

Effective methods for installing a rail support system are reviewed with consideration given to duty cycle, alignment tolerances, cost, structural integrity and maintainability. Rail joints should be welded and synthetic rubber pad used under rail to reduce impact shock and vibration. Epoxy grout between soleplates and concrete foundations is more durable than cementitious grout.

Effective methods for mounting rail systems on concrete foundations

By Paul G. Kit

MAJOR advances have been made in the mounting of rails for overhead crane systems. Unfortunately, these technologies have not been widely applied to rail systems fixed on concrete foundations. Poor service life and complete system failures on critical equipment have occurred. Grout, anchor bolt, foundation failures and loss of rail alignment tolerances are a few of the symptoms. The key is to install a rail-support system that will be strong enough to protect the foundation and economical as well. Several effective methods are reviewed with attention to duty cycle, alignment tolerances, cost, structural integrity and maintainability.

Efficient material handling operations rely on their machinery. Proper attention to the foundations and rail systems that these machines move on can save time and money for the owner. Although the types of machinery vary widely, the underlying principles for proper design and construction of the rail systems remain the same. Material handling equipment such as gantry cranes, container handling cranes, coke plant machinery, transfer cars, grinding machines, railroad cars and captive aisle stacker cranes have duty cycles that warrant thorough consideration for design and construction.

Typical failure modes

Throughout the various industries that employ material handling machines, common failure modes are associated with inadequately designed rail systems. These problems manifest themselves in the deterioration of the rail system from the rails down into the foundation, and affect everything in between.

Frequently, rail systems on concrete foundations are built in a recess or trench and covered with lean concrete, asphalt, rubber track filler, gravel or other materials to make the top of the rail flush with the floor line. This often conceals the structural problems as they develop.

Visual indicators of a failing rail system include lateral movement of the rail head, suggesting variations in gage. If the rail system is mounted on the surface of the floor and the grout layer is visible, cracked or broken grout may be observed. As the grout breaks out from under the soleplate, the supporting strength is lost and additional loads can be placed on the anchors, causing a loosening of the entire system. Visual indications of movement of the rail system are almost always associated with impending problems. If the soleplate is shifting relative to the concrete foundation, the anchors and grout will soon fail.

Corrosion of metal components can reduce structural integrity over time. Standing water can rust away anchor bolts or cause

freeze-thaw cycles that damage the rail system. Also, when a wheel passes, it forces the water from under the rail or pad. If the rail or pad has been placed directly on concrete, hydraulic erosion of the concrete occurs. Proper drainage or backfill can help to reduce this problem, and galvanic coatings can also prevent corrosion damage.

One of the easiest defects to detect is a broken rail or deteriorated rail joint. A rail commonly breaks at a faulty weld. Deteriorated joints, where splice bars were used, are easily visible. Pieces of the rail ends can actually break off because of high local stresses and impact, leaving a bump that damages both the machinery and underlying foundation.

The most severe damage is deterioration of the concrete foundation. It is considerably more difficult to detect this type of damage because the foundation is buried. Movement, thermal stresses, inadequate design, overloaded rails, grout deterioration and impact loads all contribute to foundation failures.

Concrete foundation considerations

A concrete foundation must support a variety of static and dynamic loads imposed by the material handling machine that moves on the rail system. The designer must consider the operation of the machinery in the design of the foundations. It is relatively simple to design a pile-supported concrete beam, but the local effects of dynamic loads are not always considered. Some machines, such as coke plant machines, impart considerable side forces to the foundation. Alternatively, gantry cranes such as container handling cranes or shipyard gantry cranes may impart relatively little side thrust but, instead, have high vertical wheel loads. Some grinding machines and captive aisle stacker cranes may have low side thrust and low vertical wheel loads, but high cycle rates and speeds.

Reinforced concrete structures that are cast in place often appear to have more steel than concrete. Structurally, this makes the foundation strong, but can often create major problems for the contractor installing the rail system. Reinforcing bars that are axial, or parallel to the rail, should be detailed and positioned to allow space for drilled adhesive anchors through the soleplates. For example, if a 1-in. dia anchor is used, an axial bar should be centered under the rail centerline with sufficient space for at least a 3-in. clear zone for each line of anchors. This greatly reduces the amount of diamond core drilling required for installation. Diamond core drilling of reinforcing steel also reduces the strength of the foundation. Transverse reinforcing bars should be detailed with spacing to match the nominal anchor bolt spacing.

