Diagnosing Bridge Crane Tracking Problems

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Introduction

Poor bridge tracking can be a stubborn and expensive maintenance problem for overhead cranes. It is also one of the most tedious problems to troubleshoot. Tracking problems are difficult to diagnose because of the many conditions that cause them. If they are not promptly rectified, the destructive action feeds on itself and problems can multiply. When this happens, the problem becomes even more complicated.

This article provides a good starting point to help maintenance technicians and engineers solve tracking problems by the process of elimination. Due to the many possible configurations of top running overhead cranes and runways, this guide can only provide general guidance on this topic.

Normal vs. Abnormal Bridge Tracking Behavior

Skewing, side thrust, and wheel/rail wear occur naturally during bridge tracking. Design specifications for cranes and runways provide for lateral crane loads and forces caused by steering and skewing. For certain hard worked crane applications, wheels and rails may be considered consumable items. For these cranes, it is difficult to discern between normal and abnormal behavior. For abnormal tracking behavior, look for one or more of the following symptoms:

- Frequent replacement of wheels, wheel bearings, and rails.
- Broken tie-backs between runway beams and columns.
- Extra drive power required to muscle through certain areas of the runway.
- Broken wheel flanges.
- Loud scraping sounds.
- Wheel flanges pressed hard against the rail head.
- End trucks cracked near the wheel assemblies.
- Loose girder connections.
- Wheel flanges attempt to climb over the rail then suddenly crash down.
- Bridge derailment.

Even if these symptoms are not present, the suggestions in this guide will help improve bridge tracking performance and reduce maintenance.

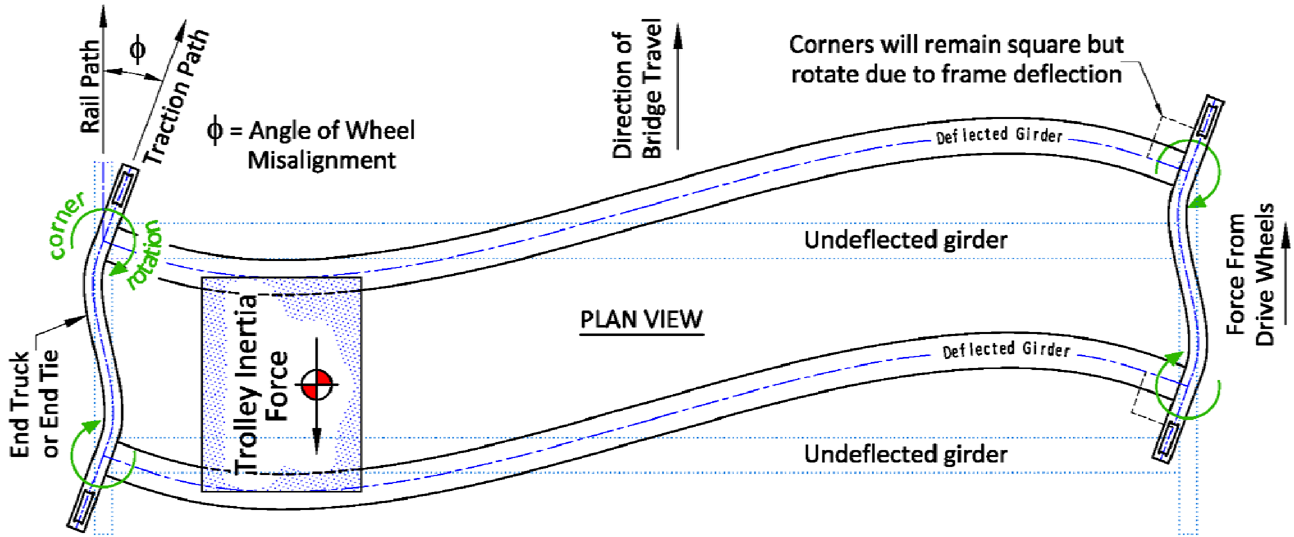

Figure 1: Bridge Frame Deformation
(Shown greatly exaggerated)

