International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-3, January 2020

Prefabricated Construction Technology for Multistoreyed Building

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Abstract*: The construction boom in India is developing at a fast rate of growth. For fast growing population, it is essential to construct more residential units with lesser cost and lesser time. Reduction in cost of structure is made by several ways and one such way is to use prefabrication techniques. To reduce the overall cost and to greatly reduce the construction time of buildings, prefabricated units are adopted. In the present study, the G+3 conventional and prefabricated multistoreyed building is analyzed and designed. For both structures, the quantities and cost have been estimated and comparision is made for effective construction methodology. Also duration of project has been estimated in both cases and compared. The building is analyzed and designed in STAAD Pro software and project scheduling and duration is evaluated by MS PROJECT (MSP) software. By using Prefab Technology, reduction in cost can be achieved within less time. Construction cost of prefabricated structure is slightly more than conventional structure. But the time duration required for prefabricated construction is less as compared to conventional structure.

***Keywords* : Prefabrication, G+3 conventional and prefabricated multistoreyed building, STAAD PRO, MSP, Cost and Duration**

I INTRODUCTION

Conventional structures are mostly built of reinforced concrete frames. The traditional construction method uses wooden formwork. It is very costly for construction which includes labour, raw material, transportation and low speed of construction time. Modularization, Pre-assembly, prefabrication, system building and industrialized buildings are the terms which have been frequently used to describe that the manufacture of building. In this study, prefabrication is preferred with special emphasis on the building components are made off-site in a factory. Many prefabrication technologies deliver a better product because building is done in a quality controlled, sheltered environment. Hence, move to more prefabrication in construction industry is inevitable.
The quantities as well as cost have been estimated for the both type of buildings.

Revised Manuscript Received on January 30, 2020.
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For mass housing project, prefabricated technology seems to be economical as duration required is less & speedy in construction. Speed of construction, reduces the cost of labour charges in Prefab technology.
Quality of surface finish can be well maintained during the project. Hence very much suitable for high rise construction.

II METHODOLOGY

The G+3 building is analyzed and designed in STAAD Pro software by considering gravity load, Earthquake load , Wind load and load combinations according to IS codes. After designing the structure, the concrete and steel quantities have been estimated for obtaining the material cost of structure. Then the cost estimation has been done for one flat and per sq.ft. In further stage of work, the same multistoreyed building is analyzed and designed by using prefabricated structural elements using STAAD Pro software. Same parameters have been estimated. Further, the project duration of both type of structures is calculated by using MS PROJECT software. Then the comparative study has been done between the both type of structures in view of cost and duration of project.

III MODELLING AND DESIGN

1. Analysis and Design of G+3 Conventional Building

In multistoried G+3 building, 16 flats have been planned and the structure is analyzed and designed in Staad Pro software. The typical plan of G+3 building is as shown in fig. 1.

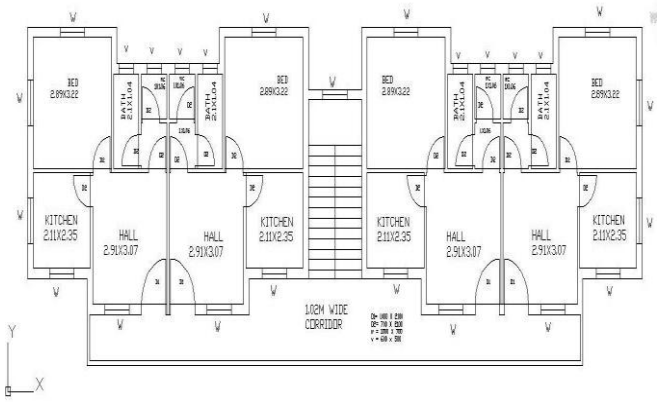

Fig. 1 : Plan of G+3 Multistoreyed Building

Following dimensions of the elements are considered while analyzing the structure in Staad-Pro.

1. Size of Column – 300 mm x 600 mm
2. Size of Beam – 230 mm x 450 mm

3. Thickness of Slab – 150 mm
4. Concrete Grade – M20
5. Grade of Steel – Fe 415

Figures 2 to 7 show the plan, 3D view, loading diagram, SFD and BMD of conventional building in Staad Pro.

