Climbing Techniques for Bridge Inspection

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ABSTRACT

California has about 24,000 publicly owned bridges that require structural evaluations to comply with National Bridge Inspection Standards (NBIS) mandates. Of these, about 800 are identified as possessing fatigue prone or fracture critical details requiring thorough tactile investigations. Gaining access to bridge elements to perform these investigations has become increasingly difficult and costly. The traditional uses of under bridge inspection trucks, lift equipment and rigging are economically and practically limited by bridge size, structure type, traffic demands and support costs. In some cases, bridges that have become damaged by earthquakes cannot safely support the loads of heavy personnel lift equipment. The California Department of Transportation (Caltrans) Office of Structure Materials and Office of Structure Maintenance and Investigations evaluated the use of rock climbing and mountaineering techniques as an alternative means of gaining access for bridge inspections. Under a small research grant, a bridge climbing training course was developed through a local University of California outdoor recreation group and 7 engineers and technicians were initially trained. A comprehensive Code of Safe Practices was created and standards of training, procedures and equipment required for bridge inspections were established. A successful climb investigation on a large, previously inaccessible arch bridge was completed at the end of the training that proved the techniques safe, economical and effective. Within one year, 20 bridge maintenance engineers were trained, and a formal program was established to organize, schedule, equip and certify engineers and technicians for bridge climbing. Several other offices within Caltrans as well as the California Department of Water Resources have since adopted these techniques for specialized structural inspection tasks. Climbing techniques are now routinely in California as an alternative means of gaining access to bridges and structures, and over 160 bridges have been identified as those where climbing is the only means available to perform structural investigations.

INTRODUCTION

California has about 24,000 publicly owned bridges. These bridges are inspected at least once every two years as part of the Federal National Bridge Inspection Standard (NBIS) requirements. With the exception of Los Angeles County, Santa Clara County and the City of Los Angeles, engineers from the California Department of Transportation (Caltrans) perform these inspections. Apart from routine biennial investigations, specialized tactile investigations are conducted on about 800 fatigue prone and/or fracture critical bridges. Historically, gaining access for both the routine and fracture critical bridge investigations required the use of specialized equipment such as under-bridge inspection trucks, personnel lifts or industrial rigging. There are problems associated with these types of access, such as taking traffic lanes from the bridge deck to accommodate the equipment,

costs and safety issues associated with this traffic control, the availability of the required equipment and the availability of support staff. Additionally, there are those bridges in the inventory that are either too large, too small, too weak or are too damaged to effectively use personnel lift equipment and support crews for inspection. Because of increasing costs and difficulties associated with using traditional inspection equipment, Caltrans bridge maintenance engineers, materials testing engineers and technicians felt it was reasonable to explore alternative means to gain access to bridges that would be safe, economical and effective.

THE BEGINNING OF THE CALTRANS CLIMB PROGRAM

Caltrans bridge engineers have historically used heavy industrial rope and rigging techniques to gain access for bridge inspections for some time. This rigging was done either by our Bay Toll bridge paint crew or private contractors and was typical of the standards of the construction industry. While effective, this type of heavy rigging was cumbersome and expensive to employ, and required a large support crew aside from the bridge inspectors. About ten years ago, a large Midwestern consulting engineering firm proposed and successfully employed lightweight rock climbing equipment and mountaineering techniques to gain access for bridge inspections. Engineers and technicians from Caltrans' Materials Engineering and Testing Service Fracture Critical Inspection Team took notice of this unusual method and suggested that these techniques may be used by personnel associated with bridge maintenance. Shortly after the Northridge earthquake in 1994, a small research grant was approved to evaluate a new method to visually inspect earthquake damaged bridges, with climbing techniques selected as the most appropriate. Aside from earthquake damaged bridges, the advantages of low cost, lightweight, compact equipment coupled with a minimum of support personnel suggested extreme versatility of these techniques for various inspection applications. Caltrans contracted with an outdoor recreation firm associated with the University of California at Davis to develop a climbing course that would be specific to bridge inspection. As part of that contract, a Code of Safe Practices for bridge climbing was drafted. Three engineers and four non-destructive testing technicians participated in the first course in 1994, and quickly realized that these methods worked very well for safely moving around bridge structures with a minimum of equipment and support. As a final evaluation of these techniques, the climb-trained inspectors performed a thorough investigation of the Cold Spring Canyon Bridge, a very large steel arch bridge that was previously only fully investigated once using extensive rigging and lift equipment. The success of this initial effort and approval of the draft Code of Safe Practices from the safety office confirmed the effectiveness of climb trained bridge inspectors.

TRAINING

Comprehensive climb training is essential for the safety of personnel as well as for the appropriate selection of techniques and equipment for a particular task.

Caltrans' bridge climb training consists of a comprehensive 24-hour basic course given by a qualified instructor. The curriculum covers knots, equipment, elementary climbing, rope and mountaineering techniques, and safety. The training sessions are

broken down into 8-hours of classroom and gym time, 8-hours of practical applications on rocks and slopes, and 8-hours of practice applying these techniques on a bridge. The climbing techniques that are learned and practiced are rappelling, ascending a fixed rope, leading or traversing, belaying and rescue. This initial course is then supplemented with an 8-hour rope rescue course in which the more advanced principles of high angle rope rescues are learned and practiced. Basic CPR and first aid training are given to all climb-trained inspectors. In order to maintain adequate skills, climbers are required to complete an 8-hour refresher course once a year emphasizing safety and rescue techniques. Costs to train a climber were about $250. At present, a core group of climbers have put together a climb training course that better reflects field conditions and refined bridge climbing techniques. This allows Structure Maintenance to train in-house.

