DESIGN REQUIREMENTS FOR USING MASONRY VENEERS ON COLD-FORMED STEEL LIGHT-FRAME CONSTRUCTION

By

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To the Faculty of Washington State University:

The members of the Committee appointed to examine the thesis of JOSEPH MICHAEL PIOTROWSKI find it satisfactory and recommend that it be accepted.

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Abstract

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This thesis was written to address the fact that the *International Residential Code* (IRC 2012) offers little aid in the design of cold-formed steel construction when brick veneer is used in regions of higher seismic risk. Using the current provisions for wood light-frame construction when brick veneer is used (BV-WSP) as a template, a series of computer analyses were performed to determine required braced wall line lengths for cold-formed steel. These results were compiled into a table similar to the one for wood, IRC Table R602.10.6.5 (2012), and will be used to propose changes in the next version of the IRC.

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CHAPTER 1

Introduction:

Little consideration has been given to aid in the prescriptive design of cold-formed steel construction when brick veneer is used. Most of the low-rise structures in North America utilize light-frame construction: a repetitively framed system sheathed with load transferring wood structural panels. These structures include residential, industrial, and commercial buildings comprised primarily of wood-based materials. For this reason, numerous research efforts have focused on the seismic performance of this type of construction. Though light-frame buildings consist of various two-dimensional systems, these systems interact to form a highly indeterminate three-dimensional structure. Currently, the *International Residential Code* (IRC) (2012) offers guidance for using brick veneer on buildings located in regions of high seismic risk and framed with wood light-frame construction; however, the IRC needs to be updated to include similar provisions for cold-formed steel construction when brick veneer is used.

A major piece of information missing from the IRC, in regards to light-frame steel construction, is a cold-formed steel table equivalent to Table R602.10.6.5 from the IRC. A section of that table has been provided below in Table 1.1 and shows the minimum total length of braced wall panels required for varying lengths of braced wall lines. This specific excerpt shows the values for structures in Seismic Design Category D_0; however, the full table takes other seismic design categories into consideration as well. The structures considered range from one to three stories, and the stories being considered are noted in the table. In addition to the required lengths of braced wall panels, single-story and cumulative hold-down forces are also provided. Table 1.1 contains useful and necessary information for prescriptive design, which is the reason why a similar table is desired for cold-formed steel.

Table 1.1: Method BV-WSP Wall Bracing Requirements (wood light-frame construction with brick veneer).

<table>
<tr><th colspan="9">Required Length of Braced Wall Panels (ft):</th></tr>
<tr><th rowspan="2">Story Considered</th><th rowspan="2">Number of Stories in Structure</th><th colspan="5">Available Wall Length (ft)</th><th rowspan="2">Story Hold-Down Force (lb)</th></tr>
<tr><th>10</th><th>20</th><th>30</th><th>40</th><th>50</th></tr>
<tr><td>1</td><td>1</td><td rowspan="3">4.0</td><td rowspan="3">7.0</td><td rowspan="3">10.5</td><td rowspan="3">14.0</td><td rowspan="3">17.5</td><td rowspan="3">N/A</td></tr>
<tr><td>2</td><td>2</td></tr>
<tr><td>3</td><td>3</td></tr>
<tr><td>1</td><td>2</td><td rowspan="2">4.5</td><td rowspan="2">9.0</td><td rowspan="2">13.5</td><td rowspan="2">18.0</td><td rowspan="2">22.5</td><td rowspan="2">1900</td></tr>
<tr><td>2</td><td>3</td></tr>
<tr><td>1</td><td>3</td><td>6.0</td><td>12.0</td><td>18.0</td><td>24.0</td><td>30.0</td><td>3500</td></tr>
</table>

*Excerpt adapted from R602.10.6.5 from the 2012 International Residential Code.

CHAPTER 2

Literature Review:

Before proceeding with this project, it is important to have an understanding of previous research on light-frame construction. Therefore, this section will provide a literature review of various related research papers that have been published in well-regarded journals. Kasal et al (1994) provided a thorough summary of past research related to nonlinear finite-element analysis of light-frame wood structures. Some of the first research in this area focused on light-frame components tested under static loading. Tuomi and McCutcheon (1974) tested a light-frame building at various stages throughout construction to better understand the behavior of individual components. This was accomplished by increasing a static pressure until the elements reached failure. Later, McCutcheon et al. (1979) performed similar tests to determine the strength of connections between the various components of light-frame construction. In the early 1980's, researchers began to recognize the need for full-scale tests. While early tests were able to determine the response of individual components, they did little to explain the behavior of light-frame construction as a complete system.

In the late 1980's, full-scale tests became more prevalent. Sugiyama et al. (1988), Stewart et al. (1988), Ohashi and Sakamoto (1988), Phillips (1990), and Phillips et al. (1993) performed full-scale tests on single- and multi-story light-frame wood structures. These tests began to focus on lateral loading, interaction between perpendicular shear walls, element load sharing, cyclic loading, and the verification of analytical models. The light-frame wood building tested by Phillips (1990) was the first test set up specifically for the purpose of verifying an analytical model. This test heavily influenced the work of Kasal et al (1994), who first combined the individual components of a light-frame system into a full-structural model, comparing both experimental and analytical results. Several important conclusions were reached from this research. First, connections between systems can be modeled as nonlinear spring elements with stiffness obtained from experimental data. Second, these tests produced results that can be used to design structural components, in addition to analyzing existing components. Finally, the authors proposed that "Although the loading conditions examined were for static and quasistatic loads only, evaluation of dynamic performance by the same method may be possible" (Kasal et al., 1994).

He et al. (2001) began further investigation on the interaction of structural systems under both static and cyclic loadings. Taking the work of Kasal a step further, He utilized a mechanics-based representation of individual nail connections, similar to the nonlinear spring elements used by Kasal. This provided a way to model both interior and exterior finishes, ultimately producing a more accurate model with better results.

In 2005, Kasal co-authored an article by Collins et al. (2005) that described a new finite element (FE) model capable of both static and dynamic analysis. Using an asymmetric L-shaped building, Collins validated the results of the tests based on global and local responses. "Experimental test results show that the energy dissipation, hysteretic response, the load sharing between the walls, and the torsional response are estimated reasonably well" (Collins et al., 2005). While all of these results were validated, the higher order values were more accurate. In other words, the results for energy dissipation were more accurate than that of load or displacement. Though nonlinear hysteretic springs were used in the model, finishes and other non-structural elements were not included. Therefore, the authors expressed the need for additional testing in order to produce more accurate results. Overall, both static and dynamic tests were analyzed; however, only the static and cyclic tests were verified. For this reason, future tests needed to be performed in order to verify the model under dynamic loading.

Building upon this previous research, van de Lindt et al. (2010) attempted to model a full-scale two-story wood townhouse building as part of the NEESWood Project. This project, created by the Network for Earthquake Engineering Simulation (NEES), was only one of many shake table tests conducted under the NEESWood Project. The analytical model associated with van de Lindt's full-scale test was created in a Structural Analysis Program (SAP) called SAPWood, specifically for the purpose of verifying the accuracy of the software. Referencing some of the previously mentioned research, van de Lindt noted the fact that there have been very few nonlinear FE models of light-frame construction: "Through 2005 only seven numerical models have been developed and, among those, only three were capable of performing nonlinear time-history dynamic analyses" (van de Lindt et al., 2010). Once again, the use of nonlinear springs was prevalent throughout this model. Shear wall elements, chords and struts, and rigid diaphragms were all modeled using these spring elements. Overall, the results of the experiment agreed with the full-scale model; however, the maximum credible earthquake test did not produce an accurate prediction. Van de Lindt et al. (2010) believed that this was due to improper modeling of the stucco and horizontal diaphragm action.

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Van de Lindt, J. W., Pei, s., Liu, H., and Filiatrault, A. (2010). “Three-dimensional seismic response of a full-scale light-frame wood building: Numerical Study.” *J. Struct. Eng.*, 136(1), 56-65.

Van de Lindt, J. W., Pei, S., Pryor, S. E., Shimizu, H., and Isoda, H. (2010). “Experimental seismic response of a full-scale six-story light-frame wood building.” *J. Struct. Eng.*, 136(10), 1262-1272.

CHAPTER 3

Methods:

Before creating the new cold-formed steel tables for the IRC that were mentioned in Chapter 1, it was necessary to consider the assumptions that would describe the basic structure. The ASCE 7-10 Simplified Alternative Method would be used to determine the design values. Therefore, the first assumption was that all of the load in the structure would go to the nearest floor level. In other words, the common assumption that half of the load from the first floor goes directly to the foundation would be made. Additionally, all of the load from the roof would go into the top story. Second, the assumption of constant acceleration with height is assumed by using the ASCE 7-10 Simplified Method (2010). It was also assumed that the building would have 20% openings in all of the walls. This assumption was agreed upon as a common reference value for the minimum number of openings to provide conservatism to the analysis. This assumption would need to be addressed later with an adjustment factor to allow other wall opening combinations as well. Overall, 15 psf was assumed for the roof weight, 10 psf was assumed for the wall weight minus the veneer, and 15 psf was assumed for the floor weight. For the weight of the brick veneer, 50 psf was assumed for structures in Seismic Design Category C and 40 psf was assumed for structures in Seismic Design Categorys D0, D1, and D2. These values were based on common assumptions for this type of construction. In order to maintain consistency with Table R602.10.6.5, Allowable Stress Design (ASD) was used for all of the calculations.

Creating a cold-formed steel table equivalent to Table R602.10.6.5 from the IRC involved numerous iterative calculations. Therefore, it was necessary to develop a computer program that could run these calculations relatively quickly, while presenting the results in an organized fashion. For this reason, an Excel program was written in VisualBasic to carry out this task. The first step to writing this program involved developing a single spreadsheet that could calculate the seismic forces on a structure for a single case. In other words, the spreadsheet used the dimensions of the structure, the number of stories, the number of walls with veneer, the seismic design category, and the direction of loading to calculate the loads that would occur at each level of the structure.

The next step was to take these loads and determine the minimum total length of braced wall panels required for the given case. Table C2.1-3 in the AISI Standard AISI S-213-07/S1-09 was used to determine the shear wall capacities for typical light-frame cold-formed steel construction. The four cases considered in this analysis can be seen in Table 3.1. From there the braced wall line lengths were determined by comparing the capacity of the walls to the demand required by the seismic forces. Having performed this calculation, the spreadsheet was set up to do one iteration at a time by manipulating the input variables within the sheet. Though the current spreadsheet saved calculation time, changing the variables and gathering the results manually would still be quite time consuming. Therefore, a second program that could change the variables automatically based on the combination of parameters considered and then gather and organize the results was created.

Table 3.1: Shear Wall Configurations and Associated Capacities.

Case	Fastener Spacing at Panel Edges (inches)	Designation Thickness of Stud, Track and Blocking (mils)	Capacity (plf)
1	6	33	700
2	4	54	1410
3	3	68	2310
4	2	68	3080

*Excerpt adapted from Table C2.1-3 in the AISI Standard AISI S-213-07/S1-09

Overall there were two general types of variables: user input variables and user selected variables. User input variables include the parameters, the values of which the user has the ability to control. The dimensions of the building, story heights, roof slope, and the percent of wall openings are all user input variables. On the other hand, user selected variables allow the user to choose which parameters the program will consider. This includes the number of stories, the number of walls with veneer, the way the program handles mass consideration, the seismic design category, the direction of loading, and the wall panel strength. These two types of variables govern the general look of the user interface for the Excel Program, shown in Figure 3.1. The user input variables are on the left and allow the user to input any desired value. The rest of the variables, however, are user selected variables of which there are only a few options that can be considered. The program will consider only one wall panel strength at a time, but it can consider multiple combinations of the other user selected variables. Figure 3.2 shows the second screen of the user interface. The percentage of openings in each wall is another user input variable that can be manipulated.

