CHAPTER 4: GRADE CONTROL, SCREEDS, AND BULKHEADS

Chapter 4 covers computations, grading, and inspections performed by the Contractor, Engineer, Structure Representative, field personnel, and construction personnel. Specific construction components include profiles, overhangs, screeds, bulkheads, and paving notches. These require in-depth scrutiny and review to prevent problems in grading and construction. Tools—particularly the finishing machine—benefit from regular maintenance and care for adequate measurement and construction. This chapter addresses the importance of attention to detail, proper planning, well-maintained tools, and meticulous processes for grading and inspection.

4-1 Computations

By thoroughly following best practices and procedures, the Contractor, Engineer, field personnel, and other partners safeguard the quality of their work and can seamlessly integrate new construction within existing frameworks. Topics covered in this section include:

1. "4-Scale" contours: Plot the entire deck construction environment and present an overview of elements, grades, and more.
2. Profiles—bridge deck widening and new construction: Ensure that new construction is well graded and built at the outset.
3. Dead load deflection, camber, and settlement: Plan for ongoing maintenance and review as construction settles and shifts.
4. Field notes: Detailed note taking and documentation are integral to the quality assurance process.

4-1.1 "4-Scale" Contours

Bridge deck contour plots drawn to a scale of 1-in. to 4-ft are referred to as "4-scales" (see Figure 4.1-1). In most cases, bridge deck contour plots (4-scales) are available from Structure Design. Bridge Construction Memo (BCM) 2-4.0, *Bridge Deck Contours and Geometrics,*[1] outlines how to obtain 4-scale contour plots.

[1] http://onramp.dot.ca.gov/hq/oscnet/sc_manuals/crp/vol_1/crp002.htm

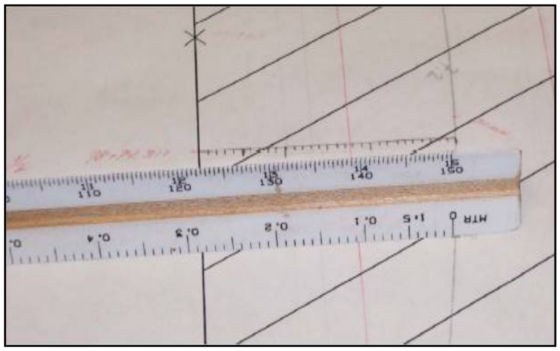

Figure 4.1-1. Deck Contour Plot Sample

After receiving the 4-scale contours, perform a detailed check of the plan dimensions and grades. Correct detail errors and conflicting dimensions before making copies of the bridge deck contour plots (4-scales) available to the Contractor. Check each bridge 4-scale sheet against the final finish grade profiles and the superelevation diagrams shown in the roadway plan sheets. Draw the edge of deck profiles to check for dips or humps caused by superelevation transitions, alignment tapers, and other anomalies. Extend the profile beyond the bridge paving notches and include retaining walls, wingwalls, bridge approach rail, and a section of roadway. Sections of the 4-scale may require revision to avoid possible grade problems.

4-1.2 Profiles

When widening or installing a new deck, the Engineer and field personnel must work together to ensure the new deck is carefully constructed and graded. Problems and poor alignment can be prevented, particularly at the outset of the project, with careful attention to detail, an understanding of potential hurdles and problems, and foresight. It is more efficient and effective to do the job well and thoroughly the first time than to attempt reworking a hurried pour.

4-1.2.1 Widenings

Widened decks are typically constructed to match both an existing bridge deck and theoretical grades generated for the outside edge of the widened deck. Field personnel generally develop deck contours for widening (see Figure 4.1-2).

Figure 4.1-2. Calculate Grades for Widened Decks.

Some features of existing decks that may cause problems are:

1. Too much camber.
2. Too little camber.
3. Bumps not corrected on the original contract.
4. Rough surfaces and other defects under removed overlays, curbs, and rails.

Correct these problems with grinding or overlays.

Sometimes medians are widened so that the top deck must match two existing bridge decks and a theoretical centerline profile. This type of widening may result in the existing bridge deck profiles conflicting with each other and with the theoretical centerline profile. If this occurs, adjust the profiles, vary the deck slopes, or seek other solutions. Closure pours between new left and right structures pose similar challenges. Determine the existing bridge deck profile elevations and cross slope by potholing overlays on existing bridges needing widening.

