PARAMERIC STUDIES ON CONFIGURATION OF POWER HOUSE BUILDINGS FOR COAL BASED SUPERCRITICAL UNITS

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PARAMERIC STUDIES ON CONFIGURATION OF POWER HOUSE BUILDINGS FOR COAL BASED SUPERCRITICAL UNITS

Major Project

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ABSTRACT

Enormous amount of energy is stored in the natural resources. Power Plant is an assembly which converts the stored energy in to mechanical and electrical energy. Power Plants of greater Power Generation Capacity are being constructed due to increasing energy demand. Design and Construction of power Plant involves huge cost.

Turbine Building is one of the biggest structures of Power Plant. General Layout of the Turbine Building is similar for different projects and minor changes are made in the dimensions based on the Power generation capacity of the Plant. As large quantity of steel is consumed in this structure, if small part of it can be saved, it turns out to be quite beneficial.

This report includes introduction of Main Power House Building in Power plant with comparison of the dimensions of the building used in different projects. Moreover, structural modeling of Turbine Building is done with the details of NTPC – BARH 3X660 MW project. Site Specific Response Spectrum is used for seismic analysis of the structure. Analysis of the Building is done for Vertical and Lateral loads acting on the Building.

Analysis and design of the building is carried out in STAADPro. Design parameters are entered manually in the software to carry out design. Section sizes are revised based on the interaction ratio of the member and deflection limits. Template for design of members subjected to Axial compression and Bending as per IS 800:2007 is developed.

Moreover, an attempt has been made to study the behavior of Turbine Building under different environmental conditions. Design for different wind and a seismic condition is carried out.

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ABBREVIATION NOTATION AND NOMENCLATURE

MW	Mega Watt
Z	Zone factor
I	Importance Factor
R	Response Reduction Factor
Sa/g	Average Response acceleration co-efficient
Cpe	External pressure co-efficient
Cpi	Internal pressure co-efficient
MTO	Material take off
N’	Unfactored Axial Load
N	Factored Applied axial load
N_d	Design Strength in Compression
l_{LT}	Non-Dimensional Slenderness ratio
c	Stress Reduction Factor
f_{cd}	Design compressive Stress
β_{MLT}	Equivalent uniform moment factor

1. INTRODUCTION

1.1 GENERAL

Power plant is an assembly of equipments that produces and delivers mechanical and electrical energy.

There are various types of energy resources available in the nature like coal and different petroleum products, wind, hydropower etc. Enormous amount of energy is stored in these resources. Energy in different form and of different scale is required in all sectors of life which is required is in the form of either Mechanical or Electrical energy. This conversion of energy from some other form to electrical energy is done with the help of Power Plant. Typical process diagram of Coal Based Power Plant is shown in Fig. 1.1.

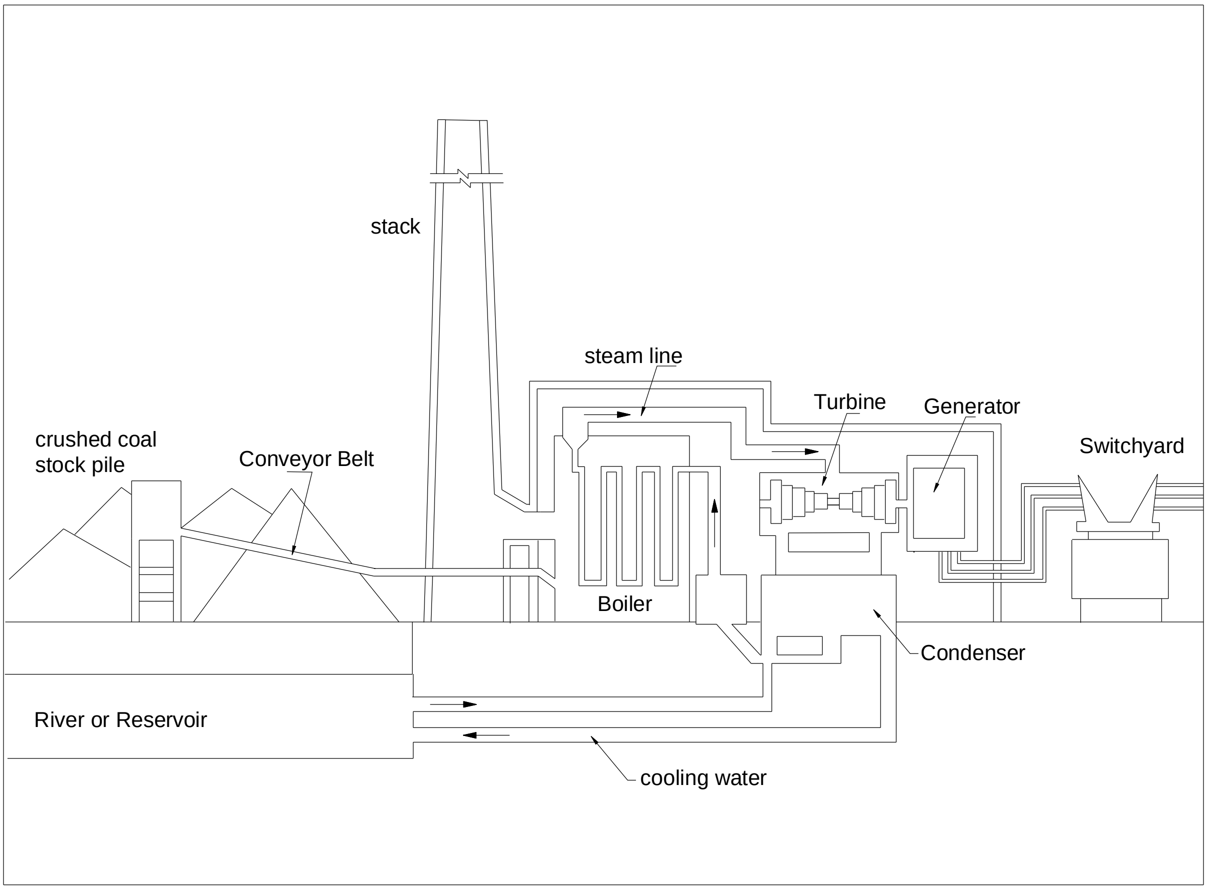

Fig. 1.1 Typical Process of Power Plant

There are some basic differences between Coal Base Plant and other types of Power Plant. In the Coal Based Plant, larger plant area is required; a lot of space is required for coal storage and handling. Precipitator and some other mechanism is used for handling and control of ash in the case of Coal Based Plant, which is not required in other types. Moreover, taller chimneys are required in Coal Based Plants.

As it is shown in Fig. 1.1, Crushed coal is stacked in separate area, which is called Crushed Coal Stock Pile. Coal is transported with the help of Conveyor Belt and Wagon Trippler mechanism to the Boiler. Boiler heats the water at very high temperature and converts it into steam. Steam of very high temperature and pressure is used to rotate the Turbine. Turbine shaft rotates the Generator, which converts Mechanical energy into Electrical energy, which is further stored in the Switchyard.

The steam used for rotation of Turbine further goes to Condenser where it is converted in to water for reuse which is called "Simple" Process. Sometimes a part of steam is again taken to the Boiler in place of Condenser, where it is heated with water, which is called "Reheat" type of process. Water from Condenser is taken to the Cooling Tower where the hot water is converted to cold water.

Different energy resources are use to convert Water in to Steam in the above mentioned process. There are different factors like availability, cost-effectiveness, environmental considerations etc. which governs the type of source used.

1.2 POWER HOUSE BUILDING

Power House Building is also called Turbine Building or TG Building or Main Plant Building. It houses the Turbine- Generator and other auxiliary equipment. It is an enclosed Steel Structure, generally consists of a Turbine Bay and an Electrical / Control Bay.

Turbine bay typically consists of the mezzanine and operating floors. The Steam Turbine-Generator is kept inside the Turbine Building at Operating Floor Level. Though it is kept inside the Building it is placed on a separate platform which is supported on Turbine Generator Foundation. The dynamic load of Turbine Generator is not transferred to any of the structural components of Turbine Building as the platform supporting the generator is detached from the Building.

In addition to the Main columns, floors of Turbine Bay are supported on Auxiliary columns in the intermediate area. Starting from Ground Level, Auxiliary columns goes up to Operating Floor level, but above that level large column free area between main columns exists. To cover this large column free area, convenient configuration of Truss is used.

Electrical / control Bay is of smaller width which has more no. of storey at different levels. The Bay consists of Electrical Switchgear room, Control room, Cable vault room and other floor levels for Deareator, AHU, Tanks (like surge tank, Auxiliary cooling water(ACW) tank, etc.)

In most cases, the Turbine Bay is bigger than the Electrical/Control bay. The roof over the turbine bay is generally RCC floor slab placed over metal deck or pre-cast concrete slabs. The building usually has metal cladding. However, in many plants, wall cladding is also provided in the control bay. There may be transformer yard near to the building; some of the portion of building shall be provided fire walls for resisting fire.

The general arrangement of Power House Building Structure is based on the Mechanical Plant arrangement or General Arrangement drawing. Inside the Power House building, there are various equipments located at different floor levels, piping, cable tray, HVAC ducts etc. Power House structure is to be designed for the appropriate gravity loads, pipe loads, cable tray loads, equipment loads, crane loads, wind loads, seismic loads, temperature loads and any other loads, under operating condition, construction condition, test condition, extreme environmental condition and abnormal load conditions.

The general arrangement of Power House Building including location of main and auxiliary columns, floor elevations like operating floor, mezzanine floor, control room, cable vault rooms, roof level, span of turbine bay & control bay, etc are normally decided by Mechanical, Piping and Electrical engineers.

Typically, structural arrangement of Power House Building may be of two types:

1) Braced frame both in longitudinal direction as well as transverse direction. In such cases, Bracing is provided in both principal directions. Moreover, floor level plan bracings shall be used to transfer the lateral loads to the appropriate braced bays.

2) Braced in longitudinal direction and with moment connection in the transverse direction

An overhead crane (EOT) is located above the operating floor level in the Turbine bay, which is used for erection/maintenance of turbine-generator components and other equipment. Crane is supported on the main columns of Turbine Bay. Larger depth of column is required below the crane level which reduces above due to less load of Truss.

Different types of Equipments are kept at various levels of the Building. Boiler feed Pump, Condenser extraction pump, condenser vacuum pump are kept at ground floor. In addition to above, Flash tanks, Generator transformer, Unit transformer etc. are also kept at ground floor. On Mezzanine floor, equipments like low pressure heater, oil cooler and strainer, jacking oil pump etc. are kept. Operating floor generally supports low pressure and high pressure heaters. Deaerator is also equipment having major load, which is kept at higher level in BC Bay.

1.3 OBJECTIVE OF STUDY

Turbine Building is an enclosed Steel Structure. It is one of the biggest structures of Power Plant enclosing the Turbine, Generator and other auxiliary equipments. Based on the study of drawings carried out for different projects, it is found that the general layout of Turbine Building remains same. However, variation in the dimensions, structural sizes and loading are based on the rating of Power Plant.

In the following study, detailed analysis and design of Power House Building is carried out in STAADPro software. Subsequently parametric study is done for different environmental conditions.

Initially, structural modeling of Turbine Building is done using STAADPro. Geometry, structural sizes and loading data are taken from the NTPC- Barh Project details. Analysis of the Building is carried out under the effect of various gravity loads like dead load, live load, cable tray load, equipment load etc. as well as lateral loads like wind and seismic loads is applied. Site specific response spectra are used for the seismic loading. An attempt has been made to optimize the sizes of the structural members for above structure in present study.

Parametric study is carried out for different environmental loading on the Building. Wind and seismic loads are changed for the above mentioned model. an attempt has been made to study the structural behavior of the building under different environmental conditions, keeping geometry and other loading conditions same as original model.

Structural design for all the above configurations is done using STAADPro software. Moreover, Excel spreadsheet is prepared for design of member subjected to axial compression and bending using IS 800:2007.

1.4 SCOPE OF WORK

Following Scope of work has been decided for major project:

- Literature Survey (Generation of loads / member design/code of practices)
- Analysis of power house building using STAADPro.
- Development of design tools & Design of elements of Power House Building.
- Impact of IS 800:2007 Limit State Method for design of steel structure
- Generation of structural database

1.5 ORGANIZATION OF MAJOR PROJECT

Introduction chapter describes typical process of power plant with overview of Main Power House Building. Further, objective of present study and scope of the work are presented in this chapter.

Chapter-2 includes the literature available and study done regarding the Bracings used in the Steel Structures. It also focuses on the design of structural members by LSM.

Basic guidelines required for structural arrangement of Turbine Building is given in Chapter-3. It discusses regarding different types of members used in the structure, its location, cross-section type used and its approximate size as well. Later dimensions of Turbine Building for different project are tabulated to have general idea of the configuration.

Next chapter, i.e. Chapter-4 gives details regarding structural modeling of the Power House Building. Dimensions of structural members are tabulated here. Details of Boundary conditions and end releases applied in different members are also included. Moreover, load calculations and combinations of loads used for analysis are also mentioned.

Chapter-5 includes Analysis and design results of the building. It discusses the results of analysis for longitudinal and transverse frame of the building. Analysis results for members provided in NTPC – Barh 3 X 660 MW project and revised member sizes are compared here.

Chapter-6 includes results of the parametric study carried out in the project. It compares the interaction ratio for different environmental conditions. Parametric study is carried out for different wind speed and different seismic loading.

Chapter-7 summarizes the whole content and gives idea regarding the future scope of the work.

2. LITERATURE SURVEY

2.1 GENERAL

This section includes, brief review of various Books, papers, journals is made for understanding Basic concepts of Power Plant and design aspects of Steel Structures.

2.2 STRUCTURAL SYSTEM OF POWER HOUSE BUILDING

Blackhall H. D. et al [1] of British Electricity International, London provides wealth of information regarding Power Plants. It covers different aspects of the various engineering streams related to Power Plant. It discusses various aspects right from the site selection for the Power Plant to the final commissioning and working of the plant. Among the 12 volumes, Volume A- Station Planning and design discusses various Power Plant related civil engineering aspects. Vol A provides information regarding geotechnical investigations, types of foundation, loading, Design Overview etc. it also gives cross-sections of Turbine Building for different plants constructed overseas.

Lawrence C. S. et al [2] of Black and Vaetch describe the basic concept of working of power plants and the working of different components of process plant and planning of power plants. The book explains the different mechanical processes which takes part in the power plants and also highlights the general requirements for structure layout. It covers the most common fundamentals of power plant engineering, maintenance and operational considerations. It also provides theoretical background of the various processes which occur in a power plant.

G. D. Rai [3] provides wealth of information regarding concepts, theories and procedures of power plant engineering and fuel handling systems and usage of various types of fuels in power plants. it focuses on classification and types of power plants.

Guha Arijit & Bandhopadhyay T. K. [6] described the procedure involved in design of structural members like tension, compression & Flexural members. Typical problems have been solved using WSM based on IS 800:1984 & LSM based on IS 800:2007. Design capacities of structural components for different sections are given in graph & table format. LSM is more economical for tension & flexure members where as WSM gives more economy in compression members.

Professionals of L & T ECC, Chennai [8] presented information regarding long span roofing used in various projects. It provides information regarding steel dome constructed as roof over stone storage sheds at 3 different locations, dia varies from 91 to 103m. it describes steel as ideal material in EQ prone areas due to its high strength, stiffness, ductility & uniform quality. It also provides arrangement of roofing for 49m span gypsum roofing yard constructed at Jayantipuram.

Dr A Saha Chaudhary & Dr. T K Bandopadhyay [7] show the efficiency of Eccentric Bracing Frames (EBF) in steel structures over Concentric Bracing Frames and Moment resisting Frames in Steel Structures. The IS 1893:2002 gives Response Reduction Factor value as 5 for EBF system and 4 for MRF. This reduces the seismic force on the building with EBF system. EBF provides more reserve strength for safety against collapse which is likely to stand even during major Earthquake.

2.3 SUMMARY

In this chapter, review of relevant literature is carried out. In this literature, overall functioning and classification of power plant is presented. Structural system of Power House Building used in different projects is shown. Contents presented are useful to carry out design of structural members by LSM.

3. STRUCTURAL ARRANGEMENT OF TURBINE BUILDING

3.1 GENERAL

General Layout for Turbine Building remains same for different projects, and dimensions are changed based on the rating of the Plant. In this chapter, general layout, dimension and structural details of NTPC-BARH 3X660 MW project are presented.

In Fig. 3.1, Turbine Bay is shown as AB Bay and Electrical/ Control Bay is shown as BC Bay. Structure is supported on Main Columns along Grid A, B and C. In addition to the Main columns, floors of Turbine Bay are supported on Auxiliary columns in the intermediate area which is arranged along the intermediate grids Aa, Ab, Ac and Ad. Width of AB and BC Bay is 36.0m and 12.0m respectively. Plan dimensions of Turbine Building are 129.0m long and 48.0m wide.

Turbine bay typically consists of the ground, mezzanine and operating floors. Mezzanine and Operating Floors are at an elevation of +8.5m and +17.0m level respectively; which can be seen in the Fig. 3.2. Roof level of Turbine Bay is at +38.0m level. Large opening is provided in AB bay, where platform is constructed for Steam Turbine and generator. Load of the platform is transferred on steam turbine and generator foundation which is isolated form the main building.

Electrical / control Bay is of smaller width which has 6 storey at different levels. The Bay consists of Heater Area, HP Heater Area, space for Cable Spreader and PRDS Station Area.

Auxiliary columns in AB bay goes up to operating floor level of the building. Large column free area of Turbine Bay above operating floor level is covered by convenient configuration of truss. Cast-in-situ RCC slab is used at intermediate floor levels, whereas roof is covered by slab on metal deck system.

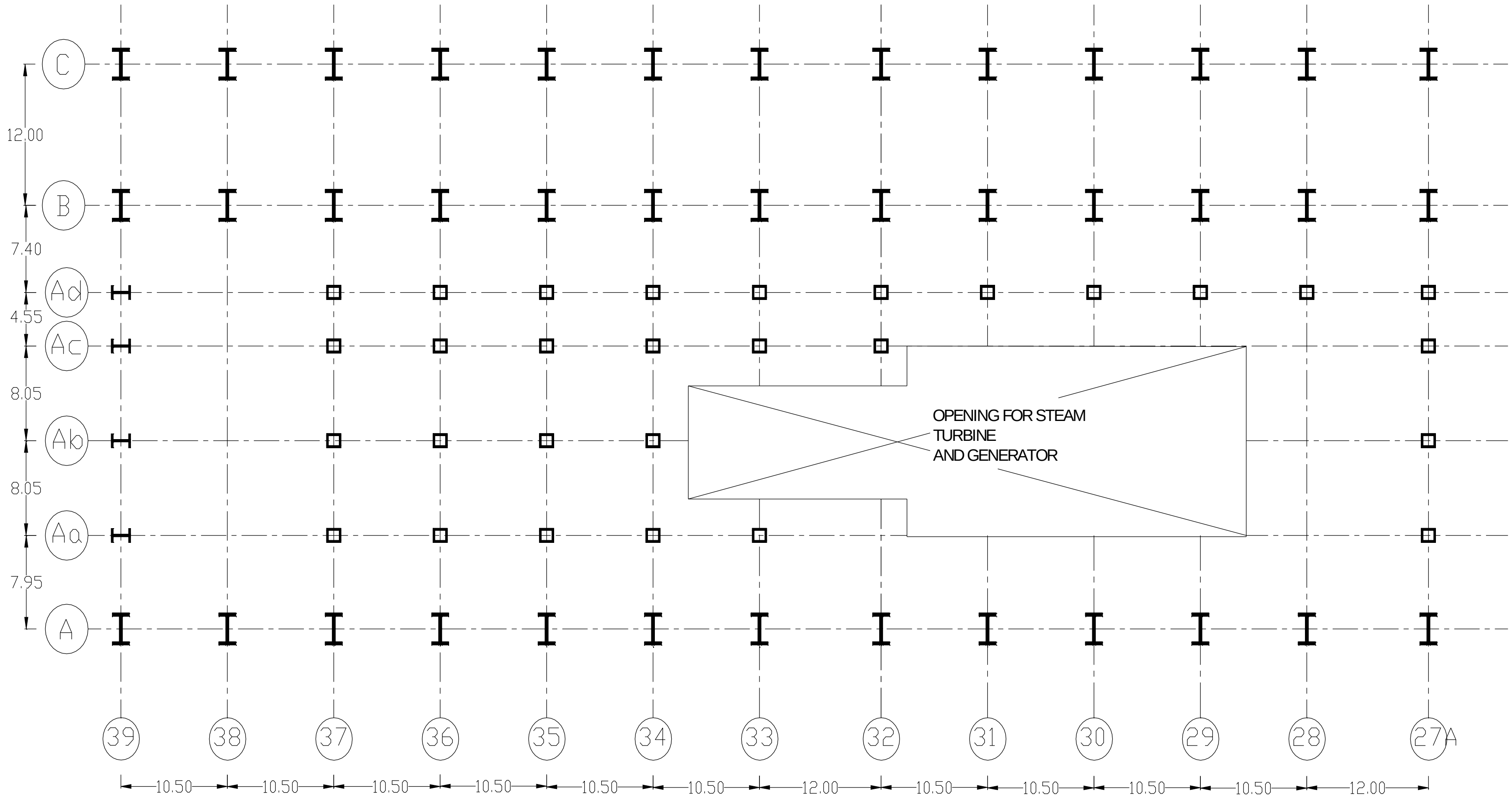

Fig. 3.1 Plan at ground level

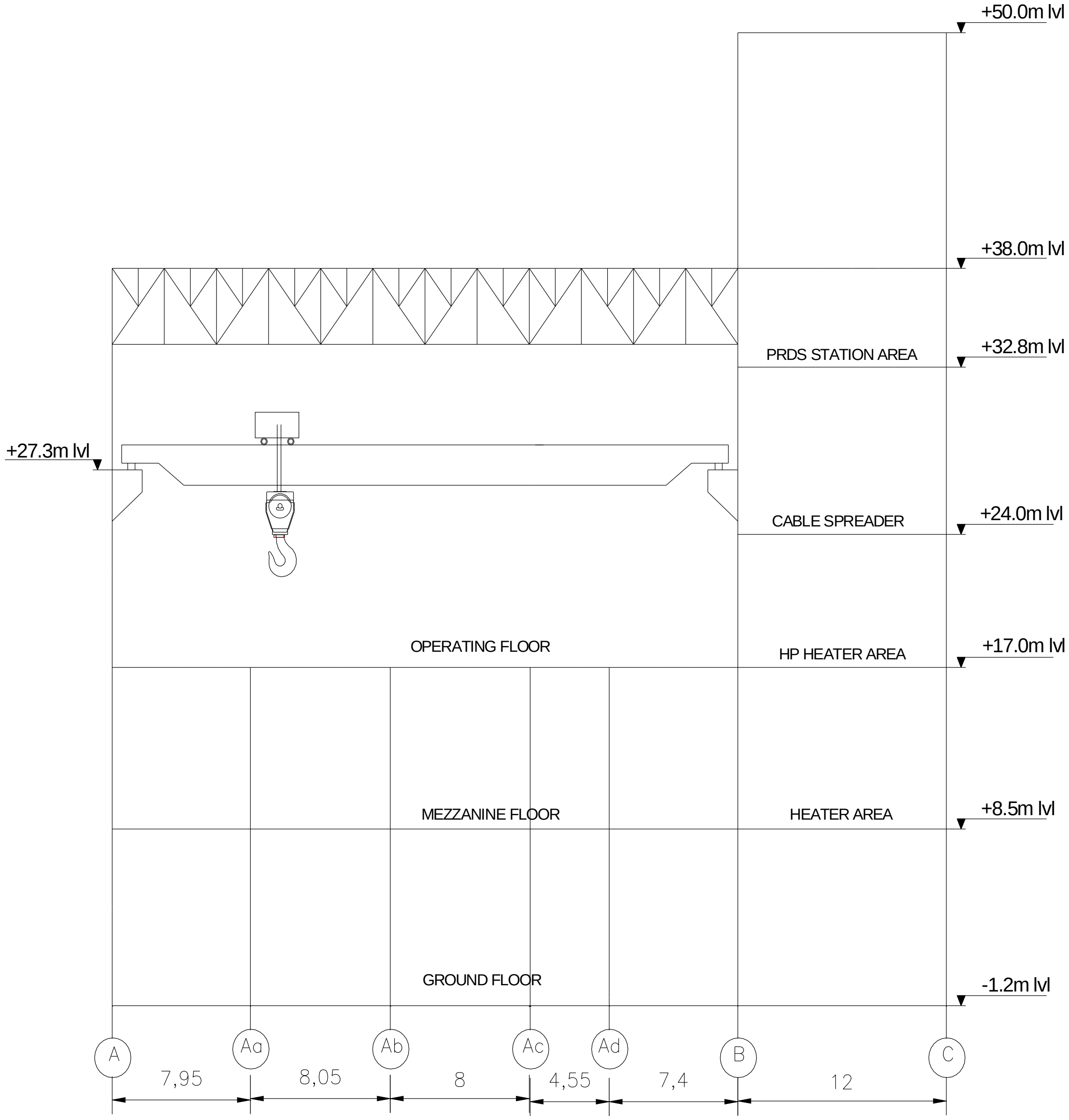

Fig. 3.2 Cross section

3.2 COLUMN

Main Columns are of heavy Built up sections made up of steel plates, Typical section is shown in Fig. 3.3. Column's strong axis is oriented along Transverse axis of the Building, the direction in which Moment-Resisting connections are used. The I-section has depth up to 1.9m.

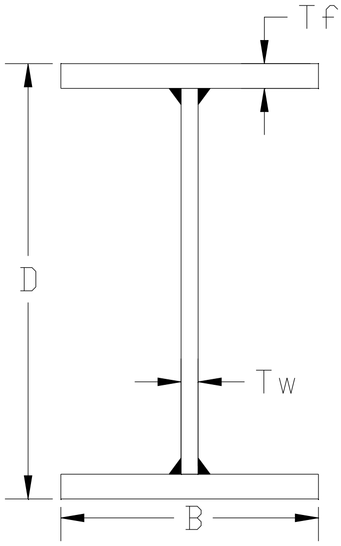

Fig. 3.3 Typical Built Up section for Column and Beam

Main columns are large sections below crane level, called Crane Columns and above crane level, the column size is reduced as it supports roof only.

Auxiliary columns are provided along Intermediate grids between AB Bay. Lighter Box sections are used as Auxiliary columns. It is founded at ground level which reaches up to Operating floor level, above which there is a large column free space in AB Bay. Auxiliary columns are not provided in BC Bay.

3.3 BEAM

Main Beams are generally Built up **I**-sections of depth up to around 1.4m. it transfers the load from secondary beam to Main and Auxiliary columns.

Secondary beams are supported on Main Beams, which are placed at a distance of around 1.5 to 2.0m. The orientation and spacing of Secondary Beams is not uniform, as many obstructions are created due to the cut outs in floor. Secondary beams are either of Built up sections or ISMB sections are used.

3.4 BRACING

Plan Bracings are provided at top and Bottom chord level of the truss, which is shown in Fig. 3.5 and 3.6 respectively. Angle sections are used as Bracing members. Bracings are also provided at Mezzanine and operating floor levels.

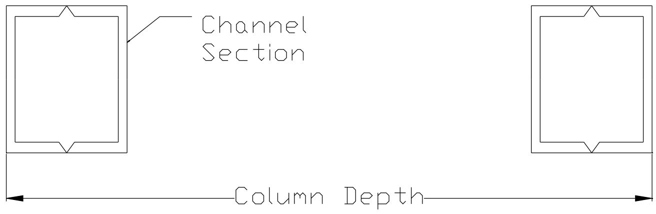

Fig. 3.4 Typical Section for Vertical Bracing

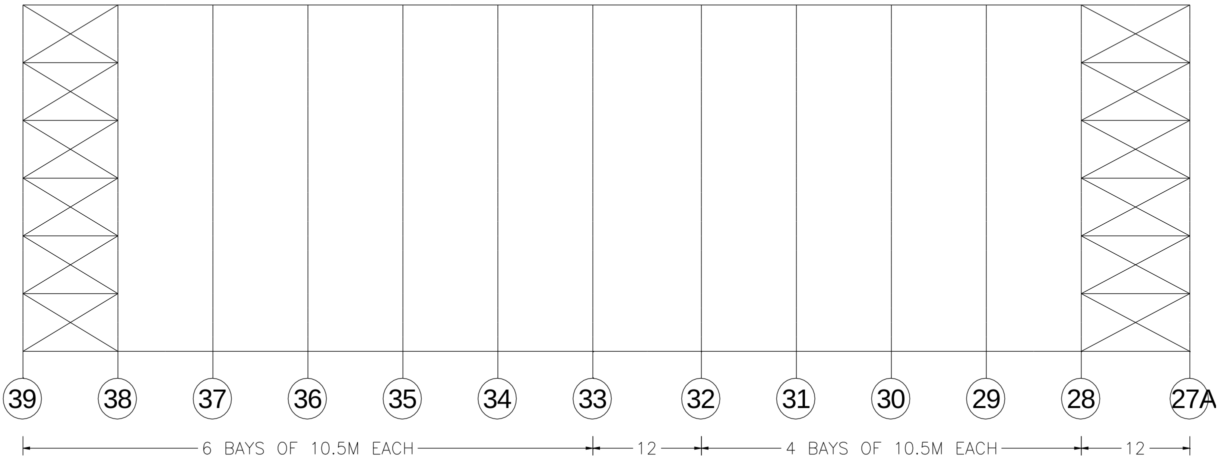

Fig. 3.5 Bracings at Top Chord of Truss

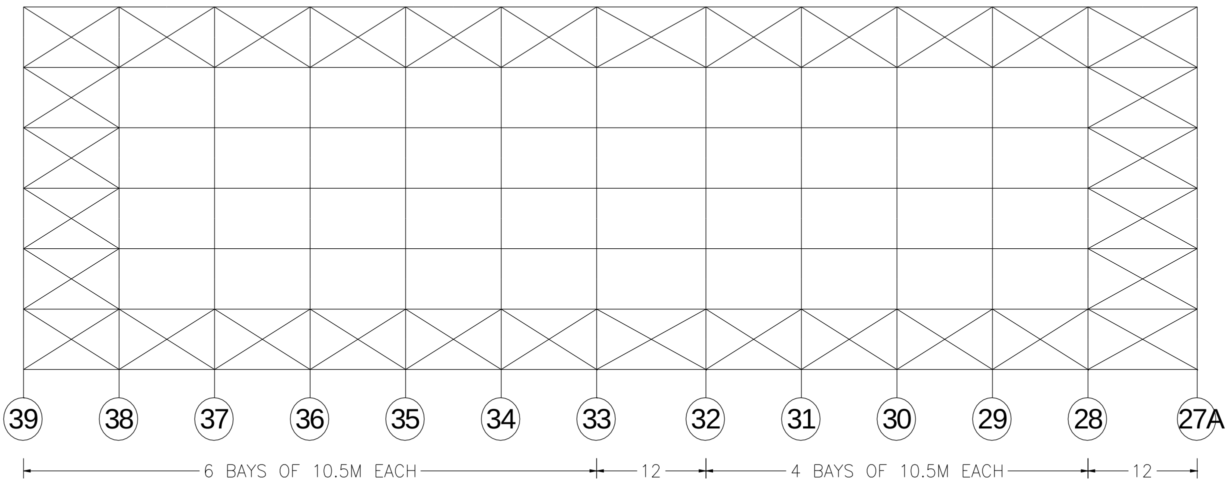

Fig. 3.6 Bracings at Bottom Chord of Truss

Vertical Bracings are provided along main A,B and C Rows of the Building. It is shown in Fig. 3.4. Generally Eccentric type of Bracing used to avoid obstructions in pipeline or Cable Tray Routing. When Vertical Bracings are used, Shear Connections are used in the longitudinal direction and Moment connections in the Transverse direction. Angle of Bracing with the Horizontal at the junction is maintained in a range to make the connections feasible. Fig. 3.7 shows arrangement of Vertical Bracing along one of the longitudinal grid.