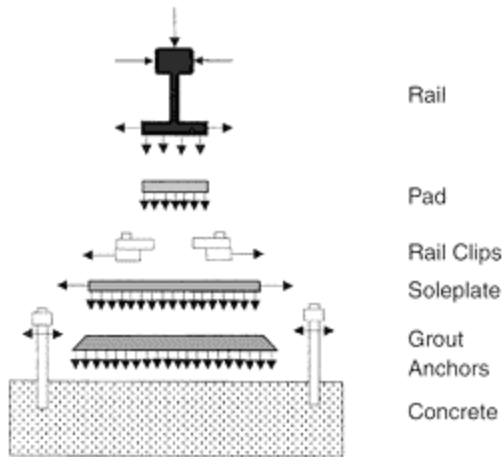


Fig. 1 — Load path from rail to concrete.

Concrete quality, or compressive strength, should be specified with consideration for the loads imparted by the rail system (Fig. 1). The static and dynamic loads from the machine are transmitted directly into the rail. The rail spreads this load over the elastomeric rail pad (where used) and through the crane rail clips into the steel sole-plate. The steel soleplate transfers the load onto the grout layer which, in turn, transfers the load to the concrete. Anchor bolts that hold the steel soleplate in position are affected only by shear loads. The concrete foundation must be able to support these static loads as well as dynamic loads imparted by the machine. Heavy-duty rail systems are often constructed on 4 or 5-ksi concrete. The designer must ensure that proper factors of safety are applied to meet local and national building codes.

For rail systems on concrete foundations, it is often advantageous to divide the construction work into separate specialties. Typically, a concrete contractor is used to excavate and pour foundations. Then, a rail specialist is used for precise installation of the rail system. This allows the concrete contractor to work to standard tolerances of, for example, $\pm 1/2$ in. for elevations. The final rail position can be accurately set by the leveling layer of grout, the drilled anchor bolt positions and the adjustable crane rail clips.

Rail alignment and elevation tolerances should be specified to follow *AISE* Technical Report No. 13.¹ This guide suggests that center to center of the rails should not exceed $\pm 1/4$ in. from the theoretical dimensions; that horizontal misalignment of the rails should not exceed $1/4$ in./50 ft of runway with a maximum of $1/2$ in. total deviation from theoretical location; and that vertical misalignment should not exceed $1/4$ in./50 ft of runway with a maximum of $1/2$ in. total deviation from theoretical location. The best way to ensure that the required design is met, is to specify and insist on an as-built survey of the final rail position.

Soleplates

The load path shown in Fig. 1 illustrates that the steel soleplate serves to spread a load over a larger area than would a system without a soleplate; the larger contact area of the soleplate spreads the load over more of the concrete to reduce local stresses. It is not advisable to set rails directly onto concrete unless the loads and duty cycle are extremely low. High local stresses between the rail base and concrete will crush the

concrete, causing failure. (Hydraulic erosion is also a concern.) Rails should be set directly on an elastomeric pad on top of a steel soleplate. The elastomeric pad spreads the loads between the rail and soleplate. In rail sections taken from the field, the actual bearing area between rail base and support is frequently 50% or less. Elastomeric pad increases the bearing area to nearly 100% under load. Steel soleplates can be continuous or intermittent depending on the requirements of the system.

In the past, it was the responsibility of the designer to detail the entire soleplate and anchoring system. Currently, standard soleplates are commercially available from rail system specialists and suppliers. The designer, contractor and owner can take advantage of pre-engineering by the runway specialist. Most of these standard soleplate designs are specified by rail size and wheel load. Complete material packages can be specified, consisting of rail, rail clips, rail pad, soleplates, grout and anchors. This provides unit responsibility and insures compatibility of the components used.

