Urban Resilient Strategies for High-rise Buildings: Lessons from San Francisco, California

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ABSTRACT
This paper aims to study the urban resilient strategies for high-rise buildings in San Francisco, California. Utilizing the Web-GIS technology to address the urban risks and also policy resilient review to understand the disaster assessment faced by earthquake. It contributes to understand urban resilient thinking and also strategically devotes to urban policy-making.

Keywords: *San Francisco, Urban resilient strategies, High-rise buildings, Earthquake disaster.*

1. INTRODUCTION

Resilience, as a term, was first introduced by Holling (1973). Urban resilience is the measurable capability of any urban system, with its inhabitants, to maintain continuity through all shocks and stresses, while positively adapting and transforming toward sustainability. A resilient city assesses, plans and conducts to prepare for and respond to all hazards that is either sudden and slow-onset, or expected and unexpected (UN-Habitat). Put it simple, urban resilience is the ability to cope with disasters such as earthquakes, wildfires, tsunamis, coastal flooding, etc., which the recovery from setbacks caused by disasters is vital for urban resilience.

The concept of resilience thinking has been profoundly studied as means of analysis by Walker and Salt in their book Resilience Thinking: Sustaining Ecosystems and People in a Changing World. Resilience thinking provides a framework for viewing a social-ecological system as one system operating over many linked scales of time and space. Its focus is about how the system changes and copes with disturbance. Resilience, a system's capacity to absorb disturbances without a regime shift, is the key to sustainability (Walker, B., & Salt, D., 2012). In that way, a city should embrace the building of future scenarios incorporating ongoing social, economic, cultural, and environmental dynamics in order to design resilience and disaster risk reduction (DRR) strategies (Resilience Learning Module II: Strategies and Actions).

However, this paper takes the aim at apprehending the importance and significance of urban resilient strategies, by learning from San Francisco, California, a city that locates on a continental transform fault that forms part of the tectonic boundary between the Pacific Plate and the North American Plate (San Andreas fault by wikipedia). Earthquake is a big threat for the city and this leads huge amount potential risk to be aware of high-rise building, which is vital to understand and address the approach, assessment, and criteria in a proper manner. Taking into account for future risks and uncertainties, and constructing the resilient mindset and strategies in preparation for urban policy-making both short-term and long-term. Instead of using "tall buildings", we use the academic word "high-rise building" as the general word for the academic reason of researching.

2. LITERATURE ON HIGH-RISE BUILDING

2.1 Definition of High-rise Building

In fact, there is no universal definition on high-rise building, which officials around the world differentiate the opinions in the definition of high-rise buildings (Al-Kodmany, 2012). A building

code definition includes buildings of over 23m in height or approximately 6 stories high (IBC, 2009) Emporis Standards (2010) define high-rise buildings as multistory structures that are 35-100 m tall, or 12-39 stories high. International organization the Council on High-rise Buildings and Urban Habitat (CTBUH) developed the international standard “CTBUH Height Criteria” on measuring levels of height, which includes high-rise, super-high-rise and mega-high-rise buildings. Among the three categorized concepts on high-rise buildings, detailed measurement contains: height to architectural top, height to occupied floor and height to tip. According to research from statistical result from CTBUH, there are 180 skyscrapers height by 300 meters and above in the top ten countries listed, where high-rise building city includes Hong Kong, New York, Dubai, Seoul, Tokyo, Kuala Lumpur, Melbourne.

2.2 High-rise Building Function

It is commonly known that a very tall high-rise building is referred to as a skyscraper. Functionally speaking, high-rise building apparently has the different use. Specifically, research indicates that a single-function high-rise building means that more than eight-five percent of the use takes the single-use, such as office. Conversely, a mixed-use high-rise building has a multiple function of use in hotel, retail, residential, office and even subway station (TB-TOD design in urban planning), and this allows each function to account for more than fifteen percentage (Al-Kodmany et al., 2022). "Mixed-use" is defined as having three or more real estate uses (such as retail, office, hotel, etc.) that are physically and functionally integrated in a single property and are mutually supporting (Schwanke D. et al., 2003.). Noted that, at least fifty-percent of the occupation considers to be a building, which is the definition different from telecommunication tower, such as Oriental Pearl Television Tower Shanghai, China (CTBUH Height Criteria).

2.3 High-rise Building Impact

High-rise buildings have positive as well as negative impacts on urban environments (Vafai, H. et al., 2020). Even though the trend of constructing the new high-rise buildings has been increasingly recognized by a number of megacities planning, it continues to be a visual isolation of its broader urban environment along with potential risks being scientifically discovered (Ali, 2007). High-rise buildings can have a myriad of effects on satisfaction, preferences, social behavior, crime and fear of crime, children, mental health and even suicide (Gifford, 2007). In addition, research also indicates that the more levels the building increases, the more resources per floor area are required to withstand the rising effects from the natural environment, such as fire, earthquake, wind-loading, bird-skyscraper collisions, airplane collisions etc. (H. James et al., 2020, Joyner M. D. et al., 2020).

3. CASE STUDY

3.1 The Setting

In according to the U.S. Geological Survey (USGS) estimation, the county and city of San Francisco has seventy-two percentage of the likelihood to sacrifice 6.1 magnitude or greater earthquake before 2043, which recalled the Great San Francisco earthquake dated back to 1906 (“Figure 1”). Due to this important reason, the city is constantly seeking new ways to protect residents, workers, and buildings. Started in early 2012, the Earthquake Safety Implementation Program (ESIP) involves a decade on-going study that evaluates the seismic vulnerabilities the city faces by 2022.

