Abridgment

Climbing: A Unique and Effective Approach to Bridge Inspection

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Bridges are a critical part of this nation's infrastructure. Their thorough and regular inspection is vital to the safety of everyone who crosses them. However, gaining access to primary structural members of a high-level bridge presents a major dilemma. In 1981, Burgess and Niple Ltd. pioneered a unique approach to bridge inspection using rock-climbing technology. Trained structural engineers and technicians use standard climbing techniques to reach bridge components that are often difficult to access. By applying climbing skills, inspectors can ascend and descend, walk and climb on, swing and hang from, and maneuver around various bridge components. The climbing approach to bridge inspection offers several advantages over traditional methods. The equipment is lighter and less cumbersome than safety equipment used by iron workers. The techniques are often quicker, less expensive, and more effective than mechanical access methods. Inspection by climbing allows little or no disruption of vehicular traffic.

Bridges are a critical part of this nation's infrastructure. Their thorough and regular inspection is vital to the safety of everyone who crosses them. However, gaining access to primary structural members of a high-level bridge presents a major dilemma. Mechanical access methods (underbridge units, aerial lift units, scaffolds, etc.) are used with varying degrees of success. Iron workers hired specifically for their climbing skills lack the technical knowledge necessary to identify and evaluate structural defects. In 1981, Burgess and Niple Ltd. (B&N) pioneered a unique approach to bridge inspection using rock-climbing technology. Trained structural engineers and technicians use standard climbing techniques to reach bridge components that are often difficult to access. This approach not only allows hands-on inspection, but has been proven safe. B&N inspectors are provided with in-house training that includes climbing terminology, use of equipment, and techniques. By applying these learned skills, inspectors can ascend and descend, walk and climb on, swing and hang from, and maneuver around various bridge components. The climbing approach to bridge inspection offers several advantages over traditional methods. The equipment is lighter and less cumbersome than safety equipment used by iron workers. The techniques are often quicker, less expensive, and more effective than mechanical access methods. Inspection by climbing allows little or no disruption of vehicular traffic. B&N climbing techniques are looked on favorably by the Occupational Safety and Health Administration (OSHA), U.S. Department of Labor. B&N realizes the importance of a safe, hands-on inspection and takes the extra effort to perform an untraditional method of inspection.

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TRAINING

B&N provides in-house training for inspectors that includes terminology, proper care and use of equipment, and techniques for safe, hands-on inspection. Climbing skills are developed through elevated rope exercises, scaling rock faces, and maneuvering on local bridges. Emphasis is placed on proper falling techniques, handling gear, and general safety procedures. Climbers develop trust in their equipment and in one another. Practice improves agility, coordination, and finesse.

EQUIPMENT

B&N uses the following basic climbing equipment, which is lightweight and durable (see Figure 1).

Rope

A nylon line that connects a two-man climbing team and is used during belaying, rappelling, ascending, and rescue operations. The rope has an 11-mm diameter and is of a kern-mantle construction consisting of an outer nylon-braided sheath surrounding a continuous stranded core. Two types of rope are used—dynamic and static. Dynamic ropes are used mainly for belaying.

Carabiner

An aluminum clip that connects climbing equipment to one another. Typically, carabiners are used to connect webbing slings to the rope or to the climber. A carabiner connected to a webbing sling is considered an anchor.

Webbing Sling

A nylon strip tied into a loop that is used primarily to anchor the climber or the rope to the bridge. The strip is 1 in. wide

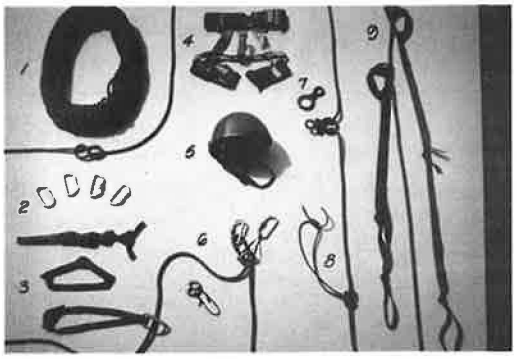

FIGURE 1 Standard climbing equipment.

and is of tubular construction. A water (wet) knot closes the sling's loop.

