

# Proceeding Paper Optimization of Resources of a Building Project <sup>+</sup>

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Abstract: The construction of building projects consists of interlinking and diverse activities which have to be completed within a yardstick cost and specific deadline. For this, a project manager needs to optimally render the planning and to schedule tasks simultaneously in such cases due to limitations of resources; for example, availability at the right place and at the right time is a big problem. Such a problem can be resolved using resource leveling. This research presents how to practice resource leveling via Microsoft (MS) Project using a case study. A three-story building is selected as a case study. The basement was allocated for parking and there were flats on the rest of the two stories. Upon different dependencies, all the activities of the project were taken in an interconnected manner, and resource leveling was brought out. Different flow charts such as cost flow, cost distribution over resources, resource scheme, etc., were drawn in MS project. MS project was found to be very productive and efficient especially in small industries, i.e., where there are fewer activities and complexities.

Keywords: resource leveling; MS project; resource optimization



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## 1. Introduction

The construction of building projects needs different resources in particular quantities at different stages in the construction process. The resources may be cost, materials, machinery, apparatuses, tools, or workmanship. The management of these resources has very sharp effects on both the economy of the project and the timeline. If the management of these resources is not carried out properly, it will leave severe damage to the project in terms of cost, material losses, and time delays.

During scheduling, project managers might plan activities in parallel. A real dilemma occurs when a similar resource is to be used in two or more activities, while its availability is limited. Project managers can settle such confrontations using resource-leveling software packages. Resource leveling is a resource optimization approach that is used to finish a project with available resources without over-reserving them or mushrooming them remotely, while its intent is to divide resources over work fairly [1].

A research study has been conducted on the use of project management (PM) software [2]. In addition, a comparative study has been conducted on using various PM software packages. It found that almost all construction industries use PM software, 83% of which use it for planning and control, and that in the construction industry, resource leveling is used by 58% and by 44% for project control. The same studies found that MS project was the well-liked and heavily used PM software in the overall study, whereas Primavera was the top trend in the construction industry. The results of MS project were close to primavera [3].

Most PM software carries out resource leveling by applying priority-based heuristics. It has two characteristic components: a scheduling scheme and a priority rule. Furthermore, scheduling schemes may be serial or parallel. Serial and parallel scheduling both have a decision set of unscheduled activities, but in the first one, they are precedence-feasible,

whereas in parallel, the activities are precedence- and resource-feasible. One activity is then selected on the basis of priority rules that are to be scheduled [4].

#### 2. Literature Review

The main types of resources in building construction projects are: Work (human and equipment) resources, material resources, and cost resources.

#### 2.1. Work Resources

Exceptional achievements are directly and immediately related to human resource management. Organizing and training the project team are the main purposes of human resource management [4]. Up to 50% of the total cost of building construction projects is allocated to labor and other technical staff [5]. Equipment resource management is of prime importance to construction projects because it ensures the project's cost and on-time completion. Great care should be taken during the selection of equipment as it has cryptic relations with the availability of space, mobility, versatility, suitability and capability of equipment, type of materials, what distances materials are to be moved, ground grade, and atmospheric conditions [6].

### 2.2. Material Resources

Providence of materials at the right time at the right place in a specified quantity to achieve the scheduled level of production at minimum cost is said to be material resource management [7]. The main dimension of material resource management is to monitor the latest information related to materials and their flow [8]. It has been reported that at the construction site, the main problem with material resource management is the lack of material tracking [5] Previous literature recommended computer-based material management [8].

#### 2.3. Resource Leveling

Technically speaking, resource leveling is a technique that assures resource demand is not exceeding resource availability [9]. The aim of resource leveling is to attain a uniform level of required resources both at peak demand periods and off-peak times [5]. It has been stated that labor and equipment resource management are the fundamental parameters of resource leveling [9].

Resource-constrained and time-constrained are the two main types [10] In timeconstrained leveling, time is critical; that is, deadline delays are not allowed and the project should be completed with limited resources at a certain time. In contrast, resourceconstrained leveling considers that the project will be completed in the near future without crossing a certain level of resource availability [5].

Fast-tracking, crashing, delay-critical path tasks, extend-critical path tasks, nonsequential pieces of tasks, authorized overtime, and Microsoft (MS) project are the techniques used for resource leveling [5]. Microsoft Project can perform resource leveling by itself, using resource schemes, activity types, activity dependencies, and their constraints input by the user. If there are resource clashes, then MS project has the option to delay, add or remove activities, place resources to different tasks, or revise dependencies [5].

