The following pair of proposals seeks to clarify the requirements of IBC Section 423 for situations where a new building or an addition is constructed on an existing school campus.

IBC Change Proposal Draft – Group E Occupancy Campuses

SECTION 423

STORM SHELTERS

423.1 General. In addition to other applicable requirements in this code and this section, storm shelters shall be constructed in accordance with ICC-500.

423.1.1 Scope. This section applies to the construction of storm shelters constructed as separate detached buildings or constructed as safe rooms within buildings for the purpose of providing safe refuge from storms that produce high winds, such as tornados and hurricanes. Such structures shall be designated to be hurricane shelters, tornado shelters, or combined hurricane and tornado shelters.

(no change to Sections 423.2 and 423.3)

423.4 Group E occupancies. In areas where the shelter design wind speed for tornados is 250 MPH in accordance with Figure 304.2(1) of ICC 500, all Group E occupancies with an aggregate occupant load of 50 or more shall have a storm shelter constructed in accordance with ICC 500. The shelter shall be capable of housing the total occupant load of the Group E occupancy.

Exceptions:
1. Group E day care facilities.
2. Group E occupancies accessory to places of religious worship.
3. Buildings meeting the requirements for shelter design in ICC 500.

<u>**423.4.1 Storm shelter location.** The storm shelter shall be located within the Group E Occupancy building that the shelter is intended to serve, or shall be located such that the maximum travel distance of at least one travel path from an exterior door on the shelter to an exterior door of the building that the shelter is intended to serve does not exceed 1000 feet (304.8 m).</u>

<u>**423.4.2 Group E occupancy campuses.** Where a Group E Occupancy building having an aggregate occupant load of 50 or more is added to an existing Group E occupancy campus, a storm shelter complying with ICC 500 and capable of housing the total occupant load of all the Group E Occupancy buildings on the campus shall be installed when the additional building increases the floor area of the classrooms, vocational rooms, and offices on the campus by more than 25%.</u>

10/28/14 notes: Move limitation at end of 423.4.2 to the beginning with the other limitation at the beginning of the section.

IEBC Change Proposal Draft – Additions to Group E Occupancy Buildings

Changes to the IEBC in the 2015 (GROUP A) cycle:

The 2015 IBC presently contains the language shown on the previous page for schools (the first paragraph of 423.4 and exceptions list). In applying the requirements of the IEBC if an addition were made to a school, one would interpret the code as meaning that a storm shelter would be required for the occupants of the addition only. This would be neither very useful for the school nor cost effective in any case. Therefore, the need is to provide a specific rule in the IEBC to deal with storm shelters when there is an addition to a school.

The following proposed IEBC code change for additions to schools mirrors the proposed revisions to the IBC for the construction of a new building on an existing school campus. The intent is to make the requirements of both sections as similar as possible, so as to not have storm shelter considerations drive the architectural decision regarding construction of a new building versus an addition.

SECTION 1106
STORM SHELTERS

1106.1 Additions to a Group E occupancy building. In areas where the shelter design wind speed for tornados is 250 MPH in accordance with Figure 304.2(1) of ICC 500, where an addition having an aggregate occupant load of 50 or more is added to an existing Group E occupancy building, a storm shelter complying with ICC 500 and capable of housing the total occupant load of the addition shall be installed. Where the addition increases the floor area of the classrooms, vocational rooms, and offices of the existing building by more than 25%, a storm shelter complying with ICC 500 capable of housing the entire occupant load of the existing building and the addition shall be installed.

Exceptions:
1. Group E day care facilities.
2. Group E occupancies accessory to places of religious worship.
3. Buildings meeting the requirements for shelter design in ICC 500.

1106.1.1 Group E occupancy campuses. Where an addition to a Group E occupancy building having an aggregate occupant load of 50 or more is added to an existing Group E occupancy campus, a storm shelter complying with ICC 500 and capable of housing the total occupant load of all the Group E Occupancy buildings on the campus shall be installed when the addition increases the floor area of the classrooms, vocational rooms, and offices on the campus by more than 25%.

1106.1.1.1 Storm shelter location. The storm shelter shall be located within the Group E Occupancy building that the shelter is intended to serve, or shall be located such that the maximum travel distance of at least one travel path from an exterior door on the shelter to an exterior door of the building that the shelter is intended to serve does not exceed 1000 feet (304.8 m).

10/28/14 Notes: Should this also be included in Prescriptive and Performance methods?? Should this also address other Groups?? NIST does not intend to address other Groups at this time; possibly future plans. Should 1000 ft. travel distance be applied to where storm shelters are provided??

Reason:

As documented in the proposal that created the original requirements for installation of storm shelters in schools for the 2015 IBC, even schools built to modern building codes are susceptible to collapse during tornadoes. That proposal described a number of schools destroyed or severely damaged in several 2011 tornadoes in Missouri, Georgia, and Alabama. As documented in the National Institute of Standards and Technology's final report on its technical investigation of the Joplin, Missouri tornado of May 22, 2011, that one storm severely damaged or destroyed 10 of the 20 public schools in the City of Joplin, and several parochial schools.[1]

In 2013, seven schoolchildren died in Oklahoma at the Plaza Towers Elementary School during the Newcastle-Moore tornado on May 20. They were taking refuge in the hallway of the New Main Classroom Building, in their designated tornado safety area, when the masonry hallway

walls collapsed on them[2] (see Figure 1). Several more students and teachers were injured in this and other buildings on the same campus. The Newcastle-Moore tornado also destroyed the Briarwood Elementary School, injuring several people, and collapsed the Gymnasium at Highland East Junior High School.

