



koffel associates, inc.
FIRE PROTECTION ENGINEERS • CODE CONSULTANTS

3300 North Ridge Road, Suite 275 Ellicott City, Maryland 21043

410-750-2246 • 301-621-4629 • Fax: 410-750-2588

William E. Koffel, P.E.
President

December 7, 2004

Mr. John H. Guy
President
Verot Oaks Building Blocks, Inc.
P.O. Box 62806
Lafayette, LA 70596-2806

**RE: VEROT OAKS BUILDING BLOCKS
ENGINEERING EVALUATION
KA 03773-001**

Dear Mr. Guy:

Koffel Associates, Inc. has been retained to evaluate the Verot Oaks Building Blocks (VOBB) product and associated installation method.

Koffel Associates has been tasked to evaluate the compliance of the VOBB blocks and associated installation procedure with the relevant portions of the 2003 Edition of the International Building Code (IBC) and the 2003 Edition of the International Residential Code (IRC). VOBB has provided Koffel Associates with test reports from Southwestern Laboratories (SWL) of Houston, TX dated April 28, 2003. The SWL test reports are attached to this letter.

In addition, Koffel Associates has attached an analysis of the VOBB system by Steven W. Doerr, P.E., structural engineer. The analysis performed by Mr. Doerr addresses the compliance of the VOBB system with the seismic requirements of ACI 530.

SUMMARY OF IBC AND IRC REQUIREMENTS

IBC Requirements

Chapter 21 of the 2003 Edition of the IBC regulates the use of concrete masonry units.

Section 2101.2 of the IBC states that the design of masonry shall comply with one of the following design methods as well as the requirements of Sections 2101 through 2104:

1. Working stress design,
2. Strength design,
3. Pre-stressed masonry design, or
4. Empirical design.

Koffel Associates shall consider the requirements for masonry associated with the strength design method. According to Section 2101.2.2, masonry designed by the strength design method shall comply with the provisions of Sections 2106 and 2108.

According to IBC Section 2103.1, load-bearing concrete masonry units shall comply with the requirements of ASTM C 90, Specification for Loadbearing Concrete Masonry Units.

Section 2104.1 of the IBC requires that masonry construction shall comply with the requirements of Sections 2104.1 through 2104.5. Section 2104.2.2 requires that hollow unit masonry construction be fully mortared. The proposed installation method does not utilize mortar. Section 104.11 of the IBC states *"the provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design, or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method, or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability, and safety."* With the documentation contained herein, VOBB has demonstrated that the installation method will provide an equivalent level of performance or greater than what is required by Chapter 21 for masonry construction.

Masonry block installation shall comply with the seismic requirements of Section 2106 and Section 1.13.2 of ACI 530, Building Code Requirements for Masonry Structures, for the relevant Seismic Design Category assigned to the area constructed in.

Section 2108 requires compliance with the requirements of Chapters 1 and 3 of ACI 530 as amended by Section 2108.

IRC Requirements

The relevant sections of the IRC are Sections R606, General Masonry Construction, and R609, Grouted Masonry. R606.1 states that masonry construction shall comply with the provisions of ACI 530 or the provisions of Section R606. The provisions of ACI 530 are intended to be met. The minimum wall thickness of 8-in. for multi-story buildings as required by Section R606.2.1 is exempted through compliance with ACI 530. The grout used in VOBB Building Block construction shall meet the performance and installation requirements of Section R609 and ASTM C 476, Specification for Grout for Masonry. Conformance with the performance requirements of ACI 530 will permit the use of VOBB Building Block masonry walls in basements and multi-story buildings if support of structural loading is adequately provided.

With the documentation contained herein, VOBB has demonstrated that the dry-stacked VOBB masonry blocks and installation method will provide an equivalent level of performance or greater than what is required by Chapter 21 for masonry construction.

DESCRIPTION OF PRODUCT

VOBB's Building Blocks are dry-stacked, masonry blocks filled with grout and steel reinforcing bar (re-bar) every 1-ft. The masonry blocks are dry-stacked without surface-bonding mortar. Each VOBB block is molded with two grooves at both ends (standard blocks) or on the sides (corner blocks) that hold plastic X-shaped clips. These clips act to connect the VOBB blocks at each course level. The ½-in. re-bar is placed in the cells within the blocks. The ½-in. re-bar is inserted at least 1-ft into the foundation on 4-ft

spacing. The cells for stacks used for support posts and lintels above doors and windows are then filled with grout. No mortaring is intended between blocks or on the face of the wall.