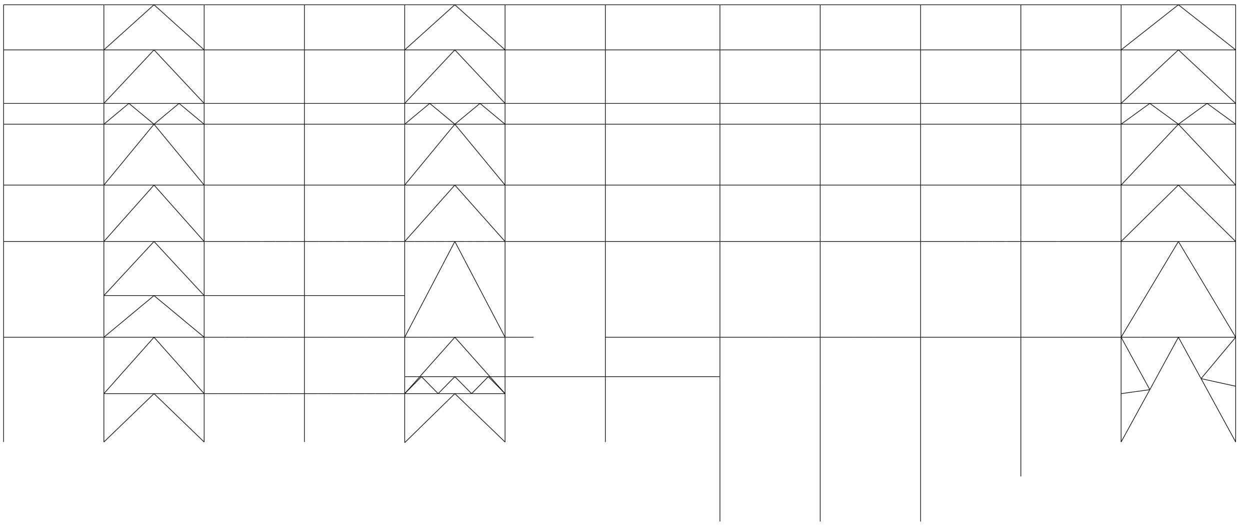

Fig. 3.7 Vertical Bracing along B Row

3.5 TRUSS

Auxiliary columns in AB Bay reach only up to Operating floor level. Above which there is a large column free space in AB Bay. This Column free space of around 30-40m is covered by Truss. Convenient Truss Arrangement used based on the span of the Truss is decided. One such arrangement is shown in Fig. 3.8.

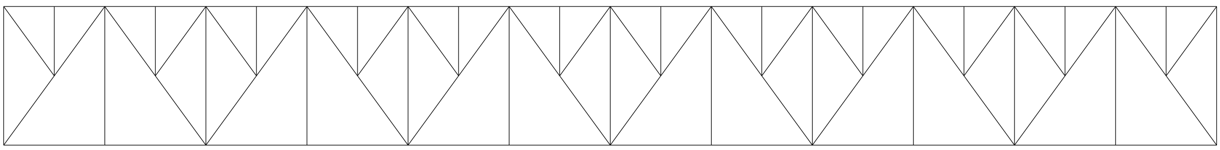

Fig. 3.8 Truss Arrangement

3.6 GANTRY CRANE

Gantry Crane of 110T capacity is provided above the Operating Floor level in AB Bay for the maintenance and transportation of heavy Equipments. Crane is supported on the larger depth main columns along A and B grid. Depth of Crane Column above crane level is reduced as it has to support Roof only.

3.7 TURBINE BUILDINGS OF DIFFERENT POWER PLANTS

Primary information of Turbine Building for different Projects is mentioned here. Projects include:

1. NTPC- BARH, 3 X 660 MW,
2. Amarkantak Thermal Power Station, 1 X 210 MW,
3. GHECO Coal Fired Power Plant, 1 X 600 MW
4. NTPC – Unchahar Thermal Power Station,1 X 210 MW

Table 3.1 General Information of the Project

	NTPC-BARH 3 X 660	Unchahar 1 X 210	Amakantak TPS 1 X 210	GHECO 1 X 600
Location	Bihar	Uttar Pradesh	Madhya Pradesh	Thailand
No. of Units	3	1	1	1
Rating (MW)	660	210	210	600
Length of one unit(m)	129	91	109.5	70
Width of one unit(m)	48	42	42	41.5
Width of Turbine Bay(m)	36	30	30	29.5
Width of Control Bay(m)	12	12	12	12

Parameters of different projects are listed in the Table 3.1. Dimensions can be co-related with that given in Fig 3.1 for NTPC-BAHR Project.

3.7.1 Turbine Bay

Turbine Bay consists of Mezzanine and Operating floor, elevation of which differs.The details mentioned in the following Table 3.2 can be seen in the cross-section given in the Fig. 3.2.

Table 3.2 AB Bay Elevations

	NTPC-BARH 3 X 660	Unchahar 1 X 210	Amakantak TPS 1 X 210	GHECO 1 X 600
Mezzanine floor (m)	8.5	6	4.5, 10.5	11.25
Operating Floor (m)	17	11	15.5	18.75
Roof Top lvl (m)	38	33.27	35	24.92

3.7.2 Electrical / Control Bay

Control Bay of the building has comparatively less width and more no. of storey. Each storey is used for different purposes in various projects.

Table 3.3 Control Bay Floor Details

NTPC-BARH 3 X 660		Unchahar 1 X 210		Amakantak TPS 1 X 210	
Floor	Level in m	Floor	Level in m	Floor	Level in m
SWAS & AHU Room	4.95	SWGRS & Turbine MCC	3	HT/LT SWGRS	3.75
Heater Area	8.5	Cable Vault	8	Elec. Maintenance	8.75
Cable Spreader Room	13.45	Control Room	11	Cable Spreading Roof	11.758
HP Heater Area	17	AHU & Auxiliary PRDS	17	Boiler Access Platform	15.5
Cable Spreader	24	Preheater Support	23.5	PPGS & Control Station	20.69
Boiler MCC	28	Boiler MCC Floor	26.5	Deaerator Space	25.6
PRDS Station Area	32.8	Cooling Tower	31.5	Roof Top	35.8
Roof Top	50.1				

BC Bay floor Levels for GHECO coal fired Project is 11.25, 18.75, 24.0, 28.75m.

3.8 SUMMARY

In this chapter, structural arrangement of Turbine Building is discussed. Study of drawings for four different projects is carried out and details are presented here. From the above details, it is evident that overall layout of Turbine Building remains similar for different projects and dimensions are changed based on rating of the plant.

4. STRUCTURAL MODELING

4.1 GENERAL

Turbine Building is modeled in STAADPro software. Geometry, loading and structural sizes are taken from NTPC – Barh Project details. Different details like structural sizes used in the modeling, load cases considered, load calculations and combinations of the load cases used for analysis are mentioned in this chapter.

- Three dimensional model of the Turbine Building is shown in fig. 4.1. Gridlines 27 to 39 is shown in longitudinal direction, A to C in transverse direction.
- Relation between STAADPro model axis and building axis is as following:

  North to South : +ve X Direction

  East to West : +ve Z Direction
- Supports conditions are as follows:

Table 4.1 Support Condition

Member	Longitudinal direction	Transverse direction
Main Column	Fixed	Released
Auxiliary column	Fixed	Fixed
Gable end column	Fixed	Fixed

- Hinge supports are provided at Mezzanine and Operating floor level. These supports are provided at locations where beams are supported on Steam Turbine and Generator(STG) Platform by Rubber Bearing.

- As it is shown in Fig. 4.2, Moment connections are provided along transverse direction in BC bay. Whereas in AB bay, shear connections are provided in transverse direction.

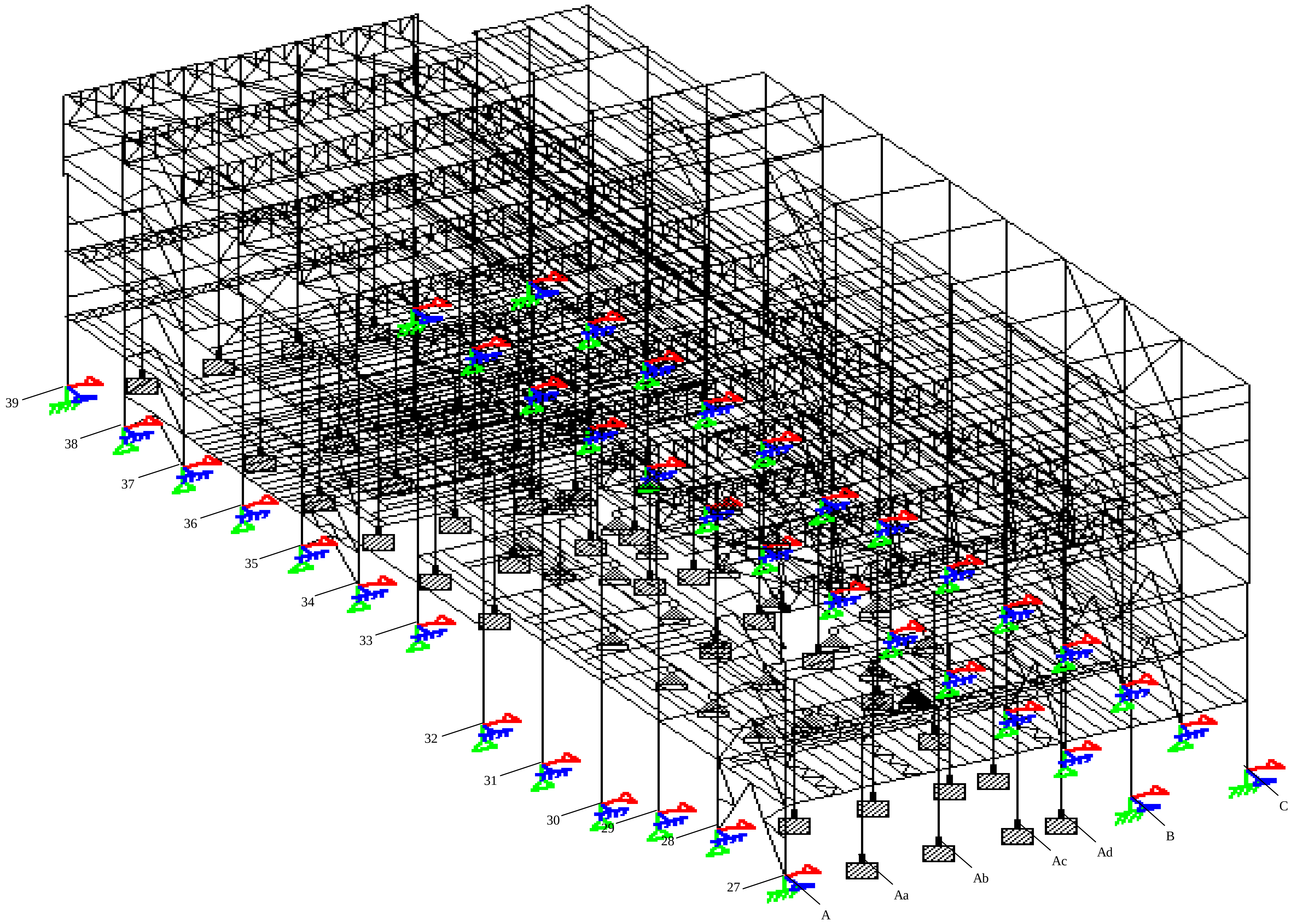

Fig. 4.1 3D Modeling of Turbine Building

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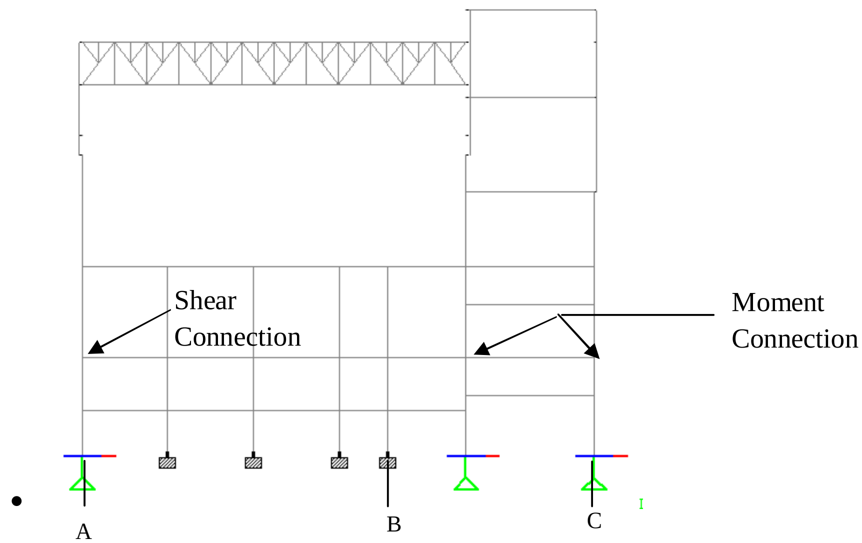


Fig. 4.2 Connection Details in Transverse Bay

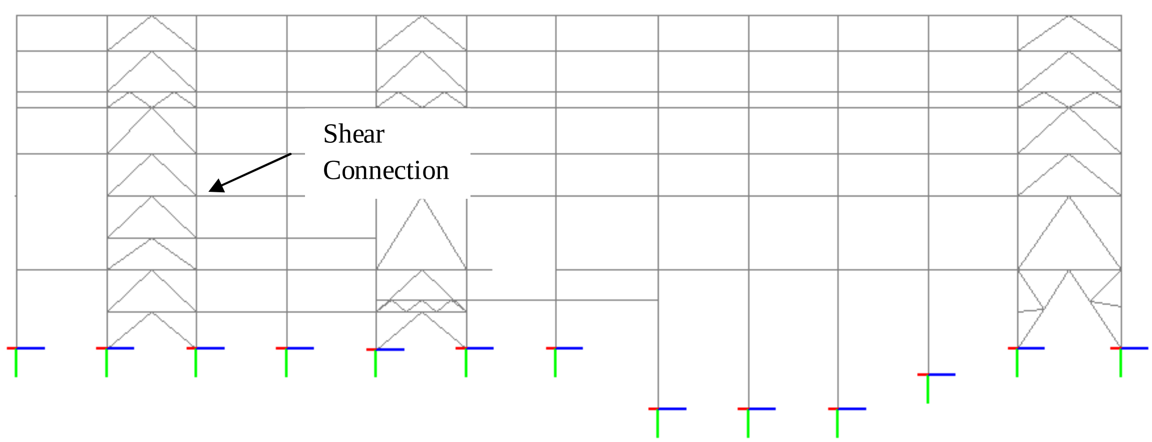


Fig. 4.3 Shear connection in Longitudinal Bay

- As it is shown in Fig. 4.3, shear connections are provided along longitudinal direction in A, B and C grids.
- Member properties which are not available in section database of software are defined by creating User Tables. Properties required for design are calculated by software for wide flanged I sections; in case of Built Up sections other than I sections, properties are calculated manually and entered in User Table.

- Along with main structural members, secondary beams at floor levels and purlins are modeled here. Secondary beams are modeled with releasing its major and minor axis bending at the ends.
- Vertical Bracings are provided along A, B and C grids in longitudinal direction. Plan Bracings are provided at Mezzanine and operating floor levels. Bracings are modeled by releasing its major and minor axis bending at the ends.
- Truss members are modeled by releasing its major and minor axis bending at the ends.
- There is abrupt change in the depth of column section at Crane level along A and B Row. Keeping the centerline for the modeling same through the height, “member offset” is provided to consider the eccentricity of the load.
- Auxiliary columns are Box sections which are defined as “Tube“sections in the User Table. Properties of above sections are calculated by software.
- Gable End columns are modeled with keeping 0.3m eccentricity to the centre line of grid 39.
- Crane is supported on A and B grid columns at +27.33m level. Loads and Bending moments due to the crane are applied at nodes.
- There are various equipments kept at different levels in the Building. Loads of smaller equipments are considered in Live loads and applied as area loads. Loads of larger equipments like Deaerator, High pressure heater, Low pressure heater are applied as Point Loads at particular locations.

4.2 MEMBER DEFINITIONS

Primary member data is taken from the details of NTPC Barh Project. Various sections used in the modeling are listed below. Mainly Built Up Sections are used in this structure, in addition to that Indian Standard Sections are used.

Member Properties for the Built Up sections are defined by creating User Tables in the STAADPro Software as shown in Fig. 4.4.

I sections for Column and Beams are defined under the category of Wide Flanged sections; Design properties of the sections are calculated by the In built functions in the software. Box sections are used as Auxiliary Columns, which are defined as tube in the user table as shown in Fig.4.5.

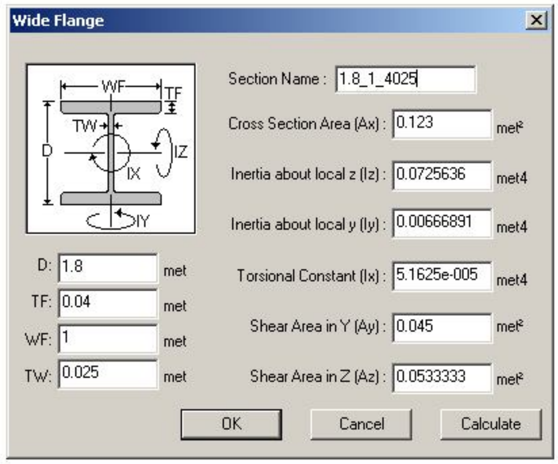


Fig. 4.4 wide flange section in User Table

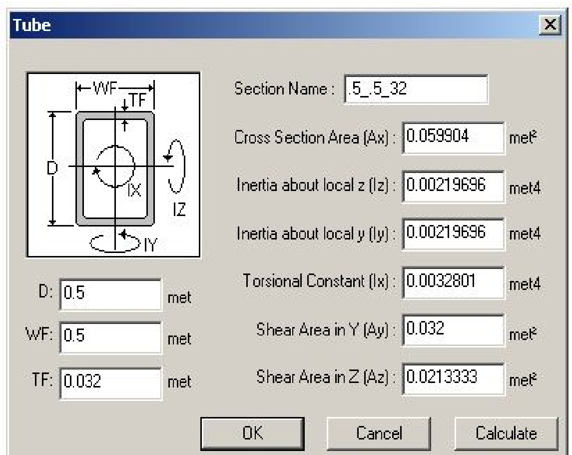


Fig. 4.5 Tube section in User Table

Dimensions of the Built up sections are chosen such that projection of flange is limited to 16 times thickness of flange.

4.2.1 Column

Typical Column section used in A, B, and C Row are shown in Fig. 4.6.

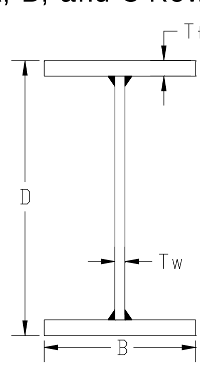


Fig. 4.6 Typical Column and Beam Section

Detail of the sections is given in Table 4.2. A specific pattern is used for section name so that dimensions of the section are evident. section name 1.9_1.1_5040 suggests I section of 1.9m depth, 1.1m width, 50mm flange thickness and 40mm thickness of web. As per the symbols shown in Fig. 4.6 it can be presented as D_B_TfTw.

Table 4.2 Column Section

Sr. No.	STAAD section Name	Depth (D)	Width (B)	Flange Th.(Tf)	Web Th.(Tw)	Weight kg/m
1	1.9_1.1_5040	1900	1100	50	40	1428.70
2	1.9_1.1_5032	1900	1100	50	32	1315.66
3	1.9_1.1_4032	1900	1100	40	32	1147.98
4	1.9_1.1_4025	1900	1100	40	25	1047.98
5	1.9_1_4025	1900	1000	40	25	985.18
6	1.9_1_4032	1900	1000	40	32	1085.18
7	1.9_0.9_4025	1900	900	40	25	922.38
8	1.9_0.9_3220	1900	900	32	20	740.41
9	1.9_0.9_3225	1900	900	32	25	812.48
10	1.9_0.9_2520	1900	900	25	20	643.70
11	1.8_1_4032	1800	1000	40	32	1060.06
12	1.8_1_4025	1800	1000	40	25	965.55
13	1.8_1_3225	1800	1000	32	25	843.09
14	1.8_0.9_3220	1800	900	32	20	724.71
15	1.8_0.9_3225	1800	900	32	25	792.85
16	1.8_0.8_2520	1800	800	25	20	588.75
17	1.5_0.9_4025	1500	900	40	25	843.88
18	1.5_0.9_3220	1500	900	32	20	677.61
19	1.5_0.9_2520	1500	900	25	20	580.90
20	1.5_0.6_2016	1500	600	20	16	371.78
21	1.1_0.9_4025	1100	900	40	25	765.38
22	1.1_0.9_3220	1100	900	32	20	614.81
23	1.1_0.9_2520	1100	900	25	20	518.10
24	1.1_0.8_2520	1100	800	25	20	478.85
25	1.1_0.6_2016	1100	600	20	16	321.54

4.2.2 Beam

Typical section used for beam is given in Fig. 4.6. Detail of sections is presented in Table 4.3.

Table 4.3 Beam Section

Sr. No.	STAAD section Name	Depth (D)	Width (B)	Flange Th.(Tf)	Web Th.(Tw)	Weight kg/m
1	2_0.65_4025	2000	650	40	25	785.00
2	2_0.65_4020	2000	650	40	20	709.64
3	2_0.5_4025	2000	500	40	25	690.80
4	2_0.45_3225	2000	450	32	25	606.02
5	1.9_1.1_4032	1900	1100	40	32	1147.98
6	1.8_1_4032	1800	1000	40	32	1060.06
7	1.5_0.6_4020	1500	600	40	20	599.74
8	1.5_0.5_3220	1500	500	32	20	476.65
9	1.45_0.45_4020	1450	450	40	20	497.69
10	1.4_0.6_4025	1400	600	40	25	635.85
11	1.4_0.55_4020	1400	550	40	20	552.64
12	1.4_0.55_3220	1400	550	32	20	486.07
13	1.4_0.4_3216	1400	400	32	16	368.76
14	1.4_0.4_3216	1400	400	32	16	368.76
15	1.4_0.4_2012	1400	400	20	12	253.71
16	1.4_0.3_4025	1400	300	40	25	447.45
17	1.2_0.65_4025	1200	650	40	25	628.00
18	1.2_0.65_4020	1200	650	40	20	584.04
19	1.2_0.6_4020	1200	600	40	20	552.64
20	1.2_0.6_4020	1200	600	40	20	552.64
21	1.2_0.55_4025	1200	550	40	25	565.20
22	1.2_0.55_4020	1200	550	40	20	521.24
23	1.2_0.55_3220	1200	550	32	20	454.67
24	1.2_0.55_3216	1200	550	32	16	419.00
25	1.2_0.5_4020	1200	500	40	20	489.84
26	1.2_0.5_4020	1200	500	40	20	489.84
27	1.2_0.5_3216	1200	500	32	16	393.88
28	1.2_0.5_3216	1200	500	32	16	393.88
29	1.2_0.5_2512	1200	500	25	12	304.58
30	1.2_0.5_2512	1200	500	25	12	304.58

31	1.2_0.5_1612	1200	500	16	12	235.63
32	1.2_0.3_3212	1200	300	32	12	257.73
33	1.1_0.4_4020	1100	400	40	20	411.34
34	1.1_0.4_3216	1100	400	32	16	331.08
35	1.1_0.3_4020	1100	300	40	20	348.54
36	1_0.4_4020	1000	400	40	20	395.64
37	1_0.4_3212	1000	400	32	12	289.13
38	1_0.4_3216	1000	400	32	16	318.52
39	1_0.4_2512	1000	400	25	12	246.49
40	1_0.4_2012	1000	400	20	12	216.03
41	0.9_0.4_4016	900	400	40	16	354.19
42	0.9_0.3_4020	900	300	40	20	317.14
43	0.8_0.5_4020	800	500	40	20	427.04
44	0.8_0.4_3216	800	400	32	16	293.40
45	0.8_0.3_4016	800	300	40	16	278.83
46	0.8_0.3_3212	800	300	32	12	220.05
47	0.8_0.3_2516	800	300	25	16	211.95
48	0.8_0.25_4016	800	250	40	16	247.43
49	0.8_0.25_3220	800	250	32	20	241.15
50	0.75_0.3_3212	750	300	32	12	215.34
51	0.75_0.3_3216	750	300	32	16	236.88
52	0.75_0.3_2516	750	300	25	16	205.67
53	0.7_0.35_2512	700	350	25	12	198.61
54	0.7_0.3_2512	700	300	25	12	178.98
55	0.6_0.3_2512	600	300	25	12	169.56
56	0.6_0.25_2516	600	250	25	16	167.21

In addition to the above Built Up sections, ISMB 600, ISMB 550, ISMB 500, ISMB 450, ISMB 300 and ISMB 200 sections are also used as beams. Plan views at different levels of the Building are shown in Fig. 4.7 to Fig. 4.10.

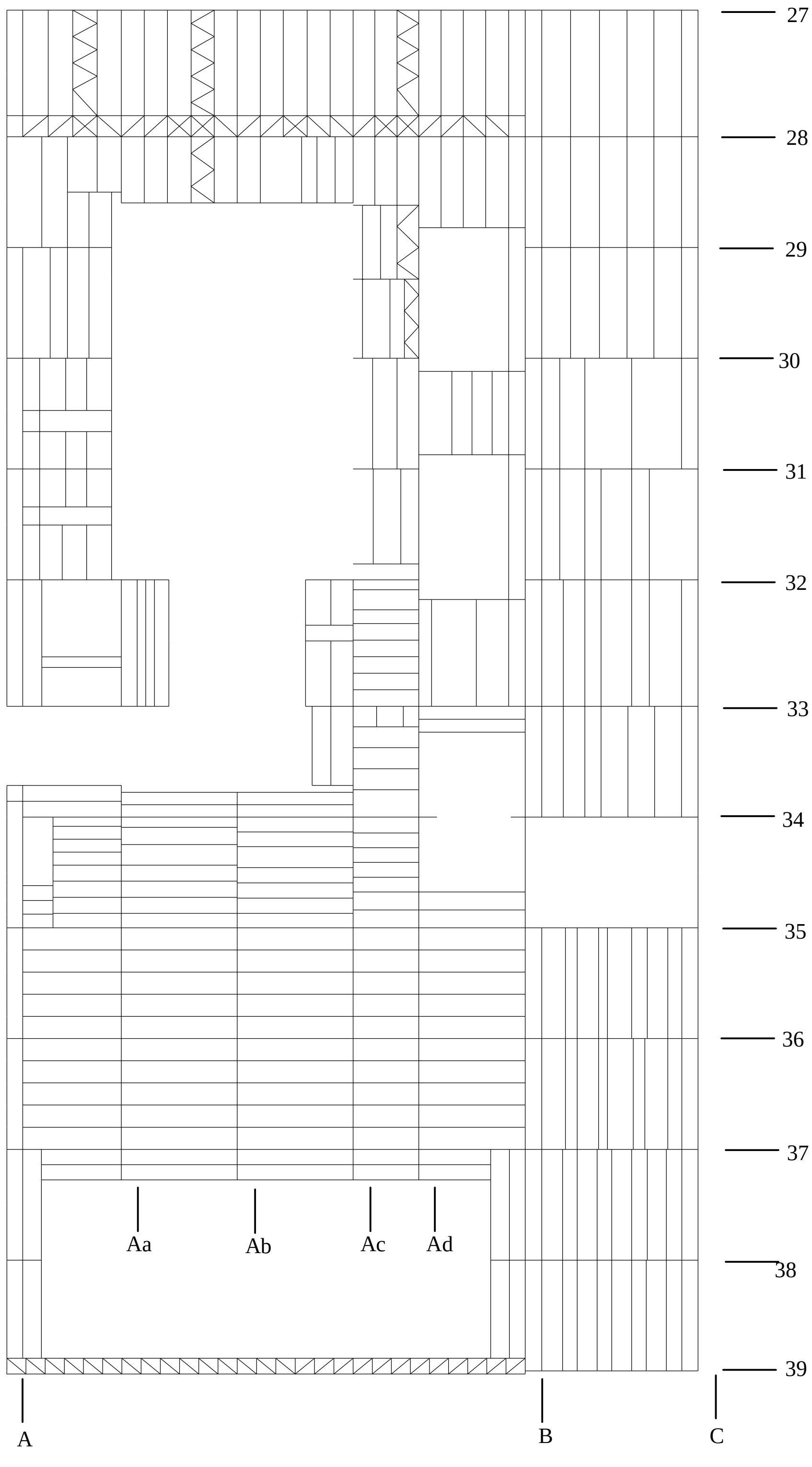


Fig. 4.7 Mezzanine Floor Plan (8.5m level)

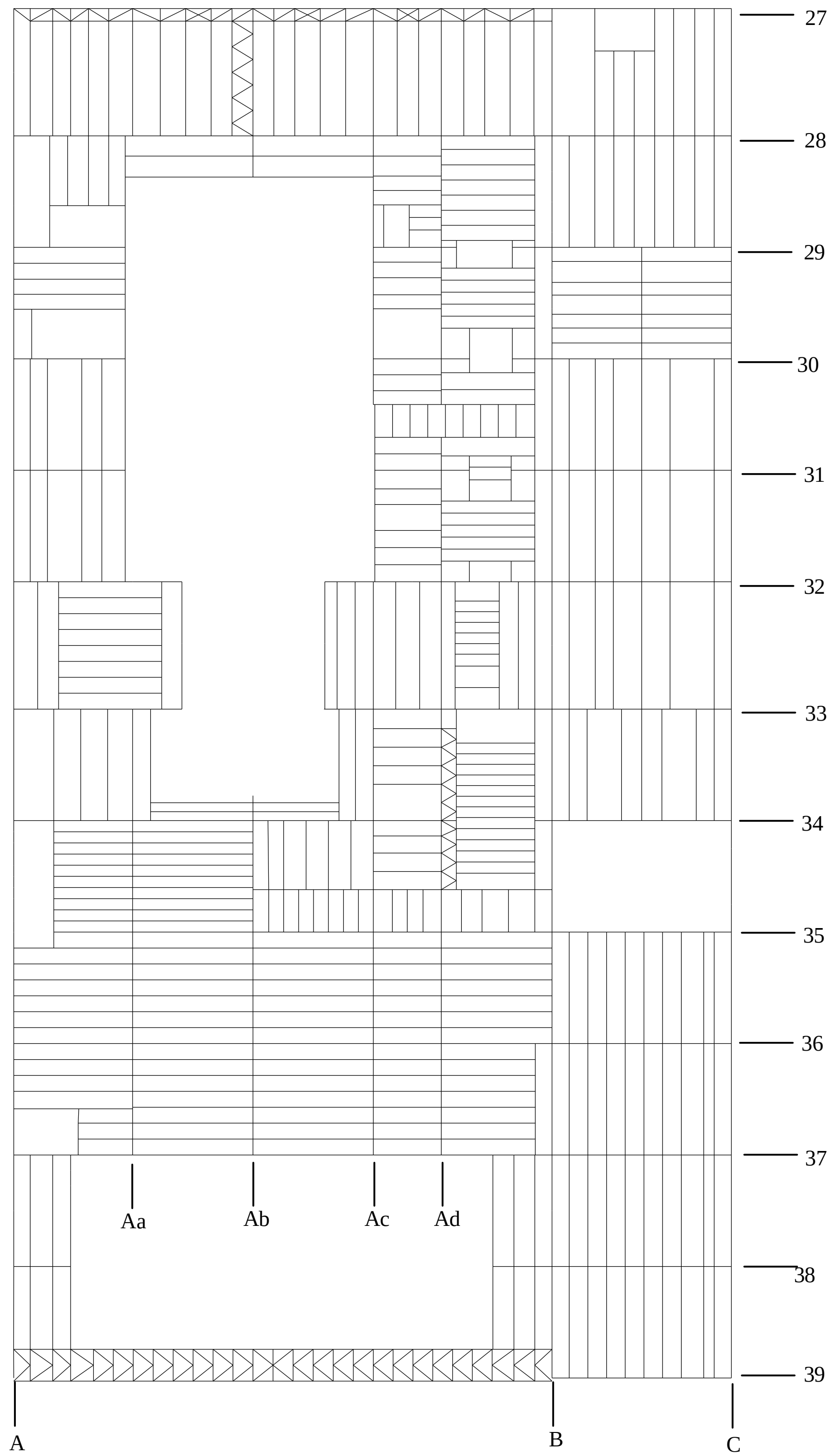


Fig. 4.8 Operating Floor Plan (17m level)

