Building Design Guidelines to Minimize Impacts from Terrorism
แนวทางการออกแบบอาคารเพื่อลดผลกระทบภัยจากลัทธิก่อการร้าย

Supreedee Rittironk
สุปรีดี ฤทธิรงค์
Faculty of Architecture, Thammasat University
คณะสถาปัตยกรรมศาสตร์ มหาวิทยาลัยธรรมศาสตร์

Abstract

The word “Terrorism” used to be a foreign term to the people of Thailand. Today, however, globalization plus technology have driven everything closer together. Thus, terrorism should no longer be a stranger to us. Although there might not be as many terrorism incidents in Thailand as in some other countries, the possibilities of attack still remain a factor for architects and engineers when designing buildings. This article begins with the facts about terrorism. Then, a few ideas are presented to be used as guidelines for design professionals, when dealing with the new awareness of terrorism. Site and building planning, strengthening structure against impact, code compliance and the sub-office and the idea of decentralization are the main topics of discussion. The ideas are not meant to prevent acts of terrorism or to protect buildings entirely. Unfortunately, it is nearly impossible to prevent attacks. This article suggests that we, as design professionals, can find ways to minimize the impact of terrorist acts or discourage those acts altogether in order to protect ourselves and our property from becoming soft targets.

บทคัดย่อ

คำว่า “ลัทธิการก่อการร้าย” เคยเป็นสิ่งที่ไกลตัวจากสังคมชาวไทย อย่างไรก็ตาม ในปัจจุบันโลกาภิวัตน์ผสมผสานกับเทคโนโลยีที่เปลี่ยนแปลงอย่างรวดเร็วทำให้โลกของเราเล็กลง ทำให้แต่ละประเทศใกล้ชิดกันมากขึ้น คำ ๆ นี้อาจจะกลายเป็นสิ่งไม่แปลกใหม่ต่อไปของประเทศไทย ถึงแม้ว่าการคุกคามจากการก่อการร้ายในประเทศไทยจะไม่มากเหมือนกับบางประเทศอื่น ๆ แต่ปัจจัยและความเป็นไปได้ของเหตุการณ์ยังคงมีอยู่ และนับเป็นปัจจัยสำคัญสำหรับสถาปนิกและวิศวกร ในการออกแบบอาคาร บทความนี้เริ่มด้วยข้อเท็จจริงที่เกี่ยวกับลัทธิการก่อการร้าย แล้วต่อด้วยการนำเสนอแนวคิดต่าง ๆ ที่อาจจะเป็นแนวทางในงานออกแบบอาคารเพื่อรองรับเหตุการณ์ที่อาจจะเกิดขึ้นจากลัทธิการก่อการร้าย แนวคิดหลักที่กล่าวถึง ได้แก่ การวางผังบริเวณและผังอาคาร การเสริมสร้างโครงสร้างอาคารให้แข็งแรงขึ้น การดำเนินตามกฎข้อบังคับอาคารและแนวคิดทางการกระจายขององค์กร แนวคิดต่าง ๆ เหล่านี้ไม่ใช่การป้องกันมิให้ผู้ก่อการร้ายกระทำการ แท้ที่จริงไม่มีใครในโลกสามารถหยุดการกระทำจากลัทธิการก่อการร้ายได้ แต่บทความนี้ เป็นการนำเสนอให้ผู้ออกแบบอาคารสามารถเข้าใจและหาวิธีที่จะลดผลกระทบจากการก่อการร้ายให้เสียหายน้อยที่สุด และทำให้ยากต่อผู้ก่อการร้ายที่จะกระทำการภัยคุกคาม และท้ายที่สุดสิ่งที่สำคัญก็เพื่อที่จะรักษาการสูญเสียชีวิตและทรัพย์สินของผู้ใช้อาคาร มิให้ง่ายต่อการตกเป็นเป้าหมาย

Keywords (คำสำคัญ)

Terrorism (ลัทธิการก่อการร้าย)
Terrorist (ผู้ก่อการร้าย)
Impact (ผลกระทบหรือแรงที่เกิดการกระแทกจากวัตถุหรือแรงระเบิด)
Strengthening (การทำให้แข็งแรงขึ้น การเสริมสร้างกำลัง)
Target (เป้าหมาย ที่หมายตา)
Building Codes & Regulations (กฎหมายอาคารและข้อบังคับ)
Design Professionals (นักออกแบบ ในที่นี้หมายถึง สถาปนิก วิศวกร)

I. Introduction

The word *terrorism* has invaded our lives since the attacks on the World Trade Center towers in New York City on September 11, 2001. Before this large-scale, highly visible attack occurred, terrorism was not considered to affect the common man. However, the world has begun to realize that it is closer than we think. It has been proven that terrorism exists and can happen anywhere and to anyone. Even though there may not be as many terrorism incidents in Thailand as in some other countries, we have heard from many sources that there are links to major world networks in this country. The possibilities of attack no longer can be separated from our daily lives.

