MINISTRY OF EDUCATION AND TRAINING

MINISTRY OF CONSTRUCTION

HANOI ARCHITECTURAL UNIVERSITY

TRAN PHUONG MAI

REFUGE SPACE IN SUPER HIGH RISE BUILDING ARCHITECTURE IN VIETNAM

SPECIALIZED ARCHITECTURE

CODE : 9580101

SUMMARY OF DOCTORAL THESIS

Hanoi - 2022

The thesis was completed at:

Hanoi Architectural University

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This thesis had been defended at the Doctoral Examination Council at Hanoi Architectural University

At ..... a.m/p.m ..... date ..... month ..... year 2022

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PREAMBLE

1) The urgency of the topic:

The most crucial consideration in the planning and management of the construction of ultra high-rise buildings is the safety of individuals leaving in the event of a subjective or objective incident. The weak, the disabled, the ill, and even the healthy may find it challenging to descend from a height of tens or hundreds of meters to the ground in super-high-rise buildings when there is a fire, explosion, terrorist attack, etc. A super-high-rise building should have a refuge area where people can temporarily hide before descending to the ground or wait for rescue personnel to arrive with specialized rescue vehicles. The architecture of super-high-rise buildings adds high artistic value to the urban form, but if leaving this space for refuge would be very wasteful, it is advised to combine other functions to increase efficiency, such as green space, utility public space, technical space to ensure safe refuge, safety and escape, and safety for rescue.

The refuge area needs to be studied to fit the Vietnamese people's economic circumstances, climatic conditions, cultural traditions, and way of life. Also, maintaining benefits for the investor and building's occupants while still adhering to the present Regulation (QC) and Standard (TC) and creating welcoming, incident-free areas that are practical for inhabitants. Modern urban forms that harmonize with nature and connect vertically with trees on the ground fascinate architects and urban designers.

In order to suggest methods to organize refuge space in super-high-rise structures to meet the following criteria: Safety, Economy, Humanity, and Sustainability, the thesis choose the topic *"Refuge space in super-high-rise building architecture in Vietnam"* for research.

2) The thesis's research goal is to:

a. *Research purposes***:** Investigate architectural methods to arrange the refuge space in Vietnam's ultra-high-rise structures in accordance with the standards of security, efficacy, humanity, and sustainability.

b. *The study's goals were to:*

- Putting forth architectural ideas to arrange the refuge area for

extremely tall skyscrapers focused within and outside the house, along with ideas for simultaneous vertical and horizontal escape routes for people.

- Making architectural suggestions to arrange the green refuge area to maximize its effectiveness when paired with other uses (elevated garden, utility public services, technical floors, etc.). ...brings ideals that are sustainable and humane.
- Offering architectural solutions to arrange refugees in dispersed shelter places in extremely tall buildings.
- Develop criteria to evaluate the organization of refuge spaces in Vietnam when arranging refuge spaces according to current Construction Standards and Regulations in combination with the above proposals to ensure effectiveness according to safety criteria, safe, economic, humane and sustainable.

3) Research object and scope:

a. *Research object*: refuge space in multi-functional super high-rise buildings, apartments and multi-functional complexes.

b. *Research scope:*

- About space: super high-rise buildings in big cities in Vietnam: Hanoi, Da Nang, Ho Chi Minh City.
- About time: until 2050.

4) Research method: survey method; statistical methods, compare, contrast; interdisciplinary approach; professional solution; forecasting method.

5) Research topics include:

- The construction of ultra-high-rise structures; evacuation and escape floors; and the lessons Vietnam has learnt on fire safety;
- Compiling scientific data on fire safety, life safety, rescue, physico-chemical properties and fire-fighting mechanisms, anti-fire spread, evacuation floors, and calculating people's escape from extremely tall buildings;
- Legal foundations influencing the layout and structure of the refuge space;
- Classification and development trends for Vietnam's extremely high-rise structures;
- Opinions, a target, a rule, a proposal to organize a refuge space, and

a proposal for standards to assess the refuge space in Vietnam's ultra-high-rise structures.

- Proposing to update rules and requirements for refuges and shelters' floors to reflect the development circumstances of Vietnam's major cities.

6) New contributions:

- Outlining three ways to arrange the refuge space in Vietnam's super-high-rise architecture (the refuge space is concentrated in the house and connects different refuge spaces on the same elevation; the refuge space green; scattered refuge space).
- Developing criteria to assess the refuge space's performance when the refuge function is combined with additional utility functions.

7) Importance in terms of science and application:

Theoretical value: advancing theoretical understanding of the architectural design of ultra-high-rise structures to assure fire safety, humanistic and sustainable values, and health and life safety; In addition to safety, the effectiveness of the refuge space must be improved. Examples of this include the creation of green refuge spaces, as well as community, humanity, and sustainability.

