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Guidelines for Tall Buildings Development

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Abstract

Tall buildings' implementation has often lacked urban design and architectural guidance. There are many examples of tall buildings that have been inappropriately located, designed, and built, and consequently dissatisfaction with high-rise development is wide-spread. This paper attempts to provide extensive urban and architectural guidelines in order to manage cityscape and to ensure safe and healthy living. Through recommendations on design and layout of tall buildings and open spaces the guidelines seek enhancing the visual experience, improving the microclimate conditions, and fostering active social life. These guidelines help in providing enjoyable urban experiences through the examination of spatial relationships, human scale, genius loci, perceptual characteristics, local identity, built heritage, economic activities, and social life.

Keywords: Urban design, Architecture, Site planning, Historic preservation, Green design

1. Overview

In more recent times, the implementation of tall building projects that would warrant compensating open spaces around them to allow light and air, fell far short of desired outcomes. The enactment of such projects has often lacked adequate urban design principles and, to a lesser extent, architectural design guidelines, and consequently, created undesirable urban environments for which dissatisfaction of the public with high-rise development, particularly with residential high-rises, is widespread (Churchman, 1984; Gifford, 2007; EH and CABE, 2007; Kempena and Musterda, 1991). "There have been too many examples of tall buildings that have been unsuitably sited, poorly designed, wrongly detailed, and badly built" (CABE, 2007).

It is important that tall building developments fit well into the urban landscape, patterns, morphology, scale, streetscape, urban character, and city skyline. Tall buildings will be successful if they relate well to the unique urban grain, visual axes, general context, and topography. For example, the spatial arrangement of tall buildings should be in due proportion to immediate streets, open spaces, and low-rises, and should prevent creating an extensive so-called canyon effect on public streets. The massing of a proposed tall building needs to integrate into surrounding development and create an elegant rather than bulky form, and to make a positive contribution to the city's public realm and skyline.

While urban design focuses on the larger scale of the urban environment, architecture tackles the finer scale. Each building, however, interfaces with the city and hence, in some way, contributes to the city's overall urban design paradigm (Smith, 1997). As a result, urban design and architecture intertwine and attain an intimate dialectic relationship by reinforcing each other's mission. Such guidelines help in providing a healthy living and an enjoyable and sustainable urban experience by examining such characteristics as the built heritage, spatial relationships, human scale, spirit of a place, perceptual characteristics, and local identity, to name a few (King, 1996).

Urban and architectural design guidelines complement the master planning and zoning regulations. Master plans concern balancing the many issues of the city, including economic, social, transportation, housing, utilities, infrastructure, etc. Zoning regulations govern specific aspects of the city such as uses, building heights, setbacks, open spaces, service lanes, etc. Urban design guidelines provide further specific directions. For example, master plans delineate appropriate areas for tall building development. Zoning regulations dictate the permitted usage of tall buildings (i.e. residential, commercial, and mixed-use) for each zone. However, urban design guidelines suggest specific spatial arrangements and clustering of tall buildings. They also recommend a particular height order and locations for landmark buildings. Urban and architectural guidelines provide guidance on connecting the ground plane to the surrounding neighborhood and tying the tall and supertall to place. As such, they support contextuality by providing means to respect indigenous culture, architectural style, and local climate. They help to make the proposed project deeply rooted in the city's urban fabric. Usually, tall buildings possess attributes of aggressiveness and loudness, and in response, urban and architectural design gui-

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delines provide a direction so that the city can preserve its intimacy and ambiances, and manage its character transformation.

2. Urban Context

A number of contextual conditions in the surroundings of tall buildings govern the thought process behind formulating the following architectural and urban design guidelines. These conditions are worthy of full considerations for best results.

2.1. The built heritage

The history of any city is best represented by its urban artifacts, and it is fitting that new tall buildings blend well with the historic fabric of the city. In some places, the built heritage could be of great significance so that no tall buildings should be allowed. However, architects view historic context differently today than in the past. Some believe that through "splendid" contrast new buildings should blend well with older buildings, and not mimic historical styles (Fig. 1). Others feel that while design should appear contemporary, it should also relate to the materials, proportions, and scales of existing buildings. This could be done without imitating existing buildings literally (Fig. 2). Nevertheless, any proposal for a tall building, however, should minimize the negative visual impact on sensitive historic fabric and observe scale issues. A proposed development should enhance and complement the historic character and respect views to and from historic buildings (Fig. 3). This will involve an assessment of the historical urban grain, architectural style, scale, and construction materials. Typically, the built heritage consists of low-rise structures and therefore, it is important that the tall building's base, in particular, positively responds to the unique urban grain and scale, visual relationships, architectural style, transitions, and materials of the surrounding historic buildings (Fig. 4).

2.2. View corridors and skyline

Figure 1. Greektown Casino Hotel in Detroit, MI. The architects argued that the tower provides a new design statement that complements the nearby historic church. The bold contrast of old and new evokes aesthetic and poetic qualities. It also helps to appreciate different architectural styles that belong to different times. *(Photograph by author)*

Figure 2. The newly constructed Trump Tower in Chicago. While the design provides a modern-looking tower, yet it respects the historic neighboring Wrigley Building by applying similar modules, horizontal belts, and building top. *(Photograph by author)*

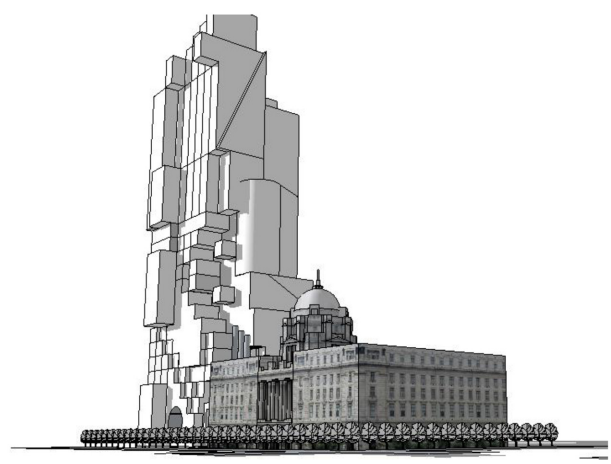

Figure 3. Historic context and architectural fit - the architectural design vocabulary of the tall building clearly does not respect the historic building next to it. *(Sketch by author)*

Figure 4. The base of Heritage at Millennium Park (rear) relates to the height of Chicago Cultural Center (front). Such architectural treatment provides a sense of visual continuity. *(Photograph by author)*

View corridors play a significant role in determining the visual character of the city by revealing destinations and assisting pedestrians and motorists to orient themselves to the layout of streets and various parts of the city, including the downtown. Distant views provide visual and psychological connections to the world surrounding the city. An analysis of the natural and urban contexts will reveal areas containing strategic views of the city that tall building development may take advantage of. For example, large water bodies (e.g. lakes, seas, oceans, rivers) and green areas (e.g. parks, gardens, orchards) are usually considered desirable features. A View Corridor Protection Plan (VCPP) for the city is desirable so that views to these coveted features and built heritage are protected (Fig. 5). Further, it is important that the location of a new tall building development ensures adequate visual access to skyviews. The spatial arrangement should avoid a "wall" effect by creating a varying building height profile where appropriate. A staggered arrangement may also facilitate a better visual access to desirable features. It breaks up the wind forces thereby minimizing the canyon or tunnel effect (Fig. 6).

