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Living and Working in Tall Buildings: Satisfaction and Perceived Benefits and Concerns of Occupants

*Cheuk Fan Ng**

Centre for Social Sciences, Athabasca University, Athabasca, AB, Canada

In the past few decades, tall buildings of 30 to over 100 storeys are becoming more common in modern cities around the world, especially in Asia and the Middle East, according to the Council on Tall Buildings and Urban Habitat. Extensive research has focused on the technical aspects of erecting tall buildings, yet few recent studies have been conducted to examine occupants' experiences and responses. To assess what is already known about living and working in these tall buildings and to provide future directions for research, this article reviews recent empirical studies on occupants' perception of tall buildings, and physiological and psychological experiences in relation to its tallness. Occupants perceive better view, less noise, and better air quality as benefits for living and working on higher floors than on lower floors. However, occupants also expressed concerns about height, difficulty with vertical transportation, strong wind, and escape in case of fire. Note that the methodologies used in many of the self-reported studies are relatively weak. Given the scarcity of research regarding human responses, this mini-review aims to encourage behavioral scientists to collaborate with building science researchers to advance our understanding of human–environmental relations in this new habitat.

Keywords: high-rise building, tall building, skyscraper, residence, workplace, psychological well-being, perception

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***Correspondence:**
Cheuk Fan Ng
cheukn@athabascau.ca

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Tall buildings of 30 to over 100 storeys are becoming common in cities around the world, especially in Asian and Middle-East countries [Council on Tall Buildings and Urban Habitat (CTBUH)].[1] Extensive research has focused on technical aspects of erecting such tall buildings. However, few studies have focused on perception, satisfaction and comfort, and physical and psychological well-being of occupants of these tall buildings. There was some research conducted in the 1960–1970s (e.g., Conway and Adam, 1977), when tall buildings were typically about 20 storeys high. More recently, Gifford (2007) provided a comprehensive review of empirical studies conducted mostly in the 1960s–1980s outside Asia and the Middle East, in which the effects of living in high-rise buildings on social behaviors and mental health were examined.

A grand challenge for researchers is to understand how new work and living conditions resulting from the development of megacities where these tall buildings reside affect us (Sorqvist, 2016). A recent report (Oldfield et al., 2014) echoes such a need in concluding, "research … on those who live and work at height, is a significant research priority" (p. 9).

People have choices of housing, but their choices are often limited by income and location. In the 1960s, high-rise buildings in developed countries were primarily public housing for low-income residents (e.g., Gillis, 1977). Since the 1990s, high-rise living has been marketed as an

[1]Council on Tall Buildings and Urban Habitat (CTBUH) at www.ctbuh.org.

urban, luxurious lifestyle for the childless and the affluent: for example, in Australia (Costello, 2005), Switzerland (Panczak et al., 2013), and Canada (Langlois, 2012). In cities such as Hong Kong, where tall building is the house form, people's choice is which floor of a tall building rather than which form of housing. Workers would have little choice if their workplace is in a tall building (e.g., Chung and Park, 2006). It is therefore important to understand how people perceive, think, and behave in this new habitat.

This article reviews the scant research literature published in diverse disciplines in the past two decades on occupants' experiences of living and working in tall buildings. Only themes emerged from this search of the literature that are directly related to the distinguishing feature of tall buildings (i.e., tallness) are discussed. Although critically important, high density and urban design implications for transportation, utilities, and services infrastructures (Ali and Aksamija, 2008) are beyond the scope of this very short review. This article will begin with occupants' perception of what is considered a tall building, followed by their perceived benefits and concerns. Finally, limitations of the review and future research are discussed.

Searches of several electronic databases (PsycInfo, SocIndex, Emerald Insight, MedPub, and Google) were conducted using search terms "tall building," "high-rise building," and "skyscraper." The searches were limited to English-language publications. The reference lists of all retrieved documents were scanned for any additional relevant material. A summary of the studies reviewed is at **Table 1**.

TABLE 1 | Studies of tall buildings.