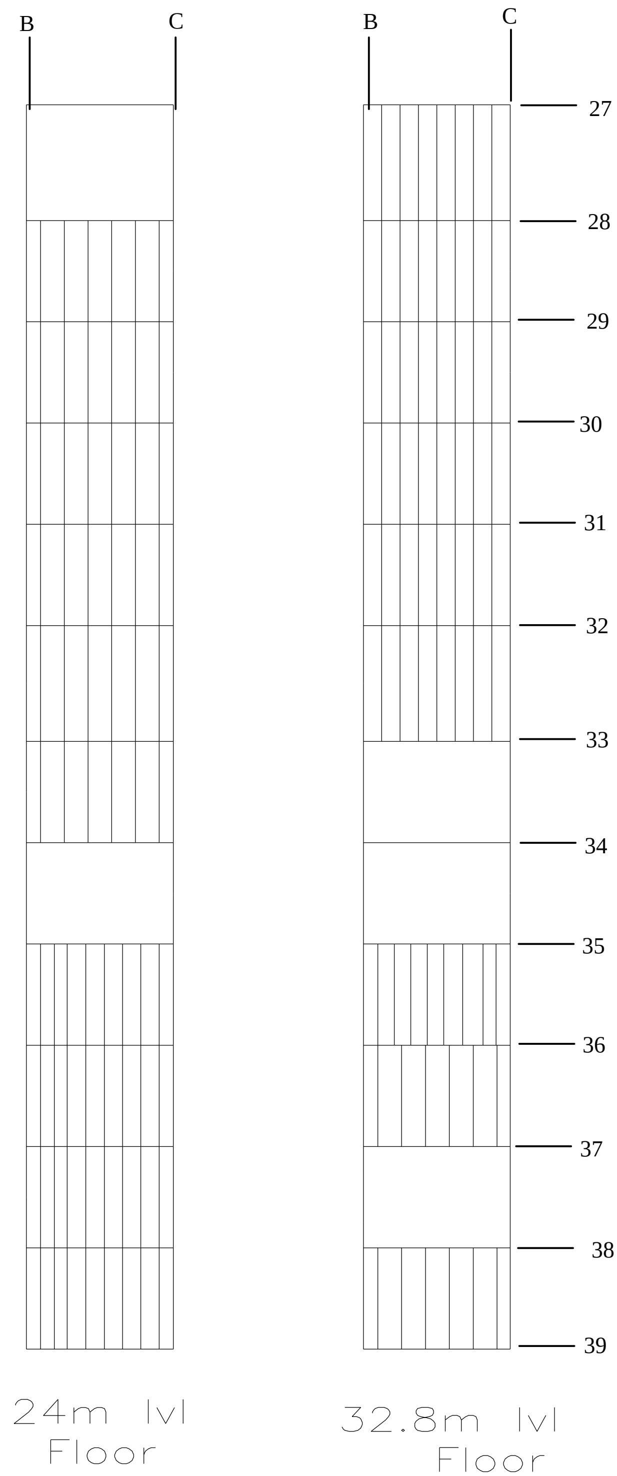


Fig. 4.9 Plan at intermediate Floors

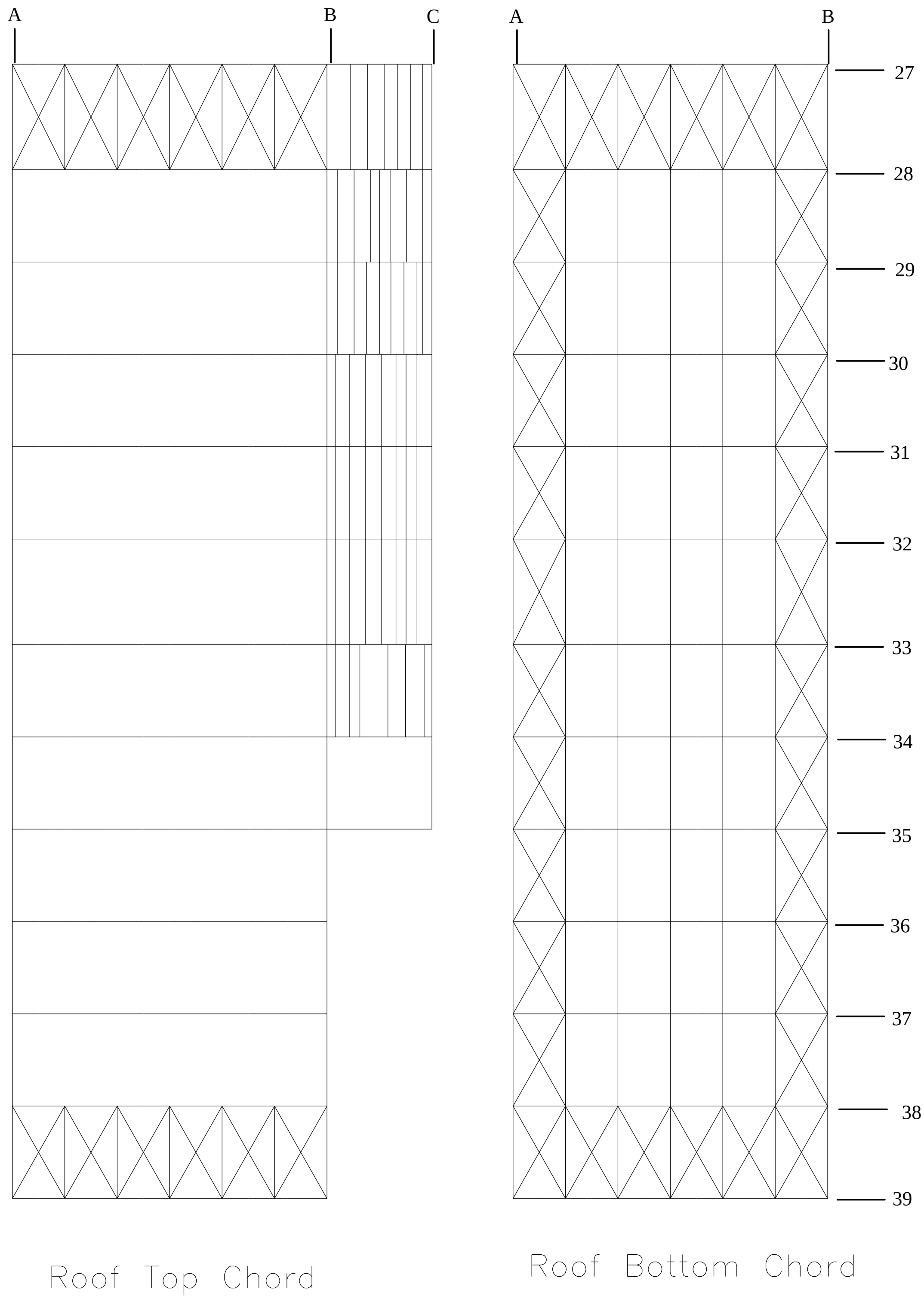


Fig. 4.10 Plan at Truss Level

4.2.3 Bracing

Typical section used for Horizontal and Vertical Bracings is shown in Fig. it shows cross-section of the bracing, which consists of four channel sections.

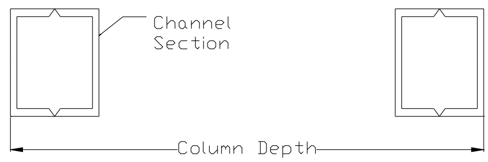


Fig. 4.11 Typical section for Vertical Bracing

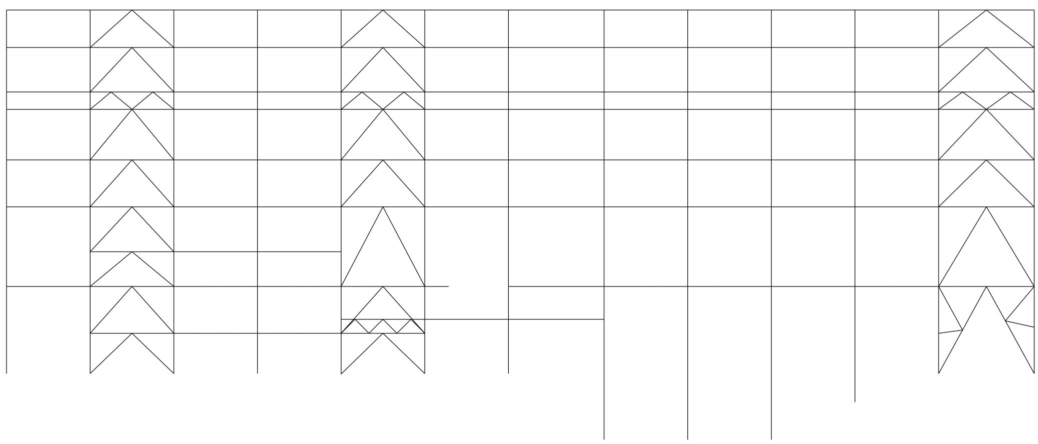


Fig. 4.12 A Row Column and Bracing

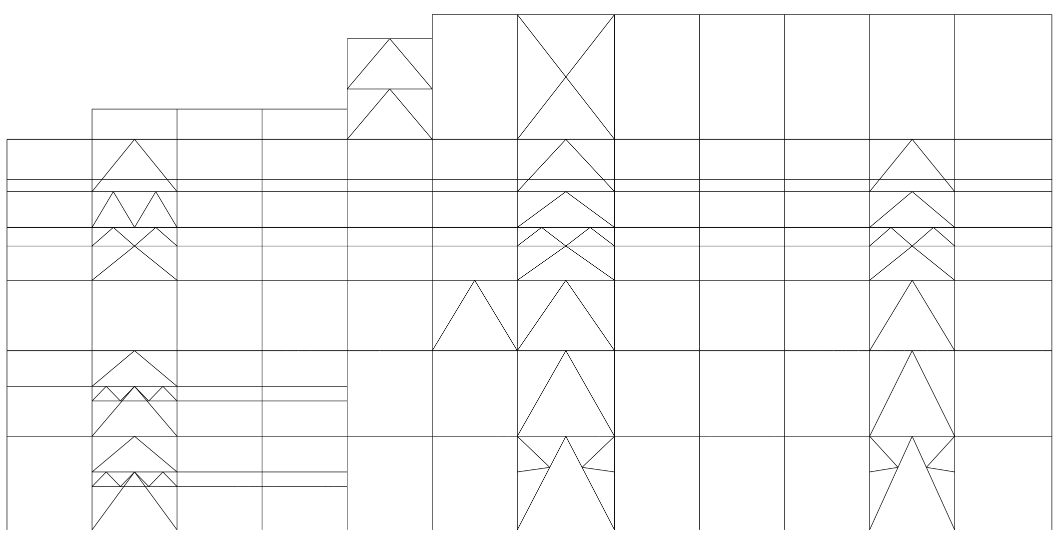


Fig. 4.13 B Row Column and Bracing

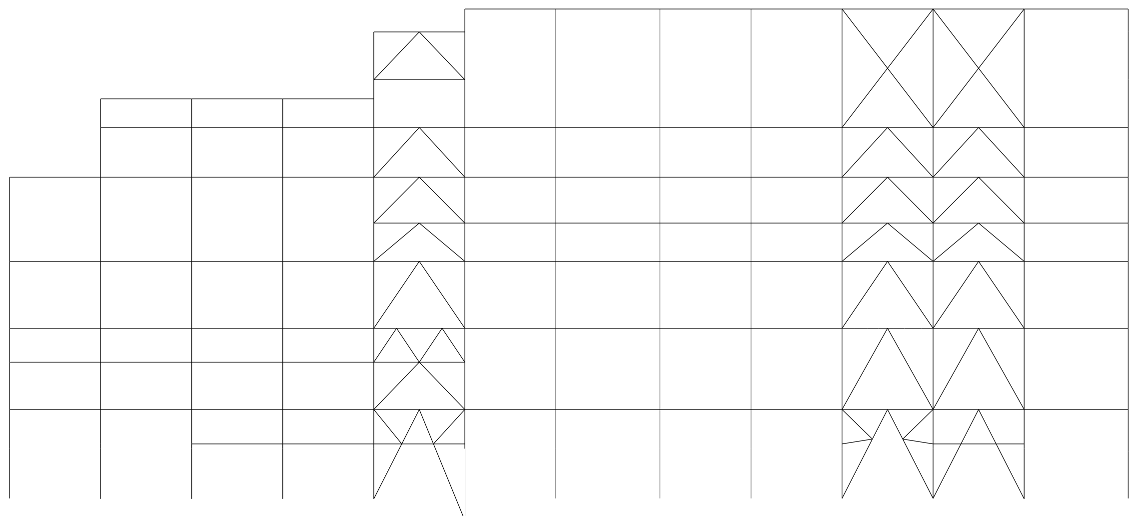


Fig. 4.14 C Row Column and Bracing

Plan level Bracings are provided at Floor level. Angle section ISA 150 X150X15 is used for this type of Bracing. Fig. 4.14 shows bracing provided at 8.5m level.

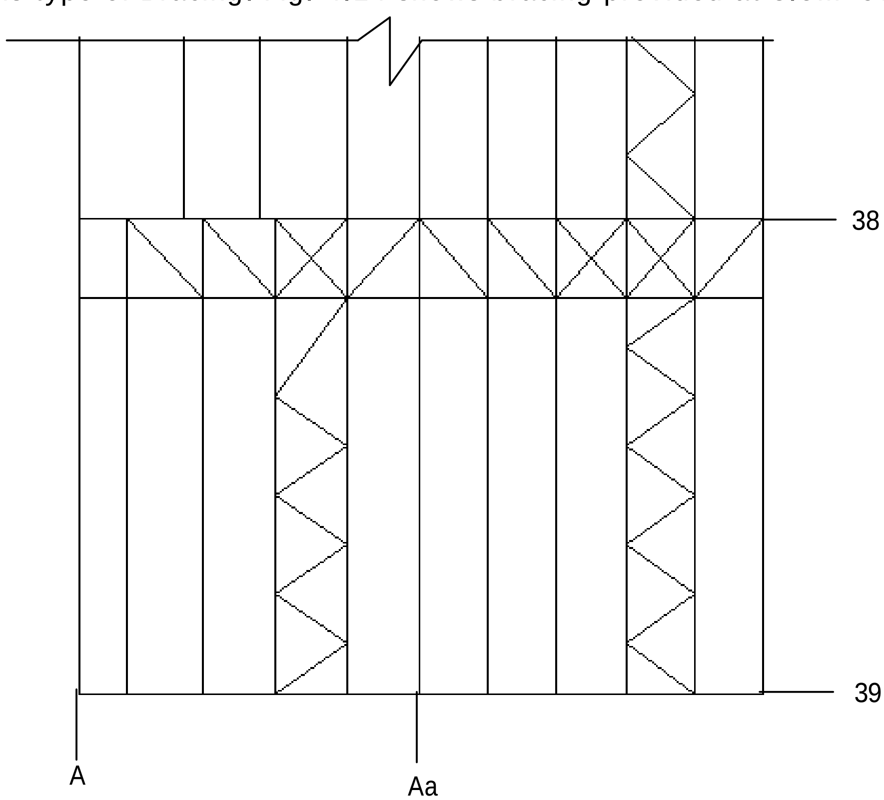


Fig. 4.15 plan bracings at 8.5m level (part plan)

4.3 BOUNDARY CONDITIONS

Supports conditions for column is shown in Table 4.1.

Supports are provided at mezzanine and operating floor level as shown in Fig. 4.15. These supports are provided at locations where beams are supported on STG Platform by Rubber Bearing.

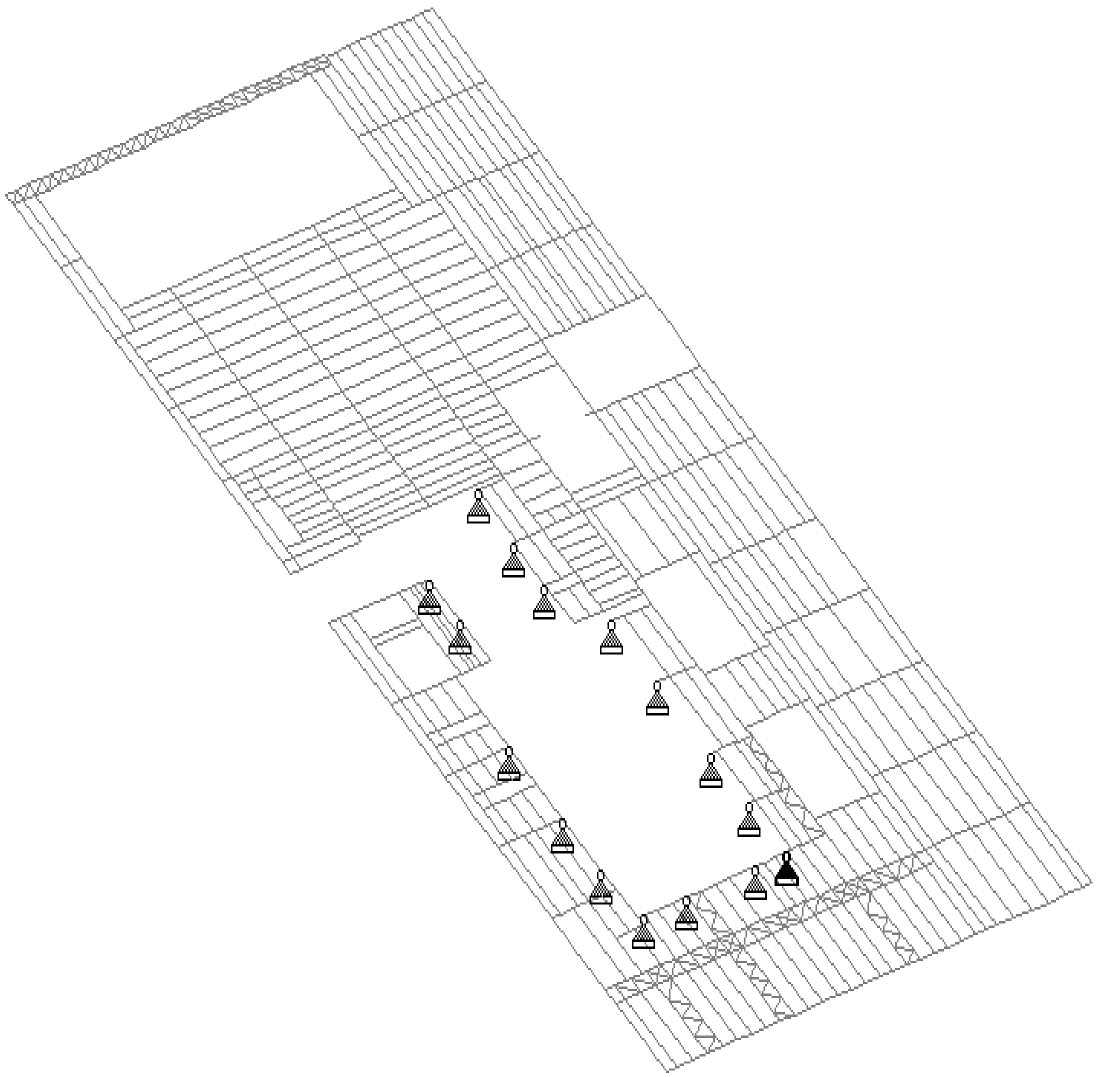


Fig. 4.16 Supports at Mezzanine floor level

Major and Minor Axis Bending for all the secondary Beams, Bracings and Truss members are released in the structural model.

4.4 LOADS

Load Cases considered in the analysis of the structure are listed in Table 4.4, which are discussed in the following section.

Table 4.4 Loads

Sr. No.	Load Symbol	Load Description
1	D	Dead Loads
2	Lf	Live Loads : Floor
3	Lr	Live Loads : Roof
4	Tr	Cable Tray Loading
5	Po	Operating Load
6	Wns1	Wind from North to South : Pressure Condition
7	Wns2	Wind from North to South : Suction Condition
8	Wsn1	Wind South to North : Pressure Condition
9	Wsn2	Wind South to North : Suction Condition
10	Wew1	Wind from East to West : Pressure Condition
11	Wew2	Wind from East to West : Suction Condition
12	Wwe1	Wind from West to East: Pressure Condition
13	Wwe2	Wind from West to East: Pressure Condition
14	Eqx	Seismic Load Along X Direction
15	Eqz	Seismic Load Along Z Direction
16	Con	Contingency Load
17	TL	Temperature Load
18	Cw	Crane Load : Weight of Crane Bridge
19	Cta	Crane Load : Surge (Lateral) Load on Frame A
20	Ctb	Crane Load : Surge (Lateral) Load on Frame B
21	Cl	Crane Load : Longitudinal Load

4.4.1 Dead Load

This includes weight of all structural elements complete with cladding, finishes, and fixtures. The piping loads, cable tray loads and the contents of the tanks, silos, bins and hoppers will be listed separately.

- Appropriate density of the material is defined and their self weight is automatically generated in STAADPro.
- Dead load of slab is transferred on beams as per contributory areas.
- Load of cladding is transferred at various points on columns.

4.4.2 Live Load

Live load includes minor equipment loads applied as area loads. Intensity of LL is taken different at various locations in the Building, which is presented as area load diagrams in Fig. 4.14 to 4.23.

4.4.3 Cable Tray Load

Cable Tray is arranged at different locations in the structure. Cable Tray Load is taken as 2 kN/m^2 in the area at which the tray is located. The loads are transferred on the secondary beams as distributed loads.

4.4.4 Equipment Load

There are various equipments kept at different levels in the Building. Loads of smaller equipments are considered in Live loads and applied as area loads. Loads of larger equipments like Deaerator, High pressure heater, Low pressure heater are applied as Point Loads at particular locations.

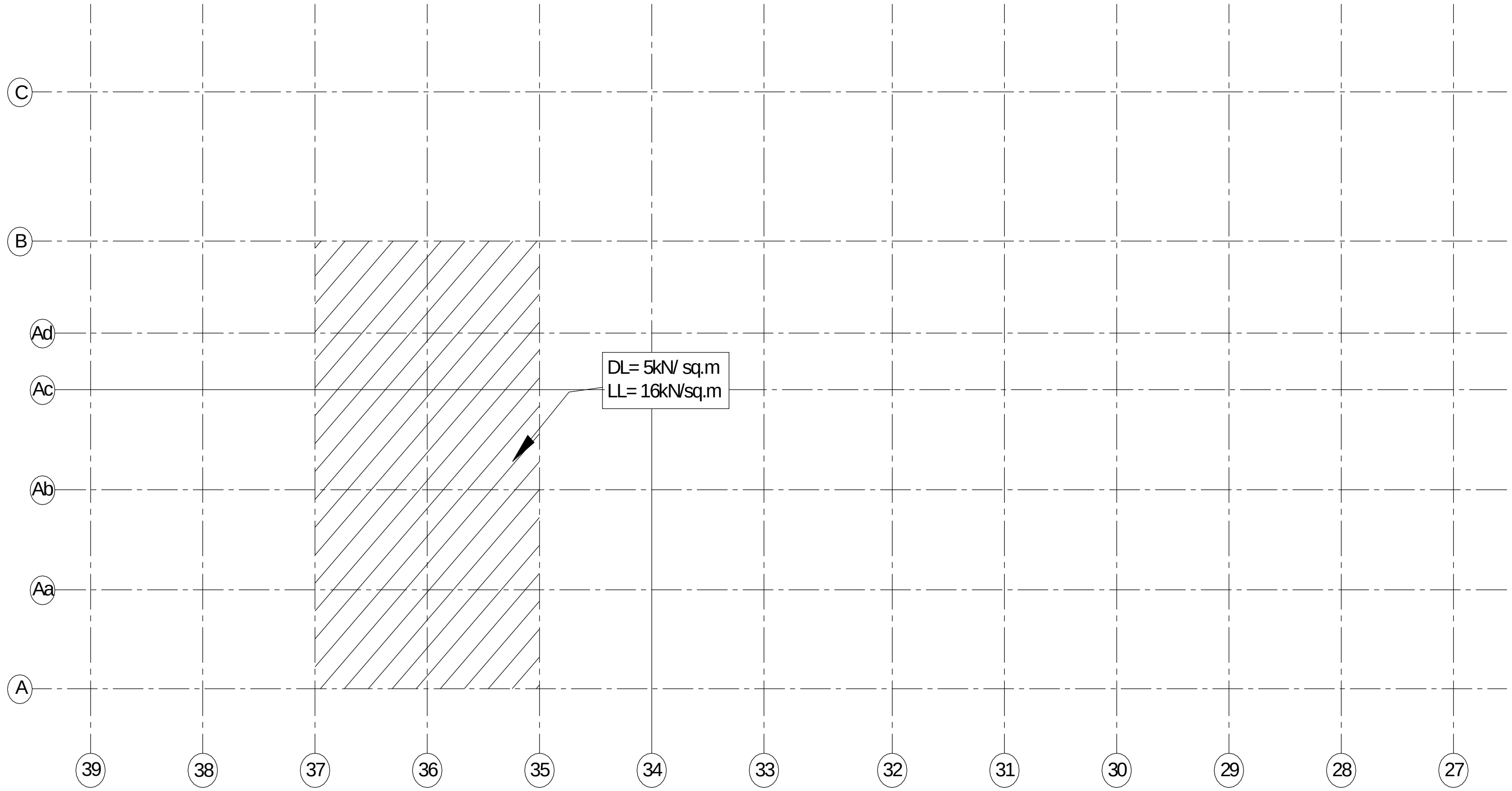


Fig. 4.17 Load at 3.1m level

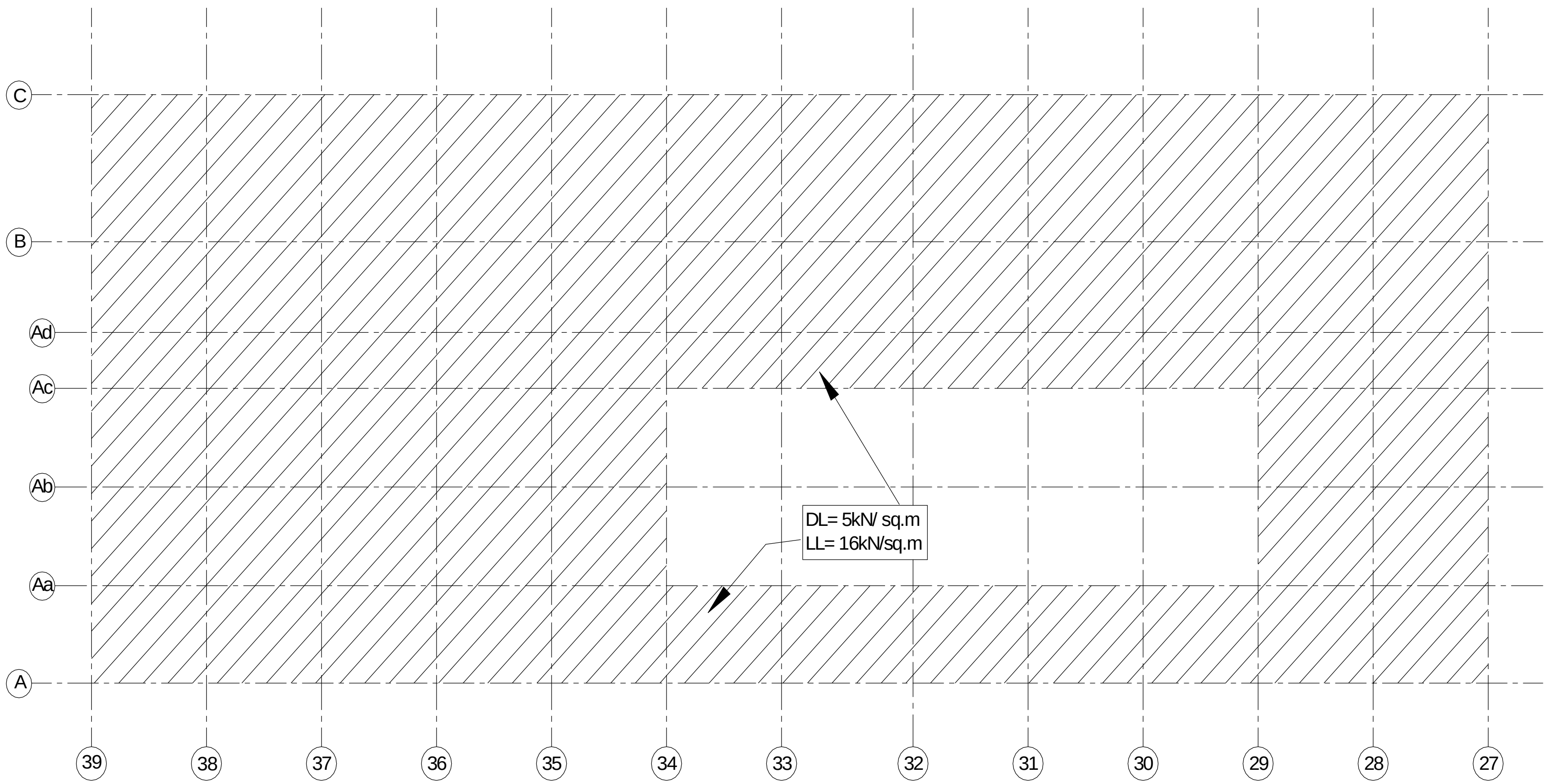


Fig. 4.18 Load at Mezzanine Floor (8.5m level)

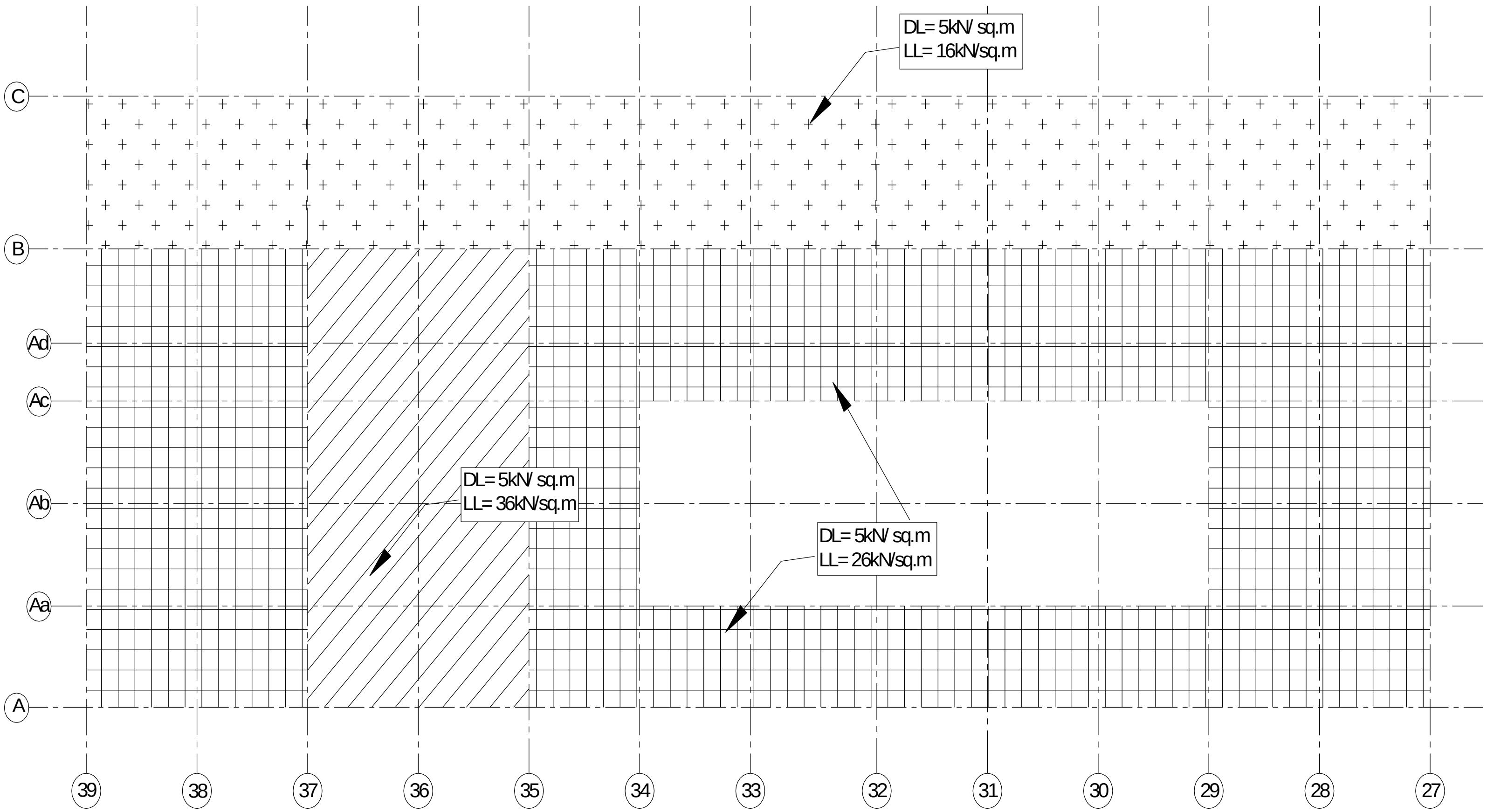


Fig. 4.19 Load at Operating Floor (17m level)