Practical value: serves as a guide for investors, architects, and construction engineers when consulting with and developing super high-rise structures in Vietnam. The evaluation criteria are rated to raise the value of the super high-rise structures and its appeal to users and investors.

8) Thesis structure: In addition to the Introduction and Conclusion, the Content section includes 3 chapters:

Chapter 1: Overview of the organization of the refuge space in the super-high-rise architecture

Chapter 2: The scientific basis for organizing the refuge space in the architecture of super-high-rise buildings in Vietnam

Chapter 3: Models and solutions for organizing refuge spaces in super-high-rise architecture in Vietnam.

CONTENT

Chapter 1: OVERVIEW OF THE ORGANIZATION OF THE REFUGE SPACE IN THE SUPER-HIGH-RISE ARCHITECTURE

1.1 Actual situation of organizing refuge spaces in super-high-rise buildings in the world and in Vietnam

1.1.1 Situation of building super high-rise buildings in the world

1.1.2 Situation of building super high-rise buildings in Vietnam

1.1.3 Overview of the refuge space in super high-rise buildings in Vietnam

1.1.4 Actual situation of fires related to escape

1.2 Research situation on the organization of refuge space in super high-rise buildings in the world

1.2.1 Issues The world and Vietnam have studied about refugee space

1.2.2 Refer to the standards of some countries in the world regarding refuge spaces

1.3 Main issues to be studied in the thesis

+ An overview and global and Vietnamese super high-rise building development trends. In particular for Vietnam as a tropical monsoon country, the flexibility and diversity in the organization of the refuge space can have a significant impact on determining the size and area of the refuge space. Due to the high demand for cooling electricity and the frequent occurrence of hot, dry, and hot, humid conditions, green space and communal areas are crucial in extremely high-rise structures.

+ To ensure the safety requirements for refuge and safe escape simultaneously vertically and horizontally out of the building safely in the quickest time, research and organize the centralized refuge space inside and outside for super-high-rise buildings.

+ Diversify the organization of the refuge space combining functions such as green space, utility public services, and can combine technical floors suitable to Vietnam's economic conditions.

+ Offer remedies for dispersed refuge spaces (refugees) with limited, narrow areas or few users in ultra-high-rise buildings. Without affecting the capacity, the refuge floor (20 floors/1 refuge floor) might be divided into refuge spaces (4-5 floors/1 refuge space).

+ Create standards for measuring the effectiveness of the refuge space, thereby recommending standards for measuring the refuge space in ultra-high-rise structures to guarantee that the refuge space is safe, compassionate, and effective, sustainable, and resource-efficient.

Chapter 2: THE SCIENTIFIC BASIS FOR ORGANIZING THE REFUGE SPACE IN THE ARCHITECTURE OF SUPER-HIGH-RISE BUILDINGS IN VIETNAM

2.1 Legal basis

2.1.1 Regulation 06 and Standards related to the organization of refuge spaces in super-high-rise buildings in Vietnam

2.1.2 Comments on the QCVN 06-2020, the additions on the refuge space in the revised QC 06.

+ The refugee floor, or concentrated refuge place, has been mentioned. It is challenging to set up a centralized refuge floor in super-high-rise buildings with small floor areas or extensive, multifaceted grounds. However, the layout of apartments or portions of apartments on the refuge floor is not permitted by QC.

+ Although the method for assisting individuals to escape has been suggested, it has not been emphasized that it combines vertical and horizontal elements to facilitate numerous escape situations in ultra-high-rise structures.

+ There are still issues like the restriction on the number of floors and the total investment, which the refuge floor often does not bring, as the area of the refuge floor has not been suggested and is not included in the land use coefficient and construction area. gains for the investors. The N1 ladder must be in close touch with the building's outside, which has restricted the building facade's design options. Super-high-rise buildings with steel and glass frames are a common example of this.

+ The refuge floor is frequently left unoccupied when there is no problem, and occasionally users are unaware of where the accident shelter is located in the building, in addition to design ideas for the refuge floor that incorporate other useful public service tasks.

2.2 Theoretical basis

Numerous aspects, ranging from theory to practice and drawn experience, affect the outcomes of the research and architectural design proposal for the refuge space. Calculating the safety of escape after moving to and from the evacuation floor as well as the safety of rescue remain the most crucial issues.

Figure 2.1. Factors affecting the architectural design

2.2.1 Physical and chemical properties of fire and explosion phenomena occurring in buildings in general and super high-rise buildings in particular

2.2.2 New trends and solutions in the world in the design of super high-rise buildings and shelter floors

In the last 5 years, the trend of tower super-high-rise buildings and super-high-rise building complexes in the world and in Vietnam not only conquers heights anymore, but often has the following characteristics:

- Hanging garden (sky garden, vertical farming, urban forest)
- Mixed use complex

2.2.2.1 Classification of ultra high-rise building architectural forms

The typical architectural style of super high-rise structures is a neat plan based on the basic shape: square, rectangular, round, triangular, and rectangular strip integrated into plans that resemble U, H, I, and T... To limit protruding balconies or air intake angles to reduce dynamic wind at height, the facade is a steel glass block, a reinforced concrete frame, or a composite deck made of wood and plastic.

