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Chapter 9 - Railing Systems and Safety Features

9.1 Purpose of Railing Systems

The fundamental purpose of a bridge railing system is to provide for public safety along the length and edges of a bridge. This includes redirecting errant vehicles back into the roadway without presenting a safety hazard when struck and ensuring the safety of bicyclists and pedestrians. Although railing systems generally do not provide structural strength to the bridge, the systems must be crashworthy. Therefore bridge railing differs from typical highway railing in that it is more rigid than flexible highway railing. Transition railing is used as the connection between the two as it provides a gradual change in the stiffness of the two railing systems.

Changes in the size and power of vehicles have spurred changes in railing design and requirements. The AASHTO Manual for Assessing Safety Hardware (MASH) is the latest practice for the crash testing of safety hardware devices for use on the National Highway System (NHS). It updates and replaces National Cooperative Highway Research Program (NCHRP) Report 350. Many states require that any new railing installed meet these standards. However much of the existing bridge railing in place today does not meet current code requirements because it was designed for the standards in place at the time of construction. It is generally recognized that replacement of all such railing would be a significant expenditure and therefore in many instances agencies allow it to remain until it requires replacement. Typically, if the damage incurred is significant, the railing system should be removed and replaced with a currently approved system. As applicable, repair may be an option when the damage is minor and the bridge still has a reasonable service life remaining.

To meet these intents, the following points are basic to good bridge railing systems:

- A roadside barrier on a bridge approach should provide a smooth transition to the bridge barrier. Exposed bridge rail ends or parapet walls should be avoided. After an emphasis was placed on smooth transitions by FHWA, the proportion of single-vehicle accidents at the end of bridge rails of parapets decreased. For example California and Texas went from 52 to 13 percent and 57 to 25 percent respectively.
- When a barrier or bridge railing installation is substandard; upon a significant project for repair, rehabilitation or reconstruction of the bridge and/or of its approaches; consideration should be given to either modifying the barrier to conform to an adequate system or replacing it with a current system meeting standards. Typical modifications would be to replace with approved crashed tested system such as a Jersey-type barrier (see Figure 9.1), if the structure can carry the additional dead load. Another alternative is to mount a metal guardrail across the structure (see Figure 9.2).
- If the railing has been severely damaged either by collision or weathering, complete replacement rather than repair may be more cost effective. Since most rails are from a standard design, it should be relatively easy to obtain plan details that might be needed for replacement.
- Collision-damaged railings should be repaired as soon as possible. Repair should include upgrading an old bridge railing that has been subjected to substantial damage to the current operational standard.

- In many cases, it is not possible to replace a collision damaged railing with one that meets current standards. In these cases, the damaged railing should be repaired/replaced in kind until the bridge is scheduled for rehabilitation or replacement.

Figure 9.1 Jersey Barrier and Guard Rail

Figure 9.2 Metal Beam Guard Rail

9.2 Components and Types of Railing Systems

There are many different shapes of railing used throughout the country. The selection of the railing is based on service level requirements such as design speed, average daily traffic volumes, how many trucks use the route, and site geometry. Other criteria such as functional and aesthetic considerations also play a role in the preference of railing to be used.

Railing systems at bridges and approaches are composed of four basic components:

- Bridge railings
- Transitions
- Approach guardrail
- Approach guardrail ends

These four basic components (shown in Figure 9.3 below) are designed to satisfy agency standards, which specify acceptable heights, materials, strengths, and geometric features.