As terrorism enters our everyday lives as a permanent fixture, we need to address it as an equal to other factors that we consider when locating, designing and constructing buildings for safety. Interestingly, whether or not terrorists implement their acts directly against buildings or other structures, these unintentional targets, often become casualties of war. It is important for design professionals to be aware of this issue.

II. Background facts

A. How do we define terrorism?

The U.S. government defines terrorism as "Premeditated, politically motivated violence perpetrated against noncombatant targets by sub-national groups or clandestine agents, usually intended to influence an audience [1]." Interestingly, the terrorism expert and writer, Brian Jenkins, mentioned in 1974 that Terrorism is like a theatre [2]. In other words, it is a show designed to cause change by using violence.

The U.S. Council on Foreign Relations, a national, non-profit organization, has identified six types of terrorism: nationalist, religious, state-sponsored, left wing, right wing, and anarchist [3]. Article "Terrorism: An Introduction", Terrorism Q&A by U.S. Council on Foreign Relations. Some types of terrorism are more common than others, but all are an equal threat.

B. Terrorism in Thailand and Southeast Asia

1980	Five locomotive cars crashed into Hua Lumphong (Bangkok Railway Hub Station).
1999	Burmese dissidents seized Burmese Embassy in Bangkok on October 1.
2000	Nine Burmese inmates broke out of Samut Sakhon prison, Thailand, and held prison officials hostage on November 23.
2001	A bomb exloded in a bag at Had Yai Railway station, Songkla, Thailand, on April 6. Pattani United Liberation Organization (PULO),the Muslim separatist group, was suspected.
2002	Car bomb outside nightclub in Bali, Indonesia, on October 12.
2003	Cambodian riots set the Thai Embassy in Phnom Penh, Cambodia, on fire on Janury 30.
2003	Hambali, the operational chief of Jemaah Islamiah,was captured in Ayudhaya on August 11. He helped finance and organize terrorist attacks by Jemaah Islamiah, including the Bali bombings.
2004	Twenty schools in Narathiwat province were set on fire on January 5, and at about the same time, a group of gunmen attacked the armory at the non-combat Narathiwat Rajanakarin Army camp, where they shot four soldiers dead before escaping with more than 100 assault rifles and pistols.

Figure 1 Major Terrorism-related incidents in the recent past

Statistical data by U.S. Department of State shows 135 significant world incidents by terrorists from 1961-2001 [4]. Fifty-two percent involved the destruction of structures or portions of buildings. In nearly 70 percent of those attacks, the terrorists used explosive devices to implement their acts. The terrorism treat shall range from car bomb to missile impact, and even from the airplane.

An article from Parliament of Australia addresses increasing evidence that Southeast Asia is becoming an important arena for international terrorism. There are terrorist groups that are allegedly active in at least four countries: Indonesia, Malaysia, Thailand, and the Philippines [5].

Some names of terrorist groups that we hear often in Southeast Asia are: Pattani United Liberation Organization (PULO), Barisan Revolusi National (BRN), Jemaah Islamiah (JI), and Kumpulan Mujahideen

Malaysia (KMM). Many sources have reported that there are also strong links between Islamic separatist groups in southern Thailand and Al-Qaeda [6]. These Muslim separatist groups are seeking their independence from majority Buddhist Thailand.

All of this statistical data tells us that terrorism in Thailand actually exists. Even though, the disastrous acts are not quite as extreme as those in other countries, it is not wise to wait and see what the terrorists are planning next. If terrorists were able to target western tourists in Bali, where do we stand on the protection of tourists to Thailand's many tourist and historical destinations? The world is growing smaller. This issue is no longer foreign to us. Although, some incidents may not be easily categorized as terrorism, but even so, these acts can involve building damage. It is important that Thai design professionals take terrorism and related acts into account in their everyday work.

