APPENDIX G
SAMPLE PROBLEMS

All the data necessary for the approval of the adequacy of a permanent foundation for the manufactured home can be located in this handbook and on worksheets submitted by the homeowner. The HUD field office (or user) must refer to Design Worksheet as a guide through the process of collecting and verifying data.

There are two steps in the approval process: (1) the Owner's Site Acceptability / Manufacturer's Worksheets, with accompanying forms as required, from the owner, and (2) the Design Worksheet. The reader is referred to the completed worksheet samples in Appendix E.

Example #1 is a proposed site for a **multi-section** manufactured home in Champaign, Illinois. The **marriage wall has two adjacent large openings of 16 and 12 feet respectively**. The remainder of the wall is continuous. Both the Owner's Site Acceptability / Manufacturer's Worksheet and the Design Worksheet for Example 1 have been filled out. Asterisks (*) on the Design Worksheet mark the items that were filled in based on data submitted by the owner. The remaining data on the Design Worksheet must be collected from the handbook as described herein.

COMMENTS - EXAMPLE # 1

Item #   DESIGN WORKSHEET

Part 1 -- Site Conditions

9. Refer to the Average Depth of Frost Penetration map on page H-4. The average frost depth for Champaign Illinois is 30 inches.

14. Refer to the Termite Infestation map on page H-10. The site is in a moderate to heavy infestation region.

15. The owner has indicated compliance with CABO R.308.

Part 3 -- Design Loads

21. Calculate the distributed weight per foot of length by dividing the total weight of the home by its length: 33,040/56=590 lbs./ft.

Dead Load

25. From Table 4-1 (402-1.A1). The light dead load value is 560 lbs./ft.

26. From Table 4-1, the heavy dead load value is 805 lbs./ft.

27. Yes, the distributed weight of the home is within the limits defined by this document. The design tables may be used.

Snow Load

28. Refer to the Ground Snow Load (Pg) map on page H-12 for the central United States. The average ground snow load is 20 psf.

29. Refer to Section D-200.2.B for minimum roof live load based on roof slope. For a 2 in 12 roof slope, the minimum roof live load is 20 psf.

30. Comparison of roof snow load (14 psf) and minimum roof live load, minimum roof live load is greater; therefore, it controls.

Wind Load

31. Refer to the Design Windspeed map on page H-14. The site location is near the 70 mph design wind isobar. Use minimum 80 mph for *MPS* in lieu of map value.

32. Based on the map provided by the owner, the site is not near a hurricane coastline. The site is Inland.

Seismic Load

38a. Refer to the maps for Seismic acceleration Aa and Av on pages H-15 and H-16. The site has Seismic acceleration values: Aa = 0.05 and Av = 0.05.

38b. Residential construction is exempt from seismic considerations if Av is less than 0.15.

41. Checking the Foundation Design Concept Tables for Type **E1**, this foundation type is not recommended for seismic areas where Aa and Av are greater than or equal to 0.3. This is because the piers are unreinforced. The Type E1 concept is permitted in seismic areas where Aa and Av are greater than 0.3, if the piers are reinforced.

Part 4 -- Final Design Procedure

42. From the table (600-2.A.1), the nominal width for a 13'-6" home width is 14'-0".

44. The user will compare the Foundation Design Concept, Figures 6-7 and 6-8 with foundation drawings and details provided by the owner. The concept drawings identify the bearing and vertical anchorage locations. An anchorage system for the transverse and longitudinal directions must be clearly shown on the documents provided by the owner.

Required Footing Size

49. In order to determine the Required Footing sizes, the user needs the data from the following items on the Owner’s Site Acceptability Worksheet: Nos. 10 or 11 and on the Design Worksheet: Nos. 24, 30, 43, 48.

Item Number

#10 or #11	Net allowable soil bearing pressure = 1000 psf
#24	Foundation System, Multi-Section type **E1**
#30	Ground snow load Pg = 20 psf. Use 30 psf for the Foundation Design Table. The 30 psf value with load factors applied is equivalent to a minimum live load of 20 psf.
#43	Nominal Building width: Wt = 14'-0"
#48	Pier Spacing: Interior and exterior piers, 5'-0"; Continuous Marriage wall piers, 8'-0".