Figure 1 San Francisco in ruins, 1906 (George R. Lawrence).

3.2 Approach

To address the risk area that might be destroyed, the officials is conducting a study called “HAZUS Earthquake Loss Estimation Study”, which has analysis standard by evaluating the physical and economic impacts regarding earthquake scenario on specifics.

Based on the HAZUS program, a nationally standardized risk modelling distributed as free GIS-based database, led by the Federal Emergency Management Agency (FEMA) in the United States. High-rise building safety strategy is on the basis of closely working with local communities, as well as utilizing the primary tools on HAZUS Earthquake Loss Estimation Study and Seismic Hazard Ratings, as part of priority ESIP tasks, whilst the HAZUS program maintains models for estimating the risk of

damage from disasters such as earthquakes, floods, hurricanes, and tsunamis, including levels of analysis on Basic or Advanced to generate more accurate and applicable estimations on urban loss.

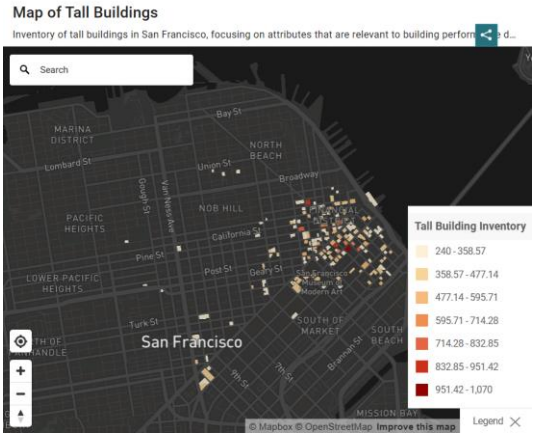

Figure 2 Distribution of high-rise buildings height by 240 feet and above.

Technically speaking, it goes with data indeed. The project database compiled information about buildings, which is called “inventory”, and it aims at focusing on the building construction during an earthquake or relating to post-earthquake recovery.

As shown in “Figure 2”, the possible area might be destroyed during an earthquake refers to the northeastern part of city via the Web-GIS online map (filter setting by height_ft greater than or equal to 240, excluding missing or null values), which is the downtown area calculated by 156 buildings (Of course, not from the look in “Figure 3”). Summary table attached building attributes includes specific information on location, height, age, year of retrofit, material, foundation type, etc. based on Web-GIS platform. Roughly 60% of the buildings mainly used for business, whilst others predominantly used for residential (“Figure 3”). In this way, each building has been evaluated on an individual level, in order to calculate the loss value where on the estimates as a whole.

3.3 Levels of Assessment

Research shows that San Francisco is the first city that pioneers the safety strategy for high-rise building in the United States. In the downtown area, there is high building density posing an aggregate risk to neighborhood, whereas citywide recovery is the opposite scenario with low density and less risk. Hence, this is a vital reason why high-rise buildings need urban resilient strategies to preserve and recover.

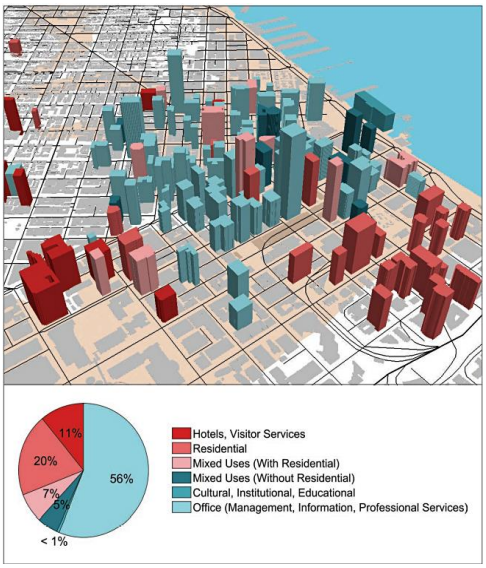

Figure 3 High-rise building occupancies in San Francisco Downtown (onesanfrancisco.org).

To understand this scenario caused by the high-rise building seismic risk, the officials listed an action plan dependent on two levels of assessment. One is the high-rise building itself, whilst two is the adjacent district and neighborhoods. Actually, it is likely that high-rise buildings may damage and even crash with each other during an earthquake and also making huge impacts on areas closed by beyond their own footprints. Assessment guideline on high-rise buildings and neighborhood areas are summarized and listed on “Table 1” based on the official document.

Table 1. Aims and actions of the assessment guideline (onesanfrancisco.org)

Assessment	Aims	Actions
High-rise buildings	To compile a database on high-rise buildings dependent on detailed information	Setup and expand the database of tall buildings
Areas of neighborhood	To address the effect of high-rise building on the downtown neighborhoods	Organize a comprehensive recovery plan for adjacent neighborhoods
Recommendations		
Actions for high-rise building		•Developing mechanisms for harvesting building data •Enabling the database online for the public •Expanding the database in line with: - All buildings taller than 75 feet employment sector - Foundation type of any building on a site
Actions for areas of neighborhood		•Developing a recovery plan •Considering alternative habitability facility standards for high-rise building

4. CONCLUSION

This study reviews the urban resilient strategies for high-rise buildings in San Francisco, California, in terms of urban context, working approach, and levels of assessment. It contributes to understand urban resilient thinking applied into a city, and how cities should address and cope with disaster in a strategic manner - from short-term focus to long-term strategies - from building footprints to adjacent neighborhoods. Future research direction on wind, fire, energy, vertical transportation of high-rise building resilient study can be recommended.

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