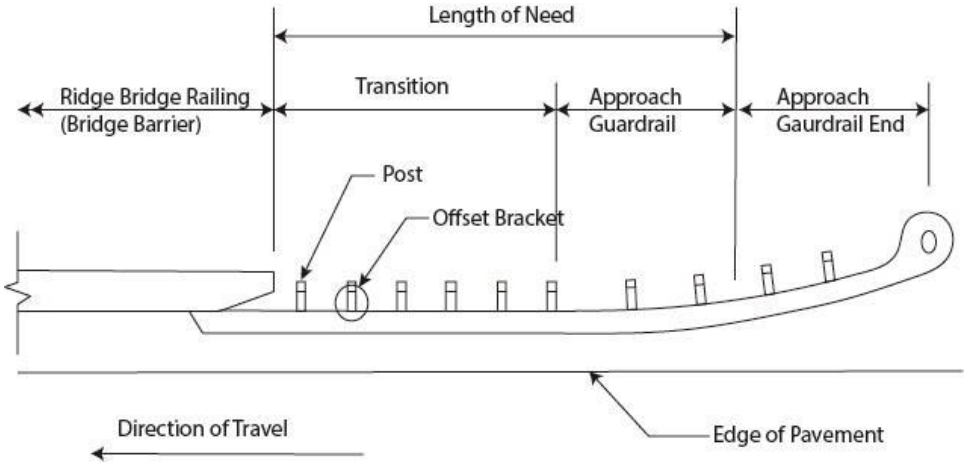

Figure 9.3 Schematic of Components of Railing Systems at Bridges

9.2.1 Bridge Railings

The function of bridge railing is to contain and smoothly redirect errant vehicles on the bridge. Many bridge rails could conceivably do this, but the safety of the driver and redirection of the vehicle must be taken into account.

9.2.2 Transitions

A transition occurs between the approach guardrail system and bridge railing (see Figure 9.3). Its purpose is to provide both a structurally secure connection to the rigid bridge railing and also a zone of gradual stiffening and strengthening of the more flexible approach guardrail system. Stiffening is essential to prevent “pocketing” or “snagging” of a colliding vehicle just before the rigid bridge railing end.

If, on impact, a redirective device undergoes relatively large lateral displacements within a relatively short longitudinal distance, pocketing is said to have occurred. Depending on the degree, pocketing can cause large and unacceptable vehicular decelerations. When a portion of the test vehicle, such as a wheel, engages a vertical element in the redirective device, such as a post, snagging is said to have occurred. The degree of snagging depends on the degree of engagement. Snagging may cause large and unacceptable vehicular decelerations.

9.2.3 Approach Guardrail

The approach guardrail system is intended to screen motorists from the hazardous feature beneath the bridge as they are approaching the bridge (see Figure 9.3). This approach guardrail screening is often extended in advance of the bridge so as to also keep motorists from any additional hazardous roadside features on the approach to the bridge.

Approach guardrail must have adequate length and structural qualities to safely contain and redirect an impacting vehicle within tolerable deceleration limits. Redirection should be smooth, without snagging, and should minimize any tendency for vehicle rollover or subsequent secondary collision with other vehicles.

9.2.4 Approach Guardrail Ends

The approach guardrail end is the special traffic friendly anchorage of the approach guardrail system. It is located at the end at which vehicles are approaching the bridge. Ground anchorage

is essential for adequate performance of the guardrail system. A special approach guardrail end is necessary in order to minimize its threat to motorists as another fixed object hazard within the roadside recovery area.

9.2.5 Common Types of Railing Systems

Some common railing shapes include:

- W-Beam Bridge Railing (Steel)
- Thrie Beam Bridge Railing (Steel)
- Metal Tube Bridge Rails (Steel, Aluminum)
- Vertical Concrete Parapet (Open or Closed) (Concrete)
- New Jersey Barrier (Concrete)
- F-Shape Barrier (Concrete)
- Single Slope (Concrete)
- Timber Bridge Railing (Wood)
- Laminate (Wood)

Photographic Examples of these common railing shapes are presented in Figure 9.4 thru Figure 9.12.

Figure 9.4 W-Beam Bridge Railing (Steel)

Figure 9.5 Thrie Beam Bridge Railing (Steel)

Figure 9.6 Metal Tube Bridge Rails (Steel, Aluminum)

Figure 9.7 Vertical Concrete Parapet (Open or Closed) (Concrete)

Figure 9.8 New Jersey Barrier (Concrete)

Figure 9.9 F-Shape Barrier

Figure 9.10 Single Slope Concrete Barrier

Figure 9.11 Timber Bridge Railing (Wood)