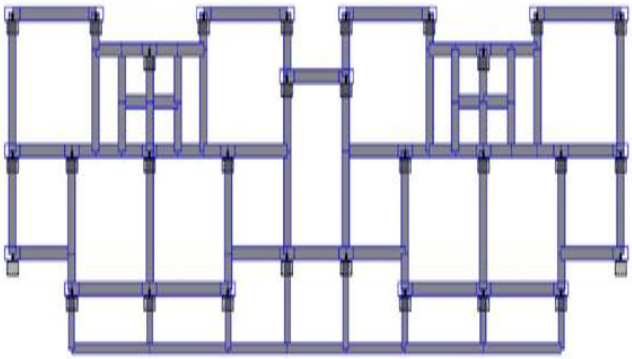

Fig 2: G+3 Building Plan in Staad Pro

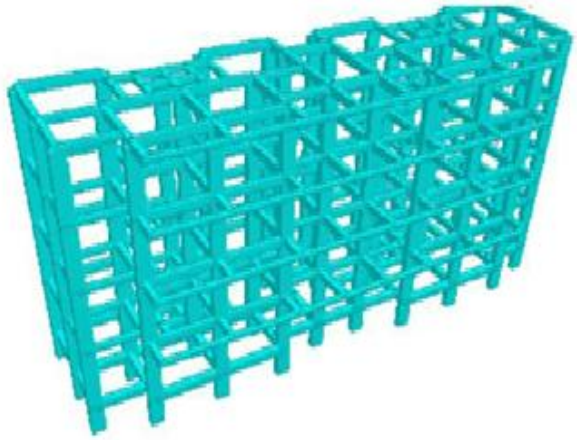

Fig 3: 3D View of G+3 Conventional Building in Staad Pro

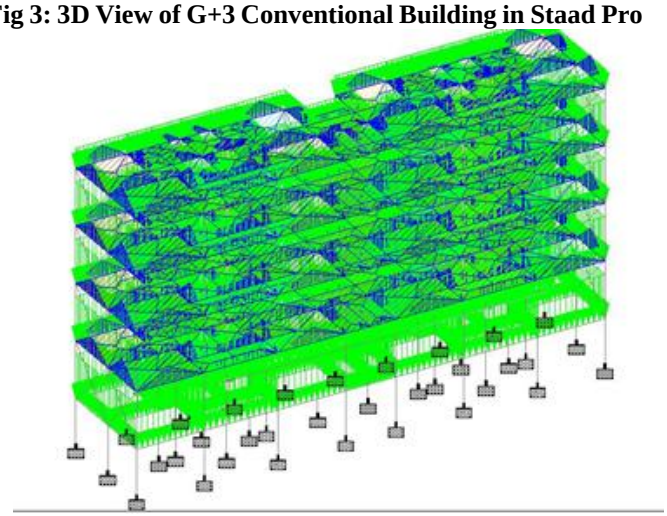

Fig 4: Gravity Loading on G+3 Conventional Building

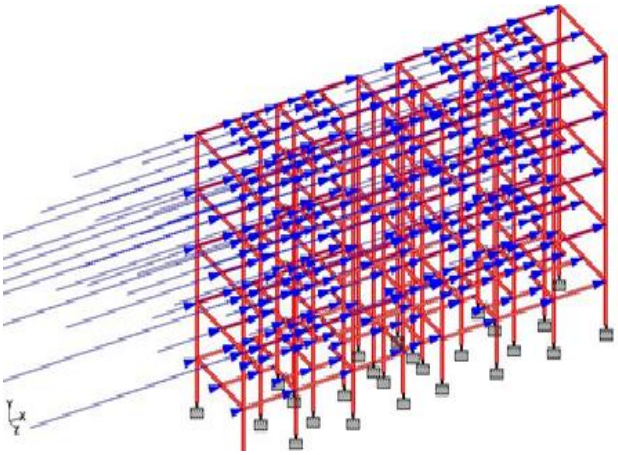

Fig 5: Earthquake Load on G+3 Conventional Building

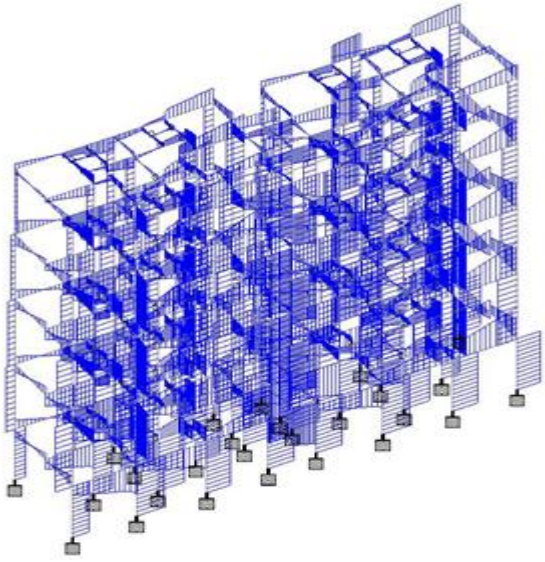

Fig 6: Shear Force Diagram of G+3 Conventional Building

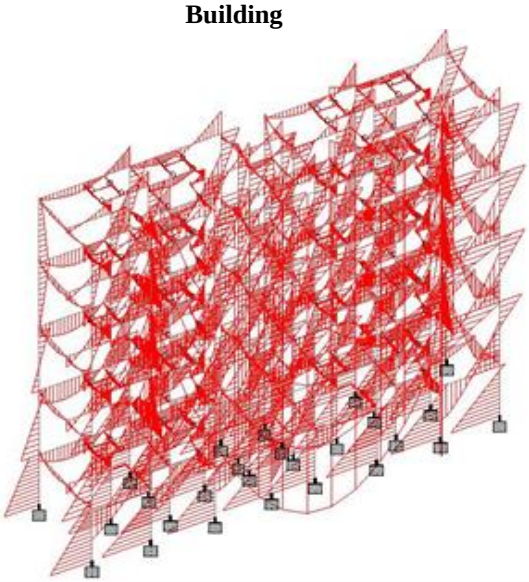

Fig 7: Bending Moment Diagram of G+3 Conventional Building

2. Analysis and Design of G+3 Prefabricated Building

The G+3 prefabricated building is analyzed and designed in Staad Pro software. Following dimensions of the elements are considered while analyzing the structure.

1. Size of Column – 230 mm x 230 x 8 mm Square Tubular section
2. Size of Beam – ISMB 225 & ISMB 175
3. Size of Plinth Beam – 300 mm x 450 mm
4. Thickness of Slab – 125 mm
5. Size of Bracings – 100 mm x 100 x 5 mm Square Tubular section
6. Concrete Grade – M20
7. Grade of Steel – Fe 415

Figures 8 to 12 show the 3D view, loading diagram, SFD and BMD of model for G+3 prefabricated building in Staad Pro.