Door and window lintels will have all blocks with all cells filled with grout and ½-in. rebar on a vertical basis. In addition, lintels will have ½-in. rebar on a horizontal basis installed in accordance with VOBB's specifications as follows:

- for lintels 4 ft and less
one ½-in. rebar
- for lintels greater than 4 ft and up to 7 ft
two ½-in. rebars
- for lintels greater than 7 ft and up to 10 ft
three ½-in. rebars

VOBB Building Block walls are connected to roofs and floors with steel J-anchors. J-anchors are spaced every 4-ft.

CODE COMPLIANCE

ASTM C 90 Compliance

Samples of the VOBB masonry units were submitted to Koffel Associates. The VOBB units are available in lengths of 6-in., 12-in., and 18-in. The face shell thickness is 1-1/2-in. within permissible variations in dimensions. The web thickness of the 12-in. unit is 1-1/8-in. within permissible variations in dimensions. The web thickness of the 18-in. unit is 1-1/4-in. within permissible variations in dimensions. These dimensions comply with the minimum requirements of Table 1 of ASTM C 90.

Table 2 of ASTM C 90 requires that the minimum compressive strength of an individual unit is to be 1,700 psi for an individual unit and 1,900 psi for an average of 3 units. The maximum water absorption of lightweight concrete shall be 18 pcf. The following table shows the results of testing performed by SWL:

Item	Net Compressive Strength (Unit 1) (psi)	Net Compressive Strength (Unit 2) (psi)	Net Compressive Strength (Unit 3) (psi)	Average Compressive Strength (3 Units) (psi)	Maximum Water Absorption of Units (pcf)
6" x 6" x 6" VOBB Block	4018	3998	4377	4131	15.0
6" x 6" x 12" VOBB Block	2774	3093	3230	3032	15.3
6" x 6" x 18" VOBB Block	2350	2515	2169	2344	17.4

The strength and absorption requirements of Table 2 of ASTM C 90 are met by VOBB masonry blocks.

ASTM C 90 contains material handling provisions. The manufacturer's data requires compliance with these provisions. All material handling requirements of ASTM C 90 shall be complied with.

Compliance with IBC Section 2103

The installation requirements require the cells of the VOBB blocks to be filled with grout. The grout shall conform to the proportional requirements of Table 2103.10 of the IBC and ASTM C 476, Specification for Grout for Masonry.

Compliance with IBC Section 2104

The preparation and installation requirements of Section 2104 shall be followed.

Compliance with IBC Section 2106

VOBB Masonry Block installation shall comply with the seismic requirements of Section 2106 and Section 1.13.2 of ACI 530, Building Code Requirements for Masonry Structures. Section 2106.2 requires masonry walls to be anchored to the roof and floors that provide lateral support for the wall. The VOBB Building Block walls are anchored to the foundation with imbedded re-bar. The VOBB Building Block walls are anchored to the roof and floors with steel J-anchors.

Attached find an analysis of the VOBB system by Steven W. Doerr, P.E., structural engineer. The analysis performed by Mr. Doerr addresses the compliance of the VOBB system with the seismic requirements of ACI 530.

Compliance with IBC Section 2108

Section 2108 requires compliance with the requirements of Chapters 1 and 3 of ACI 530 as amended by Section 2108.

Section 1.7.1 of ACI 530 states that masonry shall be designed to resist applicable loads. Section 1.10.1 of ACI 530 states that the deflection of beams and lintels due to dead load plus live load shall not exceed the lesser of $L/600$ or 0.3 in. SWL performed tests to determine the deflection of a seven-ft lintel. A deflection of $L/600$ is calculated to be 0.14. The maximum sustained compressive load sustained was 60,000 lbf. A lateral flexural load of 1,875 lbf was applied. A deflection of 0.042 in. was observed. A four-ft lintel was tested. A deflection of $L/600$ is calculated to be 0.08. A deflection of 0.08 was observed at 5,000 lbf.

Section 1.12 of ACI 530 provides minimum requirements for reinforcement. The installation requirements of Section 1.12 shall be followed.

Section 1.14 of ACI 530 states that a quality assurance program be followed by the manufacturer in accordance with ASCE 7-98, Minimum Design Loads for Buildings and Other Structures.

