Preface

The Industry Specific Subcommittee, in association with the Society of Professional Rope Access Technicians, has developed the Bridge Inspection – Typical Rope Access Techniques document to identify rope access techniques used to aid in the inspection of various bridge types. Due to the length of time necessary to complete this document, various photographs contained herein may be outdated and show technicians utilizing equipment in a manner not currently authorized by the manufacturer. Photographs are incorporated into this document only to clarify rope access situations on bridges, and not to highlight equipment usage. Furthermore, this document also discusses the typical rope access equipment used during bridge inspections, as well as other commonly used bridge inspection equipment not related to rope access. Jobsite safety is addressed as well.

This document is intended for bridge inspectors starting off in the field of rope access. It may also aid current rope access bridge inspectors that may encounter types of bridges they are not familiar with. This document is intended solely as a guide for means and methods that have facilitated safe and efficient completion of past bridge inspection projects. It is not intended to be the only way to inspect a bridge via rope access.

This document is intended to be a living document; hence, it will be revised periodically to reflect new bridge inspection access techniques that may work well. All access techniques that may be useful to future bridge inspections should be submitted to the Industry Specific Subcommittee for consideration of incorporation into this document.

Document Disclaimer

*Industrial rope access and working at height are inherently dangerous activities in which severe injuries or death could result. When accessing a bridge using rope access or other work at height techniques, you must rely on your skill, training, experience, and equipment to work safely. If you have any doubts as to your ability to safely perform bridge inspection work while using rope access, do not attempt it.*

*This document is neither a professional climbing instruction manual, nor a substitute for one. It is not an instructional book. Do not use it alone. It contains information that is nothing more than a compilation of means and methods that have been used by others to climb various types of bridge structures. Treat the information as opinions and nothing more. Do not substitute these means and methods for your own common sense and experience. If you do not have extensive work at height and/or rope access experience on bridges, you should hire qualified work at height and/or rope access professionals to plan and supervise any and all bridge access activities.*
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1.0 History of the National Bridge Inspection Standards in the United States

The emphasis on safety and reliability of the nations’ in-service bridges underwent a dramatic shift on December 15, 1967 with the collapse of the 2235-ft long Silver Bridge in Point Pleasant, West Virginia.

![Silver Bridge Prior to Collapse](image1)

Figure 1.1: Silver Bridge Prior to Collapse

![Silver Bridge after Collapse](image2)

Figures 1.2 and 1.3: Silver Bridge after Collapse

The holiday-season disaster claimed the lives of 46 people and aroused increased scrutiny of the safety inspection and maintenance of bridges carrying public routes. The following year, the U.S. Congress enacted the Federal Highway Act of 1968. This act directed the U.S. Secretary of Transportation to develop and implement the first National Bridge Inspection Standard outlining bridge inspection qualifications, definitions, and recommended frequencies. Also as a result of the Act, a training program was developed establishing the first formal training for bridge inspectors.
There are numerous types of bridge inspections being performed worldwide:

- **In-depth**: Prescribes hand's-on or arm's reach range inspection of specified components, may be above or below water level.

- **Routine**: Regularly scheduled (usually every 2 years) inspections determining the physical and functional condition of the bridge. Underwater components are usually examined during low flow periods.

- **Inventory**: Initial inspection before a new bridge enters active service verifying as-built dimensions, recording various site data, and providing a baseline bridge inspection report.

- **Damage**: An unscheduled inspection in response to an acute event that is either natural or manmade. Examples include earthquakes, floods, collisions affecting the structure, or vehicle fires.

- **Special**: An inspection conducted outside the normal inspection cycle to monitor a particular area of the structure only.

Due to its versatility, industrial rope access is typically used to perform in-depth inspections; however, rope access can and is used on all of the above mentioned types of inspections. For the purposes of this document, it is assumed all subject structures will be inspected at the in-depth level.
2.0 Suggested Access Techniques and Strategies for Various Structure Types

2.1 Through Trusses

Access to through trusses using industrial rope access is typically a straightforward process. Efficiencies can be gained through thoughtful planning to minimize the number of anchors the team must set.

![Inspection of a Truss Vertical Utilizing Ropes Anchored Above](image)

Figure 2.1.1: Inspection of a Truss Vertical Utilizing Ropes Anchored Above

The inspection of verticals can be accomplished with descending and ascending techniques, or slings with oversized scaffolding carabiners, depending on the configuration of the structure and members being inspected. However, care must be taken to always properly orient the oversized carabiners as the possibility of side loading is increased with larger carabiners.

Inspection of inclined truss members, otherwise referred to as diagonals, can be effectively inspected by using a rope-to-rope transfer with the pairs of ropes anchored at adjacent verticals. Another method would be to ascend the diagonal from ropes anchored to the top chord while using a sling around the diagonal to prevent an uncontrolled swing if a fall were to occur. The slings should not be used as the primary means of fall protection and should always be used in conjunction with rope mounted overhead.
In the case of Pratt or Howe type through trusses, the rigging team needs only to set ropes at each vertical location. By ascending the ropes at each vertical and utilizing a rope transfer between verticals to return to deck level while simultaneously inspecting the intervening diagonal, the ropes provide a smooth, constant, efficient work path between support locations. In the case of other common truss types like the Warren, Whipple, or Baltimore trusses, a certain amount of repeated ascents is inevitable.
2.2 Deck Trusses

Deck trusses, similar to through trusses, tend to be a straightforward inspection in terms of access. Typical rope access methods include ascending and descending for vertical members and rope-to-rope transfers for diagonal members. In certain truss configurations/designs, the vertical/diagonal members are constructed of lacing bars, or plates with access holes for inspection. The inspector can use these configurations by using an oversize carabiner and shock absorbing assembly or dynamic lanyards in lieu of rope-to-rope transfers. This may decrease the amount of rigging necessary. However, care must be taken to always properly orient the oversized carabiners as the possibility of side loading is increased with larger carabiners. Furthermore, a dynamic connection should be used with these components.