#### 3. Research Significance

Each year, the construction industry expands. To handle this expansion, it is necessary to conduct more studies and practice. Construction companies strive to conserve resources to lower the project's overall cost, especially when they are involved in several different projects that share resources. To solve this problem, resource optimization (resource leveling) is necessary. As a result of resource leveling, the contractor should know when and where to use each resource, and this will minimize importing more expensive resources from outside the company. So, this study will briefly show how beneficial MS project is to small construction industries also.

# 4. Methodology

## 4.1. Selection of a Residential Flat Building

We have selected a residential (three-story) building with a 5600 square feet cover area for our case study; the details are in Table 1. Activities are computed in MS project and connected by various dependencies, e.g., finish–start, start–start, start–finish, and finish–finish.

Table 1. Details of the residential building.

S.NO.	Description							
	Basement	Sixteen (4 feet $\times$ 4 feet) Columns						
		Girders	]	12				
1		Gilders	Туре В		8			
		10-feet-height						
		beams			4			
	Ground, first, and second story		Type-1	Bedrooms	2			
		Five Flats		Guest Room	1			
				Kitchen	1			
				Store	1			
2				Bathrooms	2			
			Type-2	Bedrooms	4			
				Kitchen	1			
				Store	1			
				Bathrooms	4			

## 4.2. Plan of Basement, Ground, 1st, and 2nd Floor

Figure 1 shows the layout of the basement in which there are sixteen columns of dimensions 4 ft  $\times$  4 ft of the square type. There are two types of girders (type A and B) and a beam. The height of the basement is 10 ft. The number of girders of type A is 12 and type B is 8, and there are 4 beams. The ground floor consists of five flats and Figure 2 shows the detail of the 1st, 2nd, and ground floors.

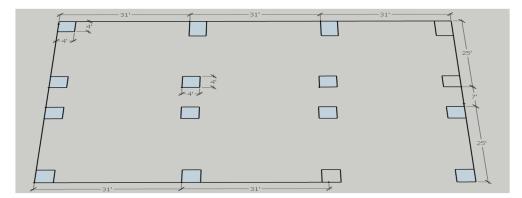


Figure 1. Layout of basement.

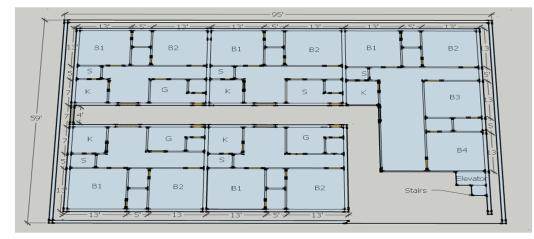


Figure 2. Plan of ground, 1st, and 2nd floor.

# 5. Results and Discussion

Planning of activities in MS Project: The activities are enlisted in MS Project and the cost of each resource is taken from the Market Rate System of Communication and Work Department. Figure 3 shows the activities in MS Project.

