Summary Minutes for the July 22nd and 23rd Meeting of

International Code Council/National Storm Shelter Association

Consensus Committee on Storm Shelters

(IS-STM)

Revised 2/6/2004

Meeting Location: Embassy Suites Orlando, Orlando Florida
Chair: Marc L. Levitan
Vice-Chair: E. Scott Tezak
Committee Secretary: Dave Bowman

1. Call to Order
   Meeting was called to order at 8 a.m. on July 22.

2. Roll Call/Introductions
   Committee members in attendance:
   - *Danny Kilcollins*
   - *Mitchell Hort*
   - *Roger Robertson*
   - *Kurt Roeper*
   - *Mark Whitaker*
   - *Bob Franke*
   - *Robert Wills*
   - *Ernst Kiesling*
   - *Tim Reinhold*
   - *Joe Knarich*
   - *Dennis Graber*
   - *Jim Messersmith*
   - *Jim Waller*
   - *Majed Dabdoub*
   - *Scott Tezak*
   - *Marc Levitan*

   Guests in attendance
   - *Corey Schultz, PBA Architects*
   - *Russell Carter, Texas Tech University*
   - *Todd Davison, FEMA Region 4*

   ICC Staff: David Bowman, Committee Secretary

   Chairman Marc Levitan noted that a quorum of the committee members was present. Committee members not in attendance were Joseph Belcher, Kenneth Ford (alternate

Joseph Knarich attended), Lawrence Twisdale, and Paul Tertell.

- Report on standards council appointments
Dave Bowman reported that the ICC Standards Council appointed Stephen Skalko as an alternate to Jim Messersmith, Paul Tertell as an alternate to Bob Franke, and John Holmes as an alternate to Marc Levitan. Corey Schultz was advised that his application as a non-voting member had been received, but was not yet reviewed and approved by the ICC Standards Council.

3. Approval of Agenda
The agenda was approved unanimously with no modifications.

4. Approval of minutes of the May 1 and 2 meeting
The minutes were approved, with the following modifications:
1. Addition of the name of the chair for each task group.
2. Addition of the list of task groups with members.

5. General discussion for committee input into each of the separate topic areas and task groups:
The chairpersons for each task group were asked to give a brief update on any progress or any new information available since the previous meeting. Of note:

Design Events/Wind speeds

Scott Tezak reported that he would be proposing an approach to wind speed maps that would deal with Tornado regions and Hurricane regions separately. In addition, he was prepared to address concerns over the consistency in the approach and regarding the interface between tornado dominated regions and hurricane dominated regions.

Wind loads, Debris, and Design Events

Ernie Kiesling submitted a brief entitled "Design Criteria for Storm Shelters." as a discussion point for the respective groups.

Debris

Regarding the committee's desire to develop a different test standard for impact loading, Bowman advised that, before raising any concerns with ASTM, the committee should get a better definition of what they would want to do. If the end result is simply the same test protocol with different criteria, there is really no problem regarding interface with ASTM.

Levitan asked Bowman if it was possible for ICC to fund some testing to scope out the effort? Bowman reported that he doubted that ICC was prepared to do that.

Inspections

Bowman reported that he believed that the IBC provisions for Special Inspections would adequately deal with commercial construction. Regarding inspections of

residential construction, the IRC contained no provisions for special inspections, so the standard would need to provide some specific manner of dealing with such special inspections.

6. Breakout with separate task groups
   - General discussion/review
   - Formulate work plan, make assignments

7. Committee meets as a whole to hear reports from task groups

   The separate task group breakout sessions started at approximately 9:30 on the first day and continued until the afternoon of the second day. Following is a report from each group:

   a. ***Design Events/Wind speeds*** *See below*
   b. ***Wind loads*** *See below*
   c. ***Ingress/egress & Life Safety*** *DAB*
   d. ***Debris*** *See below.*
   e. ***Special Occupancy*** *See below*
   f. ***Structural interface/separation*** *See below*
   g. ***Flood/multi-hazard*** *See below*
   h. ***Inspections*** *See below*

8. Review assignments/ discussion on direction of each group

   Assignments are included in the group reports from agenda item 7.

