Schedule Control of an Apartment Building using Primavera Techniques

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Abstract - Resource management is one of the most important aspects of construction project management in today's economy because the construction industry is resourceintensive and the costs of construction resources have steadily risen over the last several decades. Thus general schedule control techniques are useful in optimizing resource scheduling and project duration. General methods such as crashing techniques, reducing the activity duration, increasing the resources, applying calendar or increasing the working hours of the resources. These techniques help to reduce project duration use of unlimited availability of resources for completion of a project. Through it is observed that resources are limited in real project scenario. It has been observed that the project delays occur due to insufficient supply of resources. In large scale projects, preparing an accurate and workable plan is very difficult. Computer packages like MS Project and Primavera project planner are used in construction industry. Project management techniques can be used to resolve resource conflicts and also useful in minimizing the project duration within limited availability of resources to make the project profitable. The main aim of this study is to analyze the schedule control techniques by constraints and activity types is done using primavera P6 software for an apartment building. The project schedule control decreases the duration due to apply of constraints, level of effort, resource dependent it has an effect on the project duration.

Keywords; Schedule control, Constraints, Activity types, Level of Effort, Resource Dependent, Primavera.

1. INTRODUCTION

A resource can be defined as an entity that is assigned to an activity and is required to accomplish the task. It is recommended to create and assign the minimum number of resources to activities. A resource is any quantifiable item in limited supply and of sufficient value to justify tracking and assigning of specific activities for a project.

Every project schedule has its own precedence constraints, which means that each activity can be processed when all its predecessors are finished. In general the purpose of project scheduler is to minimize its completion time, subject to precedence constraints. A more general version assumes that to develop one or more activities, resources such as tools, equipment, machines, or human resources are needed. Vijay K², ² Associate Professor, Department of Civil Engineering, NCET,Bangalore,Karnatka, India

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Each resource has limited capacity; consequently at a certain moments one activity may not begin their processing due to resource constraints even if all their predecessors are finished. This type of problems is called Resource-constrained project scheduling problem (RCPSP) which involves assigning jobs or tasks to a resource or a set of resources with limited capacity in order to meet some predefined objective.

In this study we can find out the different factors which affect the time and cost of a construction project. The actual cost and time can be also reduced so that the project can be efficient.

2. OBJECTIVES OF STUDY

- **1.** To control the scheduling of project by applying constraints and activity types to reduce the project duration.
- **2.** As it has inbuilt linear programming techniques and where we can give the best schedule or duration to save cost and proper utilization of resources.
- **3.** A study on the optimization of the schedule of resource constrained construction project using primavera techniques is carried out on a residential apartment in this study.

3. PROJECT DETAILS AND ANALYSIS

Table	31	Pro	iect	detail	s
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Project name	Columbus Square (residential apartments) consists of 6 towers (A,B,C,D,E,F) each consisting of B+G+12 floors
Total area	4 acres
Project under study	Tower A (B+G+4 floors)
Total built up area (from basement to terrace)	5557.3 sqm (59797.38 sq ft)
Total no of flats	25 flats
Project start date	15 Nov 2013
Project completion date	15 Sep 2015
Total duration of project	568 days
Estimated cost	6,35,41,828.78 Rs

In this study using the features of primavera we have worked out on to reduce the scheduled project duration without using conventional methodology. Schedule control techniques used in primavera are explained below.

In this project it is observed that on a regular schedule using primavera P6 we got the following results.

Table 3.2 Before applying schedule techniques using Primavera

Estimated project duration	568 days				
Start date	15 Nov 2013				
Completion date	15 Sep 2015				
Estimated budgeted total cost	Rs. 6,35,41,828.78				
This project deals with the data of one tower construction with 4					

This project deals with the data of one tower construction with 4 floor of 59797.38 sq ft with 5 flats per floor.

3.1 Constraints: Applying date constraints to the activities based on the type of work. Constraints are used to impose restrictions on activities that cannot be realistically scheduled with logical links Sometimes activities must be accomplished according to specific dates rather than the dates determined by other activities in the project. The need to use a constraint to delay an activity to start as late as possible without affecting any activities after it.