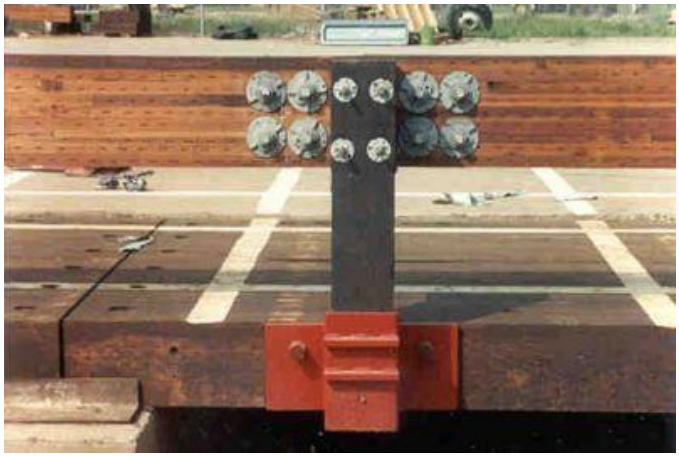

Figure 9.12 Laminate (Wood)

The purpose of this guide is to address the maintenance and possible repair of common materials of railing systems, as well as posts and anchors bolts as they are integral components of the system. A functional condition assessment of the entire damaged railing run is recommended prior to determining whether the entire railing system should be replaced in lieu of planning spot repairs.

When to Call the Engineer

Call the Engineer for a functional conditional assessment of the entire damaged rail run. The Engineer will determine whether the entire railing system should be replaced in lieu of planning spot repairs.

9.3 Preventive and Basic Maintenance of Railing Systems

Preventive maintenance can be thought of as the process of protecting the railing system from the unavoidable deterioration caused by moisture, de-icing chemicals, traffic vibration and the environment. Sometimes materials are flawed from the start, such as thin spots of galvanizing on steel or cracks in concrete due to improper curing when poured, which can cause early failure. It should be kept in mind that any railing system begins to deteriorate the day it is constructed. It is the purpose of preventative maintenance to slow the failure process as much as possible by using techniques and materials that are considered best practices. This section presents some methods to provide such maintenance; it is not meant to be all inclusive.

Prior to working on any bridge railing you should determine the extent of maintenance and supplies that will be required, as well as what signs and traffic controls are needed.

9.3.1 Concrete Maintenance

What To Look For

- Cracks
- Spalls
- Scaling
- Impact damage
- Deteriorating concrete/reinforcing
- Vegetation growing in cracks

Pressure washing of barriers to remove salt or other contaminants and dirt should occur on a regular basis. Many state DOT's recommend cleaning once every other year, early in the spring. Just like the deck of the bridge, the concrete railing is as susceptible to cracks and spalls from salt damage. Therefore it is essential to protect the surface and seal cracks with the appropriate sealant. The same methods of crack sealing can be used on the deck can be used on the railing. Application of concrete sealants and coatings will protect the reinforcing steel from corrosion by stopping or minimizing the intrusion of water and salt through the concrete. There are more options for protective coatings because the railing does not receive the same traffic wear as the deck. Some DOT's are using coatings, such as white epoxy, that not only waterproof the railing, but also enhance its visibility by reflecting light. These coatings should be applied before the railing becomes salt contaminated. They also must be reapplied on a regular basis, according to the manufacturer's recommendation. An example of coating a barrier is shown in Figure 9.13.

Figure 9.13 Application of Elastomeric Paint on Alkali-Silica Reactivity-Affected Barrier

Regular inspection for scaling, pop-outs and cracking should be performed. If scaling or pop-outs are found, the use of epoxies or methyl methacrylates should be used once the surface has been well cleaned. Small cracks (less than 1/16 in) should be cleaned and sealed with epoxies or high molecular weight methacrylate, whereas larger cracks should be routed out and sealed with flexible caulk. These defects should be sealed as soon as possible to ensure that salt does not have an opportunity to corrode the rebar.

If present on the structure, electrical conduits imbedded in concrete railings are exposed at the expansion joints. Slip joints in the conduit should be protected to prevent corrosion that may impair the function of the joint. Frequent inspection and maintenance of the protective coating is recommended.

In summary, preventative maintenance of concrete barriers includes:

1. Sealing the concrete (see Section 13.1.4).
2. Inspecting for and repairing scaling, pop-outs and cracks as soon as possible.
3. Reapplying the sealant as needed.
4. Keeping the railing free of salt, dirt, and debris by regular cleaning.