When edge profiles for the existing decks and roadways are included in contract plans, verify their elevations prior to starting construction. Develop profiles as early as possible to determine if remedial work is necessary. Identify grade problems and solutions early as well. For structures that cross over ramps, roads, or tracks, ensure that required permanent clearances will not be impaired by using field-acquired grades and extending the planned widening girder bottoms or soffit elevations from the existing structure.

4-1.2.2 New Construction

On long ramp structures, viaducts, and structures requiring multiple pours, potential bump problems exist at each transverse bulkhead, expansion joint, or hinge. Proper profiling and grade control of the adjacent work safeguards against grade or slope discontinuities at the edge of deck grades.

Extra care and caution are required when a second deck pour must match an existing deck at a hinge or a transverse construction joint. Care taken at the end of the first pour is essential to obtain a satisfactory joint. It is much easier and more effective to match a correctly poured joint than it is to compensate for irregularities.

After the first deck pour, create a cross section and profile of the deck. Establish a grid of points on the first day after the pour, preferably at even stations and offsets. Shoot and monitor elevations at this time until grades are established for the second deck pour. Use these elevation points to check for the possibility of long-term falsework settlement and to monitor the movement of post-tensioned hinges. Adjust soffit grades, “lost deck,” and screed grades if necessary. Extend and compare profiles of the first deck onto the second deck profiles with theoretical values. Then, adjust the second deck pour grades.

Maintain exact stationing and bench data on decks with steep cross-slopes, sharp vertical curves, or steep profile grades. The Engineer assures the correct stationing for the next segment, either by marking stationing in the newly finished edge of deck or another method. Lay out and shoot edge of deck points the first day after the pour as well.

4-1.3 Dead Load Deflection, Camber, and Settlement

Camber for the decks of conventionally reinforced concrete box girder, T-beam, and slab bridges is the algebraic summation of the anticipated long-term deflection due to creep of the concrete and the initial dead-load deflection. Experience shows that for box girder and T-beam structures, essentially all of the falsework deflection occurs when the girders are poured. This is true even for post-tensioned bridges with long falsework spans. Studies indicate that for a post-tensioned box girder bridge, 50% or less of the theoretical deflection due to the deck slab dead load is realized when the deck is poured. Therefore, the deck camber for conventional reinforced or post-tensioned box girder and T-beam structures would normally not include falsework deflection.

Deck camber for precast, prestressed girder bridges depends on the elapsed time between stressing the girders and placing the deck (see Figure 4.1-3). Because a significant portion of the dead load is not applied to the girders until the deck is placed, the prestressed "I" girders tend to creep upwards. The Contractor furnishes camber calculations[2] for precast, prestressed girders and shows them on the shop drawing submittal. When reviewing the shop drawings, pay particular attention to the time between casting and storage of the girders and the placement of the deck, especially for stage construction projects and widenings.

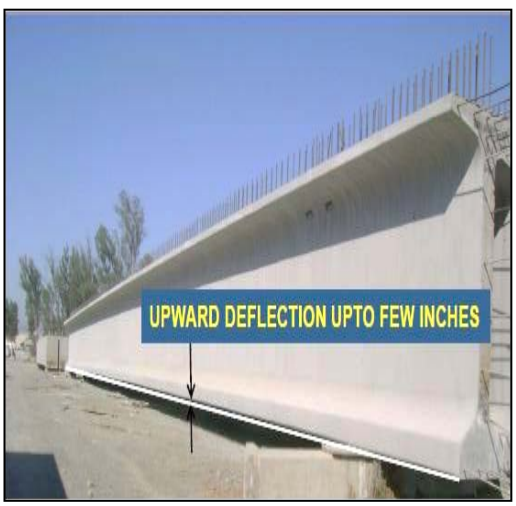

Figure 4.1-3. Measuring for Precast, Prestressed "I" Girder Camber.

Deck camber for steel girder bridges includes the initial deflection of the girder(s) from the dead load of the deck but does not include the deflection caused by the weight of the girder(s). In the case of composite design, add a residual amount to compensate for the additional deflection due to drying shrinkage of the slab.

[2] http://www.dot.ca.gov/hq/esc/techpubs/manual/bridgemanuals/bridge-memo-to-designer/page/Section%2011/11-1.pdf.