Sit Harness

A nylon body unit with adjustable waist and leg loops that secures the climber to the rope or webbing sling.

Helmet

A climber's protective headgear. It has safety features such as a bonded urethane foam liner and adjustable chin strap.

Sticht Plate

An aluminum device that rope is fed or retrieved through during belaying. The rope is looped through this plate and both are connected to an anchor.

Figure 8 Ring

An aluminum device that rope is fed through during rappelling. The rope is looped through the larger ring and over the smaller ring. The Figure 8 ring is attached to the rappeller's harness with a carabiner.

Prusik Sling

A nylon static line tied into a loop that secures the climber to the rope during rappelling or ascending. The line has a 5- to 7-mm diameter and is of the same construction as the climbing rope. A double grapevine (fisherman's) knot closes the loop of the sling. The sling is attached to the climbing rope with a prusik knot and to the climber's harness with a carabiner.

Ascenders

A pair of hand-held aluminum mechanical devices that slide along the rope during ascending. Webbing or prusik slings attached to the ascenders are used as footholds by the climber.

TECHNIQUES

B&N uses four standard techniques: climbing with rope, climbing with webbing, rappelling, and ascending.

Climbing with Rope (Belaying)

A method of providing security for a climber by controlling the play of the rope. This technique is typically used when climbing girders, arches, and large truss members. Each end of the rope is connected to a climber of a two-man team. One climber remains stationary (belayer) while the other climber moves about the bridge. The belayer and rope are secured to the bridge with an anchor. The belayer's function is to feed out and retrieve rope at a controlled rate through a sticht plate, so that any fall by the climber will be as short as possible.

As the climber moves away from the belayer, he sets anchors around the bridge components (floor beams, cross frames, diaphragms, bracing members, etc.). The rope is placed through the carabiner of each anchor. Once the climber has used the available length of rope, he secures himself to the bridge and becomes the belayer. The former belayer becomes the climber who removes and sets anchors as he moves toward and beyond the new belayer. By the team members alternating duties of climber and belayer, they are able to leap-frog their way along the bridge.

Climbing with Webbing

A method for climbers to move independently of each other while providing their own security by using webbing slings. This technique is generally used when climbing bracing members and small- to moderate-sized truss members. An anchor is looped around a bridge member and connected to the climber's harness. As the climber moves, the anchor is slid along the bridge member. A climber can hang from his anchors to reach the underside of bridge members. A long sling knotted into several loops can be used as a webbing ladder for ascending or descending.

Rappelling

A controlled means of descending a rope. Friction across the rappeller's Figure 8 ring and body controls the rate of descent. A prusik sling is attached to the rope and used as a safety brake for resting or if the descent rate gets out of control. When descending a single rope, the rappeller should be belayed with another rope as a safety precaution. However, if only one rope is available (generally the case), then it should be doubled and the rappeller descend both halves. In this case, each half of the rope should be secured to an anchor with a butterfly knot. Rappelling is used to descend truss verticals, arch columns, piers, etc., or to exit off a bridge.

The Figure 8 ring is limited to a rappel of less than 100 ft because it is difficult to increase or decrease friction of the rope around the ring. This situation requires the use of a rappel rack that varies the friction of the rope thereby con-

trolling the rappeller's rate of descent. The rack is a steel bar bent into a U-shape on which aluminum brake bars move freely up and down, and which attaches to the rappeller's harness with a carabiner. Passing the rope over and under successive bars creates the friction that controls the rappeller's rate of descent.

Ascending

A progressive method of climbing a rope by using ascenders with attached webbing or prusik slings. The climber alternately ratchets each ascender up the rope while using the slings as steps. A prusik sling is attached to the rope and used as a safety brake for resting. Ascending is used to return to a specific point of a bridge after rappelling or falling from it.

