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## TOWARDS A BETTER AND SAFER BUILT ENVIRONMENT

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### Abstract

There is a need to educate the ordinary consumer about their built environments; the buildings in which they live and work. Most people know very little about the structures in which they spend the majority of their time. However, in the aftermath 9/11, there has been widespread questioning of the safety and structural integrity of our buildings. In response, there has been initiatives to re-write building code provisions and make our buildings indestructible and safe under any circumstance. This may not be what is needed and certainly may not be economically or socially feasible. The first step is to begin a dialogue with the "consumer" of the built environment that serves to educate them and provide a feedback mechanism. The Council on Tall Buildings and Urban Habitat has taken a leadership role in representing all disciplines concerned with the built environment and educating the general public so that appropriate expectations can be formulated concerning building performance in response to various hazards and threats.

**Keywords:** consumer feedback, building code, Council on Tall Buildings and Urban Habitat, structural integrity, egress, emergency preparedness, fire protection, guidebooks

### 1. Where is the Consumer?

The building industry is unique. Few other industries produce thousands of prototypes (buildings) each year, each building is somehow different than the next. These prototypes are regulated by a set of rules called building codes. The purpose of these codes is to establish a minimum level of safety and performance for the buildings that are produced.

Another unique aspect of the building industry is that it does not have an efficient feedback mechanism. Since it can take years to plan, design, and execute the construction of a major building, consumer feedback is often too late to significantly impact the delivery process for any one building. Only from trial and error over many years are the subtleties of consumer preferences learned.

The design of other consumer products, such as packaged food, automobiles, and electronics have much more direct feedback mechanisms that can instantly influence the design of a product. In fact, the products we all purchase are largely the result of consumer feedback. This feedback comes in a variety of forms, from focus groups, to surveys, to polling and ultimately to units sold.

Does this process exist for buildings? In any measurable way, it does not.

Still another unique aspect of the building industry, and one that became very evident in the aftermath of 9/11, is that the consumers of buildings; the occupants, are generally very poorly informed, or even misinformed, about their surroundings. Somehow the safety of the buildings in which we live and work has been taken for granted. Unlike the automobile industry where millions of dollars are spent each year researching, testing, and reporting on auto safety so that the consumer will be well informed when making their next purchase, there does not exist any "Consumer Reports" for buildings.

With an uninformed consumer and an inefficient feedback mechanism, how do we know which, if any, building code provisions should be modified or added as a result of 9/11? There is no clear evidence from the investigations following 9/11 that there is anything fundamentally wrong with the building code. In fact, the World Trade Center Towers performed heroically, considering the hazard. How can there then be an informed dialogue concerning building code modifications when the consumers voice is not actively participating in the process?

## 2. The Rush to Write Building Code Provisions

There seems to be a rush to write new code provisions. But what hazard are we attempting to address? Airplanes crashing into buildings? Meteors falling from the sky? Truck bombs similar to that of Oklahoma City? Which hazards are acceptable risks and which are not? Which hazards do we want our buildings to protect us from and which are better met through some alternative means? Will the new code provisions affect all buildings equally, or just certain "high risk" buildings? Where do we draw the line?

Since the answers to these questions affect each and every one of us, some amount of public discussion is essential. The costs, affecting both our pocketbooks and our personal freedoms, can be high. Before architects, engineers, and building officials unilaterally decide for all of us what is best, some form of public debate and discussion is essential.

In the absence of efficient feedback mechanisms, the political process may be the only vehicle through which this debate can effectively occur. To this end, it is important that architects, engineers, and building officials assume a leadership role in directing an informed debate. Ensuring that the facts are well understood before policy is enacted.

## 3. Current Research

Currently, throughout the world, a number of building code and research agencies are devoting significant resources toward the investigation of certain perceived problems in response to 9/11. This research is all well intended with the goal of creating better and safer buildings. We can all agree that better, safer buildings are a good thing. But at what cost?

The results of this research may lead to future building-code changes, therefore it is important to understand what is being investigated in order to have an informed dialogue and to influence the outcome. Some of the many agencies conducting this research include:

- US - CTBUH, ICC, NIBS, NIST, NFPA, ASCE, AISC
- UK - BRE
- Europe - CIB
- Japan - AIJ
- Korea - AIK

Topics being investigated by these agencies are numerous, but generally fall into these four categories:

- Structural Integrity
- Building Egress (Exit Stairs)
- Fire Protection
- Emergency Preparedness

Each of these areas of investigations and considerations are summarised in the foregoing paragraphs:

### 3.1 Structural Integrity

The primary issue being investigated is progressive collapse. Since the World Trade Center Towers collapsed as a result of an impact, explosion, and enormous fire, concern over the structural integrity of buildings under extreme events has been raised. Should buildings be strengthened? Are certain types of construction more susceptible to collapse than others? What hazards should be considered?

