Latif Onur UĞUR

Ümran PEHLİVAN

University of Düzce
Faculyt of Technology

THE ANALYSIS OF TIME-COST CHANGES IN PLANNING OF CONSTRUCTION PROJECTS BY NETWORK DIAGRAMS IN TECHNOLOGY USE ORIGIN

A b s t r a c t

In rapidly developing World, not only feasibility and technical implementation but also planning and cost management effort shaves an increasing importance. In this study, varied cost-planning construction procurement of housing development Project carried out by Prime Ministry Development (TOKİ), was investigated. For this purpose, work program was prepared based on the contractual time of Project which has quantity and estimation and by using network diagram. After that, alternative CPM planning was obtained by reducing different proportion of time. Reducing of time edited according to the basis of new technological applications. For each alternative Project plan, monthly manufacture and ration costs were calculated, base Project has been moved to the date of delivery by net present value (NPV) method. Additional costs to be brought by Project time reductions were reflected as costs of technology and also saving amount scores corresponding to unit reduction time were determined to be equal to reduce general expenses. As a result of study; it has been determined that the completion of the project in 18 months' time specified in the contract and corresponding to the most appropriate time economically is the most appropriate solution.The authors emphasize that; prior to the procurement of medium and large scale construction projects, performing time-cost studies has a key attribute for optimum solutions both national and construction companies, because performing time-cost studies provides minimum cost of production.

Chapter 1

In order to carry out the work in an optimal time and cost, in the face of internal and external boundary conditions the coordination of all parties (owner, contractor, equipment vendors, official institutions, etc.) and employees (engineer, architect, etc.) in terms of time, place, capacity and costs is described as planning. In other words, planning is putting the productions to be conducted in order of importance by considering preferences and physical row. These are:

1. Physical Row: It is the row arising from the fact that starting of a production depends on the completion of another production.

2. Preferential Row: It is the row conducted due to special reasons and ensuring the conduction of healthier production although the starting of a production does not depend on the completion of another production [1].

In order to make decisions correctly and the conduction of the activities about these decisions correctly, the most important planning must certainly be conducted. If no planning is made, it is impossible to see the opportunities and dangers to arise. Besides, some of the necessary measures to solve the problems that may arise in the future may not be taken.

In the project, it is required to record which work and when will be performed, how many workers will be employed in this work, in which time intervals these people will work, the number of machines and equipment and shorty it is required to time all steps that may arise from the beginning to the end of the construction project.

Project control is the activity performed to evaluate the activities in the project, to compare the status of the project to the planned situation and if necessary to take preventive measures. Thanks to project control, it will be possible to focus on the critical and semi critical activities that may cause problems during the conduction of the project [2].

While making the investment planning of a project, to make different planning due to different conditions and to prefer the most rational one after making time, source and cost analysis of each planning will be the most appropriate way [3].

A project is a study or project having a definite beginning and end, to be performed to reach its foundation purpose, that are separate from each other but related to each other and having an activity using one or more sources [4].

In order to make right decisions and to conduct the activities accordingly, the project must certainly has a planning process. Since it will be impossible to see the future opportunities and dangers if planning is not made, it cannot he taken necessary measures about this matter [5].

Without making planning studies describing what will be made for which reason, when and how, ensuring the conduction of the studies in the project and managing the employees in the project, it is impossible to conduct and finalize the project successfully. In the development of project plan, definition of duties and responsibilities, preparation of project timeline and he preparation of project budget are among the most important studies [6].

Although simulation studies are used widely in managements, especially for construction engineering and management, continuous simulation models with cost estimation purpose remained undiscovered enough. Chou conducted a study with the aim of early phase cost distribution for budget allocation by using self-developed algorithms and a spreadsheet. Ancient construction project data was used hereby as a sample study data. For conceptual cost range estimations, his

study submits comprehensive random processes including a number of investigations from simulation building blocks [7].

Project management arises double problem predicting future commitments and the activity to realize this [8]. If a construction project is not successful, some problems such as low performance, time delays, cost overflows and quality defects arise [9].

Planning process consists of three phases as the preparation of the plan, implementation of it and monitoring/evaluation of its implementation. These phases forming project planning processes follow a logical process and sometimes work in a reversible cycle i.e.it forms a new cycle. Losing sight of any one of these processes that are tightly correlated with each other and that must be handled in an integrated way make difficult to make correct decisions. So, passing from one of these processes to another must base on a definite and clear decision. These processes forming project cycle can be divided into six main categories (Figure1) [10].

