

ROOF DECKS

A to Z

Part X: Precast Hollow-Core Concrete Planks

By L.D. Hogan, RRC, FRCI, PE

This is the tenth in a series of articles examining various deck types. Of the numerous considerations when selecting a roof system, the type of decking is among the most important. With the variety of decks to be encountered (both new and old), it is incumbent upon roofing experts to be the authority on these matters. This article will explore features of precast hollow-core concrete planks.

Hollow core planks are precast, pre-stressed concrete members with continuous voids provided to reduce weight and cost (Figure 1). These slab systems are patented regarding the manufacturing technique and are licensed to the various producers in many locations worldwide. There have been several iterations of hollow-core systems over the decades, with patents found dating back to the 1930s. In older structures, the planks may be found situated into inverted concrete T-joists, wide-flange steel beams, or even bulb-tee rails (such as found on poured gypsum decks).¹

Flexicore® slabs were developed in the early 1940s, in the infancy of pre-stressed concrete.² The system came into vogue following WWII, when there was a need to rebuild Europe's heavily damaged infrastructure. In 1948, the standard cross section was 6 by 12 inches with two 4.625-inch holes running the length of the slab (Figure 2). At that time, spans were limited to ~22 feet, but some manufacturers later modified the reinforcement, void size, and other parameters that affected the product strength and stiffness characteristics. There is currently wide variation in the dimensions and shapes of both the slabs and the core openings.

Figure 2 – Flexicore® slabs were developed in the early 1940s, in the infancy of pre-stressed concrete. In 1948, the standard cross section was 6 inches by 12 inches with two 4.625-inch holes running the full length of the slab.

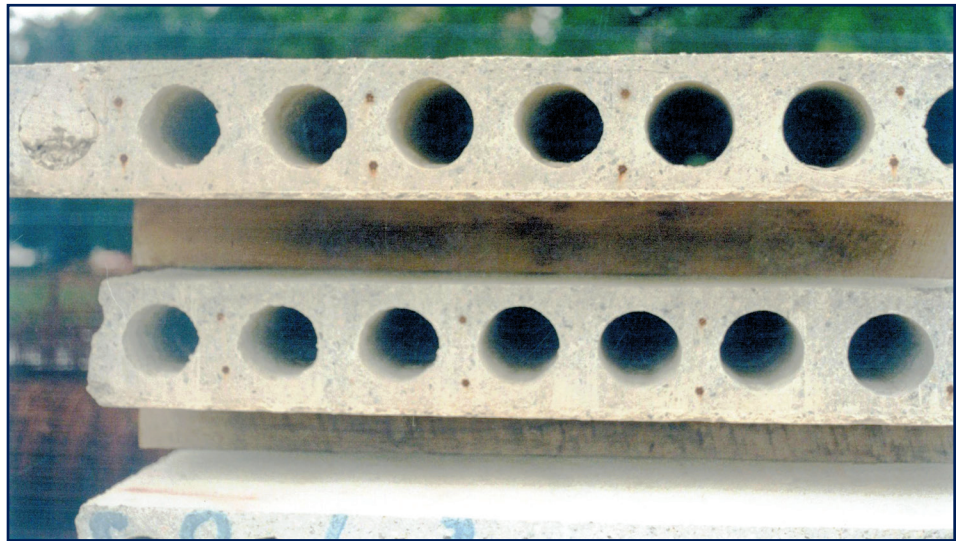


Figure 1 – Hollow core slabs are precast, pre-stressed concrete members with continuous voids provided to reduce weight and cost. The systems are patented based on the manufacturing technique and are licensed to the various producers in many different locations.