Next the user will locate the Required Effective Footing Area tables in Appendix B, Part 1. The user locates the table for a multi-wide E with a nominal width of 14 feet.

49. The user finds a note which indicates that the minimum longitudinal foundation wall footing width is 1 foot.

50. Interior pier and exterior pier

1) For the interior and exterior piers, the user finds the block of values for minimum roof live load of 20 psf.

2) Next, the user finds the two rows of values for a Net Allowable Soil pressure of 1000 psf (read ext, int row).

3) Under the column for a pier spacing of 5 feet, the required pier footing area is 2.1 square feet (1'-6" x 1'-6").

51a. Continuous Marriage Wall Piers

1) Refer to the same block of values as for the exterior/interior footings.

2) Next the user finds the second line of values for a Net Soil Pressure of 1000 psf (labeled mar).

3) Under the column for a marriage wall pier spacing of 8 feet, the required pier footing area is 6.9 square feet (2'-8" x 2'-8").

51b. Marriage Wall Openings

1) Refer to the lower block of values as for the ext/int footing.

2) Next, the user finds the average of two adjacent openings from item#48 (14 feet). Read area of footing at piers under posts as 11.4 sq.ft. (3’-6”x3’-6”).

Vertical Anchorage Requirements In The Transverse Direction

52. In order to determine the Required Vertical Anchorage the user needs the data from the following items on the Design Worksheet: Nos. 24, 31, 32, 43. With this information, the user can determine Vertical Anchorage in the transverse direction by using the appropriate table in Appendix B, Part 2.

1) The user locates the Tables for a Multi-Section E with a nominal width of 14 feet and 2 tie-downs.

2) Then the user finds a block of values for the Inland condition.

3) To the right of the 80 mph wind value, the user finds a value of 130 lbs./ft along the longitudinal exterior walls.

53. The user verifies that the manufacturer's design value (200 lbs./ft.) shown on line 16b of the Manufacturer’s Worksheet is greater than the required value shown on line 52a. Otherwise repeat the process with four tie-downs.

Horizontal Anchorage Requirements In The Transverse Direction

55. Two (2) transverse foundation shear walls are initially selected in order to compare the required horizontal anchorage with the values provided by the manufacturer. This is trial #1.

56. In order to determine the Required Horizontal Anchorage the user needs data from the same items on the Design Worksheet that were required for Approval item number 52a plus item No. 22 (namely, the building length L = 56'-0"), No. 30, roof snow/minimum roof live load and No. 36, Seismic Acceleration values. Proceed knowing that you are exempt from seismic considerations.

Next, the user will locate the Required Horizontal Anchorage table in Appendix B, Part 3.

1) The user locates the tables for a Multi-Section E with a width of 14 feet and two (2) transverse walls.

2) Then the user finds the block of values for the Inland condition and the line of values for a design wind speed of 80 mph.

3) Then the user finds Seismic Aa range 0.05-0.2 and snow load range 0-100 psf. Only one row of values remains.

4) For a length L of 56 feet, the user rounds the value to the next highest number shown on the top line of the table -- 60 feet.

5) Under the column of values for 60 feet, the user finds the required anchorage Ah = 420 pounds per lineal foot along the length of each transverse shear wall. Note that the value was not grayed over, indicating the force calculations were controlled by wind.

Note: if the manufacturer has specified (1) diagonal metal straps to complete the transverse short foundation walls, or (2) vertical x-bracing in place of transverse foundation walls, for comparative purposes, the user shall use the formulas in section 602-5.G.1 or 602-5.G.2 and proceed with item #55b or #59 respectively.

58. Verify the Manufacturer's design value shown on line 57a (400 plf) is greater than the required value shown on line 56. Since it is not (420 > 400), attempt trial #2 ans consider 4 short walls. Repeat steps 1) to 5). Read (Ah) exterior 140 plf and (Ah) interior 280 plf, both less than the manufacturer’s value 400 plf. Thus, 4 short walls will provide adequate sliding resistance.

Horizontal Anchorage in the Longitudinal Direction

62a. In order to determine the Required Horizontal anchorage in the longitudinal direction the user needs the same data as used in steps 52 and 56 from the Design Worksheet.

