Cost Optimization Of Project By Crashing Project Schedule Using Linear Programming Technique.

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Abstract

Project scheduling is very essential part of the project planning phase. Cost optimization of project can be achieved by completing the project before the completion time of the project, which saves additional overhead cost of the construction project. To complete the project work before the scheduled time activity crashing is the best solution to that. Project having more activities can be difficult and so linear programming technique can be applied to the project crashing work and the optimum value to crash the project duration for the desired time can be calculated using LINDO (linear programming software). Three different options are selected having different construction materials for a defined size of floor work. Crashing of project is carried out for the one floor of the apartment of MIG housing scheme having 4192 sq ft super built up area.

Keywords : *linear programming model, CPM network, project scheduling, cost optimization.*

1. Introduction

Critical path method and Project evaluation and review techniques are both the very basic concept of the project planning. Project scheduling is also very essential part of the project planning stage. Project scheduling can be carried out using MSP (Microsoft project) software. Sometimes project is not running according to the scheduled time of the project. Sometimes delays in project can be occurred due to various reasons like site accidents, weather effect, natural calamities, financial crises, etc. In that cases project have to take back on the scheduled time and for that crashing of project activities is a best solution. With bigger project work more activates are there to crash which can be very complex to solve manually. in that case linear programming techniques are applied to the crashing problem of the project work.

Linear programming is nothing but the mathematical formulation of the crashing project and solution of the problem is carried out in LINDO software. LINDO is linear programming software to solve the very complex formulas easily. In linear programming Main formula of optimization is formulated and the different constraints on which that main formula depends are formulated. Crashing of activities can reduced the construction time but for crashing the activities some cost is needed which is the cost of the resources needed to complete the activity before the given completion time of the project. Thus crashing of activities adds additional cost to the total project cost. But reduction in the total completion time of the project can reduce the overhead cost of the project which impact more than the additional crash cost of the activities.

2. Linear programming technique.

Case study is taken of MIG housing scheme and different three options are prepared using different non conventional construction materials. Project scheduling is prepared using Microsoft project software and crash day

of each activities are decided. Crash cost is assigned by Appling cost of the resources needed to crash the activities. Here crashing of activities is carried out for one floor of the apartment having 4192 sq ft. AON network is prepared for the activities for the one floor of the apartment. From the AON network actual completion time of the activities can be calculated by critical path method. Cost optimization formula is formulated for all potions and constraints on which activities depends are formulated and solution is driven from the LINDO(linear programming software).

3. Variables of the problem,

Let Z be the total cost of crashing activities. The problem then is to minimize Z, subject to the constraint that project duration must be less than or equal to the time desired by the project manager. The natural decision variables are :

Xj = reduction in the duration of activity j due to crashing this activity, for j = 1,2,3…7.

YFINISH = project duration.

Yj = start time of activity j (j = 1,2,3….7).

Here (Yj) = (start time + normal duration - crash duration) for this immediate predecessor.

Thus Problem statement will be,

Minimize Z = $\sum_{j=1}^{7} U_j X_j$**.**

Subject to,

a) Non negativity constraint, Xj>=0 (j = 1,2,3…7), Y1 = 0, Yj>=0(j = 2,3,4…7)

b) Maximum reduction constraints, Xj <= crash duration (j = 1,2,3…..7)

c) Start time constraint , Yj = Duration of (j-1) activity - X(j-1)

d) Project duration constraint, Yfinish <= Total Crash Duration.

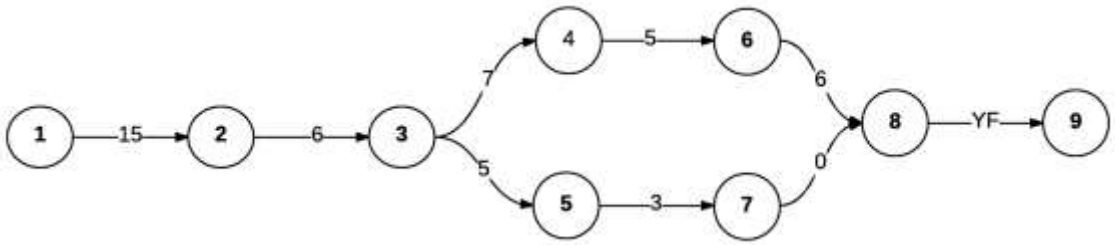
Solution of the formula is generated using LINDO software (linear programming software).