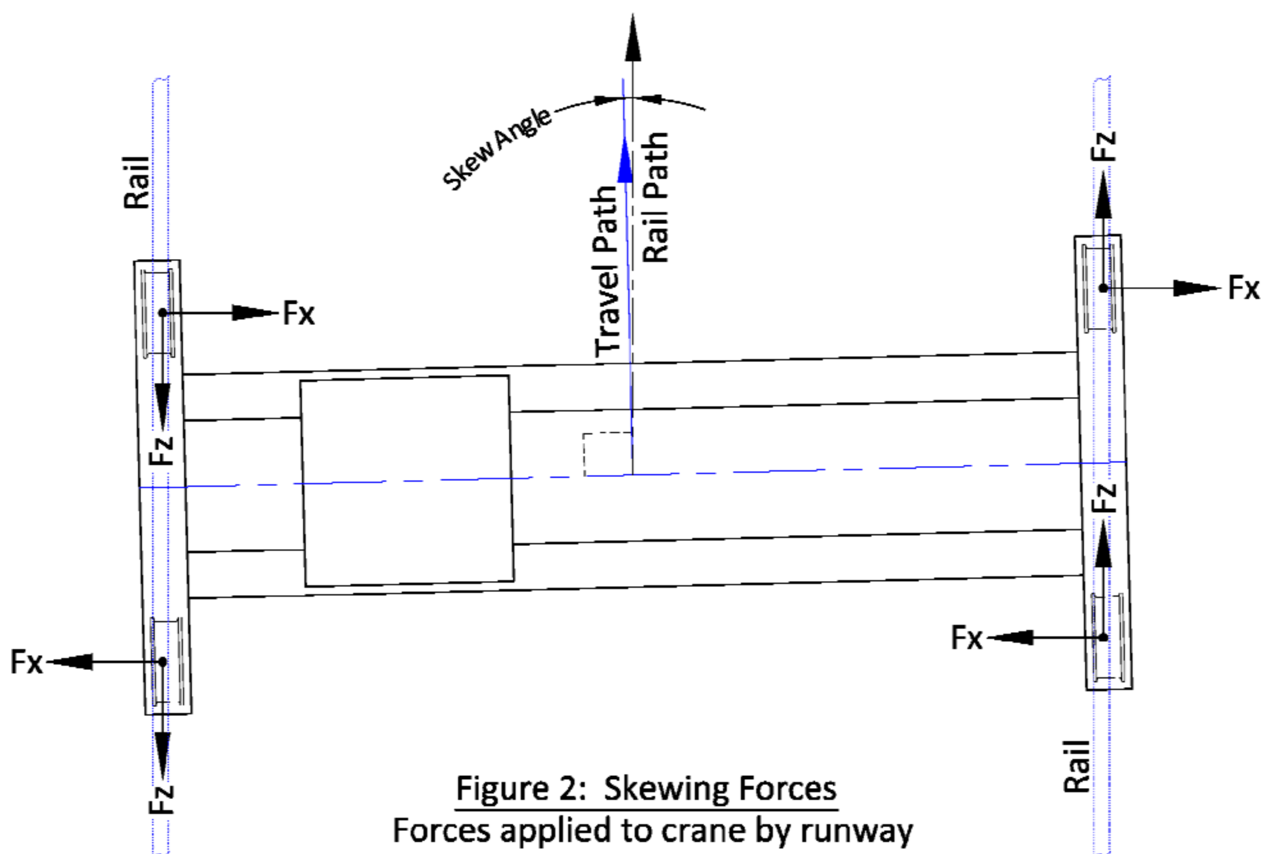

Figure 2: Skewing Forces
Forces applied to crane by runway

A Simplified Description of Skewing

Skewing occurs when there is a difference in traction or speed between the driven ends of the bridge.

For this description we will assume that skewing is initiated by one drive end moving faster than the other, or from drive wheel skidding/slippage. When this happens, the following events are set into motion:

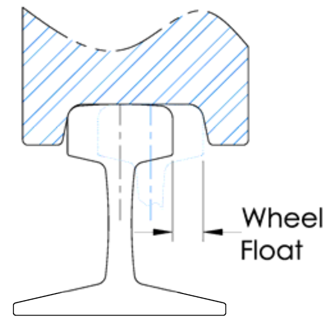

Figure 3: Wheel Float

Recommended float for straight tread bridge wheels:

- CMAA #70: $\frac{3}{4}$" to 1".
- AIST TR-6: 1 $\frac{7}{16}$" minimum. Up to 1 $\frac{1}{2}$" for 171 lb. rail.

1. The drive effectively delivers a larger traction force to one end of the bridge.
2. The difference in traction between the driven ends causes the bridge span to act as a lever arm. The lever arm forces are resisted by lateral loading of the wheels and rail.
3. The lever-arm action causes the bridge frame to temporarily deform as shown in figure 1.
4. The deformation causes the corners of the bridge frame to twist, and the wheels to become temporarily misaligned. If the frame is not stiff enough, the misalignment will contribute to the tracking problem.
5. The frame will remain deformed as long as there is a difference in traction force between the driven ends.
6. The traction difference causes the crane to steer to one side of the runway.
7. The crane will continue to steer to one side until the wheel flange touches the side of the rail head.
8. The wheel flange applies a lateral force to the runway.
9. The lateral force creates a friction force parallel to the runway.
10. The friction force counteracts the traction force.
11. The random differences of the friction forces between bridge ends causes the skew angle to intermittently increase and decrease.
12. See Figure 2. The crane rotates (in plan) until the cumulative effect of wheel flange contact and lateral friction are equal to the effect of the traction force difference between the driven ends. The angle of rotation is the skew angle.
13. If the skew angle is allowed to be large enough, the friction force parallel to the runway will equal or exceed the traction force and the crane will bind and come to a halt.