III. What can be done?

Although at times, terrorists' intentions may extend beyond physical violence to voicing ideals, opinions or demands, it is the attacks that inflict damage to institutional or public buildings, transportation hubs or stations, embassies, and even civilians that we must consider when designing and building. There are some simple ways of protecting people, buildings and assets which we can easily consider, such as: site & building planning, strengthening structure against impact, code compliance, and the sub-office & the idea of decentralization.

A. Site & Building Planning

Land prices in urban areas are skyrocketing. Land owners, developers or even investors will do whatever they can to maximize the return on their investment. On urban sites, buildings are more likely to grow vertically. This will create so-called 'tombstones of the city's in terrorists' eyes, but what we simply call skyscrapers or high-rise buildings. The term *tombstone* signifies that a building is an easy target to attack. There are plenty of issues which should be addressed at the initial planning stages, and that will help protect buildings from becoming an easy target.

In terms of locating a building on a site, a few ideas can be taken into consideration. Parking design is a key element. In many cases, terrorists use cars or trucks as weapons. Buildings that have a parking garage underneath or adjacent to the building provide an easy opportunity for terrorists to plan an attack. It is an excellent idea in saving space, especially in urban situations, but does not work well in the matter of security. If there is no way to avoid this organization, due to site restraints or program requirements, design professionals should consider strengthening the structural system to protect the building and its inhabitants from attack. Access to the garage should be well monitored. If a parking garage is adjacent to a building, isolation of the structural system, or locating it as far as possible from the building, can deter these types of attacks. (see Figure 2)

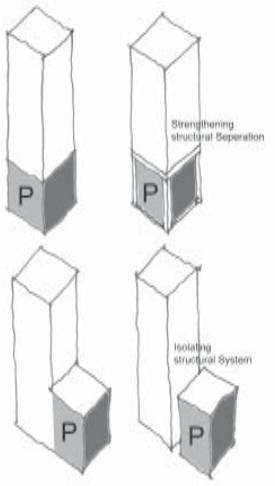

Figure 2 Locating parking adjacent to a building and isolating the structural system from the occupied space is a preferred organization, so the two can be independent, structurally. If a parking structure must be underneath, the building design professionals should consider strengthening the structure between the parking and the building above.

In many cases, terrorists will use a main driveway, drop-off area, or staff entry for their explosive vehicular access. In this way, they can maximize their impact by getting closer to the target. Front setback lines should be seen as ways to help maintain the distance of a building from both the street and any unwanted access. Although buildings, especially in dense urban locations, are often built at the setback line, sacrificing square footage for security can protect the building from becoming an easy target. Any other approaches that must be close to the building such as drives, drop-offs and secondary entrances should be well lit and controlled in order to deter unwanted traffic from approaching or entering the building. (see Figure 3)

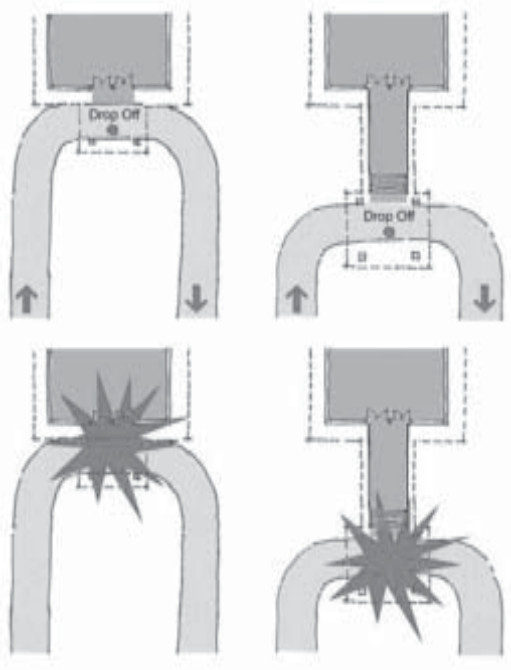

Figure 3 Convenient vehicular drop-off areas provide easy access for building users, but also provide easy access for unwanted vehicles. Even though a remote drop-off location is inconvenient for users, it can discourage acts of terrorism or minimize their impact. Creating even a small transition in grading between the remote drop-off and a building can also help to deter vehicles from getting close to the building.