Fig. 1.Processes forming the project cycle
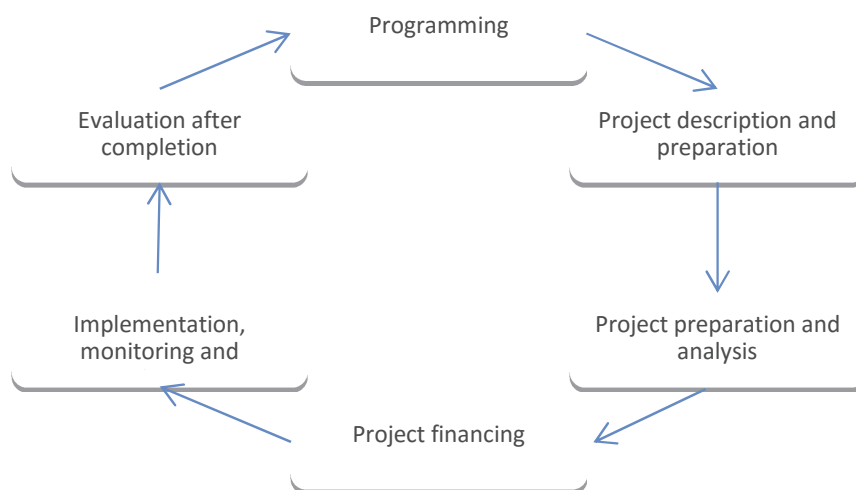
In source analysis, it should be noted that the cash may often create a restrictive source. Knowing cash flow and income/expense situation, pre-determination of the occurrence of cash-strapped times, and taking the necessary measures previously are extremely important.For this, the adaptation of some activities except for critical circle due to cash status is one of the most outstanding solutions. During the times when the occurrence of cash problems is expected, it is clear that taking some measures is required for increasing cash inflow and reducing cash outflow in general. In the situations when cash deficits that cannot be solved by such kinds of adjustments are in question, it is paved the way of taking on loan or closing this gap from other sources.

In a study of Kanıt and Uğur, the work program of Vaccine, Serum and Drug Control Institute of Ankara and the cost dependig on this were calculated based on contract conditions and critical affairs and critical circle were detected by forming CPM diagram. The times of the affairs on critical circle were jammed at the rate of 5%, 10% and 15% compared to the first programand the completion time of the project was backdated. These timing jams were met by working overtime for the labor force required by normal labor program as material and material equipment values are fixed. Considering that project total value is 1.705.946.946.970.- TL as for 2013, the surcharges brought by time reductions are seen to be respectively 0,02% (two in ten thousand), 0,03% (three in ten thousand) and 0,1% (one in a thousand). The authors express that although the surcharges corresponding to the mentioned time reductions give the impression of causing the same work to cost the earth, the real situation may be more different than this. They stated that the reductions in general expenses brought by working for less time of the labor force at certain amount would provide a significant saving; total progress payment would not change but since the progress payments will be taken previously, the inflation losses would reduce as well as the income corresponding to the interest to be obtained in the evaluation of this amount would again provide a serious increase and most importantly, there is so much significant number of social benefits ensured by the early completion and put into service of thid building that it is impossible to express this financially [3].

In their study, Uğur and Erdal prepared a work plan belonging to collective housing composed of 8 planned blocks in Düzce/ Kaynaşlı TOKİ B type and that will be completed in 16-month time mentioned in the contract and they calculated project cost, and by forming CPM (network) diagrams , they detected critical activities and critical circle. This 16-month contract time was backdated to 12, 10, 8 and 6 months with the aim of detecting what will the benefits be in compensation for different completion times and they were recalculated and organized. The increases in labor force that will correspond to each time reduction and ensure necessary employee hour value and the cost increases caused by these increases were calculated. The bank interest incomes of the progress billing to be taken for each time and the losses resulted from the inflation were calculated and at the end of 16th month, benefit/cost rate of the project with which term would be more appropriate was analyzed. As a result of the studies, the completion of the project in 8 months instead of 16 months was concluded to be economically more convenient. In this study, the calculations of indirect costs corresponding to "the time saved" resulted from time reductions were not made. In similar implementations, the authors who expressed that considering both this calculation and the financial saving made and obtained would reach the practitioners to more realistic results added that during the terms corresponding to the further completion times than the predicted completion date

in some implementations, reaching to the optimum cost was more possible; and maybe the time increase will be more economical for such project [11].

In this study, while performing the construction project planning, the aim is to see financial cost and loss ensured by the reduction of project time by making use of the technology. For this, different planning-cost relationships of collective housing whose construction tender was conducted by Prime Ministry Mass Housing Administration (TOKİ) were investigated. For this purpose, being based on the contract time of the project whose quantity survey and discovery was conducted and by using network diagram (CPM),work program was performed. Following this, the completion time of the project shortened at different levels and alternative CPM plans were conducted. Time shortenings were organized on the basis of making new technological applications in critical activities. For each alternative project plan, monthly manufacturing and progress payments were calculated. Base project was brought to the delivery date with Net Present Value (NPV) method. Additional costs brought by project time shortenings were revealed to the calculations as the additional costs of technology use, saving amount corresponding to unit abbreviation were accepted to be equal to reduce general expenses. Thus, the most suitable time in which the mentioned project will be completed economically was investigated.

Chapter 2

The projects of B type blocks of TOKI project whose project and planning was conducted during this study were used. The planning of this project (laying out, the detection of priority and regency relationship, forming CPMand Gantt diagrams,the detection of critical costs, etc.) was conducted by Microsoft Project program. Production items to be used during the time of the project were calculated based on the item prices of the Ministry of Environment and Urbanization in 2014. While making cost calculations and graphs, it was made use of Microsoft Office programs.

