U. S. Department of Labor
Occupational Safety and Health Administration
Directorate of Science, Technology & Medicine
Office of Science and Technology Assessment

Hazards Associated with Strand Restraint Devices in Manufacturing Prestressed Concrete Beams

Safety and Health Information Bulletin

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Purpose

The purpose of this Safety and Health Information Bulletin is to

1. Alert manufacturers of prestressed concrete beams to hazards associated with strand restraint devices;

2. Emphasize that manufacturers should follow safety related recommendations detailed in the *Precast/Prestressed Concrete Institute's Manual for Quality Control for Plants and Production of Structural Precast Concrete Products*; and

3. Provide additional safety recommendations for employers who use strand restraint devices in the manufacturing of prestressed concrete beams.

This Safety and Health Information Bulletin is **not** a standard or regulation, and it creates no new legal obligations. The Bulletin is advisory in nature, informational in content, and is intended to assist employers in providing a safe and healthful workplace. The Occupational Safety and Health Act requires employers to comply with hazard-specific safety and health standards. In addition, pursuant to Section 5(a)(1), the General Duty Clause of the Act, employers must provide their employees with a workplace free from recognized hazards likely to cause death or serious physical harm. Employers can be cited for violating the General Duty Clause if there is a recognized hazard and they do not take reasonable steps to prevent or abate the hazard. However, failure to implement any recommendations in this Safety and Health Information Bulletin is not, in itself, a violation of the General Duty Clause. Citations can only be based on standards, regulations, and the General Duty Clause.

Background

The Bismarck, North Dakota Area Office investigated a fatal accident that involved the failure of a drape strand restraint device during the manufacture of prestressed concrete bridge beams. The process required the tensioning of six extremely high strength 0.60-inch-diameter wire ropes to a tensile load of approximately 47,000 (166,000 psi) pounds each. For load bearing purposes, the wire ropes are then embedded in concrete to create a slight arch along the longitudinal axis of the beam. The tensioning deck is comprised of two sections to simultaneously form two identical beams.

Incident Description

An employer was engaged in manufacturing prestressed concrete beams. To obtain the proper tension and arch, the wire ropes were strung through steel strand restraint devices near the base of the concrete beam. These wire ropes are identified as the "drape strands," which, when tensioned, impose a total upward force of approximately 13,400 pounds on each of the two outside restraint devices for each section. Within each section, the two outside restraint devices were supporting four wire ropes, while the two inside restraint devices were supporting only two wire ropes. The bottoms of the devices were positioned approximately 1.5 inches above the bed of the pouring deck using wood shims under each device. After the proper tension was placed on the cables, the shims were removed to allow the entire device and wire ropes to be embedded in concrete.

The removal of the wood shims was accomplished by using a sharpened piece of rebar, which was approximately 19 inches long by 3/8-inches in diameter. An employee struck the rebar with a hammer, splitting each shim, and then drove the broken shims out from beneath the device with the rebar. Employees were instructed not to lean over the pouring bed while removing the shims.

An employee was in the process of removing the shims when the two outside strand restraint devices (holding four cables) in one section failed. This, in turn, caused the two inside restraint devices (holding two cables) in the same section also to fail, but in a different manner. The two outside restraint devices failed at their base due to tensile and bending stresses. On the two inside devices the bolts holding the cables failed, possibly due to bending stresses. When the drape strand cables released, a cable struck an employee in the head, resulting in a fatality. Because of cold weather conditions at the time of the accident, cold brittle metal fracture also contributed to the restraint device (clevis) failure.

The non-pivoting design of the restraint devices also imposed bending (flexural) stresses in the base of the devices, which further contributed to the failure of the devices.

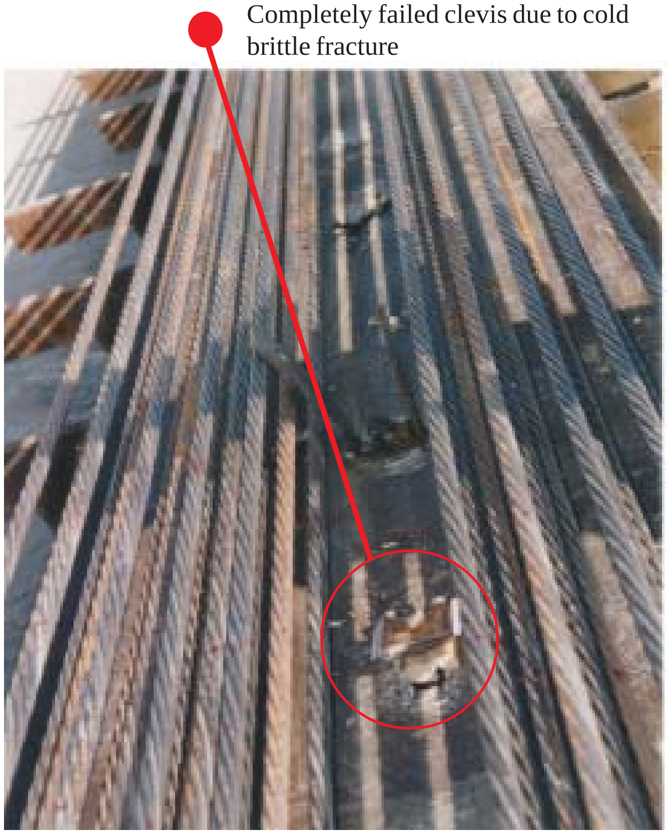

Figure #1
Failed clevises (restraint devices)