Building entries can be controlled in other ways. Using x-ray scanning checkpoints and adding or increasing security presence are also valid methods to prevent and discourage terrorists' access. A large open space in front of the entrance to a building can make intruders feel unsafe and unwelcome because it creates obviousness in their actions. Even doors and windows can be designed to include security measures, especially in lower floors which have direct - ground access. Size of openings, type of glazing and frame material can be chosen to limit intrusion. These measures for protection must be considered in the beginning planning stages of a building, in order for adequate space to be allotted for their proper function. Inevitably, this will add more hard cost to the owner, but the building will be surely safer in the long run.

A critical step is for design professionals and building owners to decide which criteria will be best suitable for a particular project. Additionally, it is never too late for some existing buildings to adopt new ideas and modify their planning to make them less susceptible to attack. (see Figure 4)

Figure 4 If previous planning has put a building at risk for terrorist attack, as seen here, there are always options for adjustment or retrofit to make the building safer.

B. Strengthening Structure Against Impact

Aside from the immediate destruction caused by any act of violence, fire and collapse hazards are lingering results after an attack. The World Trade Center (WTC) collapse in New York on September 11, 2001, was a prime example of a building that suffered greater damage from the after effects of a terrorist attack than from the attack itself. Leslie Robertson, the World Trade Center chief structural engineer said "...the towers were designed to withstand the impact of a Boeing 707 jetliner, however no one designs buildings to withstand such weapons of unimaginable magnitude-over 20,000 gallons of jet fuel [7]." The combination of structural damage and intense fire over 550 °C (1,000 °F) caused the upper floors to buckle creating a pancake effect. The impact of floors in excess of 20,000 tons (4.5 million-pound) collapsing on top of one another was too great for the entire building to withstand. Dr. Graham Owens, director of the U.S. Steel Construction Institute, stated that attempting to build terrorist-proof buildings will be expensive [8]. Basically, it would have to be a vertical bomb shelter. The WTC attack warned us that we should plan for the prevention of structural damage. To prevent such acts from occurring again, there are ways to make stronger structures.

To understand how and where structure should be strengthened, we need to learn how the buildings come down first. This can be done by looking at the building demolition process. The rule-of-thumb is to remove the main structural supports by using explosive materials [9]. When the explosion occurs, it will produce air pressure waves that strike surrounding elements. If the upper portion is heavy enough, it will come down due to its own weight and the force of gravity. (see Figure 5) By examining the way that blasts create structural weakness in buildings, we can learn how to better strengthen the buildings' structure against explosion impact.

Research by Priyan Mendis and Tuan Ngo, of the University of Melbourne talks about reactions of concrete high-rise buildings to blast loading and bombing. One of their calculations proves that if the columns were well detailed for special moment resisting connection, the shear capacity and ductility would be improved significantly, thus improving the blast and impact resistance of the member [10]. (see Figure 6)

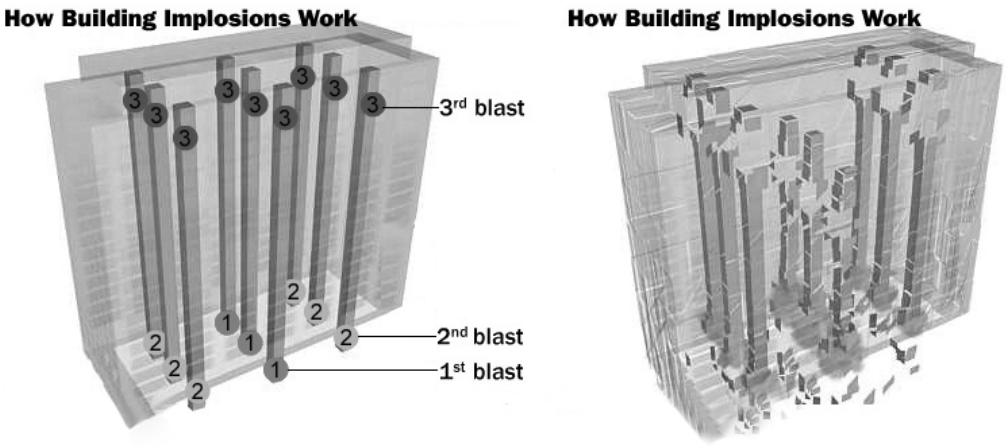

Figure 5 These diagrams demonstrates how a building is demolished using explosive materials. Blast points specifically target certain structural members, causing the building to fall easily under it's own weight.

