# Antiquated Structural Systems Series

## Part 4

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This article is the fourth in a series that is intended to provide a resource of information to structural engineers that they can refer to for projects that involve the repair, restoration or adaptive reuse of older buildings for which no drawings exist.

The purpose of this series is to compile and disseminate a resource of information to enable structural engineers to share their knowledge of existing structural systems that may no longer be in use but are capable of being adapted or reanalyzed for safe reuse in the marketplace of today and the future.

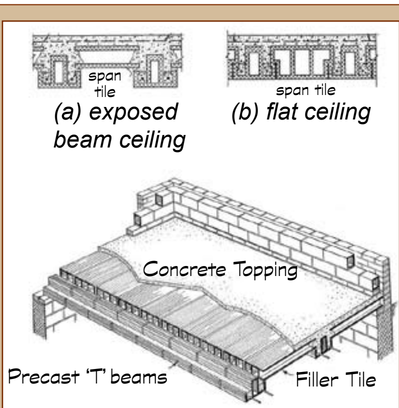


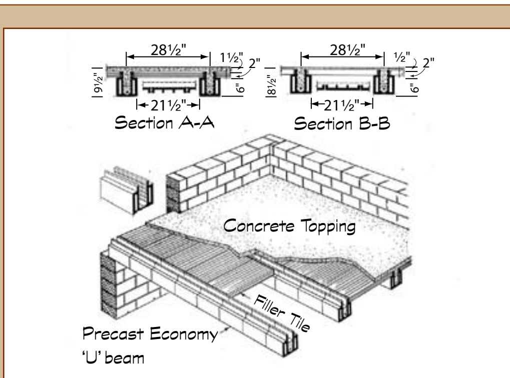

Figure 1.

## Prefabricated Clay Tile & Concrete Block Framing Systems

As discussed in the last article in this series, one and two-way joist framing systems were constructed using clay tile and masonry units, which were first arranged and supported on formwork to enable placement of internal reinforcement and infill and topping concrete in situ. In addition, as will be discussed in this article, similar modular clay tile and masonry units were also constructed offsite into prefabricated beams and slabs that could be delivered to the job site. This method of construction ultimately progressed to solid precast concrete units, which will be addressed in a subsequent article.

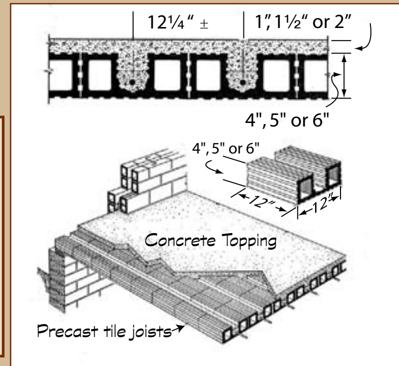
The prefabricated clay tile systems included both one-way beam and slab construction and one-way slab construction. The one-way beam system involved the placement of prefabricated beams spaced parallel to each other at regular intervals between already constructed load-bearing walls or steel beams. The areas between the beams were then infilled with tiles that were capable of spanning between each adjacent beam. The one-way slab system involved prefabricated slab units that were placed directly adjacent to each other, spanning between previously constructed load-bearing walls, steel beams or joists. Both the beam and slab systems included a site-cast concrete topping, which was poured over the beams and filler tiles or one-way slabs. The prefabricated beam and slab systems offered the advantage of not having to construct supporting formwork before the framing could be erected; however, shoring in the center of the span was sometimes employed to increase the clear span capability of the members through composite action with the site-cast topping.

Examples of the clay tile systems (*Figures 1-6*) included the "T" Beam Floor, the "U" Beam System, the Joistile System, the Sheffield Floor System, the Adel Joistile System, the Kalex Floor System, the United Floor System and the Tilecrete Floor System. Some of these systems required filling the joints between the adjacent ends of the clay tile units with mortar, while other systems allowed the ends of adjacent tiles to butt up against each other. All of the prefabricated beam and slab systems, except for the infill tiles, included internal longitudinal flexural reinforcement for positive moment resistance. Negative moment reinforcement for continuity across a supporting wall, beam or joist



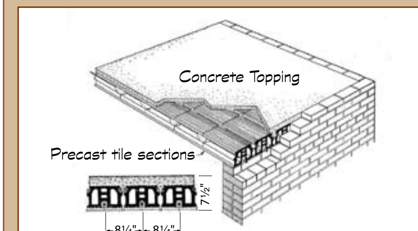

*Perspective view of "Precast 'U'-Beam Floor" and sectional details showing optional erection methods with span tile webs up or down as desired.*

Figure 2.



