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Determining Time for completion Construction Projects Using Time List

Abstract: - The main text of civil contracts consists of three main parts: the contract's subject, the contract's amount, and the contract's time. Various techniques are used to specify the amounts of civil projects. The most conventional method is using basic price lists published by Iran's Planning and Budgeting Organization. By the end of the second phase of studies and design and following the completion of all maps and execution details, as well as the specification of the materials to be consumed, the consulting engineer initially determines the volumes of all executive operations from the map and then uses the prices of the items contained in the price lists published by the organization mentioned above to specify the execution price of each of the working items. In the end, the engineer sums up the costs of executing the items and applies the overhead factor to specify the cost of executing the project to initiate the process of tender.

To determining time for completion the construction project, however, there is no computational technique, and the [time for completion process] is usually performed by the order of the employer or by taking into consideration the construction time of similar projects by the consulting engineers.

One of the techniques to schedule the project is to use the critical path network technique. Project execution time is the sum of the time allotted to perform various working packages within a critical path. The duration of each work package can be determined by using the items that make up that work package. The time to execute each working item involves a probable distribution similar to a normal distribution, and the most probable time to execute an activity is in the middle of a probable distribution diagram.

In the schedule, the duration of the execution of each work package is determined by using the previous experiences of the experts. According to Goldart, when people are asked to estimate the timing of an activity, they apply a safe time to insure themselves against unforeseeable events, though they can perform their activities at shorter times, also. In this study, to determine the execution time of each item included in the price list, the item price breakdown tables that have been published by the Program and Budget Organization have been used, and a list similar to the price list called the time list has been proposed, with the difference that For each item, instead of the implementation cost, the implementation time of that item is included according to the unit of that activity. First, the time list for building items, the price list of mechanical facilities and the price list of electrical facilities have been extracted, and then by using them, the execution time of the items of each work package is determined according to the amount of each item and the number of available resources, and the total times The implementation of work packages is the critical time of project implementation. Finally, the sum of times allotted to execute working packages will be on the critical path of project execution time. It was concluded that time for completion construction project execution by the time list showed a 22.6% reduction [in execution time] compared to the time prediction technique using expert experiences.

Keywords: construction time, time list, construction projects, price list

I. INTRODUCTION

In all projects, the executing team, including the employer, the consulting engineer, and the contractor, does its best to increase the quality and decrease the cost and time of the project execution. To determine the quality of materials, various standards developed for construction can be used. also to determine the quality of execution, National Building Regulations, as well as the National Planning and Budgeting Organization's journals or the standards compiled in the Technical and Vocational Education Organization of the country.

To specify project amounts, the price lists of the National Planning and Budgeting Organization, setting the prices of project working items in seven tiers, can be used. No documentation has been produced to determine the project

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execution time, and in this article, the method of producing a time list based on the available technical documentation is proposed.

A review of civil and non-civil projects across the country reveals that the failure rate of projects is alarming, with quantitative evaluations showing almost 30% of the projects become rejected before being completed [1].

Not all projects get completed within the initial estimated amounts and the time stated in the contract's text. One of the reasons for the rising costs of project execution is the increased time of construction.

Edwards and Roberts (1992) argue that the majority of infrastructure projects encounter a 40-200% increase rate in cost and time [8].

In this connection, the main article's questions are: "Which factors cause the project not to be completed at the initial time specified? Is the technique of time prediction wrong? Are the effects of most uncertainties the main cause of project failures at the initial time, as compared to the initial prediction? Has the supply of resources, including human resources, machinery, and budget not predicted in proportion to the costs of construction and time of execution? Does the project manager lack the appropriate tools to plan and control the project?

Almost all civil and non-civil projects at the national level face delays in execution times. The increased length of civil project execution and delays with their utilization are becoming a major crisis for Iran's planning system. Analytical surveys of some road construction and hospital projects suggest that the mean execution time of those projects has increased from 3 years to 9 years in 1990 and 15.8 years in 2004. As well, the mean execution time of the projects of hospital construction has risen from 4 years to 11 years in 1990 [2].

