DESIGNING SAFE ROOMS AND SAFE HOMES WITH LOGIX.
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Hurricanes and tornadoes have progressively caused more damage to property, personal injury and loss of life than any other natural disaster in the United States.

In fact, 2011 is proving to be a record year for tornadoes costing billions in property damage, and hundreds of lives lost.

As we continue to rebuild in the paths of hurricanes and tornadoes, stronger and more durable building materials than traditional framed or masonry wall construction needs to be considered. Basically, these buildings need to be more resistant to extreme wind events than what is currently required by building codes.

Due to its many benefits, LOGIX has been gaining popularity in the building industry as an alternative to framed or masonry construction. Over the years, LOGIX has proven to be quick and easy to install while providing the built-in insulation and vapor barrier. The thick rigid foam insulation and concrete core also creates a high energy efficient wall system.

The added benefit of a solid reinforced concrete core protected by a layer of rigid foam makes LOGIX one of the strongest, most durable wall systems available, and ideal for buildings and safe rooms in high wind-prone regions.

This document discusses the use of LOGIX in the design and construction of buildings and safe rooms in high wind-prone regions. In addition, engineered wind load tables and FEMA compliant ready-to-use safe room construction plans are noted as a design aid specific for LOGIX.

Buildings Constructed to Model Building Codes
Depending on the geographic location of the building, the model building codes require the design and construction of buildings in high wind regions to be based on basic wind speeds that may be up to 170 mph (200 mph in the Florida Building Code). Statistically, this covers approximately 90% of all wind speeds experienced in the US including those generated by hurricanes and weaker tornados.

Buildings in compliance to the model building codes are designed and constructed with adequate wall to roof, and wall to footing connections, so that a continuous load path is provided to transfer wind loads from the framing members to the foundation. **However, with the exception of window openings, model building codes have no requirements for the protection of exterior walls and roofs from wind-borne debris.** As a result, buildings hit from flying debris during high wind events can experience a breach in the building envelope through the exterior walls, even within wind speeds the building was designed for.

A breach in the building envelope during high wind events can greatly increase the pressure experienced by the building, which can lead to possible structural damage and potential harm to building occupants. **For the most part, minimum requirements of model building codes are meant to protect the loss of property rather than the loss of life.**

Generally, the costs associated to design and construct a debris resistant home, or larger building, with the intent to fully protect its building occupants, make it impractical to build. Which is likely the reason there are no wind-borne debris impact protection requirements for exterior walls and roofs in model building codes.
For the most part, minimum requirements of model building codes are meant to protect the loss of property rather than the loss of life.

However, with exterior walls being the main structural support for buildings, stronger, more durable walls offer more protection to building occupants against debris impacts, and can reduce the costs of maintenance and repairs compared to framed and masonry construction.

Without further enhancements, traditional framed buildings offer little resistance to debris impacts. In addition, air infiltrating through framed walls during extreme wind events can increase the stress on the building. Masonry construction requires full grouting and reinforcement. In comparison, LOGIX walls are naturally strong, durable and airtight structures that resist high wind loads, and debris impacts without the need to further strengthen the wall.

History has shown that reinforced concrete structures, like those built with LOGIX, are often the only buildings left standing in the aftermath of a hurricane or tornado.

Despite the lack of wind-borne debris protection in the model building codes for walls and roofs, using LOGIX can help ensure buildings stay intact and provide a higher level of safety, during extreme wind events.

Logix Wind Load Tables
Since reinforced concrete is the structural component of LOGIX, buildings constructed with LOGIX can be designed for higher wind loads than what is required by code.

To aide designers and builders, Table 3B in Section 6 of the LOGIX Design Manual offers a wind load table for above-grade walls where the design wind speed is greater than 150 mph. The table includes wind speeds of 200, 250, 275 and 300 mph for LOGIX walls of varying thicknesses and wall heights. Table 3B can be found at the end of this document.

The use of Table 3B creates LOGIX walls capable of withstanding wind speeds greater than what is required by code, and will offer more safety than framed or masonry walls. However, it is important to note that special attention should be paid to the connection details for wind loads not covered in building codes. Connection details between the wall to footing, and wall to roof, will depend on a number of factors such as wind load, height and shape of building. A local licensed engineer should be consulted if the design of the building is outside the scope of the model building codes.

