LOK-N-BLOK

Block Prism Compression Test Report

FINAL REPORT

November 16, 2021

WJE No. 2017.6646

PREPARED FOR:

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PREPARED BY:

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WJE

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TEST STANDARD

Testing was performed following ICC-ES AC447 (June 2018) *Acceptance Criteria for Fiber Reinforced Plastic (FRP) Modular Wall Systems*, Section 4.1.10, and by reference, ASTM C140-17a *Standard Test Methods for Sampling and Testing CMUs and Related Units*. The test procedure and instrumentation were modified from the requirements of AC447 and ASTM C140-17a as described below.

OBJECTIVE

The primary objective of the block prism compression testing documented herein was to determine the ultimate compressive strength of the Lok-N-Blok (LNB) fiber-reinforced plastic block units for the test configurations and conditions described below. Secondary objectives included investigating the influence of different test specimen configurations on the compressive strength and identifying the typical failure mechanism(s) of the LNB units under compression.

TEST SPECIMENS

Compression testing was conducted on ten specimens. A typical specimen consisted of a two-block stack with a partial block serving as a cap plate, as shown in Figure 1, using blocks that were produced in 2017. Each block has a nominal height of 8 inches, a nominal length of 12 inches, and a nominal width of 6 inches. Test specimens consisted of blocks stacked in four different configurations (Configuration Nos. 1-4), as shown in Figure 2.

For each specimen, a cut block approximately 3.25 inches in height was added on top of the two-block stack. The cut block was capped with a gypsum cement material to provide a more uniform top surface for applying compression loads. The use of the partial block in the test specimen, rather than capping the upper full block with gypsum cement, also reduces the lateral restraint on the blocks from the testing machine.

Test specimen properties are described below.

- **Bond Pattern.** Six of the ten specimens consisted of blocks in stack bond pattern (Configuration Nos. 1 and 2) and four of the specimens consisted of blocks in running bond pattern (Configuration Nos. 3 and 4). In stack bond, both the blocks and the vertical joints between them align in successive rows. In running bond, the blocks, and the vertical joints between them are staggered in successive rows.
- **Block Orientation.** For three of the six stack bond pattern test specimens, the blocks were oriented to align the male and female ends (Configuration No. 1). For the other stack bond specimens, the male and female ends were reversed in successive rows (Configuration No. 2).
- **Dovetails.** For four of the ten test specimens, two stack bond and two running bond specimens, the male dovetails on the block ends were cut off and inserted into the female dovetails, to mimic the male and female dovetail configuration in typical wall construction.

AC447 specifies that testing used to determine the allowable design compressive strength shall be conducted on a minimum of ten replicate specimens in stack bond pattern. The tested specimens were considered to investigate the influence of the properties described above, if any, on the specimen compressive strengths prior to testing ten replicate specimens.