9.3.2 Steel Maintenance

What To Look For

- Impact damage
- Coating failure
- Corrosion
- Vegetation
- Loose hardware
- Rail at or near expansion joints

Most steel railing is galvanized and maintenance is minimal. Small scratches in the galvanized surface present little or no problem as the zinc will corrode first, keeping the underlying steel rust-free. However, where large portions of the zinc coating have been damaged, such as gouges from snow plow blades or over width loads, it is important to repair or touch-up the damaged section. Areas of spot rust should be sanded, cleaned and recoated to maintain the finish. A zinc-rich coating will be required. A photographic example of a galvanized steel railing is presented in Figure 9.14.

Figure 9.14 Galvanized Steel Rail

Other areas of concern are where the steel is in contact with concrete or other metals. To prevent corrosion these areas should have an insulating material between the two in order to protect the steel.

A regular check of the fasteners is recommended. Any loose connections should be tightened. Finally, a regular cleaning, such as pressure washing, is recommended to keep connections free of debris.

In summary, preventative maintenance of steel railing includes:

1. Touching up any minor damage with zinc-rich paint.
2. Inspecting and maintaining fastener tightness.
3. Ensuring a bond breaker is between the steel and any other material it contacts.
4. Keeping the railing free of salt, dirt, and debris by regular cleaning.

9.3.3 Aluminum Maintenance

Aluminum weathers to a dull grey appearance and is highly resistant to atmospheric corrosion. This finish provides good corrosion resistance and an almost unlimited life expectancy. However, pitting corrosion can occur on aluminum surfaces frequently in contact with a humid environment. Generally, this is only an aesthetic consequence. Accumulation of dirt and debris on surfaces can cause a reduced durability due to the extended exposure to moisture. Dirt and debris should be removed on a regular basis. An example of an aluminum railing is presented in Figure 9.15.

Figure 9.15 Aluminum Railing

Oxidation protection is required at the contact surface with other materials and this should be checked on a regular basis. Steel to aluminum contact surfaces should be caulked with an elastic, non-staining blend of water-repellant oil, asbestos fiber, and flakes of aluminum (metal or other suitable materials) to prevent corrosion.

A regular check of the fasteners is recommended. Any loose connections should be tightened.

The contact surface of each aluminum railing post attached to concrete should be separated from the concrete with a nonreactive bedding material such as 30 pound nonperforated, asphalt-saturated felt; a galvanized or painted steel plate; or an elastomeric caulking compound. If a grout pad is used under the base plate, any damage to the pad should be repaired. If grout comes in contact with the surface of the aluminum, it will cause visible spots. These are difficult to remove and for this reason aluminum should be protected onsite.

In summary, preventive maintenance of aluminum railing includes:

1. Inspecting and maintaining fastener tightness.
2. Ensuring a caulk layer is between the aluminum and any other material it contacts.
3. Keeping the railing free of salt, dirt, and debris by regular cleaning.

9.3.4 Wood Maintenance

Wood is a durable bridge material, but over extended periods it may be subject to deterioration from decay, insect attack, or mechanical damage. Protective systems are a necessity for wood railing systems to resist decay. Most wood will have been pressure treated prior to construction and therefore require minimal maintenance.

Moisture is a prime enemy of wood. Periodic washing will remove dirt and debris that hold moisture. Mildew shows up as green or black spots on bare wood or paint. It can be removed with a solution of sodium hypochlorite (bleach) and water. Identify areas with visible wetting or high moisture and take corrective action to eliminate the source. Checks, splits and damaged areas should be treated as soon as possible. Field drilled holes should be treated with preservatives before installing bolts and other hardware.

For painted rail, a routine maintenance schedule should be followed. In order for the paint to serve its purpose, the surface of the wood has to be properly prepared. The existing railing should be pressure washed to remove flaking or chipped paint and any residue. It may be

necessary to spot sand at some locations. A sealant primer should be applied which is compatible with both the wood preservative and the paint. This will reduce the risk of further bleeding and need for repainting. Paints used for wood railing protection are usually oil-based, oil-alkyd or latex-based. Oil-based paints provide the best protection from moisture but are not very durable. Oil-alkyd paints have more durability than oil-based paints but contain lead pigments which may cause various health hazards. Latex-based paints are very flexible and resistant to chemicals.

