LEGACY REPORT

ER-4203

Reissued June 1, 2004

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www.icc-es.org

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Legacy report on the 1997 *Uniform Building Code*™, the 2000 *International Building Code*® and the 2000 *International Residential Code*®

DIVISION: 03—CONCRETE
Section: 03130—Permanent Forms

RASTRA PANEL SYSTEM

RASTRA CORPORATION
7621 E. GRAY ROAD, SUITE A1
SCOTTSDALE, ARIZONA 85260

1.0 SUBJECT

Rastra Panel System.

2.0 DESCRIPTION

2.1 General:

The Rastra panel system is comprised of individual elements, made of Thastyron™, and is a permanent formwork for reinforced concrete beams, lintels, walls, and foundation and retaining walls. Walls constructed as described in this report are permitted for use in combustible or noncombustible construction.

2.2 Materials:

2.2.1 Rastra Panels: The Rastra panels are manufactured from a mixture of recycled polystyrene beads, portland cement, admixtures and water. The proprietary mixture is trademarked as Thastyron™. The Rastra panels have a density between 20 and 24 pcf (320 and 380 kg/m^3), and a Class 1 flame-spread index and a smoke-density rating no greater than 450 when tested in accordance with UBC Standard 8-1 (ASTM E 84).

The panels are nominally 7$^1/_2$, 15, or 30 inches (190, 380, or 760 mm) wide; 8$^1/_2$, 10, 12, or 14 inches (216, 254, 305, or 356 mm) thick; and 90 inches (2286 mm) or 10 feet (3048 mm) high, with available core diameters of either 6 inches (152.4 mm) or 8 inches (1203.2 mm). When stacked in the final position, the panels form vertical and horizontal cavities where reinforcement and concrete are placed. See Figures 1, 2, and 3 for typical details of the panels.

2.2.2 Concrete: Panel cores are filled at the jobsite with normal-weight concrete having a $^3/_4$-inch (19 mm) maximum aggregate size. The concrete must have a minimum compressive strength of 2,500 psi (17.2 MPa) at 28 days. Slump should be within 8 to 9 inches (203 and 229 mm). If construction is based on the 2000 *International Residential Code*® (IRC), concrete must comply with Section R611.6.1 of the IRC.

2.2.3 Reinforcement: Deformed steel reinforcement bars must have a minimum yield strength of 40 ksi (275 MPa) and must comply with Section 1903.5 of the 1997 *Uniform Building Code*™ (UBC) or the 2000 *International Building Code*® (IBC). If the construction is based on the IRC, reinforcing steel must comply with Sections R611.6.2 and R404.4.6 of the IRC.

2.2.4 Other Components: When required by the building official, wood members in contact with concrete for plates or window and door framing must be preservative-treated with an approved wood preservative, and must be attached with galvanized steel fasteners in accordance with Section 2304.3 of the UBC, or Section 2304.9.5 of the IBC, or Section R323.3 of the IRC. Materials other than wood, such as vinyl, are permitted for window and door framing if this is approved by the building official.

2.3 Design:

2.3.1 General: The design of cast-in-place, reinforced concrete structural members formed by Rastra panels must conform to Chapters 16 and 19 of the UBC or IBC, and with the following requirements:

1. Minimum horizontal reinforcement must be No. 4 deformed rebar spaced a maximum of 30 inches (760 mm) on center for structures located in UBC Seismic Zones 0, 1, and 2 (IBC and IRC Seismic Design Categories A and B); and must be minimum No. 4 deformed rebar spaced a maximum of 15 inches (380 mm) on center for structures located in UBC Seismic Zones 3 and 4 (IBC Seismic Design Categories C, D, E, and F).
2. Minimum vertical reinforcement must be No. 4 deformed rebar spaced a maximum of 30 inches (760 mm) on center for structures located in UBC Seismic Zones 0, 1, and 2 (IBC and IRC Seismic Design Categories A and B), and for structures located in Exposure C areas having a UBC basic (fastest mile) wind speed of 70 mph (102 km/h) or an IBC basic (3-second gust) wind speed of 85 mph (123 km/h). Minimum vertical reinforcement must be No. 4 deformed rebar spaced a maximum of 15 inches (380 mm) on center for structures located in UBC Seismic Zones 3 and 4 (IBC or IRC Seismic Design Categories C, D, E, and F), and for structures located in Exposure C areas having a UBC basic (fastest mile) wind speed greater than 70 mph (102 km/h) or an IBC basic (3-second gust) wind speed of 85 mph (123 km/h). The rebar size may need to increase and/or the rebar spacing may

need to decrease, as a result of the structure being designed under Chapters 16 and 19 of the UBC and IBC.

