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Design and Comparison of Multistorey Building by LSM and WSM

A Case Study

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Abstract:- The prime objective of conducting this study was the design of a multistorey (G+2) building. Two different design methodologies were used for the design of this building and the quantities of concrete and steel obtained using both these approaches were compared. Limit State method is based on the concepts of serviceability and thus renders reduced sections of members. The study assess the amount of reduction in the quantity of steel as well as concrete when limit state philosophy is used over the working stress philosophy which is based on the safety criteria.

Keywords:- *Multisory; Design; Limit State; Working Stress.*

I. INTRODUCTION

Multistorey buildings are a common site in urban areas. Due to the boom in population in the past decade, cities are growing vertically all over the world. Construction of such tall buildings is possible only by adopting a set of rigidly interconnected beams and columns. These set of rigidly interconnected beams and columns of multi bay and multistoried buildings are called building frames.

In many places, the building laws permit the construction of ground plus three storey buildings without the provision of lifts. The loads from walls and ceilings are transferred to the beams and columns, which are subsequently transferred to the ground soil stratum.

As stated, the main objective of this study was not just the design of the multistorey building but also the comparison in quantities when both the approaches are used. The difference between the two philosophies may be summarized as follows:

- In Working Stress Method dead loads and live loads are treated equally. i.e. the factor of safety is same irrespective of the type of load. Here, the total loads that expected on the structure are considered and a single factor of safety to the members (say 1.5) is applied to the loads, regardless of the nature of the load.
- Limit State Method recognizes the inherent unpredictability of loads and assigns a much higher factor of safety to live loads (we increase them by 1.5-1.6), whereas it recognizes that dead loads are much closer to what we calculate (we only multiply dead loads by 1.2).
- Limit State Method also recognizes the uncertainty of different failure modes. For example, flexural capacity of a concrete beam is fairly predictable; therefore 90% of the theoretical value is considered. Shear in concrete, on the other hand is much less predictable; therefore, only count on 70% of the value is considered.
- In Working stress method, the members are designed to never go beyond their elastic range. The max. load a member can take is thus limited and the plastic range is not explored at all.
- Limit state method uses the ultimate strength of the member beyond the initial yielding and allows plastic deformation to a certain extent.

For this reason, limit state method provides a more economical design and thus more and more codes are starting to use limit state method instead of working stress method. Hence work working stress method is becoming more outdated.

Is 456:2000 is the code followed in India for the design of R.C.C. structures, which was also referred to while designing the building in this study. The code permits the analysis of frames by approximate methods. Thus in this study we adopted Kani's method for analysis of frames.

II. METHODLOGY

A. Effective Span

As per IS 456-2000, in the analysis of frames, the effective length of members shall be centre to centre distance.

B. Stiffness

For the analysis of frames, the relative stiffness (I/L) values of various members are required. These are based normally on the moment of inertia of the section. Thus it requires arriving at the member sizes before designing. The sizes were selected on the basis of architectural, economic and structural considerations.

In multistorey frames, columns of the upper stories carry less axial force but more moments. However, columns of lower storey carry more axial load and less moment. Design was used to roughly estimate the axial load on lower storey column and arrive at the sizes of the column.

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Next two to three storey were given the same size. Beyond that sizes may be reduced.

C. Loads

For multistorey frames, dead load, imposed (live) load, wind load and earthquake loads are important for designing. The first combination provided in the IS 456:2000 was selected for analysis in this case. Thus Dead load (DL) was 8kN/m and Live Load (LL) was 8kN/m.

Thus total load (TL) on the frame was 1.5*DL+1.5*LL, which was equally to 24kN/m.

The Fig.1 Below depicts the typical floor plan considered for the study.

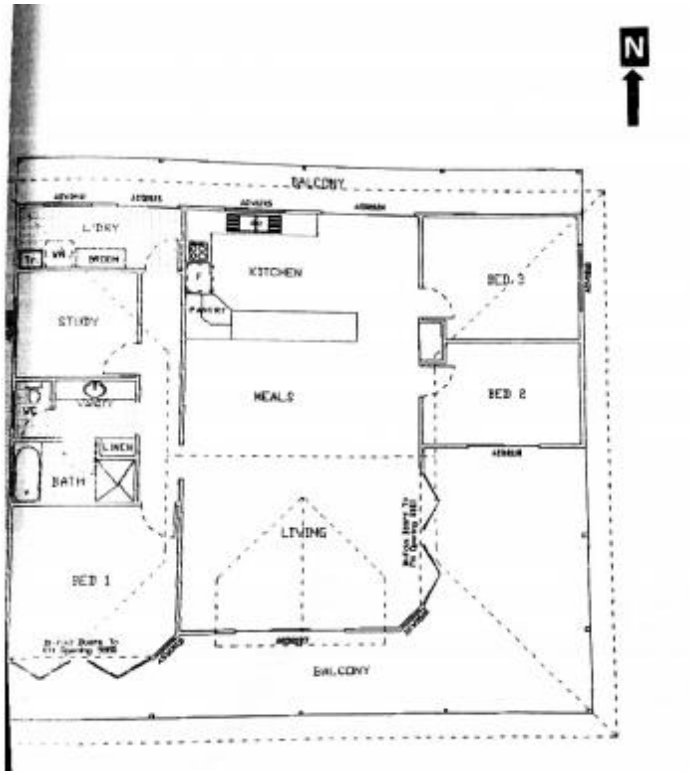

Fig 1:- Typical floor plan for the multistorey building

The analysis of the frames was carried out using software STAAD PRO and M.S. Excel.

Key features of the project were:

- Plot size 20m X 20m
- Total construction area = 65% of the plot size
- G+2 multistorey building

III. RESULTS

The design was carried out using both the philosophies and recommended software tools. The findings for the sizes of beams are summarized in Table 1 below.

S.No.	Feature	LSM	WSM
1	Cross Section	220X550 mm^2	250X700 mm^2
2	Tension Reinforcement	1196.51 mm^2	698.12 mm^2
3	Vertical Stirrup	8ϕ C/C 300 mm	8ϕ C/C 300 mm
4	Bent-up bar	1 nos. 25ϕ 45°	_
5	Development Length	750 mm	650 mm

Table 1:- Beam Features Comparison

Similarly the results of design of columns are summarized in Table 2.

S.No.	Feature	LSM	WSM
1	Cross Section	220X250 mm^2	250X250 mm^2
2	Main Reinforcement	280.36 mm^2	341.30 mm^2
3	Tie Bar	8ϕ C/C 200 mm	8ϕ C/C 200 mm

Table 2:- Column Features Comparison

IV. CONCLUSIONS

After successfully completing the planning and designing of the multistorey G+2 building it may be concluded that:

- LSM is more economical and efficient as compared to WSM of design.
- Reduction in the quantity of steel was approximately 30% when limit state method was used for the entire building design as compared to that of the working stress method.
- Reduction the quantity of R.C.C. was around 20% when LSM was used for the entire building as compared to that of WSM.

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The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g.” Avoid the stilted expression “one of us (R. B. G.) thanks ...”. Instead, try “R. B. G. thanks...”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

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