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Steel Intensive Building for Rural Applications

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ABSTRACT: For the last couple of years, INSDAG has been engaged in various types of project work specially related to effective and efficient use of steel in buildings both for urban and rural sectors. An analysis of the housing situation in India shows that more urgent need exists for bringing out designs of affordable housing to the people. This publication is an outcome of a detailed study, structural analysis and cost estimation of a few selected structures of rural sector like rural school building, rural houses, panchayat or meeting hall and anganwadi or health center. The purpose is to find out an optimum solution which is sound in strength and cost-effective and also to increase awareness of use of steel buildings in rural sector.

KEYWORDS: Steel Building, RCC Building, Cost comparison, etc.

I. INTRODUCTION

Since 70% of the country's population belongs to rural India, the need of designing sustainable rural structures is of paramount importance. But to provide the rural people with an engineered housing at an affordable price, the cost of such a unit needs to be lowered by application of proper technology giving due considerations suitable to its importance, stability, life expectancy, repairs, maintenance etc.

Therefore, the following three points have been considered:

- Fast-track construction
- Lightweight steel members
- Precast Ferro-Cement panels as walls.

While carrying out the design, it is kept in mind that steel as a framing material will provide the necessary strength to the building against all types of normal and abnormal loading conditions. So, steel Square Hollow Sections have been selected as the structural members of the frame built in grids measuring about 1 meter x 1 meter and the frame has been analyzed in a 3D model by software package STAADProV8i for different loading possibilities. The building has been checked for its stability against an earthquake tremor equivalent to Zone V and against a wind gust having a basic speed of 50 m/s as in the coastal regions of India. It has been observed that earthquake loads are not at all predominant in the design. Since there are no coastal stipulations in India to assess the possible loads from hydro-splashing during flood, it is assumed that the building, which withstands such an earthquake and wind effect, will also be durable during flood if the foundations are not scoured off. Precast Ferro-Cement panels have been used as cladding materials at walls considering its ease of construction, durability and cost. Moreover it is also expected that given some training, the dweller of the house will be able to construct these panels very easily. The connections between the steel and these panels have been so designed that much skill will not be required for erection / connection of such panels on the steel grid.

II. METHODOLOGY

1.Collection of data for Planning : Department of Rural Development and Panchayats, Govt. of Maharashtra has been carrying out various structures like unit house under IAY, health center's under Anganwadi project, meeting halls and school buildings under Sarva Siksha Mission. For comparison all the existing schemes are collected and

suitably converted to steel intensive structures. Glass panes have been designed to fit with 1 ft. width so that the wastage of materials is minimized.

2.Preparation of Design Basis : The design has been carried out with some basic assumptions in design criteria/parameters including i) assumed soil parameters, ii) wind speed, iii) earthquake zone etc. A net safe bearing capacity of soil at 1.0 m below with respect to the existing ground level is assumed to be 5 t/m² for the worst soil and 20 t/m² in case of good soil. Wind load is based on IS 875 (Part 3) for coastal region for a basic wind speed of 50 m/s having $k_1=1.0$, $K_2=1.00$ and $k_3=1.00$ i.e. for a design wind pressure of 150 kg/m². For earthquake loading, the provisions of IS 1893:2002 was considered for Zone V. For reinforcement in Ferro-Cement panels Fe 250 steel conforming to IS 432 has been used. Square Hollow Section (SHS) (conforming to $f_y = 210-240$ N/m² as per IS 2062) has been considered as structural steel. All reinforced concrete work in foundation has been designed assuming durability requirements suitable for rural application.

3.Consideration for Stability : In this publication the rural housing units have been designed to be stable against normal loads like dead load and live load as well as abnormal loadings like wind and earthquake loads. RCC foundation has been provided for these units with isolated pad foundations along with a pedestal each, placed at a depth of 1.0 meter below the existing ground level. The stability of the building has been checked against all possible worst combination of loads. The net safe bearing capacity of the soil has been considered varying between 5-20 t/m². The building has been checked for its stability against a wind pressure of 150 kg/m² and earthquake zone V. As per IS stipulations, the maximum wind and maximum earthquake have not been considered to act simultaneously. It has been observed after analysis that no tension has developed under any footing. Moreover the self-weight of soil fill over the footing satisfies the stability requirements of the building foundations against overturning and sliding. The connections between the steel members are all rigid connections, which has been designed to transfer the loads in the form of moment, shear and axial loadings to the supporting members and ultimately to the foundation. The Ferro Cement panels have been designed to withstand the lateral thrusts and its connection with the steel members have been so detailed that it performs well as a cladding material covering the steel members as well as making the structure laterally stable. From the analyses, it is found that the buildings are well within the stipulated deflection limit of IS code.