9. Work plan

   Dave Bowman reported that the tentative target date for the committee to complete its work was by the end of calendar year 2005. He also reported a working title for the document would be "ICC Standard for Design and Construction of Storm Shelters."

10. Determination of date and location of next meeting

    Next meeting will be held in Tampa FL on Oct 21-22, 2003. Times will be 8-5 Oct 21 and 7:30-4:30 Oct 22. Danny Kilcollins will arrange optional tours of hurricane shelters for Monday afternoon, Oct 20.

11. Adjourn

    Meeting adjourned at 4:00 pm on Wed. July 23.

Minutes of the Design Events/Wind Speeds Subcommittee
July 22, 2003
Marc Levitan for Scott Tezak

Scott Tezak distributed and discussed several handouts on tornadic and hurricane wind speeds (materials used to support development of the wind speed map in FEMA 361). A question arose about the conversion of Saffir-Simpson hurricane wind speeds into ASCE 7 design basis (hurricane categories are determined using one-minute wind speeds over open water at 10m, ASCE 7 speeds are 3-second peak gusts at 10m over flat open terrain). FEMA 361 shows different conversions than those provided by Vickery in a paper in the Structural Engineering journal. **Marc Levitan** to distribute reference/copy of Vickery table and **Scott Tezak** to follow up on this.

The subcommittee determined it needed additional information before it could make decisions on design wind speeds/maps, although consideration is at the moment to have separate maps for hurricane and tornado wind speeds. **Marc Levitan** to contact **Larry Twisdale** and see if he can produce 2,000, 5,000, and 10,000-year maps of hurricane wind speeds from their 100,000 year simulated hurricane database created for other projects.

The issue of hurricane-spawned tornadoes was discussed. Although generally weaker than other tornadoes, are they strong enough to effect choice of design wind speeds? How far inland do they extend? **Marc Levitan** to try and track down information on the climatology of hurricane-generated tornadoes.

Minutes of the Wind Loads Subcommittee
July 22, 2003
Marc Levitan for Scott Tezak

Internal pressures were discussed at length. The general feeling was that use of full internal pressure of +/- 0.55 was probably most appropriate. Even though the openings must be designed for debris protection, meaning the building would normally be designed as an enclosed structure, the committee discussed a number of scenarios by which the building may become a 'partially enclosed' structure from the standpoint of internal pressure:

- Purposeful opening of door for 'late arrivals' to the shelter after wind event has star
- Accidental opening of door (crowd pushing up against panic bar in dark, crowded shelter)

- Door hardware has deteriorated from repeated use/abuse (particularly a problem in some high schools)
- Shutters (operable) not functioning correctly or not installed or not installed correctly
- More and/or larger missiles than called for in the testing protocol.
  Given that internal pressurization could affect the stability of the entire structure, use of partially enclosed criteria may be most appropriate. Further consideration is needed, for cases such as where even if the openings are breached the area might be small enough not to cause change in classification from enclosed to partially enclosed. Stringent internal pressure requirements may however create problems in that door systems may not work.

  Directionality factor of 1.0 to be used for tornado shelter design, after FEMA 361. For hurricanes, 0.95 may be more appropriate. A discussion of this is presented in a thesis by Joffrey Easley from LSU. The link to download this thesis was previously provided to the committee.

  The issue of exposure was discussed. FEMA 361 requires use of Exposure C (open terrain) in all cases. In some residential areas in Florida during Hurricane Andrew, what was nominally exposure B (suburban) before the storm because Exposure C during the storm due to extreme damage. However, particularly for hurricanes, urban areas with multistory buildings, even if they suffer significant damage, would not be damaged enough to cause an effective change in the terrain roughness.