Corrosion damage can occur if the wood is in contact with uncoated fasteners containing iron. All fasteners should be galvanized. Check and repair any damage to galvanized parts.

The wood bridge post is very vulnerable to ultraviolet light degradation. The exposed end grain of the post also allows for frequent wetting and drying cycles which hasten deterioration. Consider using a post cap which shields the wood post from UV light while sheltering the end grain from wetting at the same time.

In summary, preventive maintenance of wood railing includes:

1. Maintaining a coating of paint and sealant, if the railing is painted.
2. Inspecting and maintaining fastener tightness.
3. Ensuring all fasteners in contact with wood surfaces are galvanized.
4. Keeping the railing free of moisture, dirt, and debris by regular cleaning.

9.4 Repair and Rehabilitation of Railing Systems

When to Call the Engineer

If the structural elements of the bridge to which the rail is attached are damaged, such as the bridge deck, wingwalls, back walls, etc., the Engineer should be consulted.

Most states require that bridge railing with damage or deterioration that may prevent containment and/or redirection of errant vehicles traveling at the posted speed limit be replaced. Any replacement railing generally will be required to be upgraded to meet current standards. Often this means that the entire run of railing will be replaced.

The FHWA recommends giving consideration to the replacement of substandard bridge rails as part of any bridge rehabilitation, reconstruction, or replacement project. The addition of a continuous section of standard guardrail in front of and attached to the existing bridge railing is a very common manner of upgrading substandard bridge rail.

However there may be limited instances where repair is acceptable. The remainder of this chapter will address some general repairs which may be taken prior to replacement.

Some critical actions that should be taken before the actual repair include:

- Upon notification of damage that leaves the railing nonfunctional, and if it cannot be repaired immediately, warn traffic of the hazard by putting out temporary warning

devices in accordance with the Manual on Uniform Traffic Control Devices (MUTCD), such as drums, vertical panels, cones, or other devices.

- Contact your local Dig Safe utility protection well in advance of going to the site.
- Take enough signs and channelizing devices to the site to properly mark the repair zone. When your agency uses an arrow board and/or a shadow truck or Truck Mounted Attenuator, be certain there is enough equipment and personnel to handle these items.
- Set up the Temporary Traffic Control Plan for the work area to repair the railing in accordance with the MUTCD or your agency requirements.
- Ensure all workers wear equipment as provided by the Occupational and Safety Administration (OSHA) or local requirements, such as safety visibility vests, safety glasses, and protective-type shoes.
- Ensure all equipment and procedures conform to OSHA guidance.

9.4.1 Concrete Repair

If there is minor delamination of the surface, typically caused by the corrosion of reinforcing steel, repairs can be made. In general, the process is to remove the unsound concrete; sawcut around the perimeter; and remove and patch with fast setting patch material. If there are thin areas (1-in or less), they can be patched with trowelable mortar.

For widespread surface deterioration, typically caused by corrosion of the reinforcing steel and/or poor quality concrete, the repair is more substantial. It may be possible to sawcut around the failed areas, perform a full-depth removal of the unsound areas, then recast in-kind. If the deterioration is significant it may be more cost effective to replace entire railing.

If one or more sections of railing are broken, the procedure for concrete railing repair includes the following steps:

Suggested Procedure

Concrete Rail Repair

1. Assuming that the rail will be replaced "in kind," which is a decision that should be made by the engineer; the plans should be obtained for use in constructing the new sections.
2. Mark off areas of rail to be replaced.
3. Sawcut to a depth of at least ¾ - 1 inch. Be careful not to cut through reinforcing steel.
4. Remove concrete in sections of rail to be replaced with a chipping hammer. Do not place chipping hammer on reinforcement.
5. Use sand blasting equipment to remove any rust from exposed reinforcing steel and to clean the exposed concrete surfaces. Touch up epoxy bars.
6. Replace any missing or corroded steel with new bars providing proper overlap lengths. Consult an engineer as needed. Overlap requirements may require a larger area to be chipped out, or drill and epoxy anchor bars, or mechanically splice.
7. Form new sections to conform to rail dimensions on plans.
8. Apply form release agent to forms.
9. Place concrete.
10. Cure concrete for at least 72 hours.
11. Finish surface with a rubbing stone to match existing rail and clean up the job site.