Being based on the contract time of the project whose quantity survey and discovery was conducted and by using network diagram (CPM), work program was performed. Following this, the completion time of the project shortened at different levels and alternative CPM plans were conducted. Time shortenings were organized on the basis of making new technological applications in critical activities. For each alternative project plan, monthly manufacturing and progress payments were calculated. Base project was brought to the delivery date with Net Present Value (NPV) method. Additional costs brought by project time shortenings were revealed to the calculations as the additional costs of technology use, saving amount corresponding to unit abbreviation were accepted to be equal to reduce general expenses. Thus, the most suitable time in which the mentioned project will be completed economically was investigated.

In this study, while performing the construction project planning, the aim is to see financial cost and loss ensured by the reduction of project time by making use of the technology. In the study, planning was primarily conducted based on 18-month time stated in tender documents and it was made use of additional technology. Then, the activities in which the technology on critical circle can be used for 17,16 and 15 month periods were detected, acceleration/reductions were conducted on these production items and the costs were calculated one by one for each situation. Monetary gains to be obtained at the end were detected and a comparison was conducted.

Chapter 3

In this study, it was aimed to review benefit and loss opportunities of the costs arising as a result of work program conducted on the basis of the reduction of the activities in which technology is used for 18, 17, 16 and 15 month time reductions by calculating also the monthly expenses (meal, insurance, etc. of the workers). This will ensure the comparison of price difference between project costs according to separate planning with interest income according to monthly inflation. This comparison ensures project and planning curators to clearly see whether there is an economical profit of technology use. By this way, it also helps planning experts to monitor the work process about how the project will be conducted. In line with this, if using technology has no profit during management of the project, even it is costlier, this situation must be considered. For example; while plastering, being used of spraying plaster by the worker instead of making by hands may save time, it may reduce the labor costs due to time but if the operation cost of this implementation is extremely above this profit, this situation must be corrected. This will ensure to consider alternative cost values that may be met during project processand to conduct the project process in line with these results.

Project Planning was performed on the basis of B type of TOKİ housing. Primarily, 18-month work plan was conducted and work items in which technology can be used among the activities on critical circle were shortened and the completion time was reduced to17, 16 and 15 months.

In Table 1 quantities of 63 pieces of work items calculated for B type blocks and the item prices of 2014 were multiplied and total cost value was found to be(1.442.752,21 TL). This cost is the money in compensation for completion of the work within 18-month period specified in tender announcement at the same time.

Table 1. Quantity and Discovery for a *B TypeBlock*

Order No	Description of Work to be Conducted	Item Price (TL)	Amount	Item	Cost
1	The excavation of loose rock ground by the machine (Free Excavation)	4,30	1227,49	m³	5278,21
2	Laying all-in sand gravel on foundation base by hand and compaction of it	27,04	135,15	M³	3654,46
3	Compressing the filling by hammering by hand	7,11	226,61	M³	1611,20
4	Making 200 kg of cement dose leveling layer	8,74	3443,31	M²	30094,53
5	Plastomer-based polyester rug stone in 3mm thickness Polyester vegetation two layers. Making waterproofing	27,13	938,31	M²	25456,35
6	250 dose of plain concrete	156,63	27,88	M³	4366,84
7	Bending and laying of ø 8-12 mm ofthin corrugated steel	1905,86	61,65	t	117488,65
8	Bending and laying of ø 14-28 mm ofthick corrugated steel	1878,43	75,82	t	142430,08
9	Fair-faced concrete and ferro-concrete formwork	19,59	403,92	m³	7912,79
10	Fair-faced concrete and concrete formwork (c20/25)	102,00	1504,14	m³	153422,28
11	Sewer pipes with spiral wound underground storm water(pvc based)(ts 12132)	13,00	78,50	mt	1020,50
12	Making ferro-concrete formwork with tunnel formwork system	34,09	3948,80	m³	134614,59
13	Horizontal perforated unit bricks (190*85*190)	0,18	295,55	m²	53,20
14	Horizontal perforated unit bricks (190*135*190)	0,24	144,57	m²	34,70
15	Making thermal insulation with Xps and eps foam materials (with 300 kpa pressure resistant with 3 cm of smooth surface)	10,55	145,60	m²	1536,08
16	Making external sill with white marble plaque in 3cm thickness	105,69	117,92	m²	12462,96
17	Making external sill with colored marble plaque in 3cm thickness	116,00	39,78	m²	4614,48
18	Making various iron works from lama and profileiron and putting it in place	5,53	90,00	kg	497,70
19	Doing plastic joinery manufacture and putting it in place (all kinds of door, window, coating and similar	7,83	405,66	kg	3176,32

