Calculation for rails on concrete which are discontinuously supported

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When rails are mounted discontinuously there are a number of dimensions that must be either checked or suggested for the installation.

These include:

- **Clip or soleplate spacing**
- **Soleplate plan dimension**
- **Soleplate thickness**

This note gives methods of checking or choosing the required figures. Other notes in this series cover the selection of soleplate style and holding down bolt details.

SOLEPLATE SPACING

The soleplate spacing may be dictated by the stress in the rail or the deflection of the rail. In some cases neither of these are limiting criteria and experience is used to determine spacing. A given spacing may be acceptable for stress but not for deflection or vice versa. If the rail is oversized for a particular application, calculation might result in an impractically high spacing. It is necessary to check most applications. Hence the calculation method presented in this note is made as easy as possible.

CHECKING RAIL STRESSES

The maximum bending stress in the rail should be limited to 280 N/mm^2 for normal duty applications and to 200 N/mm^2 for heavy duty applications.

There are a number of assumptions that can be taken about the way a continuous rail acts when placed on a series of supports.

The simplest calculation and one which should always be safe assumes just a single length of rail is placed over two soleplates.

The formula that gives the spacing L between soleplates is as follows:-

$$L = \frac{(4\ x\ S\ x\ I_{xx})}{(K\ x\ W)} + A$$

Where;

S $\quad is\ the\ rail\ stress\ N/mm^2$

I_{XX} $\quad is\ the\ moment\ of\ inertia\ or\ second\ moment\ of\ area\ of\ the\ rail\ in\ units\ of\ mm^4$

Y $\quad is\ the\ distance\ of\ the\ nautral\ axis\ from\ the\ bottom\ of\ the\ rail\ in\ mm$

W $\quad is\ the\ wheel\ load\ in\ Newtons$

A $\quad is\ the\ length\ of\ the\ soleplate\ along\ the\ rail\ in\ mm$

Example:
Calculate L for German A75 rail in a medium duty application
Assume it is given that W = 20 tonnes - the wheel load
From experience try A = 165 mm i.e. soleplates for a heavy duty application

From above S = 200 N/mm^2

From the British Steel catalogue:

$$I_{XX} \quad = 531mm^4$$

$$Y \quad = rail\ height\ less\ distance\ of\ neutral\ axis\ from\ top\ of\ rail\ or\ (85 - 50.4)$$

$$K \quad = 34.6mm$$

$$A \quad = 165mm$$

$$W \quad = 20\ tonnes\ or\ 20\ x\ 1{,}000\ Kilograms\ or\ 20\ x\ 1{,}000\ x\ 9.81\ newtons$$

$$\text{L} \quad = \quad \frac{(4 \text{ x } 200 \text{ x } 531 \text{ x } 1{,}000)}{(34.6 \text{ x } 20 \text{ x } 1{,}000 \text{ x } 9.81)} + 165$$

$$\text{L} \quad = \quad 791\text{mm}$$

CHECKING RAIL STRESSES
A principle of good structural engineering says that the deflection of any member under load should be limited to a reasonable value. For normal crane applications it is reasonable to study the Code of Practice. In the UK, British Standard 5950 governs the design of structures. The 1990 edition of the standard called in clause 2.5 for deflection of crane girders to be limited to 1/600th of their span. The latest version of British Standard 5950 is based on limit state principles and is more difficult to use here. It is appropriate to apply the same rule to crane rails that are discontinuously supported. For high bay warehouse cranes there may be a lower limit on deflection as their height can result in difficulties when running over excessively flexible track. Gantrail suggest a figure of 1 in 1500. Some crane companies use a figure of 1 in 1000 and others use 1 in 2000. A further factor with high bay warehouse cranes is that the wheel spacing should be a whole number multiple of the clip spacing. Otherwise, one wheel can be over the “hard” soleplate and the other over the “soft” or “bendy” centre of the rail span. This could result in oscillations building up while the crane is in motion.

A similar calculation is required to that for the stress-limited application and the same assumptions are used. The formula for spacing is as follows:

$$\text{L} \quad = \quad \sqrt{\frac{(48 \text{ x E x } \text{I}_{\text{xx}})}{(\text{K x W})} + \text{A}}$$

Where L,A, Ixx and W are as above, K is the ratio of span to rail deflection i.e. 600, 1500 or any other specified value.

E is the modulus of elasticity of the rail or 210,000N/mm^2 for steel.

Example:
Calculate L for a British steel 56 Kg/metre crane rail section on 165 mm soleplates and with a wheel load of 30 tonnes.

$E \quad = 210{,}000\ N/mm^2$

$I_{XX} \quad = 836.31cm^4 = \ 836.31\ x\ 10{,}000mm^4$

$K \quad = 600mm$

$W \quad = 30\ tonnes\ or\ 30\ x\ 1{,}000\ x\ 9.81\ newtons$

$A \quad = 165mm$

$$L = \sqrt{\frac{(48 \text{ x } 210{,}000 \text{ x } 836.31 \text{ x } 10{,}000)}{(600 \text{ x } 30 \text{ x } 1{,}000 \text{ x } 9.81)}} + 165$$

$L \quad = 690.9 + \ 165$

$L \quad = 856mm$

This figure is higher than would be recommended from good practice. Gantrail would suggest a value of say, 700 mm for such an application.

SOLEPLATE DIMENSIONS

The soleplate must carry the full rail wheel load into the grout and the concrete without over stressing it. Most construction concrete is specified with a compressive strength of 30N/mm^2 or more.

It is suggested that concrete stress is limited 10 N/mm^2 when a pad is used and 7.5 N/mm^2 when no pad is used. These give safety factors of 3 and 4 respectively. This use of a higher stress when pad is used can be justified as British Standards and the Eurocodes allow higher stresses below a crane rail for steel structure design when a pad is used.

ACCURACY OF INSTALLATION

It is important for this type of installation that the soleplates are level with the bottom of the rail. If they are not, it may cause high stress points in the grout or the pad. The best method of achieving level soleplates is to mount the rail accurately and then use it to level the soleplates. Gantrail can advise on a number of different levelling methods.

CONCLUSIONS

All cases of rails on discontinuous supports should be considered with care. It is a cost effective way of mounting rails but it is one which has some case history of failures. These are normally attributable to inadequate design or workmanship. Gantrail has developed their calculation methods so that it can be readily applied to most cases. We are pleased to comment on any design for customers if we are given the full details of the proposed installation. Gantrail data sheets give details of the products that can be used in these applications.

DESIGN RESPONSIBILITY

This technical guidance note has been prepared on the basis of many years experience at Gantry Railing Limited. However, crane rails are significant structural items in many designs and installations, and it is not possible for Gantry to fully appreciate all the local circumstances. Thus the ultimate responsibility for the design and installation must normally rest with the competent local engineer.

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