Chapter V

THE LEAST-RISK DECISION MAKING PROCESS

5.0 General

- A Least-Risk Decision Making (LRDM) table will provide:
  - A summary of the evaluation's findings in a brief, easy-to-interpret format that will indicate clearly the relative vulnerabilities of the building(s) surveyed.
  - Data essential to making informed decisions on risk acceptance with respect to local shelter inventories to emergency management and other agencies with roles in shelter planning and operations.

5.1 Preparation of Least-Risk Decision Making Table

- An LRDM table for a building:
  - Summarizes all criteria for storm surge inundation, inland flooding, wind and structural hazards, and hazardous materials vulnerabilities into preferred, marginal, and noncompliant categories.
  - Helps identify mitigation measures needed for upgrading a building from the noncompliant category to a compliant category.
  - A building with even one criterion falling into the noncompliant category should be scrutinized to determine whether the risk potential outweighs the necessity of the building's use.

(1) Storm Surge Inundation:

- The key issues here are whether the evaluated HES is within a storm surge evacuation zone and, if so, what the potential risks to shelterees are.
  - Two feet or less of inundation exposure may be considered an acceptable risk under certain circumstances.
  - More than two feet of inundation potential is noncompliant. An exception may be in the case of multi-story buildings, where upper stories are above the surge. In such cases, a structural and/or coastal engineer should be consulted to evaluate the
risk.

- **Land-falling Hurricanes versus Exiting Storms**

  - A building in a Category 5 or lower zone will not receive the same level of surge from an exiting storm, as from a land-falling storm.
  
  - In those cases where exiting storm surge data is available as well as land-falling storm surge data, evaluate the potential HES for both cases.
  
  - Compare the elevation of the site and/or shelter building to the Maximum Surge Elevation (MSE) of the expected maximum surge from a Category 5 storm (for a landfalling storm and, if the data is available, for an exiting storm).
  
  - If the elevation indicates more than two feet of water could rise in the building, the HES is noncompliant, except perhaps in the case of multi-story buildings, where the potential shelter level is above the water level.
  
  - The access route to the facility also must be evaluated to determine if it may be inundated in a Category 5 event. The storm surge is a short-term event, typically lasting six hours or less. Therefore, minor inundation of the building and/or its access route may be only a temporary situation.

- It should be noted that a particular HES building may be marginal for an exiting storm and noncompliant for a landfalling storm. Both items should be specified on the building’s LRDM table.

- **Preferred:**

  - Buildings located outside the Category 5 storm surge inundation zone, as determined by the latest edition of SLOSH
  
  - Also, at least one access road must be outside of, or elevated above, the Category 5 storm surge zone.

- **Marginal:**

  - Buildings within a Category 5 storm surge zone, and inundation potential that does not exceed two feet.
• Also, access routes may be within the Category 5 inundation zone, therefore the potential for isolation exists. Note that either inundation of the building or its access route is sufficient for this category to apply. Building inundation depth must be clearly noted on the LRDM table when building inundation is a threat. Damage to infrastructure due to saltwater inundation and/or erosion is possible in this circumstance.

• **Noncompliant:**
  
  • Buildings subject to Category 5 hurricane storm surge inundation depths greater than two feet within the building and/or subject to velocity inundation.
  
  • Coastal barrier islands always will be considered noncompliant due to their extreme isolation potential in the post-storm period.
  
  • Buildings subject to velocity inundation will always be considered noncompliant and should not be used as hurricane evacuation shelters.

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>PREFERRED</th>
<th>MARGINAL</th>
<th>NON-COMPLIANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Storm Surge Inundation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(2) **Rainfall Flooding/Dam Considerations:**

• Information is derived from Flood Insurance Rate Maps (FIRM).

• Vulnerability is evaluated in a manner similar to the storm surge criteria; both inundation potential of the facility and its access route(s) are evaluated.

• The HES may be in a flood zone but elevated above probable flood elevations. ARC 4496 requires staying outside 100-year floodplains.

  • If the HES lies above the flood, then isolation due to flooded access roads may be acceptable under some circumstances.

  • If the elevation indicates a potential of more than two feet of water in the building, then the HES is unacceptable.
Rainfall flooding typically is considered a long term event, therefore, evacuation of the HES population probably will be necessary in the post-storm period.

Preferred:

- Buildings should be outside the 500-year floodplain [Zones C or X (with white background)], as determined in the latest edition of FIRM.

- At least one access route must lie above the 100-year floodplain.

- Also, the building and its access route must not be subject to inundation due to dam or levee failure following hurricane-related flooding.

Marginal:

- When the building’s floor elevation is at or above the 100-year floodplain BFE, but the building’s site is within the 500-year floodplain [Zones B or X (with light-gray background)], the building will be considered marginal.