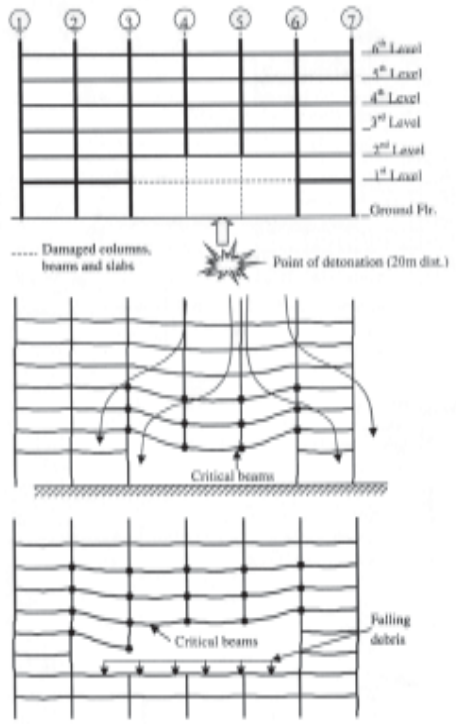

Figure 6 Graphic images by Mendis and Ngo show structural members becoming critical after the blast. The center image indicates a blast at ground level, and the bottom image indicates a blast above ground level. Their study suggested strengthening beam-column connections and using special moment resisting connection can significantly improve the impact resistance of the entire structure.

This tells us that the explosion or impact is directly related to structural connections, especially at beam-column connections. Whether using steel or concrete framing, the reaction of the connection remains crucial. The idea of using moment resisting or rigid connections is valid and not difficult to produce. Some common methods used are:

1) When using steel, moment resisting connections can be achieved by welding the top and bottom flanges of each beam to the column along its full depth (see Figure 7). A diagonally braced frame can also help to provide stiffness (see Figure 8), but the frame itself creates awkwardness in the interior space, which can be a shortcoming.

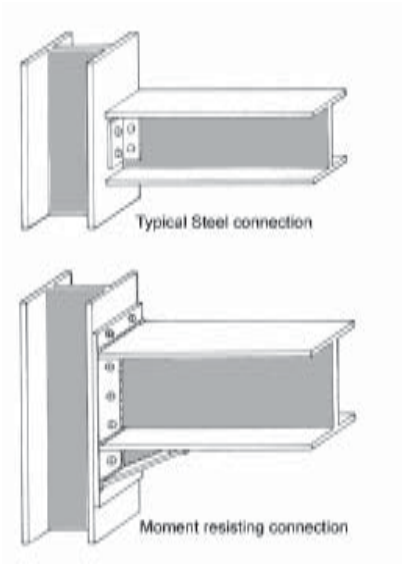

Figure 7 The image shows a moment resisting connection in steel framing compared to a typical pin connection. Welding at the top and bottom flanges will provide more stiffness to the connection, thereby improving structural performance.

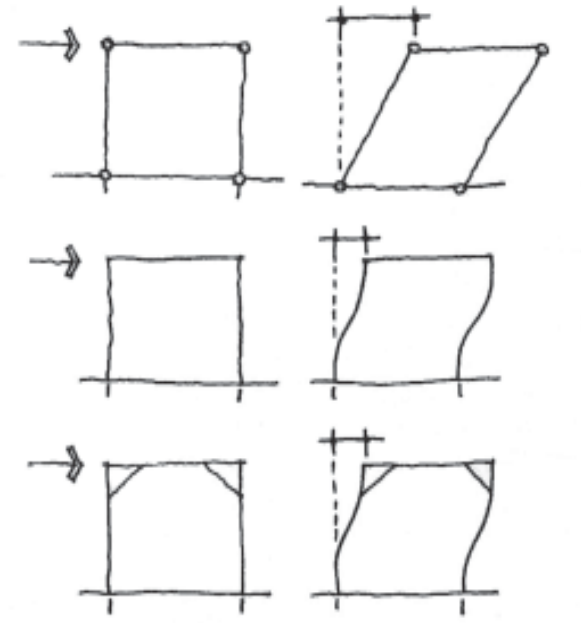

Figure 8 The diagrams show differences in structural steel framing when acting against lateral movement. Pin connections (top) seems to be less stable than the rigid connections and diagonal bracing (center and bottom, respectively) when comparing drifting distances. More drift will allow more damage to a structure and its occupants.