2.3. Gateways

City gateways are important for several reasons. They create a newcomer's first impression of the city and provide clear orientation and guiding symbols. They may also provide the visual pleasure of experiencing an attractive and livable urban environment. Further, they stimulate economic activities by functioning as anchoring points. Because of their sheer size and height, tall buildings have the potential to function as gateways to the city. Potential locations of gateways include approaches to major streets and arteries, and transit nodes, including harbors, airports, and train stations. The Shard (London Bridge Tower) in London's Southwark district, for example, is located at the London Bridge Station, which receives 70,000 people per day. The volume of traffic is likely to increase once the tower has been completed and occupied. It creates a landmark on the south bank of the Thames. These places constitute "entrances" to the city or community. Placing tall buildings in these areas may reinforce the gateway effect. Gateways through tall buildings have the potential of framing view corridors and enhancing the scale and character, and providing strong spatial definitions.

2.4. Landmarks

Landmarks provide similar opportunities and benefits to that of gateways. Landmarks enrich the visual reference and orientation, create urban legibility, and enhance the visual experience and imageability of the city. Because of their sheer size and height, tall buildings can create distinct landmarks. Spatial organization should consider the

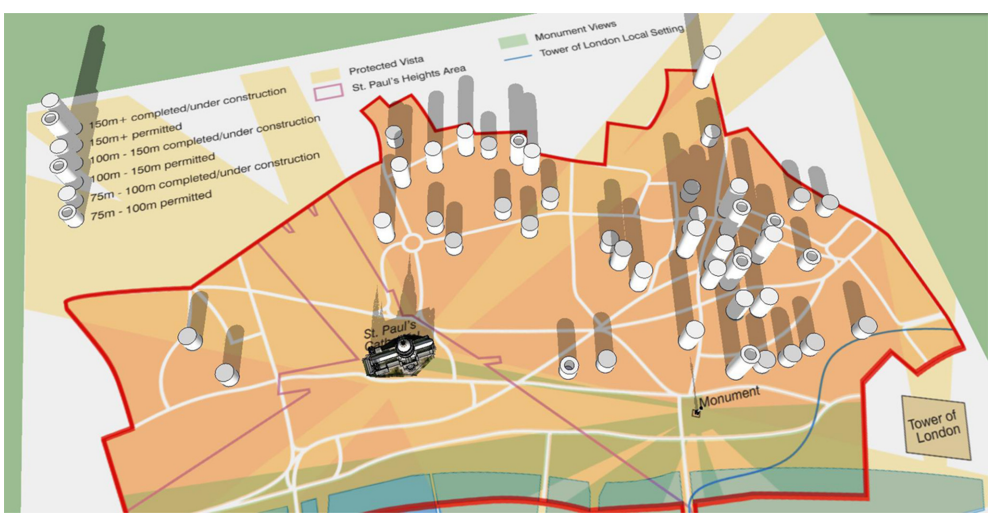

Figure 5. The City of London sets visual plans to protect its conservation areas and views leading to historically significant buildings, most notably St. Paul's Cathedral. The locations of tall buildings with their associated heights follow the visual plans. *(Sketch by author; adopted from ldfconsultation.cityoflondon.gov.uk/)*

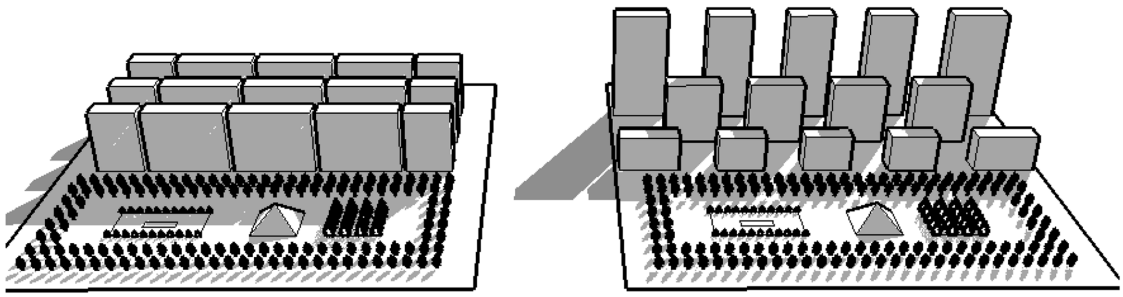

Figure 6. Spatial layout in relation to views, wind, and natural light. Layout increases shadow effect and prevents or diminishes accessibility to desirable views, blocks air flow in one direction and creates wind tunnel effect between rows of densely packed buildings in the other direction (left). Layout is pleasing and non-obstructive to desirable views, improves air flow among the buildings, and reduces shadow effect; this arrangement of buildings disperses the wind and decreases wind tunnel effect (right). *(Sketch by author)*

potential of tall buildings to function as landmarks at various geographic scales (district, region) and various key locations (primary transit nodes and corridors) as follows.

2.4.1. District landmarks

Defined as buildings between three and four times the typical building height, district landmarks provide a dominant effect on their immediate and wider surroundings. This type of tall building significantly impacts the skyline and can establish orientation and reference points. District landmarks work best when they house public and civic use, and symbolize cultural and collective meaning (Kostof, 1991). They can enhance legibility of an area by emphasizing central nodes and significant civic, cultural, or transportation activities.

2.4.2. Metropolitan landmarks

These are defined as buildings whose height is more than three to four times the typical building height in the city. Metropolitan landmarks have a stronger visual impact than district landmarks.

2.4.3. Terminus landmarks

Tall buildings may be used to terminate corridors. This is an ancient practice; for example, the towers of many churches and minarets of mosques have been located to terminate corridor views.

2.4.4. Edge landmarks

Tall buildings, as significant physical barriers, can enhance the legibility of the boundaries of a district by creating vivid edges.

2.4.5. Waterway landmarks

Views along waterways are especially significant because the openness of water spaces allows for relatively long-distance views. Development should recognize the opportunity for providing landmarks of cultural and social significance along waterways, providing orientation points, and pleasing views.

2.4.6. Block landmarks

Grouping towers within a block may provide an opportunity to create a collective landmark. Unlike single landmarks, which are more distinct, clustered landmarks are less legible, yet can be useful to viewers for visual identity.

2.5. Social issues

Reviews of residential tall building projects should address potential social problems of crowding and density, economic parity or disparity of residents, and the effects on family stability, public order, and the mental and physical states of individuals and communities. Interaction between designers and social scientists is highly recommended. Another social dimension concerns making tall buildings affordable to various social classes of a society to encourage integration. An element of affordable housing should be sought on all residential or mixed-use developments. Some guidelines propose that 30% of all dwellings be affordable housing. It is also suggested to provide affordable housing in all developments containing 25 or more new dwellings, or with a site area exceeding one hectare (2.5 acres).