Continuous soleplate systems - Continuous soleplates are used for heavy-duty rail systems with high loads and high cycle rates. Continuous plates consist of 8 to 10-ft long plates, 11 to 14 in. wide (or more), with thicknesses varying between $1/2$ and $1 1/4$ -in. A continuous soleplate system installed at a port facility is shown in Fig. 2, with section and plan views of a typical system illustrated in Fig. 3. Longer soleplates can be utilized. Plates 10 ft long typically weigh approximately 400 lb and are easier to handle during field construction than longer ones.

Soleplates should be shop fabricated rather than constructed in the field. The quality will generally be superior from the shop. Additionally, shop costs are usually lower than field construction costs.

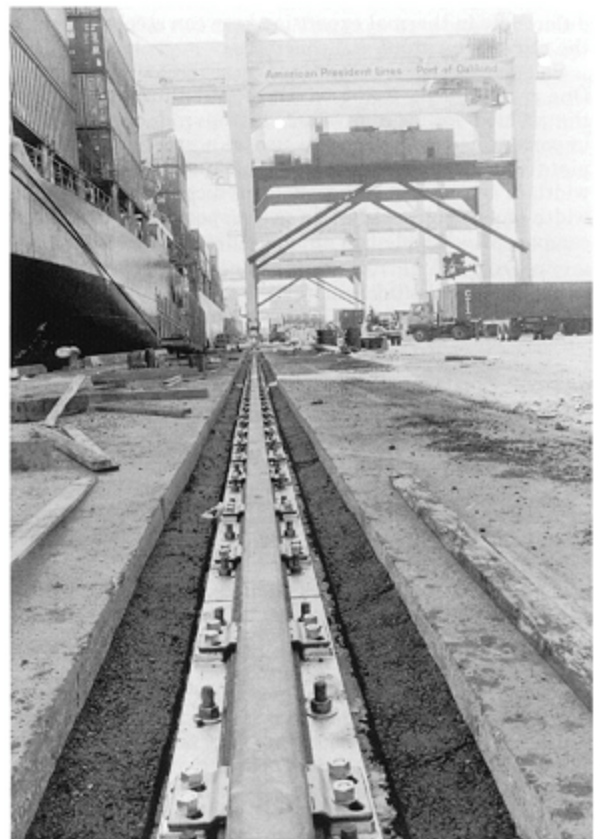


Fig. 2 — A continuous soleplate system at a port facility.

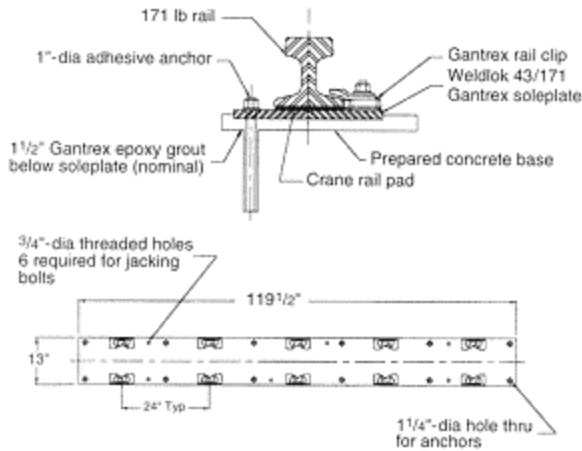


Fig. 3 — Section and plan views of a typical continuous soleplate.

Soleplates are usually constructed from A36 steel plates. Soleplate edges should be deburred and deslagged. If required, the soleplate should be stress-relieved to ensure that the plates are flat to within 1/8 in. over their length. The lower components of a rail clip can be welded in position in the shop. Holes for anchor bolts as well as jacking screws are also made in the shop. Anchor bolt holes should not be flame cut. Anchor bolt holes are typically 1/4 in. larger in diameter than the nominal diameter of the anchor bolt. Protective coatings such as an oxide primer, hot dip galvanizing or metallizing can be applied to protect the steel. A protective coating should be used in all marine environments.