Figure 2.2.1: Diagonal with Access Holes
Floor beams can be inspected utilizing beam clamps or beam rollers. This allows the inspector to access all areas of the floor beam/stringer system. Sidewalk/shoulder overhangs are common and may require multiple rigging points at the edge of the deck and on the truss. Depending on the distance between the edge of the deck and the truss, the inspector may be required to perform a rope-to-rope transfer, or rebelay to access deck truss members. A telescoping stick with a hook can be useful to reach ropes out of arm’s reach.
Anchorages at/on the deck railing may be necessary and traffic control should be deployed per the applicable regulation for traffic control to protect exposed anchor points. Depending on the railing configuration, the ropes may be attached directly to the guardrail system. If the guardrail system has heavy corrosion/deterioration, multiple anchorage locations may be necessary to develop adequate strength for an anchorage. If a concrete parapet is the only available anchorage point, anchorages may be drilled into the concrete, or a parapet clamp/roller may be used for an anchorage point. Whichever anchoring method is used, it shall meet the requirements specified in the SPRAT Safe Practices document. Care must be taken if anchorages are unprotected to oncoming traffic.
2.3 Suspension Bridges

2.3.1 Main Cables

The main cables for suspension bridges refer to the primary wrapped cable bands that support the bridge deck and superstructure elements. There are at least two main cables on these types of bridges. Often these elements have fall prevention systems built into them. The existence of fall prevention systems, though, does not necessarily entail an acceptable system. These systems are frequently installed as a construction afterthought, and are generally old and may not be well maintained. The suitability of an existing system should be determined by a competent person. Most systems involve two cables connected to the main cables by stanchions, which would be used as handrails/tie off points. When these systems are available, the most common form of access is walking along the cable with 100% tie off techniques (maintaining a fall protection connection at all times).

Figure 2.3.1: Inspector using Main Cable with Fall Prevention System.
2.3.2 Suspender Cables

Suspender cables refer to the vertical cables that carry the deck/superstructure load to the main cables and are clamped around the main cable in some capacity. Accessing these items involves one of two actions: one is access to the entire cable; the other is access to just the ends of the suspender cables.

Accessing the entire cable will involve basic descent/ascent activities. The complication will involve the method of anchoring the rope system to the structure. To ascend/descend the entire cable will require ropes to be anchored near the top of the suspender cable. This may require a person on the main cable above, setting the ropes and monitoring the ascent/descent, while having the ability to act as rescuer should a situation arise. This entails a method of anchoring the ropes at the suspender cable connection. If a sling, cable, etc. cannot easily be used, an anchoring system will need to be engineered.

Sometimes suspender cables only need to be accessed at their top and bottom connections. In this case, the bottom connections can usually be accessed from the stiffening truss. Often stiffening trusses can be accessed from the deck level. The top connections will need to be accessed from the main cable. If a handheld inspection mirror is available to the inspector, and the inspector is comfortable with what they see using the mirror, then maneuvering into position to see the full suspender cable and clamp is not necessary. If a mirror is not feasible, the inspector will need to maneuver such that they can see the entire clamp and suspender cable. This situation is bridge-dependent, but usually involves some manner of positioning and fall restraint system with an etrier (stirrup)/webbing ladder to climb down and inspect the clamp. A certain amount of dexterity and climbing ability is needed, as repositioning oneself back onto the main cable is not an easy task.

2.3.3 Stiffening Trusses

Techniques for accessing stiffening trusses are similar to other trusses. The distance between the chords of a stiffening truss is roughly 10-15 ft. Also, the top chord can often be accessed from either the deck or sidewalk. In this case proper fall protection techniques are needed.
2.3.4 Floor systems

Steel floor systems can be accessed in many ways, depending on the steel shapes used for the floor system. Beam clamps can be used to slide/roll on the bottom flanges of beams; however, an appropriate backup fall protection system must also be employed. This can be accomplished by using multiple beam clamps, a high-line, or other comparable backup system. Climbing the floor system with slings or other appropriate fall protection and work positioning can be used to access the floor system. Note that fall protection systems can be built into floor systems, but they should be inspected for their structural integrity prior to use.

Most movement will be horizontal in nature, so care must be taken to prevent or minimize pendulum swings from the anchor points. Highlines and other complicated set ups can be employed for the main means of inspection, but rope sag when at mid-point may affect the quality of the inspection. Ultimately, the inspecting company must consider the level of effort, time, and safety for the rope work involved, all of which should be addressed in the Job Hazard Analysis (JHA). These variables will need to be considered for other access methods when determining the preferred course of action.
2.4 Arches

Inspection of arch bridges via rope access can be more challenging than other types of bridges due to the curved geometry of arch bridges. Gaining adequate access for in-depth inspection with rope access can be separated into two distinct subsets: through arches and deck arches. Through arches are those in which the roadway surface passes below the arch and is typically supported by the arch through the use of cables. In contrast, deck arches support the roadway surface from below by the use of columns, called spandrel columns.

In through arches, gaining access to the top of the arch can vary considerably with the bridge's design. Some through arch bridges with hollow, box-type arch ribs allow inspection access through the interior of the arch with access hatches near the roadway and again at the apex. In the event of a closed arch, prusiks can be used to ascend the suspension cables in order to access the arch's apex. Once on top of the arch, it has been found that the most efficient access technique for inspection is to anchor two–rope systems to each panel point (connection location) to allow inspectors to efficiently ascend and descend adjacent to the suspender cables and inspect the suspender connection at the arch, as well as the arch itself.