Activity constraints applied for activity ID A1170

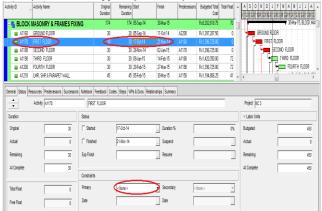


Fig 3.1 Shows before applying constraints in Primavera

Table 3.3 Before applying constraints

Activity ID	Activity name	Start date	Finish date				
A1170	FIRST FLOOR	17 Oct 2014	21 Nov 2014				
Project start and finish dates 15 Nov 2013 15 Sep 2015							
Total duration = 568 days							

Proposed change:

The WBS of block work and frame fixing of an activity first floor was started on 15 Oct 2014 instead of 17 Oct 2014

Ac	ŝvity E)	TA	ctivity I	Name			Origina Duration		ng Start on	Finish	Predecessors	Budgeted Total Cost	Total Float 🔺	A S	OND	JFMAMJJASON Wata a paga a a	
	8	BLOC	KM	ASON	IRY & FRA	MES FIXI	NG	174	1	74 (15-Sep-14	28-Mar-15		Rs8,202,618.75	0			28-Mar-15, BLDCK N	
		à116	D G	ROUN	D FLOOR			3		31 (FSep.1/	10-0ct-14	A2200	Rs1,397,287.50	-2		GROL	IND FLOOR	
Π		a A117												0	14	FIF	rst floor	
		A118	D S	ECONE) FLOOR			3		99 - 25 Nov 14	3100014	ATT/0	Rs1,396,725.00	0		2	SECOND FLOOR	
		A119	D T	HIRD I	FLOOR			3		30 07-Jan-15	12Feb-15	A1180	Rs1,420,350.00	0		1 2	THIAD FLOOR	
	6	a A120	DF	OURTH	H FLOOR			3)	30 18-Feb-15	25Mar-15	A1190	Rs1,396,725.00	0.			TOURTH FLOOR	
۲														÷	•			
6	eneral	Status	Reso	urces	Predecessors	Successors	Notebo	ok Feedback	Codes St	MPs & Dr	ocs Relationsh	ins Summary						
F									00000 00			pa cannary			_			
	•	1		covey	A1170		F	RST FLOOR									Project NC	
	Durati	on					Status										⊲ Labor Units	
	Origi	nal				30	∏ St	arted	15-0	lct-14	_	Duration %				0%	Budgeted	
	Actu	al				0	[] Fi	ished	19-1	lov-14		Suspend			_		Actual	
	Rema	sining				30	Exp Fi	nish			_	Resume				_	Remaining	
	At Cr	omplete				30											At Complete	
							Constr	aints		-								
	Total	Float				0	Primar	у		datory Start		Secondary	< Non	e>	_	Ŧ		
	Free	Float				0	Date		15-0	lct-14		Date			_	_		

Fig 3.2 Shows after applied constraints in primavera

Table 3.4 After applied constraints:

After rescheduling the changes in the plan is as follows:

Activity ID	Activity name	Start date	Finish date
A1170	FIRST FLOOR	17 Oct 2014	19 Nov 2014
Project dates	changing after	15 Nov 2013	12 Sep 2015
rescheduling			-
Total duration	– 566 days		

There is an effective schedule control on duration=568-566= 2days

3.2 Level of Effort: Level of effort activities gets their dates and durations from their predecessors and successors. It's most common to assign a predecessor with an SS relationship and a successor with an FF relationship. Then when resource is allocated to the activity his/her effort will be spread over the activity duration. The level of effort in primavera optimizes the duration.

