Analytical Study For Extension of RCC Multistory Building With Conventional And Composite Construction Technique

Abstract : Due to this dead weight, the foundation has to be design so big for tall buildings that it can easily bear the all the load. Many researches have been carried out to reduce this load by inventing light weight concrete. But still concrete will always carry more dead load than any other material. Therefore, other alternatives have to explore so that maximum reduction in dead load can be done. Steel is an impeccable alternative and an important solution to this problem as the self-weight of steel is comparatively less than concrete and it also possess high strength so that it can withstand the forces occurring at the upper storey of the building. Therefore, for this study, an attempt was made in order to reduce the dead weight of the RCC frame structure by simply introducing the steel frame structure in the upper storey while keeping economy in mind. For this, different storey buildings (12 storey & 16 storey) were analyzed and designed in staad.pro software.

***IndexTerms* – Extension of Building, RCC frame Building, Staad.pro.**

I. INTRODUCTION

Being the developing country, infrastructures play an impeccable role as it acts as a backbone of the nation and contributes to the economy of the nation. Along with the modernization, complex structures have been introduced while having the numerous researches related to different kinds of structures (such as RCC structures, steel structures, composite structures etc) and loads (such as wind load, seismic load, hydrostatic load etc). As the requirement of complex structure arises, structure designers and site engineers have to face some serious problems related to it. Each and every aspect of design has to be considered by the design engineer whether the aspect is very small or large. But, practically, consideration of all the aspects is not possible therefore, designer increases the load and moments acting on the building with some predefined multiplication factor which is called as Factor of Safety. This factor may seem unimportant but is very beneficial in providing safety to structure. These multiplication factors have been calculated with research works which had been done by the previous researchers.

From the past record of Indian infrastructures, it has been concluded that brick masonry structures had laid the foundation of Indian Infrastructures as almost every structure was built with bricks and mortar. But then concrete was introduced which became the best option for civil engineers. Concrete structure was far more superior to brick in all the aspects of structures which had very few demerits. Now, brick masonry structures are generally used for constructing temporary structures such as structure at construction site etc or infill walls for RCC framed structure. RCC has large self-weight which increases the lateral stability and helps in resisting forces such as seismic and wind etc. On the contrary side, the steel structure has less self-weight when compared to RCC which makes it vulnerable to lateral forces. But apart from this demerit, steel structure has umpteen merits over RCC such as less time to construction, less self-weight leads to less dead load of the structure and smaller foundations. Prefabricated structural components are connected by various means (bolts and welds) at construction site in order to erect the steel structure. With all the new researches on steel building with additional members resisting lateral forces, it has already embedded its feet in the soil. Composite structures are rarely built as it requires some professional high level skill and labor but it covers all the demerits of RCC structure and steel structure.

Structural analysis of a building simply means to predict the behaviour and performance of structure when some vertical and lateral loads are applied. The behaviour of different structural members of a building can be observed by different analysis methods and techniques with the help of analysis tool or calculating the forces and moments manually. Seismic analysis on a structure is a kind of structural analysis in which earthquake forces and its parameters are considered so that the building can easily resist the earthquake force. In seismic analysis, different combinations of earthquake loads and other vertical loads are considered from which the most critical combination is selected and used for designing of the structure.

II. RESEARCH METHODOLOGY

Preparing, Analysis and Design of Structures: Various RCC models were modeled using staad.pro software with having different building heights. Then, extension of the building was carried out with RCC and Steel framed structure (light weight).

Specifications of the model are as under:

- Each structure had 8 bays.
- Each bay was 5 m x 5 m in size.
- Each storey was 3 m in height.
- For steel sections, both (conventional and tubular) sections were chosen, whichever is suitable.
- All the models were regular and symmetrical in shape.

Table 3.1. Description of Various Models.

Category	Description
Category I	8 Storey RCC building with 4 Storey RCC Extension (12 Storey Building)
Category II	8 Storey RCC building with 4 Storey Steel Extension (12 Storey Building)
Category III	10 Storey RCC building with 6 Storey RCC Extension (16 Storey Building)
Category IV	10 Storey RCC building with 6 Storey Steel Extension (16 Storey Building)

Table 3.2 Cross-sectional Properties for Various Structures.