Soleplate lengths should be determined by the nominal spacing of the rail clips and anchors. For example, to maintain 24-in, nominal spacing of clips and anchors, a 10-ft plate is optimum. For a nominal spacing of 30 in. for clips and anchors, an 8-ft plate is optimum. The plate is actually shortened slightly to allow for a control joint of 1/2 in. between soleplates laid end to end. This control joint accommodates manufacturing tolerances as well as the differences in thermal expansion between steel plates and the underlying grout and concrete.

Soleplate width is determined by several simple factors. One critical factor is the width required to accommodate the welded lower component of the rail clip. Another important factor can be the use of a standard width of plate that may be readily

available. For retrofits, the width of an existing rail pocket can dictate the maximum width of a soleplate. In some cases, special, narrow, lower component weldable rail clips are used to fit the plate to the rail flange width. It is usually assumed that loads spread in a 45° pattern from the centroid of the rail section. Any soleplate width outside this region will be redundant. Therefore, the narrowest width of soleplate that can be practically fabricated will have the lowest cost.

The thickness of a soleplate is typically between 1/2 and 1 1/4 in. Soleplate thickness does not have as much effect on the pressure between the soleplate and grout as might be expected. In the lateral direction, without a pad, the compressive region for stress distribution is in a 45° pattern from the tangent to the radii of the web to flange union of the rail (Fig. 4). If a pad is used, the entire width of the rail may be considered to be the compressive zone. In the longitudinal direction, 45° from top of rail to base of rail constitutes the compressive zone. Sometimes, a 2-in, contact patch is considered at the wheel to rail interface. Laterally, the soleplate will tend to have uplift forces at the interface between soleplate and grout in the region outside the compressive zone. Small incremental increases in thickness have minor effects on this region because of the geometry. It is important that anchors be placed in the region within the compressive zone of the soleplate, to prevent uplift forces from stressing the anchors. This is typically within 2 to 2 1/2 in. from the edge of the rail flange.²

Intermittent soleplate systems - Occasionally, because of a low-duty cycle, low loads or severe cost restrictions, a system may be designed with intermittent support soleplates (Fig. 5).

A typical intermittent system consists of discrete pedestals approximately 6 x 9 x 3/4 in. thick. Each pedestal generally has a pair of rail clips to fix the rail to the plate. The soleplate is then anchored to the concrete foundation with two or more anchor bolts. The pedestals are spaced approximately 24 to 36 in. apart, nominally, depending on loads and deflections. The objective is to reduce the amounts of material required for soleplates and grout. However, if pedestal spacing is 24 in. or less, it may be more economical to consider continuous soleplates to save on the number of anchor bolts that must be installed.

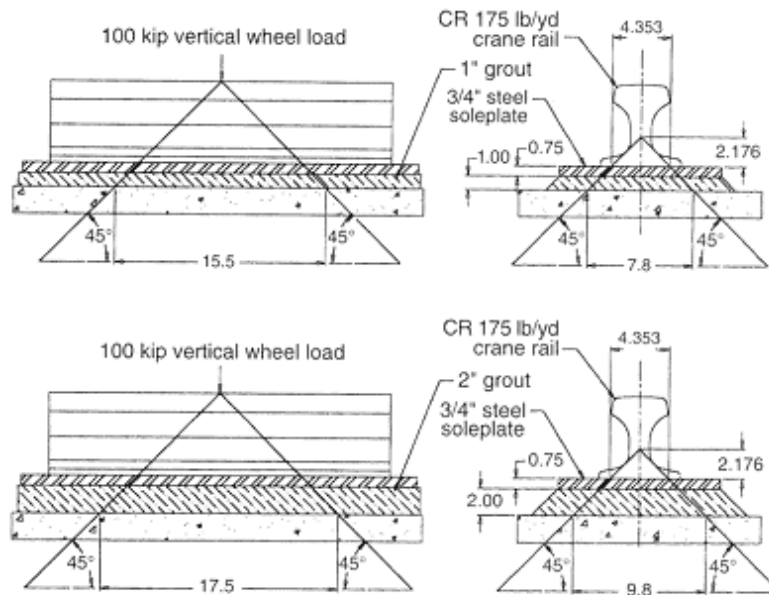


Fig. 4 — Load distribution from rail on concrete.



Fig. 5 — Intermittent soleplate rail system.