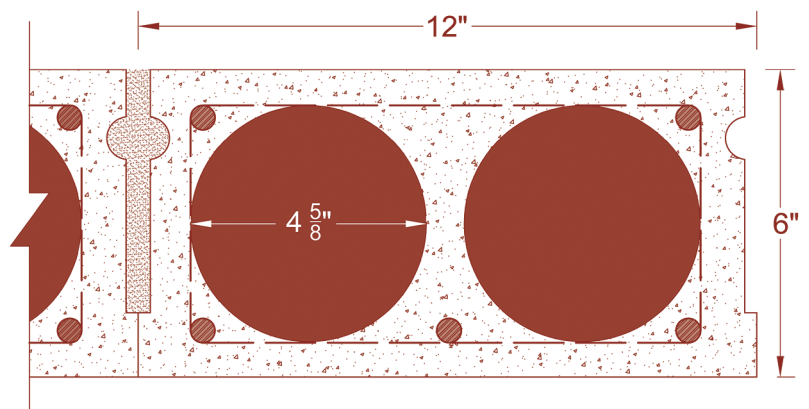


Figure 4 – The forms, also known as the “casting beds,” are prepared, after which the steel tendons are situated and stretched (stressed) prior to placement of the concrete. This image depicts a large indoor production facility (courtesy of Kerkstra Precast, Grandville, MI).



Figure 3 – Hollow-core planks are a form of “pre-stressed” concrete. That is, they have embedded tendons consisting of either steel rods or cables of multiple strands.



As stated earlier, hollow-core planks are a form of “pre-stressed” concrete. That is, they have embedded tendons, being either steel rods or cables of multiple strands (Figure 3). This arrangement is shared with certain other deck types, such as precast concrete tees, a matter covered in Part V of this series. Void openings may be used for telephone/data, electrical service wiring, and even forced-air supply return. Aside from roofs, hollow-core may also be encountered as a floor deck system and even portions of a parking deck.

The product is manufactured on a casting bed. Once the casting beds are cleaned and prepared, a wire-pulling machine is deployed, after which the tendons are stressed (tensioned) in preparation for con-

crete placement.³ Figure 4 depicts a large indoor production facility. Alternatively, casting beds may be outdoors and can be well in excess of 600 feet long. The hollow cores have been introduced by various methods, including inflatable tubes (older technology) and by more modern solid aluminum rods known as torpedoes. These are housed within the modern extruding machines and create the void openings while zero-slump concrete is placed throughout the length.⁴ Following this extrusion, finishing of the surface, and development of adequate strength, cable tension is released, and cutting is then carried out into whatever lengths the end product may have.

Release of the pent-up cable tension causes slight upward curvature of the planks, known as camber. This is also termed “force transfer,” and fairly good pre-

dition can be made regarding the amount of camber that will result. Yet adjacent planks of different lengths, strand patterns, or opening size will likely inherit some slight differences in camber, a matter to be reckoned with on the roof.

Connection between and among the deck units is by a grout key (Figure 5). Once all the slab keys are grouted, the resulting system allows concentrated loads to be shared by several adjacent slabs. This is analogous to a tongue-and-groove arrangement for wood planks, sidelap-stitching screws for metal decks, and connection brackets for concrete double-tees. It is not a deck “system” until the grout keys have been provided.

A concrete topping course may be placed over hollow-core planks (Figure 6), making it a composite system and considerably improving its seismic rating. This underscores the need for diligent under-deck examination to properly identify the type of deck being studied. With parking decks, topping course bond strength to the planks is of paramount concern because of weather exposure and the repeated axle loads. However, roof decks are not subjected to such conditions, and keying-in (such as with dowels) is not practical anyway because the hollow cores would create problems for anchor embedment. Instead, the roughened surface is deemed adequate to bond topping concrete to the planks. Epoxy bonding agents may be deployed when there is insistence upon a certain bond strength rating.

Hollow-core decks are usually left exposed on the underside. It is possible to have various inside finishes such as suspended ceilings, but these require some type of attachment for the grid, and fastening difficulties can arise (Figure 7).

