5. Structural Analysis

5.1. Global load effects

Structural analysis can be divided into the global and local analysis. The global structural analysis is concerned with the crane runway as flexural member and should, wherever possible, include the building frame. The local analysis covers top flange and bearing details. The building frame is not a static assemblage of members resisting reactions from the crane runway, but an interactive system. Lateral spacing of the building columns has to be related to the crane rail gauge and minimum clearances dictated by the crane manufacturer. Figure 10 shows the typical frame arrangement.

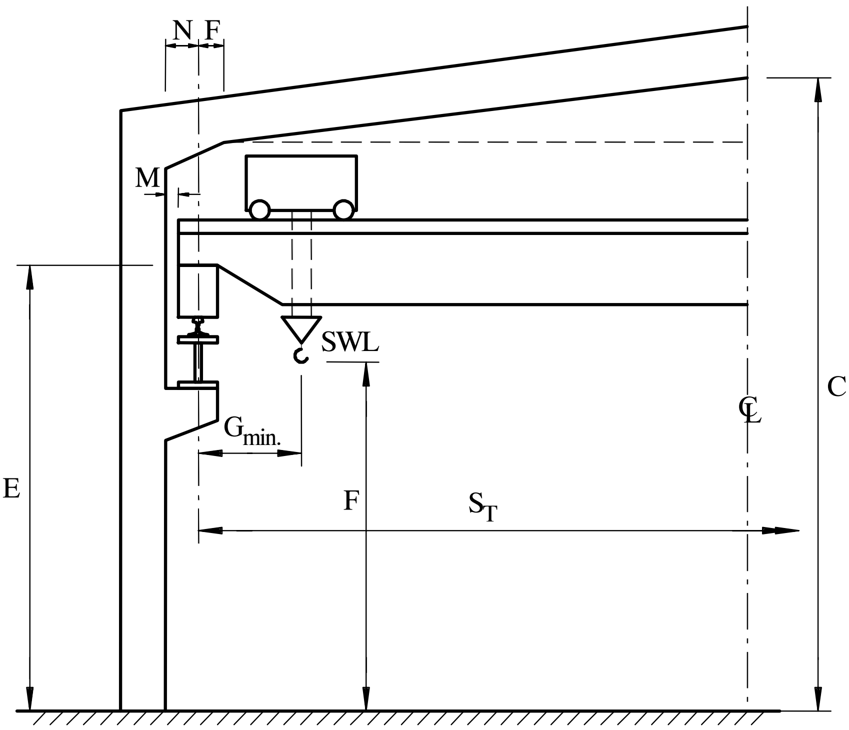
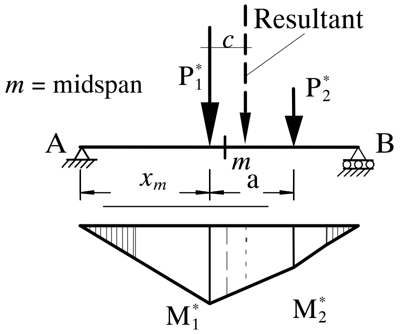


Fig 10. Frame / runway relation

Moving loads transmitted to the rails act simultaneously in three directions: vertical, lateral and longitudinal thus 3D analysis is more suited. Figure 11 illustrates the load effect diagrams. Global design should be carried out generally in accordance with the AS 4100 and AS 1418.18. The runway code allows the design to be alternatively based on the working stress method as specified in AS 3990. Most recent graduates would find the working stress method cumbersome, having been trained in the use of limit states design. This text only refers to limit states design method except for the serviceability checks.

5.2. Analysis for global loads

The global load effects include bending moments M_z and M_y at the critical section, axial loads and shear forces. The determination of global load effects is usually accomplished by moving the load train across the beam in such a location that maximum bending moment be obtained. The envelope of maximum bending moments and shears is often useful. The influence line method can be very useful when analysing continuous crane runways. The length of increments should be not more than 0.05L in order to minimise the computational error. Figure 11 illustrates the method. For manual calculations and only two wheel loads per side use can be made of Ref 36.



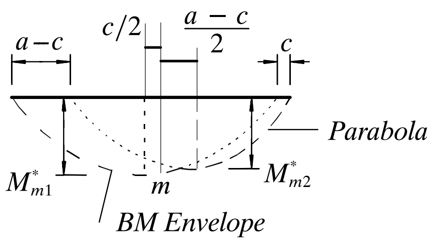
At the larger of the two loads, P_1

$$M_1^* = M_{max}^* = (P_1^* + P_2^*)\frac{x_m^2}{L}$$

where $$x_m = 0.5\left[L - \frac{P_2^* a}{(P_1^* + P_2^*)}\right]$$

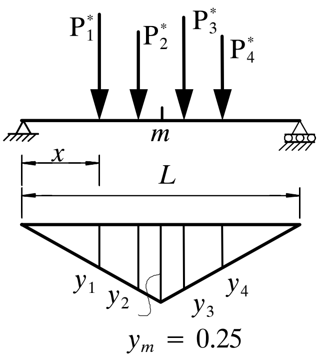
Envelope curve of maximum bending moments at all points along the beam is obtained graphically as shown. The distance c to the resultant is

$$c = \frac{P_2^* a}{(P_1^* + P_2^*)}$$



$$M_{m2} = M_{m1} - P_2^* a$$

$$R_{Amax} = P_1 + P_2^* \frac{(L-a)}{L}$$



Influence line for midspan section

The Influence line for the bending moment at mid point *m* is constructed as shown.
The maximum ordinate for midspan BM is:

$$y_m = 0.25$$

The load train is positioned by trial and error until the maximum bending moment is obtained. For any distance *x* it is necessary to compute the ordinates

$$y_1, y_2 \cdots$$

then the bending moment at *m* is

$$M_m^* = (P_1^* y_1 + P_2^* y_2 + P_3^* y_3 \cdots)L$$

this is repeated for adjoining sections until the maximum value of M^*_m is determined.