The rail in an intermittent soleplate system deflects downward under wheel load between pedestals. As the rail rotates about the edge of the soleplate, an uplift force is imparted to the rail clip. If the rail clip is hard mounted against the rail and over the anchor bolt, it will stretch and loosen the anchor bolt. A simple solution is to soft mount the rail using a proprietary rail clip with rubber nose and a rubber pad on the pedestal. This allows deflection in the vertical plane while providing lateral fixation. The load path to the anchor is reduced by an order of magnitude.

Intermittent soleplates with steel shim leveling - The low-budget approach to rail systems in industrial plants has frequently been to hard mount the rails to intermittent, steel support plates that are leveled by steel shims of incremental thicknesses. Generally, this is an inexpensive system, but it has several long-term deficiencies. The elevation tolerance is only as accurate as approximately double the thinnest shim plate used because of an allowance for flatness.

Although construction techniques may vary, these systems are generally built from the high point of the foundation and leveled away from that point. A level line is established for elevation, and stacks of shim plates are arranged as required. Shims are supplied in thicknesses such as 1/4, 1/8 and 1/16 in., depending on site conditions. The thickness of the shim stack is taken as its nominal thickness before the anchor bolts are torqued. The numerous metallic interfaces are prone to corrosion and degradation. Often, the rail clips are installed directly over the anchor bolts. In the future, a rail change will disturb the integrity of the anchor bolts, necessitating their replacement. Where possible, clip bolts that are independent of the anchors are preferred. Periodic maintenance such as tightening of anchor bolts or rail clips may be required. Deflection of the rails between pedestals tends to create uplift forces to the clips and anchors, thereby stretching the anchors or jacking the anchors out of the foundation. Periodic inspections of the concrete foundation should be performed to detect signs of damage.

Intermittent soleplates with grout leveling - The use of nonshrink grout allows for a more accurate elevation tolerance than the use of steel shims. Cementitious grouts are inexpensive, readily available and generally easy to install. Cementitious grouts, however, may crack and deteriorate because of cyclic, dynamic loading. An alternative is to use epoxy grout to support the intermittent soleplate. Epoxy grout has a faster cure time and maintains its toughness after set. It is more durable under the cyclic, dynamic loadings of material handling systems.

The same conditions for thickness, width and length apply to intermittent soleplate design as for continuous plates. The key difference is the spacing between pedestals. Spacing is predominantly based on the deflection of the rail between pedestals. The amount of deflection must be carefully considered as it can affect the performance of the machine running on it. For example, captive aisle stacker cranes are often more than 100 ft tall. Excessive deflection between pedestals can cause oscillations in the structure. Consideration of the wheelbase of the machine can also influence the spacing of pedestals.

Intermittent soleplates with continuous grout - A variation of the preceding system of intermittent sole-plates leveled with grout consists of discrete grouted pedestals connected together by grout poured continuously under the unsupported rail between pedestals. This nearly eliminates the deflection between pedestals. Because of the small bearing area of the rail footprint, epoxy grout is recommended for this application.

A significant drawback to this type of installation, however, is that the rail is essentially glued to the foundation. Any future rail change will require appreciable demolition work to remove the existing rails, which will likely disturb the anchors and require resurfacing of the concrete base. This grout pattern may appear simple, but the formwork required to properly install grout under the pedestals and under the rail can be significant. Contractors consider it easier to install long forms along the edges of the pedestals and grout everything in between. Unfortunately, this requires significantly more grout. It is seldom practical to neck down the grout between pedestals all the way to the rail flange width. Cost analyses should include the volume of grout as part of the system.

Anchor bolt hole locations

Anchor bolt spacing is commonly 24 to 30 in. longitudinally along the rail system. The gage between the anchor bolts is in keeping with the the previous discussions. Anchors should be located within the compressive zone of the soleplate. Drilled adhesive anchors are generally installed by using the soleplate as a template and drilling through the plate into the concrete foundation with a light roto-hammer drill. If reinforcing steel is encountered, diamond core drilling may be required.