Order No	Description of Work to be Conducted	Item Price (TL)	Amount	Item	Cost
	manufacturing from rigid PVC joinery profiles)				
20	Making flat plaster with 250/300 dose of cement mortar (on outer wall surfaces and base internal walls)	17,61	1819,24	m²	32036,82
21	Making single layer of flat plaster with 500kg of cement dose	12,80	1254,89	m²	16062,59
22	Flat plastering with lime-cement mixture mortar	13,48	7495,90	m²	101044,73
23	Making bending door frame from hot rolled sheet in 2.00mm thickness and putting it in place	6,71	5418,02	kg	36354,91
24	Filling behind the metal door frame with concrete grout	15,78	199,47	m²	3147,64
25	Making alum with 400 kg cement dose in 2.5 cm thickness	25,00	1669,19	m²	41729,75
26	Making alum with 500 kg cement dose in 2.5 cm thickness	30,19	214,54	m²	6476,96
27	Concrete and mortar additive work (making insulation alum in 3,5 cm thickness with the substances mixed with the mortar)	21,83	12,24	m²	267,20
28	Making ceiling plaster with lime-cement mixture mortar	13,08	21,75	m²	284,49
29	Making gypsum lining (finishing)	2,76	2693,96	m²	7435,33
30	Satin plaster coating in 5 mm thickness on rough plaster etc. surfaces	6,83	7027,17	m²	47995,57
31	Making window and doors with Square and rectangular profiles and putting it in place	5,90	2356,98	kg	13906,18
32	Wooden door wing	112,10	81,40	m²	9124,94
33	Making bending door frame from plain black sheet in thickness of 1.5 mm and putting it in place	6,78	95,64	kg	648,44
34	Colorless flat glass (6 mm in thickness)	10,11	4,29	m²	43,37
35	Colorless frosted glass (4 mm in thickness)	6,51	38,47	m²	250,44
36	Installing double-glazed window units with wooden cutting strip in 4+4 mm thickness 12 mm backlash	55,80	439,78	m²	24539,72
37	metal and PVC ceiling floor	48,55	91,77	m²	4455,43
38	Making Color flat mosaic floor covering	30,09	9,20	m²	276,83

Order No	Description of Work to be Conducted	Item Price (TL)	Amount	Item	Cost
39	Making ceramic wall tiles and wall coverings (20*25cm or 20*30cm)	31,01	1241,57	m²	38501,09
40	Making interior floor tiling with white cement, flat or patterned in every color, dimension and thickness withdouble layer terrazzo tile plaque (in 250x250mm/300x300mm/330x330mm etc. dimensions)	34,53	1,36	m²	46,96
41	Making interior floor tiling with normal cement, flat or patterned in every color, dimension and thickness with double layer terrazzo tile plaque (in 250x250mm/300x300mm/330x330mm etc. dimensions)	33,86	174,36	m²	5903,83
42	Making skirting with Pvc based materials	4,13	1779,70	mt	7350,16
43	Making flooring and wall coverings with glazed porcelain tile (30*30cm or 33*33cm)	36,81	929,37	m²	34210,11
44	Making colored mosaic wall coating with colored normal cement with marble brass in every color	37,68	370,00	m²	13941,60
45	Making frame from wood fitting (roofing with wooden coating at the base)	59,35	482,81	m²	28654,77
46	Making roofing with hot dip galvanized sheet in 0.50 mm thicknesson wooden roof	30,20	482,81	m²	14580,86
47	Making heat and sound insulation with rock wool and glass wool made of materials	9,53	463,50	m²	4417,16
48	Making heat insulation with xps and eps foam materials (200 kpa pressure strength with 3cm of rough surface and rıugh channel)	32,58	32,01	m²	1042,89
49	Supplying rigid pvc drainpipes in ø150mm diameter and the installation of it in place	16,34	56,52	mt	923,54
50	Supplying rigid pvc with muff at one end in ø 125mm diameter and the installation of it in place	12,40	115,20	mt	1428,48
51	Acrylic water-based grain/textured exterior coating	6,00	2335,71	m²	14014,26

Order No	Description of Work to be Conducted	Item Price (TL)	Amount	Item	Cost
52	Acrylic water-based exterior paint	6,50	948,38	m²	6164,47
53	Making three layers of colored lime whitewash on new plaster surfaces (interior)	2,53	294,05	m²	743,95
54	Making three layers of white lime whitewash on new plaster surfaces (interior)	2,53	294,05	m²	743,95
55	Making acrylic-based colored coating in 3 mm thickness on concrete plaster and other surfaces	17,28	8588,63	m²	148411,53
56	Pipe painting (oil painting)	1,15	490,08	m²	563,59
57	Making banister from welded iron pipes and putting it in place	5,28	3370,22	kg	17794,76
58	Making two coats of paint to iron surfaces against corrosion	7,85	136,52	m²	1071,68
59	Making floor covering with colored marble in 3cm thickness (3x30xfree length)	89,60	383,31	m²	34344,58
60	Floor covering in interiors with white cement terrazzo tile plaque with a single layer	57,74	128,09	m²	7395,92
61	Wall covering with colored marble in 22 cm thickness (2x30xfree length)	89,14	23,92	m²	2132,23
62	Stair coverings with colored marble slabs	50,35	415,20	m²	20905,32
63	Making laminate flooring coatings (ac4 class 32) (including skirting)	25,36	1651,31	m²	41877,22

Total: 1.442.752,21 TL

In CPM based work plan prepared in Table 2.,the unit prices of the work items chosen over critical circle and that are appropriate to use technology in 2014 compared to the work items that do not use technology, the differences (increases) to occur with the usage of technology are available. In order to detect the price increase brought by technology use, additional expenditure costs were multiplied by the work amount performed. This transition was performed for each time shortening (for 17, 16 and 15 months) in the activities in which shortening can be performed by using technology (existing on critical circle). Difference column in the Table 2. Indicate additional expenditure costs occurring in time shortening activities in 17 month planning.