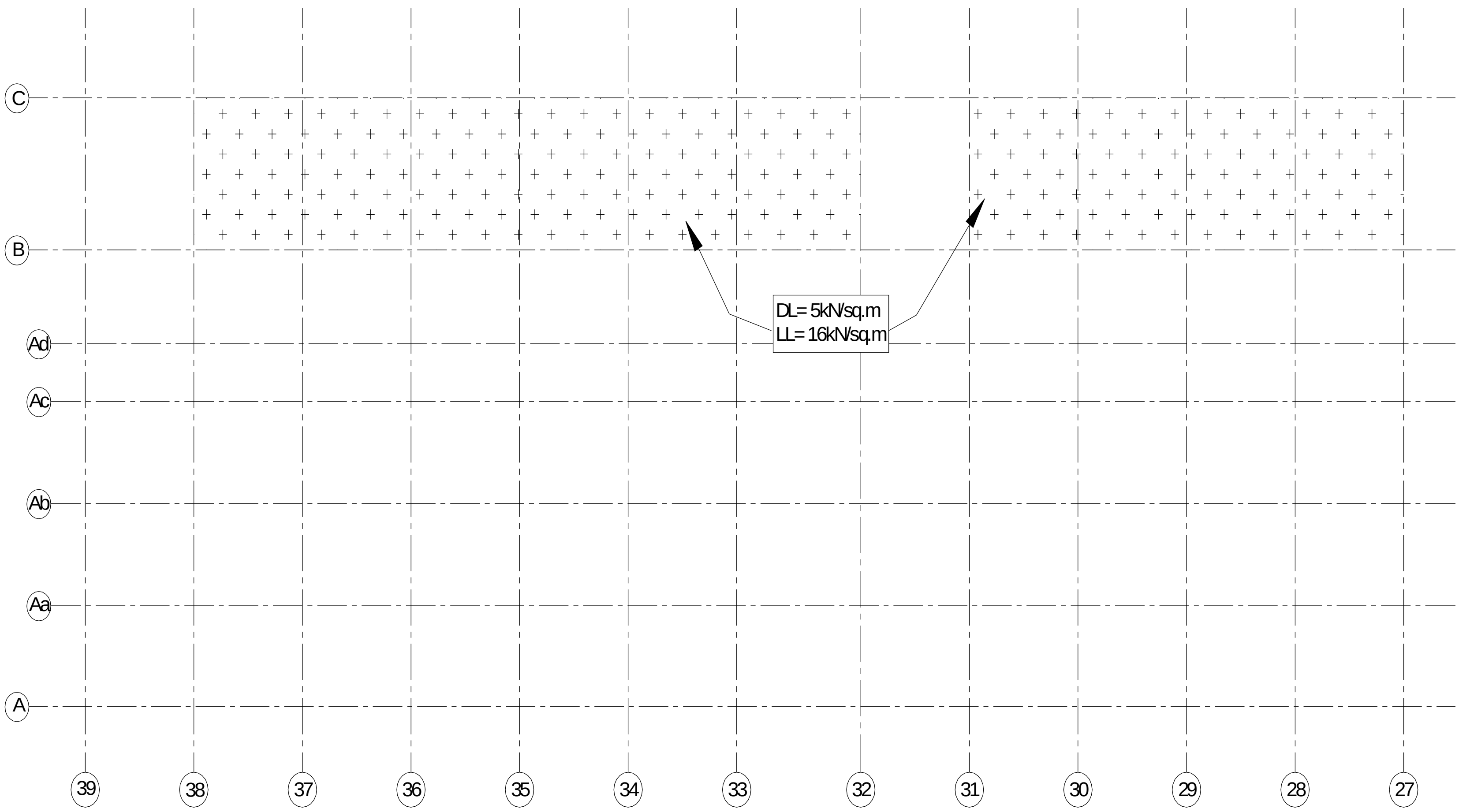


Fig. 4.20 Load at 24m level

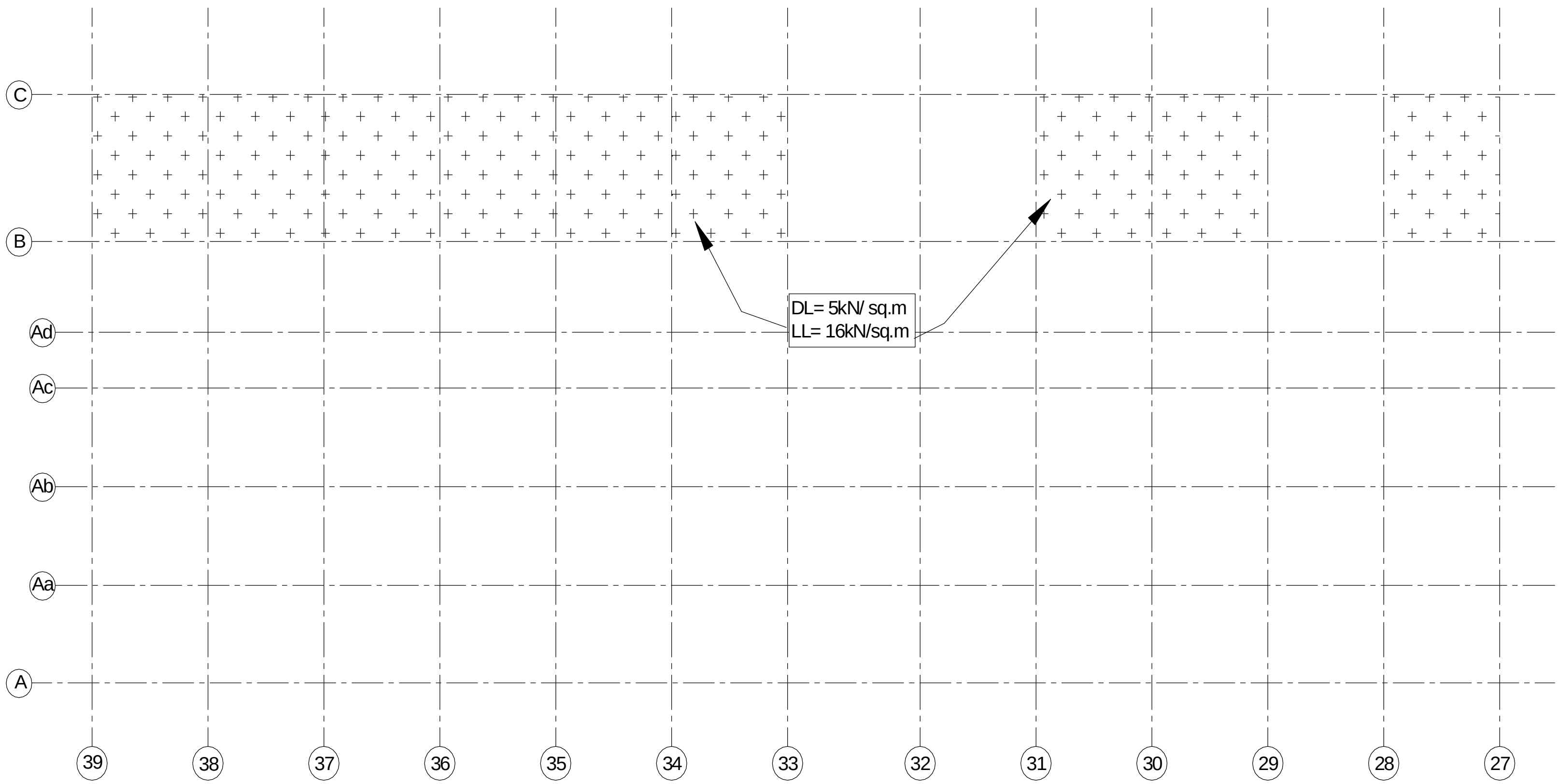


Fig. 4.21 Load at 32.8m level

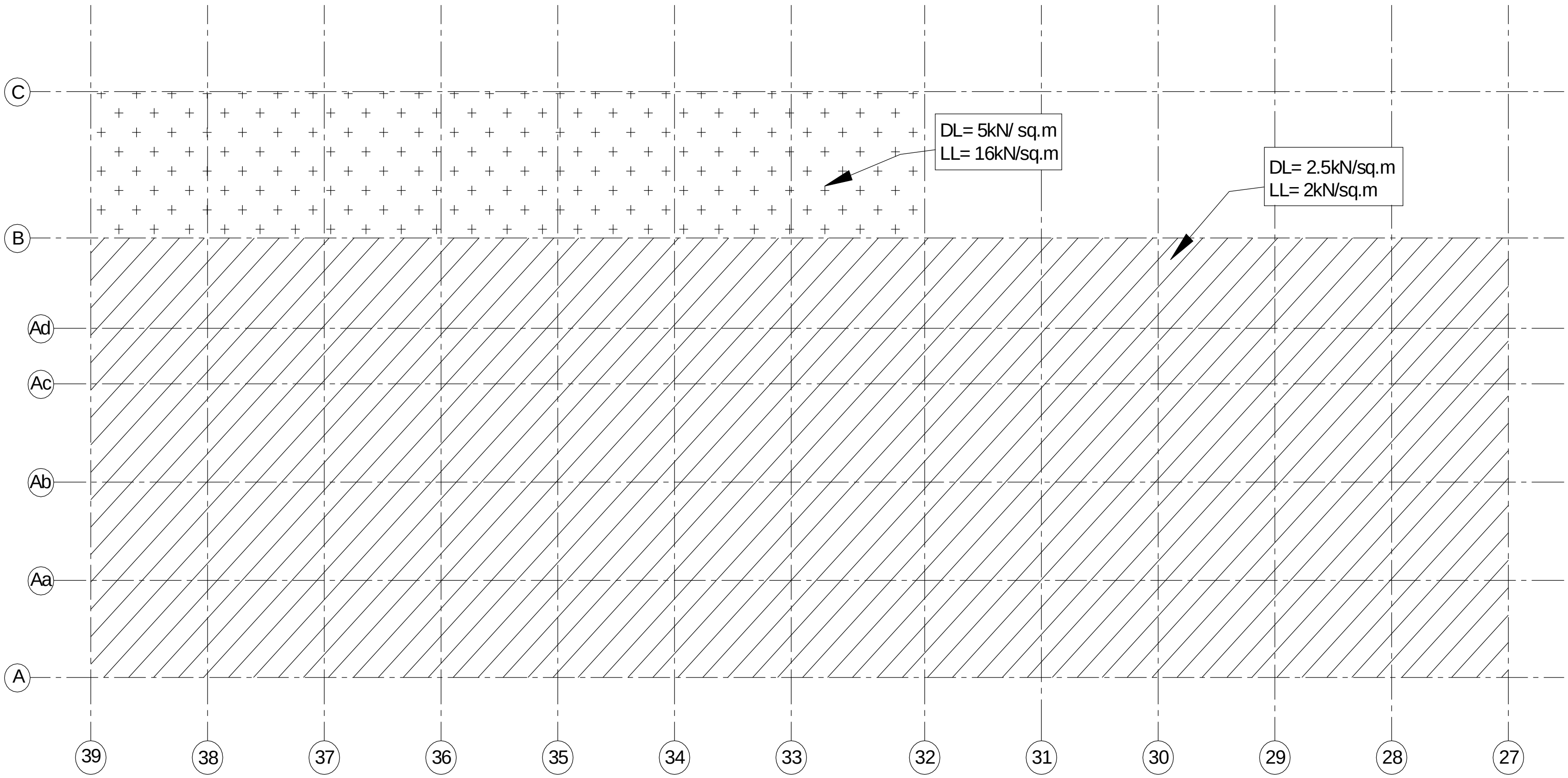


Fig. 4.22 Load at 38m level

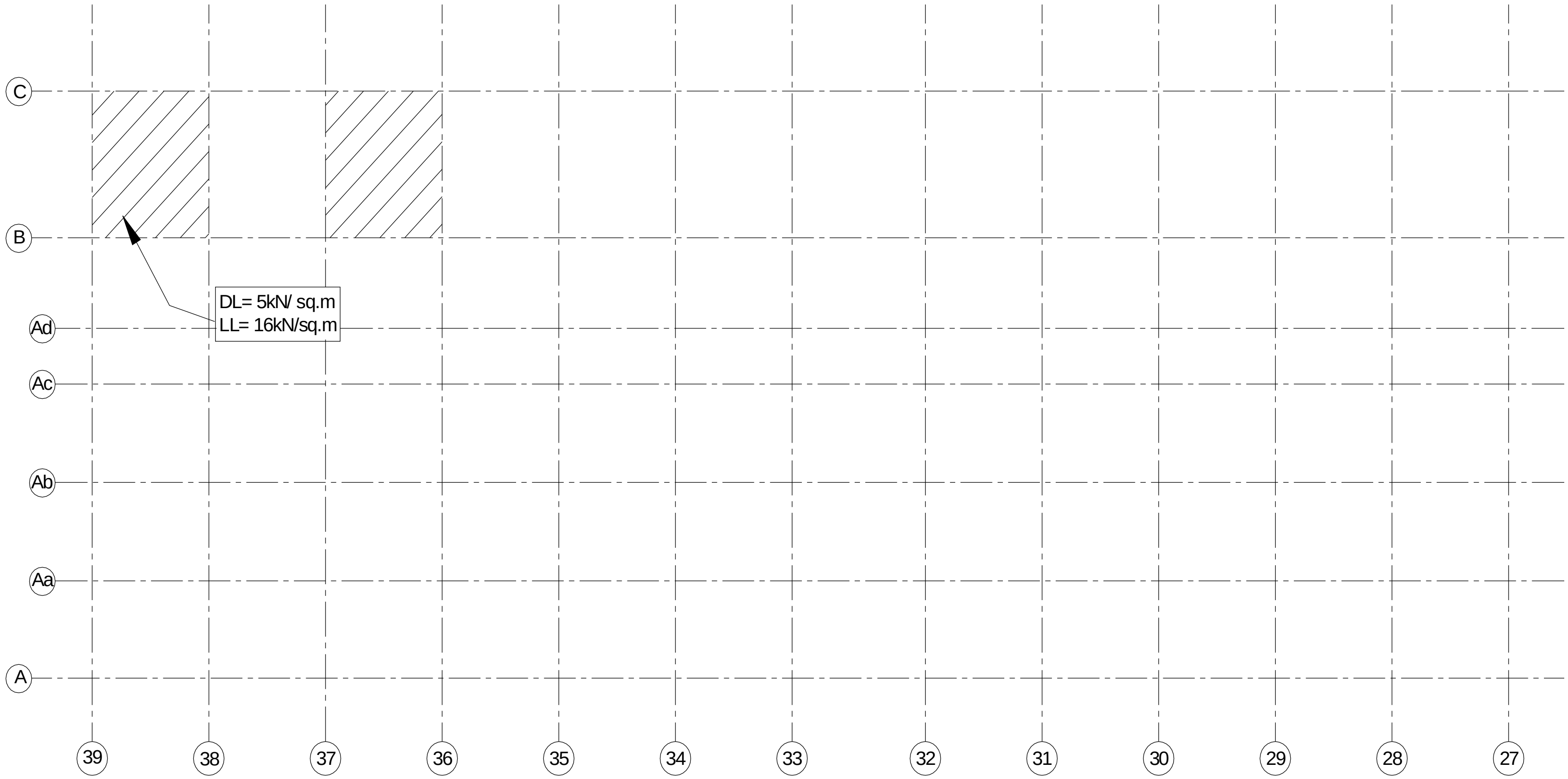


Fig. 4.23 Load at 41m level

4.4.5 Wind Load

Basic Wind Speed = 47 m/ Sec

K1 = 1.07 (for Important Building Structure with wind speed 47 m/s, Table- 1, IS-875)

Class of the structure is Class-C

K2 = Factor for relevant class of the structure with Category-2 terrain.

0.93 (for height up to 10m)

0.97 (for height 10m to 15m)

1.00 (for height 15m to 20m)

1.04 (for height 20m to 30m)

1.10 (for height 30m to 50m)

K3 = 1.0

Height of the Building (h) = 50.00m

Width of the Building (w) = 48.00m

Length of the Building (l) = 409.50m

Design wind speed, Vz = k1.k2.k3.Vb

= 46.77 m/s 0-10 m

= 48.78 m/s 10-15 m

= 50.29 m/s 15-20 m

= 52.30 m/s 20-30 m

= 55.31 m/s 30-50 m

Design wind pressure, pz = $0.6 \times Vz^2$

= 1.31 kN/m^2 0-10m

= 1.42 kN/m^2 10-15 m

= 1.51 kN/m^2 15-20 m

= 1.64 kN/m^2 20-30 m

= 1.83 kN/m^2 30-50 m

From Table - 4 of Is 875, External Pressure Coefficients, Cpe

	A	B	C	D
0	0.7	-0.3	-0.7	-0.7
90	-0.5	-0.5	0.7	-0.1

Assuming openings between 5-20% of the wall Area, Cpi is ±0.5

A) Wind from North to South – Internal Pressure

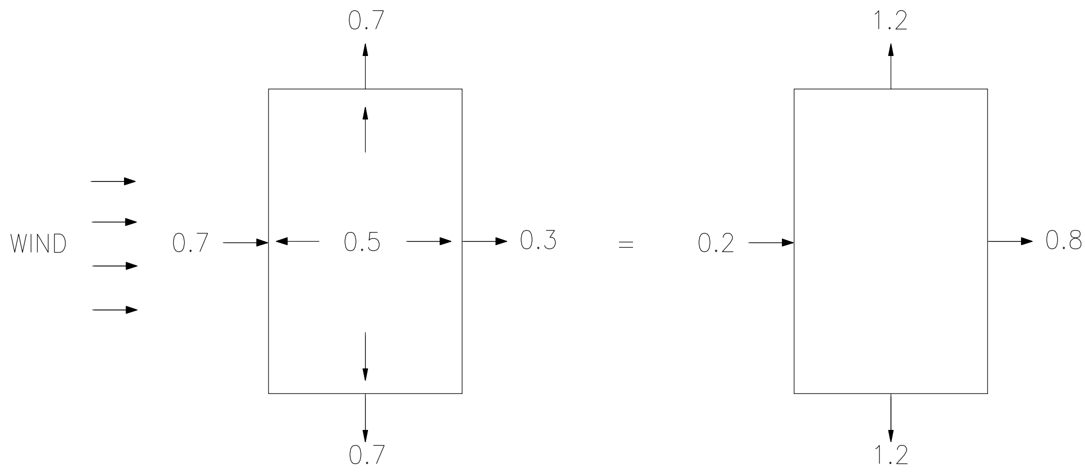


Fig. 4.24 Pressure Diagram- Wns1

Table 4.5 wind load on column – Wns1

Col No.	Tributary Width (m)	Ht. (m)	Pz (kN/m^2)	A - Row		C - Row	
				Cf	udl (kN/m)	Cf	udl (kN/m)
39	5.25	up to 10	1.31	0.2	1.38	0.8	5.50
	5.25	10 to 15	1.42	0.2	1.49	0.8	5.96
	5.25	15 to 20	1.51	0.2	1.59	0.8	6.34
	5.25	20 to 30	1.64	0.2	1.72	0.8	6.89
	5.25	30 to 50	1.83	0.2	1.92	0.8	7.69
38 to 34, 31 to 29	10.5	up to 10	1.31	0.2	2.75	0.8	11.00
	10.5	10 to 15	1.42	0.2	2.98	0.8	11.93
	10.5	15 to 20	1.51	0.2	3.17	0.8	12.68
	10.5	20 to 30	1.64	0.2	3.44	0.8	13.78
	10.5	30 to 50	1.83	0.2	3.84	0.8	15.37
33,32 & 28	11.25	up to 10	1.31	0.2	2.95	0.8	11.79
	11.25	10 to 15	1.42	0.2	3.20	0.8	12.78
	11.25	15 to 20	1.51	0.2	3.40	0.8	13.59
	11.25	20 to 30	1.64	0.2	3.69	0.8	14.76
	11.25	30 to 50	1.83	0.2	4.12	0.8	16.47
27	6	up to 10	1.31	0.2	1.57	0.8	6.29
	6	10 to 15	1.42	0.2	1.70	0.8	6.82
	6	15 to 20	1.51	0.2	1.81	0.8	7.25
	6	20 to 30	1.64	0.2	1.97	0.8	7.87
	6	30 to 50	1.83	0.2	2.20	0.8	8.78

B) Wind from North to South – Internal Suction

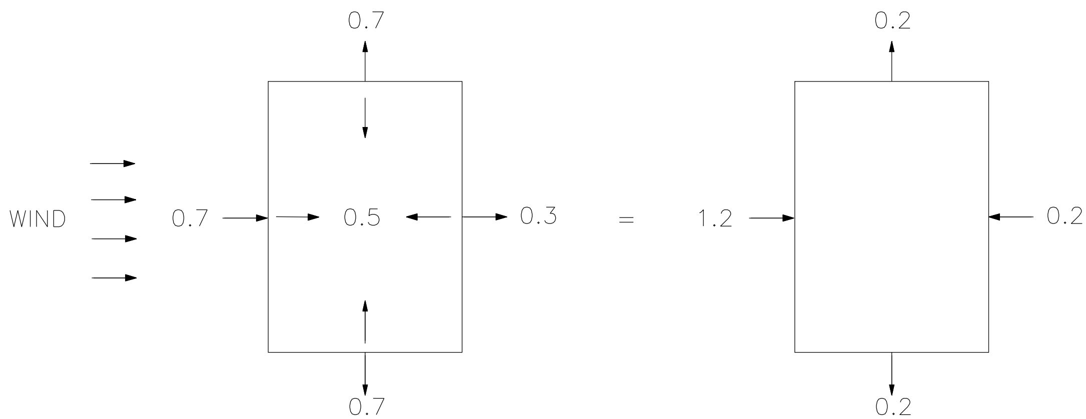


Fig. 4.25 Pressure Diagram- Wns2

Table 4.6 wind load on column – Wns2

Col No.	Tributary Width (m)	Ht. (m)	Pz (kN/m^2)	A - Row		C - Row	
				Cf	udl (kN/m)	Cf	udl (kN/m)
39	5.25	up to 10	1.31	1.2	8.25	-0.2	-1.38
	5.25	10 to 15	1.42	1.2	8.95	-0.2	-1.49
	5.25	15 to 20	1.51	1.2	9.51	-0.2	-1.59
	5.25	20 to 30	1.64	1.2	10.33	-0.2	-1.72
	5.25	30 to 50	1.83	1.2	11.53	-0.2	-1.92
38 to 34, 31 to 29	10.5	up to 10	1.31	1.2	16.51	-0.2	-2.75
	10.5	10 to 15	1.42	1.2	17.89	-0.2	-2.98
	10.5	15 to 20	1.51	1.2	19.03	-0.2	-3.17
	10.5	20 to 30	1.64	1.2	20.66	-0.2	-3.44
	10.5	30 to 50	1.83	1.2	23.06	-0.2	-3.84
33,32 & 28	11.25	up to 10	1.31	1.2	17.69	-0.2	-2.95
	11.25	10 to 15	1.42	1.2	19.17	-0.2	-3.20
	11.25	15 to 20	1.51	1.2	20.39	-0.2	-3.40
	11.25	20 to 30	1.64	1.2	22.14	-0.2	-3.69
	11.25	30 to 50	1.83	1.2	24.71	-0.2	-4.12
27	6	up to 10	1.31	1.2	9.43	-0.2	-1.57
	6	10 to 15	1.42	1.2	10.22	-0.2	-1.70
	6	15 to 20	1.51	1.2	10.87	-0.2	-1.81
	6	20 to 30	1.64	1.2	11.81	-0.2	-1.97
	6	30 to 50	1.83	1.2	13.18	-0.2	-2.20

C) Wind from South to North – Internal Pressure

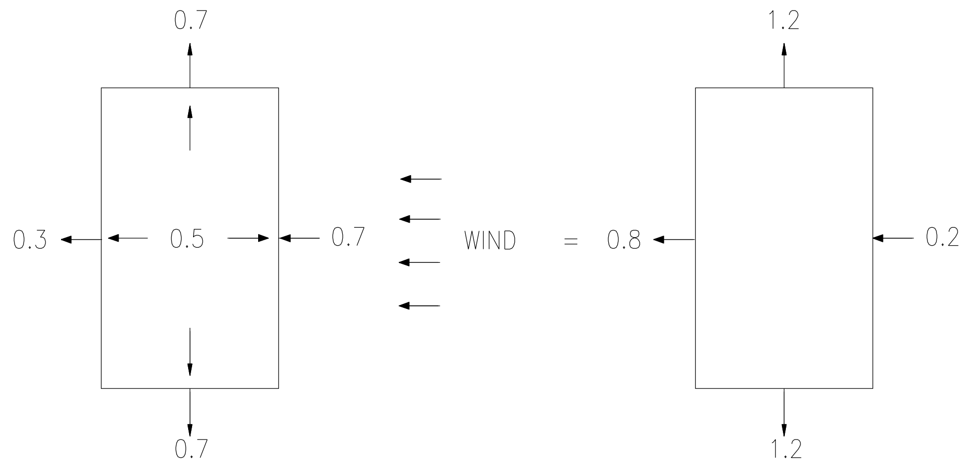


Fig. 4.26 Pressure Diagram- Wsn1

Table 4.7 wind load on column – Wsn1

Col No.	Tributary Width (m)	Ht. (m)	Pz (kN/m^2)	A - Row		C - Row	
				Cf	udl (kN/m)	Cf	udl (kN/m)
39	5.25	up to 10	1.31	-0.8	-5.50	-0.2	-1.38
	5.25	10 to 15	1.42	-0.8	-5.96	-0.2	-1.49
	5.25	15 to 20	1.51	-0.8	-6.34	-0.2	-1.59
	5.25	20 to 30	1.64	-0.8	-6.89	-0.2	-1.72
	5.25	30 to 50	1.83	-0.8	-7.69	-0.2	-1.92
38 to 34, 31 to 29	10.5	up to 10	1.31	-0.8	-11.00	-0.2	-2.75
	10.5	10 to 15	1.42	-0.8	-11.93	-0.2	-2.98
	10.5	15 to 20	1.51	-0.8	-12.68	-0.2	-3.17
	10.5	20 to 30	1.64	-0.8	-13.78	-0.2	-3.44
	10.5	30 to 50	1.83	-0.8	-15.37	-0.2	-3.84
33,32 & 28	11.25	up to 10	1.31	-0.8	-11.79	-0.2	-2.95
	11.25	10 to 15	1.42	-0.8	-12.78	-0.2	-3.20
	11.25	15 to 20	1.51	-0.8	-13.59	-0.2	-3.40
	11.25	20 to 30	1.64	-0.8	-14.76	-0.2	-3.69
	11.25	30 to 50	1.83	-0.8	-16.47	-0.2	-4.12
27	6	up to 10	1.31	-0.8	-6.29	-0.2	-1.57
	6	10 to 15	1.42	-0.8	-6.82	-0.2	-1.70
	6	15 to 20	1.51	-0.8	-7.25	-0.2	-1.81
	6	20 to 30	1.64	-0.8	-7.87	-0.2	-1.97
	6	30 to 50	1.83	-0.8	-8.78	-0.2	-2.20

D) Wind from South to North – Internal Suction

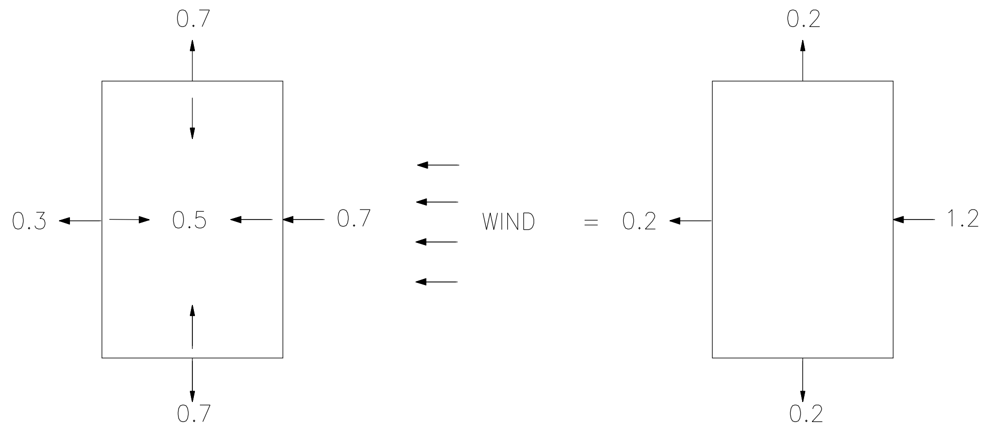


Fig. 4.27 Pressure Diagram- Wsn2

Table 4.8 wind load on column – Wsn2

Col No.	Tributary Width (m)	Ht. (m)	Pz (kN/m^2)	A - Row		C - Row	
				Cf	udl (kN/m)	Cf	udl (kN/m)
39	5.25	up to 10	1.31	0.2	1.38	-1.2	-8.25
	5.25	10 to 15	1.42	0.2	1.49	-1.2	-8.95
	5.25	15 to 20	1.51	0.2	1.59	-1.2	-9.51
	5.25	20 to 30	1.64	0.2	1.72	-1.2	-10.33
	5.25	30 to 50	1.83	0.2	1.92	-1.2	-11.53
38 to 34, 31 to 29	10.5	up to 10	1.31	0.2	2.75	-1.2	-16.51
	10.5	10 to 15	1.42	0.2	2.98	-1.2	-17.89
	10.5	15 to 20	1.51	0.2	3.17	-1.2	-19.03
	10.5	20 to 30	1.64	0.2	3.44	-1.2	-20.66
	10.5	30 to 50	1.83	0.2	3.84	-1.2	-23.06
33,32 & 28	11.25	up to 10	1.31	0.2	2.95	-1.2	-17.69
	11.25	10 to 15	1.42	0.2	3.20	-1.2	-19.17
	11.25	15 to 20	1.51	0.2	3.40	-1.2	-20.39
	11.25	20 to 30	1.64	0.2	3.69	-1.2	-22.14
	11.25	30 to 50	1.83	0.2	4.12	-1.2	-24.71
27	6	up to 10	1.31	0.2	1.57	-1.2	-9.43
	6	10 to 15	1.42	0.2	1.70	-1.2	-10.22
	6	15 to 20	1.51	0.2	1.81	-1.2	-10.87
	6	20 to 30	1.64	0.2	1.97	-1.2	-11.81
	6	30 to 50	1.83	0.2	2.20	-1.2	-13.18