ID	0	Task Name		Duration	Start	Finish	Haif 1, 2020 Haif 2, 2020 Haif 1, 2021 J F M A M J J A S O N D J F M A M J J
1	~	1 Residentia	Flats	330 days	Sat 08/02/20	Thu 25/02/21	25/02
2	1	1.1 Site Work		14 days	Sat 08/02/20	Sun 23/02/20	
3	1	1.1.1 Clear Lot		1 day	Sat 08/02/20	Sat 08/02/20	Excavation Subconfractor
4	J.	1.1.2 Stake Lot fo	r Excavation	2 days	Sun 09/02/20	Mon 10/02/20	Civil Engineer
5	1	1.1.3 Excavate fo	r Basement	11 days	Tue 11/02/20	Sun 23/02/20	Excavation Subcontractor
6	1	1.2 Foundation		7 days	Mon 24/02/20	Mon 02/03/20	
7	V.	1.2.1 Layout footi	ngs	1 day	Mon 24/02/20	Mon 24/02/20	
8	~	1.2.2 Dig Footing	s & Install Reinforcing	1 day	Tue 25/02/20	Tue 25/02/20	Excavation Subcontractor, Mason[2], Labour[4]
9	~	1.2.3 Footing Insp	ection	0.5 days	Tue 25/02/20	Wed 26/02/20	
10	~	1.2.4 Pour footing	IS	5 days	Wed 26/02/20	Mon 02/03/20	Concrete[3].Concrete Subcontractor(ML and MI)
11	~	1.2.5 Foundation	Certification	0.5 days	Sat 29/02/20	Sun 01/03/20	Civil Engineer
12	1	1.3 Basement		34 days	Mon 02/03/20	Thu 09/04/20	
13	~	1.3.1 Column ere	ction and pouring	4 days	Mon 02/03/20	Thu 05/03/20	Concrete Subcontractor(NL and MI),Concrete[2], Steel [4]
14	~	1.3.2 Brick Work	in basement	5 days	Thu 05/03/20	Tue 10/03/20	Brick Masonry Subcontractor(M and L)[2],Bricks[4]
15	~	1.3.3 Formwork a	nd Girder in Basement	4 days	Mon 09/03/20	Thu 12/03/20	
16	$\checkmark$	1.3.4 Formwok er	ection for the slab	10 days	Wed 11/03/20	Tue 24/03/20	
17	$\checkmark$	1.3.5 Steel cutting	for the slab	8 days	Wed 11/03/20	Thu 19/03/20	
18	$\checkmark$		Steel arrangment of the slab		Wed 11/03/20	Sun 05/04/20	Mason[2],Labour[4], Steel [3]
19	~		of Slab in Basement		Mon 23/03/20	Tue 07/04/20	Concrete Subcontractor(ML and MI),Concrete[2]
20	$\checkmark$	1.3.8 Curing of th			Wed 25/03/20	Thu 09/04/20	
21	$\checkmark$	1.4 Super Struc			Sat 04/04/20	Mon 28/09/20	· · · · · · · · · · · · · · · · · · ·
22	$\checkmark$	1.4.1 Ground flo			Sat 04/04/20	Thu 11/06/20	
23	$\checkmark$		n Steel reinforcement erection		Sat 04/04/20	Sat 11/04/20	
24	~	Columns	ork erection and concreting of the	,	Sun 05/04/20	Sun 12/04/20	
25	$\checkmark$		ting of the Girder		Thu 09/04/20	Thu 16/04/20	
26	<ul> <li></li> </ul>	1.4.1.4 Brick V			Thu 16/04/20	Mon 04/05/20	
27	$\checkmark$		ok erection for the slab		Mon 04/05/20	Mon 18/05/20	
28	$\checkmark$		utting for the slab		Tue 12/05/20	Thu 21/05/20	
29	$\checkmark$		rrangment of the slab		Tue 12/05/20	Tue 19/05/20	
30	✓	1.4.1.8 Concre	ting of Beams and slab	8 days	Thu 21/05/20	Thu 11/08/20	
			Task		Inactive Mile	estone 🗆	Finish-only
			Split		Inactive Sur	nmary	External Tasks
			Miestone		Manual Tas	1	External Milestone
		lential Flates				•	,
Date:	ate: Thu 10/09/20 Summary			Duration-on		Critical	
Project Summary			Manual Sun	nmary Rollup	Critical Split		
			Manual Sun	nmary I	Progress		
			External Milestone		Start-only		Deadine 🕹
			1				

Figure 3. Cont.