Table 2. Unit Price Differences Performed at the end of 17 months

The name of the work	Unit prices of 2014	Technology Unit Prices	Amount	Differences
Spray Plaster: Performing flat plaster with 250/300 cement dose mortar (exterior wall surfaces and basement interior walls)	17,61	26,13	1819,24	15.500 TL
Spray Plaster: Performing single layer of flat plaster with 500kg cement dose	12,80	18,10	1254,89	6.651 TL
Spray Plaster: Performing flat plaster with lime-cement mixture mortar	13,48	20,00	7495,90	48.873 TL
Unit Price Differences conducted at the end of 17 months				**71,027 TL**

Difference column in the Table 3 indicate additional expenditure costs occurring in time shortening activities in 16 month planning.

Table 3. Unit Price Differences Performed at the end of 16 months

The name of the work	Unit prices of 2014	Technology Unit Prices	Amount	Differences
Pre-machined iron: Bending and laying of ø 8-12 mm thin corrugated steel	1905,86	2305,86	61,65	24.658 TL
Pre-machined iron: Bending and laying ofø 14-28 mm thick corrugated steel	1878,43	2278,43	75,82	30.330 TL
Spray Plaster: Performing single layer of flat plaster with 500kg cement dose	12,80	18,10	1254,89	6.651 TL
Spray Plaster: Performing flat plaster with lime-cement mixture mortar	13,48	20,00	7495,90	48.873 TL
Spray Plaster: Acrylic, water-based exterior wall plaster	6,50	9,64	948,38	2.978 TL
Unit Price Differences conducted at the end of 16 months				**113.490 TL**

Difference column in the Table 4 indicate additional expenditure costs occurring in time shortening activities in 15 month planning.

Table 4. Unit Price Differences Performed at the end of 15 months

The name of the work	Unit prices of 2014	Technology Unit Prices	Amount	Differences
Pre-machined iron: Bending and laying of ø 8-12 mm thin corrugated steel	1905,86	2305,86	61,65	24.658 TL
Pre-machined iron: Bending and laying of ø 14-28 mm thick corrugated steel	1878,43	2278,43	75,82	30.330 TL
Machine Alum: Performing alum in 2.5 cm thickness with 400 kg cement dose	25,00	12,50	1669,19	-20.865 TL
Machine Alum: Performing alum in 2.5 cm thickness with 500 kg cement dose	30,19	12,94	214,54	-3.701 TL
Spray paint: performing three layers of colored cement plaster on the new plaster surfaces (interior)	2,53	5,00	294,05	726 TL
Spray paint: performing three layers of white cement plaster on the new plaster surfaces (interior)	2,53	5,00	294,05	726 TL
Unit Price Differences conducted at the end of 15 months				**31.875 TL**

In the calculations conducted in Table 5 the number of workers to work in totally one block in the activities on the critical circles was detected to be 32.Daily general expenses of a worker (eating, drinking, social security, housing and job security) were calculated to be 46 TL/day in total. These values are the averages acquired from four different construction firms dealing with contracting in the province of Düzce. These general expense values were added to the money taken from the administration for each time shortening as an item increasing the income for the completion of work at the end of 18th month. For example, the general expenses corresponding to 44.320,00 TLin one month time shortening for 17 month planning was added as saving/month.

Table 5. General Expense Cost

General Expenses	Daily	For 1 month	For 2 months	For 3 months
Social Security	14 TL	425 TL	850 TL	1.275 TL
Job security	15 TL	450 TL	900 TL	1.350 TL
Food & Beverage	7 TL	210 TL	420 TL	630 TL
Housing	10 TL	300 TL	600 TL	900 TL
Total	46 TL	1.385 TL	2.770 TL	4.155 TL
For 32 Masters and Employees in total	**1.472,00 TL**	**44.320,00 TL**	**88.640,00 TL**	**132.960,00 TL**

On the basis of main work program, time shortenings were conducted on the critical activities that are convenient for using technology and 3 network planning was conducted in which total project time was backdated for 1, 2 and 3 months. In compensation for each time shortening, monthly progress billings were calculated in Table 6. Progress billings belonging to 18, 17, 16 and 15 month planning processes are available. In the entire project, since there will not be any change in the amount of the work items and even if additional technology is used, the administration will make payment due to contract price (with item prices in first quantities), total progress billing amount for all of the different completion times is 1.442.954,4 TL and it will not have any change due to completion time.