E) Wind from East to West - Internal Pressure

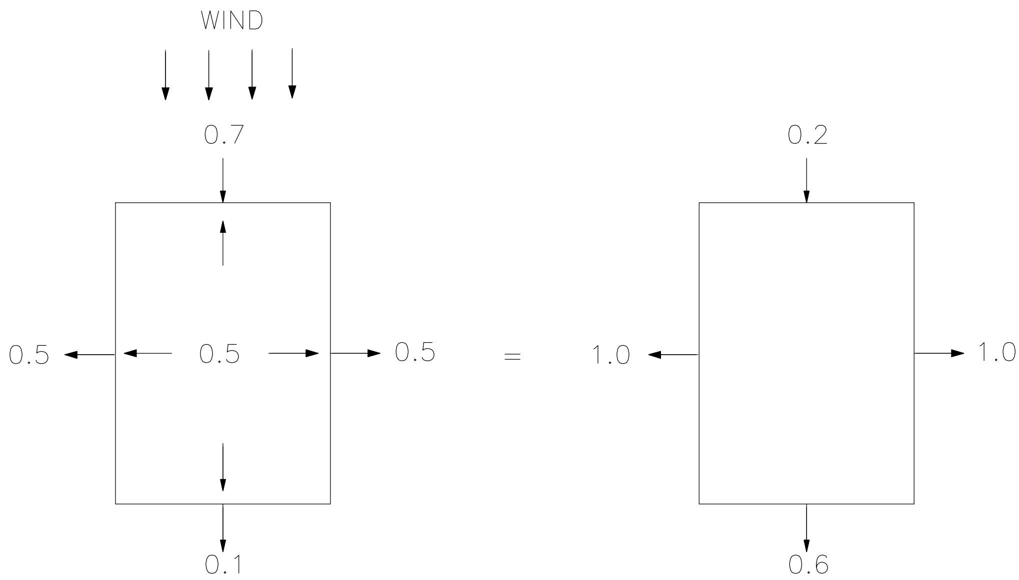


Fig. 4.28 Pressure Diagram- Wew1

Table 4.9 wind load on column – Wew1

Col No.	Tributary Width (m)	Ht. (m)	Pz (kN/m^2)	Cf	udl (kN/m)
A	4	up to 10	1.31	0.2	1.05
	4	10 to 15	1.42	0.2	1.14
	4	15 to 20	1.51	0.2	1.21
	4	20 to 30	1.64	0.2	1.31
	4	30 to 50	1.83	0.2	1.46
G1, G2, G3, B	8	up to 10	1.31	0.2	2.10
	8	10 to 15	1.42	0.2	2.27
	8	15 to 20	1.51	0.2	2.42
	8	20 to 30	1.64	0.2	2.62
	8	30 to 50	1.83	0.2	2.93
G4, C	6	up to 10	1.31	0.2	1.57
	6	10 to 15	1.42	0.2	1.70
	6	15 to 20	1.51	0.2	1.81
	6	20 to 30	1.64	0.2	1.97
	6	30 to 50	1.83	0.2	2.20

F) Wind from East to West - Internal Suction

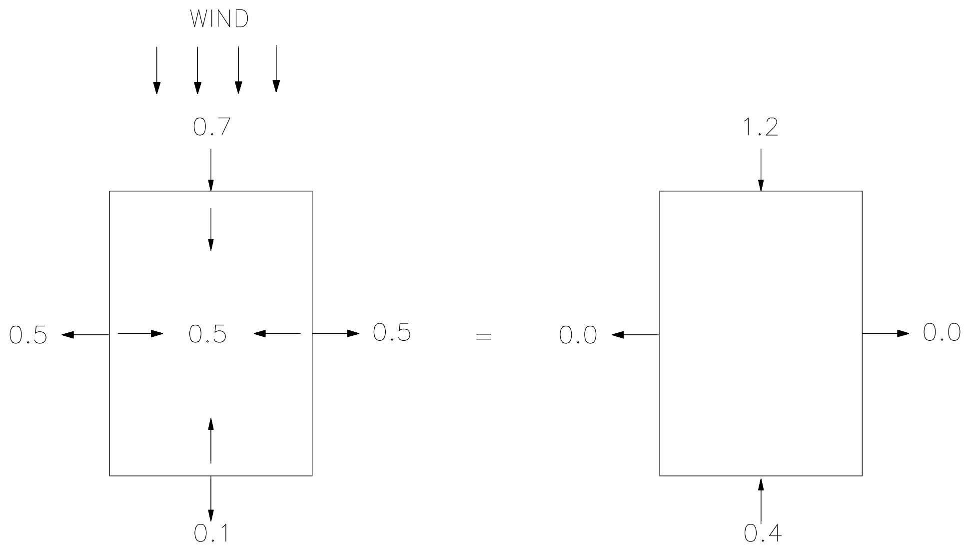


Fig. 4.29 Pressure Diagram- Wew2

Table 4.10 wind load on column – Wew1

Col No.	Tributary Width (m)	Ht. (m)	Pz (kN/m^2)	Cf	udl (kN/m)
A	4	up to 10	1.31	1.2	6.29
	4	10 to 15	1.42	1.2	6.82
	4	15 to 20	1.51	1.2	7.25
	4	20 to 30	1.64	1.2	7.87
	4	30 to 50	1.83	1.2	8.78
G1, G2, G3, B	8	up to 10	1.31	1.2	12.58
	8	10 to 15	1.42	1.2	13.63
	8	15 to 20	1.51	1.2	14.50
	8	20 to 30	1.64	1.2	15.74
	8	30 to 50	1.83	1.2	17.57
G4, C	6	up to 10	1.31	1.2	9.43
	6	10 to 15	1.42	1.2	10.22
	6	15 to 20	1.51	1.2	10.87
	6	20 to 30	1.64	1.2	11.81
	6	30 to 50	1.83	1.2	13.18

G) Wind from West to East- Internal Pressure

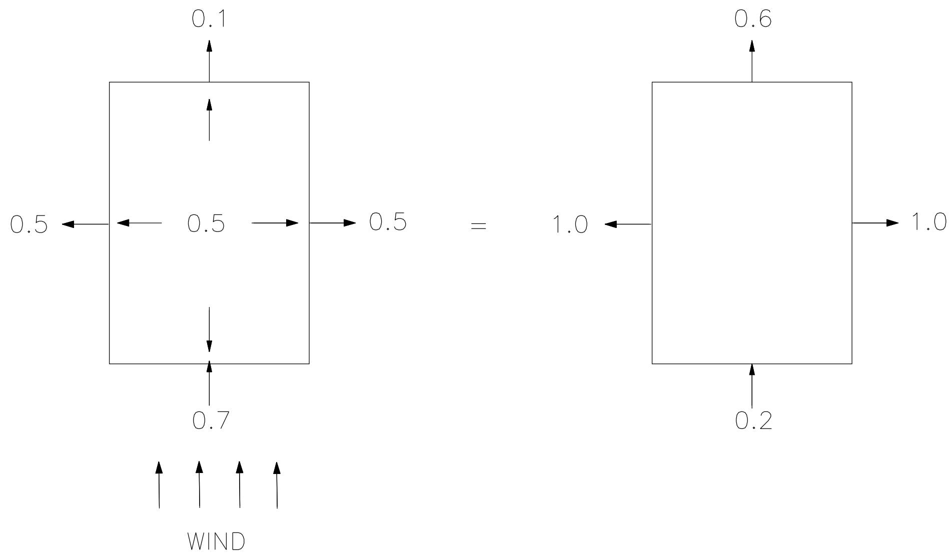


Fig. 4.30 Pressure Diagram- Wwe1

Table 4.11 wind load on column – Wwe1

Col No.	Tributary Width (m)	Ht. (m)	Pz (kN/m^2)	Cf	udl (kN/m)
A	4	up to 10	1.31	-0.6	-3.14
	4	10 to 15	1.42	-0.6	-3.41
	4	15 to 20	1.51	-0.6	-3.62
	4	20 to 30	1.64	-0.6	-3.94
	4	30 to 50	1.83	-0.6	-4.39
G1, G2, G3, B	8	up to 10	1.31	-0.6	-6.29
	8	10 to 15	1.42	-0.6	-6.82
	8	15 to 20	1.51	-0.6	-7.25
	8	20 to 30	1.64	-0.6	-7.87
	8	30 to 50	1.83	-0.6	-8.78
G4, C	6	up to 10	1.31	-0.6	-4.72
	6	10 to 15	1.42	-0.6	-5.11
	6	15 to 20	1.51	-0.6	-5.44
	6	20 to 30	1.64	-0.6	-5.90
	6	30 to 50	1.83	-0.6	-6.59

H) Wind from West to East- Internal Suction

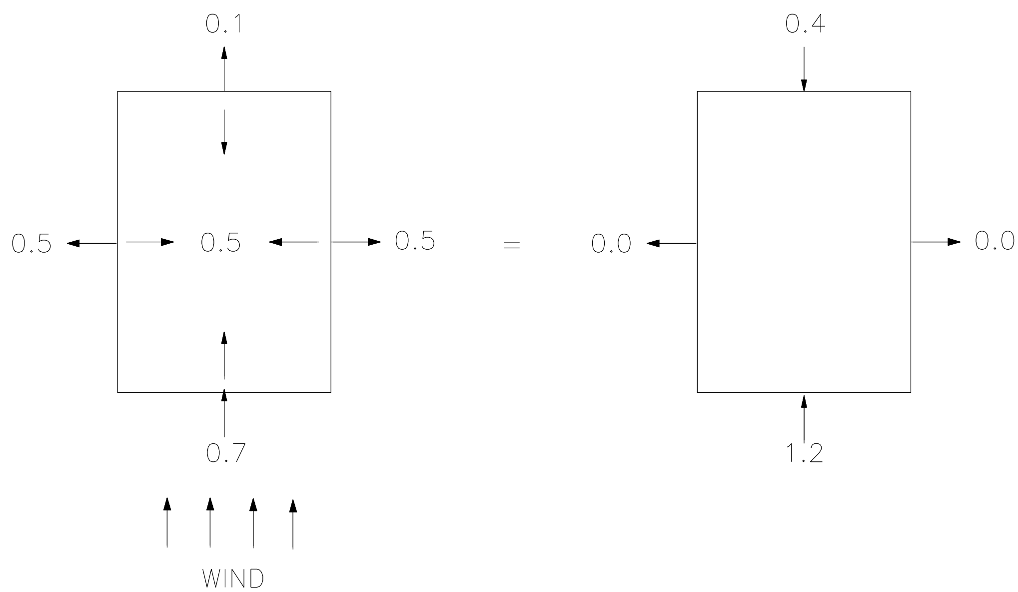


Fig. 4.31 Pressure Diagram- Wwe2

Table 4.12 wind load on column – Wwe2

Col No.	Tributary Width (m)	Ht. (m)	Pz (kN/m^2)	Cf	udl (kN/m)
A	4	up to 10	1.31	0.4	2.10
	4	10 to 15	1.42	0.4	2.27
	4	15 to 20	1.51	0.4	2.42
	4	20 to 30	1.64	0.4	2.62
	4	30 to 50	1.83	0.4	2.93
G1, G2, G3, B	8	up to 10	1.31	0.4	4.19
	8	10 to 15	1.42	0.4	4.54
	8	15 to 20	1.51	0.4	4.83
	8	20 to 30	1.64	0.4	5.25
	8	30 to 50	1.83	0.4	5.86
G4, C	6	up to 10	1.31	0.4	3.14
	6	10 to 15	1.42	0.4	3.41
	6	15 to 20	1.51	0.4	3.62
	6	20 to 30	1.64	0.4	3.94
	6	30 to 50	1.83	0.4	4.39

4.4.6 Seismic Load

The site specific design acceleration spectra shown in Fig. 4.1is used in place of the response acceleration spectra given in IS: 1893.

Table 4.13 Horizontal seismic acceration coefficient

T	Sa/g	T	Sa/g	T	Sa/g
0.00	1.00	0.13	3.80	2.27	1.04
0.03	1.00	0.13	3.80	2.37	1.00
0.04	1.31	0.60	3.80	2.47	0.96
0.05	1.62	0.62	3.80	2.57	0.92
0.06	1.86	0.63	3.74	2.67	0.89
0.06	1.89	0.67	3.54	2.77	0.85
0.06	1.92	0.77	3.08	2.87	0.82
0.06	1.95	0.87	2.73	2.97	0.80
0.06	1.98	0.97	2.44	3.07	0.77
0.07	2.07	1.07	2.22	3.17	0.75
0.07	2.21	1.17	2.03	3.27	0.72
0.07	2.24	1.27	1.87	3.37	0.70
0.07	2.33	1.37	1.73	3.47	0.68
0.08	2.63	1.47	1.61	3.54	0.60
0.09	2.92	1.57	1.51	3.56	0.60
0.10	3.21	1.67	1.42	3.67	0.65
0.11	3.50	1.77	1.34	3.77	0.61
0.12	3.67	1.87	1.27	3.87	0.58
0.12	3.70	1.97	1.20	3.97	0.55
0.12	3.76	2.07	1.14	4.02	0.54
0.12	3.80	2.17	1.09		

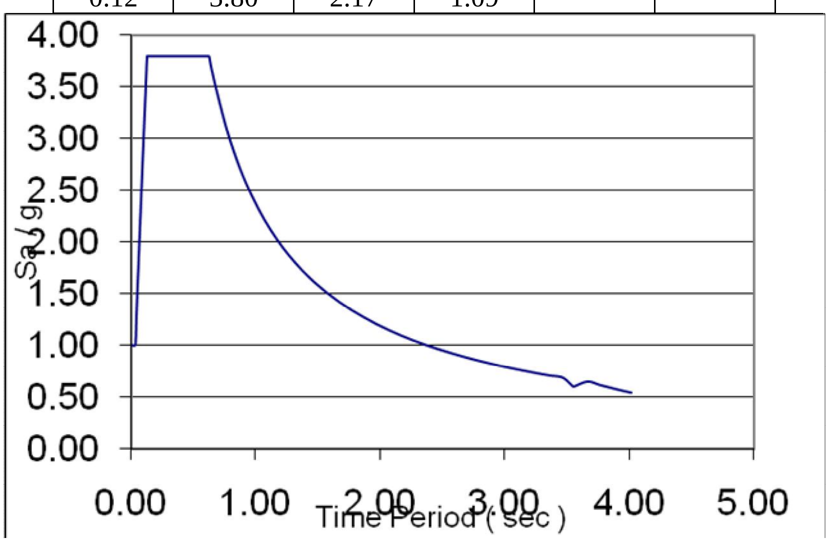


Fig. 4.32 Site Specific Response Spectra

Multiplying Factor to the weight of the Building for calculation of seismic force is given as 0.063.

The site specific acceleration spectra along with multiplying factor includes the effect of the seismic environment of the site, the importance factor related to the structures and the response reduction factor. Hence, the design spectra do not require any further consideration of the zone factor (Z), the importance factor (I) and response reduction factor (R) as used in the IS: 1893.
Site Specific Parameters are used in Seismic analysis of the Building. Hinges are created in the structure to get the value of lumped mass, which is applied in X and Z directions.

4.4.7 Crane Load

Design considerations for Vertical, Longitudinal and Lateral forces will be as follows:

1. Vertical Load (Wheel Load) will be calculated considering maximum approach of crane hook towards the building columns. A vertical impact load of 25% of wheel load will be considered.
2. Longitudinal force parallel to crane runway girder will be 5% of static wheel load on each rail.
3. Lateral crane surge force perpendicular to the crane runway girder will be 10% of (maximum lifted weight + trolley weight) on each rail. For design of monorail beams, a vertical impact load of 25% of (maximum lifted weight + hoist weight) will be considered. Lateral surge shall be 20% of (maximum lifted weight + hoist weight) will be considered.

4.4.8 Temperature Load

For temperature loading, the total temperature variation shall be considered as 2/3 of the average maximum annual variation in temperature. The average maximum annual variation in temperature for this purpose shall be taken as the difference between the mean of the daily minimum temperature during coldest month of the year and mean of daily maximum temperature during the hottest month of the year. Structure shall be designed to withstand stresses due to 50% of the total temperature variation. Following temperature data will be considered as per “Project site information”
Lowest monthly mean of daily minimum temperature = 9.1°C
Highest monthly mean of daily maximum temperature = 42.1°C.

Hence, the structures shall be designed to withstand stresses for a variation of 11°C.

4.4.9 Contingency Load

Contingency loads are applied to consider the uncertainty in the loading. Loads are applied in the form of Point Loads at the top of column. 100kN load is applied on all the A Row columns, where as 200kN load is applied on all the B and C Row columns.

4.5 SUMMARY

Structural modeling of Turbine Building in STAADPro software is done. Geometry, loading and structural sizes are taken from NTPC – Barh Project details. Member definitions used in modeling, loads and combination of loads considered are presented in this chapter. Analysis results are presented in chapter 5 of the report.

5. STRUCTURAL ANALYSIS AND DESIGN

5.1 GENERAL

This chapter briefly outlines the methodology adopted for analysis and design of Turbine Building. Analysis of the building is done using STAADPro software. Design parameters are manually entered for members and design is done in STAADPro.

5.2 DESIGN CRITERIA AND SPECIFICATIONS

Design of Turbine Building is done in accordance with following codes and standards.

- IS:800-1984 - Code of Practice for General construction in Steel
- IS:1893 – 2002 - Code of practice for criteria for earthquake resistant design of structures
- IS:875 (part I to III) –1987 - Code of practice for design loads (other than earthquake) for buildings and structures

5.2.1 Materials for Construction

Following properties of material shall be used in design:

Structural members shall be of Grade A of IS 2062,

For thickness less than 20mm	: Fy = 250 Mpa
For thickness between 20mm and 40mm	: Fy = 240 Mpa
Thickness greater than 40mm	: Fy = 230 Mpa

For all members,

- Unit weight : 7850 kg/m3
- Modulus of Elasticity : 2.0×10^5 MPa
- Coefficient of thermal expansion : 12×10^{-6} / °C

5.2.2 Loads and Load Combinations

Load cases considered for analysis and design are listed in Table 4.4. Load Combinations used in design are shown in Appendix A -1.

5.2.3 Acceptance Criteria

a. Stress ratio under normal condition for columns shall be less than 1.
b. 33% increase in stresses has been permitted environmental conditions. In STAAD.Pro design of members is done for normal conditions and environmental conditions separately.
c. Vertical static deflection at any section of member under normal working condition has been limited to span/325.
d. Horizontal deflection of the structure has been limited to H/325, where H is the height of structure at a point of consideration.

Fig. 5.1 shows direction of local axes for a beam member in STAADPro. Longitudinal axis of the member is X-X, axis along depth of the member is Y-Y and other being Z-Z axis.

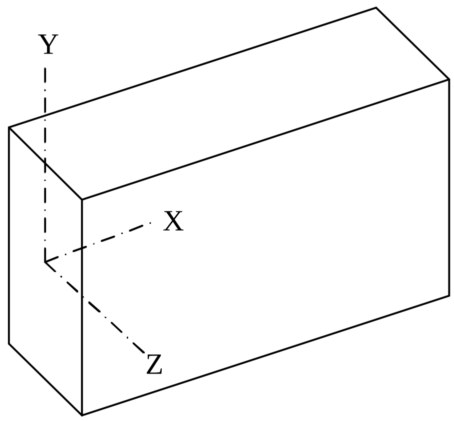


Fig. 5.1 Local axis for beam member in STAADPro

5.3 ANALYTICAL RESULTS

Three dimensional modeling of the Building is done in STAADPro. Building is 129m long and 48m wide; Height of structure is 38m in AB bay and 50m in BC bay. There are total 13 grids in transverse direction and 7 grids in longitudinal direction. Analytical results are presented in this section.

5.3.1 Analytical Results for transverse frame

Fig. 5.2 shows Bending Moment diagram for DL case. It is shown along transverse frame at grid 36.Bending moment values for columns are shown in Table 5.1. Values of Bending moment for BC bay beams are shown in Table 5.2.

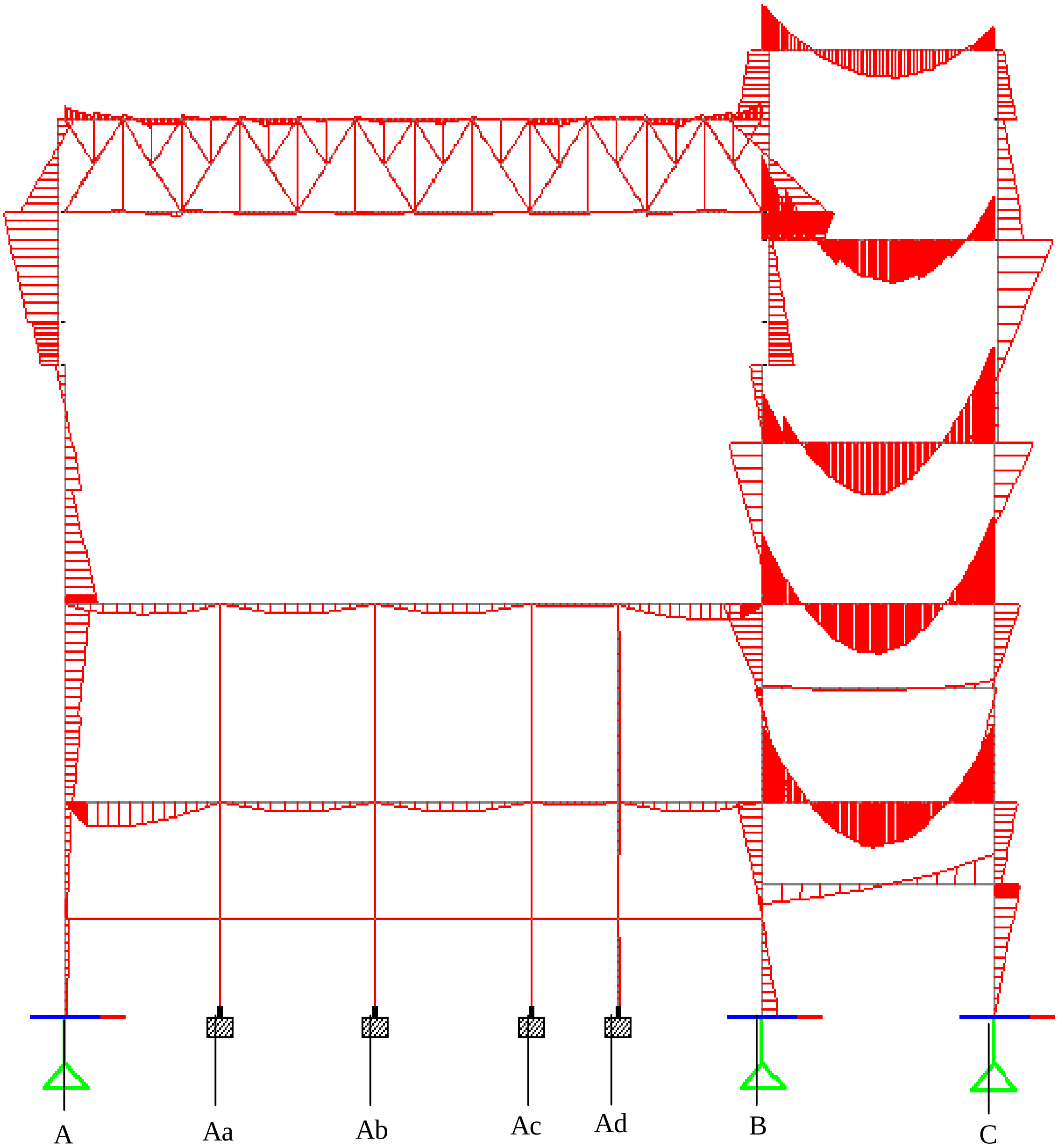


Fig. 5.2 BMD for DL case

Table 5.1 BM in Column for DL case

Column	Maxm +ve	Elevation	Maxm -ve	Elevation
A	621.5	33.6	-340.12	17.0
B	435.8	23.6	-732.86	33.6
C	456.4	16.6	-631.75	32.4
Aa	0.29	3.1	-6.33	8.1
Ab	3.75	3.1	-4.57	8.1
Ac	0.76	3.1	-3.22	8.1
Ad	1.32	3.1	-7.3	8.1

Table 5.2 Values of BM in BC bay for DL case

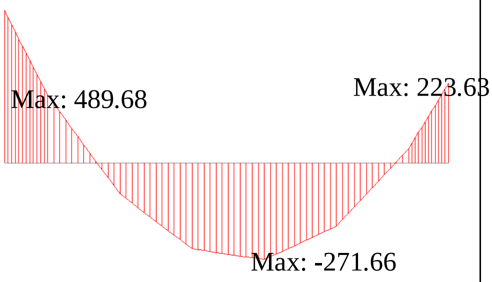
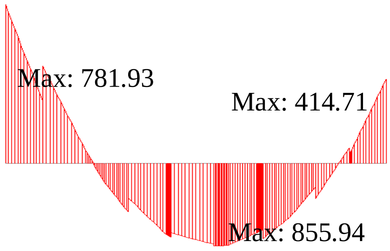
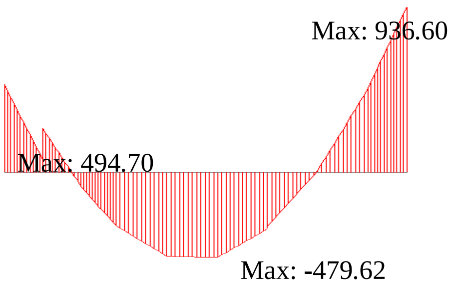
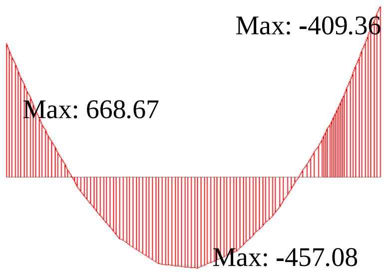
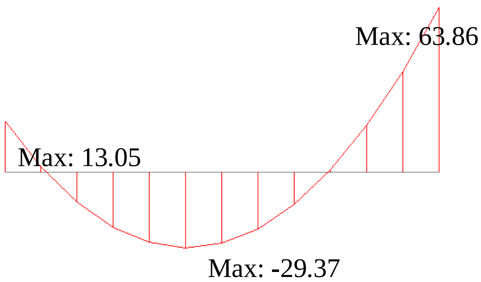
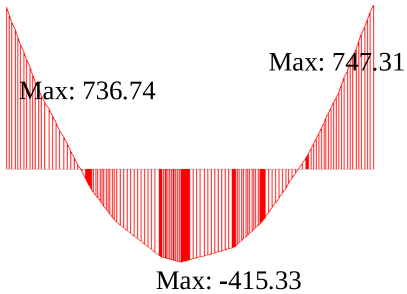
Elevation	BMD	Elevation	BMD
40.8		32.6	
23.8		17.0	
13.05		8.5	

Table 5.3 gives maximum vertical deflection values for beam along grid 36. Allowable deflection is taken as span/325 as per IS 800:1984.

Table 5.3 Deflection check for transverse frame

Beam No.	Maximum Deflection (mm)	Location (m)	L/C	Allowable Deflection (mm)	Remark
5995	12.54	5.50	103	36.92	OK
6075	9.55	5.22	105	36.92	OK
5906	9.92	4.85	105	36.92	OK
7451	8.07	5.00	105	36.92	OK
4478	4.00	0.00	101	36.92	OK
5726	7.73	6.00	101	36.92	OK
4438	4.00	0.00	101	36.92	OK
3022	6.04	3.98	104	24.46	OK
1254	8.28	3.97	105	24.46	OK
6085	8.28	3.97	105	24.46	OK
3010	21.56	4.03	106	24.76	OK
1225	15.42	4.02	112	24.76	OK
6087	15.42	4.02	112	24.76	OK
3011	21.09	4.02	104	24.76	OK
1226	15.12	4.02	101	24.76	OK
6089	15.12	4.02	101	24.76	OK
3029	10.40	2.27	104	14.00	OK
2910	7.46	2.27	101	14.00	OK
6091	7.30	2.27	101	14.00	OK
3030	7.42	4.78	108	22.76	OK
2911	3.86	3.70	104	22.76	OK
6092	3.86	3.70	104	22.76	OK

Fig. 5.5 shows Bending Moment diagram for Wns1 case. It is shown along transverse frame at grid 36.Bending moment values for columns are shown in Table 5.4. Values of Bending moment for BC bay beams are shown in Table 5.5.

Fig, 5.4 gives deflected shape of the cross frame for Wns1 case. Values of horizontal deflection at various levels are presented in Table 5.6.

