Design and Optimization of Mechanical Gantry Structure for Over Head Electrical Line (220KVD/C)

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Abstract - A Gantry Tower Structure, often known as a power tower Structure, is a tall structure that supports an overhead power line. Any type of failure in the transmission line system that causes a disruption in the energy supply will consequently result in economic losses. This paper is on the failure Gantry Tower Structure, Failure Structure implementation by using CAD, Analytical. This 220 kvD/C Gantry type tower & Beam was failed after installation in Power Grid Substation at Bikaner (Rajasthan) dt on 24-OCT-2020. The failure can be costly. This is one of the most serious issues confronting the global electrical utility industry. While previous research has focused on the behavior and failure of a single tower, the research presented in this research paper is the first to consider the re-design and progression of failure of a transmission structure segment. To accomplish this, a unique CAD/numerical model was developed in this research. The formulation and validation of this CAD/numerical model are described in several portions of the thesis, which will be explored in detail in this article.

Keywords: Failure of Gantry Tower Structure, CAD-Model & Analytical comparison

1- INTRODUCTION

Gantry structures are mainly used for guiding the power conductor from last tower near substation to the electrical equipment’s in a substation. This structure consists of a number of columns and Girder beams, which depend on number of circuits of the line. A gantry is an over head bridge-like structure supporting equipment such as a crane, signals, or cameras. A Structural design of Gantry Structure (also known as a mechanical pylon structure) is a tall structure (usually a steel lattice structure) used to support an overhead power line. In electrical grids, they are used to carry high voltage transmission lines that transport bulk electric power from generating stations, transmission and distribution lines that transport power from substations to electric customers. A Structural design of Gantry Structure plays a very important role in power distribution network and is often subject to massive load. Design of lattice gantry structure often based a linear response to various loading. A Structural design of gantry has to carry the heavy transmission conductors at a sufficient safe height from the ground. In addition to that, all gantries have to sustain all kinds of natural calamities. So Gantry structure design is an important engineering job where civil, mechanical, and electrical engineering concepts are equally applicable.
1.0 DESIGN CRITERIA

1.1 SCOPE

This document covers design Calculations of 220KV Gantry Beam Tower Structure Type (T2), Foundation Bolt and Base Plate.

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<tr>
<th>S.NO</th>
<th>STRUCTURE DESCRIPTION</th>
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<tr>
<td>1</td>
<td>220KV TOWER T2</td>
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1.2 UNITS OF MEASUREMENTS

Units of measurements used in analysis shall be of SI Units.

1.3 CODES AND REFERENCES

The following Codes and standards have been referred:

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<th>S.No</th>
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<td>IS1893:1984</td>
<td>Criterial for Earthquake Resistant Design of Structures</td>
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1.4 PLANT SITE INFORMATION

Location of site: BIKANER (RAJSTHAN)

1.5 WIND PARAMETERS

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<td>47 m/sec (Asper IS875, Part 3-1987, Appendix Acl-5.2)</td>
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<td>1.07 (Asper IS875, Part 3-1987, Table-1)</td>
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<td>Terrain, Height Factor (k2)</td>
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<td>61.13 m/sec (Vb<em>k1</em>k2*k3)</td>
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1.6 FACTOR OF SAFETY:

A) For Structures

: Normal Conditions

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</table>
DESCRIPTION OF STRUCTURES:

2.0) STAAD MODEL SKETCH:

2.1) TOWER TYPE-T1:

- Height of Beam from PL = 11.5 m
- Base Dimension at Plinth Level = 2.5X3.5 m
- Base Dimension at Girder Level = 1.5X1.5 m

2.2) GIRDER DETAILS:

GIRDER-BEAM-B2

- Clear Span of Girder = 15.50 m
- Width of Girder = 1.50 m
### 3.0) WIND LOAD CALCULATION ON TOWER: T1

#### 3.1) WIND LOAD ON TRANSVERSE FACE (T-WIND):

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<tr>
<th>Design Wind Pressure</th>
<th>= 2.29 kN/m²</th>
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<tr>
<td>Length of Tower at Top of Girder (B/B)</td>
<td>= 1.50 m x 1.50</td>
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<tr>
<td>Length of Tower at Plinth Level (B/B) Transverse face</td>
<td>= 3.50 m x 2.50 m</td>
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<tr>
<td>Height of Tower from Girder Top to Peak</td>
<td>= 4.400 m</td>
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<tr>
<td>Height of Girder-1</td>
<td>= 1.20 m</td>
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<td>Height of Tower from PL to Girder Bottom</td>
<td>= 10.90 m</td>
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<td>= 5.257 Deg.</td>
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<th>Width of Panel at Bottom (m)</th>
<th>Panel Height (m)</th>
<th>Length of Member (m)</th>
<th>No. of Member</th>
<th>Exposed Area (m²)</th>
<th>Total Exposed Area (m²)</th>
<th>Total Boundary Area (m²)</th>
<th>CG Height (m)</th>
<th>Solidity Ratio</th>
<th>Drag Factor</th>
<th>Total Wind (kN)</th>
<th>No. of Nodes</th>
<th>Wind Transfer red on Each Node (kN)</th>
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### 3.2) WIND LOAD CALCULATION ON TOWER: T1

#### 3.2) WIND LOAD ON GIRDUAL FACE (L-WIND):

- **Design Wind Pressure:**
  - $= 2.29 \text{kN/m}^2$

- **Length of Tower at Top of Girder (B/B):**
  - $= 1.50 \text{ m}$

- **Length of Tower at Plinth Level (B/B) Transverse face:**
  - $= 2.50 \text{ m}$

