Crane rails and changes in temperature

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Crane rails will normally be subject to changes in temperature. The question sometimes arises as to what effect this will have on the installation. Continuously welded rails may grow in length relative to the support on which they are placed or they may apply a significant force to the support. It is in part because of these potential changes that the Gantrail products were introduced and are still the correct choice for rail fixing. Continuously welded rails are the best solution for crane operation and any temperature effect problems need to be overcome in the details of the installation and the design of the structure onto which the rails are fixed. This note sets out to explain the possible situations that may be encountered. If rail anchor points or expansion joints are required, their design is discussed in the technical guidance notes on anchor points.

THERMAL EXPANSION

When a steel rail is heated it will expand if it is not restrained. The amount it will expand is proportional to the temperature rise and its total length. The formula for the amount of expansion is as follows:-

Expansion e in (mm) = (length (mm) x temperature rise °C x expansion coefficient)

The coefficient of thermal expansion for steel is 0.000011 mm per mm per °C

Take the example of a rail 200 metres long which is fixed to its support when the temperature is 10°C and which is subject to a temperature rise to 30°C; i.e. an increase of 20°C.

$$e = 200 \text{ x } 1{,}000 \text{ x } 20 \text{ x } 0.000011$$

$$e = 44\text{mm}$$

If the rail is sitting on a frictionless surface, it will grow in both directions by 22 mm.

In practice we do not know what temperature most rails are at when they are fixed. Thus it is normal to take the expected rise in temperature as half the expected total temperature range.

Note that the support on which the rail sits may expand and there may not be any relative expansion between the rail and its support.

FORCES DUE TO THERMAL EXPANSION

If a rail is fixed to a support and the rail temperature rises but it is not free to expand, it will apply forces to the structure on which it sits if that structure is not itself expanding. The forces that it applies are proportional; to the temperature rise, the cross sectional area of the rail, the modulus of elasticity of the rail and the thermal expansion coefficient. Note that the forces are not related to the length of the rail if the rail is truly fixed at both ends. The force in the rail in Newtons (N) = (temperature rise °C x rail area mm^2 x elastic modulus N/mm^2 x expansion coefficient per °C)

Take the example of a DIN 536 A100 rail which is fixed to its support at 10°C which is subject to a temperature increase to 30°C.

The cross sectional area of the rail is 9,580mm^2 and the modulus for steel is 210,000 N/mm^2

$$\mathrm{f} = 20 \text{ x } 9{,}580 \text{ x } 210{,}000 \text{ x } 0.000011 \text{ N}$$

$$\mathrm{f} = 442{,}596 \text{ N}$$

or

$$\mathrm{f} = \frac{442{,}596}{9.81 \text{ x } 1{,}000}$$

$$\mathrm{f} = 45.1 \text{ tonnes}$$

In practice the rail support will normally increase in temperature and will expand to some degree. Thus the very high forces that can be calculated with the heaviest rail section do not normally occur. The Gantrail clips are the most effective means of ensuring that the rail does not damage the structure. The clips allow the rail to move along the support in a controlled manner. They do not fix the rail rigidly.

WHAT REALLY HAPPENS

When a continuously welded crane rail is fixed by a series of clips, the clips act to resist the movement of the rail along the support. The amount of resistance will be dependent on the clip type, the nose dimensions and the degree of nose compression. A further complication is that the rail may creep under the nose of the clip with time. The force from the clip nose onto the rail is typically in the range 400 and 1500 Newtons (0.04 to 0.15 tonnes force). The actual figure depends on the length and depth of nose and its degree of compression. Take the case already considered; assume the clips are at 600 mm centres. Assume that each pair of clips can exert a resistance of 0.5 tonnes force. This is calculated as follows: -

$$2 \text{ x } 0.10 \text{ tonne due to the clip noses pressing on the top of the rail}$$

$$2 \text{ x } 0.10 \text{ tonne due to the reaction from below the rail}$$

0.10 tonne, which is the approximate weight of the rail between each pair of clips. Now calculate the number of pairs of clips required to resist the calculated force.

$$\text{Number of pairs of clips} = \frac{45.1 \text{ tonnes}}{0.5 \text{ tonnes}}$$

$$\text{Number of pairs of clips} = 90.2 \text{ pairs}$$

$$\text{i.e. } 91 \text{ pairs}$$

Now calculate the length of rail that is fixed by 91 pairs clips. Assume the clips at the ends of the rail are at 600 mm from the ends.

$$\text{Length} = 91 \text{ x } 0.6 \text{ Metres}$$

$$\text{Length} = 54.6 \text{ metres}$$

Thus the 54.6 metres at each end will be anchoring the centre of the rail. The centre 90.8 metres portion will not expand or contract with the temperature rise from 10°C to 30°C. The amount of movement at the ends of the rail due to expansion will be very much less than the 22 mm calculated above. Perhaps 5 mm might be expected. The calculated force of 45.1 tonnes in the rail will be taken by the clips over the end 54.6 metres.

PRACTICAL CONSIDERATIONS

Certain practical considerations arise as a result of the analysis. Each case needs to be considered on its merits.

- End stops should not be fitted too close to the ends of rails.
- When a building is to have bracing against horizontal force along the length of the rail at each end, the structure should be able to take the expected maximum horizontal force from the rail.
- Some container cranes and cranes in aluminium plants have points along the rail where the rail is cut and which cannot tolerate any expansion or contraction, e.g. the hinge on a container crane or the ‘drop girder’ which allows crane removal and maintenance in aluminium plants. At these points the rail needs to be fixed so that no movement takes place. The Gantrail Clips are not designed to do this. Welding or bolting can take the expected longitudinal force.
- Some older buildings had continuous girders instead of simply supported girders. With continuous steel girders there is unlikely to be any relative movement between rail and support. These are not common now.
- Concrete has a similar coefficient of thermal expansion to steel but it tends to have a greater mass. Hence it warms up and cools down more slowly. Thus the temperature differences may be greater than would occur with rails on steel structures.
- When considering what is actually happening with any particular installation, one needs to know the details of the girders, their expansion joints and the bearings on which they sit. The problem of carrying the forces from the rail into the structure is one for the structural design engineer. They have the necessary information on the design.
- Gantrail Technical Department will be pleased to advise on any application.

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