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"Optimizing Time and Cost of G+7 Residential Building"

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Abstract: In the construction industry, project time & project cost are given upmost priority. But since there are innumerable uncertainties involved in construction, delays in project completion are fairly common which lead to an increase in project's total cost. Thus project time crashing plays an important role in project management determining which activities duration to crash to complete the project in the stipulated time. But crashing the duration will mean adding more resources which will lead to an increased additional cost of the project. Thus, the paper deals with determining how to crash the project duration so as to complete the project at the earliest with minimum added cost obtaining a Time-Cost Trade-off for the project. Therefore for reducing total project time at the least added total cost and crashing the duration of an actual residential building construction by using primavera to schedule the project with CPM crashed using the Solver add-in of Microsoft Excel.

Keywords: Project management, project crashing, Excel Solver, Critical path method.

I. INTRODUCTION

According to the definition provided by the Project Management Institute the time and cost constitute two crucial elements of the project management (PM). The project is a temporary endeavour with a defined beginning and end undertaken to meet unique objectives, typically to bring about beneficial change or added value. Nowadays the project management is a very known and explored discipline of planning, organizing, securing, leading and controlling resources to achieve specific goals. This domain mainly serves to evaluate the impact of increasing or decreasing the level of resources on the project completion time and to find the cheapest or the shortest way of performing the whole project. Such a skill is very helpful in the project management. In the Analysis one might consider overtime, second shifts, or changing equipment to make some work proceed faster. The results of the Analysis show which activity durations should be changed to gain the intended outcomes. Crashing the activities of a project relates to the costevaluation of reducing the duration of those activities which are in the critical path. After this evaluation, the activities that correspond to the lowest cost for crashing should be worked on. This means that the addition of more financial resources, manpower (extra hours, for example), materials or equipment's, will cause an increase in the project budget. Construction of a real time structure involves thousands of activities including not only civil but also mechanical electrical & various other aspects. The project considered for this paper is that of a G+7 Residential Building which is located in Malad(w), Mumbai. Academic purposes, the scope of this paper limits to the planning & crashing of only RCC works of the G+7 Residential Building. The project is scheduled in Primavera and since manual crashing of the project of this scale will prove tedious and unnecessarily time consuming, the paper uses an adding of MS Excel called Excel Solver. The second section of this paper presents the problem statement formulated comprising of the complexities involved in crashing of the construction project. The third section presents the analysis of the crashing problem with a view to determine the least possible time for a projects completion; and to program the project crashing that would implicate.

Therefore it is recommended to use an optimization software which is able to find optimal solutions, to generate results needed in the sensitivity analysis and to allow the project manager to make quick time-cost simulations. The Solver, which is an Add-In of Microsoft Excel located under "Tools" of the main menu, is software which seems to meet all essential requirements.

II. METHODOLOGY OF WORK

The Methodology adopted to crash the project to answer the Problem Statement consequently solving the Time-Cost Trade-off is depicted in the following points:

i) Using Primavera to plan & schedule the project

A Myriad of Details Are Considered in Planning How to Coordinate All the RCC Activities, In Developing A Realistic Schedule. Of The Many Project Management Software's, Primavera Is The Most Commonly Used Software to Deal with All the Data Needed to Develop Schedule Information.





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The Various Activities Are Linked by the Software In Terms Of Their Predecessors and Successors .Once Completed, The Total Time Required to Complete the Project Is Displayed.

ii) Using Primavera doing Resource allocation and Defining Expenses

For defining cost and expenses resources should be added properly and proper resources allocation should be done to get the work done.

iii) Using Excel to reschedule the project with CPM and Excel Solver to crash the project and solve the Time-Cost Trade-Off

Each activity is scheduled by calculating its earliest & latest times (ES/EF/LS/LF) in MS Excel with the help of specific formulae.

The Problem Of Finding The Least Expensive Way Of Crashing Activities And The Consequent Time-Cost Trade-Off Can Be Rephrased In A Form More Familiar To MS Excel Sheet And Solved Using MS Excel Solver Add-In.