- Building inundation depth should be clearly noted on the LRDM table when building inundation is a potential threat.

- Buildings where access roads are below the 100-year floodplain BFE (riverine or shallow ponding) will be considered marginal, as flooding may cause isolation. Damage to infrastructure due to inundation and/or erosion is possible in this circumstance.

- The building and its access route may be subject to minor inundation of less than two feet due to dam or levee failure following hurricane-related flooding.

Noncompliant:

- Buildings that are within the 100-year floodplain.

- Buildings that are within an outflow area of a dam or reservoir that is subject to containment failure due to hurricane related flooding, and the expected inundation depth is greater than two feet.

- All buildings subject to velocity inundation are noncompliant and shall not be used as an HES.
Exceptions:

In situations where there is no other option than use of buildings within the 100-year floodplain, shallow inundation may be considered an acceptable risk. Buildings with inundation depths of less than 2 feet, for a 500-year event, may be considered marginal. The building's ground floor elevation must be above the BFE. Buildings subject to velocity inundation shall not be used as an HES.

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>PREFERRED</th>
<th>MARGINAL</th>
<th>NON-COMPLIANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Rainfall Flooding / Dam Considerations</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(3) Hazardous Materials and Nuclear Power Plant Considerations:

- If possible, have local hazardous materials experts evaluate the risks to the HES from known hazmat facilities.

- Assume there will be damage to buildings and exposed containers during the hurricane event, unless extraordinary measures are taken.

- On-site hazards
  - Significant quantities of unusually hazardous materials must be on the facility's site for this item to apply (normally generator fuel or janitorial supplies would not qualify).
  
  - In most cases the facility must be manufacturing, using, or storing materials in reportable quantities under the Emergency Planning and Community Right-to-Know Act (EPCRA).

- Off-site hazards
  - The location of an HES within the two-mile EPZ of a Nuclear Power Plant (NPP) is unacceptable.
• Whether the location of an HES within the vulnerability zone (VZ) of any other type hazardous material facility is acceptable, is a judgement call on the part of the local emergency management director and sheltering agency(ies).

• The expected risk of loss of containment of the hazardous material due to hurricane effects or storm surge, and the expected risk of exposure to the HES occupants, should both be noted in the LRDM table.

• The surveyor should specify:
  - The type(s) of hazardous material
  - Distance from potential HES
  - Risk of release during a hurricane event

• The surveyor/local hazmat experts should determine:
  - Does the hazmat facility have a plan to implement in the prehurricane situation that would substantially reduce the risk of release.
  - Whether the hazmat facility has remedial measures to reduce post-hurricane problems.
  - Whether the facility has a means of communicating with emergency management officials to notify them of a hazardous material release.
  - Whether there is a way to evacuate the HES, if need be, in the post-hurricane period and, if there is a release, what is the actual risk potential of the release (i.e., proximity to HES, type of materials and time for evacuation).
  - Guidance regarding these matters is available from LEPCs and the local fire departments.

• Preferred:
  - There are no hazardous materials stored within the HES building or in close proximity that if released during a hurricane event could present a risk to the shelterees (fumes, fire, explosion, etc.).
  - The building is outside of any EPCRA, Section 302/312 vulnerability zones and outside of 10-mile Nuclear Power Plant (NPP) Emergency Planning Zones (EPZ).
• Marginal:
  • There are small quantities of hazardous materials stored within the HES building or in close proximity, but adequate precautions are taken to prevent release in the event of hurricane-related damage.
  • The building is inside Section 302, EPCRA, VZ(s) but with low-release potential with respect to hurricane effects.
  • The potential HES is inside the 10-mile NPP EPZ, but outside of two-mile NPP EPZ(s).

• Noncompliant:
  • Significant quantities are manufactured, used, or stored hazardous materials within the HES building or in close proximity, with high potential for release during a hurricane event.
  • The HES building is within the VZ of a Section 302 facility that has a moderate/high release potential in a hurricane event.
  • The HES building is inside a two-mile NPP EPZ.

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>PREFERRED</th>
<th>MARGINAL</th>
<th>NON-COMPLIANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Hazmat and Nuclear Power Plant Considerations</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(4) Lay-Down Hazard Exposure:

• Determine the risk of a large tree or other structure (towers, chimneys, steeples, billboards, utility poles, etc.) falling on the HES during a storm. Look for a tree/structure that is large enough and near enough to damage/breach the building’s envelope, thus allowing access to hurricane force winds and rain.

• Note any medium size trees that could “batter” the roof or walls.
There must be no potential lay-down hazards within close proximity to the shelter area(s).