SAFETY

One of the major factors in the implementation of the program was to ensure worker safety while using these techniques. Caltrans' internal safety requirements did not preclude the use of any procedure and equipment as long as all known safety issues are defined and addressed through a written Code of Safe Practices. Given that basic guideline, an attempt was made to locate an existing code to modify and adapt for this use. A literature search revealed that there is no set OSHA or industrial standards or codes that address safety requirements for mountaineering and/or climbing equipment and techniques for this application. A deeper search revealed that certifications and standards even within the mountaineering community were not consistent or cohesive, and various industrial safety specifications do not directly apply. Even the term "certification" was nebulous, as there are no certifying agencies or standards that exist for this use. Based on the best information available coupled with good judgement, a comprehensive Code of Safe Practices was drafted to define training standards, personnel qualifications, procedural methods to follow, minimum crew requirements and equipment specifications. The technical resources for this document were compiled from a variety of safety organizations and agencies, including Federal and California OSHA, the Union International Alpine Association (UIAA, a European climbing equipment certification organization), the Caltrans safety office, ANSI, and the utility and rigging industries. From this effort it was realized that Caltrans would become a self-certifying agency with respect to bridge climbing; that is, Caltrans would create, maintain and implement its own safety standards from which to train and certify climbers and not require any outside approvals or review. Because of this, the most experienced inspector-climbers now do all training and certifications in-house.

EQUIPMENT

The typical equipment used by all climbers has the overwhelming advantages of being light, portable, versatile and tough. The basic inventory of equipment for each climber consists of:

- two kernmantle ropes, one static (no stretch or "give") and one dynamic (stretches about 10%)

- a full body lightweight climbing harness
- both a self-locking and traditional rappelling/belaying device
- a pair of mechanical ascender; pulleys
- a large assortment of locking steel carabiners
- an approved climbing helmet
- 4mm and 7mm prusik cordage
- A large assortment of nylon webbing and anchor straps. This webbing is used extensively for anchors, positioning and fall protection, and is the feature that strongly contributes to the effectiveness of the techniques as it is strong, light and provides good versatility for attaching to various bridge elements.

This equipment is assigned to a climber to use and maintain, and is easily carried in a standard backpack. While each individual is responsible for gear maintenance, master logs are kept of critical items to track usage and wear. Costs to fully equip a climber are between $750–$1000.

USES OF CLIMBING TECHNIQUES FOR STRUCTURAL INSPECTIONS

After the initial evaluation of climbing proved successful, authorization was given to train and equip 20 bridge maintenance engineers in these techniques. A formal program was created within the Office of Structure Maintenance and Investigations to organize, schedule, equip and certify engineers and technicians for bridge climbing. While not all engineers actively participate in every climb, the training has proved valuable for all staff by enhancing personal safety when working at heights and around slopes. The routine uses of bridge climbing include:

- the general and special inspection of otherwise inaccessible portions of very large bridges
- the inspection of those bridges with restricted or limited access
- the inspection of load posted or deteriorated bridges
- inspection of bearings or abutments on steep slopes
- tactile investigations on fracture critical or fatigue prone bridge details
- investigations of damaged bridges

Caltrans currently maintains an inventory of over 100 bridges for which climbing is the exclusive means of gaining access for inspections, and over 200 for which climbing may be used as an alternative or supplemental means of gaining access. Shortly after the routine bridge investigations began, other offices within Caltrans became interested in the techniques and adopted climbing as a means to perform preliminary engineering surveys, structural steel paint evaluations and post-earthquake research data gathering.

An interesting demonstration of the effectiveness and versatility of the techniques came to light in 1995, when one of the floodgates of a large dam in Folsom, California, unexpectedly failed during a routine opening. The US Bureau of Reclamation and the Army Corps of Engineers (the dam owners) mobilized quickly to inspect the remaining gates for distress. However, the location of the main structural components (perched on

the dam spillway about 250 feet above the base of the dam) hampered the abilities of engineers to access critical areas. For rapid deployment, it was realized that climbing techniques were the best means available, and COE called in a few climb trained engineers from across the US. Concurrently, Caltrans volunteered the services of climb trained bridge maintenance engineers to perform these inspections. For two weeks Caltrans engineers assisted the COE in the evaluation of the remaining dam gates. Extensive investigations, evaluations and materials testing were completed with a minimum of expense and effort. Since that incident, the California Department of Water Resources (who maintain and operate several dams throughout the state) has trained its field maintenance staff in climbing techniques for dam inspections, with Caltrans providing the training.

SUMMARY AND CONCLUSIONS

The use of climbing techniques for bridge inspection has proven to be a valuable tool for the investigating engineer or technician. The techniques have been proven to be economical and effective for a variety of routine and specialized bridge inspections. The equipment used is lightweight and versatile, and support staff are minimal. With appropriate training and procedures, the techniques are safe. The method has shown a definite economic advantage over conventional rigging, and can be a cost-effective alternative to specialized lift equipment in high traffic areas. In some cases, climbing is the only effective means to gain access to certain bridge elements. Due to the successful implementation of climbing within Caltrans, other Offices and Departments have adopted climbing to a variety of structural inspection and maintenance tasks.

ACKNOWLEDGMENTS

The author would like to acknowledge Mr. Phillip Stolarski and Mr. Paul Hartbower, Caltrans Office of Structural Materials, Materials Engineering and Testing Services; Mr. Jan Holan, Climbing Industry Consultants; Mr. Peter Caster, UC Davis; Mr. Erol Kaslan, Caltrans Office of Structure Maintenance and Investigations.