LOE applied for activity ID A1610, A1620, A1630, A1640, A1650

Activity D		Activity Name		Origina Duration			Frish	Predecessors	Budgeted Total Cost	Total Float	٨	JFNANJJASOND. Drononostorotopotostostostostost
e f	LOOR	NG, SKIRTING & DAE	DOING	17	171) 19Jan-15	07Aug15		Ro4,413,493,75	33		V7-Aug-15, FLOORING
	A1610	TILES SELECTION AND VEI	NOOR FINALIZATIO	Ę	i 6	i 181an15	13Ma-15	A1340	Re13,500.00	1		+ TLES SELECTION AND VENDOR RIVALIZA
	Å1620	PROCUREMENT OF TILES	(TESTING)	3	3) 13Ma-15	17.4pr-15	A1610	R:9,000.00	0		PROCUREMENT OF TILES (TESTING)
	Å1630	GROUND FLOOR		3	3) 174p-15	23-May-15	Å1620	R:572,450.00	0		GROUND FLOOR
	Å1640	FIRST FLOOR		3	3) (6Way-19	i 10Jun-15	Å1630	R:572,450.00	0	4	🛏 ARST FLOOR
	Å1650	SECOND FLOOR		3	3	23Way 13	i 27.Jun-15	Å1640	R:572,450.00	0		Feedback Second Floor
	Å1660	THIRD FLOOR		3	1 3) 10Jun-15	15Jul-15	Å1650	Rs276,450.00	Ļ		+ THRD FLOOR
	Å1670	FOURTH FLOOR		3	3) 22Jun-15	27-Jul-15	Å1660	R:972,450.00	Ļ		FOURTH FLOOR
	A1680	FIXING OF SADARAHALLI G	RANTE FOR STAR	3	i 3	5 27Jun-15	07.4ug15	Å1670	Rx224,743.75	33	•	(
General S	Status R	esources Predecessors Suc	ccessors Natebook	Feedback	Codes Steps V	Ps & Docs	Relationships Surmary					
*		Activity A1610	TLES	SELECTION	AND VENDOR FI	IALIZATION						Project NC 3
Activit	y Type		Duration Type				% Complete Typ	e		Activity (Calen	ndar
(Task	Depender	t	Fixed Duratio	n & Units			Duration		2	r 📋 NC		
WBS					Responsible	Nanager			Prinar	y Resource		
N N	C3.14 FL	OORING, SKIRTING & DADONO	3		PI				<u>_</u> n	: 30 archite	cture	

Fig 3.3 Highlighted activities shows to apply LOE

Table 3.5 Before applying LOE:

Activity ID	Activity name	Start date	Finish date
A1610	Tile selection	19 Jan 2015	13 Mar 2015
A1620	Tile testing	13 Mar 2015	17 Apr 2015
A1630	ground floor	17 Apr 2015	23 May 2015
A1640	first floor	06May 2015	10 Jun 2015
A1650	Second floor	23 May 2015	27 Jun 2015
Project start and	end date	15 Nov 2013	12 Sep 2015
Total duration =	566 days		

Proposed change:

The WBS of flooring, skirting and dadoing was changing activity type from task dependent to level of effort.

Activity D	Activity Nane	Original Duration	Remaining Start Duration	Finish	Predecessors	Budgeted Total Cost	Total Float	
🗉 🖥 Floori	ING, SKIRTING & DADOING	363	363 1540v+13	16Jan-15		Ro4,413,493,75	131	16Jan 15, FLOORING, SKIRTING & DADOR
■ A1610	TILES SELECTION AND VENCIOR FINALIZATION		0 16Jan 15	161an-15	A134]	Re13,500.00	117	TILES SELECTION AND VENDOR FINALIZA
🛢 A1620	PROCUREMENT OF TILES (TESTING)	0	0 16Jan 15	16Jan-15	A1610	R:9,000.00	107	PROCUREMENT OF TILES (TESTING)
🖬 Å1630	GROUND FLOOR	0	0 16Jan 15	16 Jan-15	A1620	R:\$72,450.00	107	GROUND FLOOR
🖬 A1640	FIRST FLOOR	0	0 30-Dec-14	300ec-14	A1630	R:\$72,450.00	107	- FRST FLOOR
🖬 A1650	SECOND FLOOR	0	0 12:Dec-14	120ec-14	A1640	R:\$72,450.00	97	SECOND FLOOR
😑 A1660	THIRD FLOOR	30	30 154Var-13	190ec-13	A1650	R£275,450.00	415	
🖬 A1670	FOURTH FLOOR	30	30 27-Nov-13	31-Dec-13	A1660	R:972,450.00	415	
🛢 A1680	FIXING OF SADARAHALLI GRANITE FOR STAIR	35	35 03-Dec-13	11 Jan 14	A1670	Rs224,743,75	44	• ()
General Status R	escurces Predecessors Successors Natebook	Feedback Codes	Sleps WPs & Docs Relati	onstips Summar	I			
* *	Activity A1610 TLES	SELECTION AND	VENDOR FINALIZATION					Project INC
Activity Type	Duration Type			% Complete Ty	pe		Activity Ca	lendar
LevelofEffort	Fixed Duration	n & Units		Duration			E NC	
WBS			Responsible Wanager			Primary	Resource	
🖣 NC.14 FLO	ORING, SKRTING & DADOING		PN				30 architect	ure