14. If the drives have sufficient power and traction, the wheels will climb up the rail and the crane may derail.

15. If the skew angle is prevented from being large, the flange will skip off the side of rail and continue tracking along the runway path.

Suggestions for Diagnosing Tracking Problems

The following tables contain conditions to investigate. The conditions listed under each of the 6 suspect items are ordered by their likelihood to cause tracking problems.

	1.0 Runway Rail-Related			
	Condition	***Comment***	***How to Detect***	***Corrective Action***
1.1	Runway rails out of horizontal alignment.	Misaligned rails cause wheels to bind.	Perform a runway alignment survey.	Align rails per CMAA or AIST tolerances.
1.2	Excessive wheel float caused by rail wear.	See Fig. 3. Excessive float allows a larger skew angle, larger lateral rail force, and binding.	Inspect sides of rail head for excessive wear.	Replace worn rails.
1.3	Excessive lateral rail movement caused by use of floating rail clamps.	Floating clamps allow rail to shift laterally, causing a larger skew angle.	Check for gaps between rail base and rail clamp. Clamps should be tight against both edges of rail base.	Replace floating rail clamps with non-floating type clamps or clips.
1.4	Drive wheel skidding or slippage.	Causes unbalanced traction between drive wheels resulting in skewing.	Inspect rail surfaces for liquid or debris.	Keep rails clean and dry. Adjust motor controls to reduce acceleration.
1.5	Runway rail elevation out of alignment.	Relatively large elevation differences are required to cause problems.	Perform a runway alignment survey.	Align rails per CMAA or AIST tolerances.

Notes:

See references 1 and 2 for runway alignment tolerances.

	2.0 Wheel-Related			
	Condition	***Comment***	***How to Detect***	***Corrective Action***
2.1	Wheel misalignment relative to other wheels and tracking direction.	Produces the same effect as rail misalignment, and causes skewing.	Complete a precise wheel alignment survey.	"MCB" bearing capsules can be shimmed for alignment.
2.2	Excessive wheel float caused by wheel flange wear.	See comment 1.2.	Inspect wheel flanges for excessive wear.	Use greater flange hardness for replacement wheels.
2.3	Drive wheel diameters not matched within tolerance.	Causes speed difference across the span, resulting in skewing.	Check wheel tread diameters. See references 1 & 2 for tolerances.	Replace drive wheels with wheel pairs that have matching diameters within recommended tolerance.
2.4	Excessive wear of drive wheel tread.	Creates variable drive tread circumference and causes a speed difference between drive wheels.	By visual examination. Normal tread surfaces should look perfectly flat.	Replace worn wheels, use greater tread hardness.
2.5	Excessive wheel float due to tread profile too wide for rail head.	See comment 1.2.	Float should be within the values shown in Fig. 3.	Replace with wheels that have proper tread width.
2.6	Wheel bearing failure.	Causes skewing due to rolling resistance at one end of the bridge.	High local temperature at the bearing capsule, paint discoloration, noise.	Replace bearing and capsule.

Notes:

2.1. See reference 2 for wheel alignment tolerance. Wheel alignment surveys are difficult to perform and should only be completed by qualified personnel who are experienced with this work. Piloted flange capsules can be replaced with eccentric bores for adjustment. Bearing alignments can only be made to spherical roller bearings.

	3.0 Bridge Frame Alignment			
	Condition	***Comment***	***How to Detect***	***Corrective Action***
3.1	Bridge trucks, bogie trucks, or end ties out of alignment.	Original equipment may be misaligned, or became misaligned from other causes.	See 2.1	See 2.1.
3.2	Bridge span dimension out of tolerance relative to runway rail span.	Has same effect as rail span misalignment.	Use a precise laser "distance meter" to measure the bridge wheel spans.	Consult with a qualified person for bridge span modifications.
3.3	Loose girder connections.	Allows bridge frame to become misaligned.	Inspect girder connections.	Complete a precise wheel alignment survey. Ream holes to next larger bolt diameter, use interference fit bolts.
3.4	Bridge acceleration or deceleration with trolley at or near one end of the bridge.	See figure 1. One end of bridge moves faster than the other causing skewing.	Observe tracking behavior during acceleration with trolley at center of span compared to acceleration with trolley at end of bridge.	Modify duty cycle so that bridge acceleration does not start until trolley is near mid span of bridge.
3.5	End trucks or end ties too flexible.	See figure 1. Frame deformation can cause temporary wheel misalignment and skewing.	Perform an engineering analysis to determine corner rotation under normal service loads.	Consult with a qualified person to increase the stiffness of the bridge frame.