Long-term deflection of conventionally reinforced concrete bridges continues over a period of about four years. Approximately 25% of the total deflection occurs immediately after falsework is removed. Delay falsework removal to reduce initial and total deflections.

Consequently, on widenings[3], the plans or Special Provisions frequently require falsework support for a longer period of time. To further reduce the grade differential between widened and existing decks, the specifications may also require that a minimum period of time elapse between falsework release and closure pour. Typically, contract plans show only one camber diagram for the widening and is usually restricted from deflecting the same as an independent bridge. Depending on the amount of camber and the time of the closure pour, the total anticipated deflection for the section of the widening located next to the existing bridge may never be realized. Therefore, it may be necessary to adjust the amount of camber for this section of the widening in order to reduce possible grade differentials that could develop between the widened and existing decks.

As with falsework members, the dead load deflection of steel girder bridges must be checked. Before steel girder fabrication, check the effect of built-in camber using the 4-scale layouts. Use fills from the girder flanges to grade deck forms and screeds for steel girder bridges. Determine deck forms by comparing the profiles of the girders with those of the finished deck, including anticipated deflection, along the girder line.

There are three important factors to remember in connection with steel girder profiles:

1. Safety: Do not perform work of any kind without adequate safety devices, such as a safety belt attached to a cable, a safety rail running the length of the girder, safety nets, etc.[4]
2. Grade points: Accurately lay out grade points and reference them to the center lines of bearing.
3. Elevation check timing: Only run level circuits early in the morning when temperature variation is minimal and while the girder temperature *is constant or stable.* Do not go back later in the day and attempt to check elevations. These elevations may not even be the same the next morning.

Settlement can occur in the falsework and the forming system. Bridge deck settlement normally results from form take-up, assuming that falsework settlement is terminated or stabilized. Exceptions include:

1. Slab bridges where settlement is compensated for by screed adjustment during concrete placement operations.
2. Post-tensioned bridges where falsework settlement occurs because of prestressing forces applied after deck pour.
3. Deck-forming systems like overhangs, designated as falsework.

[3] http://www.dot.ca.gov/hq/esc/techpubs/manual/bridgemanuals/bridge-memo-to-designer/page/Section%209/9-3.pdf.

[4] Caltrans Safety Manual, Chapter 12, *Personal Protective Equipment*.

Both the *ASTM Standard Specifications* and the *Falsework Manual* address the falsework settlement. Some falsework settlement is normal because of take-up in forms, but the quality of workmanship must yield falsework that will "support the loads imposed without excessive settlement or take-up beyond that shown on the falsework drawings."

4-1.4 Field Notes

An organized and systematic approach towards bridge deck construction is important. Proper field book entries are essential for providing required bridge deck elevations in a timely manner. Entries for box girder deck construction should include the following:

1. Lost deck elevations: Saw cuts are typically placed on girder stirrups (or rebar) cast into the girder stems to provide the Contractor with top deck elevation control points. The *Standard Specifications* state, "Elevation control points will not be closer together than approximately 8 ft longitudinally and 24 ft transversely to the bridge centerline." Space the deck elevation control points closely enough to allow use of a string line to check the deck. Deck elevation control points can be grade marks placed a constant distance below finished deck grade, grade marks at finished grade, or fills to finished deck grade from preset points.

   A small error of closure normally exists between field-measured points and layout-scaled dimensions. This is true in soffit grades as well as lost deck grades. If these errors are not adjusted and discrepancies are allowed to accumulate, the camber diagrams will not correctly relate to the substructure, and wingwall and column grades will not match the superstructure grades.

   One acceptable method for adjusting errors is to assume that bents, piers, and abutments are in the correct location and prorate the error out within the spans. Layout the points on the 4-scale as measured in the field and shrink or expand the scale to make field measurements match the layout. Adjust soffit stations and soffit grade points accordingly.

2. Overhangs: When the overhang is formed after the girder stem pour, the Contractor should use the lost deck grades to establish grade for the inside portion of the overhang located next to the exterior girder.

   Once the locations of the overhang adjustment points are determined, generate the overhang grades. Typically, these grades are taken directly from the edge of deck profiles drawn to check the 4-scale contours. Depending on the forming system used, additional camber may need to be added to the overhang grades. Always check the bench mark used for grading the overhang against that used for shooting lost deck grades.