If the centerline of the rail position is known and marked, it is acceptable to shift individual pedestal locations longitudinally to avoid reinforcing steel transverse bars, but only if the pedestals are shifted closer together than the determined nominal spacing. If longitudinal reinforcing bars are encountered at each location, shifting the rail centerline laterally as a whole may be considered. An alternate method is to predrill additional anchor bolt holes in the soleplate during fabrication. The extra holes should be on a different gage from that of the nominal anchor holes. Construction drawings should indicate the required number of fully embedded anchor bolts to obtain design strength. Thorough attention to anchor bolt hole locations and optional hole locations can save significant field installation costs. Structural integrity of the reinforcing steel is also preserved.

Methods for leveling the soleplates

Several methods have been used for leveling soleplates. These methods include manual measurement of steel shim packs, shims between pedestals during grouting, leveling nuts on anchor bolts and removable jacking screws. Probably the most common of these methods is the leveling nut. However, leveling nuts should not be used on dynamic rail system installations for several reasons. First, a solid leveling nut could provide a potential load path from soleplate into the anchor in compression. Experience has shown that this causes anchor bolts to fail. Plastic nuts and spacers designed to eliminate this possible load path often lack the strength required to accurately level the soleplate. Where rail systems are recessed in a trench in the foundation, the leveling nuts are often extremely difficult to reach with a wrench.

An efficient leveling system, consisting of drilled and tapped coarse thread holes in the soleplate in conjunction with jacking screws, has proven to be the easiest during installation. The jacking screws push down onto the concrete foundation while the nuts on the anchor bolts hold the soleplate down. It is possible to accurately level the rail system from the top while it is mostly assembled. This ensures that the rail position is set by the rail itself instead of survey points. Approximately six leveling bolts are required for an 8 to 10-ft long sole-plate. Intermittent soleplates require at least three leveling bolts for proper functioning. Often, the leveling bolt holes can be provided as tabs or ears welded to the edges of the soleplate.

Other systems for leveling such as shimming the rail between pedestals on intermittent systems may work for some contractors. It is important to use proper survey equipment at this stage to get the rail system level before the grout is poured.

Anchor bolts

A rail system is fastened to the concrete foundation by the anchor bolts. Many different types of anchor bolts can be effectively used for dynamic rail systems. Consideration should be given to the material (grade of steel), installation method, means for retaining the anchor in the concrete (pullout strength) and finish (black or galvanized).

A typical continuous soleplate has 12 anchor bolt holes of 1 1/2 in. dia each. It can be difficult to line up twelve 1 1/4-in. anchors into twelve 1 1/2-in. holes. For this reason, cast in place anchors are seldom a labor saver or advantageous on rail systems. Some contractors attempt to hang the anchors through the holes in the soleplate. The soleplate is then suspended in position and the concrete foundation poured around it. Experience has shown that this method seldom achieves better than $\pm 1/2$ in. for any dimension related to elevation or alignment. Successful operation of the final rail system is always compromised. Other methods such as cast in place sleeves have been used with mixed success.

The most reliable anchor bolt for rail system positioning and fixation is the drilled anchor. Generally, the actual soleplates are laid out in position and the holes are drilled through the plate as a template. Light rotohammer drills are used to drill through concrete; diamond core drilling machines are used to drill through reinforcing steel. The diameter of the drilled hole must be specified by the manufacturer of the anchor bolt or other qualified engineer. If the hole is too large or too small, full

strength may not be achieved. Several types of wedge anchors and lag bolts have been developed and used for light - duty rail systems with limited success. Dynamic vibrations and loadings often loosen the anchor within the hole. Anchors are rated by pullout strength. Often, a specified embedment length is required to obtain a specific strength. Many adhesive anchors have been developed that can consistently achieve breaksteel strength. This means that the steel anchor will yield before it pulls out of the concrete, provided that anchor was properly embedded. The anchor adhesive is often a polyester resin or a two - part epoxy.

Most anchor bolts consist of a continuously threaded rod. The ratio of embedded length to diameter is approximately 8.5:1. For example, for a 3/4-in. dia anchor, the suggested embedment for breaksteel strength is 6 1/2 in. The length of the required anchor is determined by adding the following dimensions:

- Minimum anchor embedment length.
- Grip length of soleplate thickness.
- Washer and heavy hexagon nut.
- Nominal thickness of grout layer plus a tolerance for variations.
- Reasonable extra amount to obtain a standard length.