Table 6. Monthly Progress Billing Amounts

	18 MONTHS	17 MONTHS	16 MONTHS	15 MONTHS
April	6.739,99 TL	6.739,99 TL	6.739,99 TL	6.739,99 TL
May	2.514,90 TL	2.643,79 TL	2.514,90 TL	1.912,92 TL
June	11.320,41 TL	16.207,28 TL	16.336,17 TL	16.207,33 TL
July	127.856,23 TL	166.157,15 TL	179.457,18 TL	211.961,07 TL
August	181.930,03 TL	138.613,36 TL	132.295,34 TL	97.892,30 TL
September	6.963,34 TL	6.963,34 TL	127.486,37 TL	82.628,19 TL
October	123.688,19 TL	123.688,19 TL	167.006,02 TL	198.028,06 TL
November	166.383,41 TL	166.383,41 TL	88.488,57 TL	47.645,26 TL
December	61.028,41 TL	64.588,06 TL	46.357,88 TL	31.372,77 TL
January	0,00 TL	0,00 TL	108.096,97 TL	276.762,98 TL
February	236.139,42 TL	237.933,93 TL	306.673,46 TL	252.961,06 TL
March	109.954,20 TL	170.481,21 TL	113.023,06 TL	76.055,47 TL
April	90.014,01 TL	117.089,87 TL	77.980,44 TL	93.660,84 TL
May	111.975,47 TL	94.906,64 TL	39.896,28 TL	60.461,69 TL
June	72.790,89 TL	53.072,71 TL	8.005,40 TL	12.725,03 TL
July	55.967,80 TL	34.120,34 TL	22.614,11 TL	
August	32.359,06 TL	43.365,17 TL		
September	45.126,44 TL			
Total Progress Billing Costs	1.442.954,4 TL	1.442.954,4 TL	1.442.954,4 TL	1.442.954,4 TL

In Figure 2 cumulative cost curves (S diagrams) according to different completion times are shown for each planning.

Fig. 2. Cash Flow Diagrams for 18th, 17th, 16th, and 15th months (S Curves)TL
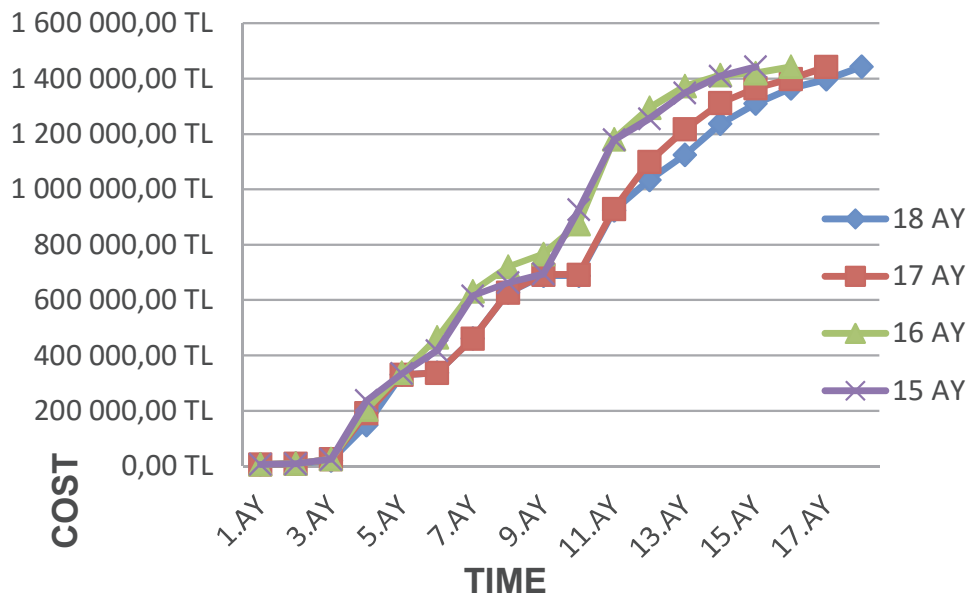
After being calculated of 18-month progress billing values were calculated, inflationist losses to be exposed by each progress billing taken as of the end of 18th month with combined nominal interest were calculated according to Net Present Value approach and indicated in Table 7. Interest income to be provided by cash flow corresponding to each time shortening and inflationist losses to be exposed were calculated separately. In the calculations, monthly inflation value (PPI monthly % change average in 2014 according to Turkey Statistics Institute) were taken to be 7.40% and bank interest values were taken to be (monthly deposit interest rates mean of the banks in 2014 according to BRSA data) 8.96 monthly.

Table 7. Interest-Inflation Effect in 18-Month Planning

Months	Cost	İnterest and Inflation Effect	
April	6.739,99 TL	1,301025	8.768,90 TL
May	2.514,90 TL	1,281041	3.221,69 TL
June	11.320,41 TL	1,261364	14.279,16 TL
July	127.856,23 TL	1,241989	158.796,01 TL
August	181.930,03 TL	1,222911	222.484,31 TL
September	6.963,34 TL	1,204127	8.384,75 TL
October	123.688,19 TL	1,185631	146.648,57 TL
November	166.383,41 TL	1,167419	194.239,23 TL
December	61.028,41 TL	1,149487	70.151,39 TL

Months	Cost	İnterest and Inflation Effect	
January	0,00 TL	1,131831	0,00 TL
February	236.139,42 TL	1,114446	263.164,52 TL
March	109.954,20 TL	1,097327	120.655,73 TL
April	90.014,01 TL	1,080472	97.257,60 TL
May	111.975,47 TL	1,063875	119.127,95 TL
June	72.790,89 TL	1,047534	76.250,93 TL
July	55.967,80 TL	1,031443	57.727,61 TL
August	32.359,06 TL	1,0156	32.863,86 TL
September	45.126,44 TL	1	45.126,44 TL

Inflation values in loss nature were subtracted from interest values in income nature and net profit/loss values were calculated and with Net Present Value Approach, the values to be taken of the planning conducted for four different times as of the completion month were detected. Findings are shown in Table 8.