Next, the user will locate the Required Horizontal Anchorage in the Longitudinal Direction tables in Appendix B, Part 4.

1) The user locates the table for a Multisection unit Type E with a nominal width of 14 feet.

2) Then the user finds Seismic Aa range 0.05-0.1 and snow load range 0-100 psf.

3) Then the user finds the block of values for the Inland condition and the row of values for a design wind speed of 80 mph.

4) For a length L of 56 feet, the user rounds the value to the next highest number shown on the top row of the table -- 60 feet.

5) Under the column for 60 feet, the user finds the required anchorage force Ah = 67 plf along each of the longitudinal exterior shear walls. Note that the value was not grayed over indicating that the force calculations were controlled by wind, not seismic.

Note: if the manufacturer has specified a diagonal metal strap X-bracing in place of the shear wall, for comparative purposes, the user shall use the formulas in section 602-5.F, which are based n the required anchorage (Ah) found in the tables. This could be the case for Type C or I units.

64. Verify the manufacturer's design value on line 63 is greater than the required value shown on line 62a.

Withdrawal Resistance Verification

67. For type E foundations answer item 67a.

67a. For this example, a masonry foundation fully grouted was depicted on the documents submitted by the owner.

1) Checking the tabular columns of Table C-1, Appendix C, for Masonry-Fully Grouted, the lowest value greater than (Av) is 231 lbs. per foot. Thus, 231 > 130 (from item #52).

2) The footing depth (Hw) is found in the far left column, hw = 2'0'. This value corresponds to the minimum depth of the footing below grade which is shown in the illustration above the table.

3) The width of the footing is found at the top of the column, 12".

4) Based on item #9, the frost depth for Champaign, IL. is 30 inches. Based on Table C-1, the depth of the base of the footing below grade is :

from Table C-1:

hw =	24"	
	+ 6"	(footing thickness)
	30"	for withdrawal resistance

for frost protection:

hw =	30"	(depth below grade)
	+ 12"	(min. wall height above grade)
	42"	

therefore; frost protection controls over withdrawal resistance

42"	
- 12"	(min. wall height above grade)
30"	(bottom of footing to grade)

for establishing the number of block courses:

42"	
- 6"	(footing depth)
36"	min. required foundation wall height

Use hw = 40", which is a multiple of the 8" masonry unit -- 40" = 5 block courses.

5) Interior piers under (item #67b.3.) chassis beams do not participate in vertical anchorage for this example. Frost depth considerations are accounted for at the perimeter walls. Interior piers may be set below the 18 " of topsoil on undisturbed soil. See item #50 for required footing size.

6) Item #67c.; Marriage wall piers do not participate in vertical anchorage in any case, and do not need to set at frost depth. Again, set footings below the 18" of topsoil onto undisturbed soil.

Vertical anchorage and reinforcement for longitudinal foundation walls and piers

68. For type **E** foundations answer item 68a.

68a.

1) From item #52, the value for (Av) was 130 lbs./ft. Using Table C-4A for a masonry foundation wall, the first value in the left

hand column is 146 lbs. per foot of wall. The 146 lbs./ft. value utilizes the maximum recommended anchor spacing by code as 6'-0" o.c. The wood material connected to the anchor bolt with a standard washer controls the final capacity. (Note the similarity in capacities with a treated wood foundation wall, Table C-4B, since wood bearing on washer controls).

2) For a masonry wall grouted solid, the following sizes are required:

   On Table C-4A - on the same line as +146 lbs./ft., read:

   a) Anchor Bolt diameter = 1/2"

   b) Anchor Bolt spacing = 72"

   On Table C-3A - on the same line as 1/2" anchor bolt diameter read:

   c.1) Rebar size = #4

   2) Lap splice = 16"

   3) Rebar hook length = 6"

Horizontal Anchorage and Reinforcement for Transverse Foundation Walls

69a. From item number 56, the value for transverse (Ah) is 140 lbs. per foot along the transverse end (shear) wall and 280 lbs. per foot along the interior transverse walls. Using Table C-5A for a masonry foundation wall, the first value in the left hand column is 300 lbs. per foot of wall which is greater than either end or interior (Ah). The 300 lbs./ft. value is based on the maximum recommended anchor spacing of 6'-0" o.c. by code. The material connected to the anchor bolt will control the final capacity.