Preferred:

- There are no large trees or other tall structures within lay-down range of the building.
- At least one access route is not tree-lined and will not be blocked by fallen trees during and after a hurricane.

Marginal:

- There may be trees or other large/tall structures within lay-down range of the HES, but they are not considered:
  - Large enough to inflict a significant breach of the building’s structural envelope; and/or
  - Within lay-down range of actual shelter area(s) within building.
- All access routes are tree-lined. (Note: local emergency management/sheltering agencies should have plans to clear fallen trees from these routes).

Noncompliant:

- Trees or other large/tall structures within lay-down range of the HES are:
  - Large enough to inflict a significant breach of the building’s structural envelope; and/or
  - Within lay-down range of the actual shelter area(s) within building.

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>PREFERRED</th>
<th>MARGINAL</th>
<th>NON-COMPLIANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Lay-down Hazard Exposure</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(5) **Wind and Debris Exposure:**

- The terrain in which a potential HES is located can significantly change pressures exerted by wind forces and, therefore, the damage vulnerability of the building.

- Determine the level of wind exposure for the building.

- Determine if there are material sources within close proximity to the HES that could generate wind-borne debris during a hurricane. Wind-borne debris may breach the structural envelope, thus permitting wind entry into the building.

- Note that two different items (i.e., wind exposure and debris exposure) are being recognized as a single criterion. The evaluator must include an entry for each of the items within a single block, with the overall compliance to this criterion controlled by the factor with the greatest risk.

- **Preferred:**
  - The building has a sheltered exposure.
  - No large unanchored objects subject to “roll-over” impact of the HES building are within 100 feet.
  - No potential lofted heavy debris sources within 100 feet, and
  - No large or small windborne debris sources are within 300 feet.

- **Marginal:**
  - The building has a limited wind exposure.
  - No large unanchored objects subject to “roll-over” impact are within 100 feet of facility.
  - No potential lofted heavy debris sources within 100 feet, and
  - There is minimal exposure to large and/or small windborne debris sources within 300 feet.

- **Noncompliant:**
  - The building has unsheltered exposure.
- Large objects that may be subject to "roll-over" impact are within 100 feet of facility.

- This classification also applies where buildings are within 100 feet, constructed in a manner that could lead to catastrophic failure and generate massive windborne objects, such as large portions of roof, bond beams, porticos, and walkways.

- There is excessive exposure to large and/or small wind-borne debris sources within 300 feet of facility.

**Exceptions:**

In situations where there is no significant debris exposure, but wind exposure is considered unsheltered, there may be latitude in use of the building, if the remaining criteria of LRDM table are classified as preferred or marginal. In this situation, special attention should be given to the wind design, construction type, roof and wall characteristics, and aperture protection. If possible, this exception should only apply to buildings designed and constructed after 1987.

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>PREFERRED</th>
<th>MARGINAL</th>
<th>NON-COMPLIANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Wind and Debris Exposure</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(6) **Wind Design Verification:**

- National Consensus Standards, such as ASCE or ANSI Standards, are considered state-of-the-art design criteria and reflect the knowledge base of research and experimental findings at the time of their publication.

- Model Codes are often based upon National Consensus Standards but are modified by a voting membership of lay persons in the fields of codes enforcement, engineering and design, and construction trades.

- Model codes often are not as stringent in their wind design criteria as National Consensus Standards.
The following are considered model codes for the purposes of this survey procedure:

- Standard Building Code (SBC, Southern)
- Uniform Building Code (UBC)
- The pre-1994 South Florida Building Code (SFBC)
- The former National Building Code (NBC)
- The Metal Building Manufacturers Association (MBMA)
- Local codes, or custom codes, that include wind regulations similar to those of the listed model codes also are considered equivalent.
- The advice of the local building department should be sought to determine the local history of building code adoption and enforcement.
- If the building was designed by an architect or an engineer, in 1960 or later, assume that the building’s design includes some degree of wind resistance provisions.

Preferred:

- The building’s wind design is in accordance with ASCE 7-88 or a later edition.
- The building is designed and constructed prior to 1989, and uses the wind design criteria of ANSI A58 (1982)

NOTE: Do not assume a building has been designed to ASCE 7 unless definitive proof exists in the “AS-BUILT” construction drawings and specifications.

Marginal:

- The building’s wind design is in accordance with the Standard Building Code or other model codes, and there are no apparent design/construction flaws that could impact wind resistance.
- In addition, HES buildings should receive a ranking based upon the following table. The ranking scale is 0-4, with 0 being the least wind resistant and 4 being the most wind resistant.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>SFBC</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2*</td>
</tr>
<tr>
<td>UBC</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>NBC</td>
<td>0</td>
<td>1</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>MBMA</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

* - Buildings constructed to SFBC after 1994 are required to comply with ASCE 7. Therefore, they are not considered built to a model code.