- **Height of Girder-1:**
  - $= 1.20 \text{ m}$

- **Height of Tower from PL to Girder Bottom:**
  - $= 15.40 \text{ m}$

- **Slope of Tower below Girder:**
  - $= 0.032 \text{ Rad}$

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DESIGN OF FOUNDATION BOLT:

Provide foundation bolt perlegnos 4 & 40 mm

Dia Area of bolt = 1257mm²

Max. Up lift Load perleg: = 213480N

Max. shear force perleg: = 37323N

Max. compression: = 200205N

Uplift force(max. Tension/bolt = 213480 / 4 = 53370N

Maximum Shear Stress per Bolt: = 37323 / 4 = 9330.8N

Allowable Tension in Bolt: = 120N/mm² (Refer Table 8.1 of IS:800-1984)

Allowable Bond strength of concrete: = 0.8N/mm² (Refer Table 21 of IS:456:2000)

Shear Stress for Bolt: = 80N/mm² (Refer Table 8.1 of IS:800-1984)

Area of bolt required(A) = 444.750mm²

Dia of bolt required: = 23.803 = 24 = 40 safe

Edge distance required, = 1.5 x 40 = 60.0 mm

Tension capacity of bolt $T_{db}$ = $T_{nb}$ / $\gamma_{mb}$

$T_{nb} = 0.9f_{ub}A_n \gamma_{mb}/\gamma_{mo}$

$\gamma_{mo} = 1.1$

$f_{ub} = 400$ N/mm²

Net tensile area at the bottom of threads($A_n$) = 980 mm²

$0.9f_{ub}A_n = 352.86$ K N

$T_{nb} = 342.7$ K N

$T_{db} = 274.2$ K N

Tension/bolt($T_{b}$) = 53.4 K N

Hence O.K

Shear capacity of bolt:

$V_{nsb} = f_{ub}A_n / \sqrt{3} = 226.4$ K N

$V_{dsb} = 181.09$ K N

Bearing capacity of the bolt:
There fore Shear capacity of single Bol= 18.4 KN

Hence O.K

Embedded Length of bolt required: 
\[
\frac{53370 \times 1}{\pi \times 40 \times 0.8} \approx 531 \text{ mm}
\]

Provide foundation bolt per legnos 4\& 40mm diaad 1500mm

DESIGN OF BASE PLATE

Max. Compression perleg: 
\[
= 200.21 \text{KN}
\]

Max. Tension perleg: 
\[
= 213.48 \text{KN}
\]

Referring to Clause 34.40 of IS:456-2000 permissible bearing stress on concrete

\[
= 0.45 \times 20 = 9.00 \text{N/mm}^2
\]

Provide M.S. Base Plate of size

\[
350 \times 350 \times 28 \text{mm perleg}
\]

Bearing capacity of base plate:

\[
= 1.6 \times 9.00 \text{ Henceok}
\]
Maximum bearing pressure on plate: $P = 213480 / 122500 = 1.743 \text{ N/mm}^2$

BB dist. of bott. Leg from C.G. of plate: $= 75 \text{ mm}$ (IS808:1989, Table-5.1)

Lever of base plate in axis A-A: $= 75 \text{ mm}$

Bottomleg: $= 110 \times 110 \times 10 \text{ mm}$

Length of base plate in axis A-A: 
\[
= \frac{350}{2} + \frac{350}{2} = 175 + 175 = \sqrt{[175]^2 + 175^2}
\]

Hence moment on the base plate $M_d = 247.487 / 4 = 61.87 \text{ mm}$

Assuming width of the plate $b = 1.00 \text{ mm}$

$f_{ck} = 25 \text{ N/mm}^2$

$f_u = 500 \text{ N/mm}^2$

$f_y = 250 \text{ N/mm}^2$

$\gamma_{mo} = 1.1$

Thickness of base plate required: 
\[
= \sqrt{\frac{6M_d\gamma_{mo}/1.2^*f_{by}}{1.2}} \leq 28 \text{ mm}
\]

Hence, Provide M.S. Stiffener Plate of size $350 \times 300 \times 10 \text{ mm}$ per leg.

Edge distance of bolt centre: $= 60.0 \text{ mm}$

Bolt to Bolt distance along$x$: $= 350 - 120 = 230 \text{ mm}$

Bolt to Bolt distance along$z$: $= 350 - 120 = 230 \text{ mm}$

Moment at the face of the column flange (for compression on column): 
\[
= 1.63432653061224\times(230/4+61.871843538229)*((60*2)/2) = 351166.6271 \text{ N-mm}
\]

Moment at face of stiffener (due to bolt tension): 
\[
= 53370\times(230-110)/2 = 320220 \text{ N-mm}
\]

Height of plate required: 
\[
= \sqrt{6M_d\gamma_{mo}/1.2^*f_{by}} = 15.32 \text{ mm}
\]

Hence, Provide stiffener plate height as $15.32 \text{ mm}$

REACTION FOR FDN AND BASE PLATE DESIGN-
CONCLUSIONS
The paper was successfully achieved its objectives that is the problems which are occurred in the Gantry tower are now overdesigned and checked by using all possible parameter which are occur red while installation as well as giving its service life without any catastrophic failure. And it is possible because of team work and support of senior person in this project. It is validate by using FEM based modeling technique, for this CAD is designing such away that the proposed model will not be failed in the future and its fatigue life will be more.

REFERENCES
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