Section 3.1.1 of Chapter 3 of ACI 530 requires compliance with Chapter 1, Section 3.1 and either Section 3.2 or 3.3. Section 3.2 of ACI 530 relates to reinforced masonry. Section 3.3 of ACI 530 is relevant for unreinforced masonry. Section 3.2 is the applicable section for VOBB building blocks.

Section 3.1.7.1.1 of ACI 530 states that the compressive strength of masonry, f'_m , shall equal or exceed 1,500 psi. SWL performed a compressive load test on each unit. The net compressive strength of each of the three types of VOBB block is greater than 1,500 psi (See table on Page 3 of this report).

Strength design of VOBB building blocks for factored flexural and axial load shall be in accordance with Section 3.2 of ACI 530 as amended by the IBC and principles of engineering mechanics.

The seven foot lintel test performed by SWL was used to ensure that the strength requirements of Section 3.2 of ACI 530 are met. The following variables apply:

f'_m = compressive strength = 40,000 psf = 278 psi
 A_n = net cross-sectional area of masonry = 2 x 61.5 in² = 123 in²
 A_s = effective cross-sectional area of reinforcement = 0.2 in² x 6 = 1.2 in²
 f_y = yield strength of steel = 60,000 psi
 h = height of masonry = 2-1/2 ft = 30 in
 r = radius of gyration = $x / (12)^{1/2} = 5.2$ in

$h/r = 16$; Use Equation 3-16 from ACI 530:
 $P_n = 0.80[0.80f'_m(A_n - A_s) + f_y A_s][1 - (h/140r)^2]$

P_n = nominal axial strength (lb)

$$P_n = 0.80[0.80(278)(123 - 1.2) + (60,000)(1.2)][1 - (30/140(5.2))^2]$$

$$P_n = 79,136 \text{ lb}$$

Per Section 3.2.4.1.1 of ACI 530, P_n shall not be exceeded. The maximum sustained load was 40,000 psf x 1.5 ft² = 60,000 lbs. P_n is not exceeded.

Equation 3-18 of ACI 530 states $V_n = V_m + V_s$, where:

V_n = nominal shear strength (lb)

V_m = shear strength provided by masonry (lb)

V_s = shear strength provided by reinforcement (lb)

Equation 3-21:

$$V_m = [4.0 - 1.75(M/Vd_r)]A_n (f'_m) + 0.25 P$$

$M/Vd_r = 1$ from ACI 530, Section 3.2.4.1.1

P = axial load (lb); 4,000 psf (from SWL test) x 1.5 ft² = 6,000 lbs

$$A_n (f'_m)^{1/2} = 34,169$$

$$V_m = (2.25)(34,139) + (0.25)(6,000) = 78,313 \text{ lbs}$$

Equation 3-22:

$$V_s = 0.5 (A_v/s)f_y d_v$$

s = spacing of reinforcement (in) = 18 in

d_v = depth of masonry in shear direction = 5 x 18 in. = 90 in.

A_v = cross-sectional area of steel reinforcement = 0.2 in.²

$$V_s = 30,000 \text{ lb}$$

$$V_n = V_m + V_s = 78,313 \text{ lbs} + 30,000 \text{ lbs} = 108,313 \text{ lbs}$$

According to ACI 530, Equation 3-20:

$$V_n \leq 4 A_n (f'_m)^{1/2} = 4 \times 34,169 = 136,676 \text{ lbs}$$

V_n does not exceed this value.

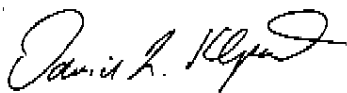
The VOBB building blocks with associated installation method meet the requirements for nominal and flexural strength as described by ACI 530, Section 3.2. Additional requirements from ACI 530, Section 3.2 for specific shapes shall be calculated.

CONCLUSION

The performance requirements of Chapter 21 of the IBC are met by using the proposed materials and installation methods of VOBB Building Blocks. Local installation requirements are not addressed by this report.

We trust that this information is consistent with your needs at this time. Please do not hesitate to contact us if you have further questions.

Report generated by:



Dave Klepitch, P.E.
Senior Fire Protection Engineer

Reviewed by:



William E. Koffel, P.E.
President

Encl. SWL Test Data and report, April 28, 2003
Seismic Analysis, Steven Doerr, P.E., November 11, 2004