Summary of Debris Subcommittee Meeting
of the ICC/NSSA Standard Committee
July 22 – 23, 2003

Ernie Kiesling, Chair

The subcommittee on debris discussed the publications and documents that will be useful in our work to define missile criteria for storm shelters. The publications include: FEMA 320, FEMA 361, DOE-STD-1020-2002, ASTM E 1886-97.

An underlying consideration for this subcommittee and, possibly for others, is the degree of protection desired for protecting human life in storm shelters.

We are to determine what publications by Twisdale that deal with wind speed and/or debris impact can be made public or used by the committee.

The following presents the areas the Debris sub-committee will address, interactions required with other committees, and personnel assignments. Those leading the effort are identified in bold font.

Missile Criteria

1. Missile types and speeds

a. Missile problem has two different considerations, aerodynamics and impact. Past research and research currently taking place on missile aerodynamics resulting in missile speed based on wind speed were identified. It was suggested that we should be able to establish missile speed as a percentage of wind speed.
b. Missile types and end conditions were discussed.
c. Current test methods and limitations were identified.
d. Ricochet and lethality was raised as a consideration of alcove/baffle style ingress/egress. Questions regarding effects of the type of opening on internal pressure were raised. A literature search would have to be performed, as no one knew of researched information.

2. Topic of falling objects and rolling debris was raised. The committee suggested working with the Structural Interface Committee to address this issue. The committee also discussed creating a section on site considerations of shelters.

John Holmes, Larry Twisdale, Tim Reinhold, and Ernie Kiesling, have committee responsibility. Brian Lee and Joe Minor might be available to review our work.

Define Failure Criteria

1. We must define failure criteria for all components, including walls, doors, and windows.

2. We must consider not only perforation or the creation of openings by the missile but possible creation of debris inside the shelter from spalling, scabbing, or loosing of pieces from the interior of the shelter.

3. Limits must be placed on deformation of the shelter envelope upon debris impact

4. Criteria will be studied, if available, from blast-resistant design from agencies such as FEMA, Department of Homeland Security, and the State Department. Joe Knarick will determine what information is available from these sources.

Ernie Kiesling, Jim Waller, Dennis Graber, Robert Wills, Jim Messersmith, Russell Carter, and John Knarick will serve on this subcommittee.

Test Procedures/Protocols

1. Test procedures or protocols must be developed for walls, doors, and hardware. ASTM standards will be studied for usefulness in designing test methods.

Russell Carter, Tim Reinhold, and Ernie Kiesling will serve on this subcommittee.

Timing of Draft Reports

Load people are responsible to draft provisions of the Standard and to transmit drafts to other members on the subcommittee for comment by October 1.

Areas of requiring work with other committees.

- Doors – Ingress/Egress
- Missile Speed – Design Event
- Cyclic load testing – Wind Loads
- Falling Objects – Structural Interface

Minutes for the Special Occupancy Sub-Committee
July 22, 2003

The Special Occupancy Sub-Committee identified the scope of the sub-committee during the May 2 meeting. Based on the scope, the sub-committee discussed the various items in more specific terms, and assigned various sub-committee members the task of working on a strawman to define the contents of the various sections.

The sub-committee confirmed with the committee as a whole the definition of a storm shelter and the duration the shelter will be used for. The shelter is for the protection of occupants from the event, and not for recovery purposes. **Kilcollins** will prepare a straw man definition of a storm shelter for the next meeting. For a tornado, the maximum stay will be 2 hours, and for a hurricane the maximum stay is 24 hours. **Franke** will check with NOAA to confirm 2 hours is sufficient for a tornado event, and **Kilcollins** will check with NOAA and NHC to confirm 24 hours is sufficient for a hurricane event.

Use and Occupancy - Use of an area as either a hurricane or tornado shelter is not covered in the existing I-Codes. Since the shelter capacity may exceed or differ from the normal day-to-day occupancy and use of the space, the sub-committee discussed the best manner to address the difference. Rather than creating a new use and occupancy classification, a section will be added to Chapter 4 of the I-Codes that covers the special detailed requirements based on use and occupancy. **Bowman, Dabdoud** and **Robertson** will work on this for the next meeting.