Figure 2.4.1: Inspection of Suspender Connection.
Note: Scaffold Hooks used to Maintain Position in High Winds
For inspection of the arch rib between connection locations, typically the arch rib top and side faces can be inspected from the top surface of the arch; however, inspection of the bottom face of the arch requires the use of edge negotiation to position oneself at an elevation lower than the arch. Depending on the geometry of the rib cross section, a choker or girth hitched sling setup might be required as in the case of the smooth box section to prevent rotation of the anchor (see Figure 2.4.2).

Due to the location of the roadway deck and live traffic, it may be necessary to secure the bottom of the ropes to prevent them from swaying into traffic. This can be compactly accomplished using a small fabric sling used as a prusik on the lower part of the suspender cable and an extra rope grab to maintain tension on both ropes. Rubberized weights suspended from the bottom of the ropes have been found to be useful to control the ropes during lowering from the arch.

In order to access deck arches, the preferred method is using rope-to-rope transfers. From the roadway deck, it has been found useful to set two rope systems at each panel point and allow the inspector to descend from the deck, inspecting a spandrel column on the way down.
When the inspector reaches the spandrel column connection to the deck arch, a rope transfer can be used to control position in two dimensions to travel along the length of the arch section to the next column connection, inspecting the rib along the way (see Figure 2.4.4). Once the inspector reaches the second column connection and the inspector ascends back to the roadway deck, performing inspection of the second column and connections during the ascent. It is important to perform this technique downhill whenever possible for maximum efficiency. Thus, in the case of a single span arch, work from the center towards the abutments if possible as shown in Figure 2.4.5 on a small timber deck arch.
2.5 Deck Girder Bridges

Deck girder bridges refer to bridges whose superstructures consist of steel beam shapes supporting a roadway deck above the beams, and typically beam shapes of a size tall enough to climb on or along. If the steel section is too short for an inspector to climb on/access safely, mechanical access should be considered. In these situations ladders and or mechanical access methods generally involves less time and/or effort to access the superstructure.

The most common and prevailing industry practice to access these bridges involves the use of an under bridge inspection vehicle (UBIV). UBIVs, such as snoopers, can usually access and inspect these areas more efficiently than climbing methods. However, there are documented instances of UBIV accidents; such as mechanical arm/hydraulics failures, or the units tipping over. Furthermore, while in use the UBIV is susceptible to an accident or crash due to its presence adjacent to live traffic, even with a truck attenuator. To date, there is no known documentation of any injuries or fatalities when proper fall protection and rope access methods have been used to access these bridges.

As a general rule, when deciding whether to use climbing/rope access methods to access steel beam spans, one must keep in mind the benefits gained by using these methods versus the drawbacks possibly encountered from a potential rescue situation. One consideration when accessing these bridges is if there are potential dangers below the bridge. In many instances, these types of bridges span over roadways or railroads below. If this is the case, would a fall from this structure put the climber in danger of traffic below the bridge? Another consideration would be how one would rescue a fallen climber, assuming the fallen climber cannot rescue themselves. How much time would it take to set up a system to put the casualty on the ground or bridge deck? These hazards and the approach to limit the hazards need to be written out in detail on the JHA.

A common method of ascending on deck girder bridges involves some sort of preexisting horizontal lifeline setup. One very common system consists of steel cables anchored to the
existing web stiffeners for the girders, and the bridge climber connects their fall protection lanyards to the steel cables in a traditional Y-lanyard climbing on a horizontal lifeline. While many of these systems are engineered and installed, the climbing parties will need to be mindful of the existing conditions of the cables. As with anything else, be sure that what the inspector is anchoring to is sufficient to support the anticipated loading per the SPRAT Safe Practices document.

Another system involves a steel rod attached to the web stiffeners to form handrails. Often these handrail connections are bolted or welded to the stiffeners, and as with the steel cable system the climber should be sure that both the steel rod sections and the connections are in suitable condition to accept shock loads from a potential fall. The welds should be checked for cracks, and the steel rods should not have excessive section loss from corrosion. In both situations, it should be noted that having an adjustable fall protection lanyard has the advantages of ensuring that the climber does not suffer a longer fall than necessary.
2.6 Cable-Stayed Bridges

2.6.1 Suspension Cables

In-depth inspection of stay cable segments can be one of the most complex operations encountered in performing bridge inspections with rope access, which will typically include long exposure times, extended rope management, complex rescue plans, and many other factors not normally encountered in other bridge inspections. There are numerous methods to accomplish this and the importance of consultation with a rope access professional with experience performing this type of inspection cannot be understated.

![Figure 2.6.1: Typical Stay Cable Arrangement, Note Wire Rope Dampening Assemblies.](image)

Typical cable-stayed bridge pylons, also called towers, provide facilities for inspectors to safely ascend from deck level to the top of the pylon. Due to the presence of aviation beacons or radio transmission equipment at the tops, these facilities are typically in good working order and well-traveled by the bridge owners personnel. Access to the top of a pylon is usually provided by installation of a hatch in the roof of the pylon. Inspection activities, including rigging, can be based from this location and cables reached by negotiating the edge of the pylon and descending to the cable to be inspected.