3.1 Option 1:

In this option of the construction work MIG apartment is taken into consideration and Concrete blocks for wall masonry work, level plast putty for plaster work and wall finish, Shahabad tile flooring for flooring work, distemper paints for the painting work, Particle bard doors for doors are taken into consideration and AON network is formed with the help of project scheduling. From the CPM completion time for one floor is 39 days. Linear programming Model is calculated for Crashing the completion time for 2 days. Thus Yfinish will be <= 37.

Activity Code	Description	Crash Day	Additional cost for Crashing	Crash cost/day
1	RCC Work	2	2000	1000
2	Wall Masonry	2	1500	750
3	Plaster Work	1	700	700
4	Panting	2	1000	500
5	Flooring	1	600	600
6	Door Work	1	600	600

7	Plumbing	2	1500	750



Problem Statement:

Minimize Z = 100X1+750X2+700X3+500X4+600X5+600X6+750X7

Subject to,

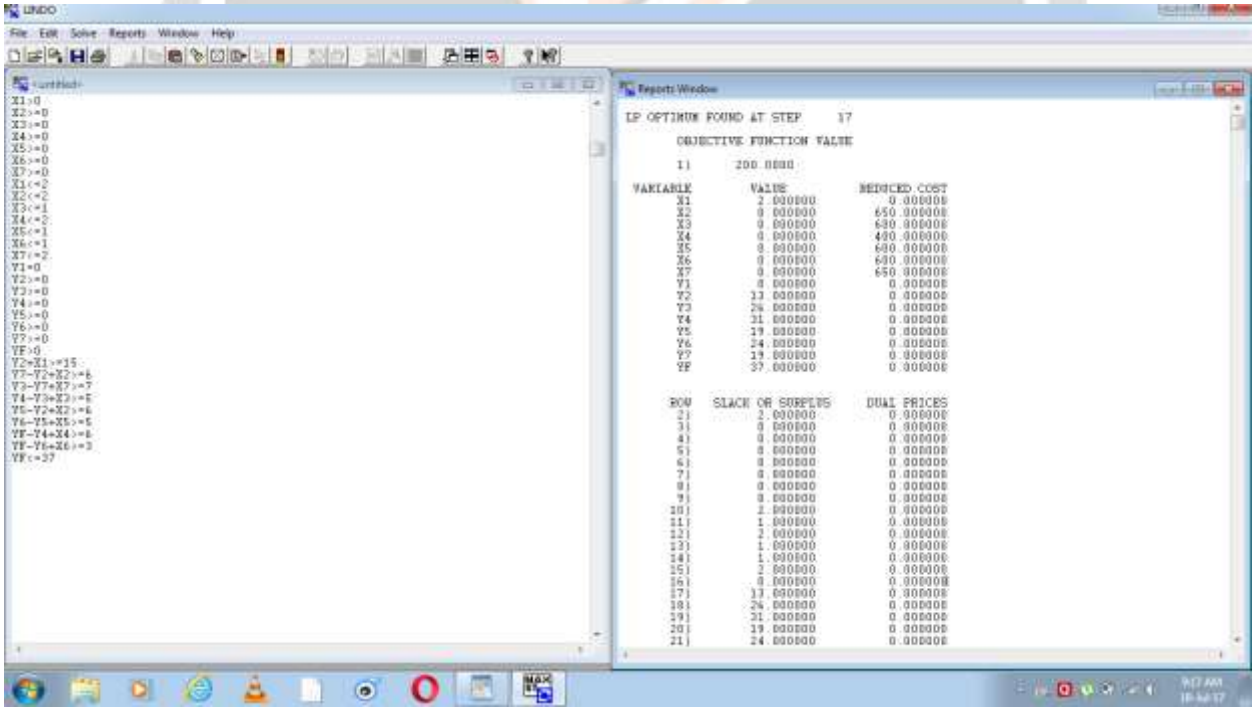
a) X1>0, X2>=0, X3>=0, X4>=0, X5>=0, X6>=0, X7>=0

b) X1<=2, X2<=2, X3<=1, X4<=2, X5<=1, X6<=1, X7<=2

c) Y1=0, Y2>=0, Y3>=0, Y4>=0, Y5>=0, Y6>=0, Y7>=0, YF>0

d) Y2+X1>=15, Y7-Y2+X2>=6, Y3-Y7+X7>=7, Y4-Y3+X3>=5, Y5-Y2+X2>=6, Y6-Y5+X5>=5, YF-Y4+X4>=6, YF-Y6+X6>=3,

e) YF<=37



Solution:

VARIABLE	VALUE	REDUCED COST
z	200	0

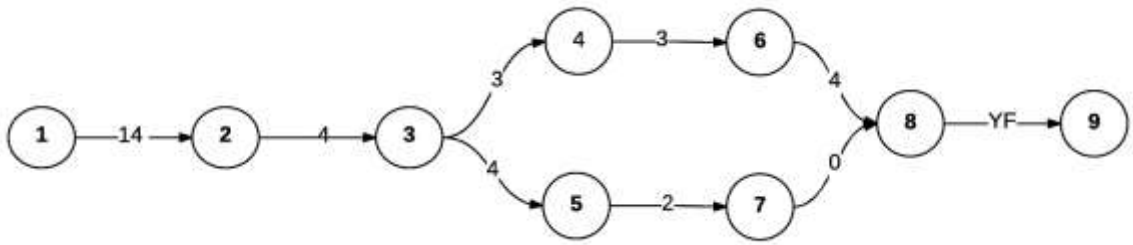
X1	2	0
X2	0	650
X3	0	600
X4	0	400
X5	0	600
X6	0	600
X7	0	650
Y1	0	0
Y2	13	0
Y3	26	0
Y4	31	0
Y5	19	0
Y6	24	0
Y7	19	0
YF	**37**	**0**

From the above solute it shows that to crash the total construction time for 2 days, 200 crash cost is needed. Thus additional 200 Rs is needed to crash the total completion time of the construction for one floor for 2 day

3.2 Option 2:

In this option of the construction work also MIG apartment is taken into consideration and light weight concrete wall panel for wall masonry work, level plast putty for plaster work and wall finish, PVC floor sheet for flooring work, distemper paints for the painting work, Particle bard doors for doors are taken into consideration and AON network is formed with the help of project scheduling. From the CPM it is calculated that the total completion time of construction for one floor is 28 days. Thus Linear programming model is created to crash the total completion time for the 5 days.

Activity Code	**Description**	**Crash Day**	**Additional cost for Crashing**	**Crash cost/day**
1	RCC Work	2	2225	1112
2	Wall Masonry	1	750	750
3	Plumbing	1	800	800
4	level plast putt	1	700	700
5	flooring	2	900	350
6	painting	2	800	400
7	Door Work	0	0	0



Problem Statement,

Minimize Z = 1112X1+750X2+800X3+700X4+350X5+400X6+0X7

Subject to,

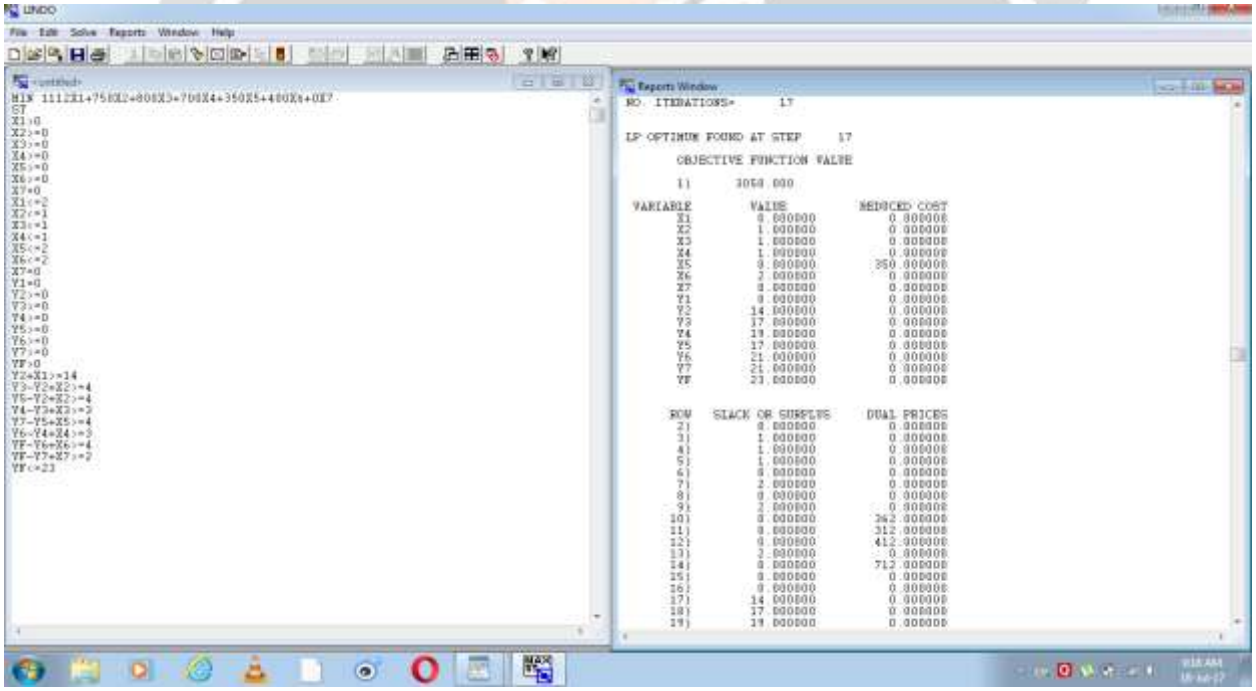
a) X1>0, X2>=0, X3>=0, X4>=0, X5>=0,X6>=0,X7=0