ID	0	Task Name	Duration	Start	Finish	Half 1, 2020 Half 2, 2020 Half 1, 2021
31	7	1.4.1.9 Curing of the concrete slab	4.31 days	Mon 18/05/20	Sun 24/05/20	
32	V	1.4.2 1st Floor	52 daya	Thu 28/05/20	Mon 27/07/20	<b>9</b>
33	V	1.4.2.1 Column Steel reinforcement erection	n 1.5 days	Thu 28/05/20	Sat 13/06/20	The Steel Supplier[2], Steel [2]
34	1	1.4.2.2 Formwork erection of the Columns	4.5 days	Sat 30/05/20	Sun 14/06/20	Goncrete \$ubcontractor(ML and MI)[2],Concrete[2]
35	1	1.4.2.3 Concreting of the Columns	7 days	Wed 03/06/20	Mon 15/06/20	Concrete Subcontractor(ML and MI),Concrete[2]
36	~	1.4.2.4 Brick Work	16 days	Wed 10/06/20	Sun 28/06/20	Erick Maeonry Subcontractor(M and L),Bricke[2]
37	$\checkmark$	1.4.2.5 Formwok erection for the slab	4.88 days	Sun 28/06/20	Thu 02/07/20	Mason[2],Labour[4]
38	$\checkmark$	1.4.2.6 Steel cutting for the slab	8 days	Sun 28/06/20	Mon 06/07/20	Roofing Subcontractor, Steel Supplier
39	$\checkmark$	1.4.2.7 Steel arrangment of the slab	6 days	Tue 07/07/20	Mon 13/07/20	
40	$\checkmark$	1.4.2.8 Concreting of Beams and slab	4 days	Tue 14/07/20	Wed 22/07/20	Concrete Subcontractor(ML and MI)[2],Concrete[1]
41	$\checkmark$	1.4.2.9 Curing of the concrete slab	4 days	Thu 23/07/20	Mon 27/07/20	Labour[2]
42	$\checkmark$	1.4.3 2nd floor	54 daya	Tue 28/07/20	Mon 28/09/20	
43	$\checkmark$	1.4.3.1 Column Steel reinforcement erection	on 6 days	Tue 28/07/20	Mon 03/08/20	
44	$\checkmark$	1.4.3.2 Formwork erection of the Columns		Tue 04/08/20	Wed 05/08/20	<u>1</u>
45	$\checkmark$	1.4.3.3 Concreting of the Columns	2.5 days	Thu 06/08/20	Tue 11/08/20	
46	$\checkmark$	1.4.3.4 Brick Work	7 days	Wed 12/08/20	Wed 19/08/20	Bick Masonry Subcontractor(M and L),Bricks[1]
47	$\checkmark$	1.4.3.5 Formwok erection for the slab	16 days	Thu 20/08/20	Mon 07/09/20	
48	$\checkmark$	1.4.3.6 Steel cutting for the slab	8 days	Tue 08/09/20	Wed 16/09/20	Roofing Subcontractor, Steel Supplier
49	$\checkmark$	1.4.3.7 Steel arrangment of the slab	4 days	Tue 08/09/20	Wed 16/09/20	Mason[2],Labour[4], Steel [1]
50	$\checkmark$	1.4.3.8 Concreting of Beams and slab	6 days	Thu 17/09/20	Wed 23/09/20	
51	$\checkmark$	1.4.3.9 Curing of the concrete slab		Thu 24/09/20	Mon 28/09/20	Labour[2]
52	$\checkmark$	1.5 Plaster work		Tue 29/09/20	Wed 13/01/21	
53	$\checkmark$	1.5.1 Plaster work in Basement	20 days	Tue 29/09/20	Wed 21/10/20	
54	$\checkmark$	1.5.2 Plaster work in Ground Floor	24 days	Thu 22/10/20	Wed 18/11/20	the second se
55	$\checkmark$	1.5.3 Plaster work in 1st Floor	24 days	Thu 19/11/20	Wed 16/12/20	
56	<	1.5.4 Plaster work in 2nd Floor		Thu 17/12/20	Wed 13/01/21	Plaster Subcontractor(M and
57	$\checkmark$	1.6 Painting Work	37 daya	Thu 14/01/21	Thu 25/02/21	
58	$\checkmark$	1.6.1 Paint Work in Basement	10 days	Thu 14/01/21	Mon 25/01/21	Paint[1],Painter
59	$\checkmark$	1.6.2 Paint Work in Ground Floor	9 days	Tue 26/01/21	Thu 04/02/21	Paint[1],Painter
60	$\checkmark$	1.6.3 Paint Work in 1st Floor		Sat 06/02/21	Mon 15/02/21	Paint[1],Painter
61	<ul> <li>Image: A second s</li></ul>	1.6.4 Paint Work in 2nd Floor	9 days	Tue 16/02/21	Thu 25/02/21	Paint[1],Painter
		Test.		In cash on Mile		Fields and
		Task		Inactive Mile		Finish-only
		Split		Inactive Sun	nmary	External Tasks 🔷
Dealer	Project: Residential Flates Date: Thu 10/09/20 Summary		•	Manual Tasi	k I	External Milestone
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		External Tasks		Manual Surr	nmary I	Progress
	External Milestone		۰	Start-only	-	Deadine 🕹
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Figure 3. Activities in MS project.

## 5.1. Cash Flow of a Project

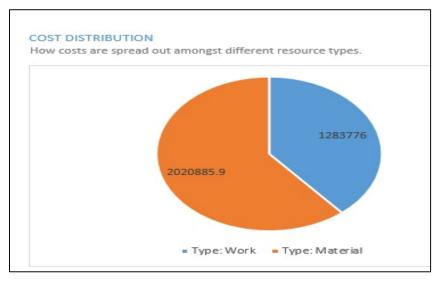
The cash flow of a project is shown by Figure 4 which shows the cost of a project before and after the optimization of an activity.