For roof coverings, this is considered a

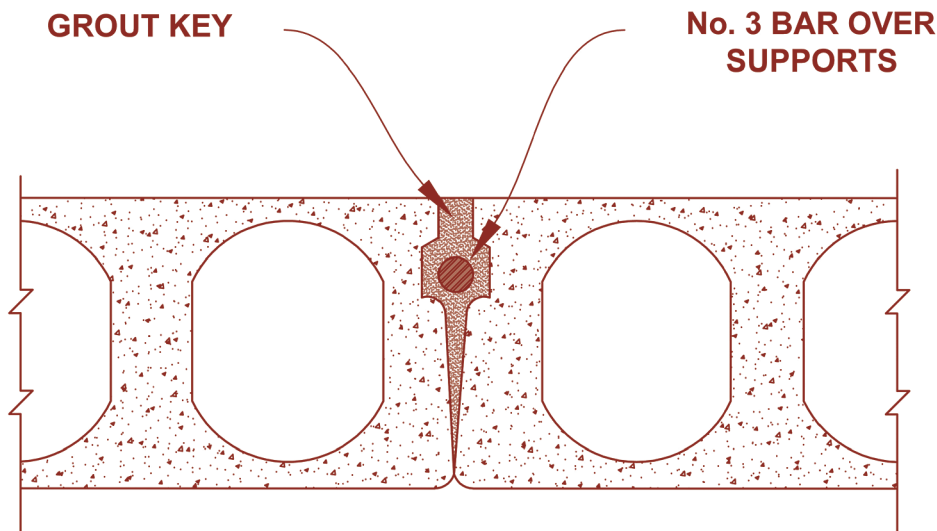


Figure 5 – Connection between and among the deck units is accomplished by a grout key. This product is not a “system” until the grout keys have been provided.

“non-nailable” deck, meaning assemblies of the adhered variety should be considered. Traditionally, mopping asphalt was the common adhesive for insulation on hollow-core projects. Direct-to-deck adhesion in this manner is still plausible if application parameters are observed, but hot bitumen attachment has given way to more modern polymeric adhesives.

Field cutting of hollow-core planks is sometimes necessary in the course of a project. Interruptions of this type should not be taken casually, and penetrations of substantial size must be fully braced or otherwise supported from below. When prac-

tical, drilled core holes are preferred over square cuts to avoid propagation of cracks at the saw-cut corners. Just as with other decks, consideration needs to be given to plank ends and fractional rows; this is especially crucial at unions with higher building walls or anywhere that a drifting snow surcharge may develop. Attachment of planks to the support members is by rebar dowels, plates with deformed bar anchors grouted into the keyways, or other arrangements of fixity. A great resource for the various connections is the *PCI Manual for the Design of Hollow-Core Slabs*.⁵

In reroofing scenarios, there is sometimes a temptation to remove down to the old vapor barrier (if present). In that event, however, the entire new assembly (if adhered) is dependent upon the bond between the concrete deck and the vapor

barrier. That surface will be the limiting element in overall uplift resistance; test it, carefully evaluate it, or tear it off if there is any question about this interface bond.

On older structures, hollow-core decks may have experienced creep during service life, resulting in negative camber and ponding water near mid-span of the planks (Figure 8). Creep is also the reason that old ceilings (if present) may begin to sag. The broad definition of creep is a time-dependent strain of solids caused by stress. Simplified here, it is the permanent deforma-





Figure 6 – A concrete topping course may be placed over hollow-core planks, making it a composite system. This underscores the need for diligent under-deck examination to properly characterize the type of deck. (Image courtesy of REI Engineers.)

tion of components from long-term service loads for whatever reason. It can occur in several other deck types, and on rare occasions, it may be exacerbated by the failure of the internal reinforcing (broken rods or cable strands). Moreover, products incorporating lightweight aggregates, such as blast-furnace slag (or expanded clay, shale, or slate having been fired in a rotary kiln), have greater likelihood to develop creep. In any event, dead-flat decking of

any kind that exhibits creep can be a perilous arrangement, especially during periods of rain on snow or any condition that significantly increases live load of the roof deck.

SUMMARY REMARKS

Hollow-core decks are a relatively small part of new construction in this country, so encountering it in a reroofing scenario is more probable. Since these roof decks may be decades old (and possibly dead flat), it is prudent to investigate for creep that may be present. Unless

internal reinforcement has ruptured, many decks exhibiting only moderate creep could be corrected by a properly configured tapered insulation system. 

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Figure 7 – Hollow-core decks are usually left exposed on the underside, although various inside finishes may be encountered, such as spray-on textures. Suspended ceilings will require some type of attachment for the grid. These deck units are best left without drill holes, as fastening difficulties can arise.



Figure 8 – This hollow-core deck has experienced creep during service life and now exhibits negative camber between the interior bearing walls. It can certainly occur in other deck types, but deformation of this nature can be perilous, especially during periods of rain on snow.

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Hogan has designed and administered roofing projects in half of the U.S. using a variety of systems. He has received RCI's Lifetime Achievement Award, and its Michael DeFrancesco, William C. Correll, and Richard M. Horowitz Awards.

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