

## CALCULATION FOR RAILS ON CONCRETE WHICH ARE DISCONTINUOUSLY SUPPORTED

### INTRODUCTION

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 suggests methods of checking or choosing the required figures. Pages 71-72 covers 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 a impractical 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 280N/mm<sup>2</sup> for normal duty applications and to 200N/mm<sup>2</sup> 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:-

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

Where *S* is the rail stress in N/mm<sup>2</sup>

*I<sub>xx</sub>* is the moment of inertia or second moment of area of the rail it is in units of mm<sup>4</sup>

*Y* is the distance of the neutral axis from the bottom of the rail in mm

*W* is the wheel load in Newtons

*A* is the length of the soleplate along the rail in mm

#### Example:

Calculate L for German A75 rail

Take A = 165mm i.e. soleplates for a heavy duty application

Take W = 20 tonnes as the wheel load

From above S = 280 N/mm<sup>2</sup>

From the British Steel catalogue:

$$I_{xx} = 531 \text{ cm}^4$$

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

$$= 34.6 \text{ mm}$$

$$A = 165 \text{ mm}$$

$$W = 20 \text{ tonnes} \\ \text{or } 20 \times 1000 \text{ kilogram} \\ \text{or } 20 \times 1000 \times 9.81 \text{ Newtons}$$

$$L = \frac{(4 \times 200 \times 531 \times 10,000)}{(34.6 \times 20 \times 1000 \times 9.81)} + 165$$

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

## CHECKING RAIL DEFLECTION

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. Clause 2.5 calls for deflection of crane girders to be limited to 1/600th of their span. 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:

$$L = \sqrt{\frac{(48 \times E \times I_{xx})}{(K \times W)} + A}$$

Where  $L, A, I_{xx}$  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<sup>2</sup> for steel.

### Example:

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

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

$$I_{xx} = 836.31 \text{ cm}^4 = 836.31 \times 10000 \text{ mm}^4$$

$$K = 600$$

$$W = 30 \text{ tonnes}$$

$$\text{or } 30 \times 1000 \times 9.81 \text{ Newtons}$$

$$A = 165 \text{ mm}$$

$$L = \sqrt{\frac{48 \times 210,000 \times 836.31 \times 10000}{(600 \times 30 \times 1000 \times 9.81)} + 165}$$

$$L = 690.9 + 165$$

$$L = 856 \text{ mm}$$

This figure is higher than would be recommended from good practice. Gantrail would suggest a value of say, 700mm 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 strength of 30N/mm<sup>2</sup> or more.

It is suggested that concrete stress is limited 10 N/mm<sup>2</sup> when a pad is used and 7.5 N/mm<sup>2</sup> 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 Standard 5950, allows 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.

## CONCRETE MOUNTED RAIL: CALCULATION FOR DISCONTINUOUS SUPPORT

Customer..... Date .....

Project..... Reference Number.....

Rail..... Rail I<sub>xx</sub>..... cm<sup>2</sup>

Rail Y (base to neutral axis)..... mm Rail foot width F..... mm

Gantrail clip type..... Gantrail pad ( ) No pad ( )

Allowed rail stress S {200 N/mm<sup>2</sup> for heavy duty ( )} {280 N/mm<sup>2</sup> for light/medium duty ( )}

Vertical wheel load W..... tonnes kN..... Other.....

Horizontal wheel load..... tonnes kN..... Other.....

Horizontal wheel load: supplied by customer ( ), assumed ( )

Deflection ratio K: 600 Crane ( ), 1500 Highbay ( ), Other .....

Crane wheel spacing if a high bay warehouse crane mm

Sole plate length along rail A..... mm (must equal a pad size if pad is to be used)

Steel elastic modules E 210,000 N/mm<sup>2</sup> Sole plate thickness T..... mm

### SOLEPLATE SPACING CONSIDERING RAIL STRESS LEVEL

$$L_{rs} = \frac{(4 \times S \times I_{xx}) + A}{(Y \times W)}$$

*For all equations Note:- W to be in kN  
I<sub>xx</sub> to be in cm<sup>4</sup>*

$$L_{rs} = \frac{(4x \quad x \quad x 10)}{( \quad x \quad )} + ( \quad )$$

$$L_{rs} = \quad mm$$

### SOLEPLATE SPACING CONSIDERING RAIL DEFLECTION

$$L_{rd} = \sqrt{\frac{(48 \times E \times I_{xx})}{(K \times E)}} + A$$

For the latest calculations click here to go to the Gantry Railing Website.

$$L_{rd} = \sqrt{\frac{(48 \times 210,000 \times x \quad x 10)}{( \quad x \quad )}} + ( \quad )$$

$$L_{rd} = \quad mm$$

For highbay crane wheel base spacing must be whole number of sole plate spacings.

$$L_{hb} = \frac{\text{crane wheel base mm}}{\text{whole number}}$$

$$L_{hb} = \text{_____ mm}$$

**FINAL SUGGESTED SOLEPLATE SPACING CONSIDERING ALL MATTERS = \_\_\_\_\_ mm**

**GROUT AND CONCRETE STRENGTH**

Stressed area of grout      A mm x (F + 2T) mm

Allowable grout stress P:    10 N/mm<sup>2</sup> with Gantrail pad (    )

7.5 N/mm<sup>2</sup> without Gantrail pad (    )

Figures assume high strength grout on concrete with a cube crushing strength of 30 N/mm<sup>2</sup>

**Stress on grout**       $P = \frac{(W \times 1000)}{(A \times (F + 2T))}$

$$P = \frac{( \quad \quad \quad \times 1000 )}{( \quad \quad \quad \times ( \quad + 2 \times \quad ) )}$$

**P = N/mm<sup>2</sup>    Acceptable (    ) Unacceptable (    )**

**CLIP LATERAL LOAD CAPACITY**

Gantrail clip type \_\_\_\_\_ Lateral load capacity \_\_\_\_\_ kN

Expected maximum lateral load \_\_\_\_\_ kN    Acceptable (    ) Unacceptable (    )

Check rail head and web stress to Gantrail recommendations

**Head**    Acceptable (    ) Unacceptable (    )    **Web**    Acceptable (    ) Unacceptable (    )

**Calculation performed by** \_\_\_\_\_ **Signature** \_\_\_\_\_ **Date** \_\_\_\_\_

**COMMENTS**