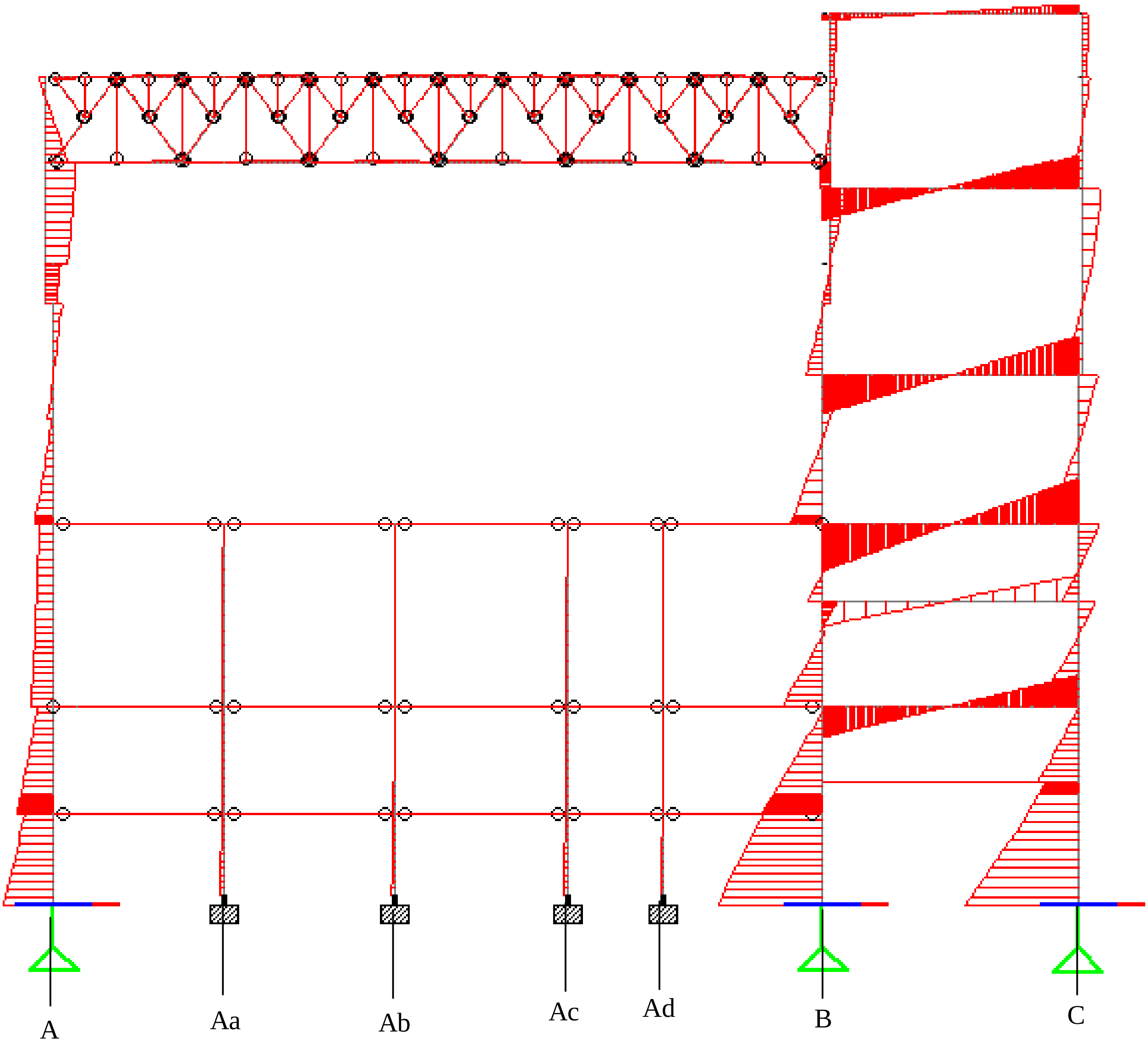


Fig. 5.3 BMD for Wns1 case

Table 5.4 BM in Column for Wns1 case

Column	Maxm +ve	Elevation	Maxm -ve	Elevation
A	1209.6	-1.2	-731.0	33.6
B	2536.0	-1.2	-570.5	23.6
C	2777.0	-1.2	-461.1	32.4
Aa	82.2	-1.2	-	-
Ab	82.7	-1.2	-	-
Ac	86.05	-1.2	-	-
Ad	90.4	-1.2	-	-

Table 5.5 Values of BM for Wns1 case

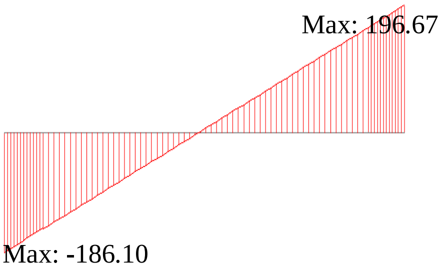
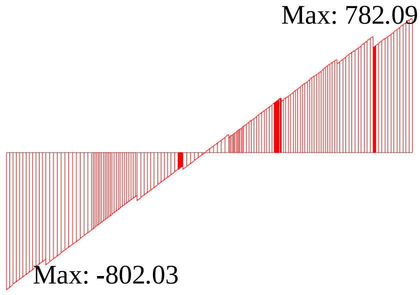
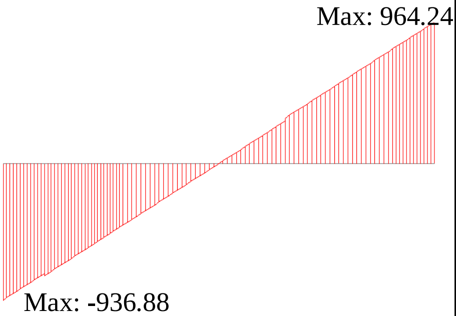
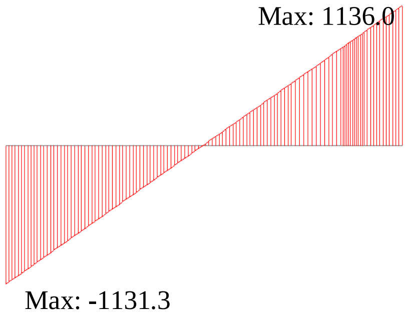
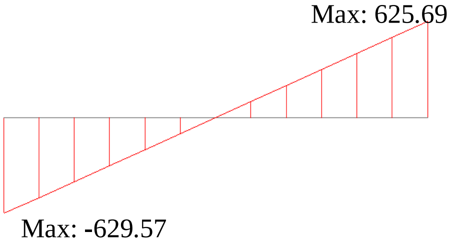
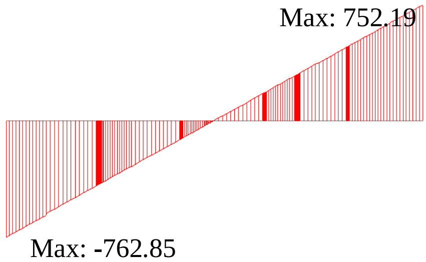
Elevation	BMD	Elevation	BMD
40.8		32.6	
23.8		17.0	
13.05		8.5	

Table 5.6 Horizontal Displacement for Wns1 case

A Row			B Row			C Row		
Node	Elevation	Disp.	Node	Elevation	Disp.	Node	Elevation	Disp.
111	37.6	22.49	590	40.6	26.64	594	40.6	26.64
98	33.6	24.83	276	37.6	25.01	427	37.6	25.01
85	28.85	23.19	790	33.6	22.25	414	32.6	21.68
72	27	21.38	250	28.85	18.93	375	23.6	15.04
59	21.6	15.42	224	23.6	15	362	16.6	9.81
46	16.6	10.15	211	16.6	9.8	357	13.05	7.35
41	11.8	6.04	2137	13.05	7.32	343	8.1	3.92
25	8.1	3.47	206	11.6	6.28	337	4.5	1.82
1662	4	1.25	186	3.1	1.04	1717	4	1.57
4	-1.2	0	288	-1.2	0	439	-1.2	0

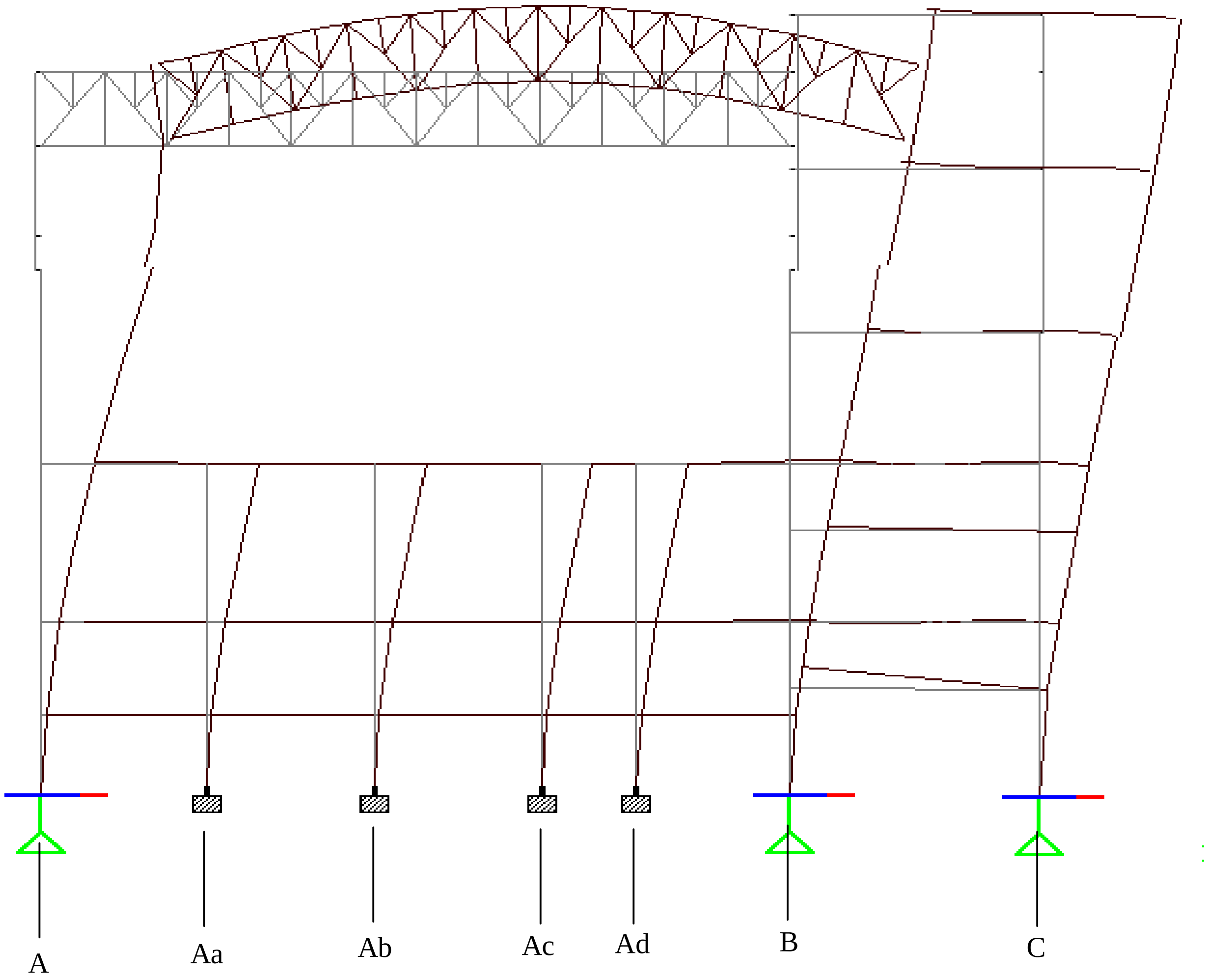


Fig. 5.4 Deflected shape for Wns1 case

Horizontal deflection check for the structure is presented here,

Maximum deflection in X direction = 35.01mm @ node 561 (50.0m lvl)

Allowable Deflection = Height/325

= 50000/325

= 153.84mm

Maximum deflection in Z direction = 31.31mm @ node 3893 (20.0m lvl)

Allowable Deflection = Height/325

= 20000/325

= 61.53mm

Maxm Deflection < Allowable Deflection in both directions……… hence OK.

5.3.2 Analytical Results for longitudinal frame

BMD along longitudinal frame A is presented in Fig. 5.5 and Fig. 5.6.

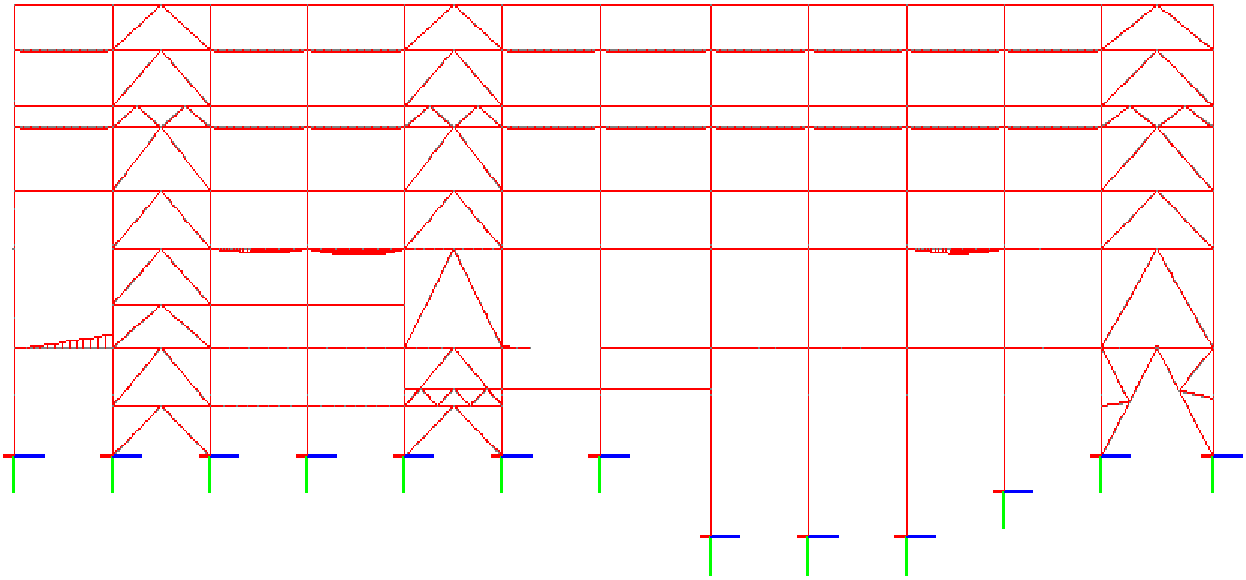


Fig. 5.5 BMD for DL case

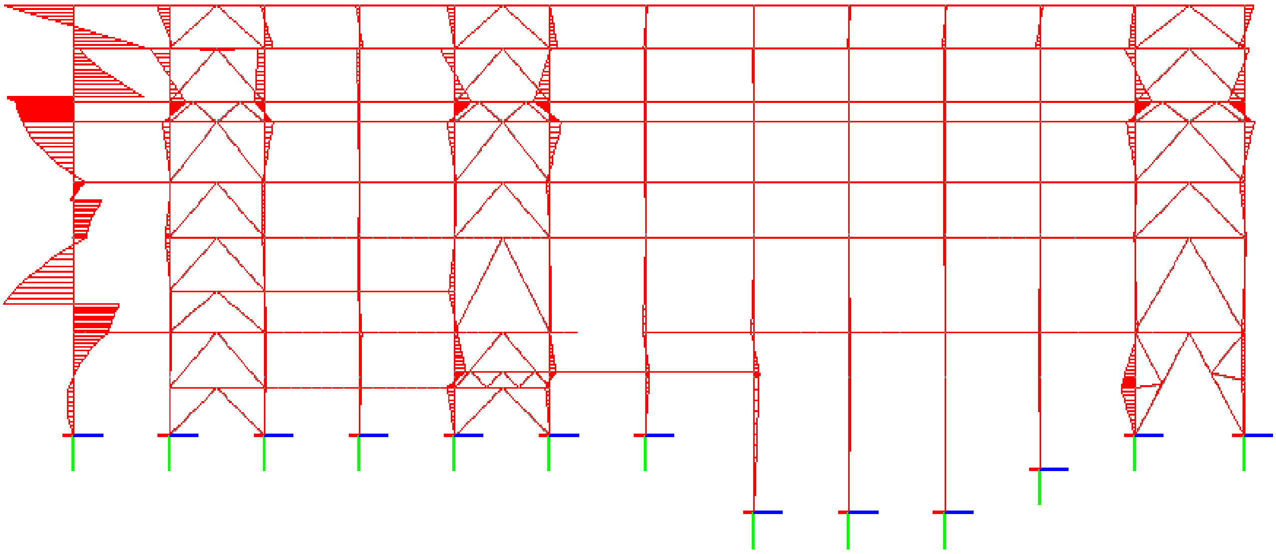


Fig. 5.6 BMD for Wew1 case

Table 5.7 gives governing load combinations for member design and design forces for the section.

Table 5.7 Design Forces

Sr. No.	Beam No.	Governing Load Comb.	Fx	Fy	Fz	My	Mz
1	A Row - 37 Grid						
	10020	121	4877.7	549.9	6.8	29.1	3137.9
	10024	131	4327.5	219.9	3.8	13.4	1358.1
	10029	142	1106.4	263.0	24.1	70.1	1157.8
2	B Row - 35 Grid						
	10251	142	9409.0	371.8	78.8	338.7	2839.0
	10254	142	7852.6	366.0	110.0	258.7	1739.1
	10262	131	1717.3	451.7	82.5	120.6	1288.7
	10264	153	840.5	435.4	42.3	107.1	990.1
3	C Row - 36 Grid						
	10423	113	7555.1	758.5	22.8	119.6	4415.8
	10425	111	7401.4	679.5	10.8	131.0	1770.1
	10428	131	2472.1	473.7	37.7	283.9	2175.5
	10430	153	884.8	246.6	86.3	254.8	969.2
4	Beam at 8.5m level						
	6856	142	-131.6	198.9	0.0	0.0	522.1
	6945	142	-34.9	312.1	0.0	0.0	819.2
	4103	119	-94.7	168.9	0.0	0.0	380.1
5	Beam at 17.0m level						
	7701	111	31.9	320.8	0.4	4.6	932.6
	6399	119	0.0	324.8	6.0	32.4	1696.3
	6352	153	398.7	352.1	37.3	279.8	1148.8
6	Beam at 24.0m level						
	5893	131	-16.5	149.4	0.0	0.0	392.2
	5899	124	-191.4	152.4	0.0	0.0	400.0
7	Beam at 32.8m level						
	6082	139	324.6	1.9	0.0	0.0	2.2
	6059	111	4.2	156.6	0.0	0.0	411.0
8	Auxiliary Column						
	5645	121	5392.1	27.3	218.9	583.2	131.2
	5637	151	4909.6	39.5	258.7	690.6	165.8
	5643	151	3067.8	29.2	235.2	610.5	143.8
9	Vertical Bracing						
	251	124	691.3	6.1	0.0	0.0	10.3
	252	124	-615.7	6.1	0.0	0.0	10.3

5.4 DESIGN OF STRUCTURE

All members have been designed to satisfy strength and serviceability criteria of IS: 800-1984. Using the STAAD.Pro design option, all the structural members have been designed. Parameters for the steel design have been entered manually into STAAD.Pro.

5.4.1 Design Parameters

Parameters entered in software are described in Table 5.5.

Table 5.8 Design Parameters

Parameter	Description
ky	Effective Length Factor applied to the member along minor axis of the member. It is based on the end restraints provided. Value is taken from Table 5.2 of IS 800:1984.
kz	Effective Length Factor applied to the member along minor axis of the member. It is based on the end restraints provided. Value is taken from Table 5.2 of IS 800:1984. In case of stepped column, this value is calculated as per Appendix D-1 of IS 800:1984
ly	Length in local Y direction to calculate slenderness ratio.
lz	Length in local Y direction to calculate slenderness ratio.
UNL	Unrestrained member length. It is lower of ly and lz value.
dj	Node Nos. between which deflection of the beam is to be calculated.
DFF	Factor provided for deflection check of beams. DFF = 325 is applied for keeping deflection limit up to length/ 325
Main	Limit of Slenderness ratio for member.

5.4.2 Design in STAADPro.

Designing of structure is done in STAADPro software. Design parameters are entered for members in software and by CHECK CODE command stress ratio for provided member is checked.

Table 5.6 gives summary of stress ratio results for different members. Section properties shown in the table are as per given in NTPC – Barh 3 X 660 MW project drawings.

Table 5.9 Design Summary

Sr. No.	Beam No.	Section Property	Stress Ratio		L/C	
			Basic	Env.	Basic	Env.
1	A Row - 37 Grid					
	10020	1.8_1_3225	0.566	0.584	104	121
	10024	1.8_0.9_3220	0.536	0.488	101	131
	10029	1.1_0.8_2520	0.517	0.566	108	142
2	B Row - 35 Grid					
	10251	1.9_1.1_5040	0.528	0.567	108	142
	10253	1.9_1_4025	0.726	0.732	106	142
	10262	1.1_.9_2520	0.517	0.536	101	131
	10264	1.1_.6_2016	0.577	0.65	102	153
3	C Row - 36 Grid					
	10423	1.9_1.1_5040	0.369	0.547	103	113
	10425	1.9_1_4025	0.56	0.602	101	111
	10428	1.5_.9_2520	0.499	0.624	101	131
	10430	1.5_.6_2016	0.366	0.884	101	153
4	Beam at 8.5m level					
	6856	.6_.3_2512	0.775	0.77	108	142
	6945	.7_.35_2512	0.838	0.839	104	142
	4103	ISMB 600	0.852	1.21	103	119
5	Beam at 17.0m level					
	7701	.8_.3_3212	0.778	0.787	101	111
	6399	1.2_.5_3216	0.742	0.76	102	119
	6352	.8_.4_3216	0.752	1.18	106	153
6	Beam at 24.0m level					
	5893	ISMB 600	0.62	0.62	101	131
	5899	ISMB 600	0.943	0.95	106	124
7	Beam at 32.8m level					
	6082	ISMB 500	0.24	0.26	102	139
	6059	ISMB 600	0.65	0.65	101	111
8	Auxiliary Column					
	5645	.5_.5_.04	0.68	0.731	104	121
	5637	.5_.5_.04	0.634	0.759	104	151
	5643	.5_.5_.04	0.49	0.576	104	151
9	Vertical Bracing					
	251	4025_12	0.173	0.195	106	124
	252	4025_12	0.148	0.168	106	124

Table 5.10 Design Forces for Revised Section

Sr. No.	Beam No.	L/C	Fx	Fy	Fz	My	Mz
1	A Row - 37 Grid						
	10020	14	5474.0	381.3	1.1	4.6	1635.5
	10024	131	4058.6	267.5	1.0	5.7	1297.1
	10029	143	1101.3	283.8	31.0	86.1	763.3
2	B Row - 35 Grid						
	10251	142	9403.6	344.7	57.4	247.0	2115.1
	10254	142	7942.0	441.2	99.7	239.7	1835.9
	10262	153	1863.5	453.1	96.1	101.5	794.0
	10264	153	873.2	504	73.6	150.6	1022
3	873.2						
	10423	113	7399.0	602.1	13.9	72.8	2838.0
	10425	111	7285.3	523.0	13.5	87.1	1587.0
	10428	131	2431.5	480.9	12.4	85.8	2043.0
	10430	153	802.8	250.5	75.0	223.6	718.8
4	Beam at 8.5m level						
	6856	142	-120.6	196.6	0.0	0.0	515.8
	6945	141	-31.6	311.1	0.0	0.0	816.6
	4103	113	-111.0	168.9	0.0	0.0	380.1
5	Beam at 17.0m level						
	7701	111	32.1	308.1	1.5	10.4	866.9
	6399	119	0.0	315.8	7.3	39.2	1578.2
	6352	153	441.2	551.7	40.7	305.9	1146.2
6	Beam at 24.0m level						
	5893	119	78.8	147.0	0.0	0.0	385.9
	5899	124	-188.6	152.4	0.0	0.0	400.0
7	Beam at 32.8m level						
	6082	139	244.9	1.0	0.0	0.0	1.1
	6059	111	3.1	156.6	0.0	0.0	411.0
8	Auxiliary Column						
	5645	151	5431.7	47.0	309.3	820.9	200.9
	5637	151	4941.1	62.0	305.2	812.7	245.1
	5643	151	3087.7	39.4	327.1	849.3	190.1
9	Vertical Bracing						
	251	124	744.9	6.1	0.0	0.0	10.0
	252	124	-666.1	6.1	0.0	0.0	10.3

Table 5.11 Design Summary for Revised Section

Sr. No.	Beam No.	Section Property	Stress Ratio		L/C	
			Basic	Env.	Basic	Env.
1	A Row - 37 Grid					
	10020	1.5_.6_2518	0.863	0.873	104	121
	10024	1.5_.6_2518	0.876	0.845	101	131
	10029	.75_.6_3218	0.931	0.994	108	142
2	B Row - 35 Grid					
	10251	1.5_.9_4025	0.825	0.864	108	142
	10254	1.5_.9_4025	0.815	0.867	108	142
	10262	.75_.4_3225	0.809	0.935	101	131
	10264	.75_.4_3225	0.81	1.13	103	153
3	C Row - 36 Grid					
	10423	1.5_.8_4018	0.683	0.96	103	113
	10425	1.5_.8_3018	0.866	1.01	101	111
	10428	1.5_.6_2018	0.804	1.04	101	131
	10430	1_.4_1815	0.63	1.11	104	153
4	Beam at 8.5m level					
	6856	.6_.3_2512	0.775	0.77	108	142
	6945	.7_.35_2512	0.838	0.839	104	142
	4103	ISMB 600	0.852	1.21	103	119
5	Beam at 17.0m level					
	7701	.7_.35_2512	0.902	0.912	101	111
	6399	1_.4_4020	0.924	0.95	102	119
	6352	.8_.4_3216	0.752	1.18	106	153
6	Beam at 24.0m level					
	5893	ISMB 600	0.62	0.62	101	131
	5899	ISMB 600	0.943	0.95	106	124
7	Beam at 32.8m level					
	6082	ISMB 400	0.49	0.56	106	139
	6059	ISMB 600	0.65	0.65	101	111
8	Auxiliary Column					
	5645	.5_.5_.04	0.68	0.731	104	121
	5637	.5_.5_.04	0.634	0.759	104	151
	5643	.5_.5_.04	0.49	0.576	104	151
9	Vertical Bracing					
	251	4025_12	0.173	0.195	106	124
	252	4025_12	0.148	0.168	106	124

5.4.3 Revised sizes of members

Sizes of members provided in NTPC – Barh 3 X 660 MW project are revised based on the results of detailed analysis. 1.8m deep column along A Row and 1.9m deep columns are provided along B and C row in the project, which can be replaced by 1.5m column. Provided section is checked for stress ratio and vertical deflection of the structure is calculated. Deflection check for revised sizes is shown here.

Maximum deflection in X direction = 47.43mm @ node 558 (50.0m lvl)

Allowable Deflection = Height/325

= 50000/325

= 153.84mm

Maximum deflection in Z direction = 36.31mm @ node 3893 (20.0m lvl)

Allowable Deflection = Height/325

= 20000/325

= 61.53mm

Maxm Deflection < Allowable Deflection in both directions……… hence OK.

6. RESULTS BASED ON PARAMETRIC STUDY

6.1 GENERAL

This chapter gives behavior of structural members under different environmental loads. Analysis and design of Turbine Building for NTPC – Barh 3 X 660 MW is presented in chapter 5. Above mentioned structure have been designed taking 47m/s wind speed and site specific response spectra for seismic loading. In this chapter, analysis and design is performed for changing wind and Seismic forces, keeping all other forces same. An attempt has been made to study the behavior of structure under 50m/s and 55 m/s wind speed, keeping Seismic force of NTPC – Barh 3 X 660 MW project. In other case, seismic zone 2 and zone 3 loading is applied on structure with wind speed 47m/s.

6.2 DESIGN FORCES FOR DIFFERENT CONDITIONS

Design forces are presented for 55m/s and 50m/s wind speed. wind load calculations are carried out as per section 4.4.5 shown in chapter 4 of the report.

Governing load cases and design forces for the members are presented in this section. Load combinations considered are presented in Appendix A-1. Combinations 101 to 108 are basic load combinations, in which only gravity loads are considered. Combinations 111 to 146 are combinations in which effect of wind load is considered. In 151 to 154 combinations, effect of seismic load is considered.

In Tables 6.1 to 6.4, design forces for different members are presented. Fx is the axial force in the member, Fy and Fz being shear forces in Y and Z directions respectively. My and Mz are bending moments about Y and Z directions respectively. Results are presented as per the local direction of members as shown in Fig. 5.1.These results are presented in kN,m units.

6.2.1 Design Forces for 55m/s wind speed

Table 6.1 Design forces for 55m/s

Sr. No.	Beam No.	L/C	Fx	Fy	Fz	My	Mz
1	A Row - 37 Grid						
	10020	121	5261.2	425.4	1.1	4.7	1846.9
	10024	131	4123.0	320.1	1.4	5.7	1467.2
	10029	120	1198.2	338.6	34.9	96.8	840.1
2	B Row - 35 Grid						
	10251	142	9687.9	366.4	58.8	250.3	2766.3
	10254	142	8200.6	540.8	109.3	2525.4	2147.8
	10262	153	2006.5	562.6	88.1	94.8	844.6
	10264	153	894.9	522.2	68.7	142.6	1085.2
3	C Row - 36 Grid						
	10423	113	7704.1	719.2	10.9	57.3	3472.9
	10425	111	7589.7	611.0	12.2	62.8	1731.1
	10428	131	2486.4	365.9	10.8	75.2	2304.5
	10430	153	869.8	284.9	67.9	202.4	719.0
4	Beam at 8.5m level						
	6856	142	-124.8	195.6	0.0	0.0	515.8
	6945	141	20.4	311.1	0.0	0.0	816.6
	4103	113	-123.2	168.9	0.0	0.0	380.1
5	Beam at 17.0m level						
	7701	111	32.7	308.1	0.8	8.3	867.0
	6399	119	0.0	316.0	6.4	34.6	1579.4
	6352	153	440.8	352.1	40.5	305.6	1147.9
6	Beam at 24.0m level						
	5893	131	-17.6	147.0	0.0	0.0	385.9
	5899	124	-194.6	152.4	0.0	0.0	400.0
7	Beam at 32.8m level						
	6082	139	256.6	1.0	0.0	0.0	1.1
	6059	111	3.3	156.6	0.0	0.0	411.0
8	Auxiliary Column						
	5645	121	5435.5	54.3	259.1	692.4	237.6
	5637	151	494.3	70.0	290.7	776.0	283.3
	5643	151	3088.1	45.8	276.5	720.2	226.3
9	Vertical Bracing						
	251	124	782.3	6.1	0.0	0.0	10.3
	252	126	-703.6	6.1	0.0	0.0	10.3

6.2.2 Design Forces for 50m/s wind speed

Table 6.2 Design forces for 50m/s

Sr. No.	Beam No.	L/C	Fx	Fy	Fz	My	Mz
1	A Row - 37 Grid						
	10020	141	5261.2	397.0	1.1	4.6	1729.4
	10024	131	4074.5	286.3	1.2	5.3	1357.7
	10029	142	1105.0	303.3	32.4	89.9	790.3
2	B Row - 35 Grid						
	10251	142	9483.3	314.0	57.7	248.2	2347.1
	10254	142	8007.6	476.7	103.2	244.3	1947.1
	10262	153	1867.8	492.1	88.1	94.8	812.1
	10264	153	880.9	518.9	68.7	142.7	1033.6
3	C Row - 36 Grid						
	10423	113	7508.2	643.8	10.8	56.7	3024.2
	10425	111	7393.7	554.4	12.2	62.1	1638.4
	10428	131	2451.1	511.2	10.8	75.2	2136.5
	10430	153	865.0	262.8	67.9	202.4	718.8
4	Beam at 8.5m level						
	6856	142	-122.1	196.5	0.0	0.0	515.8
	6945	141	19.7	311.1	0.0	0.0	816.6
	4103	113	-115.4	168.9	0.0	0.0	380.1
5	Beam at 17.0m level						
	7701	111	32.3	308.1	0.7	7.8	866.9
	6399	119	0.0	315.9	64.0	34.6	1578.7
	6352	153	440.8	351.9	40.5	305.6	1146.9
6	Beam at 24.0m level						
	5893	119	-17.6	147.0	0.0	0.0	385.9
	5899	124	-190.8	152.4	0.0	0.0	400.0
7	Beam at 32.8m level						
	6082	139	249.1	1.0	0.0	0.0	1.1
	6059	111	3.2	156.6	0.0	0.0	411.0
8	Auxiliary Column						
	5645	151	5433.1	50.5	259.1	692.4	218.0
	5637	151	4941.4	65.8	290.7	776.0	268.9
	5643	151	3087.8	42.2	276.5	720.2	206.2
9	Vertical Bracing						
	251	124	750.3	6.1	0.0	0.0	10.3
	252	124	-679.5	6.1	0.0	0.0	10.3

6.2.3 Design Forces for zone 2 loading

Table 6.3 Design forces for zone 2

Sr. No.	Beam No.	L/C	Fx	Fy	Fz	My	Mz
1	A Row - 37 Grid						
	10020	141	4378.0	381.3	1.0	4.5	1635.5
	10024	131	4058.6	267.5	1.0	5.2	1297.1
	10029	142	1101.3	283.8	31.0	86.1	763.0
2	B Row - 35 Grid						
	10251	142	9403.0	285.0	57.4	247.0	2115.1
	10254	142	7942.0	441.2	99.7	239.7	1835.9
	10262	131	1863.5	453.1	54.3	71.2	794.0
	10264	139	837.2	504	36.7	60.4	1022
3	873.2						
	10423	113	7349.7	602.1	10.7	56.4	2838.0
	10425	111	7285.2	523.0	9.4	61.8	1587.0
	10428	131	2431.5	480.9	3.7	23.7	2043.0
	10430	153	862.8	250.5	23.6	70.5	718.8
4	Beam at 8.5m level						
	6856	142	-120.6	196.5	0.0	0.0	515.8
	6945	141	19.3	511.1	0.0	0.0	816.6
	4103	113	-111.0	168.9	0.0	0.0	380.1
5	Beam at 17.0m level						
	7701	111	32.1	308.1	0.7	7.1	866.9
	6399	119	0.0	315.9	3.9	22.0	1578.2
	6352	120	75.7	351.7	5.3	40.8	1146.4
6	Beam at 24.0m level						
	5893	119	-6.8	147.0	0.0	0.0	385.9
	5899	124	-188.6	152.4	0.0	0.0	400.0
7	Beam at 32.8m level						
	6082	139	244.9	1.0	0.0	0.0	1.1
	6059	111	3.1	156.6	0.0	0.0	411.0
8	Auxiliary Column						
	5645	121	5431.7	47.0	90.0	184.2	200.9
	5637	121	4941.1	62.0	81.2	166.7	245.1
	5643	121	3087.7	39.4	115.6	238.5	190.1
9	Vertical Bracing						
	251	124	744.9	6.1	0.0	0.0	10.3
	252	124	-666.1	6.1	0.0	0.0	10.3

