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Analysis and Design of Indoor Stadium using STAAD.Pro and RCDC

Rohit Mandolkar[1], Melagiri Micheal[2], Sunny M Sharma[3] ,Shriram Naik[4], Parasharam Sawant[5]

Undergraduate Students, Department of Civil Engineering, S.G. Balekundri Institute of Technology, Belagavi Karnataka, India[1].

Undergraduate Students, Department of Civil Engineering, S.G. Balekundri Institute of Technology, Belagavi Karnataka, India[2].

Undergraduate Students, Department of Civil Engineering, S.G. Balekundri Institute of Technology, Belagavi Karnataka, India[3]

Undergraduate Students, Department of Civil Engineering, S.G. Balekundri Institute of Technology, Belagavi Karnataka, India[4]

Assistant Professor, Department of Civil Engineering, S.G. Balekundri Institute of Technology, Belagavi Karnataka, India[5].

Abstract: In a major step to develop the multi sports infrastructure in our institute, we have proposed to design a INDOOR STADIUM at S.G.Balekundri Institute of Technology Belagavi. The principle objective of this project is to provide a design of indoor stadium for our institute. The design methods used in STAAD.Pro analysis are Limit State Design conforming to Indian Standard Code of Practice. From model generation, analysis and design to visualization and result verification, STAAD.Pro is the professional's choice. This indoor stadium has a playing court that meets the standards for district level sports events. The total area of stadium is 1577m2. In the total area we have innovated 32m x 46.78 m area as column free, so it gives an unobstructed view of the play court from anywhere in the stadium. All the designs are based as per IS 456-2000 and IS 875 Part I, II & III. The wind load values were generated by STAAD.Pro considering the given wind intensities at different heights and strictly abiding by the specifications of IS 875 part III. Limit state method is adopted for designing various components of the stadium. The stadium consists of free court were indoor games namely basketball, volley ball, badminton and table tennis can be played. All the facilities like refreshment rooms, storage room etc. is also provided in the stadium.

Keywords: Indoor Stadium, Analysis, design, STAAD Pro, RCDC

I.INTRODUCTION

An indoor arena is a fully enclosed stadium or hall with raked seating around a performance area and a fixed roof. The indoor stadium can host sporting events such as a basketball court, badminton, table tennis, boxing, judo, wrestling and weight lifting.

DESIGN OF STRUCTURAL COMPONENTS

Our project involves analysis and design of a Indoor Stadium using very popular designing software STAAD Pro. We have chosen STAAD Pro because of its following advantages:

- User-friendly interface
- Indian Standard Code conformation based software
- The ability to solve any type of problem with versatile
- Margin of error is very rare

The components of the stadium were of steel and concrete. The structural components are analysed and designed by using the software "STAAD.Pro", the designs are based on the "Limit State Method".

In steel design follows the following design checks.

- Slenderness
- Section classification
- Tension
- Compression
- Shear
- Bending
- Combined Interaction Check

In concrete design follows the following design checks.

- Flexure
- Compression
- Shear
- Torsion
- Deflection
- Cracking

LIMIT STATE METHOD

The structure must be built to safely support all loads that could be applied to it during the course of its life using the limit state concept design process. Additionally, it must meet serviceability standards including cracking and deflection limitations. The acceptable limit for the safety and serviceability requirements before he aim of design is to achieve acceptable probabilities that the structure will not become unfit for the use which id intended, i.e., that it will not reach a limit state.

II.STRUCTURAL DESIGN

The systematic study of a structure's stiffness, strength, and stability is refer as structural design. Building a framework that is capable of supporting all applied loads without breaking during its intended life is the main objective of structural analysis and design.

Any structure's design must primarily adhere to five fundamental steps

- Modelling
- Analysis of load
- Analysis of structure
- Design of structure
- Detailing

Software Implemented to perform the analysis

- AUTO CADD
- STAAD PRO
- RCDC

AUTO CAAD: Engineering plans and blueprints are produced in the domains of architecture, construction, and manufacturing using AutoCAD, 2D and 3D computer-aided design tool.