Safe Rooms
Typically buildings are not designed to fully withstand wind-borne debris impacts generated by hurricanes and tornados.

Wind driven debris presents the greatest hazard to building occupants and to building structures during a tornado or hurricane. In cases of extreme wind events, building occupants should evacuate to safe rooms designed to protect building occupants.

Every component of a safe room, from the roof to the foundation, is designed to withstand missile impacts and associated wind loads up to 250 mph. This represents more than 99% of all tornados known to have occurred in the United States, and higher than Category 5 hurricanes.
Research has shown that for strength and resistance to debris impacts, ICFs outperform other wall assemblies making them ideal for Safe Rooms. Traditional framed construction requires considerable improvements to match the strength and resistance of ICFs. CMUs require full grouting and reinforcing. Only traditional reinforced concrete and tilt-up panels were comparable to ICFs. However, ICFs were the only wall system that showed no signs of damage to the structural component of the wall assembly—no visible damage to the concrete core of the ICFs tested.

It is worth noting, that the tested ICF walls consisted of a 4 inch reinforced concrete core, and performed better than tested 6 inch thick traditional reinforced concrete walls. This is likely due to the layer of rigid foam insulation that blankets the concrete core absorbing energy from debris impacts. Hence, reducing the impact load to the concrete core (analogous to rigid foam used in helmets to absorb impacts).

LOGIX form panels have the thickest foam insulation in the ICF industry ranging from 2.75 to 8 inches, making LOGIX one of the most debris impact resistant ICFs available.

Residential and Small Business Safe Rooms
FEMA 320, Taking Shelter from The Storm, offers a prescriptive guide to the design and construction of safe rooms specifically for residential and small businesses. These safe rooms are intended to hold no more than 16 persons, and include the use of ICFs for the construction of safe rooms.

As an aid to home owners, builders and designers, LOGIX has developed a set of construction plans for the construction of residential and small business safe rooms using LOGIX. The LOGIX construction plans are FEMA compliant and include plans for in-ground, basement, crawl space and detached safe rooms. For reference, the LOGIX Safe Room plans can be found at the end of this document.

Although the LOGIX safe room construction plans are complete, consulting a local engineer to review the plans can also help in indicating other local hazards that should be considered before construction.

Community Safe Rooms
The construction of a safe room designed to hold a large number of people dictates a larger building than that required for residential or small business safe rooms. Hence, a structural engineer is required for the design of a community safe room.

FEMA 361, Design and Construction Guidance for Community Safe Rooms, offers design and construction guidelines for community safe rooms, and notes 4 inch ICFs as a wall system capable of providing sufficient protection against extreme wind events and debris impacts.

Depending on the size of the community safe room, designers can use the wind load table, Table 3B, in Section 6 of the LOGIX Design Manual to aide in design of the safe room.

Improving occupant safety means constructing stronger, more durable buildings capable of withstanding large wind loads, including debris impacts, than typical framed and masonry structures. Well recognized for their inherent resistance to large wind loads, and debris impacts, ICFs are the perfect choice for constructing buildings in high wind prone regions. And choosing LOGIX makes it easier for builders and designers to create a building, or safe room, by providing detailed engineered high wind load tables, and FEMA compliant ready-to-build safe room construction plans.

For more information contact LOGIX at info@logixicf.com
6.1 – U.S. ENGINEERING ANALYSIS REPORT

TABLE 3B - LOGIX ABOVE-GRADE WALL MINIMUM VERTICAL REINFORCEMENT
(WIND SPEEDS GREATER THAN 150 MPH)

NOTE: LOGIX recommends builders, owners and/or designers using these tables confirm that on-site building conditions are w/in the scope of the tables being used.

LOGIX ABOVE-GRADE WALLS - VERTICAL REINFORCEMENT SPACING, in.