Further, tall buildings, particularly when grouped together, need to be complemented with a network of open spaces easily accessible by the occupiers of the proposed development. The amenity value of communal space, outdoor space, and recreational space within the building should also be considered. In the past, the importance of making residential tall buildings adaptive to local culture, context, and the environment was not adequately underscored. This is reflected by literature survey demonstrating general user dissatisfaction with residential high-rise buildings. To create an organic lifestyle similar to the ground plane that will appeal to residents' demands, a new way of thinking, in which green design and sustainable community development principles are given utmost priorities by designers, is needed. For successful

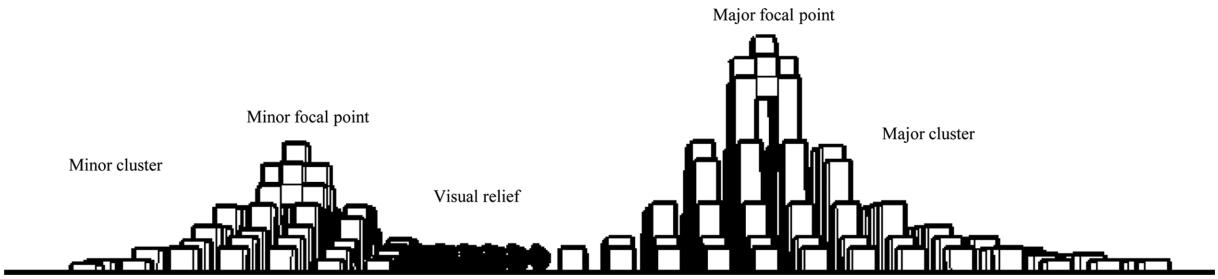

Figure 7. The relationship between areas of low, small-scaled buildings and areas of high, large-scaled buildings forming clusters can be made more pleasing if the transition in building height and mass between such clusters is gradual. *(Sketch by author)*

urban design of the 21st century, a major consideration is to meet the goals of sustainable community planning. This is especially important for urban residential developments. The goals are the efficient use of space, minimizing natural resource consumption and environmental impacts, as well as preserving open space and unique cultural, historical, and scenic urban landscape in terms of physical space planning.

3. Spatial Clusters Design Guidelines

Locating tall buildings in clusters assists in creating distinct and imageable environments.

Clustering tall buildings as an urban design strategy preserves open spaces since the development uses "vertical" space rather than lateral space. Further, clustering tall buildings has an agglomeration effect and results in fostering synergy and improving and diversifying amenities. Clustering creates a "ripple effect" that promotes powerful socio-economic and cultural agglomerations. Another benefit is that clustering provides opportunities to strengthen the city's imageability. The strategy of clustering tall buildings is most effective when the city changes from an expanding to a compact metropolis.

We recommend that clusters incorporate the following features. Figure 7 illustrates the importance of incorporating the following urban design qualities in tall buildings' clusters.

3.1. Focal points

It is recommended that cluster compositions incorporate central points of significance. These points are intended to provide visual references and improve spatial orientation and navigation. Therefore, focal points should be developed where they logically orient people and mark significant places. On the other hand, miss-located focal points detract from the intended emphasis on significant places. The employed density, height, and architecture of focal points may vary to give a cluster an identity. The specific perceptual characteristics of focal points may further vary to reflect functional use such as residential, commercial, and civic activities.

Gateways can also serve as focal points since they are the entry points to a city, neighborhood, or a district. It would be appropriate to designate gateways in a cluster in order to enhance its legibility and provide clear orientation for pedestrians and motorists. Gateways are also symbolic signs of welcome and serve as preludes to what lies behind. Architectural style, landscaping intensity and schemes, as well as scale all are important to make gateways distinct and recognizable.

3.2. Visual relief

Drops in elevation facilitated by, for example, open spaces and parks can offer visual relief to viewers. Without pedestrian access to an open space buildings provide little to no visual relief. Varying architectural details also help to achieve visual relief. This includes façade variation, materials and window treatment, and shape.

3.3. Transition

We recommend that a coherent gradation in building height profile from the high density core area to the fringe/low density areas be provided. Such transition creates a positive visual effect on viewers. While many cities may achieve a pyramidal skyline when tall buildings are clustered in the CBD, other forms are common. Tall buildings are usually located at transportation nodes and in urban regeneration districts. Consequently, each district can have visual hierarchy in relation to the skyline of the city (Fitzner, 2008). When more than one cluster is introduced in a city next to each other, a gradual transition should be observed between the clusters.

3.4. Varying building heights and massing

It is preferable to achieve varied building heights; for example, higher buildings can be sited where they add a landmark quality. On the other hand, lower buildings can be sited next to the "pedestrian spine" and other important open public spaces. Zoning laws and ordinances regulate both FAR and OSR that restrict building massing. Consequently, tall buildings generally step or taper as they rise. Beyond that are functional and structural reasons to change building massing. In mixed-use buildings, offices and retail spaces require larger floor plates

than residential functions. The building form often expresses these distinctions. They also require different floor-to-floor heights and, possibly, different structural solutions.

3.5. Design diversity

It is preferable that multiple towers within a development not look identical. They should, at a minimum, be varied in form and/or façade design (e.g. materials, fenestration, hierarchy, curtain wall system) to create diversity for viewing pleasure. Mixed-use urban design schemes that incorporate a variety of socio-economic activities are helpful to achieve physical design diversity.

3.6. Visual coherence

All cluster elements should conform to a coherent design rationale and appearance that demonstrates a unity of style, rhythm, and balance. While diversity in design is important, it does not imply viewing incoherence. Unity in diversity as a design concept is of utmost importance in clustering tall buildings. Many architects, however, will agree that unity is important relative to the design principles; however, they could object to the notion that merely style is that important. New buildings should generally reflect the era in which they are designed in tune with the fashion of the time. Many modern buildings co-exist with historical buildings designed in other styles. Urban variety is often more desirable than bland uniformity.

3.7. Ventilation

The layout of tall buildings and the design of individual buildings should facilitate natural ventilation in order to ensure a healthy environment. The layout of buildings and their massing should facilitate the movement of air among buildings. Important layout and design considerations are illustrated in Figs. 8 and 9 (Zacharias, 2001; Ng, 2010a). Within the tall buildings, the employment of me-

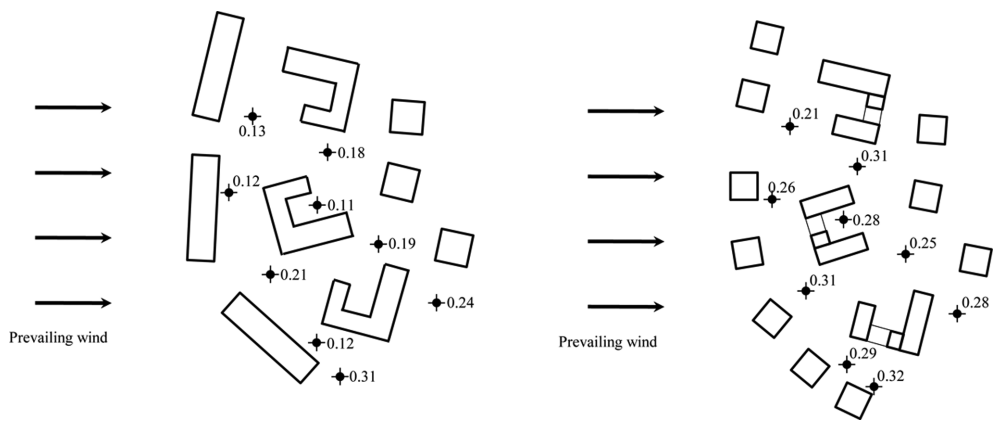

Figure 8. Two urban layouts with different wind speeds: lower speed due to higher building blockage (left); higher speed due to more wind penetrability (right). Numbers in the figures represent degrees of wind penetrability. *(Sketch by author; adopted from E. Ng, 2010a)*