STAAD PRO: STAAD PRO is frequently used for cold-formed steel, concrete, steel, and aluminium in factories, tunnels, bridges, multi-story buildings, and many more applications.

RCDC: RCDC (Reinforced Concrete Design and Detailing) is comprehensive software developed by Bentley Systems for the design, analysis, and detailing of reinforced concrete structures.

OBJECTIVES:

- To analyse and design an Indoor stadium with a large span steel roof truss by avoiding intermediate column.
- To compare the results between STAAD.Pro and Manual calculation.
- To obtain the reinforcement details using RCDC and compare the results with STAAD.Pro.
- The project is to design an indoor stadium with large span without compromising safety. It's has been the prime requirement of structural design and construction that a structure shall be so designed that it will not collapse in any way during its expected life span.

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- To promote popularize, propagate all forms of sports and games in college level.

III.METHODOLOGY

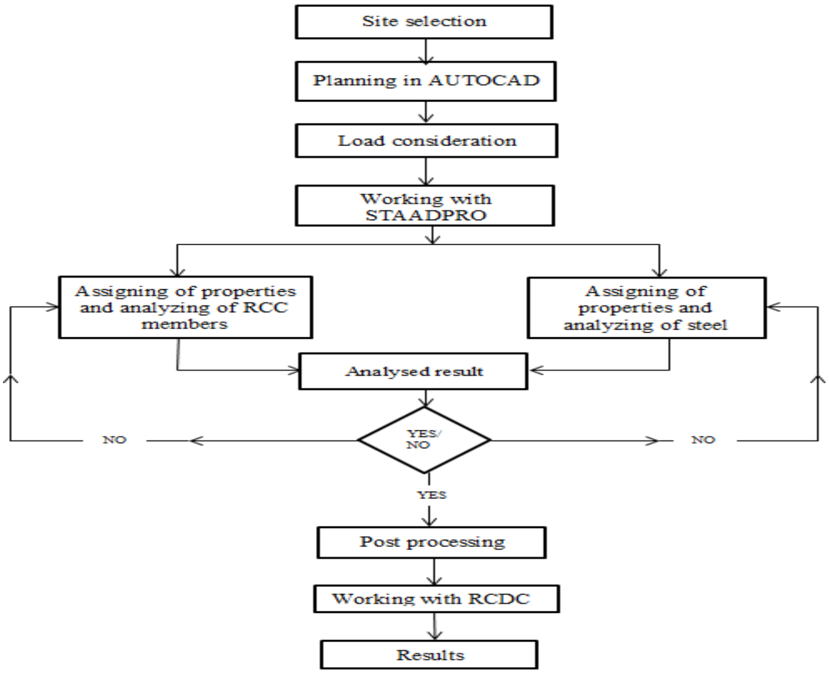

Chart -1: Methodology sequence in form of flow chart

Manual calculation:

Data:
Beam:
Breadth, B = 500 mm
Overall depth, D = 600 mm
Stair:
Breadth, B = 1000 mm
Overall depth, D = 400 mm
Density of concrete =25kN/m3

- Self weight of beam
  = Breadth X Depth X 1 X Density of concrete
  =0.5 X 0.6 X 1 X 25
  D.L =7.5 kN/m

- Self weight of Stair's
  = Breadth X Depth X 1 X Density of concrete
  =1 X 0.40 X 1 X 25
  D.L =10 kN/m

- Total Loads (W)
  = D.L of Beam + D.L of Stair's
  = 7.5 kN/m + 10 kN/m
  W = 17.5 kN/m

- Moment (M)

$$M = \frac{Wl2}{8}$$

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$$M = \frac{17.5 \times 8.12}{8}$$

$$M = 143.52 \text{ kN/m}$$

- Shear force(SF)

$$SF = \frac{Wl}{2}$$

$$SF = \frac{17.5 \times 8.1}{2}$$

$$SF = 70.87 \text{ kN/m}$$

AUTO CADD PLAN:

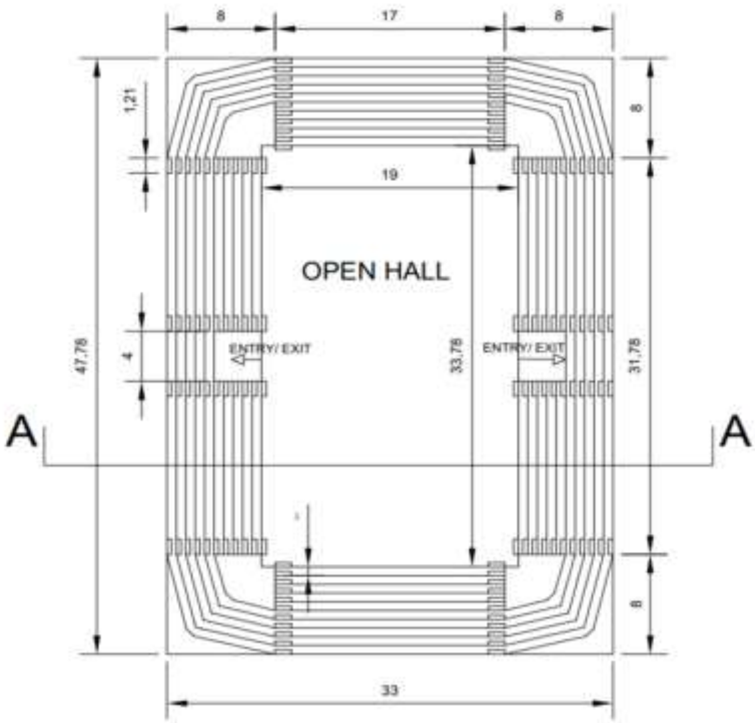

Fig – 1: Mezzanine Floor Plan

STAAD.Pro Results:

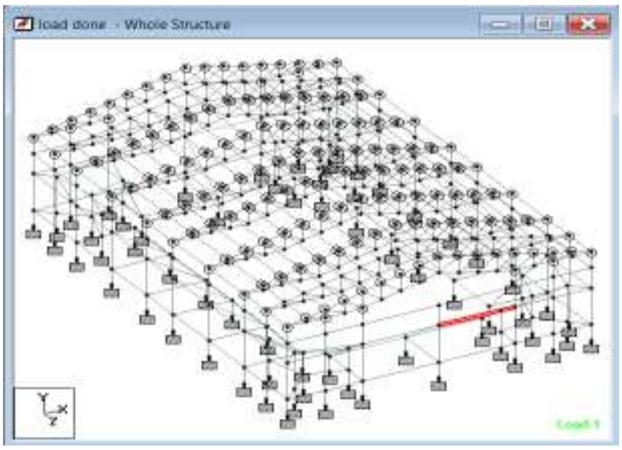

Fig – 2: Geometry of structure

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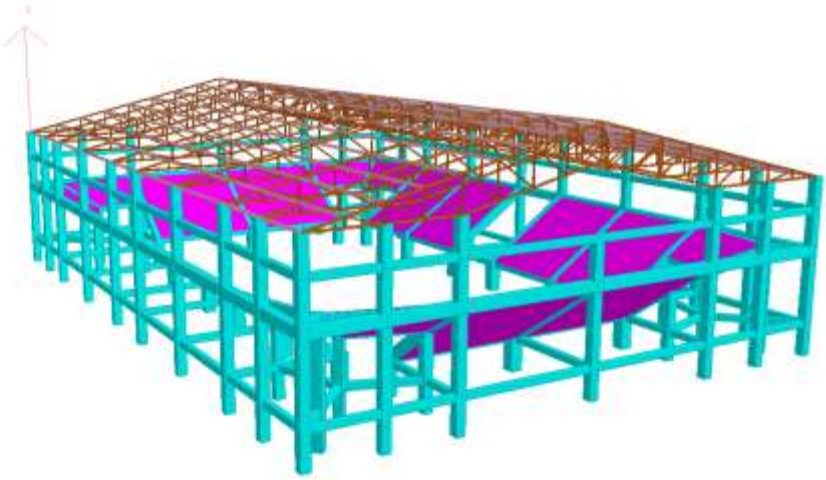