The difference in estimating the credits of capital (civil) asset ownership plans accelerated in various years, where around 26183 billion rials had been foreseen for the completion of remaining semi-completed plans in 2003, whereas around 79000 billion rials, i.e., 2.5 times the estimates of the prior year, had been foreseen for the same plans in 2004, with an average rate of 1.63 years added to the length of each period [5].

This delay in execution caused rising costs, changing working policies, lowering investment percentage of profits, rising time of capital return, contractors' rising demands, and employers' rising engagements with judicial problems and other major issues.

Using the duration of the items listed in the time list cannot determine the project execution time, because the effective factors that indirectly and unavoidably increase the execution time of the desired work items should be identified and their impact should be considered as the overhead factor in the calculation of the execution cost. As the indirect costs in the implementation of work items are specified in the price index published by the country's planning and budget organization, and their impact is introduced as an overhead factor and increases the cost of implementing the desired items. The overhead coefficient of the project execution time is a number greater than one, which is multiplied by the total execution times of the work items in the critical path and the actual project execution time will be determined.

One of the major factors causing errors in estimating credits is the presence of errors in predicting the appropriate project execution time. Reducing errors in predicting project execution time can reduce investment wild values and help national capital to be utilized more effectively. The results of this article can be applied in all civil and non-civil projects across the country and help to increase capital returns.

Time for completion Project Execution Technique

Project execution time is defined in a variety of forms, including the critical path network, project execution time, the time of performing various activities within the critical path, etc. In the critical chain technique, project execution time is defined as equal to the execution time of a set of project activities, because common resources, including physical and information (non-physical) resources, are used for parallel activities [4],[10].

Activity Execution Time

The duration for executing any activity has a probable distribution similar to a normal distribution, which can be demonstrated in a diagram where the activity duration is shown by the horizontal axis and the probability of the activity time by the vertical axis. The most probable execution time of an activity is its average time, which can be defined as the execution time of activities, as seen in the middle of the probability distribution diagram [4].

Activity Execution Time Prediction

In a schedule, the duration allotted for each activity is specified by the prior experiences of expert people. According to Goldart, when people are asked to estimate the timing of an activity, they apply a safe time to insure themselves against unforeseeable events, though they can perform their activities at shorter times, also. The duration between the time estimated and the most probable time of activity execution is referred to as the safety time stock [4] ,[9].

Time Management in American Project Management Standard

- **Work Breakdown Structure (WBS):** This structure is used for breaking down all projects. This structure begins at the project scale and is subsequently broken down into more levels or details. The lowermost level is the working package which, for every package, refers to a set of activities to be delivered distinctly. To produce a work breakdown structure, various factors such as the geographical factors of project execution and the lifecycle of the secondary projects must be taken into consideration. The WBS involves a hierarchical approach to organizing resources and can be demonstrated as a hierarchical diagram [6].
- **How to determine the duration of activities:** Time for completion each of the project activities is calculated by estimating the time at which each working package is executed using expert views or group decision-making techniques or using quantitative methods such as parametric estimation, analogous estimation, and 3-point estimation [6].
- **Parametric Estimating Technique:** Here, time for completion working packages is performed for the work completion, and then, the real working hour is specified by applying the following:
    a) Dividing the hours estimated for each working package by the amounts of resources available
    b) Dividing the hours estimated by the percentage of the time at which each of the resources is available, i.e., 100%, 75%, or 50% of the time

It should be explained that resources are people, equipment, materials, provisions, and places (if necessary)

    c) Multiplying the estimated hours by the performance factor; experts in a working field usually perform the work more rapidly than people with middle-level skills or amateur people. Therefore, performance factors are taken into consideration to reflect productivity in the final estimation of the time at which each working package is executed. The performance factor can be made more accurate by considering the real working conditions; for example, most people are productive only 75% of the time.