b) X1<=2, X2<=1, X3<=1, X4<=1, X5<=2, X6<=2, X7=0,

c) Y1=0, , Y2>=0, Y3>=0, Y4>=0, Y5>=0, Y6>=0, Y7>=0, YF>0

d) Y2+X1>=14, Y3-Y2+X2>=4, Y5-Y2+X2>=4, Y4-Y3+X3>=3, Y7-Y5+X5>=4, Y6-Y4+X4>=3, YF-Y6+X6>=4, YF-Y7+X7>=2

e) YF<=23



Solution:

VARIABLE	VALUE	REDUCED COST
z	3050	0
X1	0	0

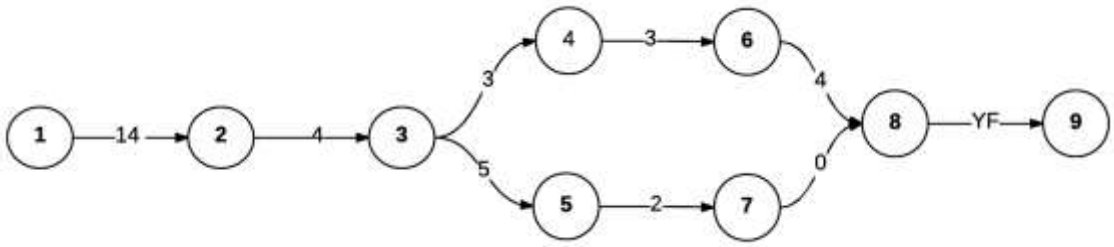
X2	1	0
X3	1	0
X4	1	0
X5	0	350
X6	2	0
X7	0	0
Y1	0	0
Y2	14	0
Y3	17	0
Y4	19	0
Y5	17	0
Y6	21	0
Y7	21	0
YF	**23**	**0**

To crash the total completion time of construction of one floor for 5 days, 3050 Rs is needed.

3.3 Option 3:

In this option of the construction work also MIG apartment is taken into consideration and Foam concrete wall panel for wall masonry work, level plast putty for plaster work and wall finish, ceramic tile flooring for flooring work, distemper paints for the painting work, Particle bard doors for doors are taken into consideration and AON network is formed with the help of project scheduling. From the CPM total completion tie for construction of one floor is 28 days. Thus Linear programming model is created to crash the total completion time for one floor for 23 days.

Activity Code	**Description**	**Crash Day**	**Additional cost for Crashing**	**Crash cost/day**
1	RCC Work	2	2225	1112
2	Wall Masonry	1	750	750
3	Plumbing	1	800	800
4	level plast putt	1	700	700
5	flooring	1	1000	1000
6	painting	2	800	400
7	Door Work	0	0	0