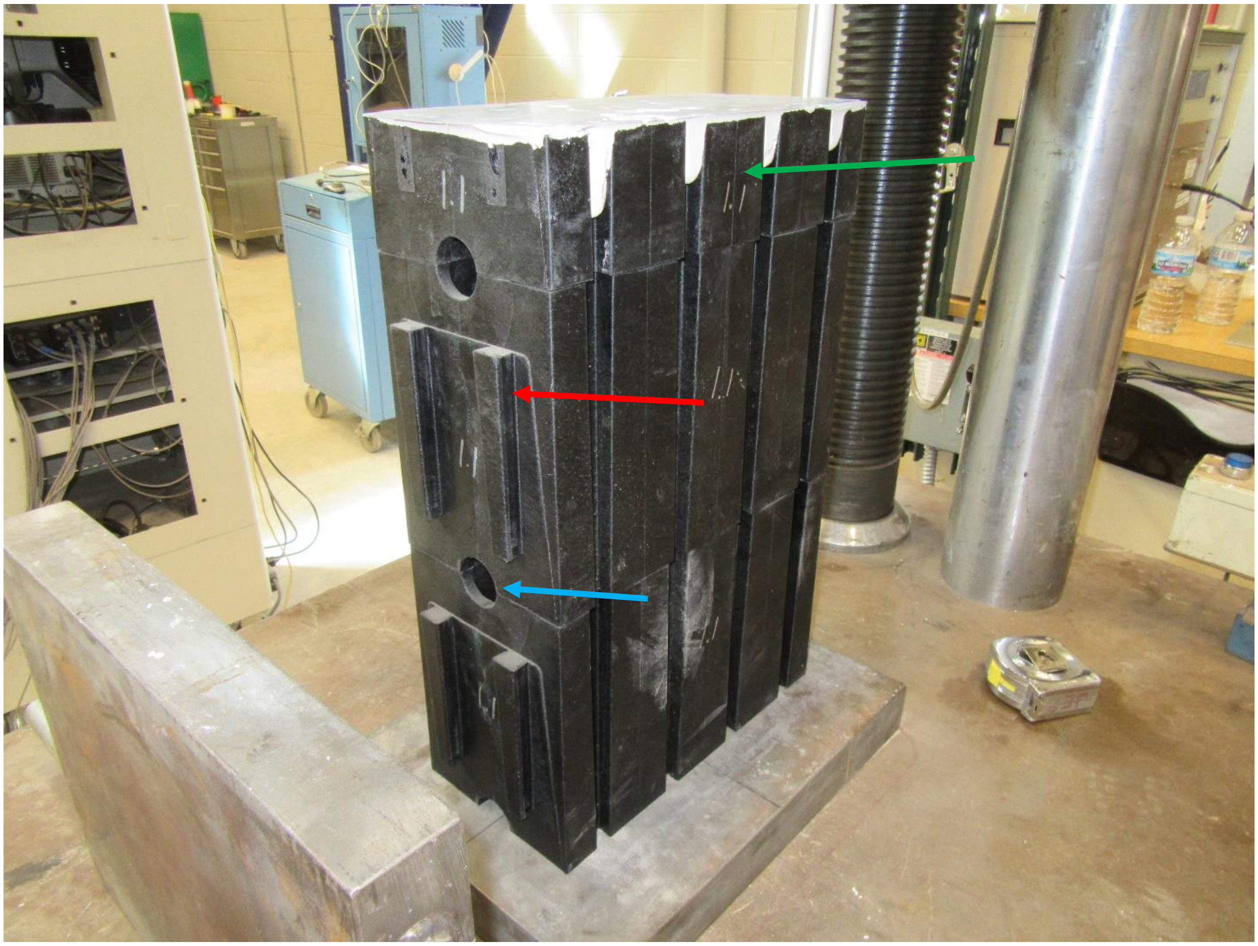

Figure 1. Typical test specimen with blocks in stack bond pattern. A partial block cap plate is indicated with a green arrow, a typical block utility hole is indicated with a blue arrow, and a typical block dovetail is indicated by a red arrow.

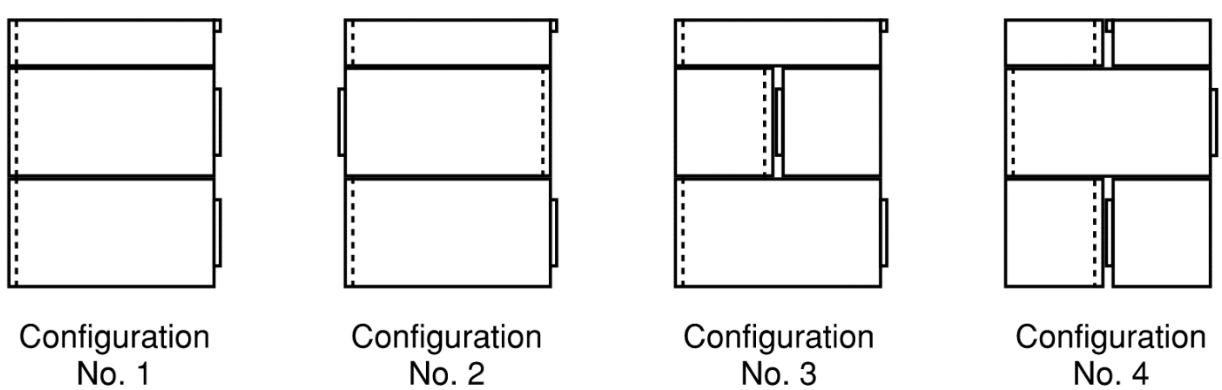

Figure 2. The four test specimen configurations used for the testing. Configuration Nos. 1 and 2 used a stack bond pattern and Configuration Nos. 3 and 4 used a running bond pattern.

TEST PROCEDURE

Compression testing was conducted over a period of several months using a universal testing machine (Riehle, Model MK111 500 FH) with a 500-kip (kilo-pound or 1,000 pound) capacity. Steel plates were used to apply pressure at both ends of the specimens. The displacement rate of the top head was controlled manually in general accordance with ASTM C140, and the compressive load was recorded using a computer. A typical specimen in the test machine is shown in Figure 3.