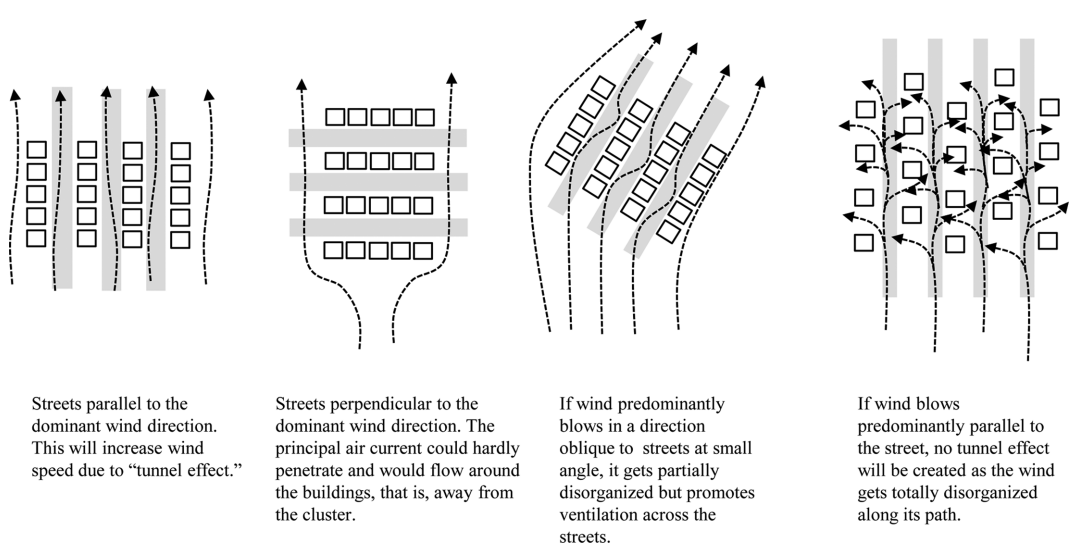

Figure 9. Wind in relation to tall buildings' layout and street orientation. *(Sketch by author, adopted from E. Ng)*

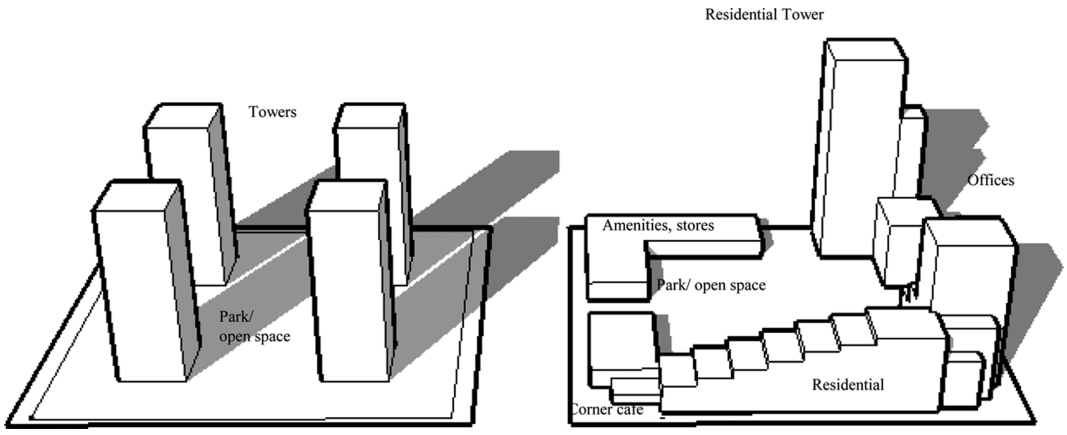

Figure 10. "Towers in the park" block model (left) envisioned by Le Corbusier has been criticized as anti-urban. The revised mixed-use block model (right) suggests mingling the towers with mid- and low-rises in the same block based on required functions, services, and activities. *(Sketch by author)*

thods such as the E/V shaft cooling method is proven to be effective to decrease the stack effect problems (Lee, Song, and Jeong, 2012).

4. Block Considerations

Within a block, several issues should be observed in arranging buildings, as follows.

4.1. Spacing of towers

To ensure adequate light, air, access, and view for residential units on upper floors, a minimum distance between tall buildings should be observed. Some urban design regulations specify 25 m (80 ft) as a minimum distance. The required distance should, however, increase with increased heights. In dense arrangements, rounded and curved tall buildings and diagonal arrangements may help to mitigate the problem of closeness. Spacing should provide for adequate natural light to the interior spaces of towers (Ng, 2010b). This can be ensured through the sun's movement and shadow studies. Further studies should be conducted to develop a relationship between the height and spacing of tall buildings to allow adequate light and air between them.

4.2. Corridor views and visual privacy

An adequate respect for privacy is achieved when orientation, facing distances, and spaces in general are arranged to mitigate overlooking across the residential windows and balconies of one building and the residential windows and balconies of another. 340 On the Park, a high-rise condominium tower in Chicago is shaped to take advantage of views overlooking Lakeshore East Park, Millennium Park, and Lake Michigan. A certain amount of care regarding residential visual privacy is essential when locating a high-rise next to low-rise buildings. The desirable level of privacy is a cultural variable. The regulations should ensure that the achieved visual privacy matchs the desired visual privacy (Al-Kodmany, 1999).

4.3. Transitioning

Tall buildings can limit their impact on neighboring streets, parks, buildings, and open space, particularly in corner blocks, in terms of visual intrusion and human scale violation by creating appropriate transitions in scale to existing and planned buildings in the neighborhood. Achieving transitions among buildings also help to break monotony and create visual interest and pleasure.

4.4. Revised "Towers-in-the-park" model

The freestanding "towers-in-the-park" model was initially presented by Le Corbusier in the 1920s. However, this model has created repetitive and dull urban patterns that are characterized by inflexibility. It is inadaptable to functional changes and emerging needs; and is therefore anti-urban in character. The comfort of open space in the central district of cities is manifested in its treatment as a positive element in design, not as a leftover space in between or outside tall buildings. The revised model suggests blending the towers with medium- and low-rises in the same block based on required functions, services, and activities (Fig. 10).

4.5. Functional connectivity

Layout should enhance pedestrian connectivity between tall buildings and open spaces. Placing barriers such as roads between tall buildings and open spaces may hinder the utility of open spaces. Further, the street views of the containment of open spaces filled or seamlessly connected with tall buildings viewed from the interconnected pedestrian level are instrumental in generating the beauty of the urban environment (Fig. 11).