- **Noncompliant:**
  - A building designed and constructed prior to 1960 and is a single story. There may be individual exceptions to this rule (e.g., some large courthouses built as bomb shelters), however, in every case a structural engineer should review any building built prior to 1960.
  - A building where field surveys and other research indicate a lack of good wind engineering design and construction attention, or
  - The building is designed to wind speeds less than a Category 1 hurricane (94 mph), and/or
  - Evaluated by a structural engineer to wind speeds less than local building code wind design requirements.
(7) Construction Type / Loadpath Verification:

- Focus on the Main Wind Force Resistance System (MWFRS) and the presence of a definable and continuous loadpath throughout the building’s superstructure.
  - The MWFRS must be capable of transferring all wind-induced lateral, debris impact and uplift forces to the building’s foundation.
  - Multistory structures with concrete floor diaphragms and reinforced masonry or concrete shear walls typically perform well as a MWFRS.

- **NOTE:** This criterion is not to be confused with the exterior wall construction criterion. In some situations, buildings may have exterior walls that are loadbearing and serve both the MWFRS and exterior envelope functions.

- **Preferred:**
  - A building has a heavy steel or reinforced concrete frame and/or fully reinforced masonry or concrete loadbearing/shear walls.
  - A clearly defined and continuous loadpath from roof deck to foundation must be present.
  - All connections between MWFRS components must be able to withstand vertical uplift and shear forces. Connections that depend upon gravity, grout/friction, or withdrawal reactions do not provide a continuous loadpath.

- **Marginal:**
  - Buildings that have masonry exterior walls with partial reinforcement (complies with NCMA TEK 63 [1975], or the equivalent) with or without a pinned steel frame.
  - Buildings constructed of light wood or metal stud wall systems that meet SSTD 10-93 (or more recent versions).
Preengineered Metal Buildings (PEMBs) designed to the MBMA (1986 or later edition) will also be included in the marginal classification, if bracing is present in both the roof diaphragm and longitudinal wall planes and if clearly defined loadpaths from roof deck to foundation are present.

- **Noncompliant:**
  
  - A building has unreinforced masonry loadbearing walls, or roof systems that lack sufficient shear connections to provide diaphragm action effectively.
  
  - PEMBs constructed to a standard other than MBMA (1986) or better and lacking adequate bracing.
  
  - Buildings with no observable or verifiable continuous loadpath from roof deck to foundation to resist wind uplift forces.
  
  - All buildings that have connections between MWFRS components that depend upon gravity, grout/friction, or withdrawal reactions are considered to not have a continuous loadpath, and are therefore noncompliant.

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>PREFERRED</th>
<th>MARGINAL</th>
<th>NON-COMPLIANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Construction Type / Loadpath Verification</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(8) **Building Condition:**

- Focus here on the overall condition of the building with respect to wind resistance.

  - Note any signs of deterioration, observable cracks, or corrosion that may significantly increase the building’s vulnerability to wind storms. Particular attention should be given to loadpath and structural envelope components that affect lateral stability and uplift action.

  - Ascertain any history of wind/storm damage to the building. This will assist in determining any special vulnerabilities of the building, as well as any recently repaired areas.
The building owner or facilities manager should be able to provide the needed information. Be sure to check out areas reported damaged in the recent past.

- **Preferred:**
  - The building is in good condition with no apparent signs of deterioration.
  - The building is approximately as sound as it was when new, and the structure shows none of the signs of deterioration indicated in the following categories.

- **Marginal:**
  - A building has minor deterioration. There are some cracks in walls and other signs of slight deterioration that do not appear to impact significantly on wind resistance.

- **Noncompliant:**
  - A building shows major deterioration. This is observable deterioration of a facility's superstructure that may impact on wind resistance.

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>PREFERRED</th>
<th>MARGINAL</th>
<th>NON-COMPLIANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Building Condition / Wind Damage History</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(9) Exterior Wall Construction:

- The integrity of the wall envelope (walls, doors, windows, louvers, etc.) is critical to the survivability of the HES.

- Only one percent of the windward side opened is sufficient for a building to begin to pressurize, reaching maximum internal pressure with as little as five percent opened. At the maximum internal pressure, the outward pressure on side and leeward walls, as well as uplift on the roof doubles. Even if the roof remains intact, openings in the wall envelope subject the building and its contents to wind, debris impact, and water damage. This damage can significantly reduce the suitability of the building as a post-storm mass care shelter.
In addition to the wall envelope integrity, the resistance capability of the exterior walls to both wind effects and to windborne debris impact must be considered.