Reference	# of Storeys/city	Research design/sample	Major findings
Averill et al. (2012) (National Institute of Standards and Technology; http://wtc.nist.gov)	110 storeys; World Trade Center in New York	Telephone interviews with 803 evacuees; 225 face-to-face interviews; 6 focus groups	Covered technical aspects of fire protection, emergency training and preparedness, occupants' experiences immediately after the attack, during the time between initial awareness and evacuation, and evacuation, and demographic information On average, occupants began their evacuation within 6 min (much faster than after 1993 bombing), but there was great variation. The slow average speed (0.2 m/s) in stairwells was due to crowding and obstacles in stairwells, evacuees' physical conditions, and emergency responders counterflow
Brown et al. (2015)	71 storeys; Hong Kong	Random sample of households; 10,077 interviews with individuals; city-wide measurements of road traffic noise exposure at the most exposed external façade	Floor level (0–15, 16–35, 36–71 storeys) was not a significant predictor of annoyance (highly annoyed or not) or self-reported sleep disturbance (yes or no) But residents at higher floor level may experience fewer noise events than at lower floors
Chan et al. (2009)	26–30 storeys; Hong Kong	250 residents	Willing to pay the most for a medium height unit (18th–28th floor). Sea view raised price; mountain, street, and building views decreased price
Choy et al. (2007)	Up to 34 storeys	749 transactions	Price increased with floor level but at a decreasing rate. Sea view and garden view were positively related with price
Chung and Park (2006)	37–43 storeys; Seoul, Korea	150 office workers working at or above 30th floor of 2 supertall buildings	Only 24% of respondents wanted to work in these buildings. If no choice given, would prefer 30th floor or higher Most respondents (63%) were in favor of medium floor levels (6th–15th floor) when purchasing or renting dwelling Preference for high office floor level was significantly correlated with choice of floor height in future purchase ($r = 0.4$) or rental ($r = 0.38$) of residence Preference for working in super-high-rise office building was significantly positively correlated with air quality Preference for high floors was significantly negatively correlated with worries about fire Long waiting time for elevator was significantly negatively correlated with preference for working in these buildings
Cohen et al. (1973)	32 storeys; New York	54 elementary school children	Children who lived on the lower floors impacted by higher traffic noise had lower auditory discrimination and reading scores than those who lived on higher floors of the same building
Fahy and Proulx (1995)	110 storeys; World Trade Center in New York	406 respondents to questionnaire survey	Delays in evacuation time (several minutes to 3 h) were attributed to ambiguous cues, lack of information and instructions, smoke, lack of lights, and crowdedness in stairwells
Galea et al. (2012) (Project HEED; http://fseg2.gre.ac.uk/HEED/)	110 storeys; World Trade Center in New York	Face-to-face and telephone free-flow narrative and semi-structured interviews with 271 evacuees	Developed an interactive, online database and computer modeling analysis Examined in detail occupant experiences in relation to premovement delays, response times, risk perception, and stair travel speeds Slow travel speed in stairwells—likely due to crowd density, fatigue, and group dynamics

(*Continued*)