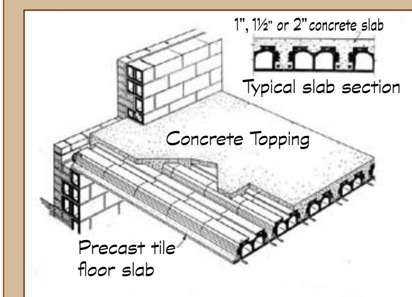

*Perspective view of standard "Precast Joistile" floor system and typical sectional detail.*

Figure 3.



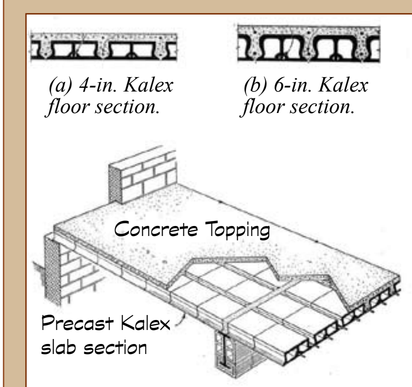

*Perspective view of "Sheffield" precast tile floor system and sectional detail.*

Figure 4.




*Perspective view of "Adel" precast joistile floor system and typical slab section.*

Figure 5.




*Perspective view of precast "Kalex" tile floor system and typical floor sections.*

Figure 6.

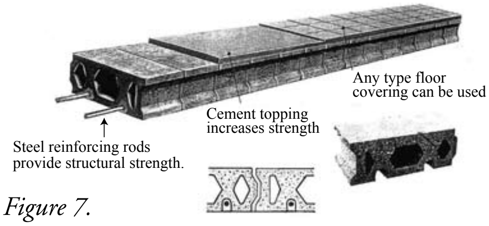



*Figure 7.*

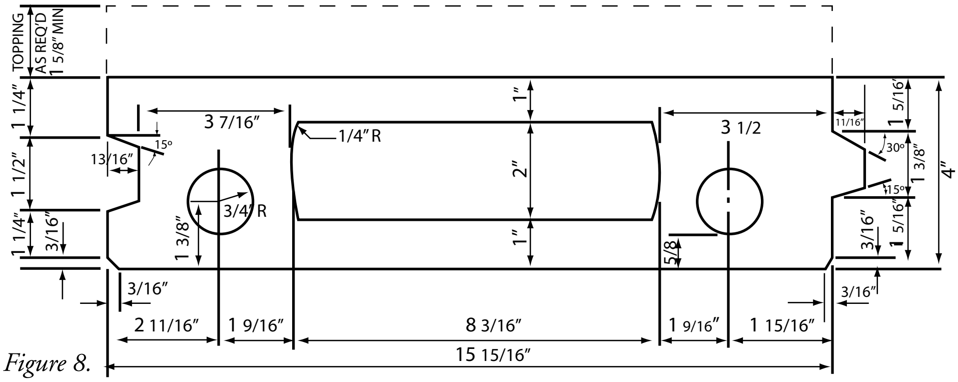



*Figure 8.*

was also sometimes placed in the site-cast topping. None of the units included shear reinforcement. *Table 1* summarizes all of the clay tile systems mentioned above.

Similar prefabricated beam and slab systems were also developed from modular concrete block. Most of these systems used conventional internal reinforcement for flexural strength; however, a few were developed using prestressed bars and strands. Probably the most widely used masonry block product in the eastern U.S. during the 1950s was the Dox Plank system developed by NABCO in Washington, DC (*Figure 7*). This product was manufactured with recessed slots in the bottom of the block to allow for the flexural reinforcement to be grouted into the bottom of the plank. There was no mortar required between the adjacent ends of each block.

Other cross-sectional variations of the Dox Plank were developed by members of the Dox Plank Manufacturers Association. *Figure 8* shows an example of an alternate block that differed from that originally developed by NABCO. In this case, the internal reinforcement was completely encapsulated by the block by means of a continuous sleeve. It is not clear whether the continuous reinforcement in the sleeves was grouted in place, or if the bars were threaded at each end of the plank so that the modules could be precompressed together via tensioning of the bar as it was tightened against each end of the member using a nut.