**Preferred:**

- A building’s exterior walls are constructed of fully reinforced masonry or concrete wall systems and has less than five percent of any wall face’s area comprised of softspot area.
- No softspot area in the building can have direct exposure to the shelter area(s).
- Fully reinforced masonry is defined per ACI 530. Generally, if #5 rebar (or larger) is spaced four feet on center or closer, at the corners and wall-to-wall intersections, and around all openings, this indicates that a building probably complies with ACI 530 requirements.

**Marginal:**

- The building has partially reinforced masonry exterior walls.
- Other masonry exterior wall systems with similar wind-resistance characteristics (flexural, shear, uplift loadpath, etc.) to partially reinforced masonry.
- Other nonmasonry systems that include light wood or steel framed exterior walls, fully wrapped in ½ inch or greater thickness plywood, with a relatively impact-resistant exterior veneer or cladding. The veneer or cladding should have impact resistance characteristics similar to four-inch brick or stone veneer.
- A building with greater than five percent of any wall face’s area comprised of softspot area but the softspot area cannot have direct exposure to the shelter area(s).

**Noncompliant:**

- A building has unreinforced masonry exterior walls, glass panel facade walls, light metal cladding, EIFS cladding, or other lightweight panels.
- Any building that has a softspot with direct exposure to the shelter area(s).
<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>PREFERRED</th>
<th>MARGINAL</th>
<th>NON-COMPLIANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Exterior Wall Construction</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(10) Fenestrations and Window Protection:

- The ability of fenestrations (windows, doors, overhead doors, louvers, skylights, etc.), or aperture assemblies, to resist hurricane windloads and windborne debris impacts will have a significant role in the survivability of an HES.
  
  - The connection of the fenestrations assembly to the surrounding walls is as important as the actual wind- and debris-impact resistance.
  
  - Other important considerations are the size, type and location of glass panes.

- **Preferred:**
  
  - All exterior wall fenestration assemblies and/or protection systems comply with, or exceed, the performance standards/protocols of SSTD 12-94, or the Dade County version of the South Florida Building Code (Sections 2314.1, 2314.5, and 2315.1-2315.4).

- **Marginal:**
  
  - A building has other types of fenestration protective systems that are not certified to meet the standards/protocols required for the preferred category above.
  
  - All fenestrations with direct access to shelter area must be protected from penetration by windborne debris.

  - **Note:** Systems not certified to, or exceeding, the standards listed in the "Preferred" criterion above may not provide sufficient windborne debris impact and/or wind load resistance under hurricane conditions.

- **Noncompliant:**
• A building has unprotected fenestration(s) that lead into shelter areas.

Exceptions:

In situations where a fully enclosed core area, or portion of a building, is physically separated by a construction joint and wall barrier, latitude may be given to the five percent fenestration total area requirement if destruction of the weak portion of the building will have a negligible effect upon the core area or stronger portion of building. For example, a 1994 classroom addition is constructed adjacent to a 1968 classroom building. The new addition is constructed of fully reinforced masonry exterior walls with a single-window fenestration (3' x 5' emergency egress) at each classroom unit; the maximum percent aperture is four percent. A common 10-foot wide corridor runs down the middle of the building and has metal security-type doors at the ends. The older building is constructed of unreinforced masonry and has larger (9' x 5') fenestrations; the maximum percent aperture is 12 percent. The roofs of the two buildings are joined at a temperature expansion joint and the exterior walls are separated by a control joint. The older building also has a common 10-foot wide corridor that connects the buildings with a fire-rated metal security door separating the two buildings. In this situation, the roof expansion joint and wall control joints will reduce the impact of destruction of the older building, therefore, HES space may be available in the new addition.

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>PREFERRED</th>
<th>MARGINAL</th>
<th>NON-COMPLIANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. Fenestrations / Window Protection</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(11) Roof Construction / Roof Slope:

• The type of construction, geometry, weight, slope, and other characteristics of the roof are evaluated for compliance with ARC 4496.

  • A shallow roof is one which has a slope from one to 10 degrees.
  
  • A moderate slope roof has a slope from 11 to 30 degrees and
  
  • a steep roof has a slope of 31 to 45 degrees.
  
  • A lightweight roof weighs 25 psf or less.
• A moderate weight roof weighs 26 to 49 psf and
• A heavy roof weighs 50 psf or greater.

- This criterion may be heavily influenced by loadpath considerations; an inadequate loadpath between roof deck and supporting walls or beams will negate factors listed in preferred and marginal categories below. The absence of an adequate loadpath will render the potential HES noncompliant.

- Preferred:
  • A building has a roof of heavy construction, such as reinforced structural concrete with a four-inch-minimum-thickness deck.
  • A light or moderate weight deck with a roof slope 30 degrees or greater.
  • Roof eave or overhang lengths are limited to less than one foot.
  • Also, no unanchored roof appendages can be present.
  • Metal decks must be 22 gage or thicker.