3. Screeds: Use overhang grades to shoot the screed. Depending on the forming system used, additional camber may need to be added to the screed grades to compensate for deflection due to the weight of the finishing machine.

4. Bulkheads: Finishing equipment establishes finish deck grades at bulkheads and paving notches.

Tie together all grades used for deck construction and always check back to previously shot grades for continuity. Spot check lost deck grades when shooting overhang grades to check for long-term falsework settlement. Coordinate stationing and level data between adjacent pours to provide a matching deck surface. Location and accessibility to bench marks require foresight to prevent the loss of key elevation points.

4-2 Grading and Inspection

Grading and inspection address the many different components that must come together for quality assurance. As in the previous section, care and consideration of each of these elements is imperative to establish consistent grade and pass inspection. This section gives guidance regarding the following elements during grading and inspection:

1. Contract surveying: Structure Representatives and bridge construction personnel must check the quality of surveying conducted by Contractors throughout the project.
2. Levels, transits, and inspection tools: Regularly scheduled tool maintenance is critical.
3. Overhangs, screeds, bulkheads, and paving notches: The grading, inspection, and correct placement of these structural elements are some of the most important processes for deck construction.
4. Finishing machines: Since there is usually only one available per job, successful bridge construction requires careful preparation and regular maintenance of this machinery.

4-2.1 Contract Surveying

Some projects, such as segmental bridge construction, incorporate contract surveying to reduce staffing and to make the Contractor responsible for providing the line and grade required to complete the job. Bridge construction personnel are expected to perform enough surveying to assure that each structure is built to the lines and grades specified. Typically, the Structure Representative checks almost all of the Contractor's survey points at the beginning of each job. As the project progresses, the Structure Representative may adjust the amount of checking to reflect the level of confidence developed in the Contractor's surveyors.

4-2.2 Levels and Transits

Establish a systematic schedule for maintaining, cleaning, and pegging levels on every project. Post it and keep it updated. Handle instruments with care, as they often get out of adjustment. Check level legs for stability as they can get loose and wobbly at leg tips and connection to the plate. Check Lenker rods for loose sole plates and sloppy operation.

4-2.3 Overhangs

Grading and inspecting the overhang bulkheads and the overhang supports are two of the most important items of deck construction. Check the Contractor's plans for structural adequacy and details that may result in uneven settlement. Give extra attention to connections and bearing areas. All joints must be solid in order to prevent differential deflections due to the weight of the finishing machine. Look for potential stability problems such as a tipping overhang caused by loads being concentrated along the outside section of the overhang.

If the overhang is constructed at the same time as the girder stem forms, the overhang must be kept clean. Methods to protect overhang forms include plastic sheeting, "lost deck" plywood covering, and building paper. If the overhang is built after the girder stem pour, check the grade at the exterior girder before the deck reinforcing steel is placed. Always check the overhang lumber for defects as the overhang is being constructed.

Install overhang jacks per the manufacturer's recommendations. For example, do not extend jacks too far, and make sure vertical legs and screw adjustments are plumb. Use bracing to prevent girder rotation and to keep web connections on steel girder bridges from dimpling. Check lumber for defects and watch for tipped joists. Ensure that the tails of the jacks do not encroach on the minimum vertical clearance.

Always rough grade the overhang before establishing the edge of deck line. Otherwise, the edge of deck line may shift if the overhang grades are adjusted an appreciable amount.

Discuss with the Contractor in advance and plan the methods and manpower requirements for grading the overhang. To get the required smooth lines that are the telltale hallmark of pride in workmanship, review with the Contractor will be necessary throughout the project. Emphasize form continuity and the importance of rechecking previously graded joints with rodmen and carpenters. Sometimes previously graded points change in elevation as the overhang is graded.

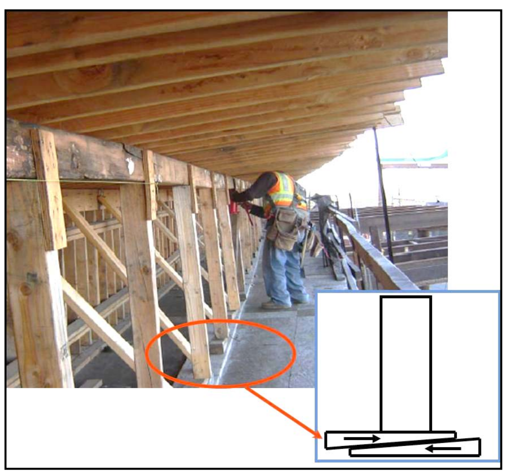

Figure 4.2-1. Wedge System for the Overhang.

