# LEGACY REPORT

**96-14**

*Reissued October 1, 2003*

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**Legacy report on the BOCA® *National Building Code*/1999**

**DIVISION: 03—CONCRETE**
**Section: 03130—Permanent Forms**
**Section: 03410—Pant-Precast Structural Concrete**

**EVALUATION SUBJECT:**

**PRECAST CONCRETE FILIGREE WIDESLAB**

**REPORT HOLDER:**

**MID-STATE FILIGREE SYSTEMS, INC.**
**P.O. BOX 435**
**CRANBURY, NJ 08512**

**EVALUATION SCOPE**

**Compliance with the following code:**

BOCA® *National Building Code*/1999

# Section 1901.1 Plain and reinforced concrete

# Section 704.1.1 Fire-resistance ratings

# Section 106.4 Alternative materials and equipment

# Section 2603.3 Surface-burning characteristics

# Section 1703.3.2 Follow-Up inspection

## 1.0 DESCRIPTION OF EVALUATION

This report evaluates the use of Precast Concrete Filigree Wideslabs as a component of composite concrete structural slabs and includes fire-resistance rated floor assemblies employing Filigree Wideslabs through a review of physical data submitted.

## 2.0 DESCRIPTION AND USE OF PRODUCT

### 2.1 GENERAL DESCRIPTION

The Filigree Wideslab Method of Construction is based on the concept of using left-in-place precast concrete forms which become an integral part of the concrete frame. In service, structures utilizing Filigree Wideslabs perform the same as poured-in-place concrete structures. This concept of construction is identified by ACI 318-95 as *Composite Concrete Flexural Construction*.

Design features for Filigree Wideslabs include the use of high tension steel for the bottom reinforcing assembly of the finished deck, and the application of factory-installed polystyrene foam voids.

High tension steel in the form of 3/8-inch- (9.5 mm) diameter, seven wire strand is substituted for mild reinforcing steel in accordance with the ACI Code criteria for strain compatibility as given in Chapter 18, prestressed concrete formula 18-3. Steel shall be 270 Ksi or 250 Ksi complying with ASTM A416.

"Voids," hollow areas within the concrete slab, are constructed from 1 lb/ft$^3$ or less density polystyrene foam. These voids are factory installed and shall only be located in areas of the structural elements where concrete can be eliminated without substantial reduction of performance as determined by the registered design professional responsible for the design of the structural element.

Filigree Wideslabs are semi-finished precast concrete panels designed to be used as a left-in-place concrete form. They are made approximately $2^1/_4$-inches- (57.2 mm) thick by up to 8 feet (2.44 m) wide and up to 70 feet (21.3 m) long. These panels are reinforced with longitudinally placed shallow steel joists. The joists have their bottom chords cast into the panels and the remainder protrudes above the top face. Wideslabs are reinforced with mild steel or prestressed. Minimum concrete cover for principle reinforcing is $^3/_4$-inch (19 mm) for rebar and $^{15}/_{16}$-inch (23.8 mm) for strand. The minimum 28-day strength of concrete used in Filigree Wideslabs is 4,000 psi (27.6 MPa).

Steel bar joists, which are referred to as Filigree trusses, are primarily used as mechanical anchors to enhance design shear transfer through the contact faces of the two concrete placements. These joists consist of two resistantly-welded bottom chord wires, one top chord wire and a laced web wire.

The smallest wire used is 6 mm in diameter. The two bottom wires anchor the web within the Filigree Wideslab and contribute to the bottom reinforcing of the deck; the top chord anchors the web wire to the poured-in-place portion of the deck; the web wire penetrates contact face approximately every 5 inches (127 mm) on center. The joists vary in height from $2^1/_2$ inches (63.5 mm) to $7^1/_2$ inches (190.5 mm). Spacing of joists is governed by the structural or fire-resistance requirements of the finished decks.

### 2.2 USE AND APPLICATION

Filigree construction is used for one-way as well as two-way decks and flat plates. The decks are reinforced with mild steel or prestressed cables and designed as continuous or simply supported spans. Wideslabs customarily provide the positive moment assembly for the entire deck. The minimum depth of a solid deck is 4 inches (101.6 mm) and a voided deck is 5 inches (127 mm).