- Marginal:
  • A building has a flat and/or lightweight roof system with engineered mechanical connections (bolts, welds, etc.) to support structures below.
  • The roof overhang must be less than one foot.
  • If it is a gable roof system, it must be braced against racking failure, or the gable walls must be constructed of a reinforced or partially reinforced masonry wall system.
  • Roof systems conform to preferred criteria above, except that a roof overhang between one and three feet is present.
  • No unanchored roof appendages are present.
  • Metal decks less than 22 gage (i.e., thinner, for example 26 gage).
Noncompliant:

- A building has a flat, lightweight roof system with gravity or friction/grout connection or other nominal connections to support structures below (i.e., fiberboard and PCF).

- Includes all lightweight roof systems with a roof overhang that is greater than one foot and preferred-type systems with overhangs greater than three feet.

- Unanchored roof appendages are present, thus the potential for a significant envelope breach exists.

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>PREFERRED</th>
<th>MARGINAL</th>
<th>NON-COMPLIANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Roof Construction / Roof Slope</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(12) Roof Open Span:

- Buildings with large open spans are susceptible to wind damage during a hurricane. Unless specifically designed with a high factor-of-safety, open-span roof systems typically have little redundancy or inherent reserve strength.

- This criterion may be heavily influenced by loadpath considerations; an inadequate loadpath between roof deck and supporting walls or beams will negate factors listed in preferred and marginal categories below.

- The absence of an adequate loadpath will render the potential HES noncompliant.

- Preferred:

  - The distance between vertical support elements (bearing walls and/or columns) of the roof are less than 40 feet.

- Marginal:

  - A building has a light- or medium-weight roof system(s) with a moderate to steep roof slope, or a hip roof with a maximum span between roof supports of 50 feet or less.
For heavy weight roof systems, a shallow or greater slope and a maximum span between roof supports of 50 feet or less is considered marginal.

- Noncompliant:
  - A building has a flat or shallow slope, lightweight roof system with a distance between vertical supports that is greater than 40 feet.
  - Includes the marginal roof systems with open spans exceeding the maximum distances listed above.

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>PREFERRED</th>
<th>MARGINAL</th>
<th>NON-COMPLIANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. Roof Open Span</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(13) **Roof Drainage / Ponding:**

- Standing water or ponding on a roof can result in a collapse under the weight of torrential rainfall during a hurricane.

  - Ponding can be a hazard only in situations where there is an area that is fully enclosed by a drainage-confining parapet.

    - An indication of ponding is prominent discoloration of roof membrane or ballast materials in relatively low-lying areas, typically near drains.

    - Inspection from underside of roof or ceiling materials also may give evidence for leakage.

    - Although one or two inches of water may help resist uplift forces by adding dead weight to the structure, excessive ponding may lead to roof collapse.

- Preferred:

  - A building has no parapet walls that confine roof drainage and no evidence of ponding.
• **Marginal:**
  
  • A building has a roof parapet that will confine rainfall drainage, and scuppers are present in parapet walls.
  
  • Scupper drainage capacity should equal or exceed the total area of roof drains.
  
  • If evidence of ponding exists, it should be minimal.

• **Noncompliant:**
  
  • A building has a roof parapet that will confine roof drainage, and
  
  • Scuppers are either not present or have insufficient drainage capacity.
  
  • There is significant evidence of ponding and/or roof damage due to excessive ponding to depths that could lead to roof collapse.

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>PREFERRED</th>
<th>MARGINAL</th>
<th>NON-COMPLIANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Roof Drainage / Ponding</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(14) **Interior Safe Space:**

• The focus of this criterion is on identifying an interior corridor or room that can be isolated from the rest of a building and used as a storm shelter area.
  
  • This is essential if the remainder of the building cannot comply with ARC 4496.
  
  • Is the roof or ceiling of the corridor sealed off (walls extend to roof deck)? If not, the corridor may not provide better protection than the building around it.
  
  • Consider the entranceway doors to the corridor. For example, glass entrance doors at the ends of corridors are vulnerable to windborne debris and, if breached, could in effect convert to a wind tunnel.
  
  • This criterion is not applicable if the building meets the previously listed criteria.
for compliance with ARC 4496.

- **Preferred:**
  - A building has interior corridor/rooms with reinforced masonry walls.
  - Walls should be loadbearing, but at a minimum must extend to roof (or floor) support structures and/or deck above.
  - A definable and continuous loadpath must be present from roof/ceiling deck to corridor foundation.