After descent to the assigned cable for inspection, several techniques can be employed. Due to the angled trajectory of the cable, two primary working systems and two backup systems, such as found in a rope-to-rope transfer, must be employed to prevent an uncontrolled swing.
The primary system will normally consist of an engineered device to provide for retention of the inspector to the cable along with a capability to traverse the cable longitudinally. This is usually accomplished through the use of a rolling device. Due to varied geometries found in cable-stayed bridges, these devices are almost always custom made. Due to the requirement for a backup device, two devices should be employed by each inspector to prevent movement away from the cable in the event the primary device fails. These devices should meet the standards of the SPRAT Safe Practices document. Furthermore, due to long exposure times during the cable inspections, a work seat is recommended for comfort of the inspector.

The secondary system should be designed to restrain the inspector from uncontrolled movement parallel to the cable. An efficient way to accomplish this is to rig a standard two rope system parallel to the cable, anchored near the pylon face. By using a descending device and a backup device, the inspector can control the rate of descent and stop for inspection data collection as desired. The effects of rope weight become more pronounced as the cable angle becomes flatter, the rope becomes longer, or wind speed increases. Combinations of these three factors can quickly make rope management challenging.

Cable stayed bridges routinely have monitoring devices and dampening assemblies attached to them. Care should be exercised to avoid damaging any electronic monitoring equipment present. The necessity of passing obstacles such as dampeners should be planned for and passing techniques rehearsed with the bridge inspection team prior to deployment.

Figure 2.6.2: Example of Cable Stayed Bridge inspection Rigging. Note Rolling Assemblies (Green), Two Rope System Parallel to Cable (Blue), and Descending Device (Red) Used to Control Descent to Bridge Deck.
2.7  Stiffening Trusses

For the stiffening trusses, similar access techniques will need to be used as with other trusses. Vertical members can be accessed via ascent or descent techniques with the ropes anchored to the top chord or top lateral bracing. Diagonals can be accessed via rope-to-rope transfer or another acceptable method that meets the requirements of preventing an uncontrolled fall and excessive pendulum.

2.7.1  Floor Systems

Steel floor systems can be accessed in many ways, depending on the steel shapes used for the floor system. Beam rollers can be used to roll along the bottom flanges of beams; however, an appropriate backup fall protection system must also be employed. Most climbing will be horizontal in nature, so care must be taken to prevent or minimize pendulum swings from the anchor points. Highlines and other set ups can be employed, but it should be realized that rope sag when at mid-point may affect the quality of the inspection. Ultimately, the inspecting company must consider the level of effort, time, and safety for the rope work involved. This will need to be contrasted with the same variables when utilizing mechanical access, to determine the best and easiest course of action.

For narrower bridges, specially designed platforms (picks) can be set up and moved along the bridge. For certain structures these methods allow for a close up access with a low setup time.

Figure 2.6.3: Inspection of a Floor Beam System
2.8 Concrete Structures

Concrete structures typically have fewer natural anchor point choices. Concrete components on bridges tend to be too large to be used as temporary anchor points, i.e. slings or webbing may not fit around them. Most concrete structures do not have manufactured anchors installed for maintenance or inspection access. For concrete components that are tall, such as pier walls and towers, simple ascent and descent techniques can be used. Furthermore, for wider concrete structures, rope access methods such as rebelay and rope-to-rope transfers can be used. For concrete components that are horizontal in nature or long in span length, such as box girder floor systems or underside of beams, aid-climbing techniques may need to be employed. When presented with this situation, a general analysis of the time, effort, and safety level of the rope access techniques must be compared to traditional mechanical access techniques to determine which one is the better option. This will naturally be site specific.
2.9 Railroad Structures

Bridge inspections involving railroad owned equipment typically encompass unique safety hazards and warrant a brief discussion on different approaches that have been found to be useful for these unique bridges.

The primary difference between railroad structures and those carrying vehicular traffic is the complexity of providing safe separation from live traffic. Where myriad different methods of traffic pattern adjustment can be used to great effect on vehicular bridges to isolate the traveling public from the inspection work zone, trains cannot be moved laterally from one lane to another. This fact, plus the physical inability of trains to stop or slow quickly has led to increasing popularity of industrial rope access for railroad inspection work due to the nonintrusive nature of rope access when compared to traditional access methods. For these reasons, it is unlikely that any work zone will be provided when working on railroad structures and traffic control will take the form of having railroad employees (flaggers) warning inspectors of impending train passages and allowing a short time to clear off the structure.

Since railroad traffic control, otherwise known as the method of train protection, usually involves temporarily removing rigging quickly, certain methods have been devised to provide expedient accomplishment of this task. In the case of truss bridges, de-rigging vertical ropes as described in through arches allows the ropes to remain in place during train passages while eliminating the risk of entanglement. Furthermore, rope rigging should be discussed with, and approved by, the railroad prior to setup to ensure proper railroad clearances.

During inspection of the floor system on railroad truss or deck girder bridges, ropes can be passed between the railroad ties on the bridge deck so that the inspector can move through the floor system with rope transfers. If these ropes are anchored to short sections of 4x4 timber or steel pipe, the ropes can be quickly removed for train passages and reset during closure windows.

![Figure 2.8.1: Railroad Timbers Used as Rope Anchorages](image-url)
3.0 Preferred Equipment for Bridge Inspection

3.1 Rope Access Equipment

It is not the intent of this document to favor one manufacturer over another, nor to give free advertising to rope access equipment but to document equipment experiences that seem to complement moving the inspector to the proper inspection range with minimal wasted effort or excess features.