<table>
<thead>
<tr>
<th>Ground Floor LOGIX Supporting Roof Only</th>
<th>Ground Floor LOGIX Supporting 2nd Storey LOGIX (or 2nd Storey Wood Frame) &amp; Roof Structure</th>
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<tbody>
<tr>
<td><strong>Wall Height, ft</strong></td>
<td><strong>4'' LOGIX Wall Thickness</strong></td>
</tr>
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<td>8</td>
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<tr>
<td>18</td>
<td>-</td>
</tr>
<tr>
<td>20</td>
<td>-</td>
</tr>
</tbody>
</table>

NOTES:
1. Table 3B must be used in conjunction with the notes listed under "Notes For Above-Grade Wall Tables".
2. Vertical bar spacing is for #4 rebar. #5 rebar can be substituted provided the spacing is multiplied by 1.5. Spacing shall be no more than 48 inches on center.
3. Steel yield strength = 60 ksi, 28 day concrete compressive strength = 3 ksi.
LIMIT OF LIABILITY
The designs in these drawing sheets are based on extensive research of the causes and effects of windstorm damage to buildings. Safe Rooms designed and built to these designs should provide a high degree of occupant protection during extreme windstorms (tornadoes and hurricanes). Any substitution of either materials or design concepts may decrease the level of occupant protection and/or increase the possibility of personal injury during an extreme wind event.

Because it is not possible to predict or test all conditions that may occur during extreme windstorms, or control the quality of construction, among other things, the designer does not guarantee the design.

The designer doesn't manufacture or sell Safe Rooms built from this design. The designers have not made and do not make any representation, warranty, or covenant, expressed or implied, with respect to the design, condition, quality, durability, operation, fitness for use, or suitability of the Safe Room in any respect whatsoever. Designers shall not be obligated or liable for actual, incidental, consequential, or other person or entity arising out of or in connection with the use, condition, and/or performance of Safe Rooms built from this design or from the maintenance thereof.

### IN-RESIDENCE & SMALL BUSINESS SAFE ROOM DRAWING LIST

<table>
<thead>
<tr>
<th>DRAWING NUMBER</th>
<th>TITLE</th>
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<tbody>
<tr>
<td>T-01</td>
<td>INDEX SHEET</td>
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<tr>
<td>G-01</td>
<td>GENERAL NOTES</td>
</tr>
<tr>
<td>IG-01</td>
<td>IN-GROUND SAFE ROOM - SECTIONS &amp; DETAILS</td>
</tr>
<tr>
<td>B-01</td>
<td>BASEMENT SAFE ROOM - CORNER LOCATION</td>
</tr>
<tr>
<td>AG-01 to AG-03</td>
<td>AT-GRADE SAFE ROOM</td>
</tr>
<tr>
<td>MS-01</td>
<td>DOOR DETAILS &amp; SIGNAGE</td>
</tr>
<tr>
<td>MS-02</td>
<td>MATERIALS LISTS</td>
</tr>
</tbody>
</table>
GENERAL NOTES

1. Concrete
   1.1. All concrete should have stone aggregate (normal weight) 28-day compressive strength \( f_{cu} \) should be 3,000 psi minimum for cast-in-place concrete.
   1.2. Reinforcing bars should be mild steel with a minimum yield strength of 60 KSI.
   1.3. Reinforcing bar protection:
       1.3.1. Concrete placed against earth = 3”
       1.3.2. Concrete placed in forms = 1.5”
   1.4. Reinforcing bar placement tolerance is 0.5” in any direction.
   1.5. Splicing of reinforcement is not permitted except as shown on the drawings. Bars should be lap spliced at all corners. Splice lengths as follows:
       1.5.1. #4 bars - 24”
       1.5.2. #5 bars - 30”
   1.6. Welded wire reinforcement: lap one and one-half mesh spaces at splices and wire in contact.
   1.7. Field welding of reinforcement should not be permitted.
   1.8. All reinforcing bar bends should be made mechanically. Heat-bending should not be permitted.