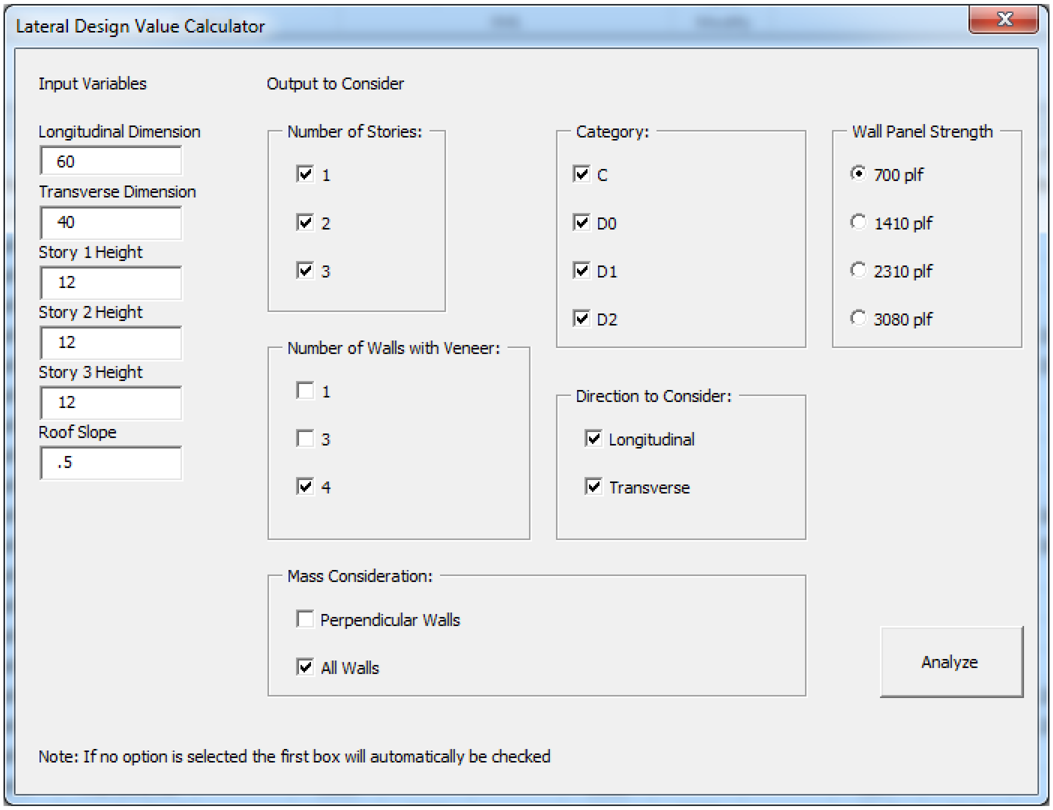


Figure 3.1: Lateral Design Value Calculator User Interface Showing Initial Parameters.

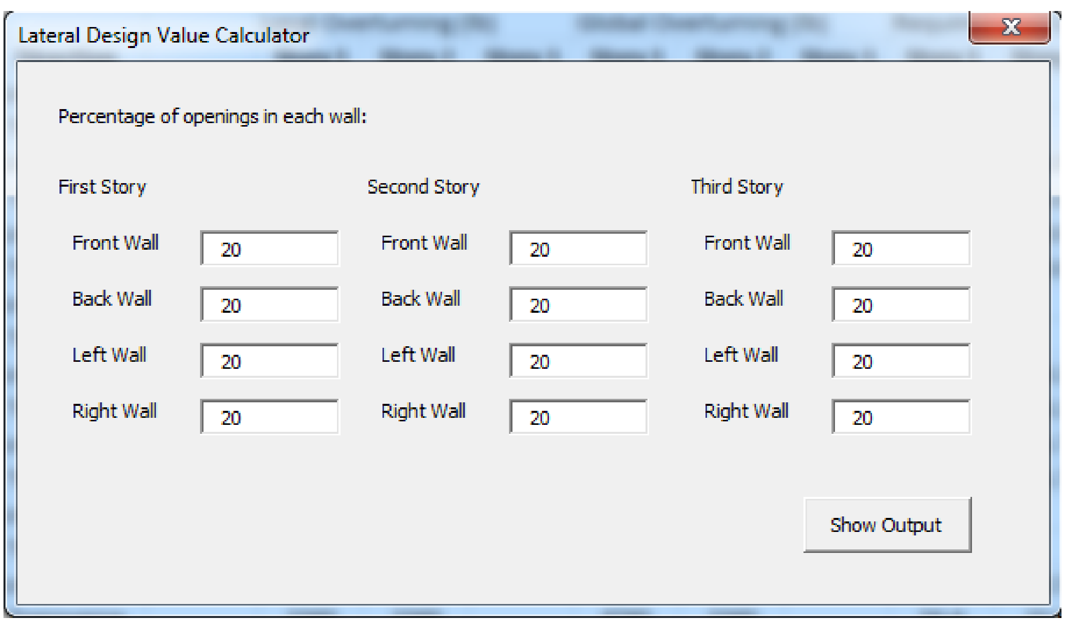


Figure 3.2: Lateral Design Value Calculator User Interface Showing Initial Parameters.

Once the user interface was designed, it was necessary to create the program that would make use of the interface. The first task involved determining the number of iterations that would need to be made. Using the variables selected in the interface, all of the possible combinations were listed in Excel. Table 3.2 shows all of the cases for the initial parameters selected in Figure 3.1. There are 24 possible cases, which implies the fact that 24 iterations need to be made. If all of the boxes had been checked on the first screen of the user interface, there would be 144 cases (there are 3 options, 3 options, 2 options, 4 options, and 2 options; 3*3*2*4*2 = 144). With all of the variables for each iteration listed, the program was designed to take each case one at a time and transfer the variables from this sheet to the correct location on the original spreadsheet. Therefore, the original sheet, which was designed to do a single iteration for a single case, could now be used to do all of the iterations, one at a time. After each iteration, the program transferred the output to a single results sheet, which can be seen in Table 3.3.

Table 3.2: List of Possible Combinations Using Intial Paramters.

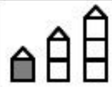
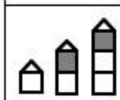
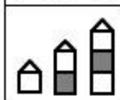
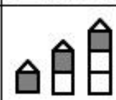
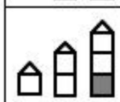
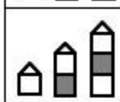
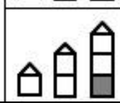
Case	Category	Stories	# Veneer	Condition	Direction
1	C	1	4	All Walls	Longitudinal
2	C	1	4	All Walls	Transverse
3	C	2	4	All Walls	Longitudinal
4	C	2	4	All Walls	Transverse
5	C	3	4	All Walls	Longitudinal
6	C	3	4	All Walls	Transverse
7	D0	1	4	All Walls	Longitudinal
8	D0	1	4	All Walls	Transverse
9	D0	2	4	All Walls	Longitudinal
10	D0	2	4	All Walls	Transverse
11	D0	3	4	All Walls	Longitudinal
12	D0	3	4	All Walls	Transverse
13	D1	1	4	All Walls	Longitudinal
14	D1	1	4	All Walls	Transverse
15	D1	2	4	All Walls	Longitudinal
16	D1	2	4	All Walls	Transverse
17	D1	3	4	All Walls	Longitudinal
18	D1	3	4	All Walls	Transverse
19	D2	1	4	All Walls	Longitudinal
20	D2	1	4	All Walls	Transverse
21	D2	2	4	All Walls	Longitudinal
22	D2	2	4	All Walls	Transverse
23	D2	3	4	All Walls	Longitudinal
24	D2	3	4	All Walls	Transverse

Table 3.3: Typical Output Showing Results Using Initial Parameters.

						Local Overturning (lb)			Global Overturning (lb)			Required Wall Length (ft)		
Case	Category	Stories	# Veneer	Condition	Direction	Story 1	Story 2	Story 3	Story 1	Story 2	Story 3	Story 1	Story 2	Story 3
1	C	1	4	All Walls	Longitudinal	3360			3360			15.8		
2	C	1	4	All Walls	Transverse	3360			3360			15.8		
3	C	2	4	All Walls	Longitudinal	3360	3360		8755	3360		40.0	15.8	
4	C	2	4	All Walls	Transverse	3360	3360		8755	3360		40.0	15.8	
5	C	3	4	All Walls	Longitudinal	3360	3360	3360	15418	8755	3360	64.2	40.0	15.8
6	C	3	4	All Walls	Transverse	3360	3360	3360	15418	8755	3360	64.2	40.0	15.8
7	D0	1	4	All Walls	Longitudinal	3360			3360			18.1		
8	D0	1	4	All Walls	Transverse	3360			3360			18.1		
9	D0	2	4	All Walls	Longitudinal	3360	3360		8745	3360		45.7	18.1	
10	D0	2	4	All Walls	Transverse	3360	3360		8745	3360		45.7	18.1	
11	D0	3	4	All Walls	Longitudinal	3360	3360	3360	15394	8745	3360	73.2	45.7	18.1
12	D0	3	4	All Walls	Transverse	3360	3360	3360	15394	8745	3360	73.2	45.7	18.1
13	D1	1	4	All Walls	Longitudinal	3360			3360			22.5		
14	D1	1	4	All Walls	Transverse	3360			3360			22.5		
15	D1	2	4	All Walls	Longitudinal	3360	3360		8745	3360		56.6	22.5	
16	D1	2	4	All Walls	Transverse	3360	3360		8745	3360		56.6	22.5	
17	D1	3	4	All Walls	Longitudinal	3360	3360	3360	15394	8745	3360	90.7	56.6	22.5
18	D1	3	4	All Walls	Transverse	3360	3360	3360	15394	8745	3360	90.7	56.6	22.5
19	D2	1	4	All Walls	Longitudinal	3360			3360			31.7		
20	D2	1	4	All Walls	Transverse	3360			3360			31.7		
21	D2	2	4	All Walls	Longitudinal	3360	3360		8745	3360		79.7	31.7	
22	D2	2	4	All Walls	Transverse	3360	3360		8745	3360		79.7	31.7	
23	D2	3	4	All Walls	Longitudinal	3360	3360	3360	15394	8745	3360	127.8	79.7	31.7
24	D2	3	4	All Walls	Transverse	3360	3360	3360	15394	8745	3360	127.8	79.7	31.7

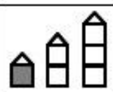
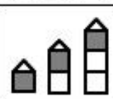
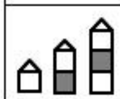
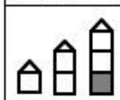
So far, the results discussed in Figure 3.1, Figure 3.2, Table 3.2, and Table 3.3 are for a building with a 40 ft. by 60 ft. footprint. However, in order to create a table similar to Table R602.10.6.5 from the IRC, the following footprints need to be considered: 40 ft. by 10 ft., 40 ft. by 20 ft., 40 ft. by 30 ft., 40 ft. by 40 ft., 40 ft. by 50 ft., and 40 ft. by 60 ft. In other words, these 24 iterations need to be repeated 6 times with different building dimensions, for a total of 144 iterations. A separate program was written to perform these 6 iterations, the output of which can be seen in Table 3.4. This output is organized in the same format as Table R602.10.6.5 from the IRC for easy comparison.

Table 3.4: Typical Output Showing Results Using Initial Parameters.

SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		8.6	10.5	12.4	14.3	16.2	18.1	3360	--
		8.6	10.5	12.4	14.3	16.2	18.1	3360	--
		**20.8**	**25.7**	**30.7**	35.7	**40.7**	**45.7**	3360	6720
		**33.0**	**41.0**	**49.1**	**57.1**	**65.1**	**73.2**	3360	10080
D_1		10.6	13.0	15.3	17.7	20.1	22.5	3360	--
		25.7	**31.9**	**38.1**	**44.2**	**50.4**	**56.6**	3360	6720
		**40.9**	**50.8**	**60.8**	**70.7**	**80.7**	**90.7**	3360	10080
D_2		14.9	18.3	21.6	25.0	28.3	31.7	3360	--
		**36.3**	**45.0**	**53.7**	**62.4**	**71.0**	**79.7**	3360	6720
		**57.6**	**71.6**	**85.7**	**99.7**	**113.8**	**127.8**	3360	10080

At this point there were still more iterations that needed to be made. Looking at Table 3.4 it is evident that many of the desired cases are not permissible. In other words, there are cases in which the minimum total length of braced wall panels required is larger than the length of wall available. These values are bolded in Table 3.4. This occurs when the minimum total length of braced wall panels required is larger than either the transverse or longitudinal building dimension. For example, for a 40 ft. by 50 ft. structure, the case is not permissible as soon as the minimum total length of braced wall panels required exceeds 40 ft. Because so many values are not permissible in Table 3.4, the table is not very practical. Recalling that this figure was created using a 700 plf nominal capacity for the shear strength of the wall panels, it was then necessary to consider other nominal strengths. The same analysis but using 1410 plf as the nominal capacity for the shear strength of the wall panels is shown in Table 3.5. To complete this analysis, similar figures were created using nominal shear wall capacities of 2310 plf and 3080 plf. All of these figures are located in Appendix A, Table 1A through Table 4A.

Table 3.5: Output Showing Results Using Initial Parameters and 1410 plf Nominal Shear Wall Capacity.

SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		4.2	5.2	6.2	7.1	8.1	9.0	6768	--
		4.2	5.2	6.2	7.1	8.1	9.0	6768	--
		**10.3**	12.8	15.3	17.7	20.2	22.7	6768	13536
		**16.4**	**20.4**	24.4	28.3	32.3	36.3	6768	20304
D_1		5.3	6.4	7.6	8.8	10.0	11.2	6768	--
		**12.8**	15.8	18.9	22.0	25.0	28.1	6768	13536
		**20.3**	**25.2**	**30.2**	35.1	**40.1**	**45.0**	6768	20304
D_2		7.4	9.1	10.7	12.4	14.1	15.7	6768	--
		**18.0**	**22.3**	26.6	31.0	35.3	39.6	6768	13536
		**28.6**	**35.6**	**42.5**	**49.5**	**56.5**	**63.4**	6768	20304

Once these tables were created, there were two previously mentioned assumptions that needed to be addressed. First, the transverse dimension of the building was held constant at 40 ft., while the longitudinal dimension ranged from 10 ft. to 60 ft. However, it is possible that a 30 ft. by 20 ft. building might need to be considered, rather than a 40 ft. by 20 ft. building. For this reason, an adjustment factor needed to be developed in order to account for transverse building dimensions other than 40 ft. To accomplish this, the previously mentioned 144 iterations needed to be run for 6 different cases, 10 ft., 20 ft., 30 ft., 40 ft., 50 ft., and 60 ft., for a total of 864 iterations. Table 3.6 shows the results of the first 144 iterations of this analysis, those required for the 10 ft. case. Because of the number of iterations required and the resulting volume of data that needed to be analyized, the tables were condensed for easy analysis. Table 3.7 shows the same 144 iterations, but for the original transverse dimension of 40 ft. In order to determine the appropriate length factor to transition between these two tables, all of the values in Table 3.6 needed to be divided by all of the values in Table 3.7. The results of this manipulation can be seen in Table 3.8.

Table 3.6: Output Showing Results Using a 10 ft. Transverse Dimension.

SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		2.6	3.9	5.3	6.6	8.0	9.3	3360	--
		2.6	3.9	5.3	6.6	8.0	9.3	3360	--
		7.4	11.2	15.0	18.8	22.7	26.5	3360	6720
		12.2	18.5	24.8	31.1	37.4	43.7	3360	10080
D_1		3.2	4.9	6.5	8.2	9.9	11.5	3360	--
		9.1	13.9	18.6	23.3	28.1	32.8	3360	6720
		15.1	22.9	30.7	38.5	46.3	54.1	3360	10080
D_2		4.6	6.9	9.2	11.6	13.9	16.2	3360	--
		12.9	19.6	26.2	32.9	39.6	46.2	3360	6720
		21.2	32.2	43.2	54.2	65.2	76.2	3360	10080

Table 3.7: Output Showing Results Using a 40 ft. Transverse Dimension.

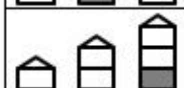
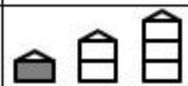
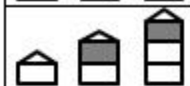
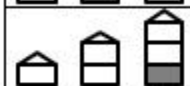
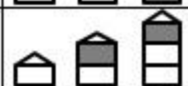
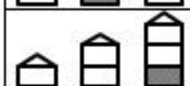
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		8.6	10.5	12.4	14.3	16.2	18.1	3360	--
		8.6	10.5	12.4	14.3	16.2	18.1	3360	--
		20.8	25.7	30.7	35.7	40.7	45.7	3360	6720
		33.0	41.0	49.1	57.1	65.1	73.2	3360	10080
D_1		10.6	13.0	15.3	17.7	20.1	22.5	3360	--
		25.7	31.9	38.1	44.2	50.4	56.6	3360	6720
		40.9	50.8	60.8	70.7	80.7	90.7	3360	10080
D_2		14.9	18.3	21.6	25.0	28.3	31.7	3360	--
		36.3	45.0	53.7	62.4	71.0	79.7	3360	6720
		57.6	71.6	85.7	99.7	113.8	127.8	3360	10080

Table 3.8: Length Adjustment Factors from a 40 ft. to a 10 ft. Transverse Dimension.

SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)					
		10	20	30	40	50	60
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE					
D_0		0.31	0.38	0.43	0.46	0.49	0.51
		0.31	0.38	0.43	0.46	0.49	0.51
		0.36	0.43	0.49	0.53	0.56	0.58
		0.37	0.45	0.50	0.54	0.57	0.60
D_1		0.31	0.38	0.43	0.46	0.49	0.51
		0.36	0.43	0.49	0.53	0.56	0.58
		0.37	0.45	0.50	0.54	0.57	0.60
D_2		0.31	0.38	0.43	0.46	0.49	0.51
		0.36	0.43	0.49	0.53	0.56	0.58
		0.37	0.45	0.50	0.54	0.57	0.60

The length adjustment factors in Table 3.8 range from 0.31 to 0.60. Therefore, in order to be conservative in the selection of the appropriate value, the maximum value of 0.60 was selected as the length adjustment factor for a 10 ft. transverse dimension. Tables for other transverse dimensions, similar to those in Table 3.6, Table 3.7, and Table 3.8 can be found in Appendix A, Table 5A through Table 16A.

In addition to the fixed 40 ft. transverse dimension, the assumption was made that the structure would have 20% openings in the walls. Therefore, another table of adjustment factors was needed to adjust for variable percentages of openings. The process to obtain this adjustment factor was exactly the same as the previous factor, the tables for which are located in Appendix A, Table 17A through Table 34A.

CHAPTER 4

Design Requirements for Using Masonry Veneers on Cold-Formed Steel Light-Frame Construction

By Joey Piotrowski

Abstract:

This paper addresses the fact that the *International Residential Code* (IRC 2012) offers little aid in the design of cold-formed steel construction when brick veneer is used in regions of higher seismic risk. There are, however, provisions for wood light-frame construction when brick veneer is used (BV-WSP), which will serve as a template for the provisions suggested in this paper. Through a series of computer analyses, required braced wall line lengths have been determined for cold-formed steel and compiled in a table similar to the one for wood, IRC Table R602.10.6.5 (2012). The results of this study form the basis for changes to be proposed to the IRC, which will include provisions to provide the necessay load path strength in cold-formed steel construction when brick veneer is used.

Introduction:

Little consideration has been given to aid in the design of cold-formed steel construction when brick veneer is used. Most of the low-rise structures in North America utilize light-frame construction: a repetitively framed system sheathed with load transferring wood structural panels. These structures include residential, industrial, and commercial buildings comprised primarily of wood-based materials. For this reason, numerous research efforts have focused on the seismic performance of this type of construction. Though light-frame buildings consist of various two-dimensional systems, these systems interact to form a highly indeterminate three-dimensional structure. Currently, the *International Residential Code* (2012) offers guidance for using brick veneer on buildings located in regions of high seismic risk that are framed with wood light-frame construction; however, the IRC needs to be updated to include similar provisions for cold-formed steel construction when brick veneer is used. The proposed changes will be based on the mechanics-based analysis presented in this paper.

Overview:

Before looking into specific code updates, it is important to first gain an understanding of the IRC, as it pertains to wood and cold-formed steel light-frame construction. One major difference between the materials is the way they are fastened together to resist lateral forces. For example, Table R602.10.4 from the IRC (2012) shows that wood structural panels with stone or masonry veneer (BV-WSP) require 8d common (.0131 in. x 2.5 in.) nails and 4in spacing at the panel edges with 12 in spacing in the field; however, cold-formed steel uses screws rather than nails to fasten the sheathing to the studs. Therefore, the initial investigation looked at No. 8 screws spaced 6 in. at the panel edges with 12 in. spacing in the field. This is an important distinction because in a study on monotonic and cyclic tests of steel-frame shear walls, Salenikovich and Dolan (1999) determined that the "bending of framing elements and head pull-through of sheathing screws was the predominant failure mode," which is different from wood light-frame construction. Furthermore, the tests showed that while the steel-frame shear walls had similar load capacity to wood-frame shear walls, the steel-frame shear walls experienced more deformation. This finding implies that the design parameters determined for steel should be comparable to existing wood values, but they will not be equal in all aspects. Each system needs to be detailed according to the expected performance.

Research on cold-formed steel shear walls is not a new topic. As early as 1980, Tarpy (1980) began experimental testing of steel-stud walls in an effort to obtain allowable shear values and deflection limits similar to existing wood values. Later, Tarpy (1984) continued this research and began to focus on the in-plane shear resistance of sheathed cold-formed steel stud walls. Salenikovich, et al, (1999) and Vagh, et al (2000) investigated the performance of long, perforated steel framed shear walls to determine if the method was applicable to the framing system. More recently, Branston (2006) began to focus on taking these new shear wall capacities and developing a design method for cold-formed steel shear walls. The aim of this paper is to continue this work for cold-formed steel construction, specifically when brick veneer is used.

A major piece of information missing from the IRC, in regards to light-frame steel construction, is a cold-formed steel table equivalent to Table R602.10.6.5 from the IRC. A section of that table has been provided below in Table 1 and shows the minimum total length of braced wall panels required for varying lengths of braced wall lines. This specific excerpt shows the values for structures in Seismic Design Category D_0; however, the full table takes other seismic design categories into consideration as well. The structures considered range from one to three stories, and the stories being considered are noted in the table. In addition to the required lengths of braced wall panels, single-story and cumulative hold-down forces are also provided. Table 1 contains useful and necessary information for design and is the reason why a similar table is desired for cold-formed steel.

In this study, the fastener schedule was selected based on the desire to obtain design values for typical construction; however, it was not guaranteed that the results would prove this arrangement to be permissible to resist the forces associated with masonry veneer in high seismic regions. The main parameter that was determined in this study was the braced wall line length required for each configuration. However, if this length exceeded the actual dimension of the wall line, then that case was not permissible. For example, a building could have a 50 ft. wall but need 60 ft. of braced wall line to adequately resist the load.

Table 1: Method BV-WSP Wall Bracing Requirements (wood light-frame construction with brick veneer).

<table>
<tr><th colspan="8">Required Length of Braced Wall Panels (ft):</th></tr>
<tr><th rowspan="2">Story Considered</th><th rowspan="2">Number of Stories in Structure</th><th colspan="5">Available Wall Length (ft)</th><th rowspan="2">Story Hold-Down Force (lb)</th></tr>
<tr><th>10</th><th>20</th><th>30</th><th>40</th><th>50</th></tr>
<tr><td>1</td><td>1</td><td rowspan="3">4.0</td><td rowspan="3">7.0</td><td rowspan="3">10.5</td><td rowspan="3">14.0</td><td rowspan="3">17.5</td><td rowspan="3">N/A</td></tr>
<tr><td>2</td><td>2</td></tr>
<tr><td>3</td><td>3</td></tr>
<tr><td>1</td><td>2</td><td rowspan="2">4.5</td><td rowspan="2">9.0</td><td rowspan="2">13.5</td><td rowspan="2">18.0</td><td rowspan="2">22.5</td><td rowspan="2">1900</td></tr>
<tr><td>2</td><td>3</td></tr>
<tr><td>1</td><td>3</td><td>6.0</td><td>12.0</td><td>18.0</td><td>24.0</td><td>30.0</td><td>3500</td></tr>
</table>

*Excerpt adapted from R602.10.6.5 from the 2012 International Residential Code.

Methods:

Before creating these new tables, it was necessary to consider the assumptions that would describe the basic structure. The ASCE 7-10 Simplified Alternative Method was used to determine the design values due to the simple box structure used as the basis for the analysis. Therefore, the first assumption was that all of the load in the structure would go to the nearest floor level. In other words, the common assumption that half of the load from the first floor goes directly to the foundation would be made. Additionally, all of the load from the roof would go into the top story. Second, the assumption of constant acceleration with height is assumed in the Simplified Method. It was also assumed that the building would have 20% openings in all of the walls. This assumption was agreed upon as a common reference value for the minimum amount of openings to provide conservatism to the analysis. Once the analysis was completed using this value, an adjustment factor was developed to allow consideration of other wall opening combinations as well. Overall, 15 psf was assumed for the roof weight, 10 psf was assumed for the wall weight minus the veneer, and 15 psf was assumed for the floor weight. For the weight of the brick veneer, 50 psf was assumed for structures in Seismic Design Category C and 40 psf was assumed for structures in Seismic Design Categorys D0, D1, and D2. These values were based on common assumptions for this type of construction. In order to maintain consistency with Table R602.10.6.5, Allowable Stress Design (ASD) was used for all of the calculations.