1) For masonry walls grouted solid, the following sizes are required:

   On Table C-5A: On the same line as Ah = 300 lbs./ft., read:

   a. Anchor bolt diameter = 1/2"

   b. Anchor bolt spacing 72" (cores must be grouted solid)

   On Table C-3A: On the same line as 1/2" anchor bolt diameter, read:

   c.1) Rebar = #4

   2) Lap splice = 16"

   3) Rebar hook length = 6"

Horizontal Anchorage and Reinforcement for Longitudinal Foundation Walls

70a. From item #62a, the value for longitudinal (Ah) is 67 plf. From Table C-5A, again the 300 plf value is adequate. All other information for reinforcement is the same along the exterior longitudinal walls.

Summary Sheet

The values can be brought forward on to the summary sheet and the design approved.

EXAMPLE 2

Example #2 is a proposed site for a **single-section** manufactured home in Tampa Florida. The data on the Owner's Site Acceptability Worksheet remains the same as Example #1, with the exception of item 1. The grade elevation is 28 feet. The data on the Manufacturer's Worksheet, regarding the superstructure, remains the same as Example #1 with the exception of the following items:

Item #		Data
1.		Single-section (Nominal 14' wide unit)
2.		Type C
7.		Roof slope = 4 in 12
8.		Unit weight = 16,500 lbs.
10.		Type C1
11a.		Pier Spacing = 7 ft.
11b.		NA
11c.		NA
11d.		7 Tie-down straps at 8'-8" spacing **Note**: Tie-downs are required to be at 2'-0" in from each end of the unit. (Section 601-2.B.)
14.		Design wind = 120 mph
16b.		Uplift capacity = 3,150 lbs./tie-down
16c.		Sliding capacity = 4,800 lbs./diag. set
16d.		Sliding capacity = 4,800 lbs./diag. set
16e.		Vertical X-bracing tension capacity = 5600 lbs./strap

Asterisks (*) on the HUD Approval Worksheet mark the items that were filled in based on data submitted by the owner. As demonstrated in Example #1, the remaining data must be collected from the handbook as described herein.

Item #   DESIGN WORKSHEET

Part 1 -- Site conditions

9. Refer to the Frost Penetration map on page H-4. The average **frost depth** for Tampa Florida is **zero inches**.

14. Refer to the Termite Infestation map on page H-10. The site is in a **very heavy** infestation area.

15. Yes, the owner has indicated compliance with CABO R-308.

Part 3 -- Design Load

23. The distributed weight is the weight of the home divided by its length:

    16,500 / 56 = 295 lbs./ft.

25. From Table 4-1 (402-1), the light dead load value is 290 lbs./ft.

26. From Table 4-1, the heavy dead load value is 425 lbs./ft.

27. Yes, the distributed weight of the home is within the limits defined by this document. The design tables may be used.

Snow Load

28. Refer to the Ground Snow Load map on page H-13 for the Eastern United States. The average **ground snow load** is **zero**.

29. Based on a 4 in 12 roof slope, the minimum roof live load is 15 psf (D-200.2.B).

30. The **15 psf minimum roof live load** controls.

Wind Load

31. Refer to the Design Wind Load map for the Eastern United States on page H-14. The average wind load is near the 100 mph design wind isobar, which exceeds the *MPS* minimum of 80 mph. Thus, **100 mph wind speed** is used for the foundation design.

32. Based on the map provided by the owner, the site is located on a hurricane coastline. The site is **Coastal**.

33-36. The manufacturer should supply details consistent with a coastal high wind site.

Seismic Load

38. Refer to the Seismic Acceleration maps on pages H-15 and H-16. The seismic coefficients for Hillsborough County, Aa and Av = 0.05. Residential construction is ex-

empt from seismic consideration since Av < 0.15.

41. Checking the Foundation Design concepts for Type C1, it is permitted for use when seismic coefficient Av < 0.15. It is not acceptable for use in areas where Aa and Av greater than or equal to 0.3.