- **Marginal:**
  - A building’s interior corridor/rooms have partially reinforced masonry walls (or equivalent) and concrete or metal roof/ceiling deck.
  - A definable and continuous loadpath must be present from roof/ceiling deck to corridor foundation.

- **Noncompliant:**
  - ARC 4496 does not require an interior room or corridor to be present in an HES building, if the remainder of the HES is considered compliant.
  - Corridors with unprotected fenestrations that are directly exposed to wind effects and debris sources are noncompliant in those exposed areas.
  - Corridors with unreinforced masonry (or structurally weaker) walls are noncompliant.
  - Interior noncompliant corridors surrounded by noncompliant areas (i.e., exterior unreinforced CMU walls) are noncompliant.
  - Interior corridors or rooms surrounded on all sides by building areas that are compliant may be considered compliant.
<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>PREFERRED</th>
<th>MARGINAL</th>
<th>NON-COMPLIANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. Interior Safe Space</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(15) **Life Safety / Emergency Power:**

- The purpose of this criterion is to clarify the compliance of the potential HES building with fire and life safety codes and the presence/absence of an emergency power source. If a building cannot meet the pertinent fire and safety codes of the jurisdiction, it should not be used as an HES building. The primary need for emergency power is to support fire/life safety and security equipment and systems.

- **Preferred:**
  - The building has an Emergency or Standby Power Generator-Set with a minimum 24-hour on-site fuel supply (a 72-hour fuel supply is recommended). The generator, its fuel supply, and other ancillary equipment and fuel lines should be hazard protected.
  - The building must be in compliance with all pertinent fire and safety codes.

- **Marginal:**
  - The building will fall into the marginal category if it has battery backup exit signage and lighting.
  - Installation of generator prewiring systems for expediting connection of a portable gen-set is recommended.
  - The building must be in compliance with all pertinent fire and life safety codes.

- **Noncompliant:**
  - The building is not in compliance with the pertinent fire and safety codes.
5.2 Analysis of Least-Risk Decision Making Table

- Use the LRDM tables to evaluate and rank the relative risks in using each building as a potential HES
  - Safety of the HES occupants is the primary consideration.
  - The LRDM table will quickly identify the most likely points of failure or the greatest point(s) of risk in a particular building.
  - Those criteria in the noncompliant column should be retrofitted/mitigated prior to use of the building as an HES.
- In some cases, retrofit may not be practical, such as a building located in a Category 2 storm surge zone with over two feet of surge expected in the building in a Category 4 storm. It is difficult, if not impossible, to mitigate this problem. In such a case, even only one noncompliant entry will indicate the building is unsuitable as an HES.
- As indicated in ARC 4496 (see Figure 5.1 below) certain exceptions may be necessary, but only if there is a high degree of confidence that the level of wind, rain, and surge activities will not surpass established shelter safety margins.
- The location of a potential HES building in a floodplain normally would indicate the building is unsuitable (without retrofitting).
  - However, in some cases, the maximum expected height of water will result in less than two feet of water in the potential HES building and at least one major means of egress is not in danger of flooding.
  - In some circumstances, the local emergency management and other sheltering agencies may deem this an acceptable level of risk when compared with other available alternatives.
In any case, ARC 4496 guidelines (see Figure 5.1 below) indicate “It is essential that elevations be carefully checked to avoid unnecessary problems.”

The elevation of the potential HES and of the major means of egress to the HES should be carefully checked against the potential height of flood waters to determine the actual risk to HES occupants.

ARC 4496 guidelines (see Figure 5.1 below) indicate that, in the absence of certification by a structural engineer, the potential HES must be in compliance with all local building and fire codes.

Use the LRDM table to evaluate each of the strong and weak points in a building and to determine what retrofits are needed to upgrade the building to HES status.

- In some cases, the building will show numerous noncompliant entries. Such buildings should be considered a lower priority for retrofit compared to buildings with fewer problems and more preferred features.

- A building that has entries only in the preferred or marginal categories can be considered suitable as an HES.

- However, even in those cases where there are no noncompliant entries, but numerous marginal entries, retrofits to upgrade the various marginal areas should be considered.

The LRDM table does not guarantee a building is safe. It is only a tool to reduce the risks in selecting HES buildings.

A sample completed LRDM table is provided in Table 5.1 below. In the table the criteria are rated in categories of Preferred, Marginal, and Noncompliant.

- The Preferred category indicates no further retrofitting or mitigation is necessary.

- The Marginal category indicates acceptable conditions, but that further evaluation and retrofitting should be considered.