Testing was conducted at a standard laboratory temperature of approximately 70°F. AC447 specifies that testing used to determine the allowable design compressive strength shall be conducted on specimens that have been conditioned at 158°F for 48 hours prior to testing, which is planned for future testing.

Figure 3. A typical test specimen in the load frame.

RESULTS

The maximum applied compression loads carried by each specimen are summarized in Table 1. A graphs of compression load vs. displacement is shown in Figure 4 for the ten specimens. The average compressive strength of the ten specimens was 89.0 kips (89,000 pounds). The minimum compressive strength was 84.3 kips, and the maximum was 92.6 kips. The data had an overall standard deviation of 2.6 kips (coefficient of variation 2.9%).

Table 1. Summary of Test Results

Specimen Number	Configuration	Bond Pattern	Installed Male Dovetails	Date Tested	Maximum Compression Load (kips)
1	No. 2	Stack	no	12/4/2017	86.6
2	No. 1	Stack	no	12/4/2017	87.2
3	No. 1	Stack	no	3/16/2018	91.5
4	No. 1	Stack	yes	3/16/2018	92.6
5	No. 2	Stack	no	3/16/2018	89.3
6	No. 2	Stack	yes	3/16/2018	87.2
7	No. 3	Running	no	3/16/2018	91.4
8	No. 3	Running	yes	3/16/2018	84.3
9	No. 4	Running	no	3/16/2018	88.9
10	No. 4	Running	yes	3/16/2018	90.6

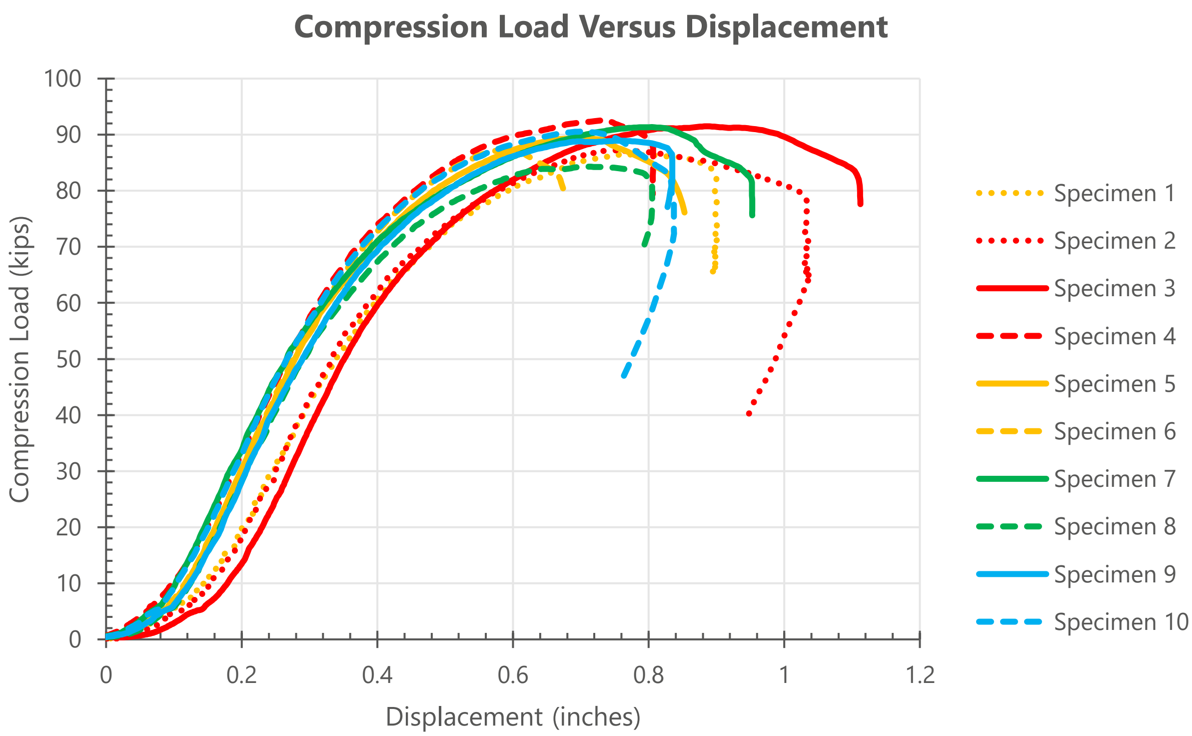

Figure 4. Graphs of compression load versus displacement for the test specimens.

DISCUSSION

Block prism compression testing was performed to determine the ultimate compressive strength of LNB units and investigate the influence of various test specimen configurations on the compressive strength.