Fig – 3: 3D rendered view

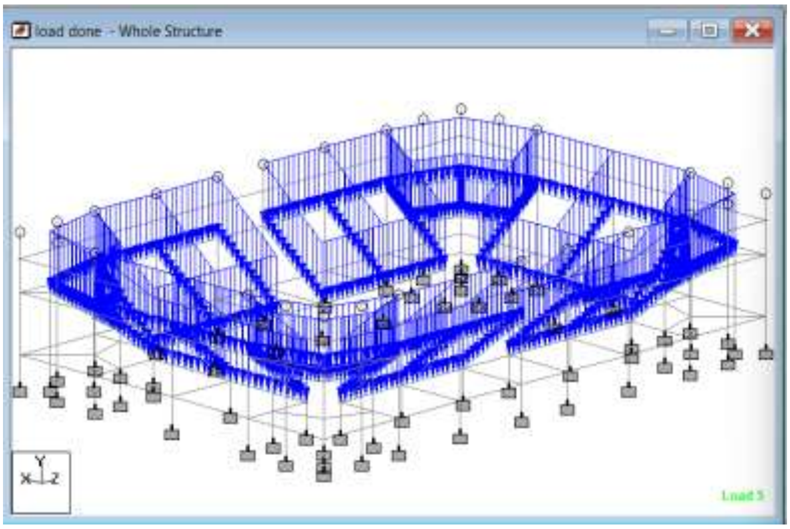

Fig – 4: Structure under live load

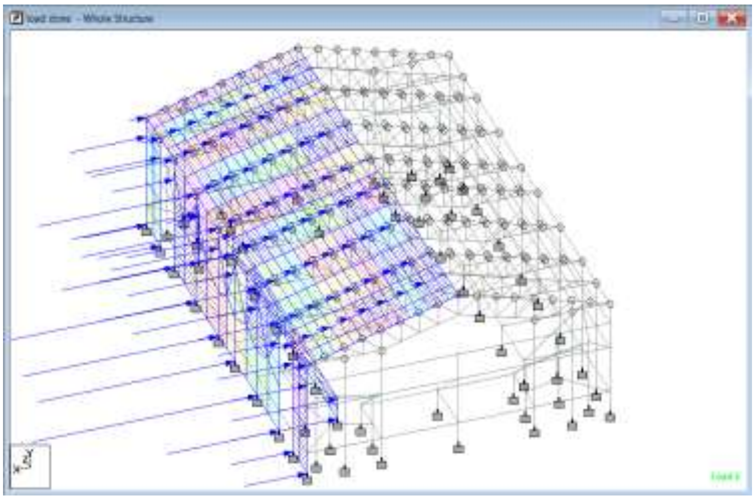

Fig – 5: Structure under wind load in X-direction

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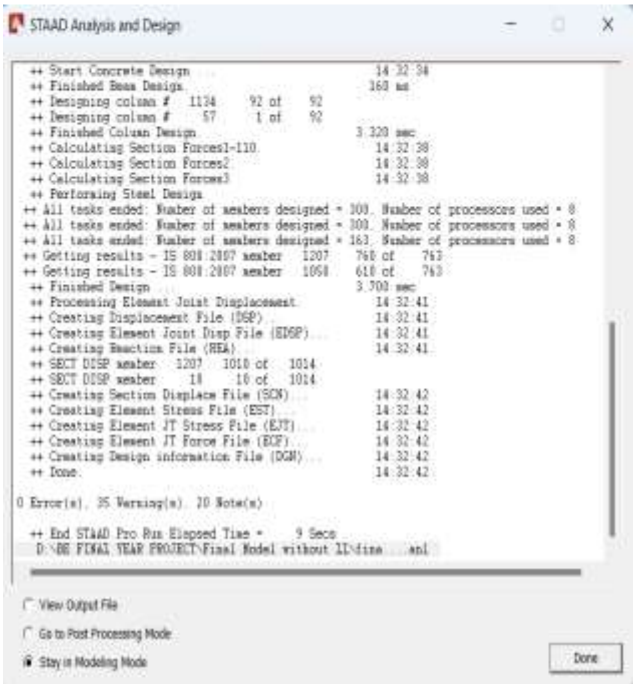

