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DBR-01

# CASE STUDY: INDUSTRIAL SHED

# DESIGN BASIS REPORT

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## 1. INTRODUCTION

The proposed Industrial Shed consists of 190 m long shed having 61 m width with **2 equal bays and double pitched roof**.

## 2. STRUCTURAL SYSTEM

The structure designed with 2 alternative structural configurations:

a. Built-up I sections
b. Tubular sections

And the steel tonnage and indicative costing is compared.

The structures are designed for the expected loads, i.e. Dead Load, Live Load, Wind Load, Earthquake Load and Crane Load. Limit State Method of Analysis and Design has been adopted for the design of the shed.

## 3. PERIPHERAL WALLS

All peripheral walls have been conceived in Red Bricks with a density of 19.2 $KN/m^3$. Peripheral walls of height 3 m have been considered on external face of the shed and 0.5 mm thick colour coated cladding above 3 m level.

## 4. MODEL GENERATION

The building is planned with the two structural configuration for optimizing the material consumption while meeting structural strength requirements. After preliminary sizing of various structural members, a 3-D CAD Model of the structural frame of the building has been generated using STAAD-Pro Connect Edition software for carrying out computer analysis for the affects of vertical and lateral loads likely to act on the structure. The permissible values of the load factors and stresses has been considered as per guidelines of Indian Standards. The computer analysis has evaluated individual internal forces, reactions at foundation level and deflection pattern of the entire structure and in the individual members. This data has been used to verify adequacy of the member sizes adopted and further iterations have been carried out as required to rationalize the system and sizes of structural members. The whole structure shall be idealized as a space frame.

## 5. CONTROL OF DEFLECTION

In order to control deflection of structural elements, the criteria given in IS: 800-2007 LSD has been used for all structural members. Detailed deflection calculations have revealed that the sway/deflections of main structural members are within the required limits.

## 6. RECOMMENDATIONS FOR MINIMIZING COST

### (i) GRID SPACING, MEMBER TYPE AND DIMENSIONS

Grid spacing of 9m has been selected with tapered columns and rafters with a clear span of 30m based on detailed study of the architectural requirements and time and cost optimization.

### (ii) MATERIAL GRADES

For Tubular sections STAAD Model:

Conforming to IS:2062 for rolled steel tube sections (Fe 355)

For Built-up I sections STAAD Model:

Conforming to IS:2062 for HR plates (Fe 345) and for rolled steel tube sections (Fe 310)

## 7. LOADS & LOAD COMBINATIONS

### (i) DEAD LOAD

The dead load on structure includes all the permanent loads attached with structure i.e. self-weight of structure, roofing sheet and solar panels. Following are the permanent loads which have been considered in design & analysis.

- Self Weight of structural members have been considered on the basis of the following criteria.
- Density of Steel - 78.5 KN/cum
- Weight of connections - 10 % of self-weight
- Steel rolled sections - As per the section tables

- 50 mm th Glass wool + wire mesh - 3 kg/sq.m. = 0.03 kN/sq.m.
- Roofing Sheet - 0.47 mm thick (TCT) Bare Galvalume Sheet of 550 MPa Grade.
- Weight of sheeting - 4.5 kg/sq.m. = 0.045 kN/sq.m.
  Load on purlins - (0.03+0.045)*1.364 = 0.1 kN/m

- Weight of cladding - 4.5 kg/sq.m. = 0.045 kN/sq.m
- Side Cladding - 0.5 mm thick (TCT) Colour Coated Sheet of 550 MPa Grade.
  Load on girts - 0.045*1.561 = 0.07 kN/m

- Utilities weight on side wall columns - 300 kg/m., lever arm of 1.2 m.
  Load on column - 27 kN force, 32.4 kN-m moment

- Walkway near sidewall columns - 100kg/m, lever arm of 0.3 m.
  Load on column - 9 kN force, 2.7 kN-m moment

(ii) <u>IMPOSED LOADS</u>

The following imposed loads as per IS: 875 (Part-2), acting on the structure have been considered:-

- Roof live load - 0.75 kN/sqm

- Load on walkway - 1 KN/m

- Crane live load - Multiple EOT cranes of 15 MT capacities and M5 duty with 2 wheels have been considered in both bays. Working in tandem in each 30 m bay with hook c/c of 2 cranes not closer than 9 mt. in any bay (with all probable critical conditions).