3.1.1 Ascenders/Rope Grabs

For ascenders, it is usually desirable to have a chest-mounted ascender integrated into the harness, with a second ascender with foot loop system attached to the working line. A connection with shock absorption capabilities, usually a pre-sewn or knotted termination lanyard should be connected between the harness and the ascender with foot loop. Utilizing this system, sometimes referred to as sit/stand, for ascents helps keep the worker upright and in a relatively comfortable position, thereby delaying fatigue during the ascent. It is not particularly necessary for the ascenders in this system to be toothed or cammed, but any device should be able to withstand a small shock (the up and down movement of ascending a rope will introduce minor shock loads) without damaging the rope. For the secondary, or backup, line, an appropriate backup device and shock absorbing system should be used, which will be discussed in Section 3.1.3.

Also, note that while this ascending system is the desirable system to employ when accessing a bridge, it is not the only method. Other methods of rope ascent will perform the desired work, and the system chosen should be the one that optimizes safety and potential rescue for the personnel involved. The chosen system should also be referenced in the JHA prior to commencing the work.

Generically, rope grabs and similar devices come in many shapes and sizes, and operate with different principles (camming vs. toothed) and goals. The rope grab used should correlate with the work to be done. Will the rope grab ever be in a position to be shock loaded? If so, avoid toothed cams unless a shock absorber is included in the system. Does the device the inspector plan to use accept the diameter of rope being used? Does the rope grab device accept one or two ropes, and which of those is the intended use?

3.1.2 Descenders

For descenders, it is usually desirable to have a device that has an easy auto-lock feature. When using rope access on a bridge, the worker frequently has to stop and start the descent to work in specific areas for a length of time. This can be to take a picture, take a measurement,
record a deficiency, or any other manner of work relating to the task at hand. Also, it is desirable to use a descender that imparts little or no twist on the rope; otherwise, the rope can become tangled. For the secondary line, the same concepts used for ascent systems should be employed, which will be discussed in Section 3.1.3.

### 3.1.3 Backup Devices/Fall Protection Systems

Within the concept of primary/back up lines for rope access work it is understood that backup devices fall into a generic category of devices that arrest a fall should the primary line fail. For these devices there are many considerations that need to be included in the decision on which device to use. One must consider the actual work being performed, and must also consider any regulatory requirements governing these devices. Most rope access work is classified as work positioning and falls under regulations in that category. Often, fall arrest has a different set of regulations than work positioning, and the bridge crew should be mindful of this.

Most backup devices for rope access work will need to be connected to the harness with a shock absorbing lanyard (cow’s tail) of appropriate length. Depending on your company preferences and training, this lanyard can be attached to the dorsal or sternal portion of the harness. Fall protection system requirements are usually spelled out in the applicable regulations. At all times, one needs to be mindful of how their connectors will be loaded in a fall. Frequently, large or oversized carabiners are used to connect the bridge inspector to a component of the bridge such as lacing bars. These carabiners tend to have very poor performance when loading off their main axes. Another option is the use of a dynamic lanyard with a sewn nylon sling around the lacing bar. When lacing bars are too big to accommodate ladder hooks, it may be necessary to use a steel/web lanyard to wrap the lacing bar to provide an anchor to connect the ladder hook. Duct tape or a specially made rubber component can be used to accomplish this. These accessories are not structural, of course, but serve to prevent dropping the steel lanyards or the nylon sling as they are reset around the structure members.

Lanyards, slings, or cables can be slung around steel beams, bracing, sheaves, or any static 5000 lb. anchor for the climber to be considered tied off. Special care should be taken to avoid loading slings, particularly the components made of nylon material, around sharp edges such as the end of a beam flange during a fall event.

As always, care should be taken to minimize the potential fall distance (or factor), and a shock absorber designed for fall arrest should be used between the climber and the attachment point if the worker is in a fall arrest situation.
3.1.4 Anchor Devices

Due to the unique nature of bridge structures, evolution of bridge technology, myriad situations that occur when inspecting bridges via industrial rope access, different types of anchor techniques have been found to be useful in a variety of situations.

3.1.4.1 Rail Sliders

Rail sliders are a specialty anchor device that can be used on railroad structures to provide structural anchors to the existing rails. These anchors can be used conveniently for fall arrest or as part of a two rope system to access components below or above (when used in conjunction with a redirect or intermediate anchor) the rails.

As with the drain hole anchor devices described below, rail sliders provide a compact anchor option for the rope access technician that can be easily and quickly repositioned to different locations along the bridge. One notable feature of rail sliders that is both an advantage and a disadvantage is the ability of the slider to move freely parallel to the rails. The advantage to this is that a rail slider can act as a passive fall protection device for personnel working on the track way. A disadvantage to this feature is that it makes the rail slider unsuitable for anchor applications in which the rope is loaded in any direction except nearly perpendicular to the rails. It should be noted that some styles of rail sliders can be loaded in one direction along rails due to an off-center ring placement. This feature locks the slide in one direction while allowing it to slide free in the other direction. Special care should be taken when selecting the proper rail slider.

Rail sliders also vary according to the rail weight they can accommodate. Modern freight railroads employ rail up to 155 lbs. (that is, 155 lbs. per 3 ft of rail length) while on short-line railroads or historic bridges it is not uncommon to encounter rail weights as low as 45 lbs. Rail sliders have different ranges of rail weights they can accommodate and still provide adequate anchor strength. Again, special care should be exercised to ensure selection of the appropriate slider for a bridge inspection project.
3.1.4.2 Drain Hole Anchors

Drain holes are placed in bridges to remove unwanted moisture in congested connection areas, box girders, and other locations. Devices exist on the market to make use of these drain holes as structural anchors for the rope access technician. Use of drain holes as anchors is advantageous due to the minimal amount of rigging material required, as well as quick installation and removal of the device. Disadvantages include the lack of flexibility with regards to location of the anchor.