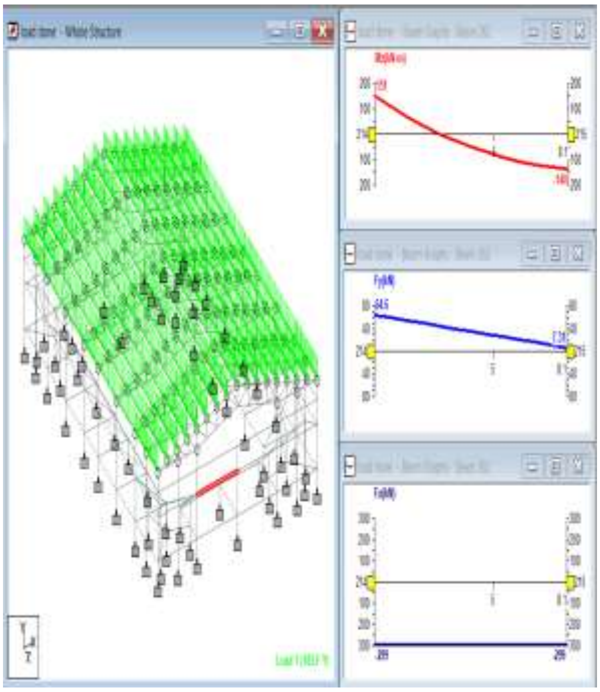

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	2025.0 mm	4050.0 mm	6075.0 mm	8100.0 mm
TOP REINF.	4-20d 1 layer(s)	4-20d 1 layer(s)	4-20d 1 layer(s)	4-20d 1 layer(s)	6-20d 1 layer(s)
BOTTOM REINF.	6-20d 1 layer(s)	5-20d 1 layer(s)	4-20d 1 layer(s)	4-20d 1 layer(s)	4-20d 1 layer(s)
SHEAR REINF.	2 legged 8d @ 180 mm c/c	2 legged 8d @ 95 mm c/c	2 legged 8d @ 90 mm c/c	2 legged 8d @ 85 mm c/c	2 legged 8d @ 180 mm c/c

IS-456 LIMIT STATE DESIGN
BEAM NO. 261 DESIGN RESULTS

M30 Fe500 (Main) Fe415 (Sec.)

LENGTH: 8100.0 mm SIZE: 500.0 mm X 600.0 mm COVER: 30.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	2025.0 mm	4050.0 mm	6075.0 mm	8100.0 mm
TOP REINF.	476.00 (Sq. mm)	476.00 (Sq. mm)	476.00 (Sq. mm)	777.41 (Sq. mm)	1826.87 (Sq. mm)
BOTTOM REINF.	1846.65 (Sq. mm)	1411.63 (Sq. mm)	802.11 (Sq. mm)	476.00 (Sq. mm)	476.00 (Sq. mm)