When to Call the Engineer

Call the Engineer when deciding if a rail will be replaced “in kind”.

9.4.2 Steel Repair

Metal railing is fabricated in standard sections and most bridges are designed with one of the standard sections. It is a good idea to have an inventory of the common sections used in a state, with necessary hardware, for replacement needs. Repair and replacement of steel pipe and tubular railings should be made as follows:

Suggested Procedure

Repair and Replacement of Steel Pipe and Tubular Railings

1. Collision-damaged steel railings generally have to be replaced. Occasionally this type of railing can be straightened and repaired. When delays in receiving new or replacement parts are encountered, a temporary railing repair should be made to protect the public.
2. Loose anchor bolts and connections should be tightened. If corrosion is present, painting or galvanizing procedures should be followed.
3. Rust stains around the perimeter of steel rail posts or anchor bolts imbedded in concrete indicate corrosion. Corroded areas should be thoroughly cleaned and painted. Railing components that have section loss should be repaired or replaced.
4. Hot-dip galvanizing is recommended for new, replacement, or existing railings. Zinc-rich paint may also be used. Painted railing will require frequent repainting when located in industrial or marine or salt laden environments. Care should be taken to touch up the protective coating after tightening the nuts on anchor bolts and other rail connections.
5. Damaged anchor bolts should be repaired or replaced as required. Refer Section 9.4.5 Anchorage Repair.

9.4.3 Aluminum Repair

Aluminum railing damaged by collision should be replaced promptly. New railing sections are generally preferred because of the high degree of experience required in straightening or welding aluminum. Consideration should be given to replacement with "New Jersey" type concrete railing. Steps similar to steel repair can be taken. Do not attempt to straighten, hot dip galvanize or use zinc-rich paint.

9.4.4 Wood Repair

Any deterioration of railing and post members will reduce effectiveness in the event of an accident. In some cases it may be acceptable to splice the members with galvanized steel plates or install protective jackets to restore structural unity and prevent further splitting. Generally if wood railing or posts have been damaged by collision or exhibit section loss from deterioration, they will need replacement. Steps similar to steel repair can be taken. Do not attempt to straighten, hot dip galvanize or use zinc-rich paint.

Wood approach guardrail does not meet minimum criteria for strength, continuity, or performance for bridges on the National Highway System. However, it may be found on some state or local bridge approaches. They are frequently hit by errant vehicles and must be replaced. For the posts, typical embedment is between three to three and a half feet. Posts can be removed using a chain attached to a tractor bucket or dump truck body. If the wood posts are entirely broken by severe impacts, it will be necessary to dig around the remaining stub to a depth deep enough to wrap a chain around the lower section of the post for removal.

There are several ways that the new posts can be reset. Wood posts generally are not driven into the ground; however in some cases it may be possible to drive a new wood post in the existing hole. Otherwise a hole is either drilled or excavated and the new post set plumb. Backfill the hole with compactable materials in 6 inch lifts and compact with pneumatic equipment to optimum compaction. After posts are installed to correct positions, blocks and guardrails may be installed.

9.4.5 Anchorage Repair

When to Call the Engineer

Call the Engineer if anchor bolts are damaged to determine if they can be repaired or replaced. Call the Engineer if the concrete in which the anchor bolts are embedded has been damaged.

In some instances, anchor bolts may require extension to accommodate the installation of a new railing. In other cases, the anchor bolts are damaged or there is damage or deterioration of the deck affecting the integrity of the anchorage. There are three common types of replacement anchors including adhesively bonded (Figure 9.16 left), through bolted (Figure 9.16 right), or a combination of the two. These should be considered temporary repairs until the bridge deck is adequately repaired or replaced. Note that the FHWA discourages the use of adhesive anchors in tension applications: http://www.fhwa.dot.gov/bridge/t514030.cfm. Additionally, adhesive anchors are not approved by some DOT's.