6.2.4 Design Forces for zone 3 loading

Table 6.4 Design forces for zone 3

Sr. No.	Beam No.	L/C	Fx	Fy	Fz	My	Mz
1	A Row - 37 Grid						
	10020	141	5007.7	381.3	1.0	4.5	1635.5
	10024	131	4058.6	267.5	1.0	5.2	1297.1
	10029	142	1101.3	283.3	31.0	86.1	763.3
2	B Row - 35 Grid						
	10251	142	9403.6	285.0	57.4	247.0	2115.1
	10254	142	7942.0	441.2	99.7	239.7	1835.9
	10262	153	1863.5	453.1	91.8	112.9	794.0
	10264	153	873	504	48.8	96.3	1022
3	873.2						
	10423	113	7399.7	602.1	10.7	56.4	2838.0
	10425	111	7285.3	523.0	10.6	61.8	1587.0
	10428	131	2431.5	480.9	5.9	37.5	2043.0
	10430	151	862.8	250.5	37.8	112.7	718.8
4	Beam at 8.5m level						
	6856	142	-120.6	196.3	0.0	0.0	515.8
	6945	141	-24.8	311.6	0.0	0.0	816.6
	4103	113	-111.0	168.9	0.0	0.0	380.1
5	Beam at 17.0m level						
	7701	111	32.1	308.1	0.7	7.1	866.9
	6399	119	0.0	315.8	5.8	31.1	1578.2
	6352	120	76.7	351.7	8.4	65.2	1146.4
6	Beam at 24.0m level						
	5893	119	-7.1	147.0	0.0	0.0	385.9
	5899	124	-188.6	152.4	0.0	0.0	400.0
7	Beam at 32.8m level						
	6082	139	244.9	1	0	0	1.1
	6059	111	-3.3	556.4	0	0	411
8	Auxiliary Column						
	5645	121	5341.7	47.0	90.0	209.9	1.1
	5637	121	4941.1	62.0	81.2	184.0	245.1
	5643	121	3087.0	39.4	115.6	238.5	190.1
9	Vertical Bracing						
	251	124	-661.0	6.1	0.0	0.0	10.3
	252	124	744.9	6.1	0.0	0.0	10.3

6.3 DESIGN SUMMARY FOR DIFFERENT CONDITION

6.3.1 Design Summary for 55m/s wind speed

Table 6.5 Design Summary for 55m/s

Sr. No.	Beam No.	Section Property	Stress Ratio		L/C	
			Basic	Env.	Basic	Env.
1	A Row - 37 Grid					
	10020	1.5_.6_2518	0.863	0.964	104	121
	10024	1.5_.6_2518	0.876	0.881	101	131
	10029	.75_.6_3218	0.931	1.102	108	142
2	B Row - 35 Grid					
	10251	1.5_.9_4025	0.825	0.906	108	142
	10254	1.5_.9_4025	0.815	0.914	108	142
	10262	.75_.4_3225	0.809	0.935	101	131
	10264	.75_.4_3225	0.81	1.13	103	153
3	C Row - 36 Grid					
	10423	1.5_.8_4018	0.683	1.07	103	113
	10425	1.5_.8_3018	0.866	1.07	101	111
	10428	1.5_.6_2018	0.804	1.14	101	131
	10430	1_.4_1815	0.63	1.63	104	153
4	Beam at 8.5m level					
	6856	.6_.3_2512	0.775	0.77	108	142
	6945	.7_.35_2512	0.838	0.839	104	142
	4103	ISMB 600	0.852	1.21	103	119
5	Beam at 17.0m level					
	7701	.7_.35_2512	0.902	0.912	101	111
	6399	1_.4_4020	0.924	0.95	102	119
	6352	.8_.4_3216	0.752	1.18	106	153
6	Beam at 24.0m level					
	5893	ISMB 600	0.62	0.62	101	131
	5899	ISMB 600	0.943	0.95	106	124
7	Beam at 32.8m level					
	6082	ISMB 400	0.49	0.56	106	139
	6059	ISMB 600	0.65	0.65	101	111
8	Auxiliary Column					
	5645	.5_.5_.04	0.68	0.731	104	121
	5637	.5_.5_.04	0.634	0.759	104	151
	5643	.5_.5_.04	0.49	0.576	104	151
9	Vertical Bracing					
	251	4025_12	0.173	0.195	106	124
	252	4025_12	0.148	0.168	106	124

6.3.2 Design Summary for 50m/s wind speed

Table 6.6 Design Summary for 50m/s

Sr. No.	Beam No.	Section Property	Stress Ratio		L/C	
			Basic	Env.	Basic	Env.
1	A Row - 37 Grid					
	10020	1.5_.6_2518	0.863	0.892	104	121
	10024	1.5_.6_2518	0.876	0.854	101	131
	10029	.75_.6_3218	0.931	1.01	108	142
2	B Row - 35 Grid					
	10251	1.5_.9_4025	0.825	0.879	108	142
	10254	1.5_.9_4025	0.815	0.884	108	142
	10262	.75_.4_3225	0.809	0.935	101	131
	10264	.75_.4_3225	0.81	1.13	103	153
3	C Row - 36 Grid					
	10423	1.5_.8_4018	0.683	1.00	103	113
	10425	1.5_.8_3018	0.866	1.03	101	111
	10428	1.5_.6_2018	0.804	1.08	101	131
	10430	1_.4_1815	0.63	1.63	104	153
4	Beam at 8.5m level					
	6856	.6_.3_2512	0.775	0.77	108	142
	6945	.7_.35_2512	0.838	0.839	104	142
	4103	ISMB 600	0.852	1.21	103	119
5	Beam at 17.0m level					
	7701	.7_.35_2512	0.902	0.912	101	111
	6399	1_.4_4020	0.924	0.95	102	119
	6352	.8_.4_3216	0.752	1.18	106	153
6	Beam at 24.0m level					
	5893	ISMB 600	0.62	0.62	101	131
	5899	ISMB 600	0.943	0.95	106	124
7	Beam at 32.8m level					
	6082	ISMB 400	0.49	0.56	106	139
	6059	ISMB 600	0.65	0.65	101	111
8	Auxiliary Column					
	5645	.5_.5_.04	0.68	0.731	104	121
	5637	.5_.5_.04	0.634	0.759	104	151
	5643	.5_.5_.04	0.49	0.576	104	151
9	Vertical Bracing					
	251	4025_12	0.173	0.195	106	124
	252	4025_12	0.148	0.168	106	124

6.3.3 Design Summary for zone 2 loading

Table 6.7 Design Summary for zone 2

Sr. No.	Beam No.	Section Property	Stress Ratio		L/C	
			Basic	Env.	Basic	Env.
1	A Row - 37 Grid					
	10020	1.5_.6_2518	0.863	0.715	104	121
	10024	1.5_.6_2518	0.876	0.845	101	131
	10029	.75_.6_3218	0.931	0.956	108	142
2	B Row - 35 Grid					
	10251	1.5_.9_4025	0.825	0.762	108	142
	10254	1.5_.9_4025	0.815	0.863	108	142
	10262	.75_.4_3225	0.809	0.487	101	131
	10264	.75_.4_3225	0.81	0.837	103	153
3	C Row - 36 Grid					
	10423	1.5_.8_4018	0.683	0.96	103	113
	10425	1.5_.8_3018	0.866	0.998	101	111
	10428	1.5_.6_2018	0.804	1.004	101	131
	10430	1_.4_1815	0.63	0.745	104	153
4	Beam at 8.5m level					
	6856	.6_.3_2512	0.775	1.16	108	142
	6945	.7_.35_2512	0.838	0.956	104	142
	4103	ISMB 600	0.852	0.87	103	119
5	Beam at 17.0m level					
	7701	.7_.35_2512	0.902	0.912	101	111
	6399	1_.4_4020	0.924	0.95	102	119
	6352	.8_.4_3216	0.752	0.79	106	153
6	Beam at 24.0m level					
	5893	ISMB 600	0.62	1.08	101	120
	5899	ISMB 600	0.943	0.95	106	124
7	Beam at 32.8m level					
	6082	ISMB 400	0.49	0.56	106	139
	6059	ISMB 600	0.65	0.65	101	111
8	Auxiliary Column					
	5645	.5_.5_.04	0.68	0.77	104	121
	5637	.5_.5_.04	0.634	0.759	104	151
	5643	.5_.5_.04	0.49	0.576	104	151
9	Vertical Bracing					
	251	4025_12	0.173	0.195	106	124
	252	4025_12	0.148	0.168	106	124

6.3.4 Design Summary for zone 3 loading

Table 6.8 Design Summary for zone 3

Sr. No.	Beam No.	Section Property	Stress Ratio		L/C	
			Basic	Env.	Basic	Env.
1	A Row - 37 Grid					
	10020	1.5_.6_2518	0.863	0.715	104	121
	10024	1.5_.6_2518	0.876	0.845	101	131
	10029	.75_.6_3218	0.931	0.956	108	142
2	B Row - 35 Grid					
	10251	1.5_.9_4025	0.825	0.762	108	142
	10254	1.5_.9_4025	0.815	0.863	108	142
	10262	.75_.4_3225	0.809	0.487	101	131
	10264	.75_.4_3225	0.81	0.92	103	153
3	C Row - 36 Grid					
	10423	1.5_.8_4018	0.683	0.96	103	113
	10425	1.5_.8_3018	0.866	0.998	101	111
	10428	1.5_.6_2018	0.804	1.004	101	131
	10430	1_.4_1815	0.63	1.02	104	151
4	Beam at 8.5m level					
	6856	.6_.3_2512	0.775	1.16	108	142
	6945	.7_.35_2512	0.838	0.956	104	142
	4103	ISMB 600	0.852	0.87	103	119
5	Beam at 17.0m level					
	7701	.7_.35_2512	0.902	0.912	101	111
	6399	1_.4_4020	0.924	0.95	102	119
	6352	.8_.4_3216	0.752	0.79	106	153
6	Beam at 24.0m level					
	5893	ISMB 600	0.62	1.08	101	120
	5899	ISMB 600	0.943	0.95	106	124
7	Beam at 32.8m level					
	6082	ISMB 400	0.49	0.56	106	139
	6059	ISMB 600	0.65	0.65	101	111
8	Auxiliary Column					
	5645	.5_.5_.04	0.68	0.77	104	121
	5637	.5_.5_.04	0.634	0.759	104	151
	5643	.5_.5_.04	0.49	0.576	104	151
9	Vertical Bracing					
	251	4025_12	0.173	0.21	106	124
	252	4025_12	0.148	0.18	106	124

6.4 DEFLECTION CHECK

Maximum horizontal deflection of the structure is limited to height / 325. Height is taken as the elevation at which deflection check is performed.

6.4.1 Deflection check for 55m/s wind speed

Maximum deflection in X direction = 59.77mm @ node 561 (50.0m lvl)

Allowable Deflection = Height/325

= 50000/325

= 153.84mm

Maximum deflection in Z direction = -98.50mm @ node 552 (47.6m lvl)

Allowable Deflection = Height/325

= 47600/325

= 146.46mm

Maxm Deflection < Allowable Deflection in both directions……… hence OK.

6.4.2 Deflection check for 50m/s wind speed

Maximum deflection in X direction = 49.88mm @ node 561 (50.0m lvl)

Allowable Deflection = Height/325

= 50000/325

= 153.84mm

Maximum deflection in Z direction = -98.50mm @ node 552 (47.6m lvl)

Allowable Deflection = Height/325

= 47600/325

= 146.46mm

Maxm Deflection < Allowable Deflection in both directions……… hence OK.

6.4.3 Deflection check for zone-2 loading

Maximum deflection in X direction = -46.87mm @ node 537 (50.0m lvl)

Allowable Deflection = Height/325

= 50000/325

= 153.84mm

Maximum deflection in Z direction = -55.17mm @ node 552 (47.6m lvl)

Allowable Deflection = Height/325

= 47600/325

= 146.46mm

Maxm Deflection < Allowable Deflection in both directions……… hence OK.

6.4.4 Deflection check for zone-3 loading

Maximum deflection in X direction = -46.87mm @ node 537 (50.0m lvl)

Allowable Deflection = Height/325

= 50000/325

= 153.84mm

Maximum deflection in Z direction = -87.35mm @ node 552 (47.6m lvl)

Allowable Deflection = Height/325

= 47600/325

= 146.46mm

Maxm Deflection < Allowable Deflection in both directions……… hence OK.

6.5 MATERIAL TAKE OFF

6.5.1 Material Take Off for Original Section

Material take off for the structural members used in NTPC-Barh 3X660 MW project is presented in Table 6.9.

Table 6.9 MTO for Original Section

Member	Weight (kN)
Main Column	13173
Auxiliary column	2480
Beam	21510
Bracings	17143
Truss members	3627
Total	**57933**

6.5.2 Material Take Off for Revised Section

Material take off for the Revised sections is presented in Table 6.10.

Table 6.10 MTO for Revised Section

Member	Weight (kN)
Main Column	8883
Auxiliary column	2480
Beam	24718
Bracings	16005
Truss members	3627
Total	**55713**

7. SUMMARY AND FUTURE SCOPE OF WORK

7.1 SUMMARY

Turbine Building is one of the biggest structures of Power Plant. General Layout of the Turbine Building is similar for different projects and minor changes are made in the dimensions based on the Power generation capacity of the Plant. As large quantity of steel is consumed in this structure, if small part of it can be saved, it turns out to be quite beneficial.

In present study structural modeling of Turbine Building is done with the details of NTPC – BARH 3X660 MW project. Site Specific Response Spectrum is used for seismic analysis of the structure. Steel Consumption in structural members is as high as 6000 Ton for one unit of the Plant.

Analysis and design of the building is carried out in STAADPro. Design parameters are entered manually in the software to carry out design. Section sizes are revised which is presented in chapter 5. Template for design of members subjected to Axial compression and Bending as per IS 800:2007 is developed.

Moreover, an attempt has been made to study the behavior of Turbine Building under different environmental conditions.

7.2 CONCLUSION

- For design of Main Power house building of the configuration used in NTPC – Barh 3 X 660 MW project, wind load is the governing load for design of majority of members.
- Major contribution in Bending Moment and Stress ratio for beams and columns is due to wind load.
- Reduction in Base shear for variation of wind speed from 55m/s to 50m/s is 17.36% and that for 55m/s to 47m/s is 26.97%
- Material take off has been carried out for sections provided in NTPC – Barh 3 X 660 MW and revised section. MTO for NTPC – Barh section is 57933kN.

After revising the sections, value of MTO comes to 55713kN, reduction being 3.85%.

- Material take off for Main column in NTPC – Barh section is 13173kN, which has reduced up to 8883kN.
- Maximum horizontal deflection in X direction is 35.01mm for NTPC – Barh section, which has increased to 46.43mm after revising the section sizes.
- Total consumption of steel after revising the section sizes is 20.45kN/m^3.
- Excel sheet for design of members subjected to Axial compression and Bending is carried out as per IS 800: 2007.

7.2 FUTURE SCOPE OF WORK

- Effect of different bracing patterns and its effects on structural sizes can be carried out.
- Structural analysis and design can be carried out for different rating of plant, or different configuration of same rating of plant.
- In the present work, excel sheet for design of members subjected to Axial compression and Bending is carried out, further tools can be prepared for other structural members and design can be compared.

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A.1 GENERAL

Parts of STAADPro input file is presented here:

```
STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 05-Mar-09
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN

JOINT COORDINATES
1 0 -1.2 0; 2 0 -1.2 10.5; 3 0 -1.2 21; 4 0 -1.2 31.5; 6 0 -1.2 52.5;
7 0 -1.2 63; 9 0 -8.25 85.5; 10 0 -8.25 96; 11 0 -4.25 106.5; 12 0 -1.2 117;
13 0 -1.2 129; 14 0 3.1 10.5; 15 0 3.1 21; 16 0 3.1 31.5; 17 0 3.1 42;
18 0 3.1 52.5; 21 0 3.1 117; 23 0 8.1 10.5; 24 0 8.1 21; 25 0 8.1 31.5;
26 0 8.1 42; 27 0 8.1 52.5; 28 0 8.1 63; 29 0 8.1 75; 30 0 8.1 85.5;
31 0 8.1 96; 32 0 -8.25 75; 34 0 8.1 106.5; 35 0 8.1 117; 36 0 8.1 129;
39 0 11.8 10.5; 40 0 11.8 21; 41 0 11.8 31.5; 42 0 11.8 42; 44 0 16.6 10.5;

MEMBER INCIDENCES
17 14 136; 18 23 137; 19 44 138; 20 57 139; 21 70 140; 22 83 144; 23 96 142;
24 109 135; 34 15 2435; 35 24 1429; 36 45 1779; 37 58 59; 38 71 72; 39 84 85;
40 97 98; 41 110 111; 51 16 2476; 52 25 1452; 53 46 1829; 54 59 60; 55 72 73;
56 85 86; 57 98 99; 58 111 112; 68 17 158; 69 26 1479; 70 47 2527; 71 60 149;
72 73 150; 73 86 174; 74 99 152; 75 112 153; 87 48 49; 88 61 62; 89 74 75;

START USER TABLE
TABLE 1
* column section for A Row
UNIT METER KN
WIDE FLANGE
1.8_1_4032
0.13504 1.8 0.032 1 0.04 0.0755319 0.00667136 6.14537e-005 0.0576 0.0533333
1.8_0.9_3220
0.09232 1.8 0.02 0.9 0.032 0.0537364 0.00388916 2.42901e-005 0.036 0.0384
END

MEMBER PROPERTY AMERICAN
10001 10010 10011 10020 10021 10031 10032 10042 10043 UPTABLE 1 1.8_1_3225
MEMBER PROPERTY AMERICAN
10002 10012 TO 10014 10022 TO 10025 10033 TO 10035 10044 TO 10048 -
10056 TO 10058 10065 TO 10068 10079 10080 10088 10089 10097 10098 -
10103 TO 10105 10514 10515 UPTABLE 1 1.8_0.9_3220

SUPPORTS
7 9 TO 11 32 124 179 TO 182 199 286 TO 291 330 TO 333 350 437 TO 441 -
442 FIXED BUT MX MY
2 3 6 12 FIXED BUT MX MY
4 FIXED BUT MX MY
2150 TO 2163 2166 TO 2168 2172 TO 2179 2181 2182 FIXED
3062 FIXED
1 13 178 183 329 334 FIXED BUT MX MZ
1362 1367 1554 1612 1627 1629 1641 1915 1920 1973 1974 1994 2110 PINNED
2169 TO 2171 2180 FIXED
3867 3869 3871 3873 FIXED
1645 1919 4144 4145 PINNED
1411 2948 PINNED
3010 3012 PINNED
3057 PINNED
3054 PINNED
2647 PINNED
```

```
2657 PINNED
2653 PINNED
1416 2595 2600 PINNED
4146 4147 PINNED

MEMBER RELEASE
3685 3756 3837 3840 3843 3846 5670 5673 5676 5679 5682 5685 5693 5696 5699 -
5756 5759 5762 START MY MZ
5765 5768 START MY MZ
6796 6799 6802 6805 6808 6811 6812 6815 6816 6948 START MY MZ
5771 5774 6367 6370 6373 6377 6380 6383 6386 6410 6537 6671 6674 6677 -
6680 START MY MZ
5860 5863 5866 5869 5872 5875 5878 5881 5932 5935 5938 5941 5944 5973 5976 -
5979 5982 5985 5988 6015 6018 6021 6024 6027 6030 6068 6071 START MY MZ
3654 3660 3757 3778 3947 4141 5670 5673 END MY MZ
5676 END MY MZ

DEFINE MATERIAL START
ISOTROPIC STEEL
E 2.05e+008
POISSON 0.3
DENSITY 76.8195
ALPHA 1.2e-005
DAMP 0.03
END DEFINE MATERIAL
CONSTANTS
BETA 90 MEMB 10523 TO 10526 10534 TO 10538 10543 TO 10550 10617 10619 10620 10734 TO 10737
MATERIAL STEEL ALL

MEMBER OFFSET
10007 TO 10009 10017 TO 10019 10028 TO 10030 10039 TO 10041 10051 TO 10053 10061 TO 10063 10071 TO 10073
10081 TO 10083 10090 TO 10092 10099 TO 10101
10108 TO 10110 10118 TO 10120 10128 TO 10130 START -0.35 0 0

CUT OFF MODE SHAPE 60

LOAD 1 LOADTYPE Dead  TITLE DL
SELFWEIGHT Y -1
MEMBER LOAD
1220 UNI GY -8.875
1221 UNI GY -8.875

LOAD 2 LOADTYPE Live  TITLE LIVE LOAD FLOOR (LF)
MEMBER LOAD
1220 UNI GY -28.4
1221 UNI GY -28.4

LOAD 3 LOADTYPE Live  TITLE LIVE LOAD ROOF (LR)
MEMBER LOAD
7716 TO 7738 8951 TO 9157 UNI GY -2.25

LOAD 4 CABLE TRAY LOADS - TR
MEMBER LOAD
136 UNI GY -1.1 0 5.2
153 UNI GY -1.1 0 3.54
170 UNI GY -1.1 0 10.5



LOAD 7 OPERATING LOAD - PO
JOINT LOAD
3241 3269 FY -1000
3246 3250 3253 3257 3260 3264 FY -1000
MEMBER LOAD
6694 6702 CON GY -270 2.62
```

6694 6702 CON GY -270 5.25
6694 6702 CON GY -270 7.87
6713 6722 6735 6741 CON GY -270 5.25
JOINT LOAD
2765 2771 FY -270
MEMBER LOAD
5779 6730 CON GY -270 2.62
5779 6730 CON GY -270 5.25
5779 6730 CON GY -270 7.87
LOAD 8 PIPING THERMAL - PF
LOAD 9 PIPING ANCHOR FORCE - PA

LOAD 10 WIND (N TO S) : PRESSURE - WNS1
MEMBER LOAD
10001 10002 10618 UNI GX 1.38
10578 UNI GX 1.49 0 4.39
10578 UNI GX 1.59 4.39 5.5

LOAD 11 WIND (E TO W) : PRESSURE - WEW1
MEMBER LOAD
10001 10002 10618 UNI GZ 1.05
10578 UNI GZ 1.14 0 4.39
10578 UNI GZ 1.21 4.39 5.99

LOAD 12 WIND (E TO W) : suction – WEW2
MEMBER LOAD
10001 10002 10618 UNI GZ 1.05
10578 UNI GZ 1.14 0 4.39
10578 UNI GZ 1.21 4.39 5.99

LOAD 13 WIND (W TO E) : PRESSURE - WWE1
MEMBER LOAD
10001 10002 10618 UNI GZ -3.14
10578 UNI GZ -3.41 0 4.39
10578 UNI GZ -3.62 4.39 5.99

LOAD 14 WIND (N TO S) : SUCTION - WNS2
MEMBER LOAD
10001 10002 UNI GX 8.25
10578 UNI GX 8.95 0 4.39
10578 UNI GX 8.95 4.39 5.5

LOAD 15 WIND (E TO W) : SUCTION - WEW2
MEMBER LOAD
10001 10002 10618 UNI GZ 6.29
10578 UNI GZ 6.82 0 4.39
10578 UNI GZ 7.25 4.39 5.99
10005 10893 UNI GZ 7.25 0 3

LOAD 17 WIND (W TO E) : pressure – WWE1
MEMBER LOAD
10001 10002 10618 UNI GZ 2.1
10578 UNI GZ 2.27 0 4.39
10578 UNI GZ 2.42 4.39 5.99
10005 10893 UNI GZ 2.42 0 3

LOAD 17 WIND (W TO E) : SUCTION - WWE2
MEMBER LOAD
10001 10002 10618 UNI GZ 2.1
10578 UNI GZ 2.27 0 4.39
10578 UNI GZ 2.42 4.39 5.99
10005 10893 UNI GZ 2.42 0 3

LOAD 18 SEISMIC (N TO S) - ENS
JOINT LOAD
1 FX 38.669
2 FX 43.196
3 FX 43.196
4 FX 17.738
SPECTRUM SRSS X 0.063 ACC SCALE 9.81 DAMP 0.02
0 1; 0.03 1; 0.04 1.31; 0.05 1.62; 0.06 1.86; 0.06 1.89; 0.06 1.92; 0.06 1.95;0.06 1.98; 0.07 2.07; 0.07 2.21; 0.07 2.24; 0.07 2.33; 0.08 2.63; 0.09 2.92;0.1 3.21; 0.11 3.5; 0.12 3.67; 0.12 3.7; 0.12 3.76; 0.12 3.8; 0.13 3.8;0.13 3.8; 0.6 3.8; 0.62 3.8; 0.63 3.74; 0.67 3.54; 0.77 3.08; 0.87 2.73;0.97 2.44; 1.07 2.22; 1.17 2.03; 1.27 1.87; 1.37 1.73; 1.47 1.61; 1.57 1.51;1.67 1.42; 1.77 1.34; 1.87 1.27; 1.97 1.2; 2.07 1.14; 2.17 1.09; 2.27 1.04;2.37 1; 2.47 0.96; 2.57 0.92; 2.67 0.89; 2.77 0.85; 2.87 0.82; 2.97 0.8;3.07 0.77; 3.17 0.75; 3.27 0.72; 3.37 0.7; 3.47 0.68; 3.54 0.6; 3.56 0.6;3.67 0.65; 3.77 0.61; 3.87 0.58; 3.97 0.55; 4.02 0.54;

LOAD 19 SEISMIC (E TO W) - EEW
SPECTRUM SRSS Z 0.063 ACC SCALE 9.81 DAMP 0.02
0 1; 0.03 1; 0.04 1.31; 0.05 1.62; 0.06 1.86; 0.06 1.89; 0.06 1.92; 0.06 1.95;0.06 1.98; 0.07 2.07; 0.07 2.21; 0.07 2.24; 0.07 2.33; 0.08 2.63; 0.09 2.92;0.1 3.21; 0.11 3.5; 0.12 3.67; 0.12 3.7; 0.12 3.76; 0.12 3.8; 0.13 3.8;0.13 3.8; 0.6 3.8; 0.62 3.8; 0.63 3.74; 0.67 3.54; 0.77 3.08; 0.87 2.73;0.97 2.44; 1.07 2.22; 1.17 2.03; 1.27 1.87; 1.37 1.73; 1.47 1.61; 1.57 1.51;1.67 1.42; 1.77 1.34; 1.87 1.27; 1.97 1.2; 2.07 1.14; 2.17 1.09; 2.27 1.04;2.37 1; 2.47 0.96; 2.57 0.92; 2.67 0.89; 2.77 0.85; 2.87 0.82; 2.97 0.8;3.07 0.77; 3.17 0.75; 3.27 0.72; 3.37 0.7; 3.47 0.68; 3.54 0.6; 3.56 0.6;3.67 0.65; 3.77 0.61; 3.87 0.58; 3.97 0.55; 4.02 0.54;

LOAD 22 CRANE LOAD (WHEEL LOAD) - CW
JOINT LOAD
69 TO 81 FY -1500
69 TO 81 MZ -900
234 TO 246 FY -1500
234 TO 246 MZ 1350
JOINT LOAD
1664 TO 1676 FY -1500
1664 TO 1676 MZ -900
1701 TO 1713 FY -1500
1701 TO 1713 MZ 1350

LOAD 23 CRANE LOAD (SURGE AT A) - CTA
JOINT LOAD
69 TO 81 FX 100

LOAD 24 CRANE LOAD (SURGE AT B) - CTB
JOINT LOAD
234 TO 246 FX 110

LOAD 25 CRANE LOAD (LONGITUDINAL) - CL
JOINT LOAD
1670 1707 FZ 160

LOAD 26 TEMPERATURE LOAD - TMP
TEMPERATURE LOAD
17 TO 24 34 TO 41 51 TO 58 68 TO 75 87 TO 92 105 TO 108 120 TO 126 136 138 -
139 TO 143 153 155 TO 160 170 172 TO 177 187 189 TO 194 205 TO 207 210 211 -
10090 TO 10092 10095 10096 10098 TO 10101 10104 10105 TEMP 11

LOAD 27 CONTINGENCY LOAD - CON
JOINT LOAD
69 TO 81 FY -100
234 TO 246 FY -200
411 552 554 TO 562 593 TO 595 FY -200

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*----- LOAD COMBINATION FOR STEEL DESIGN PER IS-800(1984) ----- *
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LOAD COMB 101 (D+LF+LR+TR+PO+PF+PA+CW+CTA+CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 22 1.0 23 1.0 25 1.0 26 1.0 27 1.0

LOAD COMB 102 (D+LF+LR+TR+PO+PF+PA+CW-CTA+CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 22 1.0 23 -1.0 25 1.0 26 1.0 27 1.0
LOAD COMB 103 (D+LF+LR+TR+PO+PF+PA+CW+CTB+CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 22 1.0 24 1.0 25 1.0 26 1.0 27 1.0
LOAD COMB 104 (D+LF+LR+TR+PO+PF+PA+CW-CTB+CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 22 1.0 24 -1.0 25 1.0 26 1.0 27 1.0
LOAD COMB 105 (D+LF+LR+TR+PO+PF+PA+CW+CTA-CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 22 1.0 23 1.0 25 -1.0 26 1.0 27 1.0
LOAD COMB 106 (D+LF+LR+TR+PO+PF+PA+CW-CTA-CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 22 1.0 23 -1.0 25 -1.0 26 1.0 27 1.0
LOAD COMB 107 (D+LF+LR+TR+PO+PF+PA+CW+CTB-CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 22 1.0 24 1.0 25 -1.0 26 1.0 27 1.0
LOAD COMB 108 (D+LF+LR+TR+PO+PF+PA+CW-CTB-CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 22 1.0 24 -1.0 25 -1.0 26 1.0 27 1.0
LOAD COMB 111 (D+LF+LR+TR+PO+PF+PA+WNS1+0.70 CW+0.70 CTA+0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 10 1.0 22 0.7 23 0.7 25 0.7 26 1.0 27 1.0
LOAD COMB 112 (D+LF+LR+TR+PO+PF+PA+WNS1+0.70 CW+0.70 CTA-0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 10 1.0 22 0.7 23 0.7 25 -0.7 26 1.0 27 1.0
LOAD COMB 113 (D+LF+LR+TR+PO+PF+PA+WNS1+0.70 CW+0.70 CTB+0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 10 1.0 22 0.7 24 0.7 25 0.7 26 1.0 27 1.0
LOAD COMB 114 (D+LF+LR+TR+PO+PF+PA+WNS1+0.70 CW+0.70 CTB-0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 10 1.0 22 0.7 24 0.7 25 -0.7 26 1.0 27 1.0
LOAD COMB 115 (D+LF+LR+TR+PO+PF+PA+WEW1+0.70 CW+0.70 CTA+0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 11 1.0 22 0.7 23 0.7 25 0.7 26 1.0 27 1.0
LOAD COMB 116 (D+LF+LR+TR+PO+PF+PA+WEW1+0.70 CW-0.70 CTA+0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 11 1.0 22 0.7 23 -0.7 25 0.7 26 1.0 27 1.0
LOAD COMB 117 (D+LF+LR+TR+PO+PF+PA+WEW1+0.70 CW+0.70 CTB+0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 11 1.0 22 0.7 24 0.7 25 0.7 26 1.0 27 1.0
LOAD COMB 118 (D+LF+LR+TR+PO+PF+PA+WEW1+0.70 CW-0.70 CTB+0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 11 1.0 22 0.7 24 -0.7 25 0.7 26 1.0 27 1.0
LOAD COMB 119 (D+LF+LR+TR+PO+PF+PA+WSN1+0.70 CW-0.70 CTA+0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 12 1.0 22 0.7 23 -0.7 25 0.7 26 1.0 27 1.0
LOAD COMB 120 (D+LF+LR+TR+PO+PF+PA+WSN1+0.70 CW-0.70 CTA-0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 12 1.0 22 0.7 23 -0.7 25 -0.7 26 1.0 27 1.0
LOAD COMB 121 (D+LF+LR+TR+PO+PF+PA+WSN1+0.70 CW-0.70 CTB+0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 12 1.0 22 0.7 24 -0.7 25 0.7 26 1.0 27 1.0
LOAD COMB 122 (D+LF+LR+TR+PO+PF+PA+WSN1+0.70 CW-0.70 CTB-0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 12 1.0 22 0.7 24 -0.7 25 -0.7 26 1.0 27 1.0
LOAD COMB 123 (D+LF+LR+TR+PO+PF+PA+WWE1+0.70 CW+0.70 CTA-0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 13 1.0 22 0.7 23 0.7 25 -0.7 26 1.0 27 1.0
LOAD COMB 124 (D+LF+LR+TR+PO+PF+PA+WWE1+0.70 CW-0.70 CTA-0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 13 1.0 22 0.7 23 -0.7 25 -0.7 26 1.0 27 1.0
LOAD COMB 125 (D+LF+LR+TR+PO+PF+PA+WWE1+0.70 CW+0.70 CTB-0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 13 1.0 22 0.7 24 0.7 25 -0.7 26 1.0 27 1.0
LOAD COMB 126 (D+LF+LR+TR+PO+PF+PA+WWE1+0.70 CW-0.70 CTB-0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 13 1.0 22 0.7 24 -0.7 25 -0.7 26 1.0 27 1.0
LOAD COMB 131 (D+LF+LR+TR+PO+PF+PA+WNS2+0.70 CW+0.70 CTA+0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 14 1.0 22 0.7 23 0.7 25 0.7 26 1.0 27 1.0
LOAD COMB 132 (D+LF+LR+TR+PO+PF+PA+WNS2+0.70 CW+0.70 CTA-0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 14 1.0 22 0.7 23 0.7 25 -0.7 26 1.0 27 1.0
LOAD COMB 133 (D+LF+LR+TR+PO+PF+PA+WNS2+0.70 CW+0.70 CTB+0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 14 1.0 22 0.7 24 0.7 25 0.7 26 1.0 27 1.0
LOAD COMB 134 (D+LF+LR+TR+PO+PF+PA+WNS2+0.70 CW+0.70 CTB-0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 14 1.0 22 0.7 24 0.7 25 -0.7 26 1.0 27 1.0
LOAD COMB 135 (D+LF+LR+TR+PO+PF+PA+WEW2+0.70 CW+0.70 CTA+0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 15 1.0 22 0.7 23 0.7 25 0.7 26 1.0 27 1.0
LOAD COMB 136 (D+LF+LR+TR+PO+PF+PA+WEW2+0.70 CW-0.70 CTA+0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 15 1.0 22 0.7 23 -0.7 25 0.7 26 1.0 27 1.0
LOAD COMB 137 (D+LF+LR+TR+PO+PF+PA+WEW2+0.70 CW+0.70 CTB+0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 15 1.0 22 0.7 24 0.7 25 0.7 26 1.0 27 1.0
LOAD COMB 138 (D+LF+LR+TR+PO+PF+PA+WEW2+0.70 CW-0.70 CTB+0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 15 1.0 22 0.7 24 -0.7 25 0.7 26 1.0 27 1.0
LOAD COMB 139 (D+LF+LR+TR+PO+PF+PA+WSN2+0.70 CW-0.70 CTA+0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 16 1.0 22 0.7 23 -0.7 25 0.7 26 1.0 27 1.0
LOAD COMB 140 (D+LF+LR+TR+PO+PF+PA+WSN2+0.70 CW-0.70 CTA-0.70 CL+TMP+CON)