2) When using concrete, moment resisting connections create stiffness. Some applications for instance: using drop panels, waffle slabs, shear heads and missive beams, at beam-column connections can improve the overall structure against movement or impact. (see Figure 9)

Design techniques used in creating structural stiffness are similar to those used to protect against lateral forces such as wind and earthquake. Rigid framing, moment resisting connections, and shear walls are some examples. These design ideas are valid for design against explosive strikes as well, since they are also non-linear forces like those mentioned above. Even though, wind and earthquake factors in Thailand are not as critical as in some other countries, we might as well use them as design considerations in strengthening a building's structure.

Shear walls and diagonal bracing are other methods that can be employed to strengthen structure, provide stability and prevent extreme drift. Shear walls are typically used to form solid walls such as elevator shafts, stairwells, or mechanical shaft walls (see Figure 10). Design professionals should challenge their creativity by integrating these ideas into their designs, even if they are not required by codes or material choice.

One of the reasons that an explosion creates more casualties, is that concrete is broken into small pieces like a series of bullets flying through the air. In some slab applications, Welded Wire Fabric (WWF) is used. It is a mesh of wire available in different square sizes. If WWF is applied to a concrete structure, it surely helps in bonding the concrete together. If the concrete gets fractured from an impact, it has a better chance of holding in place rather than breaking into pieces. This will minimize injury and building damage. Another amazing thing about WWF is that it also increases the tensile strength of concrete because the steel has added remarkably to the ductility. This will also help support the idea of creating lateral resistance, as mentioned above.

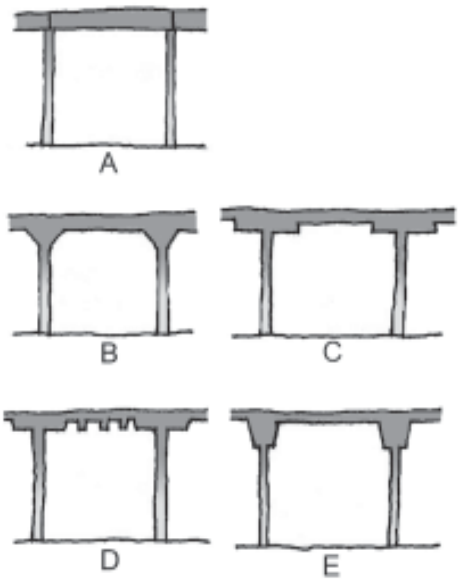

Figure 9 Image A depicts a typical, simple span. Images B, C, D, and E are examples of concrete framing that improves beam-column connections, by makng them more rigid,

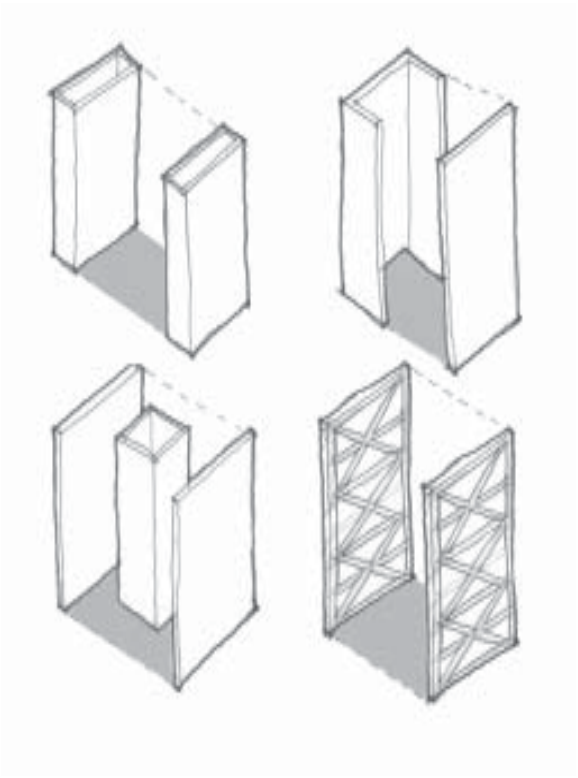

Figure 10 Shear walls are used in many different applications, including stairwells, party walls, elevator shafts and exterior skins.