Sanitation - Sanitation facilities will be required in non-residential hurricane and tornado shelters. The requirements identified in FEMA 361 and ARC 3041will be used as the basis for the storm shelter standard.

Lighting – For non-residential tornado shelters, the min. code requirements for the non-shelter use will be adequate. For non-residential hurricane shelters, an alternate power source that is protected will be required for the lights. Protection of the alternate power supply will dependent on the wind load, debris and flood/multi-hazard sub-committees to identify the hazards.

Shelter Signs – The standard will not require the posting of exterior signs. However, interior signs to direct the building population to the shelter, and to delineate the shelter will be included in the standard. **Kilcollins** and **Tezak** will work on this for the next meeting.

Space Requirements – The standard will address the amount of space required for non-residential shelters, usability factors, and allowances for aisles/circulation. **Kilcollins, Schulz** and **Franke** will work on this for the next meeting.

Ventilation – For a non-residential tornado shelter, passive ventilation will be acceptable. The min. ventilation requirements are found in ASHRAE 62. For a non-residential hurricane shelter, mechanical ventilation may be required if passive ventilation is not sufficient. Mechanical

ventilation will require an alternate power source that is protected. The need for ventilation will require openings in the shelter envelope, and coordination with the wind load, debris and multi-hazard/flood sub-committees is required. **Tezak** will coordinate with the wind load sub-committee, and **Dabdoud** will research the code requirements. For residential shelters, the provisions in the NSSA's standard will suffice. (Comments by JW)

Notification – Facilities with non-residential tornado shelters will need the means to alert the facility occupants to seek shelter. If an audible warning is used, the tone should be different from the fire alarm. A population threshold will also be determined as part of the sub-committee's work. Currently there are annunciator panels that produce a unique tone suitable for audible warnings. **Schulz** and **Robertson** will work on this for the next meeting.

Accessibility – The sub-committee discussed shelter accessibility. All non-residential storm shelters shall be accessible to individuals with disabilities. Concerns were expressed that a building may need an ADA upgrade if the 20% cost threshold is exceeded even if the shelter does not modify the existing facility. The sub-committee decided not to address this issue, but to let the code minimums and local code officials determine how to comply with accessibility.

Fire Separation/Protection – A fire occurring during shelter occupancy was added as a concern for the sub-committee. The concern is a fire in the non-shelter portion of a facility, and how to best protect the shelter occupants. While the group felt a fire was a very low probability occurrence, it should be addressed in the shelter standard. The sub-committee determined that creation of a compartment rather than suppression would be acceptable. A 2-hour rated wall for the shelter envelope will provide the necessary protection. **Bowman** will work on this for the next meeting.

Minutes for the Ingress/Egress Sub-Committee
July 22, 2003
Dave Bowman, Acting Chair

The sub-committee discussed three primary areas of concern regarding means of egress:

1. Is there a need to consider different criteria for door widths to alleviate congestion at doors during *ingress* for tornado shelters?

   The group decided to recommend that there should be no consideration for increasing egress widths to deal with rapid ingress. These shelters are going to installed in areas where an early warning system will be utilized to allow reasonable calm during ingress into a tornado safe room or shelter.

2. There is a conflict between fundamental code requirements for direction of swing for doors and needs in shelter construction for direction of swing. How do we reconcile the two?

   The issue here is that, for avoiding a blocked exit, and therefore possible entrapment in a building, it is desirable for door swing to be inward, which contradicts the fundamental code rule that the door swing be outward. The group noted that there are two ways to deal with the problem of entrapment from debris on the outside of a door if the door must swing outward: 1. Secondary means of egress, such as a window or some type of hatch, or another door or 2. Protection of the door entry against accumulation of debris.

The group discussed where the possible areas of conflict might be. They noted that two doors are always required to swing outward for spaces when the occupant load of the space as normally occupied is greater than 50. Therefore, when the occupant load is less than 50, there is no conflict in the code.

