methods and techniques that can be applied when planning the construction process, detailed analysis of the whole technical documentation for the hotel complex, gathering relevant data and information about the location of the construction site and all of the specific characteristics of the project, analysis of the technology of construction suitable for the chosen Contractor, meeting with the Investor for obtaining information about his specific requests and demands, applying different software that can be used for planning, analysis of several different scenarios for the realization of the construction project and analysis of the method for parallel construction of the buildings that can result in lowering of the total construction time while respecting of the predetermined project budget.

After all of the research and analysis it was decided to use MS Project for the planning of the construction of the above described hotel complex, taking into account the positive and negative aspects of different technologies of construction. All the specific requirements and demands of the building and its location were analyzed in detail and incorporated into the final solution of the network plan [14, 15, 16, 17, 18].

There are many different construction activities that depend on the technology of construction, specifics of the designed structure and the location, thus it is very important to choose an optimal solution for their realization in order to obtain a high quality construction but with smaller investment costs and in shorter possible time. A short description of some of the project activities is given as follows.

The initial activities on the ground include the geodetic marking of the plot and the buildings, as well as the positioning and staking of the building, on the ground with appropriate signs. Furthermore, it is planned to start the construction of preparatory activities within the framework of organization of the construction site: installation of a fence made of ribbed sheet metal, installation of an information board, installation of a container for the needs of the supervisory authority and a mobile sanitary cabin, organization of storage facilities for tools and equipment, solving horizontal and vertical transport through the construction site, etc. The construction of the building begins with the earthworks. Given that the basement part is common to the three blocks, it is planned to complete it as a set. After the surface clearing of the terrain and the excavation of the humus, it is planned to start with a wide mechanical excavation of the ground (if necessary and manual digging) in a maximum depth of 5.5 m. The excavated material can be left, in a suitable place, on a construction site, and if it is of satisfactory quality and suitable characteristics, part of it can be used for filling the construction pit, and after construction of the basement part. Excess material from the excavation will need to be loaded and transported to a landfill outside the construction site. After completing the excavation of the ground up to the designed level of the foundation, the filling of the tampon layer of gravel with a total thickness of 1.0 m begins. It is planned to compact the tampon material in layers with a thickness of 10 to 20 cm. A layer of loose concrete with a thickness of 5 cm will be placed over the gravel material. The next activity is the construction of the foundation slab, which is designed as an RC slab with a thickness of 120 cm. This activity includes several standard sub-activities, such as: procurement, transport and installation of required reinforcement, placement of formwork, concreting and dismantling of formwork. After the completion of the foundation slab, it is planned to start the construction of the RC basement walls and columns at level -1 (basement part), followed by the construction of the RC slab and beams at the same level.

The construction of the buildings from Block 1, 2 and 3 technologically is very similar and includes generally same construction activities, according to the design solution for the selection of the construction system and applied materials. It is adopted to first construct the entire RC structural system, starting from level 0 to level +4, through the construction of RC columns, inter-story structures (RC slabs) and beams. After the completion of the slab of the top floor, the construction of the facade walls and the interior walls can start, again from level 0 to level +4. Furthermore, it is planned to construct the façade of the building together with all associated installations from the outside. In parallel with the construction of the facade, the plumbing and electrical installation can be carried out inside the building, floor by floor. As soon as the plumbing and electrical installation is carried out, installation of windows and interior plastering of the walls can begin. The tiling and installation of tiles on each floor is scheduled to begin at least 7 days after the completion of the interior plastering, and the installation of the parquet 20 days after the plastering. The final phase of the installations is scheduled to begin after finishing the plastering, as well as the installation of tiles and parquet. At the end, the interior doors are installed, progressing floor by floor. After the doors have been installed, tiling in the building's corridors and common (staircase) rooms can begin. Finally, the roof structure is constructed. After all the construction, construction-craftsmanship and finishing works are completed, it is planned to carry out the paving around the building, to arrange the ground floor of the entire site and to demonetize all the temporary buildings that were placed on the construction site.

According to the requirements of the Investor, the construction of the building was planned to start on September 1, 2023 with the construction of Block 1 and Block 2. After the completion of the construction of these two blocks, it was planned to start with the construction of Block 3.