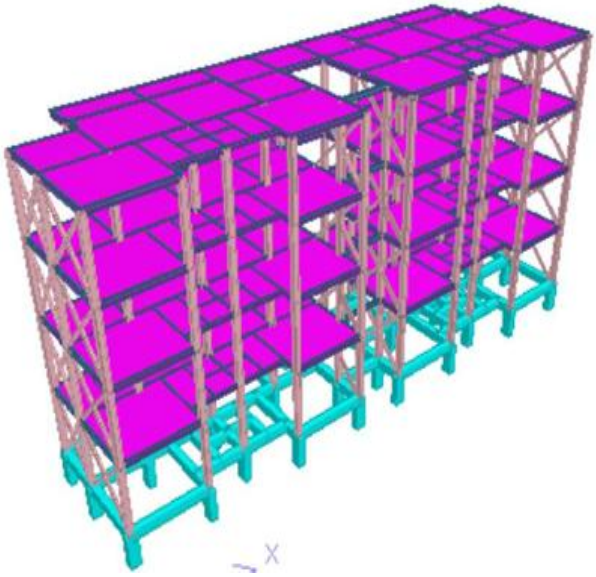

Fig 8: 3D View of G+3 Prefabricated Building in Staad Pro

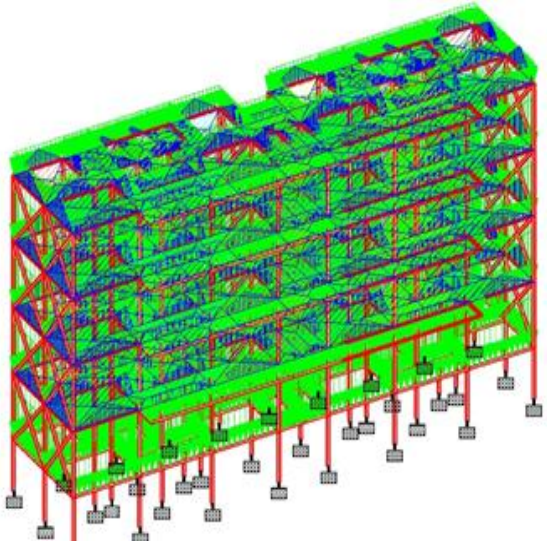

Fig 9: Gravity Loading on G+3 Prefabricated Building

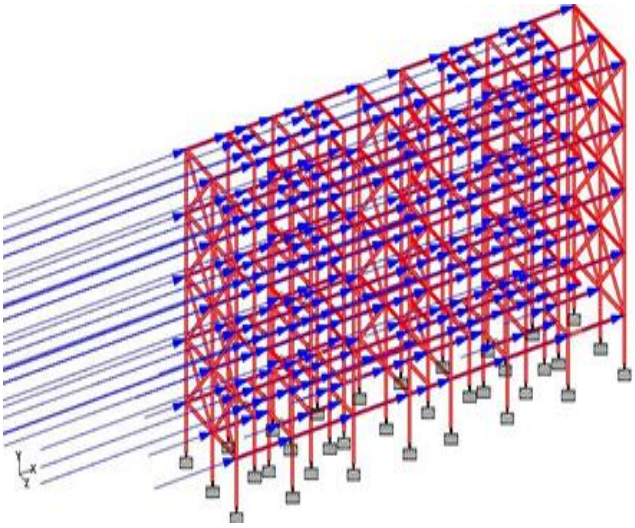

Fig 10: Earthquake Load on G+3 Prefabricated Building

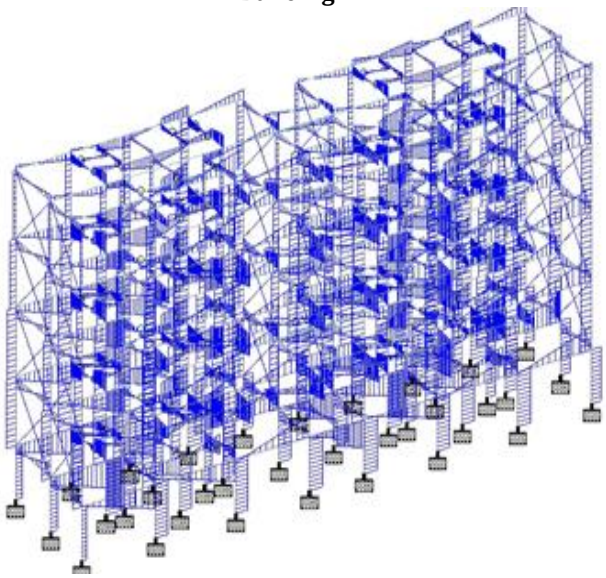

Fig 11: Shear Force Diagram of G+3 Prefabricated Building

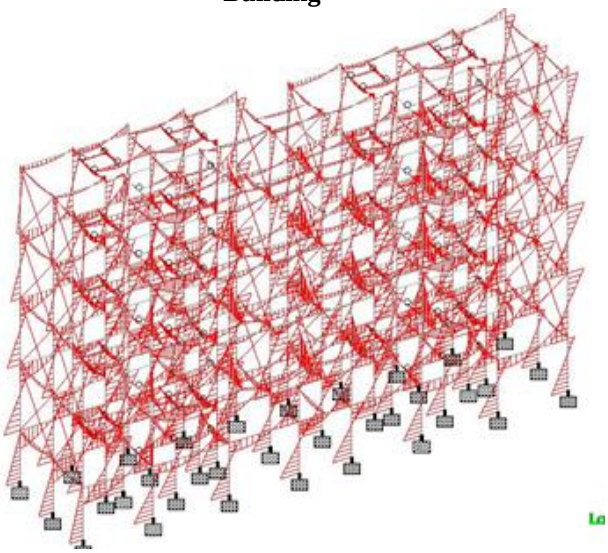

Fig 12: Bending Moment Diagram of G+3 Conventional Building

IV RESULTS

1. Concrete and Steel Quantity

After the analysis and design, the quantities as well as cost have been estimated for both type of buildings. The quantities of steel and concrete are given in table 1 for both structures.