4.6. Alignment

New tall development should be massed to define the edges of streets, blocks, parks, and open spaces. The

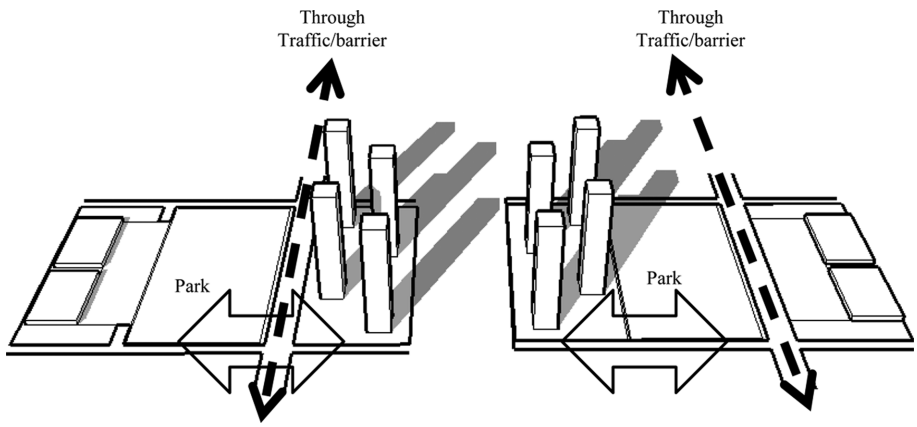

Figure 11. Connecting tall buildings with open spaces (e.g. a park). The street runs between the park and tall buildings (left). The park and tall buildings are seamlessly connected (right). The latter strategy is more desirable. *(Sketch by author)*

ground and second floors of new development should be built to the property line along street frontages. The buildings' alignment is particularly important at the confluence of transportation routes, and placement should ensure achieving a sound and comprehensible spatial relationship (Fig. 12), (Hedman and Jaszewski, 1984).

4.7. Street intersection imageability

A corner site enjoys prominence on a block because of its highly visible location. The footprint area of a tall building has to be reduced to meet setback requirements from the streets, pushing the building's height upward within the allowable FAR limit. Such a building may, however, take the opportunity to strengthen the corner with special architectural treatments, plazas, and landscaping in order to improve the intersection imageability and human scale (Fig. 13).

4.8. Sense of enclosure

Grouping of buildings should be observed to promote a sense of enclosure as a means to tie buildings together and enhance the spatial definition of public space (Fig. 14). Enclosure provides a unifying framework and a cohesive whole to the various elements of the spatial composition. By and large, enclosure improves sense of security and safety by creating visual connections among the buildings. The visible boarders of the layout create 'defensible space,' and the overlooking buildings provides natural surveillance. The enclosed space such as garden becomes a focal outdoor living-room to the community and provides a center of visual interest. Well-proportioned enclosed spaces of sound height-width ratios also mitigate the impact of tall buildings on human scale.

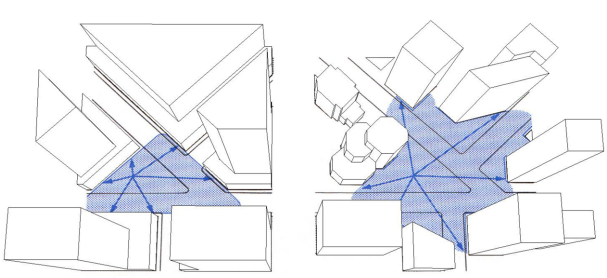

Figure 12. Aligning buildings according to sound spatial definitions. A simple and easy-to-comprehend space (left) is contrasted with a complicated and ill-defined space (right). *(Sketch by author; adopted from Hedman and Jaszewski, 1984)*

4.9. Height-to-width ratio of street

The sense of enclosure created by certain ratios of street height to street width is also important for achieving satisfying places. Building height and street width

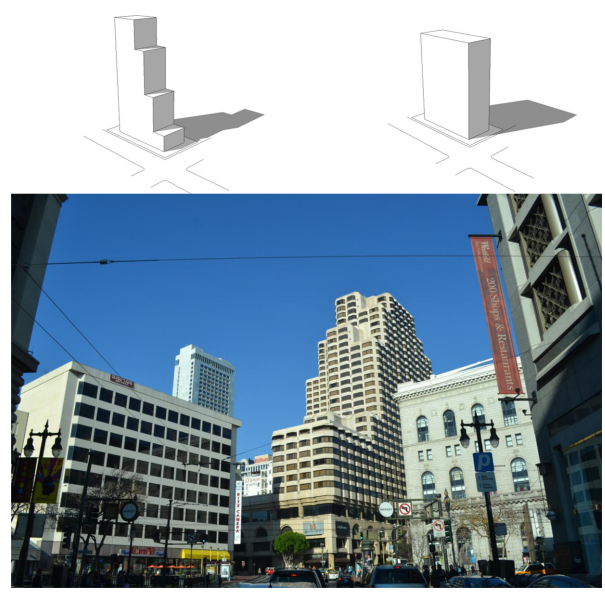

Figure 13. Step-like profile (top left) improves spatial relationship of tall buildings to human scale and street intersection as opposed to a vertical tower (top right). Picture at the bottom shows Parc 55 Wyndham Hotel in San Francisco. The step-like profile improves its relationship to human scale and street intersection. *(Sketch and photograph by author)*

Figure 14. Tall buildings layout should observe opportunities for creating a sense of enclosure, which conveys a sense of safety and comfort to pedestrians. Bottom photograph shows Lakeshore East Development in Chicago. The layout of the development provides a sense of enclosure. *(Sketch and photograph by author)*

should observe healthy ratio and respect human scale. Height-to-width ratio should avoid creating a "canyon effect" and claustrophobic spaces. Although it is not pragmatic to pinpoint an optimum ratio, a general rule is to increase the street width in relation to the average height of tall buildings flanking the street within practical limits. The actual ratio also depends on the type of street being designed for, i.e. major boulevards, arterial, collector, etc.

4.10. Daylight and shadow

A very important design consideration is the impact of the tall building on the microclimatic environment and the shadows that the tall building might cast during daytime over the pedestrian realm; including parks, plazas, and streets, (Ng, 2010b). Urban design studies require a greater analysis of shadow patterns, such as seasonal and regional effects. In cities that experience an extended period of cool autumn and spring seasons, and a cold winter season, the availability of direct sunlight to areas of pedestrian activity plays an extremely important role in supporting the use of pedestrian areas. Frequently, during these seasons, the availability of the sun's warmth makes walking on a street, sitting or standing within a park or plaza quite tolerable and often inviting whereas a shaded portion of the same areas may be uncomfortable. One strategy to reduce the effect of shadow is by manipulation of the form, for example, providing step-backs in the building, (Hedman and Jaszewski, 1984).

4.11. Wind impact

The layout, massing, height, and design of tall buildings all affect wind impact, particularly on the pedestrian realm. In general, the taller the building, the stronger is the wind potential in the form of turbulence at the building's base. Monolithic buildings (those that do not change shape with height) almost invariably will be windy at their base when they are significantly taller than most of the surrounding buildings. Downdrafts off buildings are accelerated by the tunneling of wind between buildings. The tunneling effect could be minimized with a good layout which should work positively with local prevailing winds to enhance the microclimate of inner areas and facilitate air movement and support breezeways. It should be noted that the breeze interruption effect of tall buildings is increased proportionately with their heights, most notably in Central Business Districts (CBDs), (Sato, Ooka, and Murakami, 2012). The introduction of building setbacks and pronounced architectural features, such as projecting cornices, awnings, and canopies, or other elements which give a three-dimensional relief to a structure, all tend to help mitigate the potential impact of increased winds. Careless and unintentional provision of such elements and recesses may create wind-catching pockets, increasing local wind speed and turbulence. Podiums, if properly designed, can mitigate wind-related problems at the base of the tall building. The placement of site features, such as walls, berms, and landscaping features, similarly can help to mitigate the wind impact by reducing speed or creating sheltered areas that might be most appropriate as seating or standing areas. Careful aerodynamic considerations can go a long way in reducing the downdrafts and turbulence at the ground level as is the case with the Swiss Re Building in London.