3. Development and splices of reinforcement must be in accordance with Section 1912 of the UBC and Section 1901.2 of the IBC.
4. Calculations are based on the assumption that the Rastra wall is a solid-concrete wall having an equivalent thickness, b_{eq}, equal to 4.7 inches (119 mm) for walls with 6-inch-diameter (152 mm) cores, and b_{eq} equal to 6.3 inches (160 mm) for walls with 8-inch-diameter (203 mm) cores.
5. The strength-reduction factor, ϕ, is in accordance with Section 1909.3 of the UBC and Section 1901.2 of the IBC.
6. A shape-reduction factor, Ψ, with a value of 0.85, and the strength-reduction factor specified in Section 1909.3 of the UBC or Section 1901.2 of the IBC, must be used cumulatively in the design of the structural concrete formed by the Rastra panels.
7. For members subject to shear and flexure only, the nominal shear strength provided by the concrete is determined as follows:

$$V_c = 2\phi\psi \sqrt{f'_c}\, b_{eq}\, d$$

For **SI:**

$$V_c = 0.16\phi\psi \sqrt{f'_c}\, b_{eq}\, d$$

where:

b_{eq} = Width of an equivalent rectangular section equal to 4.7 inches (119 mm) for 6-inch (152 mm) cores, and equal to 6.3 inches (160 mm) for 8-inch (203 mm) cores.

d = Distance from extreme compression fiber to centroid of tension reinforcement (inches or mm).

f'_c = Specified compressive strength of concrete (psi or MPa).

ϕ = Strength reduction factor equal to 0.85.

ψ = Shape-reduction factor equal to 0.85.

8. In-plane shear strength of shear walls is determined as follows:

$$F_v = \phi\psi \sqrt{f'_c}\, L_u b_{eq}$$

For **SI:**

$$Fv = \phi\psi \sqrt{f'_c}\, L_u b_{eq}$$

where:

b_{eq} = Width of an equivalent rectangular section equal to 4.7 inches (119 mm) for 6-inch (152 mm) cores, and equal to 6.3 inches (160 mm) for 8-inch (203 mm) cores.

f'_c = Specified compressive strength of concrete (psi or MPa).

L_u = Total length of shear wall panel (inches or mm).

ϕ = Strength reduction factor equal to 0.85.

ψ = Shape-reduction factor equal to 0.85.

9. The length of wall considered the effective length for concentrated vertical loads must not exceed the center-to-center distance between the loads or the width of the bearing plate plus four times the effective wall thickness [b_{eq} equal to 4.7 inches (119 mm) for 6-inch-diameter (152 mm) cores, and b_{eq} equal to 6.3 inches (160 mm) for the 8-inch-diameter (203 mm) cores].
10. Roof and floors must be anchored and supported at the wall in accordance with Section 1633.2.8 of the UBC or Section 1604.8.2 of the IBC. Ledger bolts must have the minimum diameter and spacing specified on the building plans approved by the building official. The horizontal reinforcement at each roof and floor level must be in accordance with the design, and must be a minimum of one No. 4 rebar.
11. Walls subject to axial loading or combined flexural and axial loading must be designed as compression members in accordance with Section 1910 of the UBC or Section 1901.2 of the IBC.
12. Anchorage to foundations must comply with Section 1915.8 of the UBC or Section 1901.2 of the IBC.

2.3.2 Alternate Design as Slender Walls: Alternate design of concrete walls formed by the Rastra panels is permitted to be used to comply with Section 1914.8 of the UBC, provided the calculations are based on the assumption that the Rastra wall is a solid-concrete wall having an equivalent thickness of 4.7 inches (119 mm) for walls with 6-inch-diameter (152 mm) cores, and 6.3 inches (160 mm) for walls with 8-inch-diameter (203 mm) cores, and providing that the following are considered in the design:

1. The height-to-thickness ratio (h/b_{eq}) must not exceed 60.
2. In any case in which the vertical service-load stress exceeds 0.04 f'_c, the height-to-thickness ratio (h/b_{eq}) must not exceed 30.

2.3.3 Design in Accordance with the IRC: Reinforced concrete walls and structural members constructed with the Rastra panels must be designed and constructed in accordance with Section R404.4 or Section R611 of the IRC.