	COLLECTED ALL ACTIVITIES WHICH IS INC	LUDED IN RRC WORK	ARE LISTED BELOW:					
ID	Activity Name	Normal Duration	Normal Cost					
1	RCC (g+7)	235						
2	RCC.1 Substructure	87						
3	Sop	0						
4	RCC.1.1 Footings	21						
5	Concreting	3	₹77,416.00					
6	Deshuttering	4	₹9,500.00					
7	PCC	7	₹64,400.00					
8	Reinforcement Fixing	4	₹25,229.49					
9	Shuttering	6	₹13,550.00					
10	RCC.1.2 Column upto plinth beam	41						
11	RCC.1.2.1 1st Step	13						
12	Concreting	2	₹77,416.00					
13	Deshuttering	3	₹9,500.00					
14	Reinforcement fixing	3	₹25,229.49					
15	Shuttering	5	₹13,550.00					
16	RCC.1.2.2 2nd Step	9						
17	Concreting	2	₹77,416.00					
18	Deshuttering	3	₹9,500.00					
19	Reinforcement Fixing	3	₹25,229.49					
20	Shuttering	5	₹13,550.00					
21	RCC.1.2.3 Plinth Beam	24						
22	Concreting	2	₹77,416.00					
23	Deshuttering	4	₹9,500.00					
24	PCC Below Plinth beams	5	₹70,400.00					
25	PCC for Plinth	5	₹68,000.00					
26	Reinforcement fixing	3	₹25,229.49					
27	Shuttering	5	₹13,550.00					
28	RCC.1.3 Construction of floor slab	25						
29	RCC.1.3.1 Pour 1	25						
30	RCC.1.3.1.1 Column and Retaining wall	14						
31	Concreting	2	₹77,416.00					
32	Deshuttering	4	₹9,500.00					
33	Reinforcement Fixing	3	₹25,229.49					
34	Shuttering	5	₹13,550.00					
35	RCC.1.3.1.2 Floor Slab	11						
36	Concreting	2	₹77,416.00					
37	Deshuttering	4	₹9,500.00					
38	Reinforcement Fixing	3	₹25,229.49					
39	Shuttering	5	₹13,550.00					
40	RCC.1.3.3 Pour 2	25						
41	RCC.1.3.3.1 Column and Retaining wall	14						
42	Concreting	2	₹77,416.00					
43	Deshuttering	4	₹9,500.00					

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44	Reinforcement Fixing	3	₹25,229.49				
45	Shuttering	5	₹13,550.00				
46	RCC.1.3.3.2 Floor slab	11					
47	Concreting	2	₹77,416.00				
48	Deshuttering	4	₹9,500.00				
49	Reinforcement Fixing	3	₹25,229.49				
50	Shuttering	5	₹13,550.00				
51	RCC.2 Superstructure	125					
52	RCC.2.1 RCC Slab Cycle	100					
53	RCC.2.1.1 1st Floor	25					
54	RCC.2.1.1.1 Slab	11					
55	Concreting	3	₹77.416.00				
56	Deshuttering	3	₹9,500,00				
57	Reinforcement Fixing	4	₹25.229.49				
58	Shuttering	5	₹13,550,00				
59	RCC.2.1.1.2 Column	23	(10,000100				
60	Concreting	2	₹77.416.00				
61	Deshuttering		₹9 500 00				
62	Reinforcement Fixing	4	₹25,229,49				
63	Shuttering	5	₹13,550,00				
64	BCC 2.1.2. 2nd Floor	28	(13,550.00				
65	RCC 2121 Slab	14					
66	Concreting	2	₹77.416.00				
67	Deshuttering	3	₹9,500,00				
68	Reinforcement Fixing	4	₹25,229,49				
69	Shuttering	5	₹13,550,00				
70	RCC.2.1.2.2 Column	14	(10,000100				
71	Concreting	2	₹77.416.00				
72	Deshuttering	3	₹9,500.00				
73	Reinforcement Fixing	4	₹25,229.49				
74	Shuttering	5	₹13,550.00				
75	RCC.2.1.3 3rd Floor	28					
76	RCC.2.1.3.1 Slab	14					
77	Concreting	2	₹77,416.00				
78	Deshuttering	3	₹9,500.00				
79	Reinforcement Fixing	4	₹25,229.49				
80	Shuttering	5	₹13,550.00				
81	RCC.2.1.3.2 Column	14					
82	Concreting	2	₹77,416.00				
83	Deshuttering	3	₹9,500.00				
84	Reinforcement Fixing	4	₹25,229.49				
85	Shuttering	5	₹13,550.00				
86	RCC.2.1.4 4th Floor	28					
87	RCC.2.1.4.1 Slab	14					
88	Concreting	2	₹77,416.00				
89	Deshuttering	3	₹9,500.00				
90	Reinforcement Fixing	4	₹25,229.49				
91	Shuttering	5	₹13,550.00				
92	RCC.2.1.4.2 Column	14	577.414.00				
93	Concreting	2	₹//,416.00				
94	Desnuttering Deinformenter Eining	3	₹9,500.00				
93	Shuttoring	4 5	₹23,229.49				
90	BCC 2.1.5.5th Floor	3 78	15,550.00				
9/	RCC 2 1 5 1 Slob	<u> </u>					
00	Concreting	1 7	₹77 /16 00				
100	Deshuttering	2	₹9,500,00				
100	Reinforcement Fixing	<u> </u>	₹25 220 /0				
101	Shuttering	5	₹13 550 00				
102	RCC.2.1.5.2 Column	24	(15,550.00				