![Installation of a Drain Hole Anchor](image)

Figure 3.1.1: Installation of a Drain Hole Anchor

3.1.4.3 Webbing, Slings, Rope Sections, Metal Cable

Webbing, slings and lanyards can be used as anchors when performing rope access work on bridges, provided they meet the SPRAT Safe Practices document, and that the climber is mindful of sharp edges and slipping potential when installing. Good practice involves anchoring to structural steel components of the bridge such as beams, bearings, channel and angle sections. Anchoring around conduit, cables, and ancillary components is usually discouraged unless it can be verified that the component meets the required strength requirements. Steel cables/slings can be a good rigging material as they are more resistant to wear and abrasion that traditional nylon webbing material. New technology soft slings also provide an increased resistance to wear and abrasion over their nylon counterparts.

In addition to using appropriate materials for an anchor, it is important that the anchor component is appropriately rigged to the structure. Anchors should be rigged such that they are not subjected to sliding or choking along the beam. Load sharing anchors tend to be unnecessary on bridges, as more often than not there is a component nearby that will meet
strength requirements. Should a load sharing anchor be required, the SPRAT certified jobsite supervisor shall oversee its construction.

### 3.1.5 Structure Climbing Tools

Structure climbing tools such as ladder hooks, also commonly known as rebar hooks, are used routinely during bridge inspections. As such, the inspections are not purely rope access but typically a combination of rope access and structure climbing. When structure climbing, inspectors are generally in a fall protection environment and there are certain instances when the suite of equipment available to the inspector allows these environments to overlap.

When climbing structures using a pair of ladder hooks attached in a Y configuration to a common shock absorbing device, the inspector may find it useful to use one hook for positioning in order to work hands free by feeding one hook lanyard through their chest ascending device. If the inspector places one leg of the Y-lanyard in their chest ascender, the second leg cannot be used as the backup as it may prevent full deployment of the shock absorber, and an independent back up system shall be used. However, if the inspector is using two lanyards with independent shock absorbers and independent connections, then the second leg can be used as a backup.

If the lanyard system shares a common shock absorber, an unused hook should be attached to the structure or allowed to hang freely. An unused hook should not be attached back to the harness, as this could defeat the shock absorber during a fall by limiting the shock absorber extension. Conversely, unused hooks on Y-lanyards with two shock absorbers may be attached back to the harness.

### 3.1.6 Specialized Rescue Equipment and Methods

No access organization should solely rely on the use of local rescue teams, fire or EMS agencies for the purpose of rescue service. While there are local rescue teams that have a great deal of experience and capability, this cannot be guaranteed for all work sites. The inspector should consult the local agency for detailed information as to their capabilities and availability to respond to complex or technical rescue situations.

Bridges differ from other rope access environments in several ways. The most notable characteristics of bridge inspection work as it pertains to worker safety include proximity of traffic, commonality of underdeck work, and inaccessible landing sites. Since bridges typically are used to cross an obstacle safely, it is common for the areas under bridges to be difficult to use for casualty evacuation.

These characteristics give rise to several important considerations for the job site supervisor and all team members to be cognizant of when planning and conducting bridge inspections. In
the event a rescue is required, the particular location of the disabled worker presents several options to the remainder of the work party.

Rescue considerations must be applied for all types of work at height. Individual styles present unique hazards and considerations. The best rescue method is one which facilitates the rescue while minimizing the hazards. When possible the site should be rigged to facilitate lowering of the access ropes. Other proactive approaches include self-rescue options. In general, nonintervention techniques are preferred over direct rescue methods (pickoffs, etc.). Regardless of the situation, a rescue plan must be established and understood by all members at the work site. All foreseeable and potential rescue scenarios should be addressed in the JHA. Some key areas in a rescue preplan are: emergency phone contact information, designated rescue equipment location, hazards and mitigation techniques, statement of approach to solving the rescue problem, individual responsibilities, communications and medical intervention.

In the event of an above deck rescue, such as the top of a through truss or arch, it is important to remember that live traffic may be below workers. If traffic control measures are available, a temporary traffic closure could be warranted but if no traffic control is available, tensioned lines may be necessary to ensure the casualty is lowered into a safe area. An extra rope of suitable length is recommended to be included in the job specific rescue kit, as well as anchors, pulleys, and methods to build a mechanical advantage.

In the event of a rescue under a solid bridge deck, the preferred rescue is to lower to the ground, waterway, or other crossed feature. For navigable waterways, harbormasters or local Coast Guard forces can be contacted prior to the inspection to coordinate prompt watercraft attendance to the scene. This is usually a good idea, even if the local regulations do not require this. Many bridge owners require a rescue boat on site for over water work; this watercraft could be used for casualty evacuation.
In most cases where rescues via lowering are anticipated to be the method of choice, anchor knots pre-rigged to lower can be quite useful and will expedite any required lowering. Of course, care should be taken to ensure adequate rope is available to lower the casualty to the anticipated evacuation elevation.

If the ground beneath the structure is unsuitable for evacuation, hauling may be required. 4:1 haul systems pre-rigged with rope grabs have been found to be a compact, efficient system for most casualty hauling operations. It is also useful to rehearse team member roles in rescue scenarios during pre-job briefings to ensure maximum efficiency should a rescue become necessary; extra hauling personnel can be useful in performing a prompt rescue. Additionally, anchor sites should be preselected where possible.