- The Noncompliant category indicates areas do not meet the minimum ARC 4496 guidelines. These areas should be retrofitted prior to use as an HES area.
Least-Risk Decision Making (ARC 4496)

Safety is the primary consideration for the American Red Cross in providing hurricane evacuation shelters. When anticipated demands for hurricane evacuation shelter spaces exceed suitable capacity as defined by the preceding criteria, there may be a need to utilize marginal facilities. It is therefore critical that these decisions be made carefully and in consultation with local emergency management and public safety officials. Guidance should be obtained from Disaster Services at national headquarters, in consultation with the Risk Management Division.

This process should include the following considerations:

- No hurricane evacuation shelter should be located in an evacuation zone for obvious safety reasons. All hurricane evacuation shelters should be located outside of Category 4 storm surge inundation zones. **Certain exceptions may be necessary, but only if there is a high degree of confidence that the level of wind, rain, and surge activities will not surpass established shelter safety margins.**
- When a potential hurricane evacuation shelter is located in a flood zone, it is important to consider its viability. By comparing elevations of sites with FIRMs, one can determine if the shelter and a major means of egress are in any danger of flooding. Zone AH (within the 100-year flood plain and puddling of 1-3 feet expected) necessitates a closer look at the use of a particular facility as a sheltering location. Zones B, C, and D may allow some flexibility. **It is essential that elevations be carefully checked to avoid unnecessary problems.**
- In the absence of certification by a structural engineer, any building selected for use as a hurricane evacuation shelter must be in compliance with all local building and fire codes. **Certain exceptions may be necessary, but only after evaluation of each facility using the aforementioned building safety criteria.**
- The Red Cross uses the planning guideline of 40 square feet of space per shelter resident. During hurricane conditions, on a short-term basis, shelter space requirements may be reduced. Ideally, this requirement should be determined using no less than 20 square feet per person. Adequate space must be set aside for registration, health services, and safety and fire considerations. On a long-term recovery basis, shelter space requirements should follow guidelines established in ARC 3031, *Mass Care: Preparedness and Operations.*

Figure 5.1 Extract from ARC 4496
Table 5.1 Sample

Least-Risk Decision Making: ARC 4496 Guideline Compliance Summary

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>PREFERRED</th>
<th>MARGINAL</th>
<th>NON-COMPLIANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Storm Surge Inundation</td>
<td>Building and at least one access road are located above the Category 5 storm surge zone.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Rainfall Flooding / Dam Considerations</td>
<td>The building and at least one access road are above the 500 year flood plain and not threatened by dam/dike/reservoir failures. Located in Zone C.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Hazmat and Nuclear Power Plant Considerations</td>
<td>The Facility lies within the Vulnerability Zones of six different hazmat facilities. In all these cases the hazardous material was listed as chlorine, with a low risk of release.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRITERIA</td>
<td>PREFERRED</td>
<td>MARGINAL</td>
<td>NON-COMPLIANT</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-----------</td>
<td>----------</td>
<td>---------------</td>
</tr>
<tr>
<td>4. Lay-down Hazard Exposure</td>
<td></td>
<td></td>
<td>On the south side of the building, a large pine tree is within laydown range of the southwest corner of the building.</td>
</tr>
<tr>
<td>5. Wind and Debris Exposure</td>
<td></td>
<td>Facility is within one mile of large body of water and within a quarter mile of an open area. Facility has an unsheltered wind exposure, and high exposure to debris.</td>
<td></td>
</tr>
<tr>
<td>7. Construction Type / Loadpath Verification</td>
<td>Loadbearing CMU walls with pilasters (four #5 rebar each) at 11 ft O.C. Continuous loadpath from roof to foundation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Building Condition</td>
<td>Good with no history of significant damage from recent hurricanes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Exterior Wall Construction</td>
<td>Eight inch CMU with pilasters (four #5 rebar each) at 11 ft O.C., with four inch brick veneer.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Fenestrations / Window Protection</td>
<td>About 12 percent of total exterior wall is unprotected glazings (about 766 sq.ft.).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRITERIA</td>
<td>PREFERRED</td>
<td>MARGINAL</td>
<td>NON-COMPLIANT</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>11. Roof Construction / Roof Slope</td>
<td></td>
<td></td>
<td>BUR over 22 gage metal decking on OWSJ. Slope is 5 degrees. Roof is lightweight with three foot overhang. Roof has pilaster reinforced masonry gable ends.</td>
</tr>
<tr>
<td>12. Roof Open Span</td>
<td>Roof spans were 35 foot between vertical supports.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Roof Drainage / Ponding</td>
<td></td>
<td>No indication of significant ponding/roof degradation.</td>
<td></td>
</tr>
<tr>
<td>15. Life Safety / Emergency Power</td>
<td></td>
<td>Life Safety inspection not performed as part of this survey. No emergency power source.</td>
<td></td>
</tr>
</tbody>
</table>