**2.2.1 ONE-WAY SLABS:**

Wideslabs which are used in this application have the principle tensile reinforcement in the longitudinal direction and temperature/shrinkage steel in the transverse direction. The steel reinforcing consists of singular bars running the full or partial length of the slab. Additionally, the slabs have trusses cast into them. The cast-in trusses are shallow steel joists embedded at the bottom in the precast slab and completely encased by the poured-in-place upper portion of the deck, as shown in Figure 1 of this report.

Initially the trusses reinforce the relatively thin precast slab and permit handling of larger units. Later, when encased by fully cured cast-in-place concrete, they serve as shear ties between the two layers of concrete. The bottom chords add to the tensile steel assembly and the top chords to the top steel.

**2.2.2 TWO WAY SLABS:**

In this application, Wideslabs carry tensile reinforcing in two principle directions. Longitudinal steel is arranged the same as in one-way slabs; transverse reinforcing, however, consists of series of short bars, equal to the width of panels (8 feet) and spliced later to form singular units.

To splice the units, the short bars cast into Wideslab are made with a large hook at each end, and cast into the panel. The hook is positioned vertically and protrudes above the top face of the wideslab. When the panels are installed, the hooks line up and a splicing bar is placed on top of the Wideslab equally lapping two abutting hooks. The splice occurs after the topping that encases the hooks and splice bar is placed and hardened.

**2.2.3 USE IN FIRE-RESISTANCE RATED CONSTRUCTION:**

**2.2.3.1 Conventional Designs for Solid Slabs**

**2.2.3.1.1 Restrained Assemblies**

The fire-resistance rating for solid concrete slabs without voids utilizing Filigree Wideslabs shall be calculated in accordance with UL 263 (ASTM E119), the same manner as the fire-resistance rating of restrained solid concrete slabs of the same thickness is calculated, provided, the maximum fire-resistance rating is limited to 4 hours; the maximum spacing of the Filigree Trusses is limited to 32 inches (812.8 mm) on center; the concrete cover for the prestressing strands and trusses is limited to those dictated by fire-resistance rating design and assembly but not less than $^{15}/_{16}$ inches (23.8 mm); and the minimum thickness of the Wideslab is limited to $2^{1}/_{4}$ inches (57.2 mm).

A restrained condition in fire tests is one in which expansion of the supports of a load-carrying element resulting from the effects of the fire is resisted by forces external to the element.

**2.2.3.1.2 Unrestrained Assemblies**

In an unrestrained assembly, as defined in UL 263 (ASTM E119), the maximum fire-resistance rating of an assembly utilizing a Filigree Wideslab shall be one hour. In this case, the minimum cover for prestressing steel shall be $1^{1}/_{16}$ inches (27 mm). An unrestrained condition is one in which the load-carrying element is free to expand and rotate at its supports.

**2.2.3.2 Assemblies With Voids**

Filigree Wideslabs constructed utilizing voids as described in this report shall be fire-resistance rated as determined by the specific U.L. listing given in Table 1. The maximum spacing of Filigree trusses shall be 32 inches (812.8 mm) on center. The height of voids made from metal or other noncombustible void forms shall not be limited. When voids are made from foam plastics, the voids made from polystyrene shall be limited so that they contain no more than 8 inches (203.2 mm) of solid foam material. The Underwriters Laboratories Listing limits the thickness of the voids to a maximum depth of 4 inches (101.6 mm), as well as limiting their width to 24 inches (609.6 mm). The listing requires the voids to be covered by a minimum topping of $1^{3}/_{4}$ inches (44.5 mm) of concrete. If the height of the voids is increased beyond 4 inches, and the cover is as required, the mass of the concrete encasing the void shall be increased by a minimum of 5.6 percent per inch of increase in void height. The height of the void can be a maximum of 8 inches, as long as the appropriate cover of concrete of $1^{3}/_{4}$ inches is maintained.

**Table 1** [2]

| U.L. LISTING | DESIGN | SLAB THICK. (IN.) | VOID DEPTH[1] (IN.) | RATING COMMENT |
|---|---|---|---|---|
| J999, K902 | Unrestrained | 8 | 4 | $^{3}/_{4}$ hr. $^{15}/_{16}''$ strand cover |
| K901, K903 | Unrestrained | 8 | 4 | 1 hr. $1^{1}/_{16}''$ strand cover |
| J999, K901 | Restrained | 8 | 4 | 2 hr. $1^{3}/_{4}''$ conc. over voids |
| J999, K901 | Restrained | $8^{7}/_{8}$ | 4 | 3 hr. $2^{5}/_{8}''$ conc. over voids |
| J999, K901 | Restrained | $10^{1}/_{8}$ | 4 | 4 hr. $3^{7}/_{8}''$ conc. over voids |
| K902, K903 | Restrained | 8 | 2 | 3 hr. $3^{3}/_{4}''$ conc. over voids |
| K902, K903 | Restrained | 8 | 0 | 4 hr. Solid slab |