Consider keeping a small cache of equipment with you at all times that can serve as elements of a rescue system. This may include, but is not limited to: small pulleys, rope grabs, extra carabiners, positioning or adjustable seat lanyards and a compact pre-rigged mechanical advantage system or mini haul. These tools are compact, lightweight and invaluable. There are many commercially available rescue kits on the market. These kits are useful in that they are usually designated for rescue purposes only and are easy to apply and use. Such kits should be easily identified through the use of colors and markings.

If an incident were to occur on the job site, it is imperative that proper documentation of the incident occurs. Occupational agencies such as OSHA or local investigative authorities will require specific information regarding the incident in a timely manner. Reference your local authorities for specific requirements. Details as to the facts of the incident must be recorded. The inclusion of photos and other visual references are very helpful to anyone using the report.
information. Statements from witnesses and others involved in the incident should also be collected.

The individual technician is ultimately responsible for their well-being and must remain vigilant in the proper application of rope access and climbing techniques and equipment use. Situational awareness and attention to detail is paramount when working at height. Members must be attentive to their personal health, mental status, condition and application of equipment as well as their surrounding environment. When an actual rescue incident evolves, it is easy to lose sight of the big picture, attempt to take shortcuts and justify hazardous behavior. Remember to always remain on at least two points of contact when exposed to falls.

3.2 Inspection Tools

3.2.1 Tool Lanyards/Retractable Leashes

Small cordelettes and lanyards can be used to attach hammers, scrapers, pens/pencils, tape measures and other tools to harnesses. Others prefer jackets/shirts/vests with many pockets and attachments to store all tools. Certain types of survey vests work well with this. When working on a bridge it is advisable to have one’s outer layer comply with the applicable regulation for clothing in maintenance of traffic situations. Also, small nonstructural carabiners found at hardware stores and on retractable key chains have proven useful for securing lightweight tools.

3.2.2 Recording/Documentation

The note system used for bridges varies. Regardless of the type or amount of notes that need to be taken, there will still be notes and plan sheets involved. Notebooks are typically attached to the harness or in a vest pocket. Due to the value of deficiency documentation during a bridge inspection, written notes are arguably the most important item carried and should be secured against loss appropriately.

For most conditions, waterproof paper and writing utensils are found to be sufficient for recording deficiencies. Two primary disadvantages of this system are the higher cost associated with these specialty items and requirement to use same branded writing utensils to ensure compatibility with the writing surface.

Notes can also be taken electronically, or in a field laptop/tablet. Advancements in electronic documentation have allowed inspectors to store all inspection information (plans, reports, manuals) on the device, which can save time during the inspection process. Care must be taken to ensure the electronic device is properly tethered to prevent dropping/breakage and charged daily.
3.2.3 Hand Tools

Due to the need for frequent stopping to record notes, hand tools should be easily accessible, controllable and protected from dropping. Tape measures, rulers, angle finders, scissor calipers, pit gauges, scrapers, hammers, and other necessary tools should all be stored in easy to reach areas, tethered, and not be cumbersome to carry. Similar concepts also apply to magnetic particle kits, ultrasonic thickness gauges, and other larger testing equipment that may be carried. One item some technicians have found to be particularly useful is a keychain tape measure. When placed on the shoulder strap of the harness, not only is a small 3-ft tape measure readily accessible and sufficient for documenting fatigue damage, pack rust, and other small deficiencies, it is easy and economical to replace should breakage occur.

3.2.4 Photography

Due to the conditions under which bridge inspection via rope access is performed, many crews have found useful cameras which are shock resistant or shockproof. Additionally, waterproof cameras are readily available and quickly pay for their initial investment. Due to the unpredictable nature of field work, photography equipment that can be immersed in water is also useful in that it can be easily cleaned should it become soiled.

3.2.5 Site Specific Tools

3.2.5.1 Long Arms

Long arms or other poles with hooks can be readily fashioned out of a variety of materials and are useful for conducting rope transfers over distances up to about 15 ft when ropes are passed through a deck surface that prohibits lateral movement. Two good examples of this situation are railroad bridges where the position of the ties and rails inhibits draping ropes to the climber and grid decks.
3.2.5.2 Dumbbells

As earlier referenced in the discussion on through arch inspection techniques, small dumbbells are a convenient way to weigh down the ends of free hanging ropes to limit wind or other forces from moving them.

3.3 Nondestructive Testing

3.3.1 Paint Removal

Up until the mid-1970’s, all steel bridges were coated with lead-based paint. It is currently estimated that over 90,000 bridges in the United States are coated with lead based paint. Since the majority of the bridges were constructed during this time period, it would be prudent that the worker assume that the bridge to be inspected contains a lead based paint. If paint removal is necessary for nondestructive testing, then proper precautions should be taken to protect the worker from being exposed to lead. Since the amount of paint removal would be minimal, typically, abatement measures would not need to be taken; however, appropriate respiratory protection should be used.
Paint removal can be done via typical rope access methods. Since the worker may be in one location for a period of time, the use of a work positioning lanyard will alleviate excess movement and allow the worker additional support and mobility during the paint removal process. Furthermore, the use of a work seat will increase comfort for longer duration paint removal. If power grinding methods are used, specific precautions should be taken to ensure protection of rope systems. Position ropes away from the surfaces to be ground and use additional rope protectors when necessary. Even if the grinder is not near the worker’s ropes, attention should be paid to the metal shavings/sparks created from the grinding. Cordless grinders are light and portable, and typically will not require the use of an additional rope for support. However, even if the grinder does not require its own rope, it should be tethered in some capacity to minimize a dropping risk. If a cordless grinder is not available, a generator and cord will be necessary. Depending on the length of electrical cord, an equipment rope may be necessary to support the added weight. Ensure all equipment is tethered prior to getting on ropes.