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104	Concreting	2	₹77,416.00				
105	Deshuttering	3	₹9,500.00				
106	Reinforcement Fixing	4	₹25,229.49				
107	Shuttering	5	₹13,550.00				
108	RCC.2.1.6 6th Floor	28					
109	RCC.2.1.6.1 Slab	14					
110	Concreting	2	₹77.416.00				
111	Deshuttering	3	₹9,500,00				
112	Reinforcement Fixing	1	₹25,200.00				
112	Shuttering	5	₹13 550 00				
113	PCC 2162 Column	28	(13,350.00				
114	Concreting	28	₹77.416.00				
115	Dashuttaring	2	₹77,410.00				
110	Desinference Eising	3	₹9,300.00				
117	Chester sing	4	₹25,229.49				
118	Shuttering	5	₹13,550.00				
119	RCC.2.1.7 /th Floor	19					
120	RCC.2.1.7.1 Slab	14	777				
121	Concreting	2	₹77,416.00				
122	Deshuttering	3	₹9,500.00				
123	Reinforcement Fixing	4	₹25,229.49				
124	Shuttering	5	₹13,550.00				
125	RCC.2.1.7.2 Column	19					
126	Concreting	2	₹77,416.00				
127	Deshuttering	3	₹9,500.00				
128	Reinforcement Fixing	4	₹25,229.49				
129	Shuttering	5	₹13,550.00				
130	RCC.2.8 Terrace	5					
131	Parapet Wall	5	₹28,709.00				
132	RCC.2.2 Over Head Tank	20					
133	Bottom Slab	10	₹10,300.0				
134	Top Slab	10	₹10,300.0				
134 135	Top Slab RCC.3 finishing	10 110	₹10,300.0				
134 135 136	Top Slab RCC.3 finishing RCC.3.1 brickwork	10 110 90	₹10,300.0				
134 135 136 137	Top Slab RCC.3 finishing RCC.3.1 brickwork fifth floor	10 110 90 6	₹10,300.0 ₹183,818.00				
134 135 136 137 138	Top Slab RCC.3 finishing RCC.3.1 brickwork fifth floor first floor	10 110 90 6 6	₹10,300.0 ₹183,818.00 ₹273,248,00				
134 135 136 137 138 139	Top Slab RCC.3 finishing RCC.3.1 brickwork fifth floor first floor fourth floor	10 110 90 6 6 6	₹10,300.0 ₹183,818.00 ₹273,248.00 ₹243,560.00				
134 135 136 137 138 139 140	Top Slab RCC.3 finishing RCC.3.1 brickwork fifth floor first floor fourth floor ground floor	10 110 90 6 6 6 6 4	₹10,300.0 ₹183,818.00 ₹273,248.00 ₹243,560.00 ₹250,600.00				
134 135 136 137 138 139 140 141	Top Slab RCC.3 finishing RCC.3.1 brickwork fifth floor first floor fourth floor ground floor second floor	10 110 90 6 6 6 4 6 6 6 6 6 6 6 6 6 6 6 6 6	₹10,300.0 ₹183,818.00 ₹273,248.00 ₹243,560.00 ₹250,600.00 ₹200,818.00				
134 135 136 137 138 139 140 141 142	Top Slab RCC.3 finishing RCC.3.1 brickwork fifth floor first floor fourth floor ground floor second floor seventh floor	10 110 90 6 6 6 6 4 6 4 6 4 6 4	₹10,300.0 ₹183,818.00 ₹273,248.00 ₹243,560.00 ₹250,600.00 ₹200,818.00 ₹200,910.00				
134 135 136 137 138 139 140 141 142 143	Top Slab RCC.3 finishing RCC.3.1 brickwork fifth floor fifth floor fourth floor ground floor second floor seventh floor sixth floor	10 110 90 6 6 6 6 6 6 4 6 4 6 4 6 4 6	₹10,300.0 ₹183,818.00 ₹273,248.00 ₹243,560.00 ₹250,600.00 ₹200,818.00 ₹200,910.00 ₹200,900.00				
134 135 136 137 138 139 140 141 142 143	Top Slab RCC.3 finishing RCC.3.1 brickwork fifth floor fifth floor fourth floor ground floor second floor seventh floor sixth floor terrace level	10 110 90 6 6 6 6 4 6 4 6 4 6 4 6 4 6 4 6 4	₹10,300.0 ₹183,818.00 ₹273,248.00 ₹243,560.00 ₹250,600.00 ₹200,818.00 ₹200,910.00 ₹200,900.00 ₹193,800.00				