Part 4 -- Final Design Procedure

43. From the Section 600-2.A table, the nominal width for a 13'-8" home width is 14'-0".

44. The user will compare the Foundation Design concept illustrations with foundation drawings and details provided by the owner. The concept drawings identify the anchorage locations. An anchorage system must be clearly shown on the documents provided by the owner.

Required Footing Size

49. In order to determine the Required Footing size, the user needs the data from the following items on the Owner's Site Acceptability Worksheet item #10 or #11 and on the Design Worksheet: Nos. 24, 28-30, 43, 48.

Item Number

#10 or #11 Net allowable soil bearing pressure = 1000 psf from Owner's Worksheet.

#24 Foundation System, Single-section type C1

#28-#30 Ground Snow Load Pg = 0 psf. Use a minimum roof live load of 15 psf for the Foundation Design Load Tables.

#43 Building nominal width: Wt = 14'-0"

#48 Pier Spacing: Exterior = 7'-0"

Next the user will locate the Required Effective Footing Area Tables in Appendix B, Part 1.

1) The user locates the tables for a Single-section Type C with a width of 14 feet.

2) Find the block of values for a Minimum Roof Live Load of 15 psf.

3) Next the user finds the row of values for a net allowable soil pressure of 1000 psf.

4) Last, the user finds the intersection of that row with the column for a 7'-0" foot pier spacing. The required footing area is 5.3 square feet (2'-4" x 2'-4").

Vertical Anchorage Requirements in the Transverse Direction

52a. In order to determine the Required Vertical Anchorage the user needs the data from the following items on the Design Worksheet: Nos. 24, 31, 32, 43 and 48. With this information, the field officer can locate and determine the Required Vertical Anchorage tables in Appendix B, Part 2.

Use the tables for a Type C1 system. Then multiply Av x Tie-down spacing.

Item No. Data

#24 Foundation System: Type C1 - Single-section

#31 Design Windspeed: 100 mph

#32 Site Location: Coastal

#43 Building Nominal Width: 14'-0"

#48 Tie-down Spacing: s_t = 8'-8". Number of tie-downs is 7 from (N):

$$N = \frac{L - 2 \times 2'}{s_t} + 1$$

1) The user locates the Required Vertical Anchorage (Appendix B, Part 2) tables for a Single-section Type C1 with a nominal width of 14 feet.

2) Then the user finds a block of values for the Coastal condition.

3) Locate the row for a wind speed 100 mph. The user finds the required vertical anchorage Av = 350 lbs./ft. of home length and multiplies this by a tie-down spacing of 8.667 feet (3033 lbs.) or conservatively move across the row to the next largest anchor spacing (10') and reads 3460 lbs. as an approximate check.

4) The Required Vertical Anchorage force for a tie-down is 3033 lbs.

54. The manufacturer's supplied value, item #53, is 3,150 pounds, which is more than the Required Vertical Anchorage of 3,033 pounds. Note: see optional details in Appendix A for Type **C1**. If the manufacturer's supplied value had been less than Av, the owner would have been notified. The owner would need to contact the manufacturer in order to have a licensed structural engineer verify the existing design or modify the anchor design or spacing to comply with the required anchorage.

Horizontal Anchorage in the Transverse Direction

56. In order to determine the Required Horizontal Anchorage, the user needs data from the same items on the Design Worksheet that were required for Approval item number 52a and item No. 22 (the building length L = 56'-0"). Also required is item #9 (6'-10") from the Manufacturer's Worksheet.

Next, the user will locate the Required Horizontal Anchorage table in the transverse direction in Appendix B, Part 3.

1) The user locates the tables for a Single-section Type C, E or I with a nominal width of 14 feet and initially selects two transverse walls for trial #1. This is required to initiate the process of selecting vertical X-bracing planes for horizontal anchorage in the transverse direction.

2) Then the user finds the block of values for the Coastal condition and the row of values for a design wind speed of 100 mph. All Seismic is on the same horizontal line, even though it need not be checked.

3) For a length L of 56 feet, the user rounds the value to the next highest number shown on the top row of the table -- 60 feet.