The group noted that when spaces are required to have two means of egress, it is possible to locate the doors in such a manner that accumulation of debris in front of both doors has a high enough probability of occurring, because the door might be on the same side of the building. However, when 3 doors are required, the spacing of the doors must be such that invariably the doors will need to be located on different faces of the building, which reduces the risk of debris accumulating in front of all doors.

Therefore, the problem occurs when there are only two means of egress doorways required out of the space. The group will recommend writing language into the standard requiring protection of the doors or secondary means of egress when this is the case. ***Roger Robertson*** *will draft that language.*

3. Should the number of doors and required egress width for a room or space that will serve as a tornado shelter be based upon the occupant load for the space as normally occupied, or the occupant load for the space when occupied as a shelter?

   The group debated this issue at length, finally deciding that the number of doors and required egress widths should be based upon the main occupancy of the space, rather than the occupant load of the space when used as a shelter. The basis for this recommendation is the fact that, for the tornado type shelter, the issue will not be egress for the short period that the space is being used as a shelter and the probability will be low that a fire could occur at the same time. With regard to hurricane shelters, the same thing is true, or the likelihood of there being a drastic difference in occupant loads is very low, given that a hurricane shelter will require considerably more floor space per occupant.

Inspections
Dave Bowman, Chair

This group consists of the entire Storm Shelter Committee. The discussion started with a discussion regarding the need for special inspections (i.e. third party inspections of all shelter construction). The special inspections for buildings that are built in accordance with the IBC will be required in some cases at any rate.

Regarding inspections of residential safe rooms, the discussion was tied to the need for a Registered Design Professional. In addition, many felt that special inspections were not needed for any structures constructed with prescriptive details that were included in the standard. For all others, the group assented that special inspections should be required.

This led to a discussion as to whether the standard should contain prescriptive details of structures or structural elements that would be "deemed to comply." The group assented that prescriptive deemed to comply details should be included in the standard. Jim Waller was a strong dissenter on this point.

Jim Waller provided the following clarification on this point:

The NSSA Standard prescribes criteria for the design of storm shelters, including design wind and test missile impact criteria, siting, access/egress requirements, essential features and accessories, and other performance requirements. The Standard requires that shelter designs and engineering documents, which will be submitted for review by an independent, NSSA-approved engineering firm, be prepared by a registered design professional. NSSA's bylaws require producing members' storm shelters to bear a serial- numbered seal containing the name of the producing member and a statement that construction of the shelter complies with the NSSA Standard. NSSA's bylaws also require the producing member to execute a Certificate of Installation which states that the shelter bearing the numbered seal has been verified to comply with the NSSA Standard. When the shelter is installed by a NSSA member, the Certificate of Installation also contains a certification that construction and installation also comply with the Standard. Where a shelter is to be installed by the customer or someone other than the NSSA member or his authorized representative, the Certificate contains a statement that installation instructions, which are on file with NSSA, were supplied to the customer. The Certificate contains a space for providing the name of the local building official or inspector, but does not require that this information be provided or that installation inspections be performed by third parties. Where a site-built public shelter is installed by a customer or by an independent contractor on behalf of a NSSA member, the member is required to perform installation inspections. However, NSSA does not require that any inspections be performed by building departments or registered design professionals.

In the August 2003 issue of Building Safety Journal, "Building Codes and Storm Shelter Safety", Waller and Kiesling stated that reference to the ICC/NSSA Standard (ICC-STM-CC) "will provide the basis for legally enforcing the production and construction of high-quality storm shelters." Providing the basis for enforcement by no means imposes a duty to enforce the provisions. It does, however, provide a rational procedure for assuring the quality of storm shelters which could be implemented or required by local building departments, lending institutions, insurance underwriters, or government agencies involved in shelter grant programs. The ICC Standard and the inspection procedure can be expected to be publicized by FEMA, the news media, etc., thereby making the public aware that storm quality assurance is available when demanded by purchasers of storm shelters.