TABLE 1 | Continued

Reference	# of Storeys/city	Research design/sample	Major findings
Gershon et al. (2012) (Centre for Disease Control and Columbia University)	110 storeys; World Trade Center in New York	1,444 evacuee respondents to questionnaire survey; 56 in semi-structured interviews and focus groups	Individual, organizational, and structural factors influenced time to start and to complete evacuation Those who delayed their evacuation time included older evacuees, with disability or medical condition, security or emergency responders, followers. Also blocked exits. Lack of emergency preparedness or training at the workplace
Hui et al. (2012)	Up to 30 storeys; Hong Kong	2,375 transactions	Buyers were willing to pay more for a wider sea view; garden view was just as desirable. Proximity to a main avenue or street was negatively related to price Low air quality and noise disturbance for condominiums close to the streets had a negative impact on housing prices of units below the 20th floor but not at high floor levels
Jim and Chen (2009)	Up to 71 storeys; Hong Kong	1,474 transactions	Floor level was positively related to apartment price. Price was highest for access to sea view, followed by mountain view, building view, and street view was the least desirable
Jung et al. (2011)	32 storeys; New York	333 young children	Lower levels of black carbon concentration detected at 6th floor or above than at lower floors during the non-heating season, both indoors and outdoors
Lau et al. (2010)	20–40 storeys; Hong Kong	173 respondents to survey	View from living room was important, but not from kitchen or bedroom
Lee (2014)	Chicago (49–63 storeys); Tokyo (34–39 storeys); Seoul (46 storeys)	116 Chicago residents and 111 Tokyo residents on >30th floor; 28 Seoul residents on >20th floor	Seoul residents preferred mid-range floors but more respondents in Chicago and Tokyo wanted top floors Most residents were quite satisfied with the openness, good view, and light Residents' responses were influenced by their experience of living in high-rise buildings, with those living in Chicago reporting more positive experience than those in Tokyo, and those living in Seoul reporting the least positive experiences; Tokyo and Seoul residents being more anxious about living high than Chicago residents
Tse (2002)	Up to 20 storeys; Hong Kong	1,000 transaction	Floor level was positively related to transaction price.
Yeh and Yuen (2011)	34–44 storeys in Hong Kong; 12–30 storeys in Singapore	961 residents in Hong Kong; 218 residents in Singapore	Building height perceived to be "tall building" and "very tall building" was higher in Hong Kong than in Singapore, but that perceived to be "not tall building" was the same Hong Kong residents preferred a higher floor level than Singapore residents (mean of 29 vs. 21 storeys) A higher percentage of Hong Kong residents than Singapore residents were willing to live above 31st floor (37 vs. 13%). Of the 11% who were willing to live above 46th floor, 78% were already living above 40th level compared with only 50% of those living below 20th floor Over 60% living above 16th floor in both Hong Kong and Singapore reported satisfaction with the floor level they were living on; only less than 15% of those in Hong Kong considered the floor they are living on to be too high. By contrast, 62% of those living below the 6th floor in Hong Kong and 45% of those in Singapore considered the floor level to be too low Being trapped in a fire was the highest ranking concern among Hong Kong residents (26%) and 5th ranking concern among Singapore residents (9%) Elevator breakdown was the second highest ranking concern among respondents in both Hong Kong (13.3%) and Singapore (20.0%) Traveling time in lift was ranked the 8th concern
Yuen (2005)	30 storeys; Singapore	348 residents in public housing	Most residents were satisfied. The benefits reported were view, breeze, and privacy on higher floors Residents were worried about safety, and in particular, height phobia, safety of children and the elderly, and lift breakdown
Yuen (2011)	30 storeys; Singapore	348 residents in public housing	The majority (66%) preferred to live on the 6th–20th floor

HOW TALL IS TALL?

One of CTBUH's qualifying criteria for a tall building is height relative to context, and the study by Yeh and Yuen (2011) supports that perception of tallness is dependent on the surrounding physical context. In their study, the mean height perceived by occupants to be a tall building and a supertall building was higher in Hong Kong than in Singapore. However, what was considered "not a tall building" was similar (see **Figure 1**); this is a height considered to be tall in most westernized countries, where low-rise housing predominates.

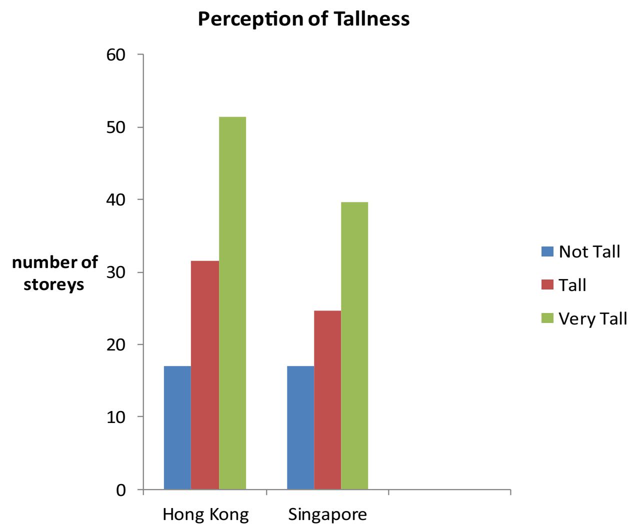

FIGURE 1 | Perception of tallness. Source: Yeh and Yuen (2011).

PREFERENCE AND SATISFACTION

Occupants have their highest preference for middle floor levels. Two-thirds of the respondents in Yuen's (Yuen, 2011) study in Singapore preferred to live on the 6th–20th floor of 30-storey buildings. In Seoul, Korea, high-rise residents also preferred mid-range floors, but more respondents in Chicago and Tokyo wanted top floors (Lee, 2014). In Hong Kong, most respondents were willing to pay the most for a medium height unit (18th–28th floor) in 26- to 30-storey buildings (Chan et al., 2009). In Korea, 63% of the office workers in two supertall buildings favored medium floor levels (6th–15th floor) when purchasing or renting their dwellings (Chung and Park, 2006).