2.3.4 Prescriptive Design—Method I (UBC Only): For buildings regulated by the UBC, the following prescriptive design approach for a two-story building specified in this section is permitted to be used in lieu of calculations required by Section 2.3.1 of this evaluation report:

1. Structures in all seismic zones are limited to two stories and 10-foot (3048 mm) unsupported wall heights. See Figures 4 and 5 for two-story height limits.
2. Maximum total roof live and dead load is 50 psf (2.4 kN/m^2), and the maximum total floor live and dead loads is 75 psf (2.6 kN/m^2), with a maximum applied load eccentricity of $5^1/_2$ inches (140 mm).
3. The maximum superimposed load applied vertically at the top of the wall is 2,500 pounds per lineal foot (36 500 N/m).
4. Maximum basic wind speed is 100 miles per hour (161 km/h) in Exposure C locations as defined in Chapter 16, Division II, of the UBC.
5. Vertical and horizontal wall reinforcements must be spaced in accordance with Table 1 of this report, and placement must comply with Section 1914.3 of the UBC.
6. Wall openings must be vertically and horizontally reinforced.
7. Roof and floors must be anchored and supported at the wall in accordance with Section 1633.8 of the UBC.
8. Ledger bolts must have the minimum diameter and spacing specified on the building plans approved by the building official.
9. Allowable in-plane shear loads specified in Table 3 of this report must be greater than or equal to design loads.

10. Anchorage to foundations must comply with Section 1915.8 of the UBC.

11. The horizontal reinforcement at each roof and floor level must consist of a minimum of one No. 5 rebar.

2.3.5 Prescriptive Design—Method II: In lieu of calculations required by Section 2.3.1 of this report, the structural design of Rastra walls is permitted to comply with the *Prescriptive Method for Insulating Concrete Forms in Residential Construction* (publication No. EB118), dated May 1998, published by the Portland Cement Association (PCA), subject to all applicability and use limits for screen-grid ICF wall systems.

2.4 Installation:

2.4.1 Footings: The Rastra wall system must be supported on concrete footings complying with Chapter 18 of the UBC or IBC, or Chapter 4 of the IRC. Vertical rebars, embedded in the footing, must extend into the panel wall system a minimum of 24 inches (610 mm), or a length complying with Section 1912 of the UBC or Section 1901.2 of the IBC, whichever is greater.

2.4.2 Panel Placement: Rastra panels may be laid horizontally or vertically provided horizontal and vertical reinforcement is placed in accordance with the approved building plans. See Figure 2 for a typical panel layout. If panels are stacked horizontally, whalers can be used and dry stacking is permitted. If panels are laid vertically, either foam adhesive or clamps may be used to affix the panels to each other in accordance with the Rastra installation instructions.

2.4.3 Reinforcement: Horizontal reinforcement is permitted to rest directly on the Rastra material in the cells of the panels. Vertical reinforcement must be placed in accordance with the design drawings before concrete is poured. Lap splices for the reinforcement must comply with requirements of Section 1912 of the UBC, or Section 1923 of the IBC, or Section R611.7.1 of the IRC.

2.4.4 Concrete: Concrete must fill all voids of the Rastra wall panels. Concrete can be placed in single-story lifts or in lifts by moving along the walls and returning immediately for the second and subsequent lifts. Field verification of a proper pour can be accomplished by pushing a $^1/_4$-inch-diameter (3.2 mm) steel rod through the face shell of the panels into the concrete core and noting upon its withdrawal the presence of wet concrete on the rod.

2.4.5 Wood Ledgers: Wood ledgers must be attached to the Rastra wall. The face shell of the Rastra panel can remain in place. Wood ledgers are attached by cutting 6-inch-diameter (152 mm) holes into the face shell of the panel at the location of a horizontal or vertical core at spacing required by design, before the placement of the concrete. A dam must be used to hold the J-bolt centered in the hole. When concrete is poured into the wall system, the holes provided for the J-bolts form a solid concrete connection from the ledger board to the horizontal bond beam.

2.4.6 Wood Plates: Wood plates must be anchored to the top of the wall. Anchor bolts used to connect the wood ledgers or plates to the concrete must be cast-in-place, with the bolts sized and spaced as required by design.

2.5 Interior Finish:

Rastra wall panels are permitted to be exposed to the interior of the building since the Thastyron™ material satisfactorily passes testing in accordance with UBC Standard 26-3. When an interior finish is provided, such as gypsum wallboard or plaster, the attachment of the finish is to be in accordance with the manufacturer's installation instructions.

2.6 Exterior Finish:

2.6.1 Above Grade: Exterior walls can be left unfinished or may be finished with an approved wall-covering in accordance with the applicable code or a current evaluation report. Negative wind pressure capacity of the exterior finish material is recognized in the code for generic materials or in a current evaluation report for proprietary materials.