Anchor bolts can be obtained in many different material grades. Mild steel anchors are made from A36 carbon steel. High-strength anchors are typically classified as A449 or A193 B7 steel. The anchor material grade, diameter and spacing are determined by the designer. Consideration shall be given to the static and dynamic loads imposed by the moving machinery on the rail system. Most rail systems with high dynamic duty cycles, or wheel loads in excess of 100 kips, require high-strength anchors. Some lighter systems with anchor bolt dependent rail clips also require high-strength anchors. Anchor bolts, nuts and washers may be specified hot dip galvanized in accordance with ASTM A 153. This will provide corrosion resistance in outdoor, marine or other applications involving standing water.

A strict, universal calculation for determining anchor bolt diameter has not been developed. Many designers utilize shear capacity. However, the bond from epoxy grout, friction between the soleplate and grout, and clearance holes around the anchors almost entirely preclude the anchor from seeing shear loads. Empirically, crane rail systems seldom have anchors smaller than 3/4 in. dia or larger than 1 1/4 in. dia.

Soleplate grout

A layer of nonshrink, cementitious or epoxy-based grout, must be installed between the steel soleplate and concrete foundation. Its purpose is to provide full, intimate bearing between the steel soleplate and concrete foundation. Typical thickness varies from 1 to 3 in. depending on application.

The effect of grout layer thickness is illustrated by considering Fig. 3 and the following calculation shown in Table I for 1 and 2-in, thick grout layers. For this example, increasing the grout layer thickness from 1 to 2 in. reduces the pressure on the underlying concrete by 30%.

TABLE I Effect of grout layer thickness on pressure

Condition	Grout layer thickness	
	1 in.	2 in.
Area	15.5 in. x 7.8 in. = 120.9 in. ²	17.5 in. x 9.8 in. = 171.5 in. ²
Pressure	100,000 lb/120.9 in. ² = 827 psi	100,000 lb/171.5 in. ² = 583 psi

Grout selection should not be based simply on compressive strength. The most important factors are durability, placeability, flowability, chemical resistance, curing characteristics and overall economy. Placement of forms should also be considered. Grout is usually installed using a head box (Fig. 6) to pour grout from one side of the soleplate. The grout flows under the soleplate as the head box is moved axially along the rail system, thus ensuring that there will be no air entrapment under the plate. Grout should never be poured from both sides of a soleplate. It cannot be overemphasized how important ambient temperature is to the success of a grout pour. The contractor must explicitly follow all installation instructions from the grout manufacturer. Epoxy grouts are extremely dependent on temperature for cure rate. For continuous soleplate systems, control joints should be placed across the grout cavity. These joints consist of a foam backer rod or similar divider to create a 1/2-in. break laterally across the grout. The control joints should be placed at least every 10 ft and ideally at 5-ft intervals. The control joint accommodates the differences in thermal expansion between concrete and grout.

Flowability is a desirable feature of grout. For example, if the grout cavity is detailed to be 1 1/2-in. nominal thickness, the actual thickness of the layer could be between 3/4 and 2 in. or more, depending on concrete placement tolerances. A nominal thickness of less than 1 in. may produce an actual field condition where the grout cavity is less than 1/2 in., and most grouts will not flow into a cavity that small. A good, flowable epoxy grout can easily flow into a cavity 3/4 in. thick. Flowable grout can be installed faster and by fewer men, thereby reducing costs.

Rail fastening system

Rails should be fixed to soleplates by an adjustable, locking rail clip. This type of rail clip is available in a boltable or weldable style. Weldable base rail clips are useful for steel soleplates because they can be shop welded to the plate. All fasteners remain on the upper surface. Boltable style clips may be used for light-duty systems where the clips are mounted over the plate anchor bolts. However, clips that allow the rail to float laterally or clamp the rail flange with metal to metal contact should not be used for medium to heavy-duty applications. Weldable rail clips can be supplied as part of a standard soleplate by a rail system specialist. Thus, the welding details of the rail clips are the responsibility of the fabricator who makes the soleplates. The use of standard soleplate designs can result in significant monetary savings on a project.