Table 1:- Quantities of Concrete and Steel

Sr. No.	Quantity	G+3 (Conventional)	G+3 (Prefabricated)
1	Concrete (m^3)	373	225.4
2	Steel (Tons)	22.70	66.53

Fig 13 shows the comparison of concrete and steel requirement for conventional and prefabricated structures.

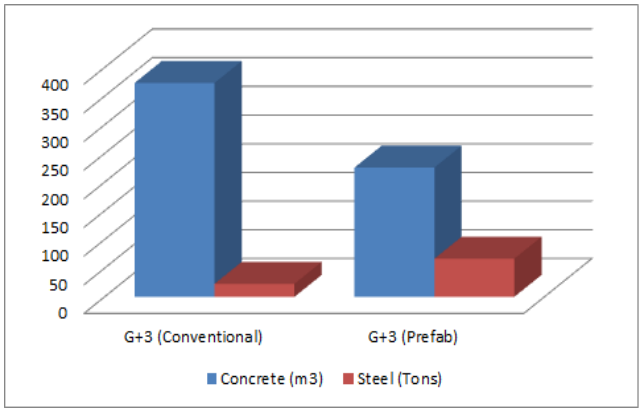

Fig 13: Concrete and Steel Requirement for Conventional and Prefabricated Structures

2. Construction Cost of Buildings

Table 5.2 shows the total construction cost and construction cost of respective buildings per unit and per sq. feet.

Table 2 : Cost of Construction of Buildings

Sr. No.	Type of Buildings	Construction cost per Unit(Rs.)	Construction cost per Sq. Ft. (Rs.)
1	G+3(Conventional)	506485.2/-	1400/-
2	G+3(Prefabricated)	426688.3/-	1200/-

3. Duration of Project

a. Conventional Building

The cost and total duration of conventional buildings are estimated in MS Project software and scheduling of activities has been prepared for multistoreyed building.

Table 3 shows the total construction cost of conventional building project in MS Project software.

Table 3: Total Cost of Construction of Conventional Buildings

Task Name	Duration	Predecessors	Cost
Project	**255 days**		**₹ 8,103,770.24**
Miscellienious	**10 days**		**₹ 51,750.00**
Site Clearance	5 days		₹ 49,250.00
Lining	5 days	3	₹ 2,500.00
ground work	**41 days**		**₹ 705,400.00**
excavation	16 days	4	₹ 57,600.00
PCC	16 days	6FS-14 days	₹ 16,000.00
Footing	15 days	7FS-6 days	₹ 504,600.00
Plinth Beam	12 days	8FS-6 days	₹ 96,000.00
Plinth Filling	12 days	9FS-4 days	₹ 31,200.00
Ground Floor	**42 days**		**₹ 677,130.00**
Column with Curing	12 days	10	₹ 149,999.99
Beam And Slab With Curing	30 days	12	₹ 527,130.00
First Floor	**42 days**		**₹ 1,275,230.00**
Column	12 days	13	₹ 149,999.99
Beam And Slab	30 days	15	₹ 527,130.00
Brick Work of GF	9 days	13FS+2 days	₹ 153,000.00
Door Window	5 days	17FS-6 days	₹ 152,500.00
Floaring Of GF	11 days	18	₹ 292,600.02
Second Floor	**42 days**		**₹ 1,275,230.00**
column	12 days	16	₹ 149,999.99
beam And Slab	30 days	21	₹ 527,130.00
brick Work of FF	9 days	16FS+2 days	₹ 153,000.00
Door Window	5 days	23FS-6 days	₹ 152,500.00
Floaring Of FF	11 days	24	₹ 292,600.02
Third floor	**42 days**		**₹ 1,275,230.00**
column	12 days	22	₹ 149,999.99
beam And Slab	30 days	27	₹ 527,130.00
brick work of SF	9 days	22FS+2 days	₹ 153,000.00
Door Window	5 days	29FS-6 days	₹ 152,500.00
Floaring of SF	11 days	30	₹ 292,600.02
Terrece Work	**19 days**		**₹ 598,100.00**
Brick work og TF	9 days	29FS+2 days	₹ 153,000.00
Door Window	5 days	33FS-6 days	₹ 152,500.00
Floaring of TF	11 days	34	₹ 292,600.02
Other Work	**46 days**		**₹ 2,245,700.00**
Electrification	20 days	26FS+10 days	₹ 500,000.00
Internal Plastering	16 days	35	₹ 407,200.00
External Plastering	14 days	35FS+10 days	₹ 204,400.00
Plumbing	10 days	38	₹ 399,999.96
Painting	20 days	40	₹ 234,100.00
staircase	20 days	28	₹ 500,000.00

Fig 14 shoes the scheduling and duration of activities of conventional building project with total project duration.