1. Width of void shall not exceed 24 inches
2 1 inch = 25.4 mm

**3.0 CONDITIONS OF USE**

This report is limited to the applications and products as stated in this report. The ICC-ES Subcommittee on National Codes intends that the report be used by the code official to determine that the report subject complies with the code requirements specifically addressed, provided that this product is installed in accordance with the following conditions:

**3.1** Each application for permit on buildings in which Filigree Wideslabs are proposed for use shall be accompanied by structural calculations signed and sealed by a registered design professional.

**3.2** The construction documents utilizing Filigree Wideslabs shall contain, as a minimum, the information listed in Section 5.0 of this report.

**3.3** When foam plastic is incorporated into the finished slab, the foam plastic shall be 1 lb/ft$^3$ density polystyrene manufactured by BASF Corporation. The foam plastic shall bear a label containing the following information:

Raw Bead: BASF
Density: 1 pcf
Molder: *
Third Party Inspection Agency: *

*Evaluation of the block molder of the polystyrene and the block molder's third party quality control agency is outside the scope of this report.

**3.4** The Filigree Wideslab shall bear the label of one of the following third party quality control agencies, signifying that the Wideslab was manufactured in accordance with the quality control manual listed:

Certified Testing Laboratories, Bordentown, New Jersey

Testwell Craig Testing Laboratories, Mays Landing, New Jersey

**3.5** Field construction of slabs and concrete structures utilizing Filigree Wideslabs shall be subject to special inspections, as required by Code Section 1705.0 of the BOCA® *National Building Code*/1999 and Section 5.5 of this report.

**3.6** Structural horizontal shear is determined from elastic analysis as described in Chapter 17, paragraph 17.5 of the ACI Code. Requirements for shear reinforcement depend upon the magnitude of horizontal shear as determined by the registered design professional. If the shear stress is under 80 psi (551.6 kPa), no shear reinforcement is required; just a roughened surface of Filigree slabs. If the shear stress is above 80 psi (551.6 kPa) but under 350 psi (2.4 MPa), the engineer shall determine the amount of shear reinforcing required, and select the appropriate number and spacing of Filigree trusses needed to meet this requirement. If shear exceeds 350 psi (2.4 MPa), the engineer shall use the shear friction concept given in Section 11.7 of ACI 318-95.

**3.7** The determination of whether or not an assembly is restrained as indicated in Section 2.2.3.1.1 of this report is outside the scope of this report.

**3.8** This report is subject to periodic re-examination. For information on the current status of this report, contact the ICC-ES.

## 4.0 INFORMATION SUBMITTED

**4.1** Structural calculations and tests that validate the load carrying capacity of the Filigree Wideslab is predicted adequately by the design methods specified in ACI 318-95, as follows:

**4.1.1** Engineering calculations from load tests in accordance with ACI 318, dated October 27, 1977, prepared by Harry H. Wise, P.E.

**4.1.2** An investigation of reinforcing splices in two-way slabs of composite concrete flexural construction built with the aid of Filigree Wideslab elements, dated February 1970, prepared by Harry H. Wise, P.E., in accordance with ACI 318.

**4.1.3** Tests of reinforcing splices in two-way slabs of composite concrete flexural construction built with the aid of Filigree Wideslab elements, dated February 1970, prepared by Harry H. Wise, P.E., and completed at Jersey Testing Laboratories, Inc., in accordance with ACI 318.

**4.1.4** Load test of prestressed Filigree Wideslab, dated January 1974, prepared by Jersey Testing Laboratories, Inc., in accordance with ACI 318.

**4.1.5** Load test of prestressed Filigree Wideslab, dated January 1974, prepared by Jersey Testing Laboratories, Inc., in accordance with ACI 318.

The test was performed on a 5-inch- (127 mm) thick solid, 4 feet (1.2 m) wide section continuously spanned 25 feet (7.6 m) with a live load of 40 psf (1.9 kPa).

**4.1.6** Load Test of prestressed Filigree Wideslab, dated January 1974, prepared by Jersey Testing Laboratories, Inc., in accordance with ACI 318.