Occupants' preference for floor level is influenced by prior experience and familiarity with height. Hong Kong residents generally preferred a higher floor level than Singapore residents (mean: 29 vs. 21 storeys) and a higher percentage of the respondents in Hong Kong than in Singapore were willing to live above the 31st floor. Of those who were willing to live above the 46th floor, the majority were already living above the 40th floor (Yeh and Yuen, 2011). In Chung and Park's (Chung and Park, 2006) survey of office workers in supertall office buildings, their respondents' preference for working on high floors was significantly correlated with their choice of floor height in their future purchase or rental of residence.

Over 60% of residents living above the 16th floor in both Hong Kong and Singapore were satisfied with their current floor level (Yeh and Yuen, 2011). Also most of the residents living in high rises in Singapore (Yuen, 2005) and in Chicago, Tokyo, and Seoul (Lee, 2014) were satisfied. The benefits as reported included view, breeze, privacy, openness, and light. Residents' responses were influenced by their experience of living in high rises, with those living in Chicago reporting more positive experience than those in Tokyo, and those living in Seoul reporting the least positive experience (e.g., anxiety) (Lee, 2014). Living at height can elicit fears about safety (Yuen, 2005) and concerns about physiological discomfort (Lee, 2014).

PERCEIVED BENEFITS

View

One perceived benefit of occupying the higher floors of tall buildings is an unobstructed view, as indicated in surveys of residents (e.g., Yuen, 2005; Yeh and Yuen, 2011; Lee, 2014) and office workers (Chung and Park, 2006). Several studies in Hong Kong have shown that apartments on higher floors or with nice views are sold at higher prices (e.g., Tse, 2002; Choy et al., 2007; Jim and Chen, 2009; Hui et al., 2012). In Hong Kong, a water view is valued the most (Chan et al., 2009; Jim and Chen, 2009), and a garden view is equally desirable (Hui et al., 2012), but a street or building view decreases the price (Chan et al., 2009). Whether having a mountain view adds value to a property is unclear (Chan et al., 2009; Jim and Chen, 2009) and a sea view that is obstructed by other buildings does not necessarily increase property value (Hui et al., 2012). Having a view is only important from the living room but not important from the kitchen or the bedroom (Lau et al., 2010).

Cleaner Air

Cleaner air is another perceived benefit of occupying the higher floors. In a New York study, Jung et al. (2011) reported that the level of traffic-related airborne pollutants were the lowest in residences above the fifth floor during the non-heating season. In a Hong Kong study, the low air quality had a negative impact on housing prices of units below the 20th floor (Hui et al., 2012). In a Korean study, occupants' preferences for working on higher floors of two supertall buildings were positively correlated with good air quality (Chung and Park, 2006).

Less Noise

Yet another perceived benefit of living on high floors is less noise. In a Hong Kong study (Brown et al., 2015), road traffic noise exposure was measured at the most exposed external façade of high rises of up to 71 storeys. Even though floor level was not a significant predictor of annoyance or self-reported sleep disturbance, the researchers suggested that residents at higher floor levels may experience fewer noise events than residents at lower floors. In another Hong Kong study (Hui et al., 2012), noise disturbance influenced the housing prices of condominium units below the 20th floor but not units above. In an exceptional study of the time (Cohen et al., 1973), children living on the higher floors of a 32-storey building in New York had better auditory discrimination and reading performance than those living on the lower floors of the same building that were impacted by higher traffic noise.

CONCERNS AND FEARS

Height Anxiety

Height was a concern among 1–2% of the respondents living in tall buildings in Hong Kong and Singapore (Yeh and Yuen, 2011) and was a main reason for their reluctance to live on higher floors (Yeh and Yuen, 2011; Lee, 2014).

In three experiments, Stefanucci and Proffitt (2009) showed that vertical distances were greatly overestimated, and that overestimation was greater when looking down from the top than when looking up from the ground. They also found that overestimation of distances when looking down from atop correlated with reports of trait- and state-level fear of heights.