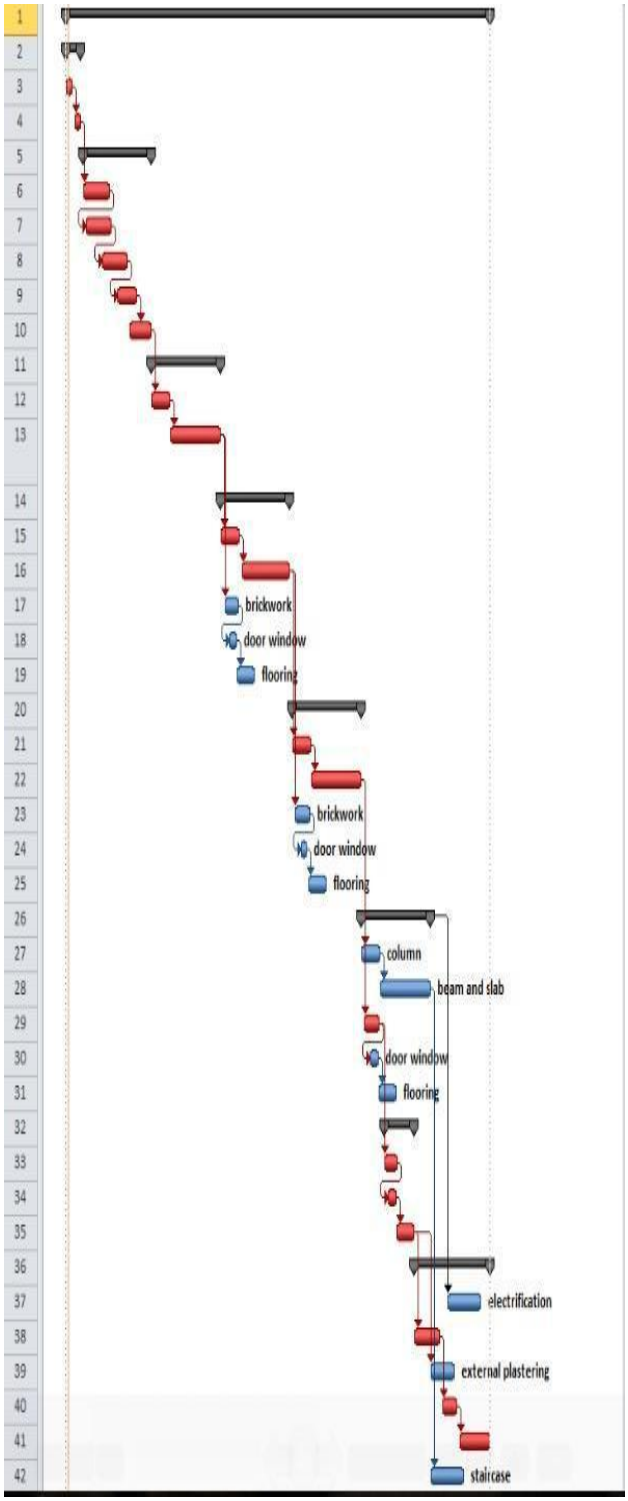

Fig. 14: MSP Scheduling of G+3 Conventional Plans

b. Prefabricated Building

The cost and total duration of prefabricated buildings are estimated in MS Project software and comparison has been done for effective method of construction for multistoreyed building. The scheduling of activities has been prepared for prefabricated multistoreyed building.

Table 4 shows the total construction cost of prefabricated building project in MS Project software.

Fig 15 shoes the scheduling and duration of activities of prefabricated building project with total project duration.