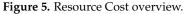


Figure 4. Cash flow.

### 5.2. Resource Cost Overview

(1) Cost overview for work resources: the cost of different types of work resource. (2) Distribution of cost between work and material resources: the cost allocated to each resource as shown in Figure 5.





#### 5.3. Resource Overview

Figure 6 shows the status of each type of work.

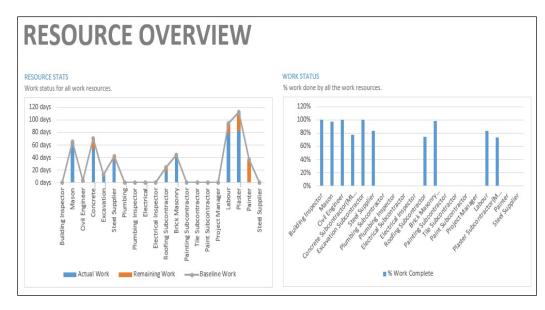


Figure 6. Resource overview.

5.4. Resource Sheet Prepared in MS Project

The resource sheet prepared in MS Project with costs assigned to each resource as per the Market Rate System is shown in Figure 7.

	0	Resource Name 🔹	Туре 🔻	Initials 💌	Max. 👻	Std. Rate 🔹	Base 👻
1		Building Inspector	Work	в	100%	Rs2,560.00/hr	Standard
2		Mason	Work	M	100%	Rs150.00/hr	Standard
3		Civil Engineer	Work	С	100%	Rs500.00/hr	Standard
4		Concrete Subcontractor(ML and Mi)	Work	с	100%	Rs696.80/hr	Standard
5		Excavation Subcontractor	Work	E	100%	Rs2,407.00/hr	Standard
6		Steel Supplier	Work	S	200%	Rs300.00/hr	Standard
7		Roofing Subcontractor	Work	R	100%	Rs225.00/hr	Standard
8		Brick Masonry Subcontractor(M and L)	Work	В	100%	Rs225.00/hr	Standard
9		Concrete	Material	м		Rs792.45	
10		Bricks	Material	в		Rs7,040.00	
11		Labour	Work	L	100%	Rs75.00/hr	Standard
12		Steel	Material	s		Rs74,250.00	
13		Plaster Subcontractor(M and L)	Work	Ρ	100%	Rs225.00/hr	Standard
14		Mortor	Material	м		Rs598.00	
15		Painter	Work	P	100%	Rs200.00/hr	Standard
16		Paint	Material	P		Rs1,800.00	
17		Steel Supplier	Work	s	200%	Rs300.00/hr	Standard

Figure 7. Resources sheet.

5.5. Graph between Baseline and Actual Work Performed

Figure 8 shows the baseline and actual work.

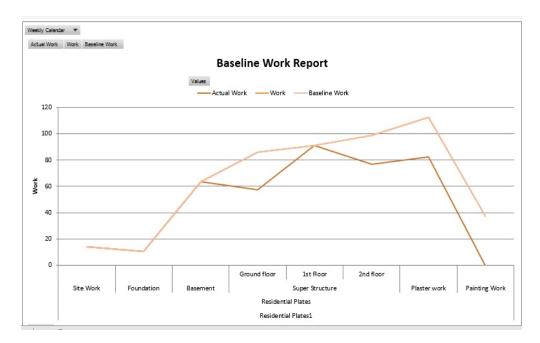


Figure 8. Baseline and actual work curves.

# 6. Conclusions

The following conclusions are drawn from the results:

- The best option for resource leveling in Microsoft Project is the manual option, not the automatic one, because the software does not know about the real conditions in the field. So, it is good to perform resource leveling manually. In the case of automatic resource leveling, the schedule should be rechecked and revised many times so that it may meet the real conditions.
- The duration of activities extends as the resource leveling is carried outs. This is okay because the overallocation of resources may be removed only in this way.

- In Microsoft Project, a single resource cannot be allocated to two activities running in parallel. It is recommended to work on and update Microsoft Project.
- Resource leveling makes small construction industries very productive even with very limited resources.
- MS project is best when you are using it, especially for small construction projects. It
  is simple and has both the options to level resources automatically or manually.

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