2.6.2 Below Grade: Wall surfaces must be dampproofed and, when required by the local building department, waterproofed in accordance with Appendix 18 of the UBC, or Section 1806 of the IBC, or Section R406 of the IRC. Dampproofing and waterproofing materials must be approved by Rastra Corporation and the local building official.

2.7 Foundation Walls:

The wall system is permitted to be used as a foundation stem wall supported on concrete footings complying with UBC Table 18-I-C, IBC Table 1805.2, or Section R404 of the IRC.

2.8 Retaining Walls:

The wall system is permitted to be used as a retaining wall with reinforcement designed in accordance with this report and accepted engineering principles.

2.9 Crawl Spaces:

The Rastra wall system in underfloor crawl spaces is permitted to be exposed to the crawl space, provided ventilation complies with Section 2306.7 of the UBC, or Section 2304.11.9 of the IBC, or Section R408.1 of the IRC.

2.10 Fire-resistive Construction:

Wall assemblies constructed from minimum 10-inch-thick (254 mm) Rastra panels have a four-hour fire-resistive rating for walls that are load-bearing or nonload-bearing. The Rastra panel units, having widths of $7^1/_2$, 15, or 30 inches (190, 380, or 760 mm), are installed in accordance with Section 2.4 of this report. The cavity of the Rastra panels system must be filled with normal-weight concrete using either carbonate or siliceous aggregate. The concrete must be reinforced with reinforcing bars in accordance with this report and the approved building plans.

2.11 Special Inspection:

Except for foundation stem walls conforming with Table 18-I-C of the UBC or Table 1805.4.2 of the IBC, special inspection is required during the taking of test specimens and the placing of reinforced concrete, as noted in Section 1701.5 of the UBC. For buildings regulated by the IBC, special inspections and verification of concrete construction are required in accordance with Section 1704.4 and Table 4.4 of the IBC. Special inspection is not required when regulation is by the IRC.

When the building official approves, special inspection is not required for construction regulated by the UBC when all of the following conditions are met:

1. Wall systems are a maximum of 8 feet (2438 mm) high and are limited to use in single-story construction of Group R, Division 3, or Group U, Division 1, Occupancies.

2. Maximum height of individual concrete lifts is 48 inches (1219 mm). Succeeding lifts must be placed in accordance with Section 1905.10.5 of the UBC.

3. Installation is by properly trained installers approved by Rastra Corporation.

4. Compressive strength (f'_c) of concrete used in design is one-half of that specified.

2.12 Identification:

Each package bears a label carrying the Rastra Corporation name and address, the Rastra logo and trademark, the evaluation report number (ER-4203), and the name and logo of the inspection agency (Underwriters Laboratories Inc.).

3.0 EVIDENCE SUBMITTED

Quality control manuals, and data in accordance with the ICC-ES Acceptance Criteria for Concrete Floor, Roof and Wall Systems and Concrete Masonry Wall Systems, (AC15), dated June 2003; UBC Standard 2-1 (ASTM E 136); UBC Standard 7-1 (ASTM E 119); and UBC Standard 26-3.

4.0 FINDINGS

That the Rastra panel system described in this report complies with the 1997 *Uniform Building Code*™ (UBC), the 2000 *International Building Code*® (IBC), and the 2000 *International Residential Code*® (IRC), subject to the following conditions:

4.1 Panels are manufactured, identified, and installed in accordance with this report and the manufacturer's installation instructions.

4.2 When required by the building official, calculations showing compliance with the general design requirements of Chapters 16 and 19 of the UBC and IBC are submitted to the building official for approval, except that calculations are not required when the building design is based upon Section 2.3.3 or 2.3.4 of this evaluation report.

4.3 When regulation is under the UBC or IBC, special inspection is provided in accordance with Section 2.11 of this report.

4.4 When regulation is under the IRC, compliance with Section R324.4 of the IRC must be demonstrated.

4.5 The Rastra units are manufactured for Rastra Corporation by Eterna Building Systems, Inc., in Pima, Arizona, and by Rastra New Mexico Corp., in Albuquerque, New Mexico, under a quality control program with inspections by Underwriters Laboratories Inc. (AA-668).

This report is subject to re-examination in one year.