4.12. Weather protection

Providing a weather protection system for the pedestrian has to be a priority in the design of groups of towers. In commercial districts, in particular, each project on the ground floor should contribute to the provision of a weather protection system that allows pedestrians to walk comfortably throughout whole districts, and may enhance the enjoyment of public amenities and the outdoor environment. The protection system may also help to articulate the base and define the street edge.

5. Tall Buildings Design Guidelines

5.1. Building design

Comprehensive architectural quality of tall buildings where interior and exterior design issues are addressed warrant a separate study. However, design guidelines that we offer in this section can go a long way to better blend tall buildings with their settings in a city.

5.1.1. Tripartite design

Tall building design is encouraged to integrate three distinct parts (base, shaft, and top) into a single whole

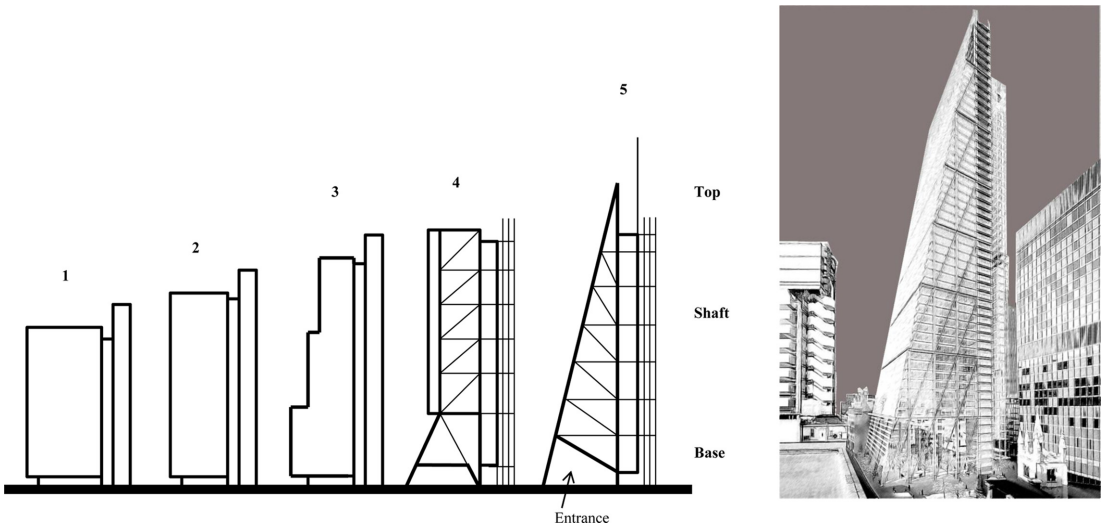

Figure 15. The 122 Leadenhall Street Building in London, by R. Rogers. Form articulations: progression from plain to intricate (1-5). Note how the articulation enhanced the entrance's prominence. The wedge-shaped tapering shaft represents interesting geometry and was designed to protect view of the nearby St Paul's Cathedral. The top is marked by a simple but distinct apex. *(Sketch by author)*

(Fig. 15). The base provides a portion of the building with articulation that is related directly to the human pedestrian scale while the middle portion of the building, called shaft or stem, generally provides a pattern of fenestration and detail that lends a sense of rhythm and scale to a building both horizontally and vertically. The top or crown of the tower typically receives special treatment that terminates the building in an ornamental or distinctive manner. Base, shaft, and top also play an urban role. The base relates the building to adjacent buildings in scale, proportion, and possibly materials, color, and/or texture. The shaft relates the main body of the building and facades to other buildings in the neighborhood and district, and the top communicates the iconic status of the tall building as an urban landmark.

5.1.1.1. Base/Podium

The base is the most important part of tall buildings as it is how the building is connected to the surrounding city. The base should not appear to be heavy and clumsy. While not essential, the incorporation of a low-level podium at the base should be considered to all proposed developments of tall buildings. It should not exceed 5-6 stories in order not to block views to the shaft. A colonnaded base also has the advantage of alleviating the wind uplift around the building and providing extra shelter and protection from weather for pedestrians. Colonnaded-base buildings and green roofs can also be used to control downward wind flows (Fig. 16).

It is important to improve the interface of the base with the public realm. Blank facades, internal refuse stores, bicycle bays, undercroft parking, etc. must be kept to an absolute minimum. Sufficient openings in the facade should support passive supervision of the street space. In proportion with the overall building, the ground floor's floor-to-ceiling height must be considerably greater than that of the building's upper stories. Building entrances should be clearly identifiable. Roughly speaking, up to 30 m (100 ft) of the tall building's base should respect the human scale and support human ability to perceive visual intricacies and complexity.

It is desirable to provide narrow retail frontage in order to increase the number of shops and potentially increase a variety of provided goods and services. According to Coquitlam's urban design codes, storefront widths should not exceed 12 m (40 ft) of frontage. The design should also avoid creating big gaps between stores in order to ensure spatial continuity that transforms the street into a

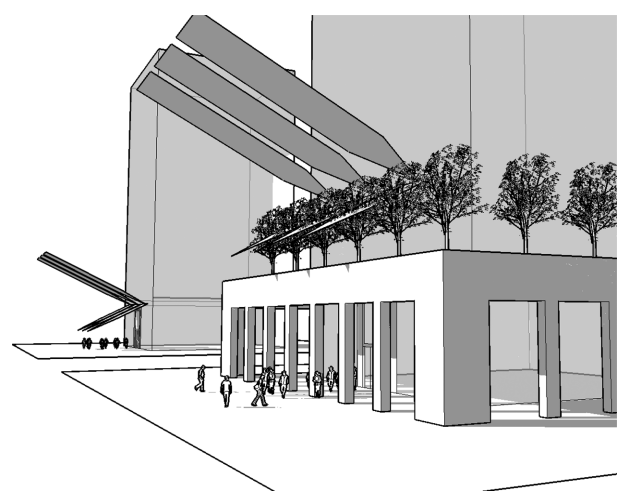

Figure 16. Protecting pedestrians from wind's reflection through podium design. Green roofs atop arcades have the potential to further mitigate wind effect and add aesthetic qualities. *(Sketch by author)*

coherent outdoor space (Ysebrant, 2008).

5.1.1.2. Shaft

The bulk of towers making up the shaft or stem should be reduced by articulating the masses with changes of plane, stepped terraces, modulated plan, balconies, and façade forms. Articulation should evolve from a rational building design approach, and avoid treating the building as a mere object. The design of individual buildings should also consider functional issues such as shadow impact and the provision of natural light. In cases where there are difficulties to provide direct natural light, it is recommended to employ techniques such as light pipes and light shelves to channel natural light deep into interior spaces (Elbakheit, 2012).

Overall, slender towers are preferable over slabs and monolithic as well as bulky towers. Thinness of a tower improves the provision of light and its elegance and sky view (Ali and Armstrong, 1995). However, overslenderness should be discouraged because it poses structural challenges for motion control and impact by flying objects, and creates proportion and scale problems. The aesthetics of a building's mass can also be improved by articulating the tower's footprint and segmenting the mass via horizontal bands (Fig. 17). We recommend that a tower's design reflects its functionality, i.e., residential, commercial, mixed-use, etc. It is also recommended to seek design diversity within the same functional use (e.g. residential).