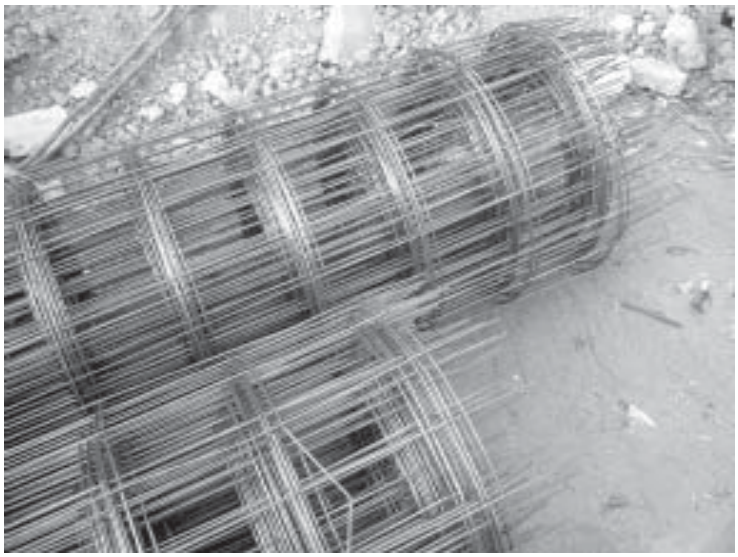

Figure 11 The image shows WWF used in construction applications today. The square size can be made in many different dimensions. More wire surface in contact with the concrete can create better bonding in building components to avoid concrete fragments breaking off in an explosion.

The above are discussions about the strengthening of structure in both concrete and steel applications. What about the choice of material between those two? Steel and concrete framing can perform equally. Regarding the terrorism discussion, concrete structural framing is preferable over steel, especially for protecting against fire that may occur as a result. The nature of concrete, which is a non-combustible material, resists burning longer than steel. Luckily, the main structural systems of major buildings in Thailand are made of concrete. Also, since it has the capability to withstand tropical conditions better than steel, we should take advantage of the fact that concrete is the preferred material choice in constructing buildings. We should learn how to use it better and more safely.

More importantly, some of above design methods require more complicated engineering calculations. To adopt these design ideas, architects shall truly understand basic structural principles and collaborate with structural engineers to achieve the design solutions.

C. Code Compliance

Even though concrete is a preferred choice of structural material, it does not mean occupants of a building will be entirely safe. All buildings should respond to codes & regulations properly. By walking down and observing many urban streets in Bangkok, there is much evidence showing that buildings do not comply with codes. Building codes and regulations are issued to protect the safety and health of building occupants, but there are many buildings that have neglected safety regulations, especially in terms of fire protection. The threat of a terrorist attack to any of these buildings can put its inhabitants at great risk, due to the poor nature of design and construction of the buildings.

Mostly found in public places, fire exits have not been properly built to comply with codes. Exit doors, that are supposed to swing in the direction of egress, are swinging to the inside. This can lead to a dangerous situation when a group of evacuating people is trying to pull the door inward (see Figures 12 & 13). A simple solution can be to switch the door hinges to swing in the

Figures 12 and 13 In some public buildings, little things like switching door swings in the direction of egress can easily save more lives during an evacuation. Design professionals should pay more attention to codes and to what makes sense.

opposing direction. In a past incident, exterior exit doors were locked to protect against outside intruders trying to get in. Unfortunately, it kept the people inside from getting out as well. This particular incident produced many casualties because the fire exit became a death trap due to the accumulation of smoke. This problem can be easily solved by using panic cross bars or door handles that automatically locks from the outside, but allow an 'easy out' for building occupants. These devices are not new. Economically, they cost much less than the damage that can be caused by leaving them out. Simple items, such as these, are often overlooked. Sometimes negligence is a truly hidden danger. If architects and inspectors pay closer attention to codes when inspecting a building before occupancy, we can prevent injury, damage and loss of life.