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		Организација на градилиште	14 days	Fri 01.9.23	Wed 20.9.23	
2		Ископ на хумус	2 days	Thu 21.9.23	Fri 22.9.23	1
3		Широк ископ	45 days	Mon 25.9.23	Fri 24.11.23	2
4		Мршав бетон за темелна плоча	7 days	Mon 27.11.23	Tue 05.12.23	3
5		Темелна плоча	30 days	Thu 29.2.24	Wed 10.4.24	4
6		Подрумски ѕидови и столбови ниво -1	30 days	Thu 11.4.24	Wed 22.5.24	5
7		Плочи и греди ниво -1	30 days	Thu 23.5.24	Wed 03.7.24	6
8		Насип	15 days	Thu 04.7.24	Wed 24.7.24	7
9		Столбови ниво 0	10 days	Thu 04.7.24	Wed 17.7.24	7
10		Плочи и греди ниво 0	10 days	Thu 18.7.24	Wed 31.7.24	9
11		Столбови ниво +1	10 days	Thu 01.8.24	Wed 14.8.24	10
12		Плочи и греди ниво +1	10 days	Thu 15.8.24	Wed 28.8.24	11
13		Столбови ниво +2	10 days	Thu 29.8.24	Wed 11.9.24	12
14		Плочи и греди ниво +2	10 days	Thu 12.9.24	Wed 25.9.24	13
15		Столбови ниво +3	10 days	Thu 26.9.24	Wed 09.10.24	14
16		Плочи и греди ниво +3	10 days	Thu 10.10.24	Wed 23.10.24	15
17		Столбови ниво +4	10 days	Thu 24.10.24	Wed 06.11.24	16
18		Плочи и греди ниво +4	10 days	Thu 07.11.24	Wed 20.11.24	17
19		Ѕидови (надворешни) ниво 0	10 days	Thu 21.11.24	Wed 04.12.24	18
20		Ѕидови (надворешни) ниво 1	10 days	Thu 05.12.24	Wed 18.12.24	19
21		Ѕидови (надворешни) ниво 2	10 days	Thu 19.12.24	Wed 01.1.25	20
22		Ѕидови (надворешни) ниво 3	10 days	Thu 02.1.25	Wed 15.1.25	21
23		Ѕидови (надворешни) ниво 4	10 days	Thu 16.1.25	Wed 29.1.25	22
24		Фасада и надв. Инсталации ниво 0	7 days	Thu 30.1.25	Fri 07.2.25	23;8
25		Фасада и надв. Инсталации ниво +1	7 days	Mon 10.2.25	Tue 18.2.25	24
26		Фасада и надв. Инсталации ниво +2	7 days	Wed 19.2.25	Thu 27.2.25	25
27		Фасада и надв. Инсталации ниво +3	7 days	Fri 28.2.25	Mon 10.3.25	26
28		Фасада и надв. Инсталации ниво +4	7 days	Tue 11.3.25	Wed 19.3.25	27
29		Ѕидови (внатрешни) ниво 0	10 days	Thu 30.1.25	Wed 12.2.25	23
30		Ѕидови (внатрешни) ниво 1	10 days	Thu 13.2.25	Wed 26.2.25	29
31		Ѕидови (внатрешни) ниво 2	10 days	Thu 27.2.25	Wed 12.3.25	30
32		Ѕидови (внатрешни) ниво 3	10 days	Thu 13.3.25	Wed 26.3.25	31
33		Ѕидови (внатрешни) ниво 4	10 days	Thu 27.3.25	Wed 09.4.25	32

Figure 2. Part of the Gant chart for the chosen solution

During the development of the Work Plan, normal working hours have been adopted, from 8:00 a.m. to 4:00 p.m., from Monday to Friday. Saturday and Sunday are scheduled as non-working days. The construction is planned to start on September 1, 2023. The preparatory activities, as well as the common activities for all three blocks (organization of the construction site, excavation of the ground, construction of the foundation slab, etc.) will end on March 19, 2023. Block 1 and Block 2 will be constructed in the same period of time, which means that the Contractor should provide a sufficient number of workers and construction machines that will be able to complete the corresponding activities in parallel on both blocks in a timely manner. At the same time, attention

must be paid to the timely procurement, transportation and delivery of necessary resources, for each position separately. After the completion of each block, it is planned to complete all the work related to the landscaping of the area around the building, the dismantling of the protective fence on the construction site and all the prefabricated buildings that were used during the construction, the clearing of the rubble and the preparation of the terrain around facilities with paving and greening of the surfaces.