A recent workshop sponsored by NIBS and NIST focused on these questions, among others. Opinions of the workshop delegates varied widely, ranging from "no immediate action is required", to "immediate building code provisions are required to strengthen buildings." There was no consensus even amongst this group of distinguished engineers.

Before the issues surrounding progressive collapse and structural integrity are investigated further, it is important that a consensus is reached regarding the nature of the hazard addressed addressing. For

instance, if the triggering event is an explosion from a car or truck bomb, one of the most cost effective ways to mitigate this hazard may be to create "stand-off distance." In other words, don't allow the bomb to get close to the building. If this can be effectively implemented, structural fortification is no longer a required response.

How do we achieve a consensus regarding the nature of the hazards to be addressed through building fortification when the next hazard is unknown to us? This is where public dialogue and even public policy needs to play a role in setting the direction, before structural engineers and building officials implement well intended, but potentially misguided provisions.

### **3.2 Building Egress (Exit Stairs)**

In the aftermath of 9/11, much attention has been directed at building egress and in particular, exit stairs. The questions raised include:

- Should more exit stairs be required?
- Should exit stairs be wider to accommodate two-way traffic?
- Should the stairs be located inside the building core or at the perimeter of the building?
- Should stairs be located in hardened enclosures?
- Should lighting be improved?
- Should stair treads be enhanced against slipping?
- Is staged evacuation a valid egress strategy or is mass evacuation the new design scenario?

Examining the facts of 9/11, little, if any, evidence suggests that the exit stairs failed to perform. A recent study of the location and fate of World Trade Center occupants concluded that 98% of all building occupants who had access to an exit stair successfully evacuated the building. People that perished generally fell into three categories: located at or above the impact floors, emergency responders entering the building, located in the plaza outside the towers.

The topic receiving the greatest amount of attention today is the consideration of the proximity of stairs to one another. Some have speculated that if the three exit stairs located in the core of each of the World Trade Center Towers had been separated by greater distances, one of the stairs may have survived the impact, explosion and fire such that people above the impact floor could have safely exited the building. However, no one will ever know if this is truly the case. Most buildings only provide two exit stairs.

Consider for a moment the thousands of high-rise residential buildings throughout North America, Europe, Australia, and Asia that include "scissor stairs" as the primary means of egress. In other words, two stairs that spiral around one-another in a common location on each floor. Two distinctly different exit doors, separated by some distance, lead to two distinctly different sets of stairs that happen to be in the same location. This arrangement of stairs is popular as it consumes the least amount of floor area, making the building very efficient. This stair arrangement however, is very vulnerable if there is any structural distress in the vicinity of the stairs.

If this stair arrangement is not allowed by building codes in the future, what will be the economic impact? What about the thousands of older buildings that already utilize this stair arrangement?

The requirement of more stairs, or wider stairs, does not appear to be supported by any evidence. In addition, the economic impact of additional shafts or width would be substantial.

### **3.3 Fire Protection**

Fire protection is the area where the most significant amount of investigation and research is being conducted. In the US, the NFPA is spearheading much of this effort. Some of the questions being addressed include:

The "design fire" contemplated by current building codes is 1,600 square feet (160 square meters), whereas the fire in the World Trade Center Towers was 160,000 square feet (16,000 square meters)

per tower. Should the design fire be reconsidered? What are the cost implications of increasing the design fire?

Spray-on fire proofing of structural steel members has been called into question in the aftermath of 9/11. Large areas of fireproofing were stripped off of the steel members from the initial impact and explosion of the aircraft. Should thicker amounts of fire-proofing be required? Should new products be developed with higher adherence values?

Fire ratings for construction assemblies for all buildings have been called into question. The common nomenclature of a 1-hour, 2-hour, 3-hour, or 4-hour assemblies bears no relation to how long a building is expected to withstand a fire. These ratings are only relative measures of an assembly's performance under controlled-burn conditions in a laboratory test. A new set of nomenclature, as well as an industry education program, are being considered.

Staged egress versus mass evacuation is also being studied. This topic is more psychological than physical, as it relates to the response of building occupants during a perceived or actual crisis. The psychological impact will also likely vary with time. What is the most appropriate strategy?

These topics, among others, are being considered and investigated with the results yet to come.

