Stretch Cables Before Concrete Is Cast

by Donald Chalaire, P.E.

There are a variety of different designs for concrete building components that require special consideration during restoration projects. Concrete slabs supported on the ground usually only have steel wire inside to help control cracking. Elevated slabs that are supported on beam and column frame systems require extensive internal systems of steel bars. Concrete alone has high compressive strengths, but low tensile strengths. You can push on concrete, but you can't pull on it. Steel reinforcing is needed to help carry portions of the load that are not directly over the beams or columns.

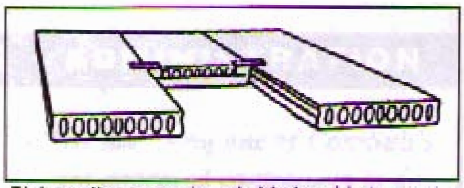
The most common steel support system is rebar, which is short for reinforcing steel bar. Rebar has deformed ridges all along the sides that are used for anchoring into the concrete. These ridges are used in the same way that the threads on a wood screw are used to anchor into wood. Normally, the rebars are installed in the proper relative locations in the forms and the concrete is then cast in place. When concrete component sections are cast elsewhere and set into final position, they are described as precast.

Other steel reinforcing systems that are frequently used include steel cables that are highly stretched inside the concrete to produce pre-compressive internal loads in the concrete. The steel cables are maintained stretched on a permanent basis much the same way guitar strings are always maintained tight. This high tension in the cables in reacted by a relatively high compression in the concrete that allows the concrete to support loads.

The high tension in the cables produces stress in direct proportion to the amount of tension. If the cables are stretched (stressed) before the concrete is cast around them, the design is called prestressed concrete. The steel cables are stretched in a frame system at each end of the forms. The concrete is then cast directly against the stretched cables.

After sufficient time, the forms and tensioning frame are removed, and the steel cables are held tight on an inch by inch basis by being bonded to the concrete. Because of the extensive framework required for pretensioning, prestressed concrete components are usually precast elsewhere and then set into final position on site.

If the cables are stretched (stressed) after the concrete is cast around them, the design is called post-tensioned concrete. The steel cables are placed or wrapped in plastic sheathes and placed into the forms. A small steel anchor is placed at each end of the sheathed cable. The cable passes through the anchors at each end. The concrete is then cast around the sheathed cables up to and including the anchor ends. After sufficient time, the forms are removed, and the steel cables are stretched tight against the anchors.



Slab sections are placed side-by-side to create a continuous floor.

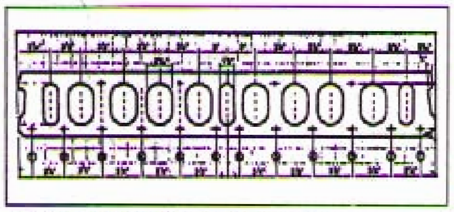
The anchors react to the high tension load into the concrete. The steel cables slide through the sheathes during the tensioning process. The steel cables are not bonded to the concrete.

The advantage of pre- or post-tensioned steel reinforcing is that the total amount of steel required is significantly less than with conventional non-tensioned rebar.

The loads that a slab must support include both its own weight (dead load) and the intended applied load (live load). The weight of the slab is a significant portion of the total design load; but it is dependent on the required load capacity for the intended applied load. When the slab weight can be reduced, while maintaining the load capacity for the intended applied load, there is a significant reduction in the total amount of steel reinforcing required. This can be accomplished by casting in pre-determined hollow places inside the slab. These hollow cores must be internal only, away from the exposed surfaces. A common way this is done is to cast in straight hollow cores that run in only one direction. This allows for steel reinforcement to be positioned parallel to the cores, above and below the cores near the outer surfaces. This system provides the required strength for long spans of narrow slab sections using prestressed steel cables. These slab sections are typically 4 - 6 ft wide and cut to length as required.

The use of prestressed hollow core slab sections is intended to reduce construction time and cost. The supporting columns, beams, and walls are built in place and the precast slab sections are set in place using cranes. The slab sections are set in place side by side across the entire floor. The edges are locked in place and construction proceeds almost immediately on the next floors supporting columns, beams and walls. A 2-inch concrete topping is applied over the top surface to hide the seams between sections.

At the section ends, conventional rebar and concrete are used to create cast in place edges bonded to the precast sections. Restoration of corrosion deteriorated concrete structures is primarily the repair of the reinforcing steel within the structures components. The concrete is not being attacked by corrosion; it is the steel that is being attacked. The concrete is only breaking away from the corroding steel that expands as it converts to rust. The concern is that the corrosion at the steel surface breaks the bond between the concrete and the steel. This bond is the anchor for the steel tension loads. In conventional rebar, this anchorage is obtained by the ridges embedded into the concrete. Loss of the bond due to corrosion consumption of the ridges causes a localized loss of load capacity. In prestressed steel cables, this anchorage is obtained by the bond of the concrete around and between the cable strands.



Typical cross section for hollow core slab section.

In conventional rebar components, lost anchorage can be restored by using bonding agents and installing lap splices. In prestressed designs, loss anchorage of the steel cables can not safely be restored. To do so would require temporary installations of frame systems to restretch cables and may cause unbonding in other locations along the cable. Restoring load capacity of prestressed slab sections usually requires installing additional conventional rebar in excavated or hollow areas.

Unfortunately, repair of concrete spalling requires more than patching in new concrete. Loss of steel reinforcing bond can occur due to corrosion, and the result is a localized loss of load capacity. Loss of load capacity, even if limited to local areas, frequently causes secondary cracking which in turn passes moisture into the slab feeding and advancing corrosion activity. Restoration should include a thorough analysis of cracking to determine the causes and solutions. Stay tuned . . . MR

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