- **Analogous Estimating Technique:** Here, the time for completion of the activity is estimated by comparing current activities with similar previous activities, as the volume of prior activities and their duration are compared to the currently expected volume of activities. Then, the ratio of the volume of current activities is multiplied by the prior duration to get the estimation done. Various factors such as complexity can be considered for more accurate estimations. If there is little information available, these types of estimates can be generally used for general estimations.
- **3-Point Estimating Technique:** Here, given the uncertainty of the duration in which each of the activities is executed, stakeholders perform some estimations for three optimistic, the most probable execution time, and the most pessimistic execution time scenarios. Then, given the project needs, they determine an appropriate relationship, with a conventional relationship being to use the Beta distribution. According to this distribution, estimated duration of implementation
- is estimated by the following:

(estimating the time at which an activity is executed) t = (pessimistic time + the most probable time*4 + the most optimistic time)/6

In this relationship, the time duration is usually represented by “t”.

The Most Probable Activity Execution Time Prediction Technique:

The estimated time is the time that is determined from the past experiences of experts in similar projects, but how can you estimate the most likely execution time?

For this purpose, it is suggested to prepare a list of the execution time of the work items. The name of this list is the same as the price list published by the National Planning and Budget Organization. In which, in front of each of the listed activities, the time of its execution is listed in terms of the unit of that activity. Providing a list of the time of activities and work items according to the basic price index of the country's plan and budget organization.

The method of determining the time of execution of work items:

As you know, each of the items listed in the price list of the National Budget Organization has a price breakdown. And in the analysis of the price of each work item, the impact of each of the factors involved in the implementation of that item, including manpower, materials, tools and machines, and the transportation of materials and tools to the place of implementation, is specified. By placing the price of each of the mentioned factors in each year, the price of the implementation of that work item in that year will be determined. In the production of time indexes, the amount of time effect of the effective factors in the implementation of the activity is decisive. For example, it can be pointed out by using the price analysis of each of the items in table number one, which is in the different chapters of the building price list of the country's plan and budget organization.

Table 1: Determining the execution time of some work items of the building price list using the price analysis of the program and budget organization[3]

No.	Chapters	Chapter title	Item description	Unit	Time (hours)
1	3	Earthwork with machinery	Spreading clay loam, adjusting and regulating it at sites intended with a grader powered by 150 hp	m^3	0.0115
2	4	Masonry operations with stones	Item: Revetment on building floor (blockage) with rubble stone	m^3	1.0670
3	7	Steelwork with rebars	Item: Preparing, transporting, bending, and planting simple rebars of 12-18 mm in diameter for reinforced concrete with necessary winding	Kg	0.0060
4	8	Cast-in-place concrete	Preparing and implementing concrete with naturally washed or broken sand and gravel with a characteristic compressive strength of 25 MPa	m^3	0.6780
5	10	Light concrete ceiling	Executing concrete ceiling of 35 cm thick with joist and clay hollow blocks, including preparing all materials except for the rebar, and also preparing equipment required in full	m^2	0.3864
6	13	Humidity insulation	Humidity insulation with three surfaces of tar coating and two layers of gunny on the surfaces of bathrooms, WCs, and bases of walls	m^2	0.3667
7	18	Coating and pointing	Cement coating of around 2 cm thick on perpendicular surfaces with 1:4 cement sand mortar	m^2	0.3636
8	19	Woodwork	Preparing and installing wood cornices of 1 to 1.5 cm thick made	Long meter (LM)	0.5710

			from interior wood whose edges are tooled.		
9	20	Tiles and ceramics	Tilework with glazed tiles with a surface of up to 2.5 dm^2	m^2	0.4950

Following the time for completion of the execution of various activities in each chapter and given the detailed project time for completion, project execution time is the execution time of working packages on the critical path. To make this time real, it is necessary to multiply the time obtained by a factor called the time increase factor, which is the effect of the factors causing unavoidable delays, and then to take the product as project execution time.

II. THE RESULTS OF USING THE TIME LIST IN DETERMINING THE EXECUTION TIME OF A CONVENTIONAL URBAN BUILDING

An overview of urban construction reveals that a significant portion of these buildings consists of 5-8 story buildings with one or two parking stories and 4-6 residential stories. The project under study consists of a parking story and four single-unit residential stories in a plot of land with an area of 18*6 m^2, with the built-up area measuring 306.8 m^2.