According to the previously defined construction activities and detail analyses of the technology of construction and all specific requirements, several different plans and schedules were made for the constructions of the three-building complex. The first positions regarding the site preparation, earth works and construction of the basement where identical (common) for all three blocks because of the design itself. The variations of the solutions and time planning and scheduling differed from the ground floor and up. The outcome of the different solutions for construction of this building was different work plans and different total construction time.

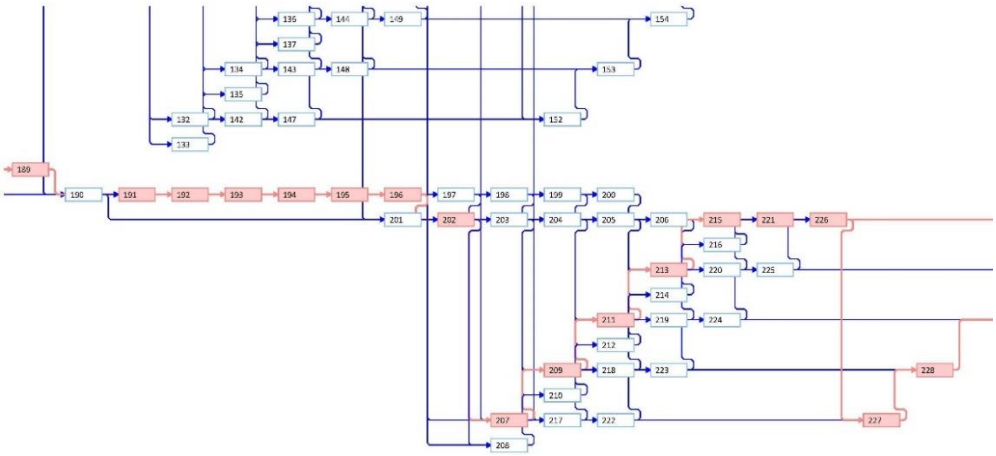

Figure 2. Part of the network diagram for the chosen solution

The first solution was parallel construction of the first two blocks from the ground floor to the roof and the team that finishes first on the active block moves to the third block. This solution resulted in total length of 679 days.

The second solution was parallel construction of the concrete works of all three blocks, but for the third block the masonry works (walls) began after completion of the walls from previous block. The total timeline resulted in 673 days duration.

The third and chosen solution was parallel construction of the first two blocks and the team for concrete works moving on the same floor from the one the two blocks to the third one. The rest of the works for the third block started after complete finish on the first two block. This solution had total length of 683 days.

Part of the planning and scheduling was dictated by the construction concept of the investor with the use of various different contractors for different positions. Working with various contractors on such a project can often lead to time overruns, lack of finance and risk generation. With keeping track of each position adequate contractors and finances can be managed.

4. CONCLUSION

Construction planning is process that should be present in every project. Detailed planning and scheduling can help eliminate various uncertainties and generate better executions of positions [12]. The planning process presented in this paper is in relation to a three-building complex with parallel construction of some of the positions. The methodology consists of theoretical research [3, 9, 10, 13] of the planning process for RC buildings, then defining the adequate approach with correlation with the investor and his concept of construction, analyzing multiple variant solutions and in the end selecting the best plan and schedule.

Through the use of MS Project [17,18], three solutions are made for the combination of positions regarding the construction of the buildings from the ground floor up. The proposed solution dictated by the use of various contractors gives an approach where two buildings are parallel constructed, while the third one is partially built when the teams from the first two blocks finish the position. This planning concept, in accordance with the specifics of the project, lead to shortening of the overall construction time, more successful and efficient construction and improved the overall insight of the construction process.

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