The article also states that "Assurance of compliance with storm shelter standards may also require inspection of the assembled, installed, or constructed shelter." The article further suggests that the "NSSA seal and Certificate of Installation may be considered adequate evidence of compliance with an appropriate standard." The authors imply by this statement that should NSSA become a certified product approval and inspection agency that the Certificate of Installation should preclude the need for additional inspections. The authors also imply by this statement that provisions for shelter quality assurance should be embodied in the ICC Standard. They further state that inspections of storm shelter installations would be best coordinated with the owner, contractor, other building trades, and the building department.

Jim Waller is of the opinion that ICC-STM-CC should contain a section entitled "Inspection of Storm Shelter Installations" which is in a format similar to Appendix D of the International Residential Code. The IRC presently provides in Section R109.1.5 "Other Inspections" for the building department to require additional inspections if deemed necessary. It is the duty of this committee to provide the basis for inspection of storm shelter installations.

Minutes for the Flood Multi-Hazard Sub-Committee

The I-Codes contain provisions that are consistent with the minimum requirements for the National Flood Insurance Program. Residential shelters should be constructed to the minimum NFIP requirements, which will require elevation to or above the Base Flood Elevation for the 1% chance of annual occurrence flood as shown on the Flood Insurance Rate Map.

Flood - The sub-committee discussed elevation requirements for non-residential tornado shelters. FEMA 361, *Design and Construction of Community Shelters*, recommends elevation to the 0.2% chance of annual occurrence flood or the 1% chance of annual occurrence flood plus 1 foot, which ever is higher. ASCE 24, *Flood Resistant Design and Construction Standards,* requires the elevation of essential facilities (Category 4) to BFE plus 1 foot. While a storm shelter is not included in the definition of an essential facility, a storm shelter is similar to other defined facilities.

The standard may consider exceptions to the higher standard if an engineering analysis can show that the probability of a 0.2% event and a tornado would not occur concurrently. **Franke** will identify possible exceptions for the next meeting. **Messersmith** will work on adding tornado shelter to the Category 4 definition in ASCE 24.

Hurricane - Hurricane shelters should be elevated above the storm surge for a Cat 5 hurricane as determined by SLOSH modeling. It was noted that organizations that have historically provided shelter management will not staff shelters located in Cat 5 surge zones, but other local agencies may provide staff for Cat 1 – 3 shelters. In some locations, shelters are constructed for the Cat 1-3 storms and evacuation occurs for Cat 4-5 storms. This concept will be discussed in the commentary. The standard will provide for shelter design for various categories, but will not provide siting guidance. **Kilcollins** and **Bowman** will work on this section. The Florida EHPA will be used as a starting point.

Hazardous Materials – Shelter occupants may be exposed to air and water borne hazardous materials. The sub-committee may require the assistance from a haz-mat specialist. LSU has conducted limited research on the subject, and **Levitan** will investigate further.

Lightning – Lightning is a part of severe storms and may pose a hazard to shelter occupants. The normal code provision for grounding may be adequate for lightning protection, and the

NSSA draft shelter standard contains some provisions. **Kilcollins** will provide additional information for the next meeting.

Rain – Heavy rain is a part of hurricanes. Debris blocking roof drains may cause water to pond in excess of normal design criteria. The ponding water in combination with wind and flood loads during a hurricane is not addressed in ASCE 7, *Minimum Design Loads for Buildings and Other Structures*. This will be coordinated with the wind load sub-committee. **Levitan** will research data for the maximum rain expected during hurricanes.

Minutes of the Structural Interaction/Separation Subcommitee

By Jim Waller

The subcommittee met on July 23 to further define the tasks delineated in the subcommittee report filed and reported in summary of minutes of May 1 & 2 meeting. An additional task was defined and discussed. This related to the effects of collapsing portions of a building in which the storm shelter is contained. It is recommended to the **Wind Loads Subcommittee** that the following be considered for the **Commentary** under the section **Design Loads**.