Problem Statement,

Minimize Z = 1112X1+750X2+800X3+700X4+1000X5+400X6+0X7

Subject to,

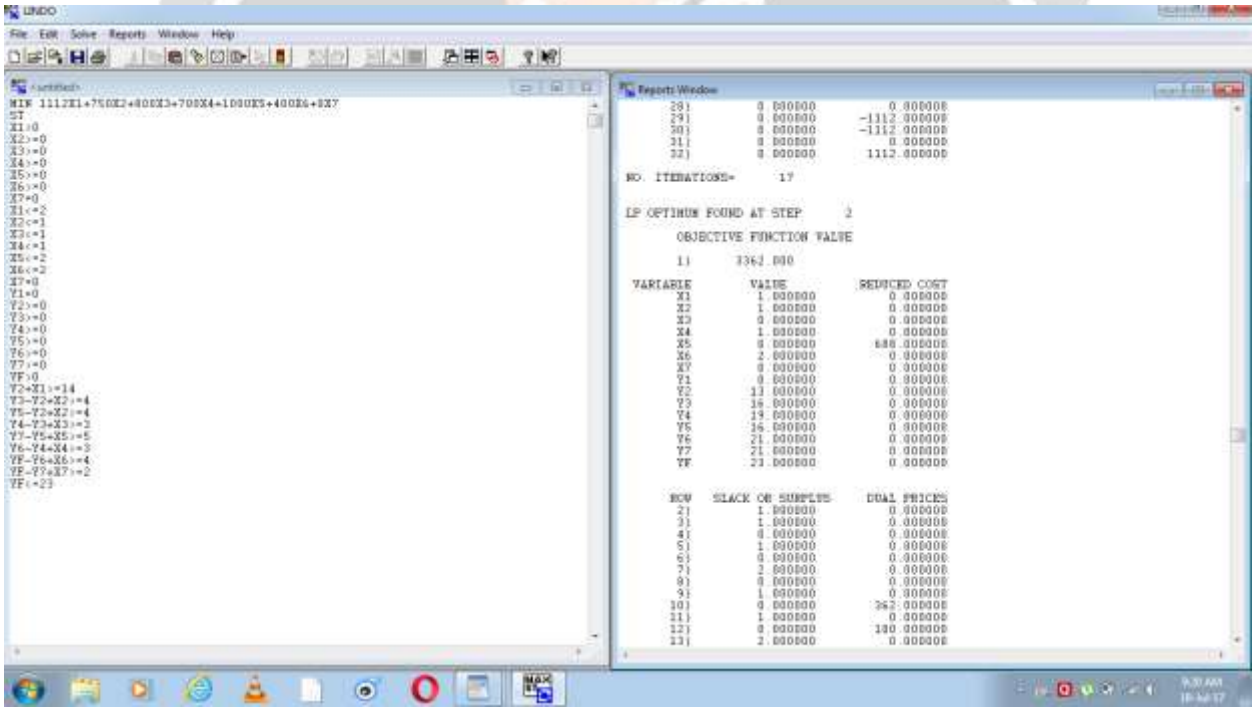
a) X1>0, X2>=0, X3>=0, X4>=0, X5>=0, X6>=0, X7=0

b) X1<=2, X2<=1, X3<=1, X4<=1, X5<=2, X6<=2, X7=0

c) Y1=0, Y2>=0, Y3>=0, Y4>=0, Y5>=0, Y6>=0, Y7>=0, YF>0

d) Y2+X1>=14, Y3-Y2+X2>=4, Y5-Y2+X2>=4, Y4-Y3+X3>=3, Y7-Y5+X5>=5, Y6-Y4+X4>=3,, YF-Y6+X6>=4, YF-Y7+X7>=2

e) YF<=23



Solution

VARIABLE	VALUE	REDUCED COST
z	**3362**	**0**

X1	1	0
X2	1	0
X3	0	0
X4	1	0
X5	0	688
X6	2	0
X7	0	0
Y1	0	0
Y2	13	0
Y3	16	0
Y4	19	0
Y5	16	0
Y6	21	0
Y7	21	0
YF	**23**	**0**

For this option 3362 Rs is needed to crash the total completion time for one floor for 5 days.

4. Cost Optimization using crashing:

Cost optimization can be achieved by crashing the project schedule using Linear Programming model. Crashing activity can reduce per day overhead cost of the project. Overhead cost of the project can be calculated by 10% of total building cost of the building.

From the Linear Programming Model project manager can reduce the total project completion time for days he/she wants to reduce and minimum crash can be calculated from the LINDO software. LINDO is a linear programming software to solve the complex linear programming formulas.

200 Rs, 3050 Rs and 3362 Rs needed to crash the total completion time of one floor for 2 days, 5 days and 5 days respectively.

Thus by using the Linear Programming Technique we can fine the best suitable option of non conventional construction materials for the affordable housing scheme.

Project manager can crash the total completion time of the project for the days he/she wants to crash with the help of linear programming model.

Considering the MIG apartment savings in overhead cost is calculated.

a) For option 1,
savings in overhead cost = (2 X 12400) - 200
= 24600 Rs.

b) For Option 2,
savings in overhead cost = (5 X 12400) – 3050
= 58950 Rs.

c) For option 3,
savings in overhead cost = (5 X 12400) – 3362
= 58638 Rs.

Like these 3 options various other option also can generated and best suitable option among them is selected by using linear programming technique.

5. Conclusion :

Thus using linear programming software project manager can calculate how much crash cost is needed to crash the total project for the desired duration. It also shows when to start the activities for crashing the overall project duration. Linear programming can make complex crashing problem into easier one.

6. References

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