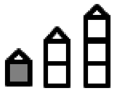
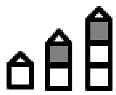
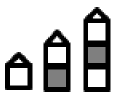
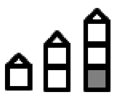
Taking these assumptions into consideration, a spreadsheet program was written in VisualBasic to carry out the Simplified Alternative Method over various different cases. The program can consider one- to three-story buildings, brick veneer on one, three, or four sides of the structure, Seismic Design Category C, D_0, D_1, and D_2, and loads in the lateral or transverse direction. This allowed for the consideration of many different variables, as well as quick comparison between multiple evaluations. The main dimensions of the building are fully customizable by allowing the user to change the building dimensions, story heights, and roof slope. The program can also take seismic mass into account in two different ways: either all of the mass is considered, or only the mass perpendicular to the wall in question is considered. This feature was added because both of these options are commonly assumed in masonry design. For the analysis used to create the new cold-formed steel table, it was assumed that veneer would be on all four walls and that the mass from all walls needed to be taken into account. This essentially implies that masonry veneer cannot support its own weight when the load is applied parallel to the wall In other words, the lateral forces are assumed to be resisted by two parallel wall lines. The program makes it simple to consider other options; however, these assumptions were made to match Table R602.10.6.5 from the IRC.

While this program may seem complex, the workings behind the interface are simple. A basic spreadsheet was set up to follow Section 12.14 of Minimum Design Loads for Buildings and Other Structures (ASCE7-10). This section provides a step-by-step procedure for the Simplified Alternative Structural Design Criteria for Bearing Wall or Building Frame Systems. The user interface, as well as the VisualBasic code running in the background, are simply tools to help optimize the process of running multiple evaluations simultaneously.

Results:

The first draft of this new table can be seen below in Table 2. Overall, this table is similar to Table R602.10.6.5, but there are a few differences. First of all, this table includes wall lengths up to a length of 60 ft, rather than 50 ft. This is to accommodate the desired maximum dimensions of building with 40 ft by 60 ft footprints, upon which the cold-formed steel prescriptive design standard is based. There are several underlying parameters that were used to formulate this table. The footprints of the buildings used in this table range from 40 ft by 10ft to 40 ft by 60 ft. In other words, the transverse dimension was held constant at a dimension of 40 ft. The story heights are always 12 ft, since this is the maximum wall height allowed by the IRC. The roof slope was 6:12. Additionally, the sheathing was assumed to be 7/16" OSB on one side, 6, 4, and 3-in. edge spacing for fasteners, No. 8 or 10 screws, and 33, 43, 54 and 68 mil framing members.

Table 2: Cold-Formed Steel Wall Bracing Requirements for Seismic Design Category D_0.

SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		8.6	10.5	12.4	14.3	16.2	18.1	3360	--
		8.6	10.5	12.4	14.3	16.2	18.1	3360	--
		***20.8***	***25.7***	***30.7***	35.7	***40.7***	***45.7***	3360	6720
		***33.0***	***41.0***	***49.1***	***57.1***	***65.1***	***73.2***	3360	10080

Overall, these results seem to be comparable to those from the original table; however, many of the values are not permissible (these values are signified in bold print) due to insufficient racking capapcity when a 6-inch fastening schdule is used. Therefore, it is necessary to consider other options in order to increase the shear capacity of the panels. These desgn capacities were obtained from Table C2.1-3 in the AISI Standard AISI S-213-07/S1-09 . After running multiple combinations, four main configurations were considered. They are shown below in Table 3.

Table 3: Shear Wall Configurations and Associated Capacities.

Case	**Fastener Spacing at Panel Edges (inches)**	**Designation Thickness of Stud, Track and Blocking (mils)**	**Capacity (plf)**
1	6	33	700
2	4	54	1410
3	3	68	2310
4	2	68	3080

*Excerpt adapted from Table C2.1-3 in the AISI Standard AISI S-213-07/S1-09

The results for Seismic Design Category D_0 for Case 1 were previously shown in Table 2. Case 2, which was considered next, can be seen in Table 4. For SDC D_0, all but three values are now permissible. However, this is not the case for SDC D_1 or D_2. Table 5 shows SDC D_1, where several of the values are not permissible.

Table 4: Case 2: Cold-Formed Steel Wall Bracing Requirements for SDC D_0.

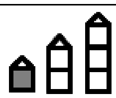
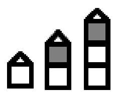
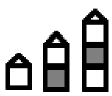
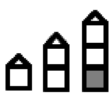
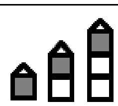
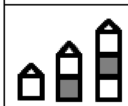
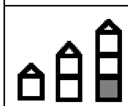
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		4.2	5.2	6.2	7.1	8.1	9.0	6768	--
		4.2	5.2	6.2	7.1	8.1	9.0	6768	--
		***10.3***	12.8	15.3	17.7	20.2	22.7	6768	13536
		***16.4***	***20.4***	24.4	28.3	32.3	36.3	6768	20304

Table 5: Case 2: Cold-Formed Steel Wall Bracing Requirements for SDC D_1.

SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_1		5.3	6.4	7.6	8.8	10.0	11.2	6768	--
		**12.8**	15.8	18.9	22.0	25.0	28.1	6768	13536
		**20.3**	**25.2**	**30.2**	35.1	**40.1**	**45.0**	6768	20304

The results for Case 3 are shown in Tables 6 and 7. All values were permissible for SDC D_0. All but one value was permissible for SDC D_1 and all but three values were permissible for SDC D_2.

Table 6: Case 3: Cold-Formed Steel Wall Bracing Requirements for SDC D_1.

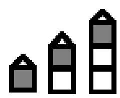
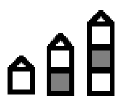
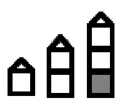
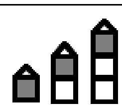
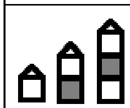
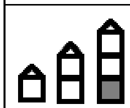
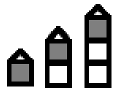
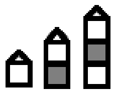
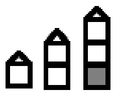
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_1		3.2	3.9	4.7	5.4	6.1	6.8	11088	--
		7.8	9.7	11.5	13.4	15.3	17.1	11088	22176
		**12.4**	15.4	18.4	21.4	24.5	27.5	11088	33264

Table 7: Case 3: Cold-Formed Steel Wall Bracing Requirements for SDC D_2.

SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_2		4.5	5.5	6.6	7.6	8.6	9.6	11088	--
		***11.0***	13.6	16.3	18.9	21.5	24.2	11088	22176
		***17.5***	***21.7***	26.0	30.2	34.5	38.7	11088	33264

Finally, Case 4 can be seen in Table 8 below. For this case, all values were permissible for SDC D_0 and SDC D_1; however, one value is not permissible for SDC D_2 , the highly loaded case of the bottom story of a three-story building.

Table 8: Case 4: Cold-Formed Steel Wall Bracing Requirements for SDC D_2.

SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_2		3.4	4.2	4.9	5.7	6.4	7.2	14784	--
		8.2	10.2	12.2	14.2	16.1	18.1	14784	29568
		***13.1***	16.3	19.5	22.7	25.9	29.0	14784	44352

In these tables, there are two previously mentioned assumptions that need to be addressed. First, the transverse dimension of the building was held constant at 40 ft, while the longitudinal dimension ranged from 10 ft to 60 ft. However, it is possible that a 30 ft by 20 ft building might need to be considered, rather than a 40 ft by 20 ft building. For this reason, an adjustment factor has been developed in order to account for transverse building dimensions other than 40 ft. Table 9 shows these adjustment factors. The required braced wall line length can be determined simply by multiplying the value obtained from the table by the appropriate adjustment factor.

Table 9: Adjustment Factors for Variable Transverse Building Dimensions.

Transverse Building Dimension	Adjustment Factor
10	0.60
20	0.73
30	0.86
40	1.00
50	1.29
60	1.61

Additionally, the assumption was made that the structure would have 20% openings in the walls. Therefore, another table of adjustment factors was created to adjust for variable percentages of openings, as seen in Table 10 below. As before, the required braced wall line length can be determined simply by multiplying the value obtained from the table by the appropriate adjustment factor.

Table 10: Adjustment Factors for Variable Percentage of Openings.

Percentage of Openings	Adjustment Factor
0	1.19
10	1.09
20	1.00
30	0.93
40	0.86
50	0.80
60	0.73
70	0.66
80	0.59

Another item worth discussing is related to the cumulative hold-down forces associated with Case 3 and Case 4. When either 2310 plf or 3080 plf nominal design values for the shear panels are used, the required hold-down forces reach as high as 33 kips and 44 kips, respectively. Hold-down forces of this magnitude are an indicator that the entire load path might be at risk. Handling these loads with prescriptive methods might be unreasonable due to the high forces in the compression members, along with the fastening schedule between elements that would be required. Therefore, it might be better to not permit these cells to be used, requiring a full analysis per the *International Building Code* (IBC), or to only provide the tables that utilize Case 1 and Case 2.

Summary and Conclusion:

With most of the low-rise structures in North America utilizing light-frame construction, it is clear that the *International Residential Code* (2012) should provide special provisions to address the seismic performance of these buildings. Currently, the IRC offers guidance for wood light-frame construction when brick veneer is used; however, little consideration has been given to aid in the design of cold-formed steel construction when brick veneer is used. Through a series of computer analyses, required braced wall line lengths have been determined for cold-formed steel and compiled in a table similar to Table R602.10.6.5 (IRC 2012). This table demonstrates the requirements for cold-formed steel construction when brick veneer is used and is ready to be implemented in the next version of the IRC. Overall, this study has shown that cold-formed steel structures can support brick veneer and still perform under seismic loading.

References:

ASCE. (2010). ASCE 7: Minimum design loads for buildings and other structures, Reston, Va.

Branston, A.E., Chen, C.Y., Boudreault, F.A., and Rogers, C.A. (2006). "Testing of light-gauge steel-frame – wood structural panel shear walls." *Canadia Journal of Civil Engineering.* Vol. 33 Issue 5, p561-572.

International Codes Council (ICC). (2012). International residential code for one- and two-family dwellings (IRC), Falls Church, Va.

Salenikovich, A.J., J. D. Dolan , and W.S. Easterling, (1999). "Monotonic and Cyclic Tests of Long Steel-Frame Shear Walls with Openings". Research Report No. TE-1999-001, Virginia Polytechnic Institute and State University, Blacksburg, VA

Tarpy, T.S. (1980). "Shear Resistance of Steel-Stud Wall Panels". *Oil shale Symposium Proceedings.*, Int Spec Conf on Cold-Formed Steel Struct., p 331-348.

Tarpy, T.S. (1984). "Shear Resistance of Steel Stud Wall Panels: A summary Report". *Univ of Missouri-Rolla*. George Winter Memorial Conference. P.203-248.

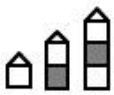
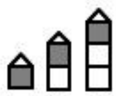
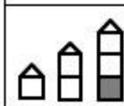
Vagh, S., J.D. Dolan, and W.S. Easterling, (2000). "Effect of Anchorage and Sheathing Configuration on the Cyclic Response of Long Steel-Frame Shear Walls." Research Report No. TE-2000-001, Virginia Polytechnic Institute and State University, Blacksburg, VA

CHAPTER 5

Conclusions:

With most of the low-rise structures in North America utilizing light-frame construction, it is clear that the *International Residential Code* (2012) should provide special provisions to address the seismic performance of these buildings. From the work of Salenikovich and Dolan (1999), it is clear that steel-frame shear walls have similar load capacity to wood-frame shear walls when the systems are detailed properly according to the expected performance. After viewing the results for the various shear wall capacities, Case 1 through Case 4, a selection needed to be made to produce a table similar to Table R602.10.6.5 (IRC 2012). It was clear from the results that Case 1, 700 plf wall panels, produced too many values that were not permissible because they required more length of braced wall panels than the available wall length. Case 2 through Case 4 gradually improved in this area, allowing more and more options with each increasing shear wall capacity. The problem with Case 3 and Case 4, however, was the fact that the hold-down forces became unreasonably large when high capacity shear panels were used. It would be imprudent use these capacities as the basis for the table because these forces are too high for prescriptive design. Taking these issues into consideration, Case 2, 1410 plf wall panels, seemed to be the best selection for the basis of the table. Many of the values became permissible, while still maintaining reasonable hold-down forces. Table 2A in Appendix A, which showed the results for the 1410 plf panels, has been modified for submission to the IRC and can be seen below in Table 5.1.