TABLE 1—RASTRA WALL PANEL REINFORCING SCHEDULE FOR THE PRESCRIPTIVE DESIGN APPROACH SPECIFIED IN SECTION 2.3.4 OF THIS EVALUATION REPORT[1,2,3,4,5]

WALL CONDITION	SEISMIC ZONES	SEISMIC CATEGORIES	REINFORCING	
			Horizontal	Vertical
Crawl space wall and above-grade wall	0, 1, 2A, 2B	A and B	#3 ea. cell	#3 ea. cell
	3 and 4	C and D	#4 ea. cell	#4 ea. cell
Basement wall with height of backfill "H" ≤ 5' - 0"	All	A, B, C, D	#4 ea. cell	#4 ea. cell
Basement wall with height of backfill "H" > 5' - 0"	All	A, B, C, D	#4 ea. cell	#5 ea. cell

For **SI:** 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 psf = 0.48 kN/m^2, 1 plf = 14.6 N/m, 1 mph = 1.61 km/h, 1 pcf = 16 kg/m^3, 1 psi = 0.0069 MPa, 1 ksi = 6.72 MPa.

[1]Maximum floor and roof joist spans shown on wall sections are based on total floor load = 55 psf and total roof load = 50 psf. Other loading combinations are allowed, with a maximum total superimposed load on the top of the wall equal to 2,500 plf.
[2]Maximum allowable wind pressure based on 100 mph, Exposure C.
[3]Equivalent fluid pressure of soil = 62.5 pcf.
[4]Concrete: f'_c = 2,500 psi, minimum. All voids must be filled.
[5]Reinforcing steel: F_y = 60 ksi. All reinforcing must be lapped as follows: #4 - 18 inches, #5 - 24 inches. Corner bars must be provided with 24-inch legs at every course at all corners and intersections.

TABLE 2—LINTEL REINFORCING SCHEDULE FOR THE PRESCRIPTIVE DESIGN APPROACH SPECIFIED IN SECTION 2.3.4 OF THIS EVALUATION REPORT[1,2]

MAX. LOAD PER FOOT	OPENING LENGTH IN WALL						
	2' - 0"	3' - 0"	4' - 0"	6' - 0"	8' - 0"	10' - 0"	12' - 0"
	Lintel Reinforcing Schedule						
100 plf	#4	#4	#4	#4	#4	#4	#4
200 plf	#4	#4	#4	#4	#4	#4	#4
400 plf	#4	#4	#4	#4	#4	#5	#5
600 plf	#4	#4	#4	#4	#4	—	—
800 plf	#4	#4	#4	#4	—	—	—
1,000 plf	#4	#4	#4	#4	—	—	—
1,200 plf	#4	#4	#4	—	—	—	—
1,500 plf	#4	#4	#4	—	—	—	—
2,000 plf	#4	#4	—	—	—	—	—
2,500 plf	#4	—	—	—	—	—	—

For **SI:** 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 plf = 14.6 N/m.

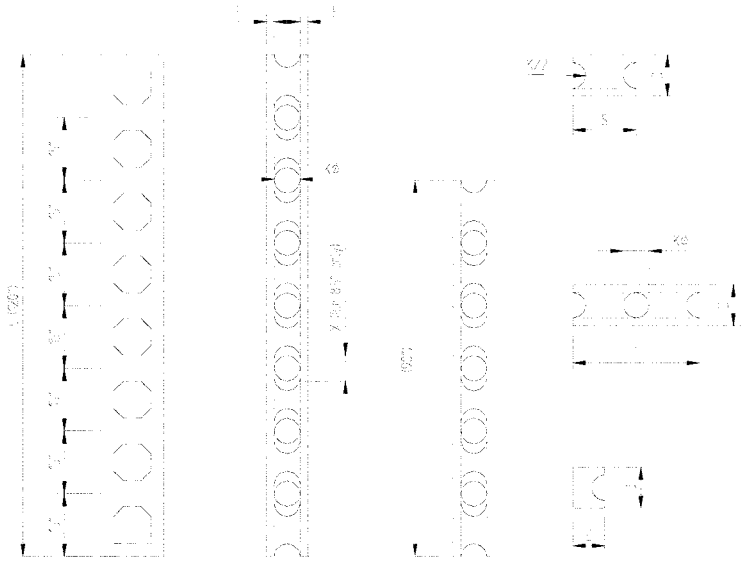
[1]Combinations below the heavy solid line require a minimum of two #3 stirrups every vertical cell, spaced at $4^3/_4$ inches on center over the entire length of the lintel. Combinations above the heavy solid line require a minimum of one #3 stirrup every vertical cell over the entire length of the lintel.
[2]Lintel reinforcing shall extend a minimum of 2'-0" past the edge of the opening.
[3]This reinforcement schedule is based on lintels having a depth such that the distance from the extreme compression fiber to the centroid of the flexural reinforcement is a minimum of 30 inches.