4) Under the column of values for 60 feet, the user finds the required anchorage (Ah) of 1240 pounds per lineal foot along the length of each transverse foundation wall (2 shear walls).

59c. The required horizontal anchorage per X-brace set (C) is calculated using the procedure of Section 602-5.G.2, illustrated in Figure 6-10.

Process always begins by selecting 2 short walls, then:

1. From item #56, Ah = 1240 lbs./ft.

2. Solving equation for H:

$$H = \frac{1240 \times 13.67 \times 2}{56} = 605 \text{ lbs./ft. of unit length}$$

Note: actual unit width, rather than nominal width is used here.

3. For a first trial, set spacing equal to a multiple of pier spacing: try 14’-0”. Solving equation for horizontal force at each X-brace set (C):

C = 605 × 14’-0” = 8475 lbs./X-brace set.

Note: number of vertical X-brace planes =

$$\frac{L}{\text{spacing}} + 1 = \frac{56}{14} + 1 = 5$$

therefore, number of X-braced planes equals 5.

61a. Verify that the Manufacturer's design value on line #57a is greater than the required value (C) shown on line #59c. In this example, the manufacturer's design value of 4800 lbs. (#57) is less than the Required Horizontal Anchorage (C) = 8475 lbs. This indicates that the connection of unit to a foundation diagonal is inadequate for sliding resistance.

The owner would be contacted at this point and notified that the horizontal anchorage is not adequate. If an inspector or owner wanted to determine how many vertical X-bracing planes would be required, they could use the following:

<u>Trial #2:</u>

Piers must be present at the extremities of any vertical X-bracing plane; therefore, the next logical choice is the actual pier spacing of 7’-0”.

1. From item #56, Ah = 1240 lbs./ft.

2. Solving equation for H:

$$H = \frac{1240 \times 13.67 \times 2}{56} = 605 \text{ lbs./ft. of unit length}$$

Note: actual unit width, rather than nominal width is used here.

3. C = 605 × 7’-0” = 4235 lbs./X-brace set.

Number of vertical planes =

$$\frac{56'}{7'} + 1 = 9$$

The required horizontal anchorage of 4235 is less than the manufacturer’s rated capacity of 4800 lbs., thus 9 vertical X-bracing planes are required at the same spacing as the piers (7’-0”).

59d. The user must estimate a height (h) on Figure 6-10, which can be revised later if necessary. Try h = 4 feet.

59e. From item #9, Manufacturer’s Worksheet, Wt - 2 dc = 6.83’:

$$\cos\theta_t = \frac{6.83}{\sqrt{4^2 + (6.83)^2}} = 0.863$$

therefore: $\theta_t = 30.4°$

$$T_t = \frac{4235}{0.863} = 4907 \text{ lbs. tension in strap}$$

61b. The rated capacity of a strap in tension, item #60 is greater than the required T_t (item #59e) for 9 vertical X-bracing planes 5600 > 4907, therefore OK.

Horizontal Anchorage Requirements in the Longitudinal Direction

62a. In order to determine the Required Horizontal Anchorage (Ah) in the Longitudinal Direction, the user needs data from the same items in the Design Worksheet that were required for item #56.

Next, the user will locate the Required Horizontal Anchorage Table in the Longitudinal Direction (Appendix B, Part 4).

1) The user locates the table for a Single-section, Type C, E, or I with a nominal width of 14 feet.

2) Then, the user finds the block of values for <u>Aa</u> = 0.05-0.10, ground snow 0-100 psf and coastal site.

3) The user finds the row of values for wind speed of 100 mph.

4) For a length (L) of 56 feet, the user rounds to the next highest length shown across the top row of the table - 60 feet.

5) Under the column for 60 feet, the user finds the intersection value with the row for 100 mph wind speed. Read Ah = 47 lbs./ft. of length along the longitudinal exterior foundation walls, if shear walls exist.

62b. For this example of a Type C1 foundation, no structural exterior longitudinal walls exist, thus vertical X-bracing planes are required between piers under chassis beam lines. Follow the procedure of Section 602-6.F and use the illustration in Figure 6-11 and Figure D-26.