Table 5.1: Cold-Formed Steel Equivalent to Table R602.10.6.5 from the IRC.

SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		4.2	5.2	6.2	7.1	8.1	9.0	6768	--
		NP	12.8	15.3	17.7	20.2	22.7	6768	13536
		NP	NP	24.4	28.3	32.3	36.3	6768	20304
D_1		5.3	6.4	7.6	8.8	10.0	11.2	6768	--
		12.8	15.8	18.9	22.0	25.0	28.1	6768	13536
		NP	NP	NP	35.1	NP	NP	6768	20304
D_2		7.4	9.1	10.7	12.4	14.1	15.7	6768	--
		NP	NP	26.6	31.0	35.3	39.6	6768	13536
		NP	NP	NP	NP	NP	NP	6768	20304

The adjustment values associated with this table that would also be submitted to the IRC can be seen below in Table 5.2 and Table 5.3. Table 5.2 shows the adjustment factor that accounts for transverse building dimensions other than 40 ft. The required braced wall line length can be determined simply by multiplying the value obtained from the table by the appropriate adjustment factor. Table 5.3 shows the adjustment factor that accounts for variable percentages of openings. As before, the required braced wall line length can be determined simply by multiplying the value obtained from the table by the appropriate adjustment factor.

Table 5.2: Adjustment Factors for Variable Transverse Building Dimensions.

Percentage of Openings	Adjustment Factor
0	1.19
10	1.09
20	1.00
30	0.93
40	0.86
50	0.80
60	0.73
70	0.66
80	0.59

Table 5.3: Adjustment Factors for Variable Percentage of Openings.

Percentage of Openings	Adjustment Factor
0	1.19
10	1.09
20	1.00
30	0.93
40	0.86
50	0.80
60	0.73
70	0.66
80	0.59

Table 5.1, Table 5.2, and Table 5.3 show the requirements for cold-formed steel construction when brick veneer is used and are ready to be implemented in the next version of the IRC. Overall, this study has shown that cold-formed steel structures can support brick veneer and still perform under seismic loading.

APPENDIX A

Appendix A contains all of the spreadsheet program output that was referenced and utilized in this study. Table 1A through Table 4A show the output results for the four different nominal shear wall panel capacities that were used. Table 5A through Table 16A show the output that was used to determine the length adjustment factor for the IRC table. Finally, Table 17A through Table 34A show the output that was used to determine the opening adjustment factor for the IRC table.

Table 1A: Program Output Showing Results for IRC Table using 700 plf Nominal Shear Wall Capacity.

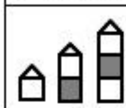
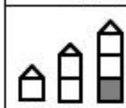
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		8.6	10.5	12.4	14.3	16.2	18.1	3360	--
		8.6	10.5	12.4	14.3	16.2	18.1	3360	--
		20.8	25.7	30.7	35.7	40.7	45.7	3360	6720
		33.0	41.0	49.1	57.1	65.1	73.2	3360	10080
D_1		10.6	13.0	15.3	17.7	20.1	22.5	3360	--
		25.7	31.9	38.1	44.2	50.4	56.6	3360	6720
		40.9	50.8	60.8	70.7	80.7	90.7	3360	10080
D_2		14.9	18.3	21.6	25.0	28.3	31.7	3360	--
		36.3	45.0	53.7	62.4	71.0	79.7	3360	6720
		57.6	71.6	85.7	99.7	113.8	127.8	3360	10080

Table 2A: Program Output Showing Results for IRC Table using 1410 plf Nominal Shear Wall Capacity.

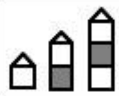
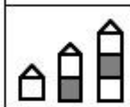
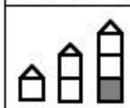
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		4.2	5.2	6.2	7.1	8.1	9.0	6768	--
		4.2	5.2	6.2	7.1	8.1	9.0	6768	--
		10.3	12.8	15.3	17.7	20.2	22.7	6768	13536
		16.4	20.4	24.4	28.3	32.3	36.3	6768	20304
D_1		5.3	6.4	7.6	8.8	10.0	11.2	6768	--
		12.8	15.8	18.9	22.0	25.0	28.1	6768	13536
		20.3	25.2	30.2	35.1	40.1	45.0	6768	20304
D_2		7.4	9.1	10.7	12.4	14.1	15.7	6768	--
		18.0	22.3	26.6	31.0	35.3	39.6	6768	13536
		28.6	35.6	42.5	49.5	56.5	63.4	6768	20304

Table 3A: Program Output Showing Results for IRC Table using 2310 plf Nominal Shear Wall Capacity.

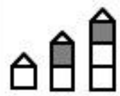
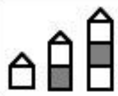
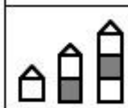
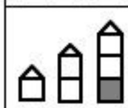
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		2.6	3.2	3.8	4.3	4.9	5.5	11088	--
		2.6	3.2	3.8	4.3	4.9	5.5	11088	--
		6.3	7.8	9.3	10.8	12.3	13.8	11088	22176
		10.0	12.4	14.9	17.3	19.7	22.2	11088	33264
D_1		3.2	3.9	4.7	5.4	6.1	6.8	11088	--
		7.8	9.7	11.5	13.4	15.3	17.1	11088	22176
		12.4	15.4	18.4	21.4	24.5	27.5	11088	33264
D_2		4.5	5.5	6.6	7.6	8.6	9.6	11088	--
		11.0	13.6	16.3	18.9	21.5	24.2	11088	22176
		17.5	21.7	26.0	30.2	34.5	38.7	11088	33264

Table 4A: Program Output Showing Results for IRC Table using 3080 plf Nominal Shear Wall Capacity.

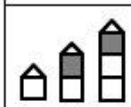
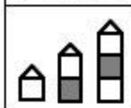
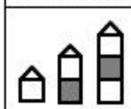
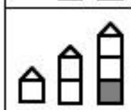
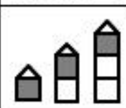
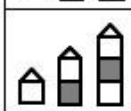
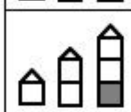
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		1.9	2.4	2.8	3.3	3.7	4.1	14784	--
		1.9	2.4	2.8	3.3	3.7	4.1	14784	--
		4.7	5.9	7.0	8.1	9.2	10.4	14784	29568
		7.5	9.3	11.2	13.0	14.8	16.6	14784	44352
D_1		2.4	2.9	3.5	4.0	4.6	5.1	14784	--
		5.8	7.2	8.7	10.1	11.5	12.9	14784	29568
		9.3	11.6	13.8	16.1	18.3	20.6	14784	44352
D_2		3.4	4.2	4.9	5.7	6.4	7.2	14784	--
		8.2	10.2	12.2	14.2	16.1	18.1	14784	29568
		13.1	16.3	19.5	22.7	25.9	29.0	14784	44352

Table 5A: Output Showing Results Using a 10 ft. Transverse Dimension.

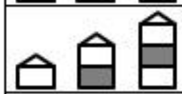
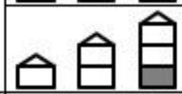
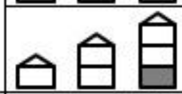
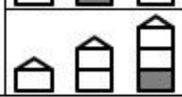
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		2.6	3.9	5.3	6.6	8.0	9.3	3360	--
		2.6	3.9	5.3	6.6	8.0	9.3	3360	--
		7.4	11.2	15.0	18.8	22.7	26.5	3360	6720
		12.2	18.5	24.8	31.1	37.4	43.7	3360	10080
D_1		3.2	4.9	6.5	8.2	9.9	11.5	3360	--
		9.1	13.9	18.6	23.3	28.1	32.8	3360	6720
		15.1	22.9	30.7	38.5	46.3	54.1	3360	10080
D_2		4.6	6.9	9.2	11.6	13.9	16.2	3360	--
		12.9	19.6	26.2	32.9	39.6	46.2	3360	6720
		21.2	32.2	43.2	54.2	65.2	76.2	3360	10080

Table 6A: Length Adjustment Factors from a 40 ft. to a 10 ft. Transverse Dimension.

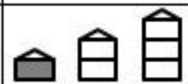
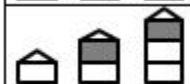
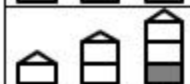
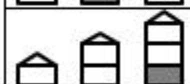
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)					
		10	20	30	40	50	60
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE					
D_0		0.31	0.38	0.43	0.46	0.49	0.51
		0.31	0.38	0.43	0.46	0.49	0.51
		0.36	0.43	0.49	0.53	0.56	0.58
		0.37	0.45	0.50	0.54	0.57	0.60
D_1		0.31	0.38	0.43	0.46	0.49	0.51
		0.36	0.43	0.49	0.53	0.56	0.58
		0.37	0.45	0.50	0.54	0.57	0.60
D_2		0.31	0.38	0.43	0.46	0.49	0.51
		0.36	0.43	0.49	0.53	0.56	0.58
		0.37	0.45	0.50	0.54	0.57	0.60

Table 7A: Output Showing Results Using a 20 ft. Transverse Dimension.

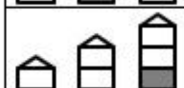
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		4.3	5.9	7.4	8.9	10.5	12.0	3360	--
		4.3	5.9	7.4	8.9	10.5	12.0	3360	--
		11.6	15.8	20.0	24.2	28.4	32.6	3360	6720
		18.8	25.7	32.6	39.5	46.4	53.2	3360	10080
D_1		5.4	7.3	9.2	11.1	13.0	14.9	3360	--
		14.4	19.6	24.8	30.0	35.2	40.4	3360	6720
		23.3	31.9	40.4	48.9	57.4	66.0	3360	10080
D_2		7.6	10.2	12.9	15.6	18.3	20.9	3360	--
		20.2	27.6	34.9	42.3	49.6	57.0	3360	6720
		32.9	44.9	56.9	68.9	81.0	93.0	3360	10080

Table 8A: Length Adjustment Factors from a 40 ft. to a 20 ft. Transverse Dimension.

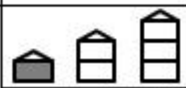
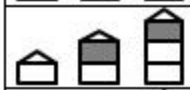
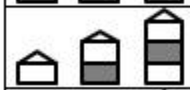
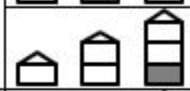
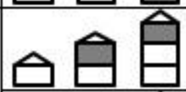
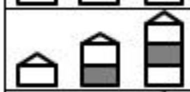
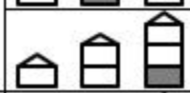
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)					
		10	20	30	40	50	60
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE					
D_0		0.51	0.56	0.60	0.62	0.64	0.66
		0.51	0.56	0.60	0.62	0.64	0.66
		0.56	0.61	0.65	0.68	0.70	0.71
		0.57	0.63	0.66	0.69	0.71	0.73
D_1		0.51	0.56	0.60	0.62	0.64	0.66
		0.56	0.61	0.65	0.68	0.70	0.71
		0.57	0.63	0.66	0.69	0.71	0.73
D_2		0.51	0.56	0.60	0.62	0.64	0.66
		0.56	0.61	0.65	0.68	0.70	0.71
		0.57	0.63	0.66	0.69	0.71	0.73

Table 9A: Output Showing Results Using a 30 ft. Transverse Dimension.

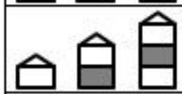
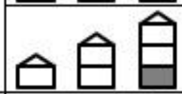
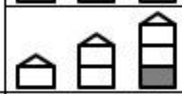
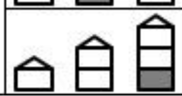
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		6.3	8.0	9.8	11.5	13.2	14.9	3360	--
		6.3	8.0	9.8	11.5	13.2	14.9	3360	--
		16.0	20.6	25.2	29.8	34.4	39.0	3360	6720
		25.8	33.2	40.7	48.2	55.6	63.1	3360	10080
D_1		7.8	10.0	12.1	14.2	16.4	18.5	3360	--
		19.9	25.6	31.3	36.9	42.6	48.3	3360	6720
		31.9	41.2	50.4	59.7	68.9	78.1	3360	10080
D_2		11.0	14.0	17.1	20.1	23.1	26.1	3360	--
		28.0	36.0	44.1	52.1	60.1	68.1	3360	6720
		45.0	58.1	71.1	84.1	97.1	110.2	3360	10080

Table 10A: Length Adjustment Factors from a 40 ft. to a 30 ft. Transverse Dimension.