A steel-reinforced, synthetic rubber crane rail pad has been shown to greatly increase the bearing area and reduce stress concentrations and vibration. Pads should be used to protect the grout layer and underlying concrete from impact and machine-induced vibrations. As previously discussed, even intermittent soleplate systems benefit considerably from the use of preformed pads on each soleplate pedestal.

Rails

The selection of a rail section for an application is based on the consideration of several items including maximum vertical wheel load, lateral thrust, available space, wheel size and configuration, hardness, availability and economy. Rail selection is achieved from a consensus among the runway designer, owner and machine manufacturer. It is recommended that heat-treated rail sections be used where available. The modest cost increase is worth the return of additional service life of the system.

Rails should be welded at their joints whenever possible. Thermite welding, gas pressure welding and flashbutt welding have proven to be effective methods for joining rails.

It is also the designer's prerogative to specify the stock lengths of rails used to make up the runway. Essentially, this allows the designer to specify the number of joints in the rail system. Most rails are supplied in standard 39-ft lengths. The use of 60-ft lengths of rail reduces the number of joints with only minor increases in handling difficulty. Rails 78 ft long are also available, but are more difficult to work with and transport. The longest rail section that can be transported by truck, without special permits, is 60 ft, often the most practical stock length.

Construction methods

Construction methods vary widely depending on the contractor performing the installation. It is most important in obtaining a proper installation to clearly specify the requirements. Consider including a list of contractor qualifications. Include requirements for preliminary surveys to verify actual foundation conditions. The contractor should also perform an as-built survey to prove that the rails are where they are supposed to be. Identify the materials by performance, brand, model number or supplier to ensure that the items will meet the required life expectancy. Select the installation contractor by reviewing his references for similar types of projects. Unit responsibility and system warranties are available from rail system specialty contractors.

Maintenance and inspections

A rail system on a concrete foundation should be inspected similar to the way that an overhead crane runway is inspected. It should be visually inspected on a periodic basis. Visual indications of excessive rail wear may indicate a loss of gage or crane skewing. If the rail head is moving laterally, problems may extend to the foundation. It is important to inspect for worn or broken joints in the rail and repair as necessary. If they are exposed, inspect the rail clips and anchor bolts for loose, broken or missing bolts. If the grout layer is visible, inspect for grout deterioration; however, cracks in grout do not necessarily indicate a problem. Missing pieces of grout or voids under the soleplate signal a problem. An annual or semiannual survey of the rails can help to indicate problems before they become irreversible. A properly designed rail system should last with little or no maintenance after installation.

Conclusions and summary

A rail system on a concrete foundation is more than the sum of the initial materials costs. It must allow for easy, cost-effective installation and require little or no maintenance. The dynamic effects of the machinery on the rail system and the duty cycle govern the design. Ambient conditions should be considered in the design with respect to chemical and atmospheric resistance, material selection and temperatures during installation. The design of the rail system should allow for future rail changes without disturbing the grout, anchors or foundations. Rail joints should be welded and synthetic rubber pad used under the rails to reduce impact shock and vibration. Locking, adjustable rail clips should be used to allow rails to be aligned and locked into position. Epoxy grout between the soleplates and concrete foundation is considerably more durable than cementitious grout in dynamic applications. Although epoxy grout costs more than cementitious grout as a raw material, the installed cost is relatively minor, considering ease of installation and life

expectancy. Periodic inspections of the rail system should be performed and repairs initiated before complete system failure occurs. Rail systems should be designed to make use of standard components specifically developed for the mounting of rails on concrete foundations. The use of standard design soleplates can reduce materials costs considerably. An understanding of the field conditions and construction techniques is critical to the design economy and overall success of the installation.

REFERENCES

1. Technical Report No. 13, "Guide for the Design and Construction of Mill Buildings," 1997, Association of Iron and Steel Engineers, Pittsburgh, Pa.
2. Faville, W. S., Technical Bulletin No. 15, "Soleplate Thickness," 1981, Gantrex Corp., Hanover, Mass.