Structural Detailing of a Reinforced Concrete Structure Duplex Building

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***Abstract*—** Reinforced Concrete structures are very common in buildings because they are strong last long are affordable and can be made in many different ways. Duplex buildings need to be planned, designed and built to make sure they are safe and will last a long time. If the details are not done correctly it can cause cracks make the Reinforced Concrete structure weak and make it harder for the building to withstand earthquakes.

This study is about the details of a Reinforced Concrete duplex building. We looked at the parts like the floors, beams, columns, footings, stairs and windowsills. We used computer programs like STAAD Pro and ETABS to analyze the structure and make sure it can handle different kinds of loads like weight, wind and earthquakes. We also used AutoCAD to make drawings of the Reinforced Concrete structure. The building was designed to meet the requirements of the Indian Standard codes like IS 875 and IS 1893:2016. The structural design was done using the Limit State Method as per IS 456:2000. We also made sure the Reinforced Concrete structure can withstand earthquakes by following the rules of IS 13920:2016 and SP-34.

The study shows that if we do the analysis, design and detailing correctly and make a plan for the construction we can build a safe, stable, affordable and long-lasting Reinforced Concrete duplex building.

Keywords **—** Reinforced Concrete, Duplex Building, Structural Detailing, STAAD Pro, ETABS, AutoCAD Bar Bending Schedule IS 456:2000 IS 1893:2016 IS 13920:2016.

I. INTRODUCTION

Reinforced Concrete structures are widely used in construction because they are strong last long and are affordable. Reinforced Concrete is a choice for duplex houses, apartments, villas and multistorey buildings. A duplex building has two living units in one system. Such buildings need to be planned designed and built to make sure they are safe, stable and will last a long time. It ensures that the Reinforced Concrete structure is built correctly with the amount of steel and concrete and that the different parts of the building are connected properly. If the details are not done correctly it can cause problems like cracks, uneven floors and weaknesses in the Reinforced Concrete structure. It can also make the building more likely to be damaged by earthquakes. This study is about the analysis, design and structural details of a Reinforced Concrete duplex building using computer programs like STAAD Pro, ETABS and AutoCAD and following the Indian Standard codes.

II. OBJECTIVES OF THE STUDY

The main objectives of this study are:

- To analyze a reinforced concrete duplex building under load conditions.
- To design RCC components using the Limit State Method as per IS 456:2000.
- To prepare reinforcement detailing drawings for slabs, beams, columns and footings.
- To apply ductile detailing provisions as per IS 13920:2016 for improved resistance.

III. LITERATURE REVIEW

Reinforced Concrete is a combination of concrete and steel. The concrete is strong against compression while the steel is strong against tension and helps the building to be flexible.Nano-silica improves compressive, tensile, and flexural strength.

- Previous studies have shown that using computer programs for analysis and design can improve the accuracy and reduce the chances of errors. Programs like STAAD Pro, ETABS, Revit and CYPECAD are useful for modeling, analysis, design and detailing.
- The studies also show that the structural details of a building are very important for its safety and durability. If the details are not done correctly it can cause problems like cracks, weaknesses in the Reinforced Concrete structure and difficulties during construction.

IV. MATERIALS, CODES AND SOFTWARE USED

The study used reinforced concrete construction materials. The structural system was. Detailed using standard software tools and Indian Standard codes.

Table: Software Tools Used in the Study

Software	Purpose	Application
STAAD Pro / ETABS	Structural Analysis and Design	Structural modelling, load calculations, and seismic analysis
AutoCAD	Structural Detailing	Reinforcement detailing and preparation of structural drawings

Table: Indian Standard Codes Used

Code / Standard	Description	Application
IS 456:2000	Plain and Reinforced Concrete Code of Practice	RCC design and detailing
IS 875 (Part 1)	Dead Load Standards	Calculation of dead loads
IS 1893:2016	Criteria for Earthquake Resistant Design of Structures	Seismic load analysis and design

V. METHODOLOGY

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A. Data Collection

We need to collect data about the building like the plan, structural layout, material properties, soil data, loading details and the rules of the Indian Standard codes.

- Architectural plan
- Structural layout
- Material properties
- Soil data
- Codal provisions

We consider the type of concrete and steel to be used, like M20 or M25 concrete and Fe415 or Fe500 steel.

B. Structural Modelling

We make a model of the duplex building using STAAD Pro and ETABS. The model includes the coordinates of the nodes the sections of the beams and columns the thickness of the floors the support conditions and the material properties.

We make sure that the different parts of the building are connected properly to get a behavior of the structure.

C. Load Analysis

The following loads were considered:

- Dead load: self-weight of slabs, beams, columns and walls.
- Live load: occupancy load.
- Seismic load: earthquake forces as per IS 1893:2016.

D. Structural Analysis & Design of RCC Components

The structure was analyzed to obtain bending moments shear forces and axial forces.