| | | |
|---|---|---|
| Crane Duty | M5 | |
| Impact Factor | 1.32 | |
| Crane Capacity | 15.0 | MT |
| Crab Weight | 3.0 | MT |
| Span of Crane Girder | 28.7 | m |
| Depth of Crane Girder | 75.4 | cm |
| Wheel Base | 3.7 | m |
| Number of wheels per wheel base | 2 | |
| Crane Girder Weight | 1154.5 | kg/m |
| | 33.1 | MT |
| | | |
| Maximum Wheel Load without Impact | 16.7 | MT |
| Maximum Reaction on Bracket without Impact | 33.3 | MT |
| | 327.0 | kN |
| Maximum Vertical Load on Bracket with Impact | 431.6 | kN |
| | | |
| Minimum Wheel Load without Impact | 8.9 | MT |
| Minimum Reaction on Bracket without Impact | 17.8 | MT |
| | 174.7 | kN |
| Minimum Vertical Load on Bracket with Impact | 230.6 | kN |
| | | |

| | | |
|---|---|---|
| Horizontal Surge Force | 18 | kN |
| Horizontal Traction Force | 16.35 | kN |

(iii) <u>WIND LOAD</u>

Wind loads has been estimated considering basic wind speed of 47 m/s, (as per NBC 2016) terrain category 2, 50 years life of structure and as per provisions of IS:875 part 3-2015. Percentage openings in less than 5 % of wall area.

| S. No. | Input Factors | Symbols | Value | Depending Factor | | | Units | | | Area | | Ka | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Basic wind speed | Vb | 47.00 | | | | m/s | Clause | | 10 | | 1 | | | | |
| 2 | Probability Factor | k1 | 1.00 | | | | | | | 25 | | 0.9 | | | | |
| 3 | Terrain roughness | k2 | 1.05 | H = 13.5 m | Terrain Category 2 | | | 6.3.1 | | 100 | | 0.8 | | | | |
| 4 | Topography factor | k3 | 1.00 | | | | | 6.3.2 | | | | | | | | |
| 5 | Importance factor | k4 | | | | | | 6.3.3 | | Slope | 1 | 15 | | | | |
| 6 | Design wind speed | Vz | 49.12 | | | | m/s | 6.3.4 | | Roof angl | 3.814075 | rad | H/W | 0.22 | | |
| 7 | Wind Pressure | Pz | 1.45 | | | | KN/m^2 | | | L | 190 | m | L/W | 3.11 | | |
| 8 | Wind Directionality | Kd | 0.90 | | | | | | | W | 61 | m | | | | |
| 10 | Combination factor | Kc | 0.90 | | | | | | | H | 13.5 | m | | | | |
| 13 | Coeff. Of internal pressure | Cpi | 0.20 | -0.20 | Percentage Openings < 5 % | | | | | | | | | | | |
| 15 | Directions | +ve | Towards shed | | | | | | | | | | | | | |
| | | -ve | Away from shed | | | | | | | | Design Wind Load (KN/m) | | | | | |
| 9 | Area averaging | | | | | | | | 0 | | | 180 | | | 90 | |
| | | | Tributary width | Tributary length | Tributary Area | Ka | Pd>.7*Pz | | 0.20 | -0.20 | | 0.20 | -0.20 | | 0.20 | -0.20 |
| | | | | | | | | | WLL+ | WLR+ | | WLL- | WLR- | | WLONG+ | WLONG- |
| a) | **Purlins** | | | | | | | | | | | | | | | |
| | a | | 1.364 | 5.45 | 7.43 | 1.00 | 1.17 | -0.90 | -1.76 | -1.12 | -0.30 | -0.80 | -0.16 | -0.80 | -1.60 | -0.96 |
| | b | | 1.364 | 5.45 | 7.43 | 1.00 | 1.17 | -0.60 | -1.28 | -0.64 | -0.30 | -0.80 | -0.16 | -0.80 | -1.60 | -0.96 |
| | x | | 1.364 | 5.45 | 7.43 | 1.00 | 1.17 | -0.30 | -0.80 | -0.16 | -0.60 | -1.28 | -0.64 | -0.80 | -1.60 | -0.96 |
| | z | | 1.364 | 5.45 | 7.43 | 1.00 | 1.17 | -0.30 | -0.80 | -0.16 | -0.90 | -1.76 | -1.12 | -0.80 | -1.60 | -0.96 |
| b) | **Side Wall Girts** | | | | | | | | | | | | | | | |
| | A | | 1.56 | 9 | 14.04 | 0.97 | 1.14 | 0.70 | 0.89 | 1.60 | -0.25 | -0.80 | -0.09 | -0.60 | -1.42 | -0.71 |
| | B | | 1.56 | 9 | 14.04 | 0.97 | 1.14 | -0.25 | -0.80 | -0.09 | 0.70 | 0.89 | 1.60 | -0.60 | -1.42 | -0.71 |
| c) | **End Wall Girts** | | | | | | | | | | | | | | | |
| | C | | 1.56 | 7.5 | 11.70 | 0.99 | 1.16 | -0.60 | -1.45 | -0.72 | -0.60 | -1.45 | -0.72 | 0.70 | 0.90 | 1.63 |
| | D | | 1.56 | 7.5 | 11.70 | 0.99 | 1.16 | -0.60 | -1.45 | -0.72 | -0.60 | -1.45 | -0.72 | -0.10 | -0.54 | 0.18 |