4.Selection of Materials : While selecting the material of construction for the rural structures, due consideration has been given to the durability aspect like termite attack, strength aspect i.e. strength to withstand the thrusts of wind and tremor of earthquake, comfort expected in human habitation like temperature variation within the housing unit with the variation outside and proper ventilation and so on. The finished ground level of the housing units could be kept above the high flood level of a particular area to suit at site. It has been observed from the data collected from villages that during average monsoon the requirement of such elevation is 600 mm. Steel Hollow Section has been selected as member of the framing system for its strength and lightweight. Ferro-Cement panel of 15 mm thickness has been selected for cladding material because of its capacity to withstand lateral loads due to wind and also because of its durability against weathering actions of nature and attack of termite. Such panels are also lightweight. Therefore an overall benefit in foundation design is possible due to reduce self-weight of the materials. For foundation, conventional RCC of Grade M 25 conforming to IS 456:2000 has been selected with reinforcing steel of Fe 415 Grade conforming to IS 1786. Foundation consists of isolated pad footings with pedestals and tie beams around the building tying the top of pedestals.

5.Design & Engineering : 3D frames for these buildings have been considered as a grid using Square Hollow Section as structural members with all rigid joints (welded). The self-weight of the structural members and cladding panels are considered as Dead Loads. A Live Load of 75 kg/m² on the roof has been considered because these roofs are of the category of inaccessible roof conforming to the stipulation of IS 875 (Part 2). The structural frames have been analyzed and designed by STAADProV8i software package. For loadings due to Earthquake the loads have been generated by the computer program itself for an earthquake loading as per Zone V and for Wind, equivalent static loads had been calculated separately and given as input for a wind intensity of 370 kg/m² up to 10 m height i.e. the coastal wind in India. Any additional cost due to protection against corrosion of steel members and fire protection have not been considered because it is assumed that corrosion will be protected by intermittent standard enamel painting and maintenance and in case of fire the dwellers will get sufficient scope to go outside. The aspects of heat insulation and ventilation have been given due consideration because these aspects are directly related to the conservation of human energy. The thickness of Ferro-Cement Panels used in this design being only 15 mm, the insides of the buildings may not be thermally well protected when used in a single layer. But the buildings are designed in such a way that double layer of Ferro-Cement panels could also be provided, one on each side of the

Square Hollow Sections, thereby creating an air gap in between the two cladding panels, which will insulate the total building. Thus, during summer the inside of the building will remain comparatively cool with respect to its outside temperature and during winter, the reverse situation will occur. The buildings have been planned and designed in a way that a healthy environment is created inside through proper ventilation and illumination. In the model house the ferro cement panel was fixed onto the steel members by cross members at the four corners. Thermocol has been placed behind it and sand-cement (1:4) plaster has been laid on it from inside the house having a square net placed on the thermocol. Fixed glass panes at the eave's height have been provided to illuminate the room with sufficient natural light and a skylight, fitted with mosquito net is provided at the overlapping parts of the two sloped roof to provide exhaust of hot air from inside to outside of the room. In case of four sloped roof an aluminum turbo ventilator may be provided at the crown to ensure proper ventilation preventing any ingress of rain water and mosquitoes. The Steel structural grid is earthed. The connections could be detailed in such a way that the Steel sections remain concealed within claddings. Further, insulated electrical wires may be routed through PVC conduits. Hence there is no chance of electrocution out of short circuit and the effect of thunder is minimized.