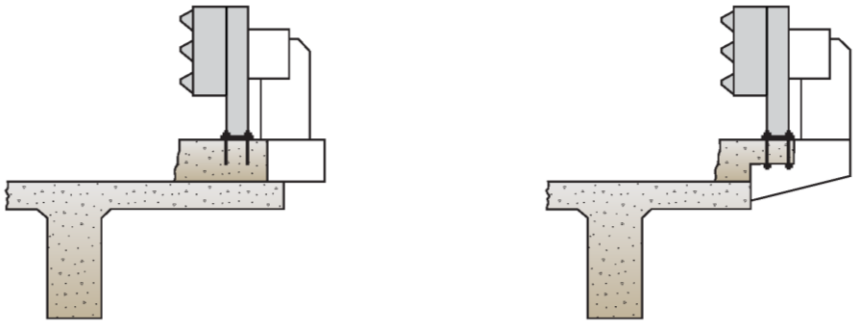

Figure 9.16 Anchor Examples. Bonded Anchor (left). Through Anchor (right).

Where anchor bolts must be extended, chip away the concrete around the bolt to allow welding below the finished surface of the concrete. Old bolts should be cut and ground at an angle to provide for a stronger weld. Replace damaged concrete or concrete that has been removed as repairs are made. Large areas justify concrete replacement after the railing has been repaired.

Post-installed anchors are those that are installed into hardened concrete. There are two main types typically used for railing installations or retrofits. These are through bolted anchors and bonded anchors. The bonded anchor systems typically include three different bonding options (discussed later).

Through bolted anchors are simply anchors that extend entirely through the thickness of the deck. Typical installation includes carefully field coring holes through the superstructure to nominally accommodate the bolts. A backer plate is placed on the bottom of the deck and a base plate is positioned on the top. Threaded anchor rods are inserted and tightened. Beveled washers may be required to allow appropriate tightening.

Bonded anchors differ in that the anchor rod is able to withstand loading due to the adhesion or bond created between the deck and the bonding agent. Consequently, adequate performance of the anchors can only be achieved when anchors are installed according to the manufacturer's published installation procedures. Once installed, it is recommended that at least one of them be tested for pullout resistance. Bonded anchor systems include the following:

1. Drill and Bond Dowel: Magnesium phosphate (mag-phos) is used as a bonding agent. Within three hours, mag-phos concrete hardens or cures. It does not require any special treatment during curing. It also takes about three days to develop its full strength. Mag-phos also has a relatively high resistance to pull out and has minimal shrinkage, therefore less cracking. However it cannot be used for galvanized anchors or come into contact with zinc or aluminum. It will be less effective in cracked concrete.
2. Drill and Grout Dowel: Neat Portland cement paste (grout) is used as a bonding agent. Generally, cement grout is less expensive than mag-phos concrete. However, the grout has to be cured for at least three days during which time the dowels should not be disturbed. The grout normally develops half of its strength in three days, and develops full strength in about 28 days. In addition, grout has a tendency to shrink, leading to cracks.
3. Drill and Bond Dowel (chemical adhesive): A chemical adhesive or a cartridge epoxy is used as a bonding agent. These adhesives are thicker than the other two bonding agents. This helps the adhesive stay better in a drilled hole. It has a relatively quick setting time which may differ slightly between manufacturers. It has little shrinkage resulting in less cracking. However, it requires stringent quality control and quality assurance testing, particularly since it may slowly deformation over time.

Installation instructions particular to the type of anchor will specify the drilling method, hole cleaning procedure, how to install the bonding agent and the metal anchor in the drilled hole, and the care to be taken until the bonding agent has cured. Under no circumstances should these types of bonded anchors be used through hollow sidewalk cores. In general, drill and grout and drill and bond (mag-phos) should be used only in holes drilled between 90 degrees and no less than 20 degrees (or 3:1) to the horizontal. In horizontal holes, chemical adhesives should always be used since the adhesives are less likely to run out of the holes. For example, these may be used in deck overhangs where horizontal holes may be the only option due to a thin or narrow deck. This anchorage system is not recommended for use in overhead applications.

For the above anchor treatments, be sure to repair any damage in the deck due to improperly cored holes. Only install guardrail retrofits on structures that have the capacity to support them, as well as withstand potential impact. For instance, do not retrofit or replace new anchors on a severely deteriorated deck. Confirm clearances before field coring into the existing deck.

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