5.1.1.3. Top

The design of building tops is important in that this is where the building meets the sky, and if well-designed, they can enhance the skyline and create legibility from a distance. Flat-top buildings designed in the International Style lacked a clearly visible top. Classical tall buildings designed prior to the Modern era, and those designed during the Post-Modern era, as well as the present era of pluralism, generally have well-defined legible tops. Attention needs to be given to the treatment of telecommunication apparatus, plant rooms, mechanical equipment, external cleaning hoists, etc. Design should demonstrate a sensitive approach to these elements which interfere with the clarity of the silhouette and the roofline of the building. In general, it is good practice to make the tops of buildings lightweight and readily visible. Integrating alternative accommodations on upper floors, such as duplex apartments or rooftop restaurants, is viewed as a desirable design solution.

5.2. Parking design

The problem of car parking is a serious issue within a city, particularly in its dense urban core where most tall buildings are located. Limiting parking provisions will ensure that the base floors of tall buildings are not dominated by car-parking and will help in delivering vibrant frontages onto the street. Where provided, underground parking is a possible choice. Alternatively, the parking should be architecturally integrated with the building design (Fig. 18) or landscaping features should wrap around parking areas to screen them. Parking structures designed as secondary utility-type structures have often been visually unappealing but attempts are being made to improve their appearance and aesthetic

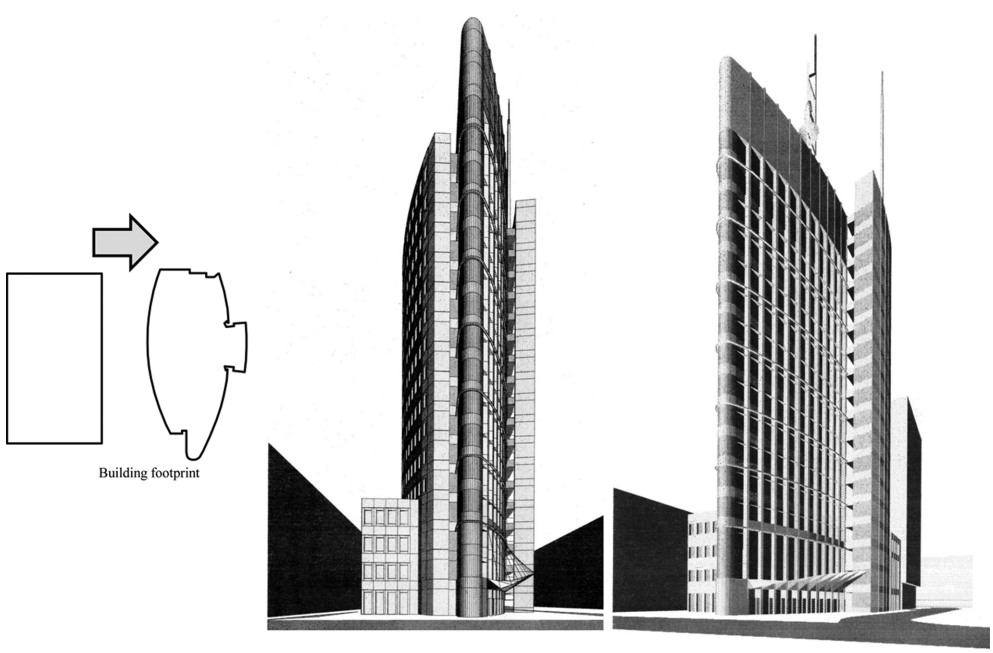

Figure 17. The National Bank of Bahrain in Manama, Bahrain (unbuilt) by A. Smith, author, and L. Oltmanns of SOM. Slenderness and excitement of form have been achieved through articulating the building footprint. *(Drawing by author)*

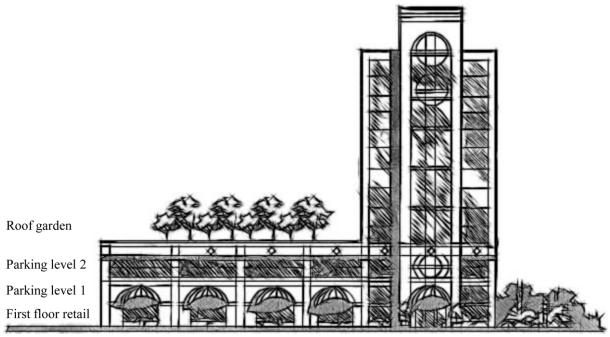

Figure 18. Architecturally integrated and enclosed parking should be encouraged for tall building design whenever possible. *(Sketch by author; adopted from www.tampagov.net)*

Figure 19. A "contextual" parking structure in St. Louis, MO. The building design picks architectural cues from neighboring buildings and appears to be a regular building that seamlessly fits into the neighborhood. Also, the ground floor integrates retails and restaurants so that they enliven pedestrian and street life. *(Photograph by author)*

quality (Fig. 19). We note that due to changes in lifestyles, parking regulations may be trending downward as more people today prefer to use public transport and choose not to use automobiles to avoid traffic gridlock and save money on expensive gasoline (Gifford, 2007).

5.3. Accessibility

Tall buildings should strive to be as accessible as possible to all people through the provision of ramps, elevators, escalators, steps, clear signage, sensitive lighting schemes, non-slip surfaces, harmonious color and texture schemes, sitting places, and legible internal layouts.

5.4. Safety regulations and building codes

Safety is more critical in tall buildings than of that in low-rise structures because tall buildings host a greater number of lives and constitute a high-value investment. It can be emphasized though that tall buildings, if appropriately designed and built, are safer in many respects than most other building types, due to structural and life-safety redundancies. Concrete cores are robust and designed to withstand extreme lateral forces and loads. Fire safety systems include sprinklers and wet and dry standpipes. Egress is handled through multiple escape routes, fire stairs, and refuge floors.

5.4.1. Stairs

North American codes conventionally require two staircases minimum for tall buildings (Allen, 2004). A stairway's width should not be less than 1.42 mm (56 in) and the walking distance to an exit staircase must not exceed 30 m (98 ft) (Fruin, 1970). Smoke-free stairwell designs are required to assist occupants in surviving high-rise fires, since immediate evacuation of fully occupied buildings is not usually a reasonable option. Stair pressurization is required to contain smoke by applying positive pressure above and below a fire floor (or floors). Another design consideration regarding stairs is that the stair door should be positioned so the flow of occupants into the enclosure merges with, rather than opposes, the downward movement of people (Pauls, 1978). For supertall buildings wider stairways are appropriate, as we have learned from the experience of the World Trade Center towers in New York.

5.4.2. Elevators

Codes often dictated that in the case of fire, passenger elevators are returned to the main lobby, parked, and shut down with open doors. Tenants' use of elevators as a means of escape under fire conditions continues to be considered as hazardous and should be avoided until a viable solution is found to overcome the danger. Elevators can only be used by firemen, by using a separate key switch in order to evacuate elderly and handicapped people and to move equipment up. The fireman's switches make elevators safe to use in the event of a blaze by giving firefighters control of them so they do not open at the floor of the fire. In some tall buildings, special elevators are dedicated for the firemen's use to bring up fire equipment and assist handicapped people to descend. Each of these elevators has a two-hour rated elevator lobby and a special pressurization shaft (Olsson, 2001).