Influence of Test Specimen Properties on Compression Strength

Six specimens were tested in a stack bond configuration and four in a running bond configuration. The average compressive strengths of the specimens with the stack and running bond patterns were 89.1 kips and 88.8 kips, respectively. There was not a significant difference in the minimum and maximum compressive strengths for the stack bond specimens compared to the running bond specimens either. These test results suggest the bond pattern did not influence the compressive strength of the tested specimens.

Of the six stack bond test specimens, three had blocks oriented to align the male and female ends (Configuration No. 1) and three had the male and females ends reversed in successive rows (Configuration No. 2). The average compressive strengths of the Configuration No. 1 and Configuration No. 2 specimens were 90.4 kips and 87.7 kips, a difference of about 3 percent. This indicates that the orientation of the blocks in successive rows is not a significant factor affecting their compression strength.

Four specimens had male dovetails installed in the female dovetails and six specimens did not. Those specimens with male dovetails installed in the female dovetails had an average compressive strength of

88.7 kips and those that did not had an average compressive strength of 89.1 kips. These results suggest that the presence or absence of the male dovetails in the female dovetails also did not significantly influence the compressive strength of the tested specimens.

Observed Failure Mechanisms

The primary observed failure mechanism was tensile splitting of the block webs. Splitting was typically observed at both the outer and inner webs and originated at the utility chase opening, shown in Figure 5. Secondary observed failure mechanisms included local crushing and buckling, particularly at the edges of the blocks as shown in Figure 7.

Compression Stiffness

The stiffness in compression of the test specimens is represented by the slope of the compression load vs. displacement curves in Figure 4. The test results indicate the stiffness in compression of the stacked blocks initially increases as the compression load increases. Once the compression load reaches about 10,000 pounds, the stiffness is relatively constant until the compression load reaches about 55,000 pounds, where the stiffness declines until ultimate failure.

The initial increase in stiffness with increasing load appears to be due to seating of the LNB units where small local deformations occur which eliminate any lack of contact between the bearing areas on the top and bottom of the blocks. The initial loss of contact at horizontal joints is likely due to irregularities in the top and/or bottom block surfaces.

Allowable Design Compressive Strength

AC447 specifies that testing used to determine the allowable design compressive strength shall be conducted on ten replicate specimens that have been conditioned at 158°F for 48 hours prior to testing. Because the ten specimens tested and documented herein were not replicate and were conditioned at room temperature, an allowable design compressive strength per AC447 cannot be determined.

For reference, AC447 specifies that the allowable design compressive strength is obtained by dividing the average ultimate compressive strength by a factor of five. Future testing performed in accordance with AC447 conditioning requirements will establish the average ultimate compressive strength; however, the LNB units are expected to demonstrate lower strengths at elevated temperatures than those reported here for conditioning at room temperature.

Figure 5. Splitting tensile failure around the lower utility hole in Specimen 8.

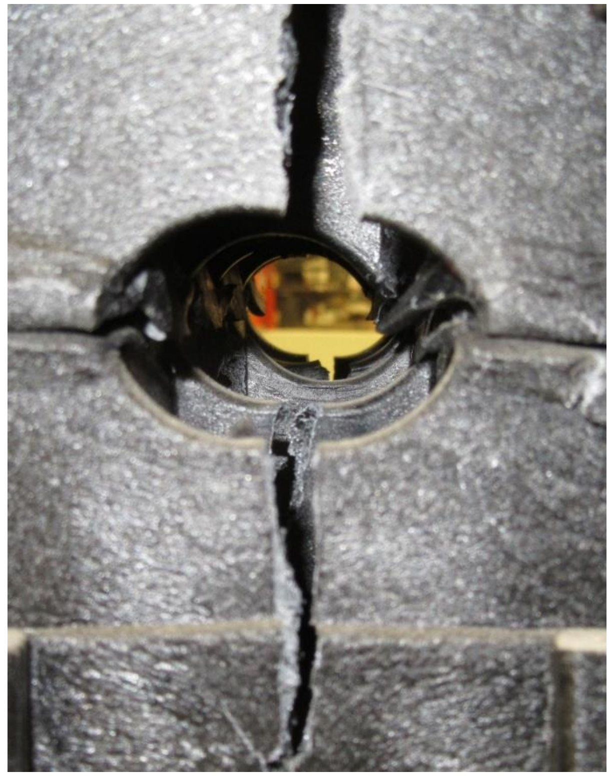

Figure 6. Splitting of the interior utility holes after testing of Specimen 2.

Figure 7. Tensile splitting and local crushing of Specimen 2 during testing.