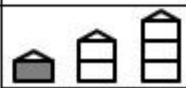
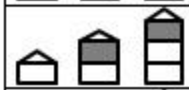
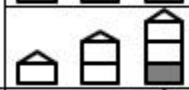
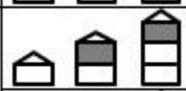
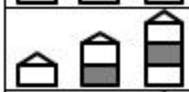
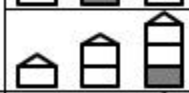
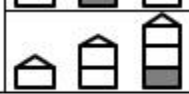
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)					
		10	20	30	40	50	60
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE					
D_0		0.74	0.77	0.79	0.80	0.81	0.82
		0.74	0.77	0.79	0.80	0.81	0.82
		0.77	0.80	0.82	0.84	0.85	0.85
		0.78	0.81	0.83	0.84	0.85	0.86
D_1		0.74	0.77	0.79	0.80	0.81	0.82
		0.77	0.80	0.82	0.84	0.85	0.85
		0.78	0.81	0.83	0.84	0.85	0.86
D_2		0.74	0.77	0.79	0.80	0.81	0.82
		0.77	0.80	0.82	0.84	0.85	0.85
		0.78	0.81	0.83	0.84	0.85	0.86

Table 11A: Output Showing Results Using a 40 ft. Transverse Dimension.

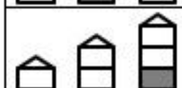
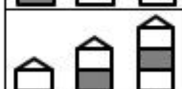
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		8.6	10.5	12.4	14.3	16.2	18.1	3360	--
		8.6	10.5	12.4	14.3	16.2	18.1	3360	--
		20.8	25.7	30.7	35.7	40.7	45.7	3360	6720
		33.0	41.0	49.1	57.1	65.1	73.2	3360	10080
D_1		10.6	13.0	15.3	17.7	20.1	22.5	3360	--
		25.7	31.9	38.1	44.2	50.4	56.6	3360	6720
		40.9	50.8	60.8	70.7	80.7	90.7	3360	10080
D_2		14.9	18.3	21.6	25.0	28.3	31.7	3360	--
		36.3	45.0	53.7	62.4	71.0	79.7	3360	6720
		57.6	71.6	85.7	99.7	113.8	127.8	3360	10080

Table 12A: Length Adjustment Factors from a 40 ft. to a 40 ft. Transverse Dimension.

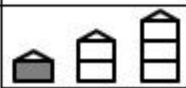
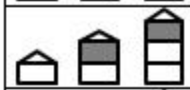
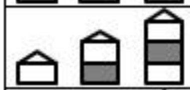
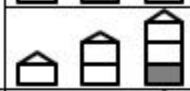
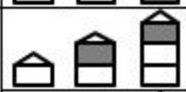
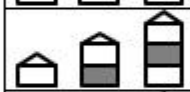
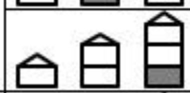
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)					
		10	20	30	40	50	60
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE					
D_0		1.00	1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00	1.00
D_1		1.00	1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00	1.00
D_2		1.00	1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00	1.00

Table 13A: Output Showing Results Using a 50 ft. Transverse Dimension.

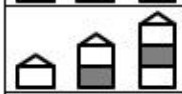
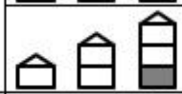
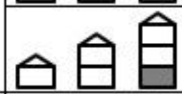
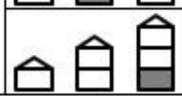
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		11.1	13.2	15.3	17.4	19.5	21.6	3360	--
		11.1	13.2	15.3	17.4	19.5	21.6	3360	--
		25.7	31.1	36.5	41.8	47.2	52.6	3360	6720
		40.4	49.1	57.7	66.3	74.9	83.5	3360	10080
D_1		13.7	16.3	18.9	21.5	24.1	26.8	3360	--
		31.9	38.5	45.2	51.8	58.5	65.1	3360	6720
		50.1	60.8	71.5	82.1	92.8	103.5	3360	10080
D_2		19.3	23.0	26.7	30.4	34.0	37.7	3360	--
		45.0	54.3	63.7	73.1	82.4	91.8	3360	6720
		70.6	85.7	100.7	115.8	130.8	145.9	3360	10080

Table 14A: Length Adjustment Factors from a 40 ft. to a 50 ft. Transverse Dimension.

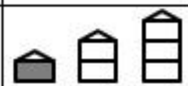
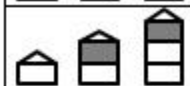
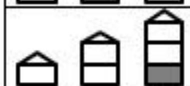
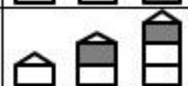
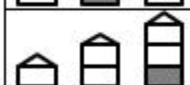
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)					
		10	20	30	40	50	60
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE					
D_0		1.29	1.26	1.23	1.22	1.20	1.19
		1.29	1.26	1.23	1.22	1.20	1.19
		1.24	1.21	1.19	1.17	1.16	1.15
		1.23	1.20	1.18	1.16	1.15	1.14
D_1		1.29	1.26	1.23	1.22	1.20	1.19
		1.24	1.21	1.19	1.17	1.16	1.15
		1.23	1.20	1.18	1.16	1.15	1.14
D_2		1.29	1.26	1.23	1.22	1.20	1.19
		1.24	1.21	1.19	1.17	1.16	1.15
		1.23	1.20	1.18	1.16	1.15	1.14

Table 15A: Output Showing Results Using a 60 ft. Transverse Dimension.

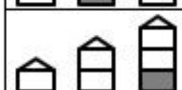
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		13.8	16.1	18.4	20.7	23.0	25.3	3360	--
		13.8	16.1	18.4	20.7	23.0	25.3	3360	--
		31.0	36.7	42.5	48.2	54.0	59.7	3360	6720
		48.2	57.4	66.6	75.8	85.0	94.2	3360	10080
D_1		17.1	20.0	22.8	25.7	28.5	31.4	3360	--
		38.4	45.5	52.6	59.8	66.9	74.0	3360	6720
		59.7	71.1	82.5	93.9	105.3	116.6	3360	10080
D_2		24.1	28.1	32.2	36.2	40.2	44.2	3360	--
		54.1	64.2	74.2	84.2	94.3	104.3	3360	6720
		84.1	100.2	116.2	132.3	148.4	164.4	3360	10080

Table 16A: Length Adjustment Factors from a 40 ft. to a 60 ft. Transverse Dimension.

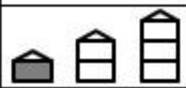
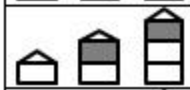
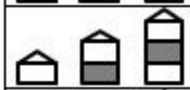
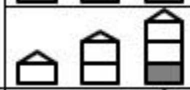
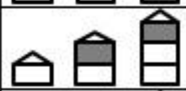
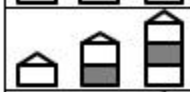
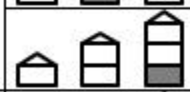
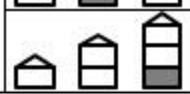
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)					
		10	20	30	40	50	60
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE					
D_0		1.61	1.54	1.49	1.45	1.42	1.40
		1.61	1.54	1.49	1.45	1.42	1.40
		1.49	1.43	1.38	1.35	1.33	1.31
		1.46	1.40	1.36	1.33	1.30	1.29
D_1		1.61	1.54	1.49	1.45	1.42	1.40
		1.49	1.43	1.38	1.35	1.33	1.31
		1.46	1.40	1.36	1.33	1.30	1.29
D_2		1.61	1.54	1.49	1.45	1.42	1.40
		1.49	1.43	1.38	1.35	1.33	1.31
		1.46	1.40	1.36	1.33	1.30	1.29

Table 17A: Output Showing Results Using 0% Openings in Walls.

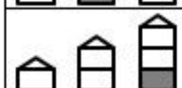
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		9.8	12.0	14.1	16.3	18.5	20.6	3360	--
		9.8	12.0	14.1	16.3	18.5	20.6	3360	--
		24.5	30.2	35.9	41.6	47.4	53.1	3360	6720
		39.2	48.4	57.7	67.0	76.3	85.6	3360	10080
D_1		12.1	14.8	17.5	20.2	22.9	25.5	3360	--
		30.3	37.4	44.5	51.6	58.7	65.8	3360	6720
		48.5	60.0	71.5	83.0	94.5	106.0	3360	10080
D_2		17.1	20.9	24.7	28.4	32.2	36.0	3360	--
		42.8	52.7	62.7	72.7	82.7	92.7	3360	6720
		68.4	84.6	100.8	117.0	133.2	149.4	3360	10080

Table 18A: Opening Adjustment Factors from a 20% to 0% Openings in Walls.

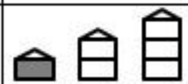
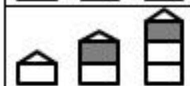
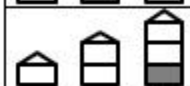
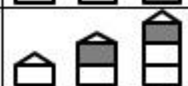
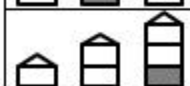
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)					
		10	20	30	40	50	60
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE					
D_0		1.14	1.14	1.14	1.14	1.14	1.14
		1.14	1.14	1.14	1.14	1.14	1.14
		1.18	1.17	1.17	1.17	1.16	1.16
		1.19	1.18	1.18	1.17	1.17	1.17
D_1		1.14	1.14	1.14	1.14	1.14	1.14
		1.18	1.17	1.17	1.17	1.16	1.16
		1.19	1.18	1.18	1.17	1.17	1.17
D_2		1.14	1.14	1.14	1.14	1.14	1.14
		1.18	1.17	1.17	1.17	1.16	1.16
		1.19	1.18	1.18	1.17	1.17	1.17

Table 19A: Output Showing Results Using 10% Openings in Walls.

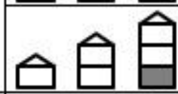
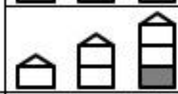
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		9.2	11.2	13.3	15.3	17.3	19.4	3360	--
		9.2	11.2	13.3	15.3	17.3	19.4	3360	--
		22.6	28.0	33.3	38.7	44.0	49.4	3360	6720
		36.1	44.7	53.4	62.1	70.7	79.4	3360	10080
D_1		11.4	13.9	16.4	18.9	21.5	24.0	3360	--
		28.0	34.7	41.3	47.9	54.5	61.2	3360	6720
		44.7	55.4	66.1	76.9	87.6	98.3	3360	10080
D_2		16.0	19.6	23.1	26.7	30.3	33.8	3360	--
		39.5	48.9	58.2	67.5	76.9	86.2	3360	6720
		63.0	78.1	93.2	108.4	123.5	138.6	3360	10080

Table 20A: Opening Adjustment Factors from a 20% to 10% Openings in Walls.

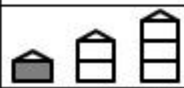
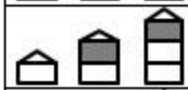
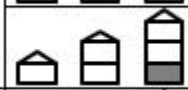
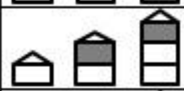
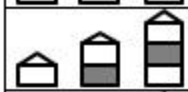
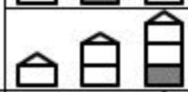
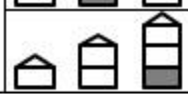
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)					
		10	20	30	40	50	60
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE					
D_0		1.07	1.07	1.07	1.07	1.07	1.07
		1.07	1.07	1.07	1.07	1.07	1.07
		1.09	1.09	1.08	1.08	1.08	1.08
		1.09	1.09	1.09	1.09	1.09	1.08
D_1		1.07	1.07	1.07	1.07	1.07	1.07
		1.09	1.09	1.08	1.08	1.08	1.08
		1.09	1.09	1.09	1.09	1.09	1.08
D_2		1.07	1.07	1.07	1.07	1.07	1.07
		1.09	1.09	1.08	1.08	1.08	1.08
		1.09	1.09	1.09	1.09	1.09	1.08

Table 21A: Output Showing Results Using 20% Openings in Walls.

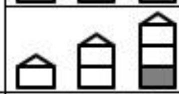
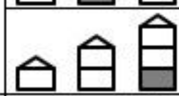
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		8.6	10.5	12.4	14.3	16.2	18.1	3360	--
		8.6	10.5	12.4	14.3	16.2	18.1	3360	--
		20.8	25.7	30.7	35.7	40.7	45.7	3360	6720
		33.0	41.0	49.1	57.1	65.1	73.2	3360	10080
D_1		10.6	13.0	15.3	17.7	20.1	22.5	3360	--
		25.7	31.9	38.1	44.2	50.4	56.6	3360	6720
		40.9	50.8	60.8	70.7	80.7	90.7	3360	10080
D_2		14.9	18.3	21.6	25.0	28.3	31.7	3360	--
		36.3	45.0	53.7	62.4	71.0	79.7	3360	6720
		57.6	71.6	85.7	99.7	113.8	127.8	3360	10080

Table 22A: Opening Adjustment Factors from a 20% to 20% Openings in Walls.