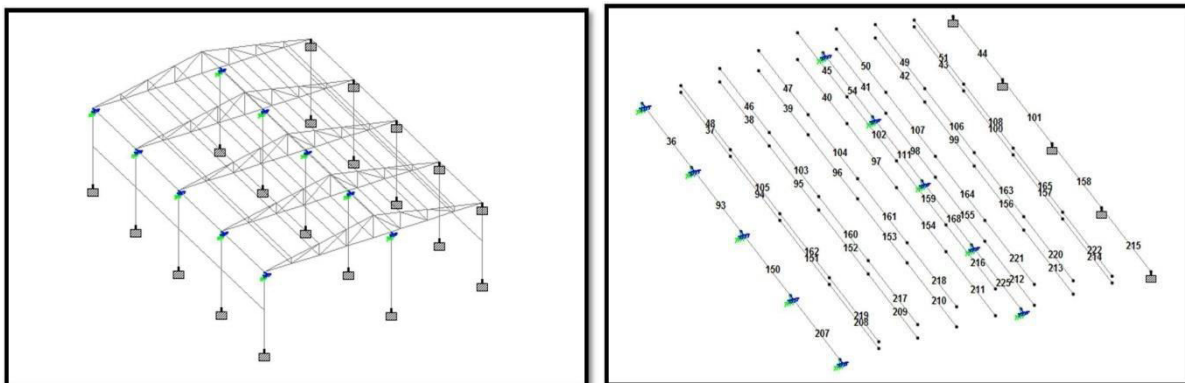
III. MODEL APPLICATION

Staadpro software was used for the design of Steel and RCC building. It can make use of various forms of analysis from the traditional static analysis to more recent analysis method like geometric non linear analysis. STAAD pro is structural analysis and design software application originally developed by research engineering international in 1997. STAAD pro is the abbreviation for structural analysis and design. It is engineering software that is used in construction. It has highly efficient structure analysis and design program developed analysis for multi-storey building system.

IV. RESULT

Overall this specific construction methodology will offer a cost effective , safe and durable solution for dwelling need in all weather conditions. From the above it is conclude that steel structure is more resist as compared to the normal concrete structure. Speed of construction is faster for steel structure over RC structure.

- Design of Steel Structure :



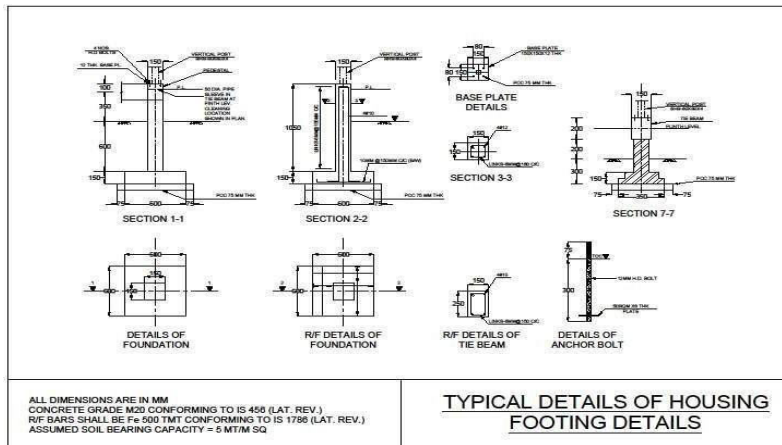
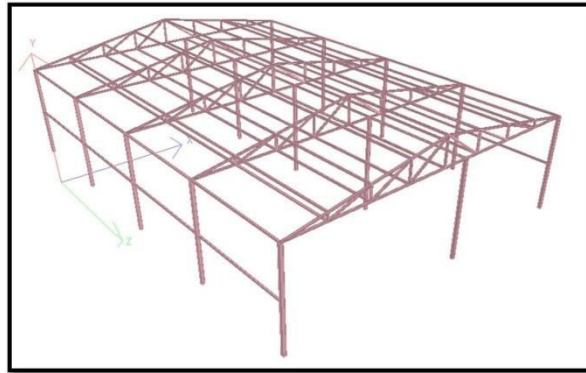


Figure 5 Footing Details

- Design of RC Structure :