5.4.3. Refuge floors

Refuge floors for supertall buildings are designed mainly as fire breaks where people can take shelter while waiting for evacuation. For example, if occupants are on the 68th floor, they don't have to run all the way down the building to escape the fire; they can just run midway down to the refuge floor in the middle of the building. By default, refuge floors provide a safe place for the disabled and injured (Wood, 2003), and serve as a firefighting base for firefighters to contain fire and have a command operation point. They can serve as a transitional point for using elevators for evacuation, and as a fire barrier to prevent the spread of fire. They may also break up evacuation stairs,

which reduces the possibility of a smoke stack effect (Wood, 2005). Some cities, such as Hong Kong, require incorporating refuge floors every 25 floors throughout the building (BDHK, 1996). Areas of refuge require features such as wheelchair locations, two-way communication, detailed instructions, signage, and identification (IBC and ICC, 2006). Refuge floor requirements can hardly be overemphasized as tall buildings are increasingly becoming taller, despite the fact that some critics have labeled these floors as "death traps" (NFPA 5000, 2006).

5.4.4. Skybridges

Skybridges provide horizontal evacuation at height between towers. They provide an alternative escape route and are useful particularly when vertical evacuation is cut off due to a fire or other threats. Employing skybridges also decreases the need for elaborate stairways. For example, by employing a skybridge between the Petronas Twin Towers in Kuala Lumpur, Malaysia, occupants in one tower can relocate to the next by crossing the bridge. The skybridge helps in reducing the time needed for evacuation of a single tower and the required number of stairways (Wood, 2005; Pelli, 2001). The skybridge application could be useful in cities of densely clustered towers, such as those found in the Far East, because skybridges provide horizontal connections at heights among these towers. These can be widened and used as certain types of common areas and occupancies. One downside of skybridges is that they may change the crowd flow pattern. In a typical evacuation, the flow goes downward to the ground floor. When a skybridge is employed, an additional flow going up to the skybridge is created. Two crowd flows may create confusion, conflict, or crashes among tenants. This problem can be alleviated by adding more skybridges at different levels so flow can always be guided downward.

5.4.5. Compartmentalization

All floors in tall buildings are required to be "fire compartments." This includes the outer walls, which need two-hour integrity and loadbearing capacity. The requirement may be met by the frame of the building and cladding systems hung from the frame. It is essential that fire sealing between floor edges and the cladding system is rated at two hours. Outer non-loadbearing walls need fire resistance properties to prevent fire transfer from floor to floor, or on the same level across re-entrant corners via the façade, limiting the possibilities of radiant heat transfer. To help control smoke movement due to the stack effect in tall buildings, walls and floor-ceiling constructions should be airtight. Collectively, these elements work together to provide a safe and secure environment in high-rise buildings (Tubbs, 2007).

5.4.6. Smoke alarms and sprinkler systems

Smoke alarms are required to alert a fire incidence. It is good practice to wire smoke alarms right to fire department dispatch so that firefighters arrive at the scene before a blaze swells. Many building codes mandate the provision of automatic sprinkler protection systems in high-rise buildings. Heat-activated sprinklers help to extinguish fires and enable people to escape sooner. These systems should be checked periodically for functionality.

5.4.7. Communication systems

To keep occupants informed of evacuation directions and status, two-way voice communication systems should be installed in all vestibules serving protected elevators, as well as within the cabs of the elevators themselves. Installing CCTV (closed circuit television) and a separate audio channel in escape stairs can provide additional information to responding firefighters and onsite personnel. This type of system can alert personnel and emergency responders to potential situations during the evacuation, so they can take steps to help occupants evacuate more efficiently. For example, they can aid the occupants by pointing out exits that may have less use or a refuge area if the integrity of the exit is compromised. In addition, the communication system needs to be able to survive the expected incident (NFPA, 2002).

5.4.8. Standby power generators

In the event of a power failure, standby power generators are needed to handle all fire systems; including fire pumps, firemen's elevators, smoke control systems, and emergency lighting. The generators should handle non-life-safety components such as dedicated chillers, lifts, fresh air plants, and computer rooms.

5.5. New safety measures

Following the WTC collapse, authorities, building owners, and the public-at-large have raised serious concerns about the issue of safety in tall buildings. Researchers and professionals of many disciplines came to the conclusion that current codes for tall buildings are inadequate. The National Institute of Standards and Technology (NIST) researched WTC's collapse and came to a greater appreciation of providing safety measures when it estimated how many people would have died if WTC were fully occupied. It would have taken more than three hours to fully evacuate the buildings, and in the process, 14,000 people -- 28% of the occupants -- would have died because of insufficient stairwell capacity (Tubbs, 2009). NIST re-stressed that time is the essence in evacuation, as damage increases exponentially as time progresses. It called for changes in high-rise building design to improve evacuation time in an emergency. The following are highlights of key NIST's recommendations (Tubbs, 2009).

5.5.1. Full building evacuation

Conventionally, high-rises have been built assuming

"staged evacuation," where the entire building wouldn't need to be evacuated at once. Instead, during a fire on one floor, occupants evacuate to adjacent floors until it is safe to return. Traditionally, the egress width has been designed to accommodate three to five floors evacuating simultaneously. Consequent to the WTC collapse, it was doubtful that a tall building's occupants would feel comfortable to remain in a tall building in an emergency situation, as is required by the phased evacuation approach (Butry, 2010). Alternatively, if a simultaneous evacuation strategy is embraced, it will have a remarkable impact on the design of the buildings and the required safety features, including increasing the number and widths of stairways (Proulx, 2006). NIST recommends that all non-residential skyscrapers that exceed 128 m (420 ft) tall must have a third stairwell and fireproofing capable of withstanding a pressure of 47,880 N/m^2 (1,000 lb/sq ft) (Puchovsky, 2007).

5.5.2. Use of elevators

Several researchers have been investigating, and some advocating for, the use of elevators in case of emergencies. Conventionally, in an emergency situation, elevators are used by firefighters only. NIST recommends code changes to increase elevator usage by the public in high-rise emergencies. The recommendations mention the need for fire-protected and structurally hardened elevators to help in evacuating mobility-impaired tenants. Every high-rise building shall have dedicated firefighter elevators incorporated into the stair core, which should have the ability to stop at every floor for handicapped tenants to be picked up (Lipton, 2008).

5.5.3. Photo-luminescent exit systems

NIST has also recommended that stairwells be marked with consistent signage and the use of photo-luminescent exit systems used in buildings higher than 23 m (75 ft) to facilitate rapid egress and full building evacuation. Photo-luminescent (glow-in-the-dark) markings will be required at all exit doors and in exit stairs. Additional signage is required when the exit path is not clear. New York was the first large city to require luminous markings in stairwells, even before it became part of the model code. More than 1,500 buildings now have the markings (Lipton, 2008).

6. Conclusion

This paper provided key urban design and architectural guidelines for tall building development. There is a need for furthering of the development of guidelines since the world continues to witness an increasing pace of tall buildings development. The Council of Tall Buildings and Urban Habitat (CTBUH, 2009) indicates that the past decade has witnessed the completion of more skyscrapers than any previous period in history. This resurgence of tall buildings has led to the construction of higher buildings in greater numbers (Wood, 2011; CTBUH, 2010b). Therefore, there is an increasing need for research that guides tall buildings development. This paper is meant to cater to these needs. Through laying out major concerns and specific directions as well as providing extensive illustrations, it is hoped that this paper serves as basis for advancing and detailing more guidelines for tall buildings development.

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