134 135 136 137 138 139 140 141 142 143 144 145	Top Slab RCC.3 finishing RCC.3.1 brickwork fifth floor fifth floor fourth floor ground floor second floor seventh floor sixth floor terrace level third floor	10 110 90 6 6 6 6 4 6 4 6 4 6 4 6 4 6 4 6 4 6 4 6	₹10,300.0 ₹183,818.00 ₹273,248.00 ₹243,560.00 ₹250,600.00 ₹200,818.00 ₹200,910.00 ₹200,900.00 ₹193,800.00 ₹210,800.00				
134 135 136 137 138 139 140 141 142 143 144 145 146	Top Slab RCC.3 finishing RCC.3.1 brickwork fifth floor fifth floor fourth floor ground floor second floor seventh floor sixth floor terrace level third floor	10 110 90 6 6 4 6 4 6 4 6 4 6 4 6 4 6 88	₹10,300.0 ₹183,818.00 ₹273,248.00 ₹243,560.00 ₹250,600.00 ₹200,818.00 ₹200,910.00 ₹200,900.00 ₹193,800.00 ₹210,800.00				
134 135 136 137 138 139 140 141 142 143 144 145 146	Top Slab RCC.3 finishing RCC.3.1 brickwork fifth floor fifth floor fourth floor ground floor second floor seventh floor sixth floor terrace level third floor Gifth floor floor	10 110 90 6 6 4 6 4 6 4 6 4 6 4 6 88 6	₹10,300.0 ₹183,818.00 ₹273,248.00 ₹243,560.00 ₹250,600.00 ₹200,818.00 ₹200,910.00 ₹200,900.00 ₹193,800.00 ₹114,000.00				
134 135 136 137 138 139 140 141 142 143 144 145 146 147 148	Top Slab RCC.3 finishing RCC.3.1 brickwork fifth floor fifth floor fourth floor ground floor second floor seventh floor sixth floor terrace level third floor RCC.3.2 internal plastering fifth floor	10 110 90 6 6 4 6 4 6 4 6 4 6 88 6 6 6 6 6 6 6 6 6 6 6 6 6	₹10,300.0 ₹183,818.00 ₹273,248.00 ₹243,560.00 ₹250,600.00 ₹200,818.00 ₹200,910.00 ₹200,900.00 ₹193,800.00 ₹114,000.00 ₹114,000.00				
134 135 136 137 138 139 140 141 142 143 144 145 146 147 148	Top Slab RCC.3 finishing RCC.3.1 brickwork fifth floor fifth floor fourth floor ground floor second floor seventh floor sixth floor terrace level third floor RCC.3.2 internal plastering fifth floor first floor	10 110 90 6 6 4 6 4 6 4 6 88 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6	₹10,300.0 ₹183,818.00 ₹273,248.00 ₹243,560.00 ₹250,600.00 ₹200,818.00 ₹200,910.00 ₹200,900.00 ₹193,800.00 ₹114,000.00 ₹114,000.00 ₹114,000.00				
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164	Terrace level	2	₹180,050.00
165	third floor	6	₹180,050.00
166	RCC.3.4 flooring	88	
167	fifth floor	5	₹90,160.00
168	first floor	5	₹90,160.00
169	fourth floor	5	₹90,160.00
170	ground floor	3	₹90,160.00
171	second floor	5	₹90,160.00
172	seventh floor	5	₹90,160.00
173	sixth floor	5	₹90,160.00
174	Terrace level	4	₹90,160.00
175	third floor	5	₹90,160.00
176	RCC.3.5 painting	92	
177	fifth floor	5	₹200,400.00
178	first floor	5	₹200,400.00
179	fourth floor	5	₹200,400.00
180	ground floor	5	₹200,400.00
181	second floor	5	₹200,400.00
182	seventh floor	5	₹200,400.00
183	sixth floor	5	₹200,400.00
184	Terrace level	4	₹200,400.00
185	third floor	5	₹200,400.00
186	RCC.3.6 extra finishing work	10	
187	doors and windows	10	₹297,000.00
188	railings	5	₹100,000.00
189	еор	0	