Recommendations

The following procedures are recommended to eliminate the potential hazard of restraint device failure and the unintended release of the drape strands or other wire cables under tension on the pouring bed:

1. Ensure that strand restraint devices are engineered and designed to withstand the forces and moments imposed by the drape strands and to prevent cold brittle fracture during cold weather. Several manufacturers make strand restraint devices that have been so engineered and designed. Pivoting or swiveling-type restraint devices can be used to prevent the bending (flexural) stresses in the base of the restraint device.

2. Redesign the prestressed concrete pouring process so there is no need to install a wood shim under the restraint devices holding the drape strands. The elimination of the wood shim would prevent impact loading on the devices as a result of removing shims and reduce or eliminate employee exposure to the danger zone. Properly engineered strand restraint devices should eliminate the need to use wood shims.

3. Implement and follow all the safety-related practices presented in the *Precast/Prestressed Concrete Institute's Manual for Quality Control for Plants and Production of Structural Precast Concrete Products*. For example, the manual specifies that protection shall be provided for personnel engaged in the tensioning operation by means of effective shields adequate to stop a flying strand resulting from strand breakage. All personnel not required to perform the tensioning shall leave the area adjacent to the bed.

Figures 2 and 3 show changes made to the process.

Figure 2: Shows the entire length of the pouring bed with the restraining devices in place over the clevis locations prior to tensioning

Figure 3. Close-up View of Restraint Device.

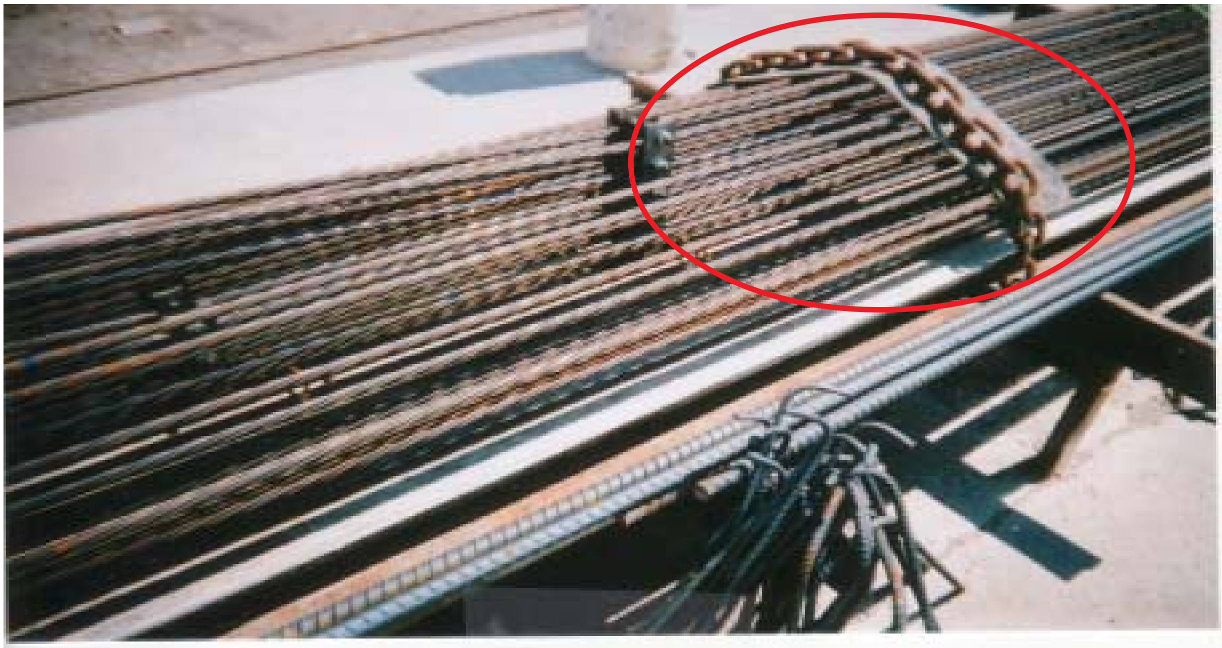

Figure 3: Shows a restraint device installed to prevent cables from releasing in the event of clevis failure during tensioning.