Table 8. The Values to be given by Project Total Values as a result of Four Different Planning as of the end of 18th Month

	18 MONTH	17 MONTH	16 MONTH	15 MONTH
April	8.768,90 TL	8.634,20 TL	8.501,58 TL	8.370,99 TL
May	3.221,69 TL	3.334,78 TL	3.123,48 TL	2.339,33 TL
June	14.279,16 TL	20.129,26 TL	19.977,68 TL	19.515,68 TL
July	158.796,01 TL	203.195,47 TL	216.089,24 TL	251.307,65 TL
August	222.484,31 TL	166.908,09 TL	156.853,49 TL	114.281,38 TL
September	8.384,75 TL	8.255,96 TL	148.830,07 TL	94.980,07 TL
October	146.648,57 TL	144.395,99 TL	191.971,32 TL	224.134,27 TL
November	194.239,23 TL	191.255,64 TL	100.154,10 TL	53.098,05 TL
December	70.151,39 TL	73.102,76 TL	51.663,34 TL	34.426,19 TL
January	0,00 TL	0,00 TL	118.617,75 TL	299.034,61 TL
February	263.164,52 TL	261.091,38 TL	331.352,04 TL	269.119,05 TL

	18 MONTH	17 MONTH	16 MONTH	15 MONTH
March	120.655,73 TL	184.200,15 TL	120.242,46 TL	79.670,68 TL
April	97.257,60 TL	124.569,03 TL	81.687,15 TL	96.605,85 TL
May	119.127,95 TL	99.417,92 TL	41.150,75 TL	61.404,89 TL
June	76.250,93 TL	54.741,49 TL	8.130,29 TL	12.725,03 TL
July	57.727,61 TL	34.652,61 TL	22.614,11 TL	
August	32.863,86 TL	43.365,17 TL		
September	45.126,44 TL			
Total Inflation and Interest Effects	1.639.148,67 TL	1.621.249,91 TL	1.620.958,84 TL	1.621.013,7 TL

In four separate planning processes, cost values of 18-month work plans were found to be lower than the others both based on the time and due to the use of technology. The main reason of this is that the machine-equipment cost applied in production items in which technology was generally used was found to be higher than labor force.

In order to detect the level of the vaues calculated in Table 8 at the end of 18th month, being moved of total amounts obtained at the end of each project (interest income and inflation loss) to the end of 18th monthwere obtained with the following calculation.

17 months:(1.621.249,91TL*1,0156)=1.646.541.41TL
**16 months:**(1.620.958,84TL*1,0156*1,0156)=1.671.927.23TL
15 months: (1.621.013,7 TL *1,0156*1,0156*1,0156)= 1.698.066.8 TL

In Table 9 the effects of the savings arising from the reduction in general expenses (+) and the effects of the expenses coming from technology use expenses (-) on the values at the end of 18th month are seen. Labor force costs were roughly accepted to be equal to general expense costs and were taken from the values calculated in Table 5.

Table 9. Total Saving Amount

	18 months	17 months	16 months	15 months
Interest and Inflation Effect for each Month completed Early	1.639.148,67 TL	1.646.541.41 TL	1.671.927.23 TL	1.698.066.80 TL
General Expenses	-	44.320,00 TL	88.640,00 TL	132.960,00 TL
The saving arising from the price difference between item prices of 2014 and item price obtained by using technology on critical circle	-	71.024,00 TL	184.514,00 TL	216.389,00 TL
Final Values	**1.639.148,67 TL**	**1.619.837.41 TL**	**1.576.053.23 TL**	**1.614.628.80 TL**

Final values belonging to four different planning terms calculated in Table 9 are shown in Figure 3 as graph. As it is ınderstood here, time shortrning provided by using technology for a block in the project reduce project total profit from 18 months to 16 months that is the contract time and after this time, it changes in lime with increasing ğroject total profit. At the same time Figure 3 gives an important opinion about how much the project will the profitable in what time it is completed.

Fig. 3. Total Saving Amounts TL for 18th, 17th, 16th and 15th Months
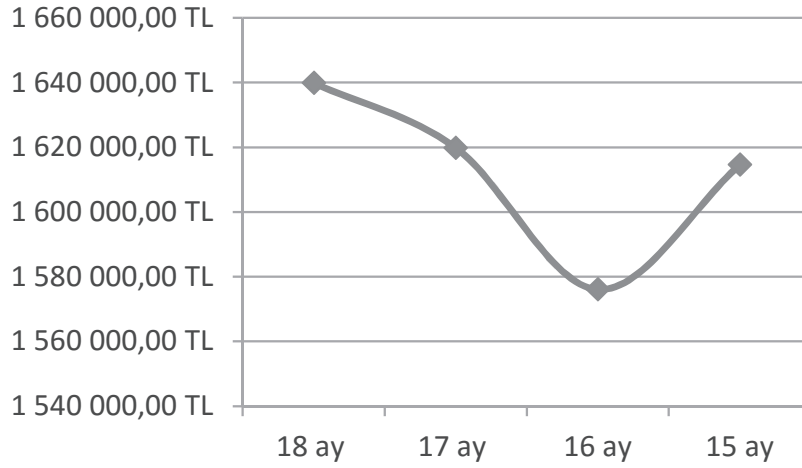
The scores whose completion time and profit value were calculated by this way and the information they give about temporal mobility skills of the contractors and different time/profit values they will obtain are predicted to submit important opportunities to the administrators during decision making process.