2. TO SCHEDULE THE PROJECT BY USING PRIMAWERA

Activities

Layout:	Classic Schedule	Layout	Filter	All Activities									
vity ID		Activity Name	Original Duration	Start	Finish	Predecessor	Resources		Jan 14 SMTWTF	Jan 21 S S M T W T F	Jan 28 S S M T W T F	Feb 04 S S M T W T F S S	F M T
RC	C (g+7)		235	17Jan-18	26-Dec-18			Ē					
🗉 🖬 R	CC.1 Subst	ructure	87	17Jan-18	23-May-18				—	_	-	_	
	0099	sop	0	17-Jan-18				1	🔶 sop,	17Jan-18			
	RCC.1.1 Footi	igs	21	17-Jan-18	15-Feb-18					_	-	_	
- 6	a A1000	PCC	7	17-Jan-18	26 Jan - 18	0099	LABOUR, MASON, PCC 1:2:4		L L <mark>a</mark> ree		PCC		
	A1020	Shuttering	6	29-Jan-18*	06-Feb-18	A1010	LABOUR, CARPENTER, PLYWO					-Shuttering	
	A1040	Deshuttering	4	10-Feb-18*	15-Feb-18	A1030	LABOUR, CARPENTER					- E	
	A1010	Reinforcement Fixing	4	26-Jan-18	01-Feb-18	A1000	MASON, LABOUR, STEEL, plate:			L _e r	Re	inforcement Fixing	
	A1030	Concreting	3	06-Feb-18*	09-Feb-18	A1020	LABOUR, MASON, CEMENT, CO					- Conc	reting
Ξ.	RCC.1.2 Colur	nn upto plinth beam	41	16-Feb-18	16-Apr-18								
	RCC.1.2.1 1	st Step	13	16-Feb-18	06-Mar-18								
	😑 A1060	Shuttering	5	20-Feb-18	27-Feb-18	A1050	plates, PLYWOOD, LABOUR, MA						
	🔲 A1050	Reinforcement fixing	3	16-Feb-18	20-Feb-18	A1040	STEEL, CARPENTER, LABOUR,						
	😑 A1080	Deshuttering	3	02-Mar-18	06-Mar-18	A1070	LABOUR, MASON, CARPENTER						
	😑 A1070	Concreting	2	28-Feb-18	02-Mar-18	A1060	COARSE AGG, GRIT POWDER,						
	RCC.1.2.2 2	nd Step	9	05-Mar-18	17-Mar-18								
	😑 A1100	Shuttering	5	10-Mar-18	17-Mar-18	A1090	plates, PLYWOOD, MASON, LAB						
	😑 A1120	Deshuttering	3	08-Mar-18	12-Mar-18	A1110	MASON, LABOUR, CARPENTER						
	🔲 A1090	Reinforcement Fixing	3	07-Mar-18	10-Mar-18	A1080	STEEL, MASON, LABOUR, CARF						
	🔲 A1110	Concreting	2	05-Mar-18	08-Mar-18	A1100	CEMENT, COARSE AGG, GRIT F						
	RCC.1.2.3 P	inth Beam	24	13-Mar-18	16-Apr-18								
	🔲 A1180	PCC for Plinth	5	09-Apr-18	16-Apr-18	A1170	PCC 1:2:4, WATER, MASON, LAI	1					
	🔲 A1150	Shuttering	5	24-Mar-18	31-Mar-18	A1140	plates, PLYWOOD, MASON, LAB						
	🔲 A1130	PCC Below Plinth beams	5	13-Mar-18	20-Mar-18	A1120	PCC 1:2:4, WATER, LABOUR, M.						
	😑 A1170	Deshuttering	4	03-Apr-18	09-Apr-18	A1160	CARPENTER, LABOUR, MASON						
	🔲 A1140	Reinforcement fixing	3	20-Mar-18	23-Mar-18	A1130	STEEL, CARPENTER, LABOUR						
	🚍 A1160	Concreting	2	31-Mar-18	03-Apr-18	A1150	COARSE AGG, WATER, GRIT PI	-	•				