Cross-section properties for 8 Storey RCC building with 4 Storey RCC Extension		
Floor	Column	Beam
1 - 4 floors	0.75 x 0.65 m	0.5 x 0.35 m
5 – 8 floors	0.65 x 0.55 m	0.4 x 0.35 m
9 – 12 floors	0.55 x 0.4 m	0.35 x 0.3 m
Cross-section properties for 8 Storey RCC building with 4 Storey Steel Extension		
Floor	Column	Beam
1 - 4 floors	0.75 x 0.65 m	0.5 x 0.35 m
5 – 8 floors	0.65 x 0.55 m	0.4 x 0.35 m
9 – 12 floors	ISWB 600 Double	ISWB 600
Cross-section properties for 10 Storey RCC building with 6 Storey RCC Extension		
Floor	Column	Beam
1 - 4 floors	0.85 x 0.75 m	0.6 x 0.35 m
5 – 8 floors	0.75 x 0.65 m	0.5 x 0.35 m
9 – 10 floors	0.65 x 0.55 m	0.4 x 0.35 m
10 – 12 floors	0.65 x 0.55 m	0.4 x 0.35 m
13 – 16 floors	0.55 x 0.4 m	0.35 x 0.3 m
Cross-section properties for 10 Storey RCC building with 6 Storey Steel Extension		
Floor	Column	Beam
1 - 4 floors	0.85 x 0.75 m	0.6 x 0.35 m
5 – 8 floors	0.75 x 0.65 m	0.5 x 0.35 m
9 – 10 floors	0.65 x 0.55 m	0.4 x 0.35 m
10 – 12 floors	ISWB 600 Double	ISWB 600
13 – 16 floors	ISWB 600 Double	ISWB 600

Seismic Analysis: Once the modeling is done, seismic analysis as per the guidelines and design criteria of new seismic code IS: 1893-2016 will be performed in order to analyze the structures in seismic zone IV. According to the latest seismic code as mentioned before, dynamic seismic analysis was performed with response spectrum analysis. Various seismic parameters such as seismic zone, soil type, response reduction factor etc was considered for the analysis.

Parameters	Value	Unit
Zone	0.24	
Response reduction Factor (RF)	5	
Importance factor (I)	1.2	
Rock and soil site factor (SS)	2	
* Type of structure (ST)	1	
Damping ratio (DM)	0.05	
* Period in X Direction (PX)		seconds
* Period in Z Direction (PZ)		seconds
* Depth of foundation (DT)		m
* Ground Level (GL)		m
*Spectral Acceleration (SA)	0	
* Multiplying Factor for SA (DF)	0	

Figure 3.6. Seismic Parameters as per code IS: 1893-2016.

III. Results of 12 Storey Building

The results of various parameters have been represented below:

Table: 4.1. Bending moment in outer Beams for 12 Storey building.

Beam No	Category I	Category II
1	177.545	228.118
2	175.476	208.307
3	175.287	207.080
4	175.009	207.015
5	175.296	207.068
6	175.091	207.007
7	175.476	208.307
8	177.545	228.118

Table: 4.2. Shear force in outer Beams for 12 Storey building.

Beam No	Category I	Category II
1	123.392	135.050
2	122.674	129.316
3	120.797	119.748
4	122.570	128.298
5	120.753	119.818
6	122.488	128.430
7	120.476	117.866
8	117.234	102.442

In 12 Storey building, the values of maximum bending moment in beams of category I and category II are 175.545 KN-m and 228.118 Kn-m respectively. Whereas, the value of shear force in same beam of category I and II are 123.392 KN and 135.050 Kn respectively. It has been concluded from figure 19 that there is an increase of 30 % and 10% in bending moment and shear force in Category II with respect to Category I.

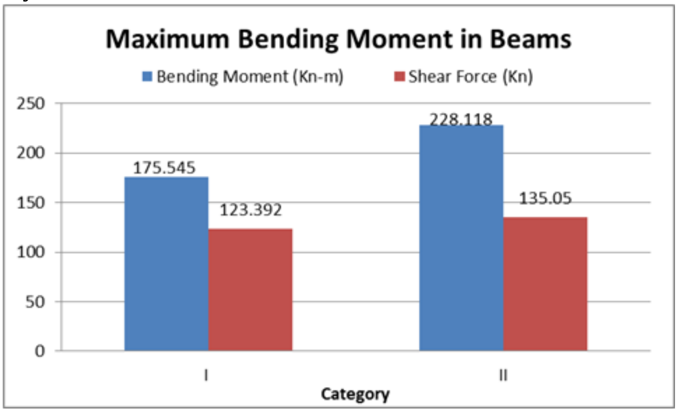

Figure 4.7. Maximum Shear Force and Bending Moment in beams of 12 Storey Building.