Summary

According to 18-month work plan that is the contract delivery time of mass housing project composed of TOKI B Type blocks in Düzce, cost calculations were performed with critical circle method, critical circle was formed and after being found the critical activities on critical circle and by using technology in work items that may be appropriate, the completion of this work was performed for 17, 16 and 15-month work plans and Net Profit Value were calculated. For each mentioned time, technology calculation was performed and different data was obtained. The calculations were conducted for a block. The cost calculated will increase as much as block number [8].

It is required to make cost calculations for each project according to different completion times in line with providing cost minimization in construction projects and to reach the most optimum temporal value specifically according to the calculation conducted for this project is understood to be 18-month period specified in the contract. For time shortening wanted to be performed with different purposes, it was understood that a time period of 15 months instead of 16 months would provide more time saving with less spending. It is a very interesting finding that the additional cost to be brought by 17 month completion time took a close value to the additional cost to be brought by 15 month completion time.

In current circumstances, the 18-month completion period is more profitable than the other three completion terms. Furthermore, that the graph obtained as a result of the study (Figure 3) will continue in 14 months or less completion time in a similar manner points out the possibility that the completion of the project with less additional cost in less time may be possible.

When the results of this study were evaluated with the findings of time-cost analysis studies conducted in the sources with no[1] [3] and[2] [11] in literature review, it was understood that all projects have specific features, different time-cost studies must be conducted for each project, the effects of time shortening methods on the costs are at different dimensions.

In this study, it is mentioned only a certain part of the factors that may affect the work within the processes of the activities in the construction projects (whether the technology is used or not). The adverse events such as weather conditions, machinery and equipment failures, delays in the supply of materials and workers' special reasons, work slowdown or stoppage were excluded from this study.

References

[1]   Sorguç,D.,Kuruoğlu,M.,1*, İnşaat İşletmelerinde Çağdaş Yönetim ve Değişim Modeli*, İstanbul Ticaret Odası, 2001- 37, İstanbul

[2]   Monks, J. G. "Schaum's *Outline of Theoryand Problems of Operations Managment 2nd ed.*", USA McGraw-HillInc., 128,1996

[3]   Uğur, O. L. Kanit R. "S*üre Kısıtlı İnşaat Projelerinde İşgücü Maliyetinin CPM İle Analizi*" Politeknik Dergisi, 7/2,Ankara, s 159-168 2004

[4]   Yalgın, C. "*Proje İdaresi ve Kontrolü*" Ankara 1965

[5]   Barutçugil, İ. S. "*Büyük Ölçekli Yatırım Projelerinin Yönetimi*", Uludağ Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 1984 5/2:162

[6]   Kutlu Temiz, N. "*Proje Planlama Teknikleri ve PERT Tekniğinin İnşaat Sektöründe Uygulanması Üzerine Bir Çalışma*" Dokuz Eylül Üniversitesi Sosyal Bilimler Enstitüsü Dergisi Cilt 3, Sayı:2, 2001

[7]   Chou, J. "*Cost Simulation in and Item-Based Project Involving Construction Engineering and Management.*" International Journal of Project Management 29 2011 706–717.

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[1] Uğur, O. L. Kanit R. "S*üre Kısıtlı İnşaat Projelerinde İşgücü Maliyetinin CPM İle Analizi*" Politeknik Dergisi, 7/2,Ankara, s 159-168 2004
[2] Uğur, O. L. Erdal A. "*İnşaat Projelerinin Ağ Diyagramlarıyla Planlanmasında Süre-Maliyet Değişimlerinin Yeni İşgücü Eklenmesi Orijininde Analizi*" Düzce Üniversitesi Bilim ve Teknoloji Dergisi, 2 2014 362–373

[8]   Garel, G. "*A history of Project Management Models: Frompre-Models To the Standard Models.*"International Journal of Project Management 31 2013 663–669.

[9]   Pillai, A.S.,Joshi, A., Rao, K.S., "*Performance Measurement of R&D Projects in a Multi-Project, concurrent Engineering Environment*". International Journal of Project Management 20 2002, 165–177.,

[10]   Albayrak, B. "*Proje Yönetimi ve Analizi*" Ankara Ekim 2009

[11]   Uğur, O. L. Erdal A. "*İnşaat Projelerinin Ağ Diyagramlarıyla Planlanmasında Süre-Maliyet Değişimlerinin Yeni İşgücü Eklenmesi Orijininde Analizi*" Düzce Üniversitesi Bilim ve Teknoloji Dergisi, 2 2014 362–373