Fig – 6: Analyzed window Fig –7: Shear force and bending moment graph

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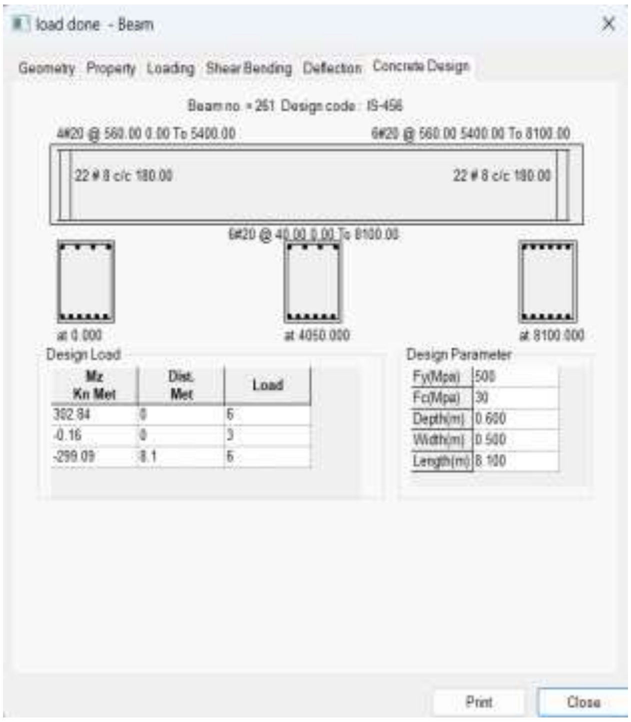
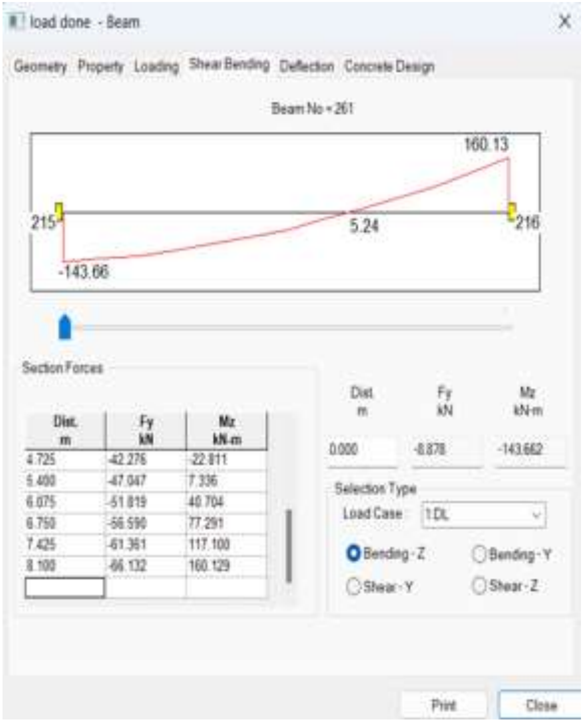
Beam Results:



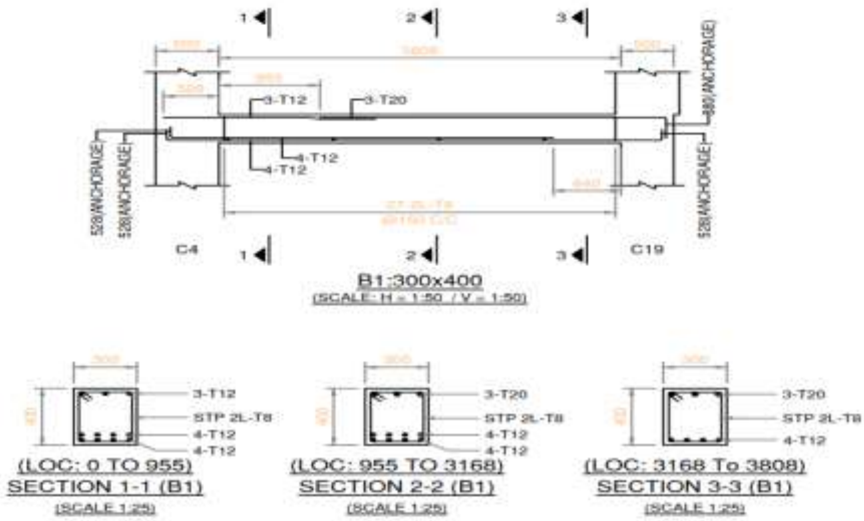


Comparing beam results between STAAD. Pro and manual (Beam no: 261)

Description	STAAD.Pro	Manual
Moment	143.66 kN/m	143.52 kN/m
Shear Force	66.13 kN/m	70.87 kN/m

The bending moment value obtain from STAAD.Pro and Manual are 143.66kN/m and 143.52kN/m respectively. The calculated manual value of beam is closer to STAAD.Pro value. Similarly, the shear force value obtain from STAAD.Pro and Manual are 66.13kN/m and 70.87kN/m whereas manual value is also closer to STAAD.Pro values.