(iv) <u>EARTHQUAKE LOAD</u>

In light weight low-rise structures such as the proposed building, seismic loads are inconsequential while wind load affects are pre-dominant, still seismic loads have been evaluated by static method and the structure have been checked for adequacy for relevant seismic load combinations.

Seismic Co-efficient Method has been adopted as per IS:1893 (Part-1): 2016 with the following data.

$$Ah = (Z * Sa) / (2 * (R/I) * g)$$

Ah is Design horizontal seismic coefficient.

Z is Zone factor = 0.16 (Structure lies in Zone III).

I is Importance factor = 1.0

T is Time period as per clause 7.6.2 b) of IS:1893

R is Response reduction factor = 4 for Ordinary Moment Resisting Frames

(Sa/g) is average response acceleration coefficient. This is the function of the fundamental time period of vibration of the structure and the type of the founding soil, the value shall be considered for Soil Type III, as per Geotechnical report and 7.6.2 (b) of IS:1893, 2016.

(v) LOAD COMBINATIONS:

D – Dead Load
Cr - Crane Load (Inclusive of Crane weight and Lifted load)
L - Live Load
W - Wind Load
E - Combined effect of Seismic induced forces

**IS-800-2007 – ULS:**
Basic Load Combinations

1) 1.5 D + 1.5 L
2) 1.2 D + 1.2 L + 1.2 W
3) 0.9 D + 1.5 W
4) 1.5 D + 1.5 W

Seismic Load Combinations
5) 1.2 D + 1.2 L + 1.2 E
6) 0.9 D + 1.5 E
7) 1.5 D + 1.5 E

Crane Load Combinations
8) 1.5 D + 1.5 L + 1.05 Cr
9) 1.5 D + 1.05 L + 1.5 Cr
10) 1.5 D + 1.5 Cr
11) 1.5 D + 1.05 Cr
12) 1.2 D + 1.2 Cr + 0.53 L + 1.2 (W or E)
13) 1.2 D + 0.5 Cr + 1.2 L + 1.2 (W or E)
14) 1.2 D + 1.2 Cr + 1.05 L + 0.6 (W or E)
15) 1.2 D + 1.05 Cr + 1.2 L + 0.6 (W or E)

**Note:-**
1) ULS - Denotes Ultimate Limit State (For Strength Design)
2) Live roof and floor is treated as one class of imposed loads
3) Collateral Load is considered in Dead Load

**IS-800-2007 – SLS:**
Basic Load Combinations
1) D + L
2) D + 0.8 L + 0.8 W

3) D + W

Seismic Load Combinations
4) D + 0.8 L + 0.8 E
5) D + E

Crane Load Combinations
6) D + L + Cr
7) D + Cr
8) D + 0.8 Cr + 0.8 L + 0.8 (W or E)

**Note:-**
1) SLS - Denotes Serviceability Limit State (For Deflection)
2) Live roof and floor is treated as one class of imposed loads
3) Collateral Load is considered in Dead Load
4) The combination is only reported for reference, it cannot be used, since the limits are not provided for these combinations.

## DESIGN STANDARDS

The important codes which are being followed are.

a) IS:800 - 2007 , General Construction in Steel, Code of Practice

b) IS: 875 (Part-I, II), Code of practice for Design loads (other than earthquake)

c) IS: 875 (Part-III) – 2015, Code of practice for Design Loads (Wind Load)

d) IS: 1893 part 1-2016 (Criteria for E/Q Resistant Design for Structure)