When at height, most people experience imbalance to some extent. When the eye–object distance is greater than 20 m in a stationary position, the visual system may provide information that conflict with those of the somatosensory and vestibular systems, leading to height imbalance. When an individual perceives a risk of falling, that individual feels a sense of danger (Salassa and Zapala, 2009).

Individuals vary in their psychological reactions to heights, ranging from acrophobia, height intolerant, height tolerant, to height seeking (Salassa and Zapala, 2009). Height intolerance is prevalent in 28% of the Germany population (Huppert et al., 2013), even though only less than 10% of individuals with height intolerance have acrophobia (Menzies and Clarke, 1993). When standing still, individuals who are susceptible to fear of heights cope by freezing their gaze to the horizon, but this behavior may impair their postural balance (Kugler et al., 2014).

Visual height intolerance affects the quality of life of these individuals (Schaffler et al., 2014). To reduce the effect, height-intolerant individuals should avoid gazing at distant moving objects but should include near objects within their peripheral vision (Salassa and Zapala, 2009). In tall buildings, having higher setback of windows might help residents to focus their view on the horizon instead of the ground below (Yeh and Yuen, 2011). Music can significantly reduce subjective anxiety associated with fear of height when riding up an external elevator (Seinfeld et al., 2016).

Wind-Induced Motion

Tall buildings oscillate or resonate in strong winds but building occupants may believe that buildings should remain stationary. When vibrations are perceptible, and if their occurrence is frequent or for a long time, such building motions can cause discomfort or even fear in some occupants. In addition to kinesthetic cues, visual and acoustic cues can trigger occupants' perception of motion (Burton et al., 2015).

Because of the difficulty in accessing building occupants, few field studies have been conducted (Burton et al., 2015; Lamb and Kwok, 2017). Researchers have used shake tables and purpose-built motion simulators in experiments to measure the effects of varying frequencies, amplitudes and durations on postures, perception of motion, and cognitive task performance. Peak acceleration threshold at 5 mG is perceptible to some occupants but unlikely to cause alarm; at 10 mG, is perceptible to most occupants; and at 35–40 mG, would cause fear and safety concerns as some occupants can lose balance (Burton et al., 2015).

Motion in tall buildings typically does not induce vomiting, but individuals vary in their sensitivity and susceptibility to motion sickness (Burton et al., 2015). Exposure to prolonged low frequency, low-acceleration motion may cause sleepiness, low motivation, difficulty in concentration, and low mood among occupants for up to 12 h after the motion has stopped—the "sopite syndrome" (Lamb and Kwok, 2017). Lamb et al. (2004, as cited in Lamb and Kwok, 2017) compared the well-being and work performance of office workers on the high floors and those near the ground floor of 22 wind-sensitive buildings in New Zealand over months. When building motion was detectable, occupants reported significantly higher rates of nausea, dizziness and feeling of being unwell, distraction, and tiredness. Those who experienced symptoms of the sopite syndrome or motion sickness had a decrease in work performance. Lamb and Kwok's (Lamb and Kwok, 2017) review of other studies showed that occupants who were affected to be 5%, but other studies have shown a much higher percentage (47–72%) at very tall buildings (170–226 m) during strong winds. There is a clear need to further understand the effects of motion acceleration, frequency, duration of exposure, and wave form on health, work performance, and behavior during wind-induced building motions.

Fire

Being trapped in a fire was the top concern among Hong Kong residents and the fifth concern among Singapore residents (Yeh and Yuen, 2011). Worries about fire were significantly negatively correlated with office workers' preferences for high floors in the Korean study (Chung and Park, 2006).

Extensive research on fire safety, evacuation, and rescue is being done (e.g., Chow et al., 2013), but research on how occupants perceive the situation, make decisions, and behave before and during a fire is equally important (Boyce and Shields, 2012). A few reviews of studies on evacuation behaviors have been conducted in recent years (e.g., Kobes et al., 2010; Ronchi and Nilsson, 2013). Kobes et al.'s (Kobes et al., 2010) review analyzes how fire characteristics, human characteristics, and building structural characteristics influence survival or response performance during a fire. Ronchi and Nilsson's (Ronchi and Nilsson, 2013) review discusses how egress components (e.g., stairs), strategies in use (e.g., full evacuation), and types of buildings (office, residential) can influence pre-evacuation times.