Fig 11. Bending moment envelope and influence lines

Global design consists of verification of:

- Bending moment resistance, in vertical plane, inclusive off lateral torsional buckling
- Lateral bending moment resistance in horizontal plane
- Shear resistance
- Torsion resistance
- Resistance to axial loads combined with bending

Lateral torsional capacity shall be determined in accordance with AS 4100 - Steel Structures.

Capacity verification is required at the critical of cross sections: at midspan, over supports, cantilever springing, change of girder depth and for each relevant load combination.

Lateral load pattern is often different from the vertical load pattern as can be seen from Figure 12, and thus it is necessary to consider all loads. Where computer analysis is used it is convenient to combine the vertical and horizontal load in the same load train to obtain the reliable maximum BMs and shears and being weary of wheels which lay off span.

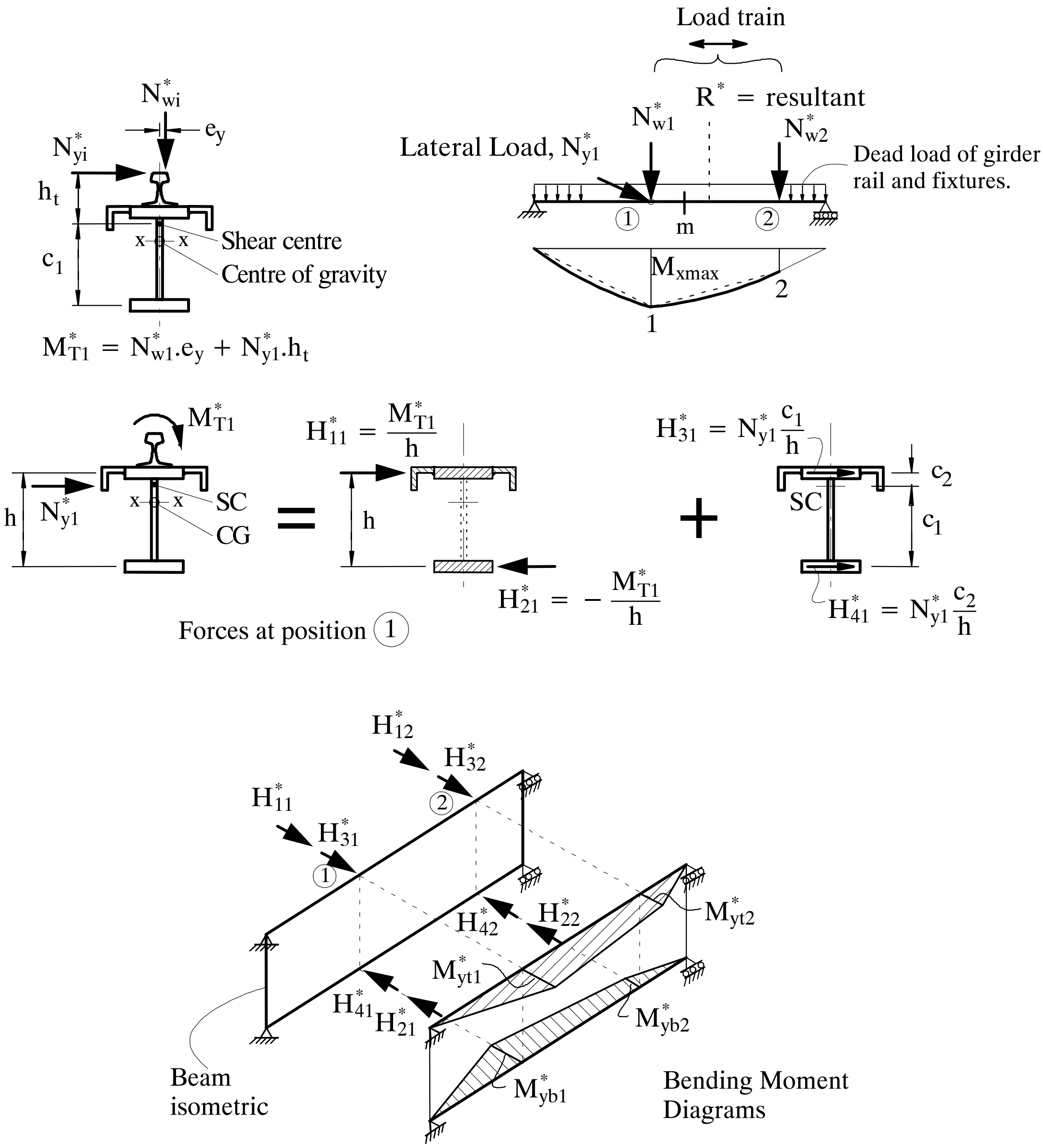


Fig 12. Global analysis for vertical and torsional loads

Crane Runway Girders

Limit States Design

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