The test was performed on an 8-inch- (203.2 mm) voided slab, 8 feet (2.4 m) wide, simply spanned 30 feet (9.1 m). The void was 4 inches (101.6 mm) thick and a live load of 40 psf (1.9 kPa) was used. There was $1^3/_4$ inches of concrete above the void and $2^1$/4 inches of concrete below the void.

**4.2** Report on precast concrete units with poured-in-place concrete topping in a floor/ceiling assembly, File #R7743-1, project 75NK5639, dated August 16, 1976, revised September 16, 1976, prepared by Underwriters Laboratories, Inc. The report includes testing in accordance with UL Standard 263 (ASTM E119) and an engineering analysis to establish the UL design numbers given in Table 1. Based upon the limited size of the furnace, the testing laboratory was unable to test slabs in thicknesses actually used in the field. Based upon the critical case of where polystyrene board stock is used as a form, this increase in concrete mass (as indicated in Section 2.2.3.2 of this report) will offset any heat produced by combustion of the polystyrene provided the fuel contributed rating of the EPS, as determined by ASTM E84 is not more than 50.

The test was conducted also to assure that the composite decks will not delaminate and lose their structural integrity. Based upon this test, the maximum spacing for Filigree trusses in fire-resistance rated applications shall be 32 inches (812.8 mm).

**4.3** Underwriters Laboratories Project R5817, Assignment 85NK3820, dated June 4, 1985. Based upon tests conducted in accordance with ASTM E84, and an engineering study, the flame spread classification and smoke-developed index of BASF foamed plastic at 6 inches in thickness was determined to be, respectively, 15 and 125.

**4.4** Report by Armand H. Gustaferro, dated July 1975. Fire tests were conducted on concrete slabs with polystyrene voids that were completely encased in $1^3/_4$ inch concrete. The polystyrene did not contribute to the propagation of fire, even if a portion of the polystyrene becomes exposed. Fire tests were performed on a 3 foot × 3 foot panel exposed to a standard ASTM E119 fire-time temperature curve.

Based upon the tests performed, the maximum thickness of 8 inches of polystyrene is considered supported by the analysis performed in Section 4.4 above, since Code Section 106.4 of the BOCA® *National Building Code*/1999 permits alternatives based upon appropriate testing.

**4.5** Quality Control Manual -- Plants and Production of Filigree Wideslab Products, dated November 1975. The manual is written to assure construction of the Filigree Wideslab in accordance with plans and specifications.

**4.6** Agreement dated August 8, 1990, between Certified Testing Laboratories of Bordentown, New Jersey, and Mid-State Filigree Systems, Inc., of Cranbury, New Jersey. The Certified Testing Labs agree to conduct in-plant inspections in accordance with the Quality Control Manual listed above.

**4.7** Agreement dated August 8, 1990, between Testwell Craig Testing Laboratories of Mays Landing, New Jersey, and Mid-State Filigree Systems of Cranbury, New Jersey. Testwell Craig Testing Laboratories agree to conduct in-plant inspections in accordance with the Quality Control Manual listed above.

**4.8** Information on qualifications of Certified Testing Laboratories and Testwell Craig Laboratories, relating to the competence and independence of each testing laboratory.

## 5.0 INFORMATION REQUIRED ON CONSTRUCTION DOCUMENTS

To aid in the use of this report, the following represents the minimum level of information to be reflected on construction documents in order to determine compliance with this report.

**5.1** The language "See ICC-ES Legacy Report No. 96-14."

**5.2** Construction documents submitted at the time of application for building permit shall be signed and sealed by a registered design professional.

**5.3** Construction documents submitted for permit shall include pertinent information to convey all essential requirements for the system, including as a minimum:

**5.3.1** Required physical dimensions.

**5.3.2** Amount of reinforcement required.

**5.3.3** Required concrete strength.

**5.3.4** Size and spacing of steel joists.

**5.4** Construction documents shall include indications of the method of attachment of Filigree Wideslabs.

**5.5** Special inspections shall be identified by a special inspections statement, in accordance with Code Section 1705.1.1 of the BOCA® *National Building Code*/1999. Special inspection items shall include, but not necessarily be limited to the following: materials, placement of steel reinforcing, concrete placement, as well as any question relative to mode or manner of construction and materials.

**5.6** Construction documents submitted at the time of application for building permit shall be accompanied by calculations signed and sealed by a registered design professional.