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ities WBS Reports			
ayout: WBS			
Code	WBS Name	Total Activities	May 2018 June 2018 July 2018 August 2018 September 2018
	L.		22 29 06 13 20 27 03 10 17 24 01 08 15 22 29 05 12 19 26 02 09 16 23
RCC.2	Superstructure	59	23-May-18
📲 RCC.2.1	RCC Slab Cycle	56	23-May-18
🖻 🖶 RCC.2.1.1	1st Floor	8	23-May-18 28-Jun-18
- 🍋 RCC.2.1.1.1	Slab	4	23·May-18 07-Jun-18
ure RCC.2.1.1.2	Column	4	25-May-18 28-Jun-18
🖻 🖶 RCC.2.1.2	2nd Floor	8	07-Jun-18 18-Jul-18
- 🖶 RCC.2.1.2.1	Slab	4	07Jun-18 28Jun-18
- ECC.2.1.2.2	Column	4	28-Jun-18 18-Jul-18
🖻 🖶 RCC.2.1.3	3rd Floor	8	28-Jun-18 08-Aug-18
- 🏪 RCC.2.1.3.1	Slab	4	28-Jun-18 18-Jul-18
- RCC.2.1.3.2	Column	4	18-Jul-18 08-Aug-18
🖻 🛀 RCC.2.1.4	4th Floor	8	18-Jul-18 28-Aug-18
- 📇 RCC.2.1.4.1	Slab	4	18Jul-18 08-Aug-18
- RCC.2.1.4.2	Column	4	08-Aug-18 28-Aug-18
🖻 🍯 RCC.2.1.5	5th Floor	8	08-Aug-18 18-Sep-
- 🍢 RCC.2.1.5.1	Slab	4	08-Aug-18 28-Aug-18
- RCC.2.1.5.2	Column	4	14-Aug-18 18-Sep-
🖻 🛀 RCC.2.1.6	6th Floor	8	28-Aug-18
- 📇 RCC.2.1.6.1	Slab	4	28-Aug-18 18-Sep-
- RCC.2.1.6.2	Column	4	28-Aug-18
🗄 🖶 RCC.2.1.7	7th Floor	8	18-Sep-18
- RCC.2.1.7.1	Slab	4	18-Sep-18
RCC.2.1.7.2	Column	4	18-Sep-18
- RCC.2.8	Terrace	1	
- RCC.2.2	Over Head Tank	2	
RCC.3	finishing	48	10 1.10

3. PROJECT CRASHING

Using Excel solver:

The calculations for scheduling (ES, LS, slack, etc.) are set up in MS Excel. They require use of the "min" and "max" functions and (to identify the critical path) the "if" function.