Using expert views, the break-down structure of construction activities in thirty working packages is given in Table 2 below:

Table 2: Determining working packages and their execution times using expert views

Activity No.	Working package	Previous activity No.	Next activity No.	Execution time based on expert views
1	Delivering the workshop, interrupting the branches, and equipping the workshop	-	2	7
2	Dumping and transporting construction waste to the authorized landfill	1	3	21
3	Excavating and digging for structural foundation	2	4	14
4	Executing lean concrete and foundation molding	3	6	7
5	Making frames and painting in the factory	-	8	70
6	Reinforcing and installing column plates	4	7	7
7	Foundation concreting	6	8	1
8	Installing the frame and completing the welding	2 and 14	9	30
9	Executing ceiling metal-decks	8	10	14
10	Reinforcing and molding ceiling	9	11	7
11	Ceiling concreting	10	12	1
12	Executing walls and installing door and window frames and cement coating	11	14, 17, and 28	20
13	Piping electricity, wiring, and cable-laying	14	21	7
14	Mechanical installation piping (water, sewage, gas), and air canal	13	18	14
15	Sloping ceiling and WCs and Executing light concrete	14	16	3
16	Insulating rooftops, WCs and kitchens	15	20	4
17	Soil and plaster coating	12	13	14
18	Executing suspended ceiling	21	25	7
19	Executing WC and kitchen tiles	21	22	14
20	Executing ceramic, stairway, and parking stones	16	25	14

21	Executing whitening and plasterwork	13	18	14
22	Installing mechanical installation items	19	22	7
23	Installing electrical installation items, tableaus, and meters	22	26	7
24	Painting	25	27	13
Virtual	-	24	22	0
25	Installing wooden doors and UPVC windows with glass	18 and 20	24	7
26	Installing cabinets	23	-	14
27	Installing elevators	14	-	14
28	Executing façade	12	29	60
29	Constructing compounds	28	30	7
30	Branch connections, delivering the workshop, and dismantling equipping the workshop	29	-	7

The execution time in this project is determined by the CPM method (Critical Path Method). For this purpose, the execution time of each work package listed in the above table has been determined according to the opinion of experts and the critical path has been determined using the activity sequence table. The project execution time will be equal to the execution time of the work packages on the critical path

It is worthy of note that at times outlined in the table, the factors causing delays, such as cold days and lack of funding by the employer, were not taken into consideration.