2. The construction drawings should not be scaled. Dimensions apply.
3. If there is a conflict among the General Notes, Specifications, and Plans, the order of precedence is Notes, then Specifications, then Plans.
4. The construction drawings represent the finished structure. The contractor is solely responsible for providing all measures necessary to ensure that the structure is protected during construction. These measures include (but not limited to) shoring and bracing for construction loads and worker safety purposes.
5. Follow manufacturer’s recommendations for nailing requirements of uplift/shear resistance connectors.
6. Ventilation is to be provided in accordance with the local building code. Ventilation may be either natural or mechanical such that minimum ventilation is 0.5 air changes/hour.
7. The designs shown are compliant with the 1997 NEHRP recommended provisions.
8. To ensure the safe room provides the desired level of protection, a professional engineer or architect should be consulted for any design conditions found to be different from those represented by these plans.
9. See Drawings MS-01 and MS-02 for the materials list for Safe Rooms at-grade (referred to as Drawings AG-01 to AG-03).
10. To obtain an equivalent level of protection, Safe Room designs not meeting the specific requirements of the designs in these plans should be designed to meet the FEMA Safe Room Criteria set forth in FEMA 361, “Design and Construction Guidance for Community Safe Rooms.”
11. The doors shown in these plans were laboratory-tested for debris impact for door widths from 2’-6” to 3’-0”. DHS strongly encourages individuals to use a minimum door width of 2’-8” for wheelchair access.
12. For all construction, use only United States manufactured screws and hardware as there have been high recorded failure rates of screws and hardware imported from other countries.

DESIGN BASIS

1.1. Live loads used in design:
   1.1.1. Wind pressures developed from 250 mph 3-second gust in accordance with the wind load calculation procedure in ASCE7-05, Section 6.5 Method 2-Analytical Method as modified by FEMA 361, Chapter 3 for Safe Room Design and Life-Safety Protection.
   1.2. Windborne debris (missile) impact loads created by a 15 lb 2x4 traveling horizontally at 100 mph, traveling vertically at 67 mph, and impacting normal to wall surface.
2. Soil bearing capacity of 2,000 psf min. has been assumed.

ABBREVIATIONS

A.B. Anchor
O/C On Center
dia. Diameter
E/W Each Way
ICF Insulated Concrete Form
MH Manhole
Min. Minimum
Max. Maximum
Ksi One thousand pounds per square inch
psi Pounds per square inch
mph Miles per hour
P.T. Pressure Treated
EPS Expanded polystyrene
ga. Gauge
NOTES:

1. While not all contractors are familiar with the type of hatch cover shown in these drawings, the names of some companies that manufacture hatch covers have been included in this table. Logix recommends hatch covers with a minimum size of 4’ x 4’ for a standard hatch. However, it is not intended to express a preference for those manufacturers.

2. Space required inside In-ground Safe Room is min. 5.5’ / person.

3. Ladders installed should conform to the requirements of ICC-500.

CAUTION!

DO NOT INSTALL IN-GROUND SAFE ROOM IN AREAS OF EXPANSIVE CLAY OR HIGH WATER TABLE, OR IN AREAS THAT ARE FLOOD-PRONE.

NOTES:

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2. Space required inside In-ground Safe Room is min. 5.5’ / person.

3. Ladders installed should conform to the requirements of ICC-500.

CAUTION!

DO NOT INSTALL IN-GROUND SAFE ROOM IN AREAS OF EXPANSIVE CLAY OR HIGH WATER TABLE, OR IN AREAS THAT ARE FLOOD-PRONE.
The drawing represented herein is to be used as a reference guide only; the user shall check to ensure the drawing meets local building codes and construction practices by consulting local building officials and professionals, including any additional requirements. Logix reserves the right to make changes to the drawing without notice and assumes no liability in connection with the use of the drawing including modification, copying or distribution.

**Project:**

**Title:** AG-01 AT-GRADE SAFE ROOM

**Drawing:** SAFE ROOM PLAN

**LOGIX ICF WALL SIZES**

- **2'-6" for LOGIX 6.25" ICF**
- **4" for LOGIX 4" ICF**
- **11.75" for LOGIX 6.25" ICF**
- **9.5" for LOGIX 4" ICF**
NOTE:
Locate fan opening between ceiling reinforcing bars. Do not cut reinforcing bars.
Alternative Door:
12 ga. skin w/ 20 ga. metal ribs, honeycomb core or polystyrene in-fill. The extra armor plate required and door CH-200 specifications below.