### ***3.4 Emergency Preparedness***

Although not specifically required by building codes, there is a growing movement to enhance emergency preparedness measures. Some of these measures are described below:

#### ***3.4.1 Training of Firefighters .***

Providing firefighters with basic training in structural engineering will allow them to make more informed decisions when entering a hazardous situation. Firefighters commonly deal with life-threatening conditions. Requiring a structural engineer to respond to emergency situations and advise firefighters each step of the way will not only slow the process, but will likely be ineffective as the firefighters will proceed with their work despite warnings. Providing firefighters with basic training in structural engineering principles will enhance their own personal safety as well as provide them with the knowledge to proceed quickly in dangerous conditions.

#### ***3.4.2 Availability of Building Plans.***

Providing emergency responders with remote access to building plans will allow them to understand the nature of the building they will be entering before even arriving at the scene. The cost and effort involved in cataloguing this information is enormous, but the benefits are commensurate.

#### ***3.4.3 Emergency Response Plans.***

Building owners and managers should be encouraged to prepare formal, written emergency response plans that are disseminated and practiced by building occupants. Occupant safety will be greatly enhanced.

### ***3.5 CTBUH Response***

It is clear in the months following the attacks on the World Trade Center and Pentagon that there is a great need for leadership in the building industry. The public is demanding more information about safety and design professionals are wondering how best to respond. Faced with these demands, the Council on Tall Buildings and Urban Habitat has identified a clear opportunity to provide leadership. This is not only an opportunity, but an obligation for all design professionals and building officials. The obligation is to educate the general public so that appropriate expectations can be formulated concerning building performance in response to various hazards and threats.

Specifically, the Council on Tall Buildings and Urban Habitat has published two guides:

- Building Safety Assessment Guidebook
- Building Safety Enhancement Guidebook

The Assessment Guidebook is aimed at the average citizen. It is a resource that provides the reader with insight into the various safety systems present in modern buildings, how buildings are expected to perform when faced with hazards such as fire, explosions, bio/chemical attacks, as well as natural hazards such as windstorms and earthquakes. In a sense, this Guidebook is for buildings, what *Consumer Reports Magazine* is for appliances and automobiles. With this guidebook, the average employee, business owner, or apartment dweller will be able to compare the safety aspects of various buildings, allowing them to make more informed personal safety choices.

The Enhancement Guidebook is geared towards building owners, managers, and designers. It is a resource that provides a listing of possible enhancements, beyond the requirements of the building code, that might be incorporated into a particular building design. It is important to note, that in publishing this Guidebook, CTBUH is not promoting code changes that incorporate the enhancements presented. Instead, CTBUH is promoting Performance Based Design. In other words, each building should be evaluated for its particular circumstance and possible threats. Once the specifics are identified, appropriate design criteria can be developed.

#### **4. Implementation of Building Enhancements Post 9/11**

In the 18 months following the disaster of 9/11, several building owners have voluntarily opted to implement physical enhancements to their buildings in order to increase the level of safety and security for their tenants. The implementation of these enhancements has been fairly random and the nature of the enhancements has varied widely in their initial cost and potential benefit. Unfortunately, there remains no industry consensus as to which enhancements should, or should not be implemented.

As a specific example, a dozen or more new and existing buildings have attempted to implement some form of structural enhancement to provide further protection against street level blasts. However, there is no consensus in the design industry regarding the size and proximity of the blast that should be considered. Each of the buildings that has considered this design condition has randomly elected a design direction, varying widely one to the next.

Other enhancements that have been implemented include enhanced fire protection measures such as improved spray-on fire proofing of structural steel members, wider exit stairs, wireless emergency communication systems with repeaters to increase the reliability of the signal, re-location of air in-take grills to protect against potential bio/chemical attacks, and enhanced structural robustness through composite construction, welded connections, and additional structural members.

Majority of these enhancements cost little however is a good attempt to increase the "market appeal" of the particular building. Building owners are attempting to lure potential tenants to their buildings by providing some form of "safety enhancement". So far, unfortunately, there is no way in which to quantify how tenants are reacting to these enhancements. Are tenants willing to pay more rent for these improvements, or are building owners merely chalking this up to a "marketing expense"? Time may tell us the answer to this question. However, with the general safety of the populous at stake, it is astonishing that more attention is not directed toward this topic.

#### **Conclusions**

The building industry is facing some difficult challenges in the months and years ahead. Compounding the technical issues are broader-reaching social issues, issues of uninformed, or misinformed consumers, and inefficient market feedback mechanisms, issues related to which hazards we as a society, want our building stock to withstand.

The building code changes that are being contemplated are potentially far-reaching, yielding significant impacts on construction costs and personal freedoms. Before these code modifications are implemented, there is a clear need to educate the consumer and to engage in a public dialogue in the direction we should proceed.