Fig 3.4 Highlighted activities shows LOE is applied

Table 3.6 After applied LOE:

After rescheduling the change in the plan is as follows:

Activity ID	Activity name	Start date	Finish date			
A1610	Tile selection	16 Jan 2015	16 Jan 2015			
A1620	Tile testing	16 Jan 2015	16 Jan 2015			
A1630	Ground floor	16 Jan 2015	16 Jan 2015			
A1640	First floor	30 Dec 2014	30 Dec 2014			
A1650	Third floor	12 Dec 2014	12 Dec 2014			
Project changing rescheduling	ng dates after	15 Nov 2013	28 Jul 2015			
Total duration = 527 days						
There is a effe	ctive schedule co	ontrol on durati	on = 566-527			

There is a effective schedule control on duration = 566-: =39days

3.3 Resource dependent: By changing the resource calendar and relationships with lag and lead with the available total float. When the scheduled work hours of a particular resource divert from the project default calendar. Primavera has an exclusive feature in which the activity type called Resource Dependent, when applied will use the calendar over riding the activity duration by increasing usage of resource in term of number of hours. This feature can be used where resource utilization is used and can be given more number of working hours, so that we further optimize the schedule.

Resource dependent applied for activity ID A1310

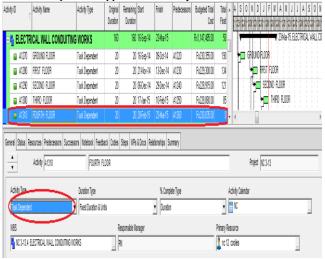


Fig 3.5 Highlighted activity shows to apply Resource dependent

Table 3.7 Before applying resource dependent:

Activity ID	Activity name	Start date	Finish date		
A1310	Fourth floor	28 Feb 2015	23 Mar 2015		
Project start and	end dates	15 Nov 2013	20 Jun 2015		
Total duration =	494 days				

Proposed change:

The WBS of electrical conduting in activity A1310 was changing activity type from task dependent to level of effort.

Activity D	Activity liane	Original Duration	Remaining Duration	Slart	Frish	
B ELECTR	ICAL WALL CONDUITING WORKS	160	160	16-Sep-14	24-11ar-15	24/Jar-15, ELECTRCAL WALL CONDUTING WORKS
A1270	GROUND FLOOR	20	20	16:Sep-14	09-Oct-14	- 💾 GROWD FLOOR
A1280	FRST FLOOR	20	21	22-Nov-14	16:Dec-14	HIST FLOOR
A1290	SECOND FLOOR	20	20	06-Dec-14	30-Dec-14	SECOND FLOOR
A1300	THRD FLOOR	2	21	17.Jan-15	11-Feb-15	THRD FLOOR
	FOURTH FLOOR	20	21	28-Feb-15	2418-35	FOURTH FLOOR
(•••••	
General Status F	esources Predecessons Successons Notebook Feedback Codes	s Steps WPs &	Docs Relator	istips Sum	nary	
<u>×</u>	Activity A1310 FOURTH FLOOR	_	_			Project NC
Activity Type	Duration Type			% Complete	eType	Activity Calendar
Hesource Dep	endent 💦 Fixed Duration & Units		,	Duration		
WBS		Responsible Har	lager			Prinary Resource
NC.4 ELEC	TRCAL WALL CONDUTING WORKS	RI				🙎 nc 54 ccole 1 📃