Density of people is a direct factor in the design of means of evacuation. With a tough economy, some major shopping malls in Bangkok have sub-divided rental spaces into hundreds of tiny spaces to maximize their efficiency. If there are at least one seller and one buyer per space, that can magnify the number of people per floor. This situation alone is a hazard in case of emergency. Fire exits should be provided based on actual calculation of building occupants. If the number is not accurate or being later added to, the amount of fire exits and their locations cannot serve their function properly and efficiently. The safety of occupants should be one of the prime factors in design decision making. This should make the users feel comfortable and safe. When businesses show that they are concerned for the community, the community will, in turn, business. Architects must assist building owners to understand the significance of safety and compromise between the business and value of its users, by simply and strictly complying with codes and regulations when designing buildings.

D. The Sub-Office and the Idea of Decentralization

The rapid growth of technology has changed people's lives dramatically. Email, high speed internet, and wireless networking are making the world smaller. Recent terrorist acts have shown that businesses can be destroyed very easily due to their locations. Since many business can be accessed from any online location, locating large headquarter buildings in downtown areas becomes no longer necessary. While they function as an aesthetic object to produce an image for corporations,

sub-offices may be a new option to protect a business' welfare in case of attack or emergency.

For instance, in the banking business, people do not necessarily have to travel to the headquarters or main office to do important transactions. Most small sub-offices can handle everything. Sometimes, people also are able to do their business online while they are at home. Computer are getting less expensive everyday. Computer ownership has significantly increased, as everybody is online. In the future, architects may no longer have to design bombproof high-rise buildings with the budget that is ten times taller than the building. The formation of offices or businesses may include a series of smaller buildings that can handle business and terrorism better, being that small scale is easier to control. The size of sub-offices can vary depending on sizes needed by the business and the community. The office headquarters might turn to be merely an icon for a corporate image, rather than the center of business.

This idea is not to encourage people to change their methods of doing business, or to suggest to having many smaller buildings. These ideas are expressed in the anticipation of something that might or might not occur. There are always changes that happen when new technology is developed. Many questions are raised about the Thai people being ready for these new ideas. What about computer ownership and internet access? The answer is that the trend is on the rise. The numbers from National Electronics and Computer Technology Center (NECTEC) have shown that internet users have grown from 23,000 users in 1994 to 6 million users this year [11].The dramatic growth of communications in Thailand also should be credited to the Cabinet's approved new cellular system (with an investment of 4.2 billion baht by three state agencies) in November 2000. It is amazing that internet has become a strong influence in the way people live. Technology has been integrating into all areas of society, including the architectural community.

Figure 14 Dividing shopping malls into many small spaces adds more occupants per floor and makes the corridor narrower, which creates difficulty for evacuation in case of incidents that could occur.

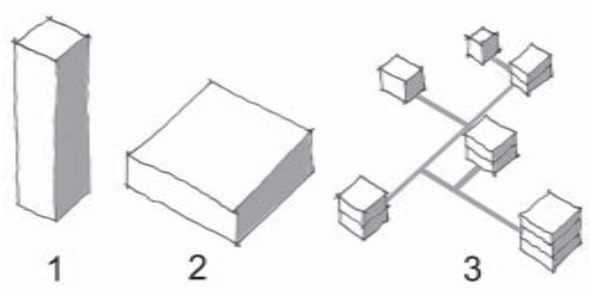

Figure 15 Images 1 and 2 are examples of an easy target. Image 3 demonstrates potential business networking that might occur in the future, and perhaps discourage strikes against large businesses.

IV. Conclusions

Some people may think that the possibility of terrorism occurrences is quite slim in Thailand, but if we think carefully, it is not entirely foreign to us. The result from damage is so much greater than trying to prevent it. The goal can be simply achieved if design professionals take the issue more seriously and add it to their design factor checklists. Design professionals should understand that they could make it harder for attacks on our buildings and our lives. Design to protect against terrorism is a hidden factor: it is not on the front page of any design checklist. However, it is still wise to take it into considerations because not only could the building withstand a terrorist strike, it would also be strong enough to protect against fire, earthquake, and other accidents that can delay acollapse during evacuation. These are all means to protect lives, and that is most important. This preventative method of design can add more construction cost to the project significantly. Design Professional should be considerate when designing and not to forget what the building is intended to do, and lastly to add more safety definition to it.

Design Professionals must open their minds, keep themselves up-to-date, and be ready for new ideas and changes.

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Figures Credit.

Figure 5 Adapted from "How Building Implosions Work", Howstuffworks, Inc. http://www.howstuffworks.com