Total collapse of multistory engineered buildings seldom occurs during severe windstorms, including tornadoes. Steel framed roof structures may fail but concrete floor slabs and MWFRS are typically not collapsed by tornadoes. It is realistic to expect a roof may collapse upon a storm shelter and that ceilings and ceiling support framing, mechanical ductwork, etc. below a building floor above a storm shelter may fall upon the roof of the storm shelter during a severe windstorm. In-residence storm shelters consisting of a roof and one or two floors above the storm shelter might be expected to collapse upon the roof of the storm shelter during a severe windstorm which exceeds structural capacities of the building to resist wind. The 200 pounds per square foot live load is a reasonable allowance for the equivalent uniform live load which would be imposed upon a storm shelter roof by the impact of falling structural or non-structural objects.

Discussion of Acceptable Connectivity of Non-shelter Elements

- Hurricane shelters may be designed for wind forces which are not sufficiently higher than design wind forces for the building such that separation of non-shelter structural elements will be separated from the storm shelter structure at shelter design wind forces.
- Roof framing where shelter design wind forces exceed building design wind forces by such magnitude that failure of connections of the roof framing to the top of a shelter wall, whether part of the MWFRS or not, such connections assumed to have capacities of (say) 1.3 times the average ultimate connection capacities, may not impose forces on the storm shelter which will result in uplift, overturning, or lateral movement which exceed 1.25 (per NSSA) times the resisting capacities.

- Roof trusses bearing on storm shelter walls for gravity load but connected to shelter walls such that uplift forces on roof trusses do not transmit to shelter.
- Wall framing for similar design wind force ratios which result in only limited portions of non-shelter walls remaining connected to the storm shelter at the shelter design wind speed. Interim proposal is being made to assume that the areas of attached non-shelter walls which are tributary to the storm shelter structure be taken as equal to a tributary portion of wall which remains standing and is defined as a triangle of height and base equal to the building wall height (a graphical description of this word definition will describe the presumed remaining wall and portion assumed to be tributary to the shelter wall). Further consideration must be given taking into account the distance to intersecting building walls which might result in larger or smaller tributary wind areas.
- Walls and tie beams which join the storm shelter at a control joint in a building with similar design wind force ratios which result in separation of the walls and tie beams as described for roof framing (above).
- Roof or wall framing which is designed for wind forces equal to the design wind forces for the storm shelter, where the building does not otherwise qualify as a storm shelter under the provisions of the standard.
- Stud walls above or adjacent to storm shelter which are glued, nailed, or screwed to storm shelter using standard connections for stud walls.

Discussion of Connectivity of Storm Shelter to Concrete Floor Slabs

- Should resistance to uplift of slabs by suction forces between slab and soil be considered as resisting uplift and overturning forces on slab for short duration peak wind loads?
- Should the inertia of concrete floor slabs, subject to short term maximum wind forces (3-second gust wind speeds) be ignored as resisting uplift and overturning forces on slab?
- Should inelastic deformations of reinforced concrete floor slabs be considered in analysis of shelter anchorage/stability.
- Should energy dissipation of uplift and overturning wind forces as the result of inelastic deformations of floor slabs be considered?
- Minimum properties of building concrete floor slab considered adequate for storm shelter anchorage to be as described in NSSA *Standard*, paragraph **7. Structural Design Criteria.** [Note: Dr. Ernst Kiesling, TTU has agreed to perform structural analyses of stabilities of various configurations of storm shelter footprints on varying concrete slab thicknesses and configurations. This subcommittee will suggest shelter locations and slab configurations and boundary conditions.]
- Horizontal wind over floor slabs which are at, or very near grade level do not produce uplift forces on the floor slab. A statement to this effect should be considered for inclusion in the **Commentary**.

Discussion of Acceptable Penetrations of Storm Shelter by Utilities

- Penetrations of shelter envelope by steam or gas lines must have automatic shutoffs for threshold motions.
- Plumbing, electrical, and ductwork penetrations of the shelter envelope shall be protected from tornado debris intrusion. Size and location of penetrations need to be considered. These items require input from **Debris** subcommittee.