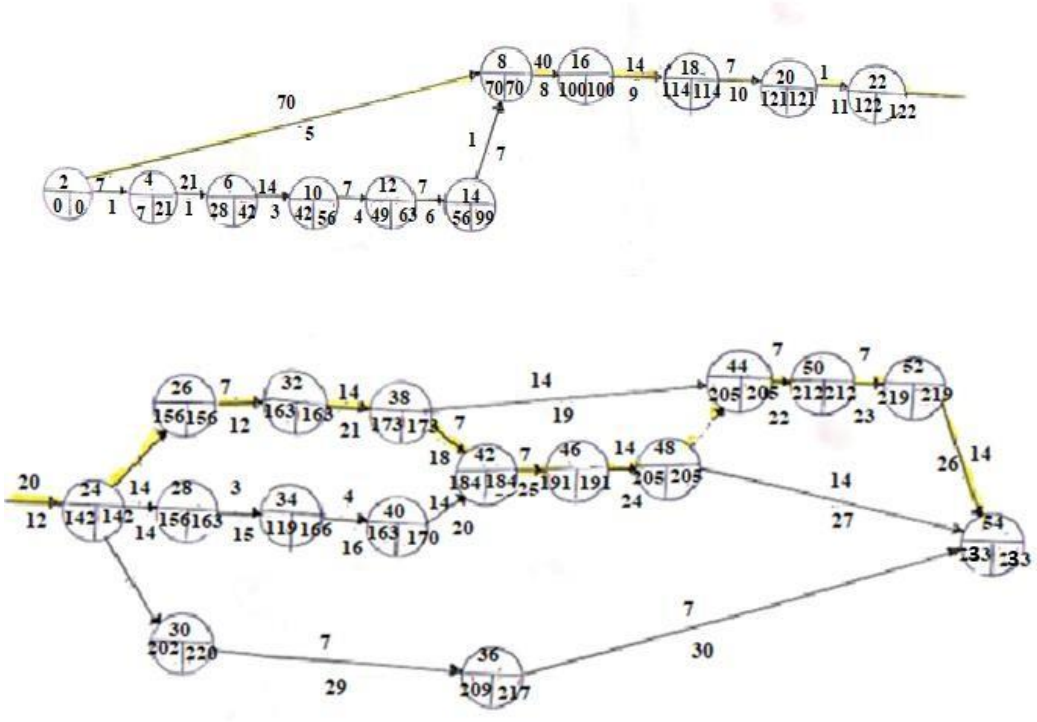

Diagram 1: Determining critical path using the AOA method

In this project, as shown by Diagram 1, the working packages on the critical path include 5-8-9-10-11-12-17-13-21-18-25-24-22-23-26, with the execution time being 233 days by calculating the execution time of the said packages.

To estimate time, the parametric method, set out by the American Project Management Standard, The volume of each work item is determined by the meter of the maps; then, the items relating to each working package were determined by using the price lists published by the National Planning and Budgeting Organization.

Then, by analyzing the price of each of the items, the time of execution of that work schedule is determined, and then according to the volume obtained from the meter, the time of execution of that work package is determined assuming that the work is executed by only one team. For example, the time of two of the work packages is determined as follows:

The first step was to prepare the quantity survey of the working volumes from the executive techniques and the second step was to determine the items related to the working packages, given in Table 3 [7].

Table 3: Time for completion the execution of working packages' items Nos. 5 and 8: Constructing the frame in the factory and installing the frame and completing welding

No.	Description	Unit	Amount	Item execution time	Total execution time
090103	Preparing, manufacturing, and installing columns made from two or more iron beams, channel beams, or angles, welded directly together	Kg	13600	**0.059112**	803.92
090234	Preparing, manufacturing, and installing the plate-made main beam in the form of iron beams or other forms, along with strengthening and hardening plates.	Kg	12280	**0.064773**	795.41
090224	Preparing, manufacturing, and installing stair beams made from iron beams or angles, together with related connections	Kg	750	**0.055712**	41.78
090402	Preparing, manufacturing, and installing wind bracing consisting of one or several profiles made of angles, iron beams, channel beams, etc. with all parts connected to the column, beam, or bracing members together	Kg	1800	**0.6658**	119.84
250103	Preparation or removing the rusts of steel frames using sandblasting	m^2	521	**0.1067**	55.6
250330	Preparing materials and applying two-component polyamide epoxy painting on a steel frame of 40 μ thick	m^2	521	**0.23**	119.83
280101	Transporting iron parts to the workshop site within a 75-km distance	Tonne*kilometer (t.km)	27430	**0.0375**	77.14

	Total time	Hours			2013.52

To execute each kilogram of ironware, the price breakdown table, published by the planning and Budgeting Organization, is used, which is given in Table 4 below.

Table 4: Time for completion the items of working packages Nos. 5 and 8 using the analyses published by the National Planning and Budgeting Organization [3]

No.	Agent (manpower or machinery)	Unit	Agent coefficient	Item 090103	Item 090242	Item 090234	Item 090402	Item 250103	Item 250330	Item 28011
1	**Simple worker**	Individual-hour	**1**	**0.0136**	**0.0136**	**0.0136**	**0.0136**	**-**	**-**	**-**
2	**Number one frame maker**	Individual-hour	**1**	**0.002834**	**0.002834**	**0.002834**	**0.0034**	**-**	**-**	**-**
3	**Number two frame maker**	Individual-hour	**1**	**0.011339**	**0.011339**	**0.011339**	**0.0136**	**-**	**-**	**-**
4	**Frame welder**	Individual-hour	**1**	**0.017**	**0.022661**	**0.0136**	**0.01938**	**-**	**-**	**-**
5	**Cutter**	Individual-hour	**1**	**0.011339**	**0.011339**	**0.011339**	**0.0136**	**-**	**-**	**-**
6	**Crane**	Device-hour	**1**	**0.002**	**0.002**	**0.002**	**0.002**	**-**	**-**	**-**
7	**Forklift**	Device-hour	**1**	**0.001**	**0.001**	**0.001**	**0.001**	**-**	**-**	**-**
8	**Compressor (truck)**	Device-hour	**1**	**-**	**-**	**-**	**-**	**0.1067**	**-**	**-**
9	**Painting spraying pump**	Device-hour	**1**	**-**	**-**	**-**	**-**	**-**	**0.23**	**-**
10	**22-ton trailer**	Device-hour	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**0.375**
		Total		**0.059112**	**0.064773**	**0.055712**	**0.06658**	**0.1067**	**0.23**	**0.375**