The maximum displacement in column of category I and Category II has been found to be 139.778 mm and 93.670 mm. From the displacement values, it can be concluded that displacement is reduced when steel extension is used rather than RCC extension and approximately 33% reduction has been seen.

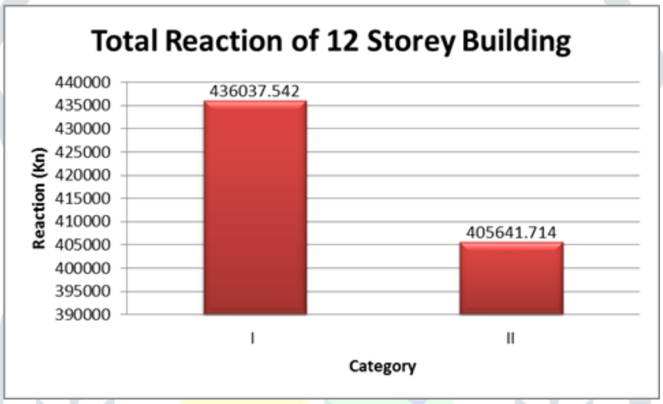

Figure 4.12. Total Reaction of 12 Storey Building.

Table: 4.12. Total Material Quantity of 12 Storey Building.

Type of Building	Concrete (m3)	Steel Reinforcement (Kn)	Steel Section (Kn)
Category I	2244.8	2326.728	-
Category II	1728.6	1636.926	6299.812

Due to introduction steel portion (Category II) as extension rather than RCC (Category I), the quantity of concrete and steel reinforcement has reduced upto 23% and 30% respectively for 8 Storey building with 4 storey extension. Although, the quantity of steel sections were added in category II building i.e. 6299.812 KN.

IV. RESULTS OF 16 STOREY BUILDING

The results of various parameters have been represented below:

Table: 4.3. Bending moment in outer Beams for 16 Storey building.

Beam No	Category III	Category IV
1	182.049	199.152
2	174.285	173.952
3	173.326	169.197
4	173.118	167.114
5	173.329	169.196
6	173.185	167.116
7	174.286	173.952
8	182.049	199.152

Table: 4.4. Shear force in outer Beams for 16 Storey building.

Beam No	Category III	Category IV
1	127.278	124.080
2	124.288	115.816
3	119.986	103.737
4	123.802	113.137
5	120.038	103.337

6	123.871	112.601
7	119.324	99.168
8	111.438	83.504

In 16 Storey building, the values of maximum bending moment in beams of category III (10 Storey RCC building with 6 Storey RCC Extension) and category IV (10 Storey RCC building with 6 Storey Steel Extension) are 182.049 KN-m and 199.152Kn-m respectively. Whereas, the value of shear force in same beam of category III and category IV are 127.278KN and 124.08 Kn respectively. It has been concluded that there is an increase of 10 % in bending moment and decrease of 3% in shear force in Category IV with respect to Category III.

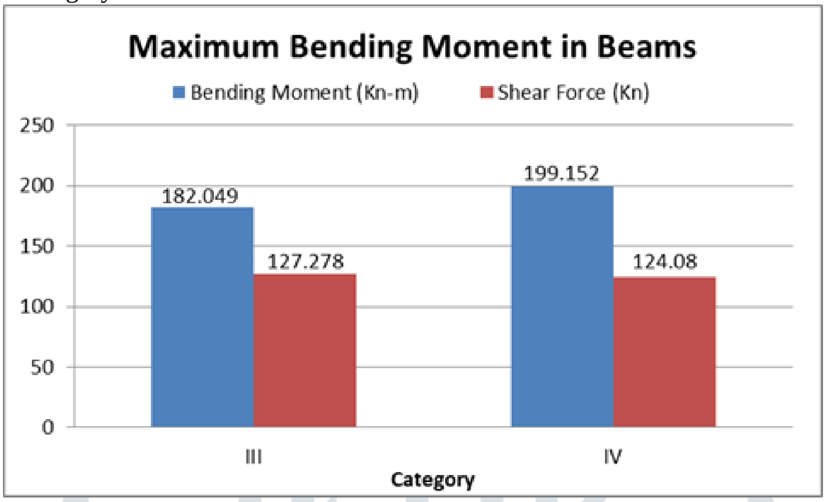

Figure 4.19. Maximum Shear Force and Bending Moment in beams of 16 Storey Building.