It is common practice for the Contractor to rough-grade the overhang approximately 0.50 in. low. The Engineer then directs the final grade adjustments. It is usually easier and quicker to jack or wedge the overhang up than to try to lower it (see Figure 4.2-1). Grade both the interior and exterior supports simultaneously before the final grading operation to prevent overhang support geometry from causing a grade change at the edge of deck. After grading, feather wedge the joists tightly and eyeball the overhang.

4-2.4 Screeds

Since screeds are normally placed on the overhang, one method for grading is to shoot the screed using the overhang grades and adjust the Lenker rod to compensate for the elevation difference between the overhang and the screed. Alternatively, the Contractor uses a template, or “story pole,” set on the graded overhang to grade the screed. As a last resort, the Contractor can grade both the overhang and the screed from the deck grades on the exterior girder. Spot-check screeds for adequate support.

Screeds for the finishing machine should be two in. diameter heavy wall pipe with spacing of supports not exceeding the recommendation of the manufacturer, typically 24 to 30 in.

Make sure the screed pipe is in good condition. Screeds should run the full length of the pour and extend beyond both ends enough for the finishing equipment to clear the pour area (see Figure 4.2-2). Grade screeds beyond the limits of the pour for proper grade at the bulkheads and paving notches. Put screed pipe splice sleeves in place to prevent cantilever action of the screed pipe. Vibrations sometimes turn screed pipe saddle adjustments and overhang adjustment nuts; wire or secure them to prevent rotation. Check all screed support elements during concrete placement. Non-uniform screed displacement or settlement can be caused by:

1. Lack of washers between adjusting nut and edge of deck panel.
2. Spaces between top plate and studs of overhang panel.
3. Spaces between overhang soffit and edge of deck panel.

Make field notes and have a level available during every deck pour in case of grade problems.

Figure 4.2-2. Screed Rail Should Extend Beyond Pour Area.

4-2.5 Bulkheads

The *Standard Specifications*[5] require the Contractor to "locate longitudinal construction joints in bridge decks along lane lines if a joint location is not shown." Past practice is to place longitudinal bulkheads within a foot of lane line.

To ensure positive support, place bulkheads and screeds over girder lines whenever possible. Check reinforcing steel splice details with regard to joint locations. Avoid the bend areas of truss bars as they are very difficult to work around. Minimize deflection and settlement of bulkheads needing to be installed on the lost deck in a girder bay by "legging up from the soffit." Check all operations in the vicinity of a bulkhead carefully to avoid creating a bump (see Figure 4.2-3). Refer to the appropriate section of the Standard Plans and/or the Project Plans for allowable deck construction joint details.

Figure 4.2-3. Check Carefully to Avoid Creating a Bump.

Place transverse bulkheads at the inflection points of the structure (usually the 1/5 point) or in the deck compression areas. The location can vary somewhat on prestressed box girder bridges. Discuss reinforcing steel splice details related to joint location before reinforcing steel fabrication, and again during deck concrete placement planning. Grading transverse bulkheads is basically the same as for paving notches.[6]

Consider any transverse bulkhead as a potential bump or problem area. Check all operations in the vicinity of a transverse bulkhead carefully–particularly grade control. A good straightedge during the first bulkhead pour will not guarantee a good riding joint. The area needs to be reprofiled before the second bulkhead pour.

Make sure bulkhead forms are properly constructed and bulkhead areas cleaned prior to placing concrete. Prohibit premature stripping of transverse or longitudinal bulkhead forms because of spalling and questionable repairs that result. Also prohibit simultaneous pouring on both sides of a joint, especially those with a waterstop.

[5] 2010 SS, 51-1.03D(4), *Construction Joints.*
[6] Section 4-2.6, *Paving Notches.*

4-2.6 Paving Notches

Grade all paving notches approximately 0.5 in. low to clear finishing equipment. When the paving notch is not formed prior to the girder stem pour, leave the concrete for the girder stem or abutment diaphragm low enough to receive the paving notch forms. Make sure there is an adequate method for holding the paving notch to proper line and grade.