- Components were designed using the Limit State Method as per IS 456:2000.

E. Reinforcement Detailing and BBS

Reinforcement detailing drawings were prepared using AutoCAD.

Detailing includes:

- Bar spacing
- Anchorage length
- Development length
- Lap splices
- Concrete cover
- Stirrups
- Reinforcement continuity

Bar Bending Schedule is prepared for quantity estimation and construction execution.

VI. RESULTS AND DISCUSSION

A. Structural Analysis Results

The analysis results showed that the RCC duplex building performed satisfactorily under gravity and lateral loads.

Table: Summary of Structural Analysis Results

Parameter	Result Status	Observation
Dead load performance	Safe	Permanent loads were resisted effectively
Seismic performance	Safe	Structure resisted earthquake load combinations satisfactorily.

B. Design Results of Structural Components

The compressive strength of the concrete increased when we added the nanomaterials. The best mix we found was the combination of nano-silica and nano-titanium dioxide, which made the concrete 20% stronger than the concrete.

Table: Design Results of RCC Components

Component	Design Status	Observation
Slab	Safe	Adequate main and distribution reinforcement provided
Beam	Safe	Flexural and shear requirements satisfied
Column	Safe	Axial load and moment capacity achieved
Chajja	Safe	Proper reinforcement is provided for local load transfer
Beam-Column Joint	Properly Detailed	Ductile detailing improves seismic performance
Overall Design	Satisfactory	A safe and economical RCC design is achieved

C. Reinforcement Detailing Results

Reinforcement detailing is prepared for all structural members.

- Beam detailing includes bars, bottom bars, extra support reinforcement, stirrups, anchorage and development length.
- Column detailing includes bars, lateral ties, lap splice locations and confinement reinforcement.
- Slab detailing includes reinforcement, distribution reinforcement and additional reinforcement near supports.
- Footing detailing includes reinforcement mesh, column starter bars, anchorage, cover and load transfer details.
- Ductile detailing provisions are applied to beams, columns and beam-column joints as per IS 13920:2016.

Table: Reinforcement Detailing Summary

Detailing Parameter	Status	Result
Beam Reinforcement	Completed	Top, bottom and shear reinforcement is provided
Column Reinforcement	Completed	Longitudinal bars and ties are detailed properly
Slab Reinforcement	Completed	Main and distribution bars are arranged clearly
Footing Reinforcement	Completed	Reinforcement mesh and anchorage are provided
Ductile Detailing	Provided	Seismic resistance is improved
Concrete Cover	Maintained	Durability requirements are satisfied
Lap Splice and Anchorage	Proper	Load transfer continuity is maintained
Bar Bending Schedule	Prepared	Quantity estimation and execution are simplified
Construction Feasibility	Good	Reinforcement placement is made easier

D. Discussion

The results show that software-based structural analysis combined with codal design and proper reinforcement detailing provides a reliable approach for RCC duplex building construction.

- STAAD Pro/ETABS helps in evaluation of member forces while AutoCAD-based detailing improves clarity of construction drawings.
- The use of IS 456:2000 ensures safety and serviceability while IS 13920:2016 improves ductility and seismic resistance.
- Proper anchorage length, lap splice arrangement, stirrup spacing and reinforcement continuity are found essential for integrity.
- The preparation of BBS further improves reinforcement management. Reduces the possibility of material wastage at site.
- In general a structure may be analytically safe. Poor reinforcement detailing can reduce its real performance during construction and service life.
- Therefore structural detailing must be treated as a stage in RCC building projects.

VII. CONCLUSIONS

The following conclusions are drawn from the study:

1) The reinforced concrete duplex building is successfully. Designed using STAAD Pro/ETABS according to relevant Indian Standard provisions.
2) The structure safely resists load, live load, wind load and seismic load combinations.
3) Structural components such as slabs, beams, columns, footings, staircase, lintels. Chajjas satisfy strength and serviceability requirements.
4) Deflection and displacement values remain within limits confirming satisfactory serviceability performance.
5) Ductile detailing as per IS 13920:2016 improves seismic resistance and reduces the risk of brittle failure.
6) Reinforcement detailing drawings prepared using AutoCAD improve construction clarity, bar placement accuracy and site execution quality.
7) Bar Bending Schedule helps in reinforcement quantity estimation, material planning and reduction of wastage.
8) The integration of analysis, codal design, reinforcement detailing and BBS preparation results in a safe economical, durable and practically constructible RCC duplex building.

VIII. FUTURE SCOPE

Future work may include:

- Nonlinear static or dynamic analysis for seismic performance evaluation.
- Soil-structure interaction analysis for foundation design.
- Use of Building Information Modelling for coordination between architectural and structural drawings.
- Application of intelligence and optimization tools for economical member sizing.
- Use of concrete materials and green building concepts.
- Integration of automated reinforcement detailing software for more accurate detailing.
- Time structural health monitoring using sensors for long-term performance assessment.

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