## 6.0 PRODUCT IDENTIFICATION

All Mid-State Filigree Systems, Inc., Precast Concrete Filigree Wideslabs manufactured in accordance with this report shall be marked at the plant with the identifying language "See ICC-ES Legacy Report No. 96-14."

## Illustrative Construction Details

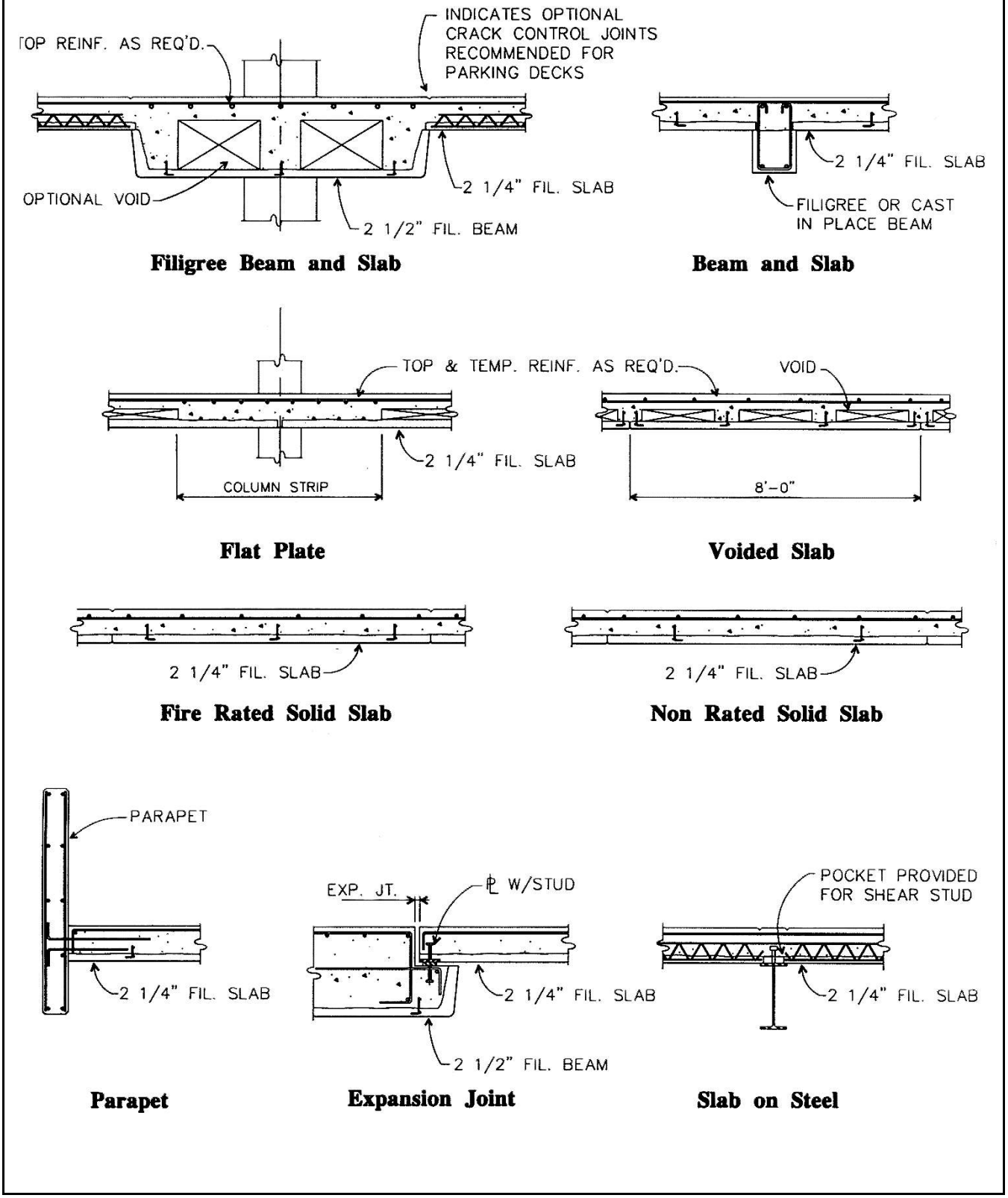


**FIGURE 1***

*THESE DRAWINGS ARE FOR ILLUSTRATION PURPOSES ONLY. THEY ARE NOT INTENDED FOR USE AS CONSTRUCTION DOCUMENTS FOR THE PURPOSE OF DESIGN, FABRICATION OR ERECTION.