Table 4: Total Cost of Construction of Prefabricated Buildings

Task Name	Duration	Predecessors	Cost
Project	**179 days**		**₹ 4,662,691.84**
Miscellienious	**10 days**		**₹ 51,750.00**
Site Clearance	5 days		₹ 49,250.00
Lining	5 days	3	₹ 2,500.00
ground work	**35 days**		**₹ 945,400.00**
excavation	16 days	4	₹ 57,600.00
PCC	16 days	6FS-14 days	₹ 256,000.00
Footing	15 days	7FS-12 days	₹ 504,600.00
Plinth Beam	12 days	8FS-6 days	₹ 96,000.00
Plinth Filling	12 days	9FS-4 days	₹ 31,200.00
Ground floor	**13 days**		**₹ 446,147.96**
Erection of column and beam	4 days	10	₹ 36,748.00
Grouting of column upto 2m height	2 days	12SS+2 days	₹ 1,400.00
Placing of plate	2 days	13SS	₹ 4,000.00
Grouting of slab joint and silicon oil apply	2 days	14	₹ 1,000.00
Reinforcement laying & formwork Eraction	3 days	15SS+1 day	₹ 3,000.00
concreting	5 days	16	₹ 399,999.96
first floor	**13 days**		**₹ 446,147.96**
erection of column and beam	4 days	17	₹ 36,748.00
Grouting of column upto 2m height	2 days	19SS+2 days	₹ 1,400.00
Placing of plate	2 days	20SS	₹ 4,000.00
Grouting of slab joint and silicon oil apply	2 days	21	₹ 1,000.00
Reinforcement laying & formwork Eraction	3 days	22SS+1 day	₹ 3,000.00
concreting	5 days	23	₹ 399,999.96
Second floor	**13 days**		**₹ 446,147.96**
erection of column and beam	4 days	24	₹ 36,748.00
Grouting of column upto 2m height	2 days	26SS+2 days	₹ 1,400.00
Placing of plate	2 days	27SS	₹ 4,000.00
Grouting of slab joint and silicon oil apply	2 days	28	₹ 1,000.00
Reinforcement laying & formwork Eraction	3 days	29SS+1 day	₹ 3,000.00
concreting	5 days	30	₹ 399,999.96
Third floor	**13 days**		**₹ 446,147.96**
erection of column and beam	4 days	31	₹ 36,748.00
Grouting of column upto 2m height	2 days	33SS+2 days	₹ 1,400.00
Placing of plate	2 days	34SS	₹ 4,000.00
Grouting of slab joint and silicon oil apply	2 days	35	₹ 1,000.00
Reinforcement laying & formwork Eraction	3 days	36SS+1 day	₹ 3,000.00
concreting	5 days	37	₹ 399,999.96
Other Work	**87 days**		**₹ 1,880,950.08**
Brick Work	20 days	38	₹ 199,999.98
Door & Window	5 days	40SS+16 days	₹ 152,500.00
Flooring	10 days	40SS+20 days	₹ 266,000.00
Electrification	10 days	42SS+24 days	₹ 250,000.00
Internal Plastering	8 days	43SS+10 days	₹ 203,600.00
External Plastering	8 days	44SS+10 days	₹ 116,800.00
Plumbing	5 days	45SS+8 days	₹ 199,999.98
Painting	10 days	45SS+8 days	₹ 117,050.00
staircase	15 days	37	₹ 375,000.00