[1] *Final Report, National Institute of Standards and Technology (NIST) Technical Investigation of the May 22, 2011, Tornado in Joplin, Missouri*. Erica D. Kuligowski; Franklin T. Lombardo; Long T. Phan; Marc L. Levitan; David P. Jorgensen; NIST NCSTAR-3. March 2014. Available at http://dx.doi.org/10.6028/NIST.NCSTAR.3

[2] *Preliminary Reconnaissance of the May 20, 2013, Newcastle-Moore Tornado in Oklahoma*. Erica D. Kuligowski; Long T. Phan; Marc L. Levitan; David P. Jorgensen. NIST SP 1164. December 2013. Available at http://www.nist.gov/manuscript-publication-search.cfm?pub_id=914721.

Figure 1. Damage to the New Main Classroom Building at Plaza Towers Elementary School. The seven schoolchildren died in the central hallway when the classroom walls collapsed on them. An additional two staff members and one student were injured in this building.

In recognition of the need to provide protection for schoolchildren from tornadoes, and that the existing school building stock is not capable of providing that protection, some states and communities have already begun to take action. Following the death of 8 students at Enterprise High School in a 2007 tornado, the State of Alabama enacted legislation in 2010 (Act 2010-746) requiring that all public schools incorporate tornado shelters built to ICC 500. Illinois recently became the second state to require ICC 500 tornado shelters in all new school building construction, when the Governor signed Public Act 098-0883 into law in August 2014.

Another positive trend in school shelter construction is that some of these facilities are also being made available as public shelters. For example, during the rebuilding following the 2011 tornado, the Joplin School District has been proactively outfitting its new and rebuilt schools with tornado shelters, and installing shelters at undamaged schools as well. These shelters, commonly in gymnasiums, are sized not only to handle the full daytime occupant load of the school but also the population of the surrounding neighborhoods within a quarter to half mile radius. The investment of public funds in these shelters is further leveraged to improve public safety by making them available whenever there is a threat from tornadoes, 24 hours a day and year-round. The shelter doors are automatically unlocked as soon as a tornado watch goes into effect.[3] Tornado shelters at several school districts in Arkansas (Greenwood, Fort Smith, Alma, and Van Buren Public Schools) are also open to the public. At these shelters, the doors are automatically unlocked when the tornado siren sounds.[4]

Explanation of Provisions

The 25% trigger in IBC 423.4.2 is based upon the ratio of the occupant density of a classroom (20 s.f. /person) vs. the occupant density of a community tornado shelter (5 s.f./person). If the new building increases the floor area of the school by that much, there should be enough square footage to accommodate a storm shelter big enough to house the entire school population. The 25% triggers in the proposed IEBC Section 1106 follow the same rationale.

The additional language in IBC 423.4.1 requiring the shelter to be within 1000 feet of a building it is intended to serve provides for an approximate 4 minute walk at 3 mph, which is an average speed that humans tend to walk. Add that to an assumed few hundred feet travel distance to first reach the exit of the building being served, and the total travel time is 5 minutes. This is

[3] See http://www.joplinschools.org/domain/635 for more information about Joplin community safe rooms.
[4] See for example http://www.greenwoodpd.org/Community/Storm-Shelters.

consistent with current FEMA guidance for a maximum five minute walk time to reach the tornado shelter.

Cost Impact: This proposal will increase the cost of construction.

The most recent information on costs is available in FEMA P-361, *Design and Construction Guidance for Community Safe Rooms (Second Edition, August, 2008).* All of the values described below related to cost come from that publication. It should be noted that tornado shelters designed and constructed in accordance with FEMA P-361 guidelines are called safe rooms. FEMA's safe room guidelines are similar to ICC 500, but there are some differences. Where there are differences, in all cases, FEMA requirements are *more* stringent than ICC 500, as documented on page 1-2 of FEMA P-361, which states "All safe room criteria in this publication meet or exceed the shelter requirements of ICC 500." Shelters built to ICC 500 would therefore cost less, but there is no data available to quantify that cost reduction.

FEMA 361 describes safe room costs for new building projects as follows. "For large new building projects, however, the percent increase in the overall project cost is quite small. For example, many safe rooms protecting 200 to 300 occupants being constructed as part of a new school have added only 1 to 2 percent to the total project cost when the safe room was included in the design process at the beginning of the project."

Based on review of 36 safe room grant applications from 2008, the average safe room cost per square foot for projects considered technically feasible and effective for providing protection was $188/sf. From more expanded grant application data from years 2005 to 2008, the percent increase in building cost to harden a portion of a building to meet the safe room requirements ranged from 5-32 percent (cost increase per square foot of the safe room area being hardened). More information on safe room costs can be found in Chapter 2 of FEMA P-361.

Costs for storm shelters are anticipated to decrease as their use becomes more widespread. The adoption of requirements for storm shelters in tornado prone areas for Group E Occupancies and first responder facilities in the 2015 IBC will lead to installation of many more storm shelters than are currently being built. Subsequently, shelters will become less of a specialty item from a design and construction standpoint.[5] As the market expands for specialty products needed in shelters, like tornado resistant doors, windows and shutters, economies of scale and new manufacturers joining the industry will also lead to cost reductions.

[5] Previous studies have shown that the premium for new-technology introduction costs disappear once the designer is satisfied with the technology's performance, the technology enters full implementation, and its application has become routine. See for example Ehlen, Mark A., and Harold E. Marshall. 1996. The Economics of New-Technology Materials: A Case Study of FRP Bridge Decking. NISTIR 5864. Gaithersburg, MD: National Institute of Standards and Technology.