The following columns are imported to Primavera from MS Project:

- Activity ID
- Activity Description
- Normal Duration
- Normal Cost
- The Immediate Predecessors
- The Immediate Successors

Filling in the columns:

1. First five columns are just the imported information on the activities

2. Forward pass for "Early" times (ES; EF): In the column for ES the entry is always "= max (the EF entries for the immediate predecessors {separated by commas})". The immediate predecessors are the nodes listed in the "Predecessors" column. In the EF column all entries are "= cell with ES + cell with Realised Time". For the "Finish" node (if there is one) ES is "= max (all EF entries)"

3. Backward pass for "Late" times (LS; LF): In the LS column, the entry is "= cell containing LF - cell containing Realised Time" In the LF column, the entry is "= min(the LS entries for all the immediate successors { separated by commas})" The immediate successors of an activity are all the activities that have the activity in their "predecessors" list) [If you don't have a "Finish" node you need to remember that for an activity that has no successors, the LF entry is "=max(all EF entries)"

4. Slack is "=cell for LF - cell for EF" (or = cell for LS - cell for ES)

5. Critical is "=IF (slack=0,"1","0")". This will put "1" in the cell if "slack = 0" is true and "0" if it is not. Finish time is "= EF of the "Finish" node" if there is a Finish node, or "= max (all EF entries)". Use the mouse to select the range of all EF entries.

6. Finish-to-Start (F-S) is the most commonly used Task relationship and is by default used by MS Project to link the predecessors and successors unless specified otherwise. Complications may arise if there are different Task Relationships involved such as Start-to-Start (S-S), Start-to Finish (S-F) & Finish-to-Finish (F-F). For this project there are a number of activities linked with S-S relationship.

7. Activity Crash Time & Cost:

According to the site engineers, the regular working time of workers is 8 hours a day for 7 days a week from 9:00am to 6:00pm with 1 hr lunch. According to the project managers, the only way activities can be accelerated is through using overtime. Since the maximum overtime allowed is 6 hours on top of the regular 8-hour working day, (from 8:00am to 12:00am, 14hrs a day) activities may be crashed on average at a ratio of 4:7 (i.e. Regular 8/ Overtime 14). The results





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are the maximum crash durations used. Site managers also believed that when activities need to be crashed, the cost increase is mostly due to the double rate for overtime. As consequence, they had no problem in accepting the assumption of linear relationship between cost escalation and time crashed.

Maximum crash time for each activity has been calculated by the following formula:

- 1. Maximum crash duration = Normal Duration Crash Duration
- 2. Cost of crashing per day = Crash cost/day = (Crash cost Normal cost)/ Maximum crash duration
- 3. Realized time = Normal duration Days to crash

CONCLUSION

The Existing Software Supporting The Project Management Does Not Have The Functionality Allowing The Manager To Optimize The Time And The Cost Of A Project On The Basis Of Different Time-Cost Variants For Particular Activities Belonging To The Project. This Paper Shows Excel Solver Can Be Applied In The Project Time And Cost Management.

- Excel Solver Allows the User to Find Very Quickly the Optimal Solutions, Which In The Project Time-Cost Management Means the Cheapest or the Shortest Schedule Meeting All the Customer's And Technical Requirements.
- Crashing Of Any Project Must Be Undertaken Only When The Benefits Received From Crashing Are More Than The Actual Cost Of Crashing.
- Productivity of Excel solver which can be used in Project management.

REFERENCES

- [1] Bhushan V Tatar, Rahul S Patil, "optimization tools for time cost trade off applicable in construction project management" Department of Civil Engineering, Padmashree Dr. D.Y. Patil Institute of Engineering & Technology, Pune, (M.S), (India) International Journal of Science, Technology & Management, Volume No 04, Special Issue No. 01, March 2015
- [2] Wenfa Hu and Xinhua He, "An Innovative Time-CostQuality Tradeoff Modeling of Building Construction Project Based on Resource Allocation", ScientificWorld Journal 2014.
- [3] "Introduction to Operations Management" Hillier & Lieberman 8th-edition, chapter 22.
- [4] Elazouni, A.M., and Metwally, F.G., (2007). Expanding finance based scheduling to derive overall optimized project schedules. Journal of Constitution Engineering and Management, 133(1), 86-90.
- Shahsavari Pour, N., Modarres, M. R., Tavakkoli- Moghaddam, R., (2012). Time-Cost-Quality Trade-off in Project Scheduling with Linguistic Variables. World Applied Sciences Journal 18 (3), 404-413.