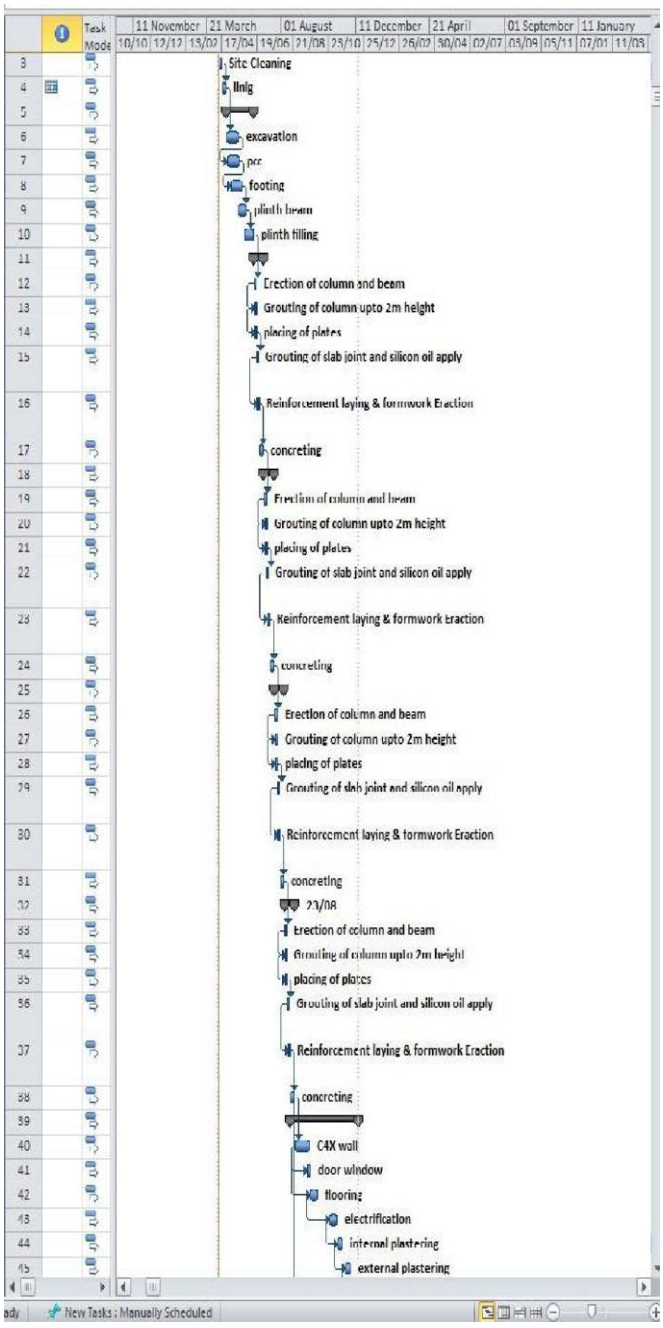

Fig. 15: MSP Scheduling of G+3 Prefabricated Plans

Table 5 shows the comparision of total duration of project in days required for conventional as well as prefabricated structure.

Table 5: Total Duration of building

Sr. No	Type of Building	Duration(Days)
1	Conventional Building	**255**
2	Prefabricated Building	**179**

Fig 16 shows the comparison of duration of project required for both type of buildings.

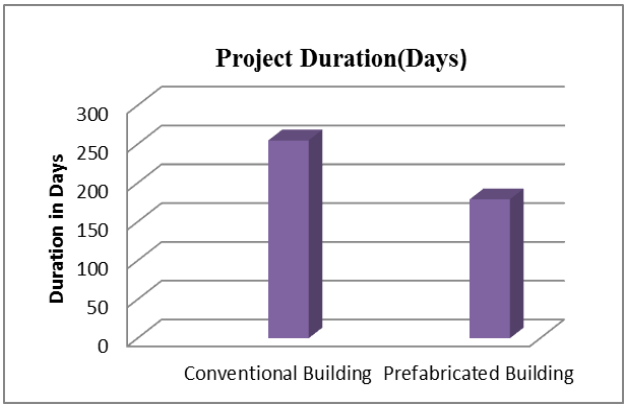

Fig. 16: Comparison of Project Duration

From the above study, it can be observed that

- In G+3 prefabricated building, the concrete quantity required is less as compared to G+3 conventional building but the steel quantity is more in prefabricated building.
- In conventional method, the cost of construction is directly proportional to project duration of building. So the cost of construction will reduce in G+3 prefab building if project duration is taken into consideration.
- The duration of the prefab technology is comparative less than conventional technology. Duration required for prefab is 179 days and it is less than conventional 255 days.

V CONCLUSIONS

Various formwork systems provide a wide range of concrete construction solutions. The modular formwork systems are designed for speed and efficiency in construction. Prefabricated structures are the effective solutions in terms of construction cost as compared to the traditional methods due to the materials, fast and short time duration of construction. The present study is focused on the influence of reduction of cost and duration of structure which leads to economical construction methodology.

From above study, following conclusions are made.

- The sections required for conventional G+3 building are heavier than prefabricated structure.
- The quantity of steel required for prefabricated technology is more as compared to conventional buildings. But concrete quantity is less as it consists of structural steel members.
- Construction cost of prefabricated structure is slightly more than conventional structure. But the time duration required for prefabricated construction is less as compared to conventional structure.
- Cost and Duration of the prefab building is less as compared to conventional building.
- Speed of construction, reduces the cost of labour charges in Prefab technology.
- By using Prefabricated Technology, reduction in cost can be achieved within less time.

- Very much suitable for high rise construction.

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