Proper width, straight, and plumb joints are important when saw-cutting for Type B joint seals. Check reinforcing steel clearances, sealed hinge joints, and paving notches for possible interference with the joint seal saw cuts. Make straight material available, such as a nailing strip, after finishing operations to establish the grade. Nail the strip to the paving notch and use as a guide for edging only. Use a 0.25 in. edger without depressing the concrete or other methods approved by the Engineer.

4-2.7 Inspection Tools

Have these tools on hand:

1. Twelve-foot straightedge: Used for projecting surface planes of adjacent structural sections, checking surface of finished deck, and checking localized grade deviations on screeds, bulkheads, and armor plate.
2. String line: Used to check "lost deck" forms from grade marks, deck thickness, reinforcing steel clearances from screeds, alignment of finishing machine carriage rails, and for laying out lines. Always watch for sags when using a string line.
3. Eyeball: The final, and probably the most important step; visually check for line and grade.

4-2.8 Finishing Machines

The Terex® Bid-Well is the finishing machine most frequently used for bridge decks in California. Other brands of finishing machines used include the Allen, Borges, and Gomaco. Following are details about setup and adjustment of the Bid-Well. Bid-Well finishing machine weights[7] are available online.

Take great care in adjusting the finishing machine. Depending on the condition of the equipment, anticipate three to eight hours to complete adjustments. Note that adjustments must be done during daylight (See Figure 4.2-4). If the machine appears to suffer from poor maintenance, be extra cautious—insist on chain repair kits, belts, even extra bearings, sprockets, etc. Machine maintenance and care is incredibly important: If the finishing machine breaks down, there is usually no alternative deck finishing method available on the job.

[7] http://www.terex.com/construction/en/products/new-equipment/terex-bid-well/bridge-pavers/index.htm

Figure 4.2-4. Inspect Adjustment of the Finishing Machine.

Subtle adjustments of the machine during a pour for a 0.02 ft. change in grade often do more harm than good. Although much has been said and written about how a finishing machine can be programmed for various subtle changes in grade, it is more prudent to leave the machine at one setting for the entire deck pour.

Following is the recommended method for setting up and adjusting the Bid-Well Deck Finisher (double or single roller):

1. String line both trusses and adjust for crown or no crown conditions (make sure carriage is at center of truss and string line is not sagging).
2. Move carriage to left or right side of deck adjacent to legs.
3. Place string line, which represents finished surface, across deck and parallel to trusses. Distance from truss rail to string on both sides of roller carriage should be equal.
4. Move machine over string line until ends of both rollers are over the string. Check finishing machine height with lowest end of rollers over string line (see Figure 4.2-5).

Figure 4.2-5. Check Finishing Machine Height.

5. Check distance from roller surface to string. It should be the same for both rollers.

6. Lower or raise rollers to string via leg adjustment. Move both legs—fore and aft—an equal amount.
7. Fine tune legs (raise rear leg 0.25 in. if desired). See Figure 4.2-6.
8. Repeat steps 4 to 7 by moving machine forward until back end of rollers are checked.

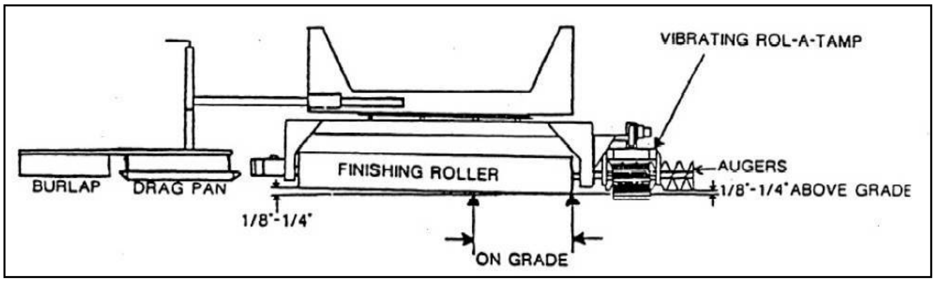

Figure 4.2-6. Fine Tune Legs.

When pouring the concrete, pay attention to the auger adjustment and roller skew.

- At the beginning of the pour, observe the auger adjustment. Often, it is not set low enough, which causes the rollers to load up and results in a ridge behind the machine.
- During the concrete pour, the skew of the rollers is critical. If a ridge is left behind the roller, it may be due to a change in the skew of the centerline of the rollers. Correct this by moving one side of the machine forward or back.