RCDC Results:



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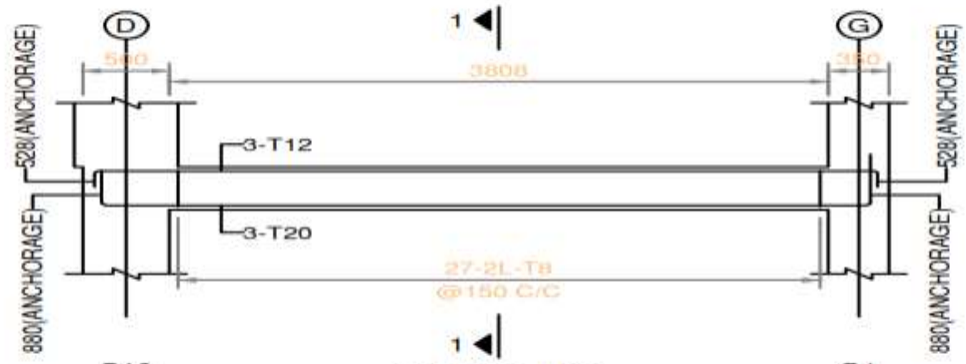
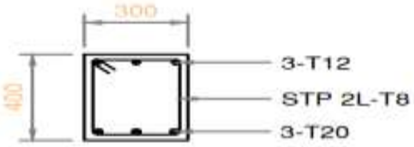


B3:300x400
(SCALE: H = 1:50 / V = 1:50)



B3
(SCALE 1:25)

Beam	Size (mm)	Bottom Left	Bottom Mid	Bottom Right	Top Left	Top Mid	Top Right	Shear Left	Shear Mid	Shear Right
B1	300 x 400	4-T12 4-T12	4-T12 4-T12	4-T12	3-T12	3-T20	3-T20	2L-T8 @ 155	2L-T8 @ 155	2L-T8 @ 155
B2	300 x 400	4-T12	4-T12 4-T12	4-T12 4-T12	3-T20	3-T20	3-T12	2L-T8 @ 155	2L-T8 @ 155	2L-T8 @ 155
B3	300 x 400	3-T20	3-T20	3-T20	3-T10	3-T10	3-T10	2L-T8 @ 155	2L-T8 @ 155	2L-T8 @ 155
B4	300 x 400	3-T20	3-T20	3-T20	3-T10	3-T10	3-T10	2L-T8 @ 155	2L-T8 @ 155	2L-T8 @ 155
B5	300 x 400	3-T20	3-T20	3-T20	3-T10	3-T10	3-T10	2L-T8 @ 155	2L-T8 @ 155	2L-T8 @ 155
B6	300 x 400	3-T20	3-T20	3-T20	3-T10	3-T10	3-T10	2L-T8 @ 155	2L-T8 @ 155	2L-T8 @ 155
B7	300 x 400	3-T20	3-T20	3-T20	3-T10	3-T10	3-T10	2L-T8 @ 155	2L-T8 @ 155	2L-T8 @ 155
B8	300 x 400	3-T20	3-T20	3-T20	3-T10	3-T10	3-T10	2L-T8 @ 155	2L-T8 @ 155	2L-T8 @ 155

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Comparing reinforcement results of STAAD.Pro and RCDC (Beam no: 261)

Description	**STAAD.Pro**	**RCDC**
Bottom reinforcement	**#6 Ø20mm**	**#4 Ø25mm**
Area of steel	**1884.92mm^2**	**1963.49mm^2**

The area of steel obtain from STAAD.Pro and RCDC are 1884.92mm2 and 1963.49mm2 respectively, whereas the value obtained from RCDC Software is higher than Staad.pro Software

CONCLUSION

• The planning was done effectively within the available space.
• The designing has been done based on reference of IS code 456:2000, IS 875 part I, II & III.
• The structure analyzed using staad.pro software and is checked for safety. The structure is redesigned until the safety of the building is attained.
• Various load combinations as per IS code were used, considering wind load as the major apart from other loads. The structure is stable under various load combinations.
• The design of Beam, Columns are done in Limit State Method which is safe at control of deflection and in all aspects.
• Indoor stadium will increase the revenue for the college.
• By designing a sports complex for S G Balekundri Institute of Engineering. It will help in overall development of the college.

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