TABLE 3—ALLOWABLE IN-PLANE SHEAR CAPACITY OF RASTRA SHEAR WALLS FOR THE PRESCRIPTIVE DESIGN APPROACH SPECIFIED IN SECTION 2.3.4 OF THIS EVALUATION REPORT[1]

WALL LENGTH "L"	ALLOWABLE IN-PLANE SHEAR CAPACITY (plf)
L < 4' - 0"	0
4' - 0" ≤ L < 6' - 0"	400
6' - 0" ≤ L < 8' - 0"	600
L ≥ 8' - 0"	800

For **SI:** 1 foot = 304.8 mm, 1 plf = 14.6 N/m.

[1]Walls must be reinforced with horizontal and vertical rebar in accordance with Table 1.



DIMENSIONS - in (mm)

D	K	F	L	S	T	E	X
8.5" (215)	5" (127)	1.75" (45)	90"(2286)	15"(380)	30"(760)	7½"(190)	5.25"(135)
10" (250)	6" (152)	2" (50)	90"(2286)				N.A.
12" (305)	6" (152)	3" (76)	or				
14" (355)	6" (152)	4" (100)	120"(3050)				

VOLUMES and WEIGHTS

Thickness ins(cm)	Length ins(cm)	Standard Element cuft(dm^3)			End Elem.	Weight Std.E. ≤ lbs(kg)
		Outside	Cavity	Net	Net	
8.5"(21.5)	90"(228)	6.64 (188)	1.97 (56)	4.67 (132)	-	112 (51)
10"(25)	120"(305)	10.42 (294)	3.67 (104)	6.75 (190)	4.22 (119)	158 (72)
	90"(228)	7.81 (221)	2.73 (77)	5.08 (144)	3.17 (90)	120 (54)
12"(30.5)	120"(305)	12.5 (354)	3.67 (104)	8,83 (250)	5.26 (149)	197 (90)
	90"(228)	9.37 (265)	2.73 (77)	6.64 (188)	3.95 (112)	148 (68)
14"(35.5)	120"(305)	14.58 (412)	3.67 (104)	10.91 (308)	6.31 (178)	243 (110)
	90"(228)	10.94 (309)	2.73 (77)	8.21 (232)	4.73 (134)	183 (83)