Perhaps the most important research that have contributed to our understanding of human behavior in high-rise building evacuations are the studies of the World Trade Centre disasters in 1993 (Fahy and Proulx, 1995) and 2001 (Averill et al., 2012; Galea et al., 2012; Gershon et al., 2012). Based on first-person reports in various media and interviews with survivors, these studies provided data on escape and premovement times and actions, the flow rates in staircases, and the use of elevators (Kobes et al., 2010; Shields, 2012; Fahy, 2013). These studies of evacuees concluded that personal factors (e.g., knowledge and emergency response experience, perception of sensory cues and risk, and mobility), group behavior (e.g., following a leader and crowd density), organizational factors (e.g., emergency preparedness and training), structural factors (e.g., signage and staircase width), and situational factors (e.g., degree of awareness of the events, environmental conditions at the start of and during evacuation, and pre-evacuation activities) had significant effects on initiation and full evacuation times.

Vertical Transportation

Air pressure differential is a concern for high-speed elevator systems in supertall (300 m) and megatall skyscrapers (600 m) (CTBUH). In addition to wind noise and vibration, a quick and drastic change in air pressure as the elevator ascends and descends rapidly can result in physiological discomfort in some people—the "ear-popping" effect. Although elevator speeds can technically be as high as 16.8 m or more per second, current descent speed is kept at 10 m/s for riders' comfort, unless the cabin is pressurized (Al-Kodmany, 2015).

Elevator breakdown was ranked the second highest concern among high-rise residents in Hong Kong (13%) and Singapore (20%). Residents were anxious about being trapped in the elevator when there was a power failure (Yuen, 2011). Unlike when on the ground, occupants of tall buildings are dependent on elevators for vertical transportation; they feel a total lack of control if and when the elevators break down; there is no personal elevator, or alternative means of transportation yet.

Traveling time in elevators was ranked the eighth concern among residents in both Hong Kong and Singapore (Yeh and Yuen, 2011). Long waiting times for an elevator were significantly negatively correlated with occupants' preference for working in tall office buildings (Chung and Park, 2006). In supertall buildings, elevators users may have to change elevators two or three times just to reach or leave their homes or offices. To reduce waiting time, destination dispatch systems can be used to improve passenger ridership flow (Al-Kodmany, 2015).

DISCUSSION

This mini-review has included studies of perception of tall buildings and perceived benefits and concerns of living and working in tall buildings. These studies using questionnaire surveys and interviews of occupants have provided some preliminary findings, but their methodologies are weak. The response rates are not reported in most of these studies, and it is unclear how representative the samples are of the population of occupants. One basic question is how many people live and work in tall buildings. The self-selective nature of housing makes the conduct of any experiments with real occupants almost impossible. Lab simulations, computer modeling, and virtual reality are likely the methodologies of choice at the moment. Surveying hotel guests and visitors to observation decks atop tall buildings may also provide data on short-term reactions. Future research needs to use objective measures, larger and representative samples, and a diversity of research methods, and to examine moderating variables (e.g., occupants' life stage). It would be beneficial to use complementary approaches by comparing responses of occupants from buildings of different heights and those of occupants at different heights within the same building.

Given where in the world tall buildings are growing, this review is limited by its exclusion of non-English publications making it difficult to examine issues from a cultural perspective. Nevertheless, it has demonstrated a clear need for understanding human responses to tall buildings and its surrounding urban habitat; the erection of very tall buildings should not be driven entirely by technological advances. Engineers, behavioral scientists, and design researchers (e.g., Hartkopf and Loftness, 1999; Veitch, 2008; Vischer, 2008; Lamb and Kwok, 2017) recognize that buildings should be designed for occupant comfort, work performance, and well-being. There is a great potential for contributions from various fields of social and behavioral sciences. How do prospective occupants perceive risks associated with occupying these buildings? Do occupants of tall residential buildings differ from occupants of commercial or mix-use buildings in their perception and behaviors? Are residents more satisfied in a stand-alone tall building with lots of open space than are residents in a tower block complex? I would encourage you to seek answers, alone and in collaboration with practitioners and researchers from various disciplines. Tall buildings must be designed well and be integrated into cities to ensure livability for occupants (Ali and Aksamija, 2008; Al-Kodmany, 2012).

AUTHOR CONTRIBUTIONS

CN contributed to this article in entirety.

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