Recommended Signage Criteria (See Also ICC-500):
1. Install a plaque, sign, or other markings to clearly identify:
   - 250 mph, 3-second gust Safe Room design wind speed
   - Missile impact resistance rating for:
     - 15 lb 2x4 traveling horizontally at 100 mph
     - 15 lb 2x4 traveling vertically at 67 mph
     - Name of shelter, manufacturer or builder
2. The sign shall be mounted on the inside wall of the Safe Room in a prominent location 60" above the floor.

* Construction of 14 ga. Skin Door as follows:
1. Vertical steel stiffeners
2. Closer reinforcement
3. 7 ga. hinge reinforcement
4. Reinforced lock boxes
5. Additional 14 ga. skin attached to door w/ 14" x 11" self-tapping screws/hexagon washer heads spaced 6" o/c along perimeter and 12" o/c in the field

** Construction of 12 ga. Skin Door as follows:
1. 12 ga. vertical steel stiffeners
2. 12 ga. full perimeter channel along the door edges (doubled at door head)
3. 7 ga. hinge reinforcement
4. Additional lock boxes
5. 12 ga. reinforced lock boxes
6. Additional 12 ga. skin attached to door w/ 6" x 11" self-tapping screws / hexagon washer heads spaced at 6" o/c along perimeter and 12" o/c in the field.

NOTE: Doors can be either 14 ga. skin or 12 ga. skin. See construction details below for clarification.
NOTES:
Quantities for 4” and 6.25” LOGIX Safe Rooms based on At-grade Safe Room with the following max. dimensions (See Detail 1, Drawing AG-01 and Drawing AG-02):

- 4” LOGIX: 12’ x 12’ x 8’ tall
- 6.25” LOGIX 12’ x 12’ x 10’ tall

### LOGIX ICF WALL

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<thead>
<tr>
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<th>MEASURE</th>
<th>QUANTITY</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOGIX Standards</td>
<td>4” / 6.25”</td>
<td>Each</td>
<td>20 / 50</td>
<td></td>
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<tr>
<td>LOGIX Corners</td>
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<td>LOGIX Taper Top</td>
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<td>Each</td>
<td>13 / 13</td>
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<tr>
<td>LOGIX Half Height Standards</td>
<td>6.25”</td>
<td>Each</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>LOGIX Half Height Corners</td>
<td>6.25”</td>
<td>Each</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Concrete</td>
<td>4” / 6.25”</td>
<td>yd³</td>
<td>5 / 10</td>
<td></td>
</tr>
<tr>
<td>Straight #4 bars</td>
<td>4” / 6.25”</td>
<td>each</td>
<td>#3 / 10</td>
<td></td>
</tr>
<tr>
<td>Bent bars, 4’-2” x 2’</td>
<td>4” / 6.25”</td>
<td>Each</td>
<td>#2 / #2</td>
<td>Bent bars at corners</td>
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### SLAB-ON-GRADE FOUNDATION

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<tr>
<td>Wire mesh reinforcement</td>
<td>6” x 6” x 2.5” x 2.5”</td>
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### 28” x 8” THICK FOOTING

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<td>#4 footing dowels</td>
<td>28” x 8”</td>
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### INSULATED CONCRETE ROOF ALTERNATIVE

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<td>Concrete</td>
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<tr>
<td>#5 straight bars</td>
<td>4” LOGIX / 6.25” LOGIX</td>
<td>ft</td>
<td>410 / 439</td>
<td>Dowels at top of LOGIX wall footing connection</td>
</tr>
<tr>
<td>#4 bent bars</td>
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<td>each</td>
<td>52</td>
<td>Dowels at top of LOGIX wall footing connection</td>
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### FLAT CONCRETE ROOF ALTERNATIVE

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<td>Concrete</td>
<td>6” thick slab</td>
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<td>Dowels at top of LOGIX wall footing connection</td>
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<tr>
<td>#4 bent bars</td>
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### HARDWARE

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<td>See Detail 1 and 2, Drawing MM-01</td>
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<td>Door</td>
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