Begin Trial 1 with the minimum required vertical X-bracing planes: n = 2; one pair under each chassis at both ends of the unit length. Follow the equation:

$$B = \frac{47 \text{ plf} \times 56}{2} = 1316 \text{ lbs. of horizontal}$$

force carried by each X-brace set.

64. Verify that the manufacturer's rated value (item #63) is greater than the required horizontal anchorage force (B) of item #62b.2. In this example the manufacturer's value of 4800 lbs. is greater than B. Thus, vertical X-bracing planes at both ends of the unit and under each chassis beam line is adequate.

62b.3 Approximate the height (h) in Figure 6-11 by assuming the chassis beam is 1 foot deep, thus: h = 4' - 1' = 3'.

62b.4 Return to the calculation procedure of section 602.6.F and determine the tension force in a diagonal strap:

first: $\cos\theta_L = \dfrac{7}{\sqrt{3^2 + 7^2}} = 0.919$

therefore: $\theta_L = 23.2°$

next: $T_L = \dfrac{1316}{.919} = 1432 \text{ lbs.}$

66. Verify that the manufacturer's (or product supplier) rated value (item #65) is greater than the required tension (T_L) from item #62b.4. In this example, the manufacturer's value of 5600 lbs. is greater than

(T_L). Thus, the straps proposed are adequate as tension diagonals.

Withdrawal Resistance Verification

67b. For Type C1 foundation answer item 67b for concrete "deadman" footings.

For this example, square concrete footings used as "deadmen" are depicted on the documents submitted by the owner to anchor the tie-down straps. See Appendix A - concept details for Type C1 foundation.

1. From item number 52a, the value for Av is 3033 lbs. per tie-down anchor.

2. Use Table C-2, The Withdrawal Resistance for Piers, in Appendix C. Table C-2 can conservatively be used for concrete footings used as "deadman" anchors. The footing depth (hp) in the far left column can either be hp = 3'-4" for a 3'-0" sq. ft. footing or hp = 2'-0" for a 4'-0" sq. ft. footing. Assume the least costly solution is the 3'-0" square footing.

3. Based on item #9, the frost depth for Tampa, FL. is 0". Thus, the "deadman" footings are at an adequate depth. The pier footings under the chassis beams can be set 8" below grade, if undisturbed soil (not organic material) is available, otherwise, footing must extend to firm bearing strata.

Vertical Anchorage and Reinforcement for Long Foundation Walls and Piers

68. For type C foundations answer item 68b.

1) From item number 52a, the value for Av is 3033 lbs. per foot. The lowest value greater than Av on Table C-3 is 4240 pounds.

2) For the size of bolt set in concrete "deadman" to complete connection to the tie-down rod, from Table C-3:

   a) Number of anchor bolts = 1

   b) Anchor bolt diameter = 1/2"

3) Use Table C-3A for the reinforcement of the piers under the chassis beams. Even though these piers do not directly receive anchorage overturning force, it is desirable to reinforce them to assist in force distribution in the vertical X-bracing planes.

   a) Rebar size = #4

   b) Lap splice = 16"

   c) Rebar hook length = 6"

Horizontal Anchorage and Reinforcement for Transverse Foundation Walls

69c. From item number 59c (Assume the owner decided to use 9 X-bracing planes), the value for (C) is 4235 lbs. per diagonal. Use Table C-5A for concrete. The horizontal capacity of a single bolt is shown at a spacing of 12".

Bolt size	Capacity
1/2"	1800 lbs.

Three 1/2" bolts would be required to connect the diagonal to the footing. Detail the pier footing as shown in Table C-5A. Verify that the rated capacity of the strap exceeds the required tension (T_t).

Horizontal Anchorage and Reinforcement for Longitudinal Foundation Walls

70b. From item #62b.2, record the horizontal anchorage force (B) as 1316 lbs. per X-brace. Again, from Table C-5A, the shear capacity of a 1/2” diameter bolt in concrete is 1800 lbs. One anchor bolt is sufficient into the concrete footing. Detail the pier footing as shown in Table C-5A. Verify that the rated strap capacity exceeds the required tension (T_L).

Summary Sheet

The values can be brought forward on to the summary sheet and the design approved.