FIGURE 1—CONFIGURATION AND DIMENSIONS OF RASTRA® PANELS

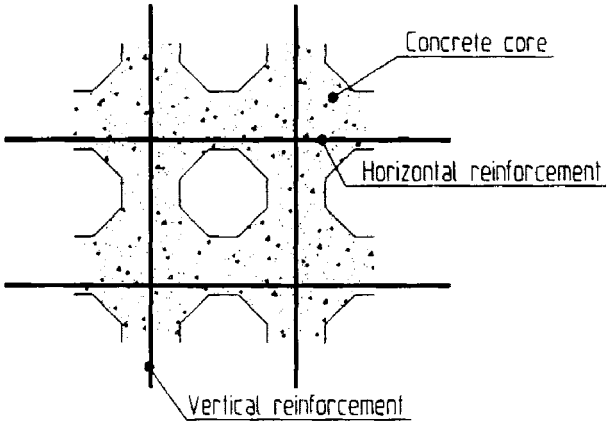
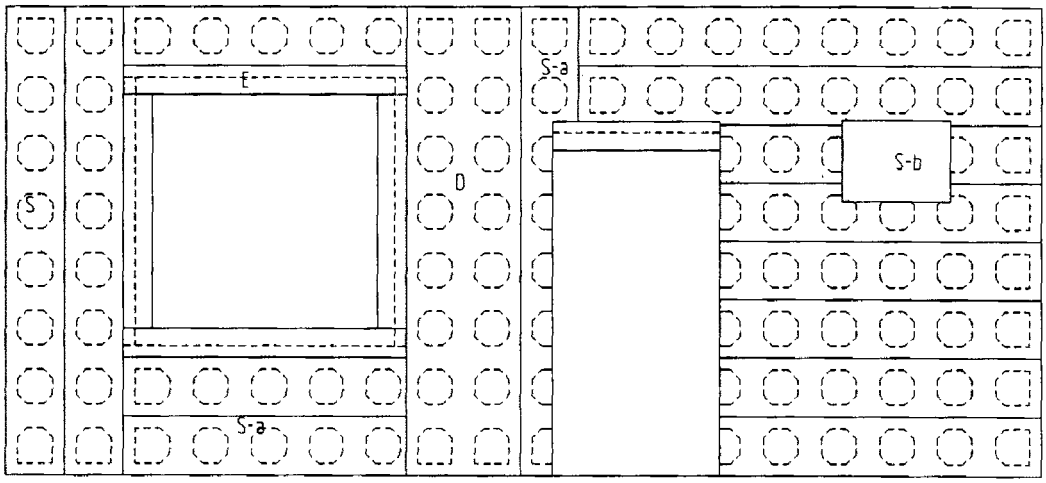
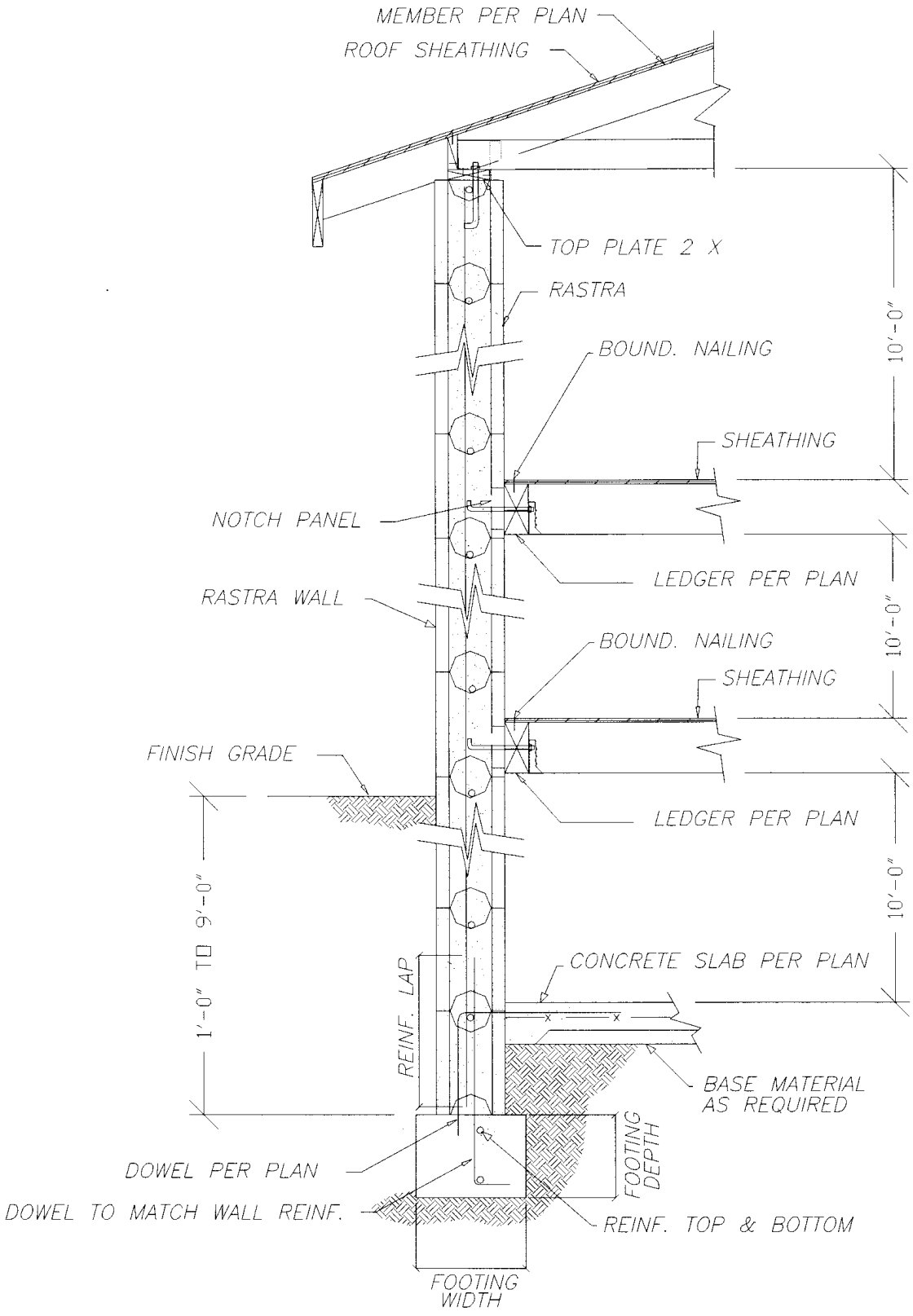