After mastering the techniques and applying his skills, some of the many things a climber can do are as follows:

- Walk on girder and floor beam flanges, arches, truss chords, and suspension cables with handrails;
- Climb arch columns, truss verticals and diagonals, bracing members, and suspension cables without handrails;
- Swing or hang from members of a floor system (stringer, floorbeams, and bracing), truss members, and arches;
- Maneuver around arch columns and girder stiffeners; and
- Descend truss verticals, arch columns, and piers.

The climber has many hand- and footholds available such as flanges, stiffeners, lacing, perforations, rivets, bolts, and various bracing members (see Figure 2).

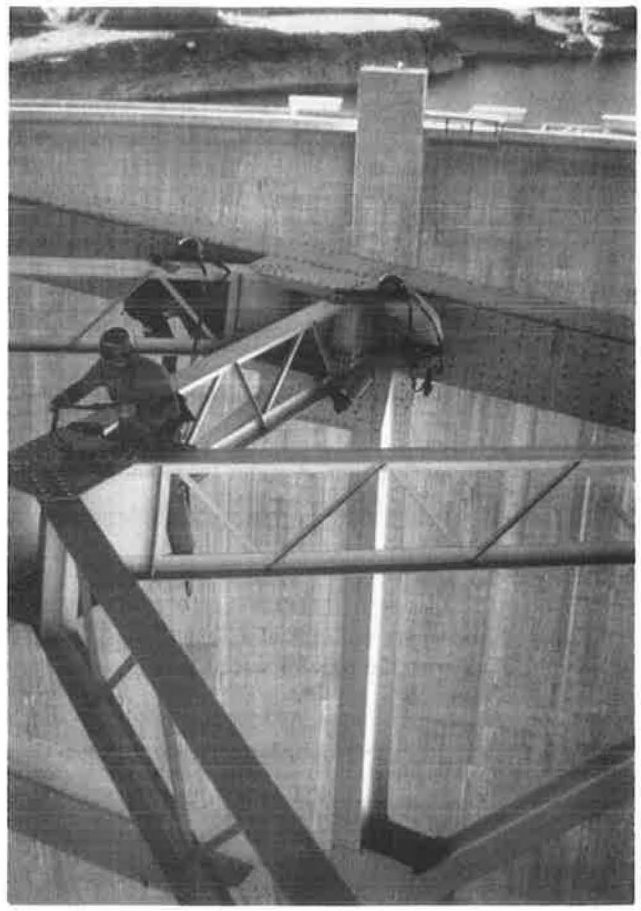

FIGURE 2 Climbing arch bracing.

ATTIRE

When an inspector is preparing for a bridge climb, he must dress according to the environment. Layered, loose clothing is preferable to tight clothing and bulky jackets. Loose clothes allow easy body movement. Layered clothes can be removed and added as the body heats and cools. Thin leather work gloves are more durable and protective than cloth gloves. The type of footwear used by inspectors depends on personal preference. Typically, tennis shoes, running shoes, hiking boots, and work boots are worn. Flexible footwear has good adhesion on sloped surfaces, fits in narrow footholds, and is lightweight. Stiff footwear is better for standing on small footholds and in webbing slings (anchors and ascenders), and provides better wedge action in footholds. Safety glasses can be worn on the climbing helmet and used during cleaning and testing operations. A helmet liner is useful to wear in cold climates. Kneepads can be worn if warranted.

ADDITIONAL EQUIPMENT

Inspectors who climb must also be ready to clean, measure, test, draw sketches, and take photographs and notes. They carry equipment for these tasks in addition to spare climbing and safety equipment in nylon fanny (waist) or back packs and on their harnesses.

Some of the measuring tools traditionally used for inspection (calipers, rules, and depth gauges) are cumbersome to use while climbing. In 1987, B&N designed three measuring tools that are adapted for climbing and allow greater flexibility such as one-hand operation and direct readout. These tools include scissor calipers, L-shaped rules, and pit gauges. The tools are used primarily to determine steel component sizes and section loss caused by corrosion.

SUPPORT SYSTEMS

B&N personnel are secured to the bridge at all times while performing their climbing techniques. Each technique has a primary and secondary support system consisting of the climber's body (hands and feet) and equipment.