The stages of frame execution are as follows:

- Purchasing and transporting steel plates to the frame-making factory
- Cutting ironware based on the maps

- Assembling cut-off parts
- Welding and constructing columns and beams
- Transporting columns and beams to the installation workshops
- Installing the frames
- Completing welding

If the assembly operation is assumed to begin after cutting one-third of the steel plates, and similarly, the welding operation begins after the execution of one-third of the assembly operation, followed by the painting operation and then transportation to the workshop, the execution time operation will decrease by 671.17 hours by taking into consideration the overlaps.

To obtain real-time, if daily functions and each 30-day month are assumed to be 10 hours and 25 days, respectively, and the productivity coefficient is assumed to be 90%, the execution time of the item of manufacturing and installing the frame will decrease from 100 days to 89 days. The table below gives the execution time of all working packages on the critical path according to the above method.

Table 5: Comparing the execution time of working packages on the critical path obtained by experts and time list

Activity No.	Working package	Execution time based on expert views	Execution time using tile list
5	Manufacturing the frame and painting at the factory	70	89
8	Installing the frame and completing the welding	30	
9	Executing ceiling metal-deck	14	10
10	Reinforcing and molding the ceiling	7	5
11	Ceiling concreting	1	1
12	Executing revetment and installing the frames of the door and windows and cement coating	20	15
13	Electrical piping, wiring, and cable-laying	7	5
17	Executing gypseous soil	14	11
18	Executing the suspended ceiling	7	4
21	Executing whitening and plasterwork	14	14
22	Installing mechanical installation items	7	5
23	Installing electrical installation items, tableaus, and contours (meters)	7	5
24	Painting	14	10
25	Installing wooden doors, and UPVC windows with glass	7	6
26	Installing cabinets	14	10
	Total (day)	233	190

As noted, time estimation using the time list and overlap elimination decreases execution time by 22.6% compared to the times announced by experts.

Project Execution Time for completion

To determine the implementation time of a construction project, it is necessary to first identify the factors that cause delays in implementation, and then, using the opinion of experts, to determine the main influencing factors, and the influence of the main factors with a coefficient greater than one as the coefficient of the estimation of the

project implementation time in the specified time It will be finalized from the list of multiplication time and execution time, which is described in another article of this coefficient and its determination method.

III. CONCLUSION

The objective of this article was to introduce a technique to systematize the prediction of construction project execution time. Here, this technique proposes how to provide a time list for the working items outlined in the price lists of the National Planning and Budgeting Organization. To prepare the time list, the analysis of the price of each work item has been used, and after identifying and determining the time of the effective factors during the execution of that item, the most reasonable execution time of each item included in the price list is determined. The present article investigated the time for completion of the execution of a conventional urban construction project using the time list. To this end, the project execution was outlined in thirty working packages, which were specified on the critical path by providing the project time for completion via the CPM technique. Then, the working items of each working package were determined And with the meter of each of the work items from the execution plans and according to the parametric method of the American Project Management Standard (PMBOK) and the elimination of overlaps, the minimum time for the implementation of the projects in conditions without delay has been determined. In conventional residential projects in the city of Tehran (5 to 8 floor apartments), the execution time using the time list shows a decrease of 22.6% compared to the opinion of experts. The project implementation time is delayed due to various factors, including forced factors such as floods and workshop factors such as rework, lack of implementation plans, lack of materials and manpower, and other factors. One has been determined as a higher coefficient of project implementation time in another independent research. Predicting the final project execution time includes the multiplication of the total times of working packages on the critical path of the project by the time overhead factor.

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