*Table 1.*

**Prefabricated Clay Tile One-Way Beam and Slab Systems**

| System | Figure | Regional Use | Mortared Joints | Beam Spacing or Slab Width | Beam Depth (including topping) x Width or Slab Depth | Typical Span | Notes |
|---|---|---|---|---|---|---|---|
| "T" Beam | 1 | Southwest, Midwest | Yes | 18" to 30" | 9½" x 8" | 24-ft. | 1, 3 |
| | | | | 18½" to 22½" | 7½" to 8" x 8" | | 2, 3 |
| "U" Beam | 2 | Texas, Oklahoma | No | 28½" | 8½" to 12" x 7" to 8" | 14-ft. | 4, 5 |
| Joistile | 3 | East, Southwest | Yes | 12" | 4" and 5" | 8-ft. | 4 |
| | | | | | 6" | 12-ft. | |
| Sheffield | 4 | Midwest, North Central | Yes | 8" | 5" | 18-ft. to 22-ft. | 6 |
| Adel Joistile | 5 | Midwest | Unknown | 12" | 5" | Unknown | 4 |
| Kalex | 6 | Ohio, Pennsylvania, New York, Illinois, Wisconsin | No | 12" | 4" and 6" | Unknown | 7, 8, 9, 10 |
| United | None | New York, New Jersey | No | Unknown | Unknown | 30" | 11, 12 |
| Tilecrete | None | Missouri | No | 16" | 4" and 6" | 12" | 13, 14 |

**NOTES:**

1. Included the use of unreinforced, 4" thick Filler Span Tile for one-way span between beams.
2. Drop-in Filler Tile was used for flush ceiling applications.
3. System load tested at Iowa State College; Engineering Experiment Bulletin No. 286.
4. Longer spans were possible with the use of center span shoring.
5. Included the use of unreinforced, 2" thick ribbed Filler Tile for one-way space between beams.
6. Patented June 1936 by Professor Walter M. Dunagan, Iowa State College.
7. Patented 1937 by D.D. Whitacre, Waynesburg, Ohio.
8. System also used as vertical wall element.
9. Reinforcement included bolted rods, which implies an applied pretensioning force.
10. Load tests of 4" slabs conducted by Professor George E. Large, Ohio State University, for the Rochester, NY Building Board in 1939.
11. Unreinforced slab system used in conjunction with open web steel joists.
12. System used in conjunction with a topping slab that provided composite action with steel joists.
13. Patented system used in conjunction with open web steel trusses; however, tiles were supported on bottom chord, which allowed a concrete topping to be placed that encapsulated the trusses, resulting in concrete ribs capable of spanning up to 24 feet.
14. Tested in 1939 at the National Bureau of Standards; BMS Report No. 16.

Flexicore, a product similar to the NABCO Dox Plank, was also available in the 1950s. A hollow core plank is still manufactured today under this same name; however, the current product is a true precast, prestressed concrete member.

In the 1950s, the consulting firm of Bryan and Dozier and the Nashville Breeko Block Company designed and constructed prefabricated, post-tensioned concrete block beams. This method of construction resulted in the first linear prestressed structure to be built in the US – the Fayetteville Tennessee High School Stadium – and the first prestressed bridge to be built in the US at Madison County, Tennessee. This method of construction was made practical and economical by the Roebling Company through the development of high-quality tendons that could be bonded without expensive end anchorages.

The Breeko Block system was further refined through the use of external, deflected tendons. However, by the late 1950s, this system was replaced by precast, pretensioned concrete members.

Other, more obscure examples of prefabricated modular concrete block beams and slabs include a prestressed bar system developed by P.H. Jackson of California in 1872; a prestressed wire system developed by C.W. Doering in 1888; a system patented by K.E.W. Jagdmann in 1919; a horizontally draped stressed reinforcement system patented by Albert Stewing and Stefan Polonyi in 1967; and a tensioned, Y-shaped block system patented by Hossein Azimi in 1987.

All of the above tile and concrete block systems were designed based on the basic reinforced masonry and concrete beam analysis theories of their era. Load tables were also commonly developed and published by most of the manufacturers. The problem with all of the above systems, when one encounters them in a building, is that in the absence of existing drawings it is difficult to determine the internal reinforcement and, subsequently, the load carrying capacity of the system. However, it is hoped that this article, by identifying the many different types of products that were in use at one time or another, will assist the readers in their research of an antiquated or archaic system when it is encountered in an existing structure.▪

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Future installments of the archaic structural systems series will cover precast concrete framing systems; antiquated post-tensioning systems; structural steel stub-girder; open web steel joist and cast iron construction. If there are other topics along these lines that you would like to see addressed, please send your suggestions and any relevant information that you have to the author.

## References

"Principals of Tile Engineering," *Handbook of Design*. Harry C. Plummer and Edwin F. Wanner, Structural Clay Products Institute, 1947. ACI Journal Proceeding, 1918

"Prestressed Concrete Innovations in Tennessee." PCI Journal January-February 1979. Ross H. Bryan

"Dox Plank for High Speed Floor and Roof Construction," *Design Tables.* NABCO Plank Company. Publication Date – Unknown; Made available by the NCMA – Accession No. TF02657.