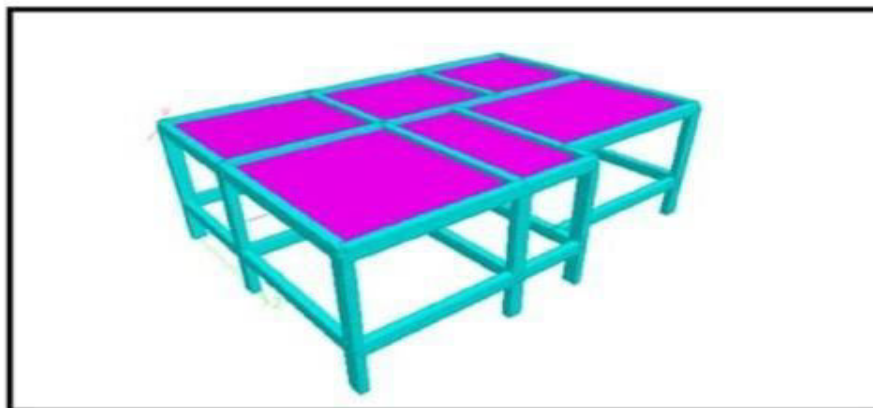


Figure 6 Rendered view of building

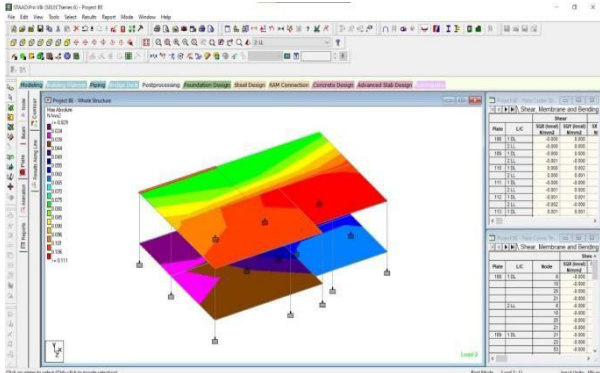


Figure 7 Max abstract value

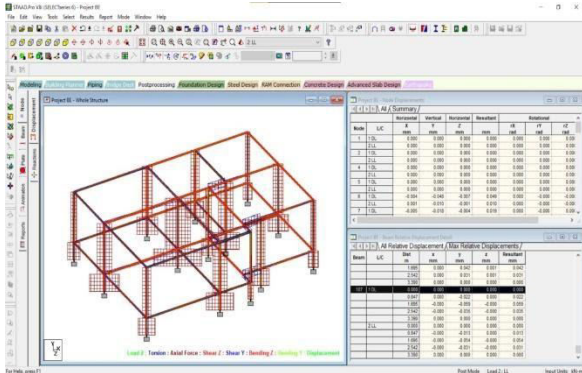


Figure 8 Torsion force in steel

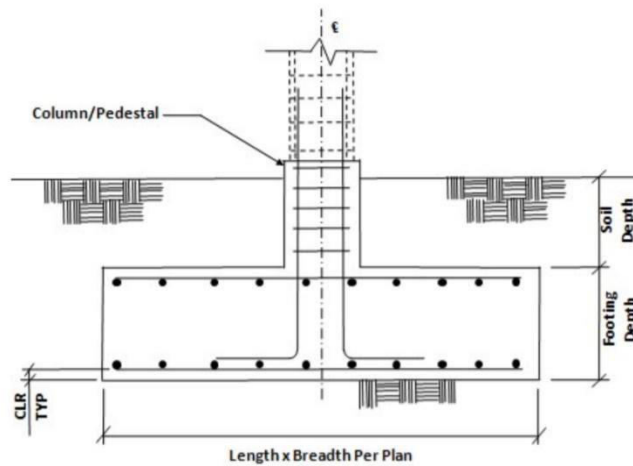


Figure 9 Footing Details

V. COST COMPARISON

In terms of costs, structural steel is cheaper than reinforced concrete. Structural steel-work just takes up 20% of steel-work used in construction. The price of construction material has increased and affected concrete more than steel and as per design and Estimate of Steel and RC structure, Steel Intensive Building is More Cost Efficient and Efficient on all other factors than the RC structure.

- Cost of RC Structure = **Rs. 31,89,494.75**
- Cost of Steel Intensive Building for Same Building = **Rs. 15,07,815.925.**

VI. CONCLUSION

In India, the dwelling needs and habits of every state and zones are different. It varies widely depending upon availability of low-cost building materials locally. So we have to think to make a system wherein people can afford to build a house. As the growth rate of villages is much faster in India, these housing units like Unit house under IAY, Health Centre under Anganwadi, Meeting Hall, School Building etc. are required to constructed rapidly. The idea of



steel intensive buildings can be introduced in all villages in India. The options developed by INSDAG for different modules are mainly steel intensive and it is possible to achieve a drastic reduction in construction time. Structural steel has been considered as one of most sustainable green material, which is user-friendly, eco-friendly and recyclable. Use of properly optimized mix with steel and other conventional and modern low cost materials can result in a very good sustainable long-term solution for rural sector. However, knowledge and awareness about the new building technologies and materials like steel has to be disseminated among the people and constructional agencies in rural sector so that they become inclined to this new ecofriendly sustainable steel based construction of their own.

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