3.3.2 Dye Penetrant Testing

Dye Penetrant Testing (PT) is a nondestructive method that reveals surface discontinuities by use of a penetrant (typically a red liquid), which is drawn into the crack via capillary action, and then drawn out of the crack by use of a developer.

PT may become cumbersome on ropes. Not only is there a necessity for grinding equipment similar to described above, but three separate spray systems must be used, as well as cleaning of the material to be tested. Furthermore, the spray systems are aerosol and flammable, so care must be taken to prevent grinding sparks from coming into contact with the aerosol cans. If feasible, leave the PT equipment away from the work area (grinding area) until properly cleaned, then have the PT equipment lowered to the inspector on a separate rope. If this is not feasible, the use of a closed equipment bag hanging off the bottom of the work seat should keep sparks away from the PT equipment. The materials used for PT testing technically would not require a separate equipment rope; however, if the location of the area to be tested is in an easily accessible area where equipment can be lowered to the worker, then this may be the best approach to keep the work area clutter free. The use of a work positioning lanyard and work seat will assist the worker with added comfort and increased mobility for the PT inspection.

3.3.3 Magnetic Particle Testing

Magnetic Particle Testing (MT) identifies surface discontinuities and near surface discontinuities by creating a magnetic field in the steel. The magnetic field will create poles on the sides of the discontinuity, which will attract iron particles. The accumulation of iron particles will show the location of the discontinuity.
Similar to the other methods of nondestructive testing, the location of suspected discontinuity can be on any part of the bridge. Due to this, there is not a standard rope access method to be used; rather MT testing can be performed from a variety of positions. If awkward positioning is required, the use of a work positioning lanyard and work seat may alleviate stress on the worker. Since the MT can be performed through thin painted systems, grinding is typically not required; but may be necessary if the painted coating is heavy, chipping or cracking. If possible and available, using a cordless MT unit will assist in mobility. Cordless units are light and would not require the use of an equipment rope. If not available, a generator and cord will be necessary. Depending on the length of electrical cord, an equipment rope may be necessary to support the additional weight. The ropes should be protected from the iron powder. Since the iron powder is easily blown in the wind, the best way to protect the ropes is to position them upwind in lieu of using rope protectors. The ropes may become prematurely worn if exposed to the abrasive iron power.

3.3.4 Ultrasonic Testing

3.3.4.1 High Level Ultrasonic Flaw Detection

Ultrasonic Testing (UT) uses high frequency sound waves to measure the properties of steel. When a discontinuity is encountered, the sound wave will reflect off the flaw and return to the UT machine.

For UT inspections, care shall be taken around ropes. Since grinding and paint removal are necessary for these actions, respirators and rope protection should be used. Ultrasonic testing equipment is light and portable, so the use of extra ropes would typically not be necessary. Similar to other methods of nondestructive testing, the use of a work positioning lanyard and work seat may aide in the workers comfort and mobility of the ultrasonic inspection process.

3.3.4.2 Ultrasonic Thickness Gauges

Ultrasonic thickness gauges work on the same principle, but the sound waves reflect off the back surface of the steel to obtain the thickness of the tested area. Employment of such devices while on rope is similar to other small tools in that the devices must be tied off to prevent loss from dropping. A squeeze bottle is typically preferred for convenient application of the coupling fluid.
3.4 Jobsite Safety

3.4.1 Radio Communications

Due to the typically large distances involved in complex bridge inspection projects as well as persistent high wind conditions encountered while working at height, simple communication within earshot may not be possible. Radio communication is one preferred alternative and as such several considerations should be addressed when selecting radios.

- Small, inexpensive radios normally available at retail sporting goods stores have unsecured frequencies and are susceptible to interference from competing radios on adjacent work sites or other electromagnetic sources.
- Higher quality radios are available from vendors with ranges up to several miles.
- The use of hand microphones is preferred since it allows the storage of the more bulky transmission unit elsewhere on the harness, usually in a bolt bag. This both decongests the front portion of the rope access harness and protects the radio from a fall should it become dislodged. Additionally, operation of the hand microphone with gloves is far easier since only the push-to-talk button is included. The base unit usually has more functions and is harder to use with gloves.
- Higher quality radios can be significantly more expensive. They usually offer reserved frequencies, eliminating interference concerns.
- Radios should be rechargeable or use alkaline batteries as appropriate for the expected jobsite conditions radios are employed on. This consideration is at the discretion of the end user.

3.4.2 Traffic Control

Maintenance and awareness of traffic are crucial for the safety of both bridge inspectors and motorists. A proper balance between maintaining adequate visibility to the traveling public and not providing an unnecessary distraction to motorists is paramount. The Manual for Uniform Traffic Control Devices provides strict standards for traffic control work zone setups and requires numerous certifications to prepare, approve, and implement traffic control plans. Properly-certified vendors should be used at all time to perform these functions. When exercising a traffic closure in conjunction with rope access, care should be taken to integrate the traffic control plan with the rescue plan to ensure adequate work zone width is available for emergency purposes, including EMS accommodations.
3.4.3 Rescue Plan

Location and availability of rescue services capable of extracting workers at height is usually problematic. While an emergency response system should be in place, and local fire departments often have technical rescue skills, oftentimes the inspection team on the bridge will be more qualified in technical rope access training than a local fire department. This should be addressed in the work plan and JHA and discussed before starting the work. It may be necessary to rehearse particularly complex rescue scenarios, if warranted.

3.4.4 Local Authorities

As a professional courtesy, notifying local authorities in addition to the bridge owner or client is helpful to defuse incoming calls from the public or wasteful use of response services in the event the bridge crew is mistaken for unofficial persons on the structure.