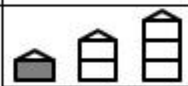
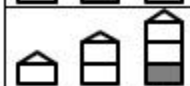
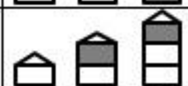
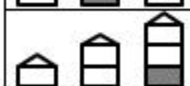
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)					
		10	20	30	40	50	60
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE					
D_0		1.00	1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00	1.00
D_1		1.00	1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00	1.00
D_2		1.00	1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00	1.00

Table 23A: Output Showing Results Using 30% Openings in Walls.

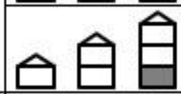
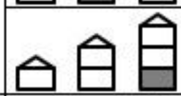
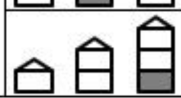
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		7.9	9.7	11.5	13.3	15.1	16.9	3360	--
		7.9	9.7	11.5	13.3	15.1	16.9	3360	--
		18.9	23.5	28.1	32.7	37.3	42.0	3360	6720
		29.9	37.3	44.7	52.2	59.6	67.0	3360	10080
D_1		9.8	12.1	14.3	16.5	18.7	20.9	3360	--
		23.4	29.1	34.8	40.6	46.3	52.0	3360	6720
		37.0	46.2	55.4	64.6	73.8	83.0	3360	10080
D_2		13.9	17.0	20.1	23.3	26.4	29.5	3360	--
		33.0	41.1	49.1	57.2	65.2	73.3	3360	6720
		52.2	65.2	78.1	91.1	104.0	117.0	3360	10080

Table 24A: Opening Adjustment Factors from a 20% to 30% Openings in Walls.

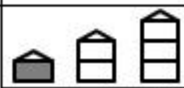
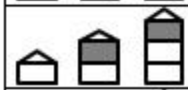
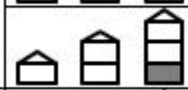
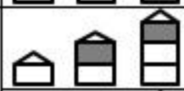
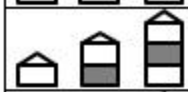
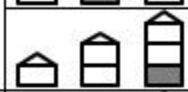
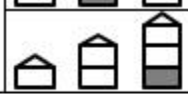
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)					
		10	20	30	40	50	60
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE					
D_0		0.93	0.93	0.93	0.93	0.93	0.93
		0.93	0.93	0.93	0.93	0.93	0.93
		0.91	0.91	0.92	0.92	0.92	0.92
		0.91	0.91	0.91	0.91	0.91	0.92
D_1		0.93	0.93	0.93	0.93	0.93	0.93
		0.91	0.91	0.92	0.92	0.92	0.92
		0.91	0.91	0.91	0.91	0.91	0.92
D_2		0.93	0.93	0.93	0.93	0.93	0.93
		0.91	0.91	0.92	0.92	0.92	0.92
		0.91	0.91	0.91	0.91	0.91	0.92

Table 25A: Output Showing Results Using 40% Openings in Walls.

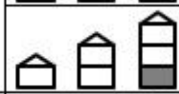
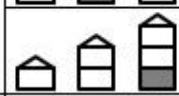
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		7.3	9.0	10.7	12.3	14.0	15.7	3360	--
		7.3	9.0	10.7	12.3	14.0	15.7	3360	--
		17.1	21.3	25.5	29.8	34.0	38.2	3360	6720
		26.8	33.6	40.4	47.2	54.0	60.8	3360	10080
D_1		9.1	11.1	13.2	15.3	17.3	19.4	3360	--
		21.1	26.4	31.6	36.9	42.1	47.4	3360	6720
		33.2	41.6	50.1	58.5	66.9	75.3	3360	10080
D_2		12.8	15.7	18.6	21.5	24.4	27.4	3360	--
		29.8	37.2	44.6	52.0	59.4	66.8	3360	6720
		46.8	58.7	70.6	82.4	94.3	106.2	3360	10080

Table 26A: Opening Adjustment Factors from a 20% to 40% Openings in Walls.

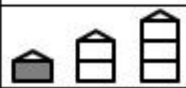
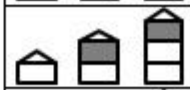
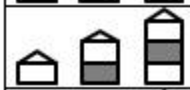
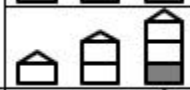
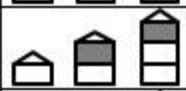
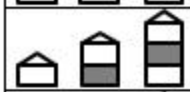
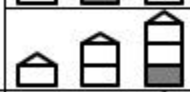
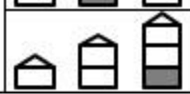
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)					
		10	20	30	40	50	60
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE					
D_0		0.86	0.86	0.86	0.86	0.86	0.86
		0.86	0.86	0.86	0.86	0.86	0.86
		0.82	0.83	0.83	0.83	0.84	0.84
		0.81	0.82	0.82	0.83	0.83	0.83
D_1		0.86	0.86	0.86	0.86	0.86	0.86
		0.82	0.83	0.83	0.83	0.84	0.84
		0.81	0.82	0.82	0.83	0.83	0.83
D_2		0.86	0.86	0.86	0.86	0.86	0.86
		0.82	0.83	0.83	0.83	0.84	0.84
		0.81	0.82	0.82	0.83	0.83	0.83

Table 27A: Output Showing Results Using 50% Openings in Walls.

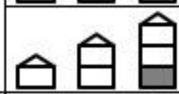
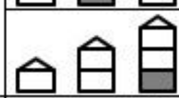
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)						SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		10	20	30	40	50	60		
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		6.7	8.2	9.8	11.3	12.9	14.4	3360	--
		6.7	8.2	9.8	11.3	12.9	14.4	3360	--
		15.2	19.1	22.9	26.8	30.7	34.5	3360	6720
		23.7	29.9	36.1	42.3	48.4	54.6	3360	10080
D_1		8.3	10.2	12.1	14.0	16.0	17.9	3360	--
		18.8	23.6	28.4	33.2	38.0	42.8	3360	6720
		29.4	37.0	44.7	52.4	60.0	67.7	3360	10080
D_2		11.7	14.4	17.1	19.8	22.5	25.2	3360	--
		26.6	33.3	40.1	46.8	53.6	60.3	3360	6720
		41.4	52.2	63.0	73.8	84.6	95.4	3360	10080

Table 28A: Opening Adjustment Factors from a 20% to 50% Openings in Walls.

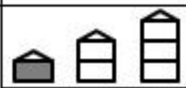
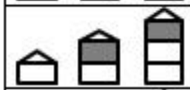
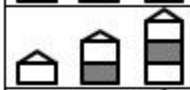
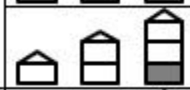
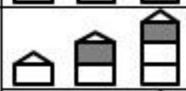
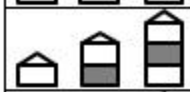
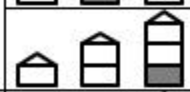
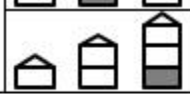
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)					
		10	20	30	40	50	60
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE					
D_0		0.78	0.79	0.79	0.79	0.79	0.80
		0.78	0.79	0.79	0.79	0.79	0.80
		0.73	0.74	0.75	0.75	0.75	0.76
		0.72	0.73	0.74	0.74	0.74	0.75
D_1		0.78	0.79	0.79	0.79	0.79	0.80
		0.73	0.74	0.75	0.75	0.75	0.76
		0.72	0.73	0.74	0.74	0.74	0.75
D_2		0.78	0.79	0.79	0.79	0.79	0.80
		0.73	0.74	0.75	0.75	0.75	0.76
		0.72	0.73	0.74	0.74	0.74	0.75

Table 29A: Output Showing Results Using 60% Openings in Walls.

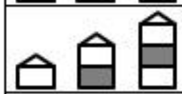
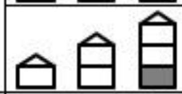
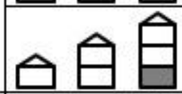
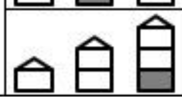
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET) 10	20	30	40	50	60	SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		6.1	7.5	8.9	10.3	11.8	13.2	3360	--
		6.1	7.5	8.9	10.3	11.8	13.2	3360	--
		13.3	16.8	20.3	23.8	27.3	30.8	3360	6720
		20.6	26.2	31.7	37.3	42.9	48.4	3360	10080
D_1		7.5	9.3	11.1	12.8	14.6	16.3	3360	--
		16.5	20.9	25.2	29.5	33.9	38.2	3360	6720
		25.5	32.4	39.3	46.2	53.1	60.0	3360	10080
D_2		10.6	13.1	15.6	18.1	20.6	23.0	3360	--
		23.3	29.4	35.5	41.6	47.7	53.8	3360	6720
		36.0	45.7	55.4	65.2	74.9	84.6	3360	10080

Table 30A: Opening Adjustment Factors from a 20% to 60% Openings in Walls.

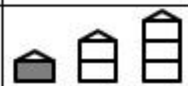
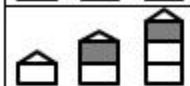
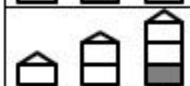
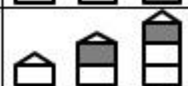
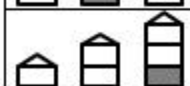
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)					
		10	20	30	40	50	60
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE					
D_0		0.71	0.72	0.72	0.72	0.73	0.73
		0.71	0.72	0.72	0.72	0.73	0.73
		0.64	0.65	0.66	0.67	0.67	0.67
		0.63	0.64	0.65	0.65	0.66	0.66
D_1		0.71	0.72	0.72	0.72	0.73	0.73
		0.64	0.65	0.66	0.67	0.67	0.67
		0.63	0.64	0.65	0.65	0.66	0.66
D_2		0.71	0.72	0.72	0.72	0.73	0.73
		0.64	0.65	0.66	0.67	0.67	0.67
		0.63	0.64	0.65	0.65	0.66	0.66

Table 31A: Output Showing Results Using 70% Openings in Walls.

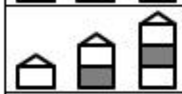
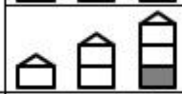
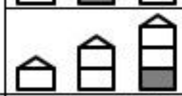
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET) 10	20	30	40	50	60	SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		5.5	6.8	8.1	9.4	10.7	12.0	3360	--
		5.5	6.8	8.1	9.4	10.7	12.0	3360	--
		11.5	14.6	17.7	20.9	24.0	27.1	3360	6720
		17.5	22.5	27.4	32.4	37.3	42.3	3360	10080
D_1		6.8	8.4	10.0	11.6	13.2	14.8	3360	--
		14.2	18.1	22.0	25.8	29.7	33.6	3360	6720
		21.7	27.8	34.0	40.1	46.2	52.4	3360	10080
D_2		9.5	11.8	14.1	16.3	18.6	20.9	3360	--
		20.1	25.5	31.0	36.4	41.9	47.3	3360	6720
		30.6	39.2	47.9	56.5	65.2	73.8	3360	10080

Table 32A: Opening Adjustment Factors from a 20% to 70% Openings in Walls.

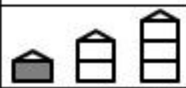
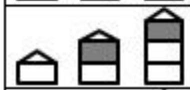
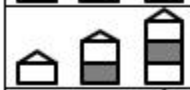
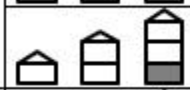
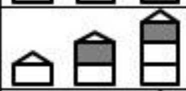
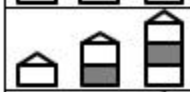
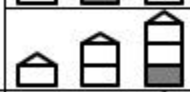
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)					
		10	20	30	40	50	60
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE					
D_0		0.64	0.65	0.65	0.65	0.66	0.66
		0.64	0.65	0.65	0.65	0.66	0.66
		0.55	0.57	0.58	0.58	0.59	0.59
		0.53	0.55	0.56	0.57	0.57	0.58
D_1		0.64	0.65	0.65	0.65	0.66	0.66
		0.55	0.57	0.58	0.58	0.59	0.59
		0.53	0.55	0.56	0.57	0.57	0.58
D_2		0.64	0.65	0.65	0.65	0.66	0.66
		0.55	0.57	0.58	0.58	0.59	0.59
		0.53	0.55	0.56	0.57	0.57	0.58

Table 33A: Output Showing Results Using 80% Openings in Walls.

