GANTRY GIRDER

Introduction

In manufacturing plant it is essential to provide overhead travelling crane to transport heavy components of machines from one place to another. The movement of the load is of three dimensional nature. The crane is required to lift heavy mass vertically and horizontally, also the crane with load is required to move along the length of the shed. The cranes are either hand-or-electrically operated. The crane moves on rails which are at its ends. The rails are provided on a girder known as a gantry girder. The gantry girder spans over gantry columns. If capacity of crane is moderate, the gantry girders rest on brackets connected to roof column of industrial shed.

Characteristics

- Design of gantry girder is a classic example of laterally unsupported beam
- It is subjected to in addition to vertical loads and horizontal loads along and perpendicular to its axis
- Loads are of dynamic nature and produce vibration
- Compression flange requires critical attention

Codal Provisions

- Partial safety factor for both dead load and crane load is 1.5 (Table 4, p.29)
- Partial safety factor for serviceability for both dead load and crane load is 1 (Table 4, p.29)
- Deflection Limits (Table 6, p.31)

<table>
<thead>
<tr>
<th>Category</th>
<th>Maximum Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical deflection</td>
<td>Manually Operated – Span/500</td>
</tr>
<tr>
<td></td>
<td>Electric operated- Span/750 upto 50t capacity</td>
</tr>
<tr>
<td></td>
<td>Electric operated- Span/1000 over 50t capacity</td>
</tr>
<tr>
<td>Lateral deflection</td>
<td>Relative displacement between rails supporting 10 mm or crane- span/400</td>
</tr>
</tbody>
</table>

Other Considerations

- Diaphragm must be provided to connect compression flange to roof column of industrial building to ensure restraint against lateral torsional buckling at ends.
- Span is considered to be simply supported to avoid bumping effect.

Design Steps

The design of the gantry girder subjected to lateral loads is a trial-and-error procedure. It is assumed that the lateral load is resisted entirely by the compression top flange of the beam and any reinforcing plates, channels, etc. and that the vertical load is resisted by the combined beam. Various steps involved in the design are as follows:

1. Maximum wheel load is to be calculated. The wheel load is maximum when the trolley is closest to the gantry girder. This load is to be correspondingly increased for the impact.
2. Maximum bending moment in the gantry girder due to vertical loads is to be computed. This consists of the bending moment due to maximum wheel loads (including impact) and the bending moment due to dead load of the gantry and rails. The bending moment due to dead loads is maximum at the centre of the girder, whereas the bending moment due to wheel load is maximum below one of the wheels. For simplicity, the maximum bending moment due to dead load is directly added to the maximum wheel load moment.

3. Maximum shear force is to be calculated. This consists of the shear force due to wheel loads and dead loads from the gantry girder and rails.
   - Generally an I-section with a channel section is chosen, though an I-section with a plate at the top flange may be used for light cranes.
   - When the gantry is not laterally supported, the equation to be used to select a trial section is as follows:
     \[ Z_p = \frac{M_u}{f_y} \] .................................................................(1)
     \[ Z_p \text{ (trial)} = kZ_p, \quad (k = 1.4-1.5) \] ......................................................(2)
   - Generally, the economic depth of a gantry girder is about \((1/12)\)th of the span. The width of the flange is chosen to be between \((1/40)\) and \((1/30)\)th of the span to prevent the excessive lateral deflection.

4. The plastic section modulus of the assumed combined section is found out by considering a neutral axis which divides the area in two equal parts, at distance \(y\) to the area centroid from the neutral axis. Thus,
   \[ M_p = 2fyA/2y = A_yf_y, \quad \text{where } A_y = \text{plastic modulus } Z_p \] ............................................(3)

5. When lateral support is provided at the compression (top) flange, the chosen section should be checked for the moment capacity of the whole section (clause 8.2.1.2 of IS800):
   \[ M_{dz} = B_mZ_p/f_y \leq 1.2Z_p/f_y \] ..............................................................................(4)
   Above value should be greater than applied bending moment. The top flange should be checked for bending in both the axes using the following interaction equation:
   \[ (M_y/M_{ndy}) + (M_z/M_{ndz}) \leq 1 \] .............................................................................(5)

6. If the top (compression) flange is not supported, the buckling resistance is to be checked in the same way as in step 4 but replacing \(f_y\) with the design bending compressive stress \(f_{bd}\) (calculated using Section 8.2.2 of the code).

7. At points of concentrated load (wheel load or reactions) the web of the girder must be checked for local buckling and, if necessary, load carrying stiffeners must be introduced to prevent local buckling of the web.

8. At points of concentrated load (wheel load or reactions) the web of the girder must be checked for local crushing. If necessary, bearing stiffeners should be introduced to prevent local crushing of the web.

9. The maximum deflection under working loads has to be checked.

10. The gantry girder is subjected to fatigue effects due to moving loads. Normally, light-and medium-duty cranes are not checked for fatigue effects if the number of cycles of load is less than \(5 \times 10^6\). For heavy-duty cranes, the gantry girders are to be checked for fatigue loads (see IS 1024 and IS 807). Refer section 13 of the code for design provisions for fatigue effects. The fatigue strength is to be checked at working loads.