The maximum displacement in column of category III and Category IV has been found to be 88.313 mm and 56.074 mm. From the displacement values, it can be concluded that displacement is reduced when steel extension is used rather than RCC extension and approximately 37 % reduction has been seen.

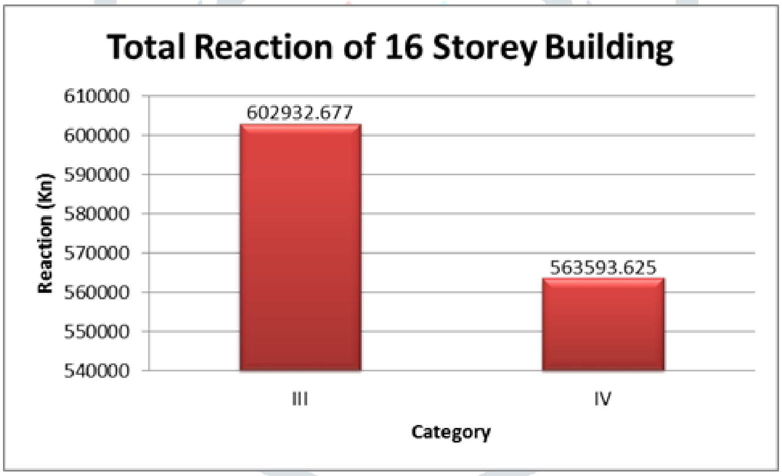

Figure 4.24. Total Reaction of 16 Storey Building.

Table: 4.12. Total Material Quantity of 12 Storey Building.

Type of Building	Concrete (m3)	Steel Reinforcement (Kn)	Steel Section (Kn)
Category III	3469.2	2672.101	-
Category IV	2577.7	1781.253	9449.69

Due to introduction steel portion (Category IV) as extension rather than RCC (Category III), the quantity of concrete and steel reinforcement has reduced upto 25% and 33% respectively for 10 Storey building with 6 storey extension. Although, the quantity of steel sections were added in category IV building i.e. 9449.685 Kn.

V. CONCLUSIONS

The conclusions drawn for 12 storey building are as under:

1. In 12 Storey building, the values of maximum bending moment in beams of category I and category II are 175.545 KN-m and 228.118 Kn-m respectively. Whereas, the value of shear force in same beam of category I and II are 123.392 KN and 135.050 Kn respectively. It has been concluded that there is an increase of 30 % and 10% in bending moment and shear force in Category II with respect to Category I.
2. The maximum displacement in column of category I and Category II has been found to be 139.778 mm and 93.670 mm. From the displacement values, it can be concluded that displacement is reduced when steel extension is used rather than RCC extension and approximately 33% reduction has been seen.
3. As Steel structural members are light in weight than RCC members, the Category II (8 Storey RCC building with 4 Storey Steel Extension) total dead load has been found approximately 7% less than Category I (8 Storey RCC building with 4

Storey RCC Extension). The total dead weight of category I building was 43603.75 tonnes whereas the total dead weight of category II was 40564.17 tonnes.

4. Due to introduction steel portion (Category II) as extension rather than RCC (Category I), the quantity of concrete and steel reinforcement has reduced upto 23% and 30% respectively for 8 Storey building with 4 storey extension.

The conclusions drawn for 16 storey building are as under:

1. In 16 Storey building, the values of maximum bending moment in beams of category III (10 Storey RCC building with 6 Storey RCC Extension) and category IV (10 Storey RCC building with 6 Storey Steel Extension) are 182.049 KN-m and 199.152Kn-m respectively. Whereas, the value of shear force in same beam of category III and category IV are 127.278KN and 124.08 Kn respectively. It has been concluded that there is an increase of 10 % in bending moment and decrease of 3% in shear force in Category IV with respect to Category III.
2. The maximum displacement in column of category III and Category IV has been found to be 88.313 mm and 56.074 mm. From the displacement values, it can be concluded that displacement is reduced when steel extension is used rather than RCC extension and approximately 37 % reduction has been seen.
3. As Steel structural members are light in weight than RCC members, the Category IV (10 Storey RCC building with 6 Storey Steel Extension) total dead load has been found approximately 6.5 % less than Category III (10 Storey RCC building with 6 Storey RCC Extension). The total dead weight of category III building was 60293.27 tonnes whereas the total dead weight of category IV was 56359.37 tonnes.
4. Due to introduction steel portion (Category IV) as extension rather than RCC (Category III), the quantity of concrete and steel reinforcement has reduced upto 25% and 33% respectively for 10 Storey building with 6 storey extension.

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