1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 16 1.0 22 0.7 23 -0.7 25 -0.7 26 1.0 27 1.0
LOAD COMB 141 (D+LF+LR+TR+PO+PF+PA+WSN2+0.70 CW-0.70 CTB+0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 16 1.0 22 0.7 24 -0.7 25 0.7 26 1.0 27 1.0
LOAD COMB 142 (D+LF+LR+TR+PO+PF+PA+WSN2+0.70 CW-0.70 CTB-0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 16 1.0 22 0.7 24 -0.7 25 -0.7 26 1.0 27 1.0
LOAD COMB 143 (D+LF+LR+TR+PO+PF+PA+WWE2+0.70 CW+0.70 CTA-0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 17 1.0 22 0.7 23 0.7 25 -0.7 26 1.0 27 1.0
LOAD COMB 144 (D+LF+LR+TR+PO+PF+PA+WWE2+0.70 CW-0.70 CTA-0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 17 1.0 22 0.7 23 -0.7 25 -0.7 26 1.0 27 1.0
LOAD COMB 145 (D+LF+LR+TR+PO+PF+PA+WWE2+0.70 CW+0.70 CTB-0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 17 1.0 22 0.7 24 0.7 25 -0.7 26 1.0 27 1.0
LOAD COMB 146 (D+LF+LR+TR+PO+PF+PA+WWE2+0.70 CW-0.70 CTB-0.70 CL+TMP+CON)
1 1.0 2 1.0 3 1.0 4 1.0 7 1.0 8 1.0 9 1.0 17 1.0 22 0.7 24 -0.7 25 -0.7 26 1.0 27 1.0
LOAD COMB 151 (D+0.50 LF+TR+PO+PF+PA+EEW+0.50 CW+CON)
1 1.0 2 0.5 4 1.0 7 1.0 8 1.0 9 1.0 19 1.0 22 0.5 27 1.0
LOAD COMB 152 (D+0.50 LF+TR+PO+PF+PA+ESN+0.50 CW+CON)
1 1.0 2 0.5 4 1.0 7 1.0 8 1.0 9 1.0 20 1.0 22 0.5 27 1.0
LOAD COMB 153 (D+0.50 LF+TR+PO+PF+PA-EEW+0.50 CW+CON)
1 1.0 2 0.5 4 1.0 7 1.0 8 1.0 9 1.0 19 -1.0 22 0.5 27 1.0
LOAD COMB 154 (D+0.50 LF+TR+PO+PF+PA-ESN+0.50 CW+CON)
1 1.0 2 0.5 4 1.0 7 1.0 8 1.0 9 1.0 20 -1.0 22 0.5 27 1.0
LOAD COMB 161 (0.90 D+0.90 TR+0.50 PE+WNS1)
1 0.9 4 0.9 5 0.5 10 1.0
LOAD COMB 162 (0.90 D+0.90 TR+0.50 PE+WEW1)
1 0.9 4 0.9 5 0.5 11 1.0
LOAD COMB 163 (0.90 D+0.90 TR+0.50 PE+WSN1)
1 0.9 4 0.9 5 0.5 12 1.0
LOAD COMB 164 (0.90 D+0.90 TR+0.50 PE+WWE1)
1 0.9 4 0.9 5 0.5 13 1.0
LOAD COMB 165 (0.90 D+0.90 TR+0.50 PE+WNS2)
1 0.9 4 0.9 5 0.5 14 1.0
LOAD COMB 166 (0.90 D+0.90 TR+0.50 PE+WEW2)
1 0.9 4 0.9 5 0.5 15 1.0
LOAD COMB 167 (0.90 D+0.90 TR+0.50 PE+WSN2)
1 0.9 4 0.9 5 0.5 16 1.0
LOAD COMB 168 (0.90 D+0.90 TR+0.50 PE+WWE2)
1 0.9 4 0.9 5 0.5 17 1.0
LOAD COMB 171 (0.90 D+0.90 TR+0.90 PO+EEW)
1 0.9 4 0.9 7 0.9 19 1.0
LOAD COMB 172 (0.90 D+0.90 TR+0.90 PO+ESN)
1 0.9 4 0.9 7 0.9 20 1.0
LOAD COMB 173 (0.90 D+0.90 TR+0.90 PO-EEW)
1 0.9 4 0.9 7 0.9 19 -1.0
LOAD COMB 174 (0.90 D+0.90 TR+0.90 PO-ESN)
1 0.9 4 0.9 7 0.9 20 -1.0
LOAD COMB 181 (0.90 D+0.90 TR+0.50 PE+WNS1+0.70 CTA+0.70 CL)
1 0.9 4 0.9 5 0.5 10 1.0 23 0.7 25 0.7
LOAD COMB 182 (0.90 D+0.90 TR+0.50 PE+WNS1+0.70 CTA-0.70 CL)
1 0.9 4 0.9 5 0.5 10 1.0 23 0.7 25 -0.7
LOAD COMB 183 (0.90 D+0.90 TR+0.50 PE+WNS1+0.70 CTB+0.70 CL)
1 0.9 4 0.9 5 0.5 10 1.0 24 0.7 25 0.7
LOAD COMB 184 (0.90 D+0.90 TR+0.50 PE+WNS1+0.70 CTB-0.70 CL)
1 0.9 4 0.9 5 0.5 10 1.0 24 0.7 25 -0.7
LOAD COMB 185 (0.90 D+0.90 TR+0.50 PE+WEW1+0.70 CTA+0.70 CL)
1 0.9 4 0.9 5 0.5 11 1.0 23 0.7 25 0.7
LOAD COMB 186 (0.90 D+0.90 TR+0.50 PE+WEW1-0.70 CTA+0.70 CL)
1 0.9 4 0.9 5 0.5 11 1.0 23 -0.7 25 0.7
LOAD COMB 187 (0.90 D+0.90 TR+0.50 PE+WEW1+0.70 CTB+0.70 CL)
1 0.9 4 0.9 5 0.5 11 1.0 24 0.7 25 0.7
LOAD COMB 188 (0.90 D+0.90 TR+0.50 PE+WEW1-0.70 CTB+0.70 CL)
1 0.9 4 0.9 5 0.5 11 1.0 24 -0.7 25 0.7
LOAD COMB 189 (0.90 D+0.90 TR+0.50 PE+WSN1-0.70 CTA+0.70 CL)
1 0.9 4 0.9 5 0.5 12 1.0 23 -0.7 25 0.7
LOAD COMB 190 (0.90 D+0.90 TR+0.50 PE+WSN1-0.70 CTA-0.70 CL)
1 0.9 4 0.9 5 0.5 12 1.0 23 -0.7 25 -0.7

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LOAD COMB 191 (0.90 D+0.90 TR+0.50 PE+WSN1-0.70 CTB+0.70 CL)
1 0.9 4 0.9 5 0.5 12 1.0 24 -0.7 25 0.7
LOAD COMB 192 (0.90 D+0.90 TR+0.50 PE+WSN1-0.70 CTB-0.70 CL)
1 0.9 4 0.9 5 0.5 12 1.0 24 -0.7 25 -0.7
LOAD COMB 193 (0.90 D+0.90 TR+0.50 PE+WWE1+0.70 CTA-0.70 CL)
1 0.9 4 0.9 5 0.5 13 1.0 23 0.7 25 -0.7
LOAD COMB 194 (0.90 D+0.90 TR+0.50 PE+WWE1-0.70 CTA-0.70 CL)
1 0.9 4 0.9 5 0.5 13 1.0 23 -0.7 25 -0.7
LOAD COMB 195 (0.90 D+0.90 TR+0.50 PE+WWE1+0.70 CTB-0.70 CL)
1 0.9 4 0.9 5 0.5 13 1.0 24 0.7 25 -0.7
LOAD COMB 196 (0.90 D+0.90 TR+0.50 PE+WWE1-0.70 CTB-0.70 CL)
1 0.9 4 0.9 5 0.5 13 1.0 24 -0.7 25 -0.7
LOAD COMB 201 (0.90 D+0.90 TR+0.50 PE+WNS2+0.70 CTA+0.70 CL)
1 0.9 4 0.9 5 0.5 14 1.0 23 0.7 25 0.7
LOAD COMB 204 (0.90 D+0.90 TR+0.50 PE+WNS2+0.70 CTB-0.70 CL)
1 0.9 4 0.9 5 0.5 14 1.0 24 0.7 25 -0.7
LOAD COMB 205 (0.90 D+0.90 TR+0.50 PE+WEW2+0.70 CTA+0.70 CL)
1 0.9 4 0.9 5 0.5 15 1.0 23 0.7 25 0.7
LOAD COMB 206 (0.90 D+0.90 TR+0.50 PE+WEW2-0.70 CTA+0.70 CL)
1 0.9 4 0.9 5 0.5 15 1.0 23 -0.7 25 0.7
LOAD COMB 207 (0.90 D+0.90 TR+0.50 PE+WEW2+0.70 CTB+0.70 CL)
1 0.9 4 0.9 5 0.5 15 1.0 24 0.7 25 0.7
LOAD COMB 208 (0.90 D+0.90 TR+0.50 PE+WEW2-0.70 CTB+0.70 CL)
1 0.9 4 0.9 5 0.5 15 1.0 24 -0.7 25 0.7
LOAD COMB 209 (0.90 D+0.90 TR+0.50 PE+WSN2-0.70 CTA+0.70 CL)
1 0.9 4 0.9 5 0.5 16 1.0 23 -0.7 25 0.7
LOAD COMB 210 (0.90 D+0.90 TR+0.50 PE+WSN2-0.70 CTA-0.70 CL)
1 0.9 4 0.9 5 0.5 16 1.0 23 -0.7 25 -0.7
LOAD COMB 211 (0.90 D+0.90 TR+0.50 PE+WSN2-0.70 CTB+0.70 CL)
1 0.9 4 0.9 5 0.5 16 1.0 24 -0.7 25 0.7
LOAD COMB 212 (0.90 D+0.90 TR+0.50 PE+WSN2-0.70 CTB-0.70 CL)
1 0.9 4 0.9 5 0.5 16 1.0 24 -0.7 25 -0.7
LOAD COMB 213 (0.90 D+0.90 TR+0.50 PE+WWE2+0.70 CTA-0.70 CL)
1 0.9 4 0.9 5 0.5 17 1.0 23 0.7 25 -0.7
LOAD COMB 214 (0.90 D+0.90 TR+0.50 PE+WWE2-0.70 CTA-0.70 CL)
1 0.9 4 0.9 5 0.5 17 1.0 23 -0.7 25 -0.7
LOAD COMB 215 (0.90 D+0.90 TR+0.50 PE+WWE2+0.70 CTB-0.70 CL)
1 0.9 4 0.9 5 0.5 17 1.0 24 0.7 25 -0.7
LOAD COMB 216 (0.90 D+0.90 TR+0.50 PE+WWE2-0.70 CTB-0.70 CL)
1 0.9 4 0.9 5 0.5 17 1.0 24 -0.7 25 -0.7
PERFORM ANALYSIS

STEEL TAKE OFF list 10001 10002 10005 to 10130 10201 10202 10204 -
10206 to 10367 10401 10496 10498 to 10513
FINISH
*design parameters
* STEEL DESIGN
PARAMETER
CODE INDIAN
* ------  A ROW- 39 GRID  ------*

* MEMBER   11068
BEAM 1 MEMB 11068
KZ 1.2 MEMB 11068
LY 8.5 MEMB 11068
LZ 8.5 MEMB 11068
UNL 8.5 MEMB 11068
*
* MEMBER   10618 10005
BEAM 1 MEMB 10005 10618
KZ 2.7 MEMB 10005 10618
LY 5 MEMB 10005 10618
LZ 17 MEMB 10005 10618
UNL 5 MEMB 10005 10618
```

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* ------  AUXILIARY COLUMNS - AA ROW  ------*
* MEMBER   5635 to 5637
BEAM 1 MEMB 5635 TO 5637
KY 2 MEMB 5635 TO 5637
KZ 2 MEMB 5635 TO 5637
LY 3.85 MEMB 5635 TO 5637
LZ 3.85 MEMB 5635 TO 5637
UNL 3.85 MEMB 5635 TO 5637

* ------  PARAMETERS FOR BEAMS  ------*
* ------  BEAM AT 40.6M LVL  ------*
DFF 325 MEMB 5988
BEAM 1 MEMB 5988
LY 0.1 MEMB 5988
LZ 10.5 MEMB 5988
UNL 0.1 MEMB 5988
DJ1 2367 MEMB 5988
DJ2 2368 MEMB 5988

*************** GABLE END COLUMNS**************
PARAMETER
CODE INDIAN
LY 4.3 MEMB 10547 TO 10550
LY 9.3 MEMB 10523 TO 10526 10543 TO 10546
LY 3.4 MEMB 10734 TO 10737
KY 1.5 MEMB 10523 TO 10526 10534 TO 10538 10543 TO 10550 10617 10619 10620 -
10734 TO 10737
KZ 1.5 MEMB 10523 TO 10526 10534 TO 10538 10543 TO 10550 10617 10619 10620 -
UNL 9.3 MEMB 10523 TO 10526 10543 TO 10546
*
************************* PURLIN ******************
PARAMETER
CODE INDIAN
LY 0.1 MEMB 7716 TO 7738 8951 TO 9157
LZ 10.5 MEMB 7716 TO 7738 8951 TO 9157
UNL 0.1 MEMB 7716 TO 7738 8951 TO 9157
DFF 325 MEMB 7716 TO 7738 8951 TO 9157
TRACK 0 MEMB 7716
PARAMETER
CODE INDIAN
DFF 325 MEMB 6076 6078 6080 6082 6083 6085 6087 6089 6091 6092 6094 6096 6098 -
6261 6263
**************************************************************
*        Basic L/c
LOAD LIST 101 TO 108
PARAMETER
CODE INDIAN
FYLD 230000 ALL
TRACK 0 ALL
BEAM 1 ALL
RATIO 1  ALL
CHECK CODE ALL

**************************************************************
*        Env. L/C
LOAD LIST 111 TO 126 131 TO 146 151 to 154 161 TO 168 171 to 174 181 TO 188 -
191 TO 196 201 TO 208 211 TO 214
PARAMETER
CODE INDIAN
FYLD 230000 ALL
TRACK 2 ALL
BEAM 1 ALL
RATIO 1.33 ALL
CHECK CODE all
FINISH
```

Appendix B LOAD COMBINATIONS

B.1 GENERAL

Load Combinations considered in the design as per IS 800: 1984 are presented here.

Load Conditions	Sr. No.	Load Comb	1 D	2 Lf	3 Lr	4 Tr	5 Pe	6 Pt	7 Po	8 Pf	9 Pa	10 Wns1	11 Wew1	12 Wsn1	13 Wwe1	14 Wns2	15 Wew2	16 Wsn2	17 Wwe2	18 Ens	19 Eew	20 Esn	21 Ewe	22 Cw	23 Cta	24 Ctb	25 Cl	26 Tmp	27 Con		Stress Limit
Normal	1	101	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	.	.	.	.	.	.	1.00	1.00	.	1.00	1.00	1.00	.	1.00
	2	102	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	.	.	.	.	.	.	1.00	-1.00	.	1.00	1.00	1.00	.	1.00
	3	103	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	.	.	.	.	.	.	1.00	.	1.00	1.00	1.00	1.00	.	1.00
	4	104	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	.	.	.	.	.	.	1.00	.	-1.00	1.00	1.00	1.00	.	1.00
	5	105	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	.	.	.	.	.	.	1.00	1.00	.	-1.00	1.00	1.00	.	1.00
	6	106	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	.	.	.	.	.	.	1.00	-1.00	.	-1.00	1.00	1.00	.	1.00
	7	107	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	.	.	.	.	.	.	1.00	.	1.00	-1.00	1.00	1.00	.	1.00
	8	108	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	.	.	.	.	.	.	1.00	.	-1.00	-1.00	1.00	1.00	.	1.00
Environ-mental Wind	9	111	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	1.00	.	.	.	.	.	.	.	.	.	.	.	0.70	0.70	.	0.70	1.00	1.00	.	1.33
	10	112	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	1.00	.	.	.	.	.	.	.	.	.	.	.	0.70	0.70	.	-0.70	1.00	1.00	.	1.33
	11	113	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	1.00	.	.	.	.	.	.	.	.	.	.	.	0.70	.	0.70	0.70	1.00	1.00	.	1.33
	12	114	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	1.00	.	.	.	.	.	.	.	.	.	.	.	0.70	.	0.70	-0.70	1.00	1.00	.	1.33
	13	115	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	1.00	.	.	.	.	.	.	.	.	.	.	0.70	0.70	.	0.70	1.00	1.00	.	1.33
	14	116	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	1.00	.	.	.	.	.	.	.	.	.	.	0.70	-0.70	.	0.70	1.00	1.00	.	1.33
	15	117	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	1.00	.	.	.	.	.	.	.	.	.	.	0.70	.	0.70	0.70	1.00	1.00	.	1.33
	16	118	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	1.00	.	.	.	.	.	.	.	.	.	.	0.70	.	-0.70	0.70	1.00	1.00	.	1.33
	17	119	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	1.00	.	.	.	.	.	.	.	.	.	0.70	-0.70	.	0.70	1.00	1.00	.	1.33
	18	120	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	1.00	.	.	.	.	.	.	.	.	.	0.70	-0.70	.	-0.70	1.00	1.00	.	1.33
	19	121	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	1.00	.	.	.	.	.	.	.	.	.	0.70	.	-0.70	0.70	1.00	1.00	.	1.33
	20	122	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	1.00	.	.	.	.	.	.	.	.	.	0.70	.	-0.70	-0.70	1.00	1.00	.	1.33
	21	123	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	1.00	.	.	.	.	.	.	.	.	0.70	0.70	.	-0.70	1.00	1.00	.	1.33
	22	124	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	1.00	.	.	.	.	.	.	.	.	0.70	-0.70	.	-0.70	1.00	1.00	.	1.33
	23	125	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	1.00	.	.	.	.	.	.	.	.	0.70	.	0.70	-0.70	1.00	1.00	.	1.33
	24	126	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	1.00	.	.	.	.	.	.	.	.	0.70	.	-0.70	-0.70	1.00	1.00	.	1.33
	25	131	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	1.00	.	.	.	.	.	.	.	0.70	0.70	.	0.70	1.00	1.00	.	1.33
	26	132	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	1.00	.	.	.	.	.	.	.	0.70	0.70	.	-0.70	1.00	1.00	.	1.33
	27	133	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	1.00	.	.	.	.	.	.	.	0.70	.	0.70	0.70	1.00	1.00	.	1.33
	28	134	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	1.00	.	.	.	.	.	.	.	0.70	.	0.70	-0.70	1.00	1.00	.	1.33
	29	135	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	1.00	.	.	.	.	.	.	0.70	0.70	.	0.70	1.00	1.00	.	1.33
	30	136	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	1.00	.	.	.	.	.	.	0.70	-0.70	.	0.70	1.00	1.00	.	1.33
	31	137	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	1.00	.	.	.	.	.	.	0.70	.	0.70	0.70	1.00	1.00	.	1.33
	32	138	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	1.00	.	.	.	.	.	.	0.70	.	-0.70	0.70	1.00	1.00	.	1.33
	33	139	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	1.00	.	.	.	.	.	0.70	-0.70	.	0.70	1.00	1.00	.	1.33
	34	140	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	1.00	.	.	.	.	.	0.70	-0.70	.	-0.70	1.00	1.00	.	1.33
	35	141	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	1.00	.	.	.	.	.	0.70	.	-0.70	0.70	1.00	1.00	.	1.33
	36	142	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	1.00	.	.	.	.	.	0.70	.	-0.70	-0.70	1.00	1.00	.	1.33
	37	143	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	.	1.00	.	.	.	.	0.70	0.70	.	-0.70	1.00	1.00	.	1.33
	38	144	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	.	1.00	.	.	.	.	0.70	-0.70	.	-0.70	1.00	1.00	.	1.33
	39	145	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	.	1.00	.	.	.	.	0.70	.	0.70	-0.70	1.00	1.00	.	1.33
	40	146	1.00	1.00	1.00	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	.	1.00	.	.	.	.	0.70	.	-0.70	-0.70	1.00	1.00	.	1.33
Environ-mental Seismic	41	151	1.00	0.50	.	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	.	.	.	1.00	.	.	0.50	.	.	.	.	1.00	.	1.33
	42	152	1.00	0.50	.	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	.	.	.	.	1.00	.	0.50	.	.	.	.	1.00	.	1.33
	43	153	1.00	0.50	.	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	.	.	.	-1.00	.	.	0.50	.	.	.	.	1.00	.	1.33
	44	154	1.00	0.50	.	1.00	.	.	1.00	1.00	1.00	.	.	.	.	.	.	.	.	.	.	-1.00	.	0.50	.	.	.	.	1.00	.	1.33
Uplift	45	161	0.90	.	.	0.90	0.50	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.33
	46	162	0.90	.	.	0.90	0.50	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.33
	47	163	0.90	.	.	0.90	0.50	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.33
	48	164	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.33
	49	165	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.33
	50	166	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	.	.	1.33

	51	167	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	.	1.33
	52	168	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	1.33
	53	171	0.90	.	.	0.90	.	.	0.90	.	.	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	1.33
	54	172	0.90	.	.	0.90	.	.	0.90	.	.	.	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	1.33
	55	173	0.90	.	.	0.90	.	.	0.90	.	.	.	.	.	.	.	.	.	.	.	-1.00	.	.	.	.	.	.	.	.	.	1.33
	56	174	0.90	.	.	0.90	.	.	0.90	.	.	.	.	.	.	.	.	.	.	.	.	-1.00	.	.	.	.	.	.	.	.	1.33
	57	181	0.90	.	.	0.90	0.50	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	.	0.70	.	0.70	.	.	.	1.33
	58	182	0.90	.	.	0.90	0.50	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	.	0.70	.	-0.70	.	.	.	1.33
	59	183	0.90	.	.	0.90	0.50	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	.	.	0.70	0.70	.	.	.	1.33
	60	184	0.90	.	.	0.90	0.50	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	.	.	0.70	-0.70	.	.	.	1.33
	61	185	0.90	.	.	0.90	0.50	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	0.70	.	0.70	.	.	.	1.33
	62	186	0.90	.	.	0.90	0.50	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	-0.70	.	0.70	.	.	.	1.33
	63	187	0.90	.	.	0.90	0.50	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	.	0.70	0.70	.	.	.	1.33
	64	188	0.90	.	.	0.90	0.50	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	.	-0.70	0.70	.	.	.	1.33
	65	189	0.90	.	.	0.90	0.50	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	-0.70	.	0.70	.	.	.	1.33
	66	190	0.90	.	.	0.90	0.50	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	-0.70	.	-0.70	.	.	.	1.33
	67	191	0.90	.	.	0.90	0.50	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	-0.70	0.70	.	.	.	1.33
	68	192	0.90	.	.	0.90	0.50	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	.	-0.70	-0.70	.	.	.	1.33
	69	193	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	0.70	.	-0.70	.	.	.	1.33
	70	194	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	-0.70	.	-0.70	.	.	.	1.33
	71	195	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	0.70	-0.70	.	.	.	1.33
	72	196	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	.	-0.70	-0.70	.	.	.	1.33
	73	201	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	0.70	.	0.70	.	.	.	1.33
	74	202	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	0.70	.	-0.70	.	.	.	1.33
	75	203	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	0.70	0.70	.	.	.	1.33
	76	204	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	.	0.70	-0.70	.	.	.	1.33
	77	205	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	0.70	.	0.70	.	.	.	1.33
	78	206	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	-0.70	.	0.70	.	.	.	1.33
	79	207	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	0.70	0.70	.	.	.	1.33
	80	208	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	.	-0.70	0.70	.	.	.	1.33
	81	209	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	-0.70	.	0.70	.	.	.	1.33
	82	210	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	-0.70	.	-0.70	.	.	.	1.33
	83	211	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	-0.70	0.70	.	.	.	1.33
	84	212	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	.	-0.70	-0.70	.	.	.	1.33
	85	213	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	0.70	.	-0.70	.	.	.	1.33
	86	214	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	-0.70	.	-0.70	.	.	.	1.33
	87	215	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	0.70	-0.70	.	.	.	1.33
	88	216	0.90	.	.	0.90	0.50	.	.	.	.	.	.	.	.	.	.	.	1.00	.	.	.	.	.	.	-0.70	-0.70	.	.	.	1.33

Appendix C TEMPLATE AS PER IS 800:2007

C.1 GENERAL

Design of members subjected to Axial compression and Bending can be designed with help of Excel sheet presented here.

Data :-

Length of Column	L	6000	mm	
Effective length factor	K	1		
Yield Stress	f_y	250	N/mm^2	
Unfactored Axial Load	N'	455	kN	
Factored Applied axial load	N	682.5	kN	
Partial Safety factor due to yielding	γ_{mo}	1.1		
Major axis Unfactored moment	M_x	20	kN.m	
Minor axis Unfactored moment	M_y	0	kN.m	
Factored applied moment @major axis	M_x	30	kN.m	
Factored applied moment @minor axis	M_y	0	kN.m	
Modulus of Elasticity of Steel	E	2E+05	N/mm^2	*CL.2.2.4.1*

Try a Section:- ***ISMB 550 @ 1017.3***

Depth of the section	D	550	mm
Width of the flange	b_f	190	mm
Thickness of the flange	T	19.3	mm
Thickness of the flange of the web	t_w	11.2	mm
Sectional Area	a	13211	mm^2
Radius of guration about Z	r_z	221.6	mm
Radius of gyration about Y	r_y	37.3	mm
Moment of Inertia @minor axis	I_{yy}	1834	cm^4
Moment of Inertia @major axis	I_{zz}	64894	cm^4
Section modulus in z-dir	Z_{zz}	2E+06	mm^3
Section modulus in y-dir	Z_{yy}	2E+05	mm^3
Plastic Section Modulus	Z_p	3E+06	mm^3

Section Classification:-

Flange Criteria:- *Table 2*

$(b_f/2)/T$ 4.92

SECTION IS PLASTIC

Web Criteria:-

	d/t_w	45.66		

SECTION IS PLASTIC

	N_d =			
Design Strength in Compression	N_d	3003	kN	*CL.9.3.1.1*
Factored Applied Major axis Moment	$M_{z(fact.)}$	30	kN.m	
Factored Applied Minor axis Moment	$M_{y(fact.)}$	0	kN.m	

Check for Section Strength against Combined Axial Force And bending moment: *CL.9.3.1.1*

Value of N/N_d	N/N_d	0.2273		

Calculation of design strength M_{dy} and M_{dz}:-

Design Strength under bending @ minor axis	M_{dy}	616.36	kN.m	*CL.8.2.1*
Thickness of flange to web ratio	t_f/t_w	1.72		
Value of "betaLT"	β_{LT}	1.2		
Value of "beta B"	β_b	1		*CL.8.2.2*
Elastic Critical Moment	M_{cr}	534.32	kN.m	
Non-Dimensional Slenderness ratio	l_{LT}	1.1264		
Value of "Alfa LT"	a_{LT}	0.2100		
Value of "phyLT"	$Ø_{LT}$	1.2317		
Reduction factor to account for lateral torisonal buckling	c	0.5780	N/mm^2	*CL.8.2.2*
Design bending strength @ major axis	M_{dz}	356.28	kN.m	*CL.8.2.2*

N/N_d + M_y/M_{dy} + M_z/M_{dz} 0.31 < 1.0 O.K!!!

Check for overall member strength against Combined Axial Force and Bending:

Calculation of design strength about minor axis P_{dy}: *CL.7.1.2.1*

Valuie of h/b	h/b	2.8947		
Thickness of flang t_f	t_f	19.3	mm	

USE BUCKLING CURVE b *Table 7*

Effective Slenderness Ratio	KL/r_y	160.86		
Euler Critical buckling Stress	f_{ccy}	76.28	N/mm^2	
Non-dimiensional Slenderness Ratio	l_y	1.8103		
Value of Imperfaction factor "Alfa"	a	0.34		*CL.7.1.2.1*

Value of "phy"	Ø	2.41		
Stress Reduction Factor	c	0.25		*Table 7*
Design compressive Stress	f_{cd}	56.72	N/mm^2	*CL.7.1.2.1*
Design compressive strength	P_{dy}	749.4	kN	*CL.7.1.2*

<u>Calculation of design strengtyh about major axis $P_{dz:}$</u>

USE BUCKLING CURVE a *Table 7*

Effective Slenderness Ratio	KL/r_z	27.08	
Euler Critical buckling Stress	f_{ccz}	2693	N/mm^2
Non-dimiensional Slenderness Ratio	l_z	0.305	
Value of Imperfaction factor "Alfa"	a	0.21	
Value of "phy"	Ø	0.557	
Stress Reduction Factor	c	0.976	
Design compressive Stress	f_{cd}	221.9	N/mm^2
Design compressive strength	P_{dz}	2932	kN

<u>Calculation of k_y and k_z:-</u>

Euler buckling stress about y-y axis	f_{ccy}	76.29	N/mm^2	
Non-dimensional Slenderness ratio @ y-axis	l_y	1.81		
Value of ψ	ψ	1		*Table 9.2*
Equivalent uniform moment factor	β_{MLT}	1.1		
Value of μ_{LT}	μ_{LT}	0.149		*CL.8.2.2*
Euler buckling stress about z-z axis	f_{ccz}	2693	N/mm^2	
Non-dimensional Slenderness ratio @ major axis	l_z	0.305		*CL.8.2.2.1*
Value of μ_{fz}	μ_{fz}	-0.399		*CL.8.2.2*
Value of μ_z	μ_z	0.149		
Moment Amplicfication factor @ major axis	k_z	0.965		
Value of μ_y	μ_y	-3.259		
Moment Amplicfication factor @ minor axis	k_y	3.968		

$(P/P_d) + ky*(M_y/M_{dy}) + kz*(M_z/M_{dz})$ = 0.9921 <1.0

O.K.!!

Therefore, Maximum safe load P_{safe} = 455