RESCUE

If a climber should fall while climbing with rope, rescue operations allow the climber to be raised or lowered. The belayer immediately notifies a ground man by way of portable radio. The belayer exits the belay by locking off and securing the sticht plate to prevent any further descent of the climber. The belayer determines if the climber is capable of ascending the rope or if he needs to be raised or lowered. Additional help

or equipment will be obtained by the ground man. The following rescue techniques can be used.

Ascending the Rope

If the climber is not injured and has not fallen a great distance, ascending the rope is the best option. The climber will connect ascenders and a prusik sling to the rope and his harness and begin ascending.

Lowering

It is easier to lower a fallen climber than to raise him as friction and gravity are working with the process. Lowering is not an alternative if any of the following conditions exist: rope is cut, lowering height is greater than the sum of the rope lengths on hand, and there is no suitable location to lower climber to (over water, railroad, power lines, etc.).

Raising

Raising is the slowest and most difficult of the three rescue techniques. Friction, gravity, and stretch of the rope are working against the process. A haul system can be set up by the belayer to aid ascension. The haul system uses pulleys to gain mechanical advantage and prusik slings to prevent the rope from slipping between pulls.

COMMUNICATION

A good communication system is essential in relaying information among the climbing teams, ground man, and authorities. Before the field inspection of a bridge, local law enforcement agencies and emergency medical services are contacted and informed of the location and nature of work. Certain jobs require the use of a cellular phone located in the inspection vehicle. However, other jobs require only ready access to a nearby telephone. The members of each climbing team and the ground man carry portable radios.

When climbing with rope, the belayer and climber must be able to communicate with one another. Communication is usually accomplished by using voice commands in lieu of portable radios. If the area surrounding the climbing team is too noisy to hear voice commands, then hand signals or portable radios are used. If the climber falls and is injured, the belayer notifies the ground man who, in turn, advises the appropriate emergency medical services.

EQUIPMENT MANAGEMENT

Climbing equipment management is a maintenance program for the safety of climbers. Effective management depends on the effort of everyone involved with the equipment including the climbers and the equipment manager. However, the bulk of management lies with the equipment manager. Guidelines inform equipment users of the care, storage, inspection, inventory, coding, and retirement for each piece of equipment.

Duties are split between climbers and the equipment manager. The climbers are responsible for their own equipment during an inspection project and monitor the condition of their equipment daily. They are aware of the possible defects that may occur and know the cause of action to take if a defect is found.

OSHA REGULATIONS

In February 1988, B&N informed OSHA of its bridge inspection program highlighting the climbing approach and requested a clarification or interpretation of the Code of Federal Regulations (CFR) as applied to bridge inspection. OSHA established that the activities of bridge inspection are regulated under the CFR, Title 29, Part 1910. This part of the CFR is the General Industry Standards. Some of the subparts included in Part 1910 are: Subpart D—Walking-Working Surfaces; Subpart F—Powered Platforms, Manlifts, and Vehicle-Mounted Work Platforms; and Subpart I—Personal Protective Equipment. Bridge operations, routine maintenance, service, and inspection are all classified as general industry functions.

B&N met with OSHA officials in April 1988 to present its bridge-climbing procedures. B&N understands that its climbing techniques used for bridge inspection comply with the OSHA Act of 1970. OSHA has acknowledged that the techniques do not fall under the provisions of the CFR, Title 29, Part 1926. This part of the CFR is considered OSHA's Construction Standards. Sections 104–106 of Part 1926 address safety belts, life lines, and lanyards; safety nets; and working over or near water, respectively. Many agencies that perform bridge inspection follow these sections of the Construction Standards.

SUMMARY

Each year many bridges in this country sag, collapse, or otherwise become impassable. Nearly all collapses caused by structural failure could be prevented by thorough inspection procedures and adequate follow-up repair. B&N realizes the importance of a safe, hands-on inspection. Climbing is quicker, safer, and more efficient than time-consuming, costly, traditional methods of inspection. B&N engineers and technicians take the extra effort to perform an untraditional method of inspection. The B&N climbing approach to bridge inspection is unique and effective.

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