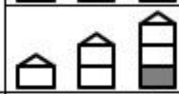
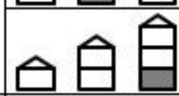
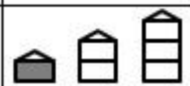
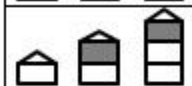
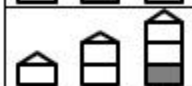
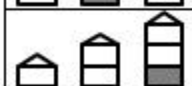
SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET) 10	20	30	40	50	60	SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		4.8	6.0	7.2	8.4	9.5	10.7	3360	--
		4.8	6.0	7.2	8.4	9.5	10.7	3360	--
		9.6	12.4	15.1	17.9	20.6	23.4	3360	6720
		14.4	18.8	23.1	27.4	31.7	36.1	3360	10080
D_1		6.0	7.5	8.9	10.4	11.8	13.3	3360	--
		11.9	15.3	18.8	22.2	25.6	29.0	3360	6720
		17.9	23.2	28.6	34.0	39.3	44.7	3360	10080
D_2		8.5	10.5	12.6	14.6	16.7	18.7	3360	--
		16.8	21.6	26.4	31.2	36.1	40.9	3360	6720
		25.2	32.8	40.3	47.9	55.4	63.0	3360	10080

Table 34A: Opening Adjustment Factors from a 20% to 80% Openings in Walls.

SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET)					
		10	20	30	40	50	60
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE					
D_0		0.57	0.57	0.58	0.59	0.59	0.59
		0.57	0.57	0.58	0.59	0.59	0.59
		0.46	0.48	0.49	0.50	0.51	0.51
		0.44	0.46	0.47	0.48	0.49	0.49
D_1		0.57	0.57	0.58	0.59	0.59	0.59
		0.46	0.48	0.49	0.50	0.51	0.51
		0.44	0.46	0.47	0.48	0.49	0.49
D_2		0.57	0.57	0.58	0.59	0.59	0.59
		0.46	0.48	0.49	0.50	0.51	0.51
		0.44	0.46	0.47	0.48	0.49	0.49

APPENDIX B

Appendix B contains the *Lateral Design Value Calculator User Manual* that was developed to help users opperate the spreadsheet program mentioned in this study. The first section helps users navigate the *Lateral Design Value Calculator User Interface* that was developed to run the initial iterative calculations performed in this analysis. The second second section helps users run the *General Table Generator*, a subprogram that can quickly develop IRC formatted tables based on a set of given input variables.

Lateral Design Value Calculator User Manual

The contents of this manual include directions for using several sub-programs within the Lateral Design Value Calculator Excel Spreadsheet. Explanations for the following sub-programs are included:

I. Lateral Design Value Calculator User Interface
II. General Table Generator

I. Lateral Design Value Calculator User Interface:

1. Enable macros for the spreadsheet.
2. Press and hold *Ctrl+Shift+R* until the user interface window pops up (Alternatively, select the *Developer* tab, select *Macros*, select *User_Interface*, and click *Run*).
3. Enter the desired parameters and click *Analyze*. Figure 1 shows the parameters that were initially used for this study.

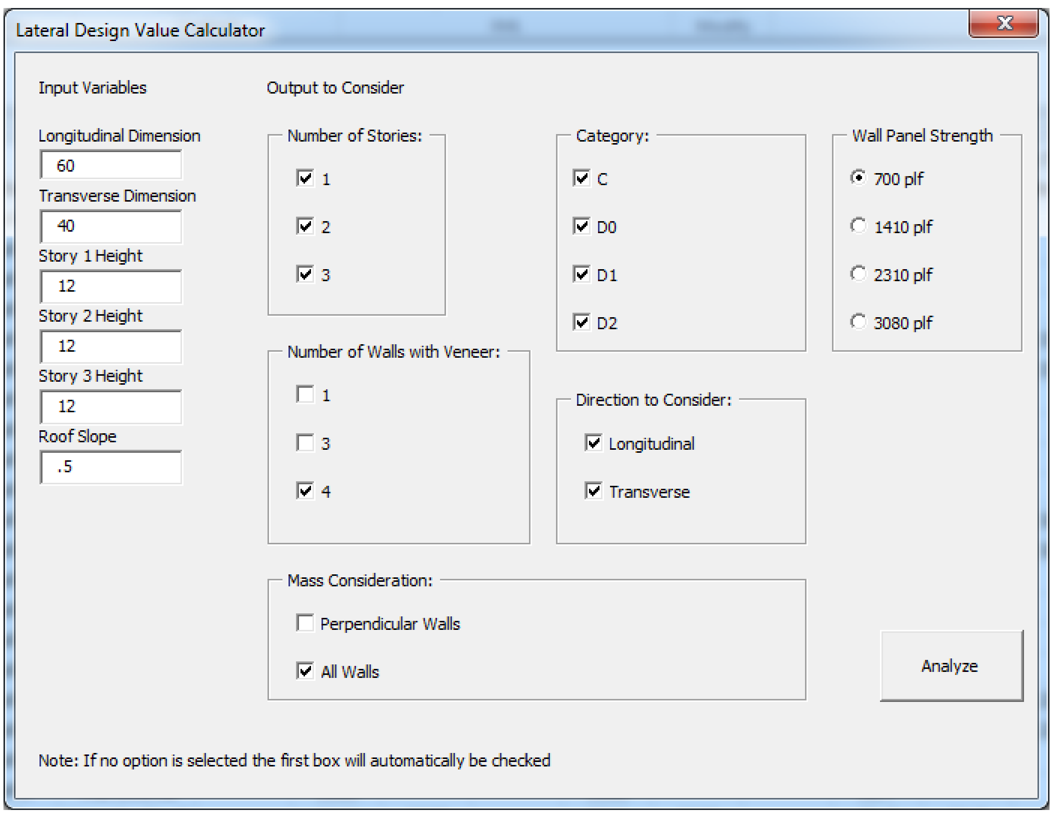


Figure 1: Lateral Design Value Calculator User Interface Showing Initial Parameters.

4. When the second window appears, enter the desired parameters and click *Show Output*. Figure 2 shows the parameters that were initially used for this study.

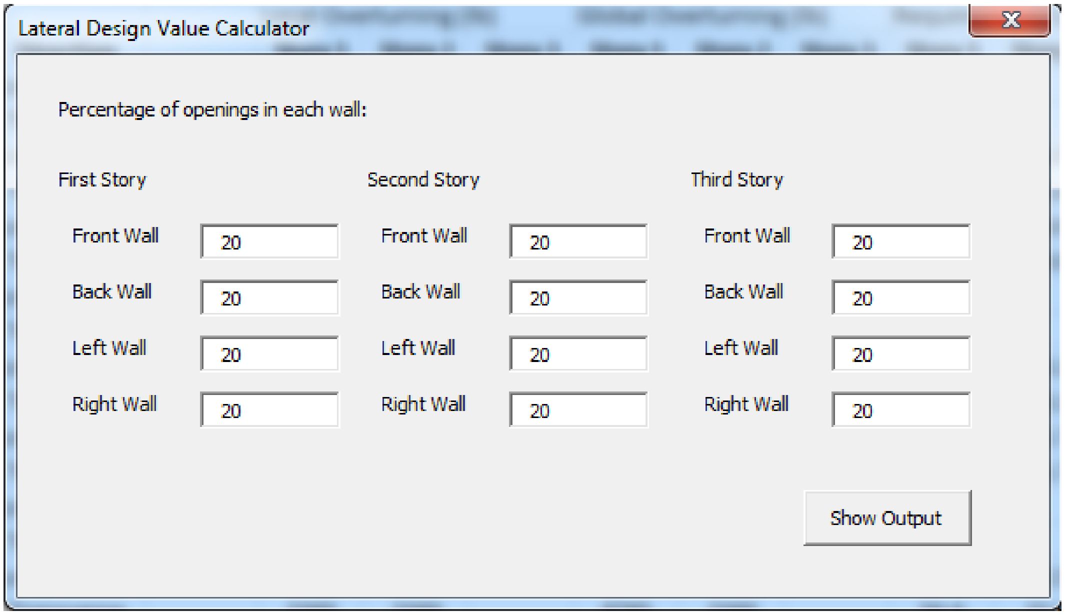


Figure 2: Lateral Design Value Calculator User Interface Showing Initial Parameters.

5. The results of the analysis will appear in the *Results* tab. Table 1 shows the results using the parameters shown in Figure 1 and Figure 2.

Table 1: Typical Output Showing Results Using Initial Parameters.

						Local Overturning (lb)			Global Overturning (lb)			Required Wall Length (ft)		
Case	Category	Stories	# Veneer	Condition	Direction	Story 1	Story 2	Story 3	Story 1	Story 2	Story 3	Story 1	Story 2	Story 3
1	C	1	4	All Walls	Longitudinal	3360			3360			15.8		
2	C	1	4	All Walls	Transverse	3360			3360			15.8		
3	C	2	4	All Walls	Longitudinal	3360	3360		8755	3360		40.0	15.8	
4	C	2	4	All Walls	Transverse	3360	3360		8755	3360		40.0	15.8	
5	C	3	4	All Walls	Longitudinal	3360	3360	3360	15418	8755	3360	64.2	40.0	15.8
6	C	3	4	All Walls	Transverse	3360	3360	3360	15418	8755	3360	64.2	40.0	15.8
7	D0	1	4	All Walls	Longitudinal	3360			3360			18.1		
8	D0	1	4	All Walls	Transverse	3360			3360			18.1		
9	D0	2	4	All Walls	Longitudinal	3360	3360		8745	3360		45.7	18.1	
10	D0	2	4	All Walls	Transverse	3360	3360		8745	3360		45.7	18.1	
11	D0	3	4	All Walls	Longitudinal	3360	3360	3360	15394	8745	3360	73.2	45.7	18.1
12	D0	3	4	All Walls	Transverse	3360	3360	3360	15394	8745	3360	73.2	45.7	18.1
13	D1	1	4	All Walls	Longitudinal	3360			3360			22.5		
14	D1	1	4	All Walls	Transverse	3360			3360			22.5		
15	D1	2	4	All Walls	Longitudinal	3360	3360		8745	3360		56.6	22.5	
16	D1	2	4	All Walls	Transverse	3360	3360		8745	3360		56.6	22.5	
17	D1	3	4	All Walls	Longitudinal	3360	3360	3360	15394	8745	3360	90.7	56.6	22.5
18	D1	3	4	All Walls	Transverse	3360	3360	3360	15394	8745	3360	90.7	56.6	22.5
19	D2	1	4	All Walls	Longitudinal	3360			3360			31.7		
20	D2	1	4	All Walls	Transverse	3360			3360			31.7		
21	D2	2	4	All Walls	Longitudinal	3360	3360		8745	3360		79.7	31.7	
22	D2	2	4	All Walls	Transverse	3360	3360		8745	3360		79.7	31.7	
23	D2	3	4	All Walls	Longitudinal	3360	3360	3360	15394	8745	3360	127.8	79.7	31.7
24	D2	3	4	All Walls	Transverse	3360	3360	3360	15394	8745	3360	127.8	79.7	31.7

II. General Table Generator

1. Enable macros for the spreadsheet.
2. Press and hold *Ctrl+Shift+M* (Alternatively, select the *Developer* tab, select *Macros*, select *Make_Table*, and click *Run*).
3. The results of the analysis will appear in the *Table for Code* tab. Table 2 shows the results using the parameters shown in Figure 1 and Figure 2.

Table 2: Typical Output Showing Results Using Initial Parameters.

SEISMIC DESIGN CATEGORY	STORY	BRACED WALL LINE LENGTH (FEET) 10	20	30	40	50	60	SINGLE-STORY HOLD-DOWN FORCE (pounds)	CUMULATIVE HOLD-DOWN FORCE (pounds)
		MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE							
D_0		8.6	10.5	12.4	14.3	16.2	18.1	3360	--
		8.6	10.5	12.4	14.3	16.2	18.1	3360	--
		20.8	25.7	30.7	35.7	40.7	45.7	3360	6720
		33.0	41.0	49.1	57.1	65.1	73.2	3360	10080
D_1		10.6	13.0	15.3	17.7	20.1	22.5	3360	--
		25.7	31.9	38.1	44.2	50.4	56.6	3360	6720
		40.9	50.8	60.8	70.7	80.7	90.7	3360	10080
D_2		14.9	18.3	21.6	25.0	28.3	31.7	3360	--
		36.3	45.0	53.7	62.4	71.0	79.7	3360	6720
		57.6	71.6	85.7	99.7	113.8	127.8	3360	10080