Fig 3.6 Highlighted activity shows resource dependent is applied

Activ	ity D	Ţ	Activity Name	Activity Type	Original Duration	Remaining Duration		Finish	Predecessors	Budgeted Total Cost	Total Float
•) NI	TESH C	OLUMBUS SQUARE(B	ELLARY ROAE	494	494	15Nov-13	20Jun-15		Rs63,544,434.65	0
	o A	2210	START OF PROJECT	Task Dependent		U	15400413	15-Nov-13		Hs0.00	-2
•	ų F	OUNDA	TION		133	133	15Nov-13	18:Apr-14		R\$5,613,121.95	361
L		A1000	EXCAVATION	Task Dependent	40	40	15:Nov-13	31-Dec-13	A2210	R:525,300.00	-2
L	0	A1010	RCC FOUNDATION	Task Dependent	90	90	04Jan-14	18:Apr-14	A1000	Rs3,513,772.80	-2
L		A1020	RETAINING WALL	Task Dependent	45	45	24Jan 14	17-Mar-14	A1010	Rs1,574,049.15	389
Β	e 📲 RCC SLAB			297	297	03Feb-14	17Jan-15		Rs17,100,743.65	129	
L	8	SUB CEL	LAR FLOOR SLAB		42	42	03Feb-14	22-Mai-14		Rs5,927,509.84	-2
L	1	🛛 A1030	POUR 1	Resource Dependent	32	32	03:Feb-14	11-Mar-14	A1010	Rs2,965,109.55	-2
L	1	a A1040	POUR 2	Resource Dependent	32	32	14:Feb-14	22:Mar-14	A1030	Rs2,962,400.29	-2
L	84	CELLAR	FLOOR SLAB		42	42	26Mar14	14-May-14		Rs2,646,529.82	-2
L	1	🛛 A1050	POUR 1	Resource Dependent	32	32	26-Mar-14	02-May-14	A1040	Rs1,323,262.83	-2
	1	A1060	POUR 2	Resource Dependent	32	32	07:Apr-14	14:May-14	A1050	Rs1,323,266.99	-2

Fig 3.7 Highlighted WBS shows duration and cost after rescheduling

Table 3.8 After applied resource dependent:

After rescheduling the changes in the plan is as follows:

Activity ID	Activity name	Start date	Finish date			
A1310	Fourth floor	28 Feb 2015	23 Mar 2015			
Project changin rescheduling	ng dates after	15 Nov 2013	20 Jun 2015			
Total duration = 494 days						

There is no effective schedule control on duration = 494 days and there is an effective schedule control on cost = 6,35,44,434.65 rs.

Table 3.9 Schedule control s	sequence table
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Proposed changes	Original	Change	Remarks		
	duration	duration			
Applying of constraints to	568 days	566 days	2 days		
WBS of block masonry and					
frame fixing					
Constraints to Groove cutting	566 days	566 days	No		
		-	changes		
Apply LOB to WBS of	566 days	527 days	39 days		
flooring		-	-		
Applying LOB to water	527 days	519 days	8 days		
proofing in balcony		-	_		
Applying LOB to WBS of	519 days	494 days	25 days		
block masonry and frame					
fixing in activity ID A1210					
Applying resource dependent	494 days	494 days	No		
to WBS of RCC slab		-	changes		
Applying resource dependent	494 days	494 days	No		
to WBS of electrical	-		changes		
conduting in activity ID			_		
A1310					
Total = 74 days					

Total = 74 days

4. CONCLUSION

Based on study carried out on the best features of primavera in schedule control techniques, it is concluded that primavera can be used to schedule project and reduce project duration in the construction projects by the following reasons:

- 1. Finally the project compares all the schedule techniques and let us knows the actual performance of the project, so as to take quick decision by the planning engineer/project manager in case of schedule parameters.
- 2. The project review was carried out to have a complete view of the case study of project and found out the difference in scheduled control against planned schedule.
- 3. For scheduling control study on constraints and activity types is done using primavera P6 software. The project schedule control decreases the duration due to apply of constraints, level of effort, resource dependent it has an effect on the project duration.
- 4. In this case study decrease in duration is 13.03% which will increase in project cost also. In a real time project, solving schedule control using primavera P6 software gives the best result can be realized.
- 5. In this project without touching any resources to optimizing, the total duration using level of efforts, resource dependent and constraint have been reduced.
- 6. A real time project solved using this optimization software shows that best converging result can be obtained.

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