Notes:

3.1. There is a common misconception that bumping the crane against the end stops will "square" the bridge frame. This procedure is not recommended due to the following:

- The end stops may not be perpendicular to the runway.
- The bridge bumpers may not be square to the bridge alignment.
- Girder connections should hold the corner joint completely rigid and not be "adjustable".

	4.0 Runway & Building Structure-Related			
	Condition	***Comment***	***How to Detect***	***Corrective Action***
4.1	Broken tie-backs for runway beams.	See comment 1.2. Causes rail misalignment.	Visual structural inspection.	Consult with a qualified person to replace tie-backs with improved design.
4.2	Long span runway beam on one side of the runway.	Longer beam spans have larger deflection. See note below.	Observe poor tracking behavior over bays where one end of the bridge is supported by a beam with a significantly longer span than the other end.	Consult with a qualified person to specify positive camber and increased stiffness for the long span beam.
4.3	Excessive deflection of runway beam support brackets on columns.	Columns are eccentrically loaded by cantilevered support brackets for runway beams, causing the runway to deflect and decrease the runway span.	Poor tracking at or near columns.	Consult with a qualified person to increase the column stiffness.
4.4	Wind load on exterior wall causes excessive lateral deflection of runway.	If the runway is adjacent to an exterior wall, wind loading may cause runway lateral deflection. More significant for tall structures.	Poor tracking behavior during windy conditions.	Consult with a qualified person to increase lateral stiffness at the elevation of the runway.
4.5	Heavy snow load causes excessive lateral deflection of runway.	Heavy roof live load may cause columns to bow outward, and increase the runway span. More significant for very wide crane bays.	Poor tracking behavior with heavy snow load on roof.	Remove snow from roof.

Notes:

4.2 When the bridge travels across the runway beam, it deflects downward and assumes a concave shape. The bridge then travels on a downward slope until it reaches the mid span of the beam. After passing the mid span, the bridge travels uphill. More power is required for travelling uphill, and less for downhill. This condition creates a difference in traction force between the driven ends and can cause skewing.

	5.0 Bridge Mechanical-Related			
	Condition	***Comment***	***How to Detect***	***Corrective Action***
5.1	Drive shaft too flexible.	Applies to cross-shaft connected drive wheels. Flexible shafting causes a larger difference in angular twist between drive wheels.	Perform an engineering analysis to confirm that angular deflection of shafting is within allowable limits.	Replace with larger diameter shafting. See references 1 & 2 for allowable shaft twist.
5.2	Drive shaft couplings loose or worn.	Causes drive wheels to be unsynchronized.	Inspect bridge drive couplings	Replace loose or worn couplings.
5.3	Drive shafts become pre-loaded, shaft windup is locked-in.	Applies to cross-shaft connected drive wheels where 4-wheels are driven. If one drive wheel slips relative to the others, the drive shafts can become preloaded with torsion.	Observe tracking and watch for wheel skidding or slippage.	Inspect rail surfaces for liquid or debris. Keep rails clean and dry. Jack the drive wheel off the rail to release the torque.

	6.0 Motor Drive-Related			
	Condition	***Comment***	***How to Detect***	***Corrective Action***
6.1	Difference in braking torque between drive wheels.	Applies to independent drives with magnetic control. One end of the bridge stops faster causing skewing.	Visual observation of one end of the bridge stopping before the other.	Adjust brake torque settings to obtain equal torque.
6.2	Drive motor speeds not equal.	Applies to independent drives with magnetic control. One end of the bridge travels faster causing skewing.	Monitor motor speeds under dynamic conditions.	Service motors and/or motor controls to obtain synchronized motor speeds.

Conclusion

Use these tables as a starting point to create a disciplined and systematic troubleshooting procedure that is suitable for your cranes and runways. It is strongly recommended that the investigation phase be carried out by qualified, personnel who have experience solving tracking problems for a variety of different crane applications.

References

1. CMAA Specification #70, 2010 ed., Crane Manufacturers Association of America, Inc., Charlotte, NC.

2. AIST Technical Report No. 6, June 2005 ed., Association for Iron and Steel Technology, Pittsburgh, PA.

3. Fisher, James M., *Industrial Buildings – Roofs to Column Anchorage, AISC Design Guide 7,* American Institute of Steel Construction, Chicago, 2004.