FIGURE 2—PLACEMENT OF REINFORCEMENT WITHIN THE WALL



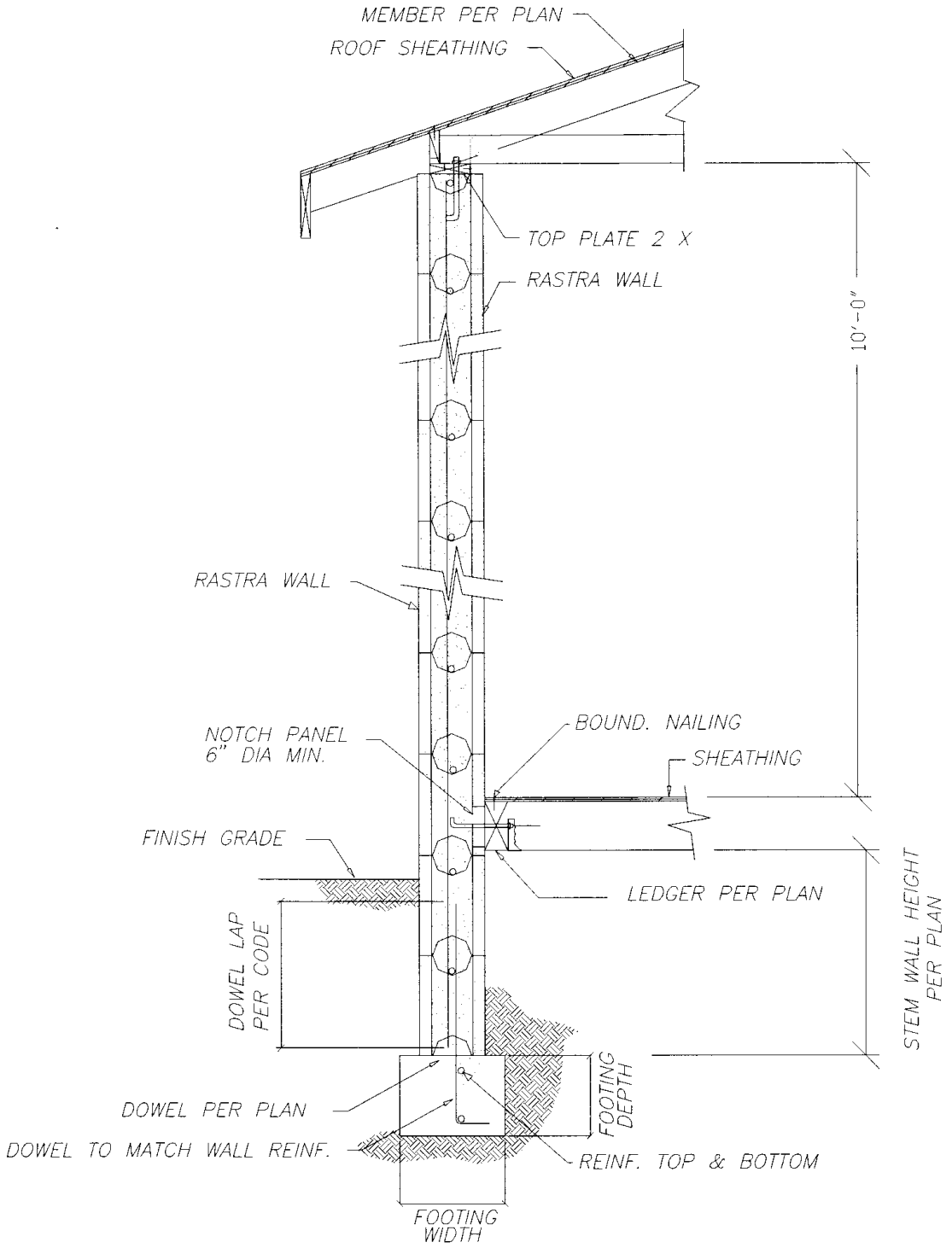
S	Standard panel
E	End panel
D	Double panel
S-a	Standard panel cut to fit
S-b	Smaller openings cut out before concrete is poured

FIGURE 3—EXAMPLE OF A RASTRA® WALL PANEL LAYOUT SCHEDULE



For **SI:** 1 inch = 25.4 mm, 1 foot = 304.8 mm.

FIGURE 4—TWO-STORY PLUS BASEMENT HEIGHT LIMIT DETAIL WHEN USING THE PRESCRIPTIVE DESIGN APPROACH SPECIFIED IN SECTION 2.3.4 OF THIS EVALUATION REPORT



For **SI:** 1 inch = 25.4 mm, 1 foot = 304.8 mm.

FIGURE 5—ONE-STORY HEIGHT LIMIT DETAIL WHEN USING THE PRESCRIPTIVE DESIGN APPROACH SPECIFIED IN SECTION 2.3.4 OF THIS EVALUATION REPORT