It can be categorized into three different kinds of ultra high-rise structures: - single tower houses; - twin or multi-tower houses; - plate houses.

2.2.2.2 Functional aspects of common refuge spaces

a. Indoor refuge space with residential function

b. Refuge space in the office building

c. Refuge space in a multi-functional mixed-use building

2.2.2.3 Classification of refuge spaces in super high-rise buildings

a. Concentrated refuge space

b. Dispersed refuge space

c. Multifunctional refuge space

2.2.3 System of escape spaces, emergency exits

2.2.4 Technical and technological foundations

2.2.4.1 Structure – Materials

The following three factors must be combined in high-rise building design in order to reach to an acceptable structural solution: bearing capacity, normal use requirements (oscillation, displacement), and stability. The horizontal load has the greatest impact on the geometry of the structure and has a stronger impact the higher the building.

A. Material usage characteristics

B. Structural classification of multi-storey buildings

B.a. According to the classification of Khan Fazlur (1966)

B.b. According to the detailed classification of Wolgang Schueller (1976)

B.c. According to the structural system classified by CTBUH, group SC (1980)

B.d. According to Chinese authors, there are four types of texture

C. Shape of the building

C.a. Floor plan, structure diagram

C.b. In the vertical direction

C.c. Effective shapes of the house.

D. Current situation of multi-storey building structural system design

E. Development trend of multi-storey building system in the

future.

2.2.4.2 Technical equipment - Ventilation and lighting

A. Super high-rise indoor emergency elevator system

B. Fire protection equipment system

2.2.4.3 The importance of on-site fire fighting and escape support equipment

2.2.5 Natural conditions of Vietnam

2.2.5.1 Climate and construction climate zoning in Vietnam

In the thesis, it is mentioned that the research sites of super high-rise buildings in big cities of Vietnam are Hanoi, Da Nang and Ho Chi Minh city located in the construction climate zone IB, IC, IIB, IIC.

2.2.5.2 Effects of climate change in Vietnam

2.2.6 Economic conditions and real estate market

2.2.7 Social-Cultural Facilities

Chapter 3: Models and solutions for organizing refuge spaces in super-high-rise architecture in Vietnam

3.1 Viewpoints and goals for organizing a refuge space in a super-high-rise building

3.1.1 Perspectives on organization of refuge space in super high-rise building architecture

- Safety is the top concern in organizing the refuge space for super high-rise buildings, safety includes all 3 stages: Safe refuge; Escape safety; Rescue safety.

- In order to ensure that the technical specifications for location, area, structure, and materials to ensure safety life for humans are met, the refuge space must carefully adhere to the existing Fire prevention and fighting legislation and construction standards. The organization of refuge spaces in super-high-rise buildings entails choosing the size and location of the spaces in the building in the form of an evacuation floor; refuge time; These spaces ensure safe refuge and escape while at the same time maintaining the architectural space structure of the building, as well as the form of the facade and the building's aesthetics.

- The refuge space connects directly and obviously to the rescue, rescue, and exit routes from the moment general planning for the building is made. It also connects to the technical infrastructure of fire prevention and fighting in the area to ensure refuge for people when incidents occur within a certain amount of time; be able to escape on their own or be rescued and rescued in the quickest amount of time.

- To improve the effectiveness of the refuge space's arrangement and to provide benefits for users and investors, the refuge space has to embrace new applications and utilities that have been updated in the world.

3.1.2 Proposed objective of organizing refuge space in super high-rise buildings

+ Putting out architectural ideas to arrange the refuge area for crowded super-high-rise structures along with ideas for people to concurrently escape vertically and horizontally within and outside the home. The quickest possible population removal is the aim of this solution.

+ Offering architectural suggestions to arrange concentrated refuge space (the refugee floor) in conjunction with other uses (green space, utility public services, technical floors, etc.) to improve efficiency. This concept aims to provide a green, secure, and effective refuge area.

+ Offering architectural solutions to arrange refugees in dispersed refugee spaces in extremely tall structures. It is planned to be added to QCVN 06-2020 in order to be able to arrange functions on the refuge floor. Rather than having a whole floor dedicated to shelter, it can be divided into several shelters.

+ Create evaluation standards (measured as a score out of 100 points) for the refugee space in Vietnam in accordance with the standards for ensuring security, economic viability, sustainability, and humanity. The objective is to assess the efficiency of the design of the refuge space; the higher the score obtained, the greater its quality and influence is the investor's motivation and the user's attraction.

3.2 Principles of designing refuge spaces in super high-rise buildings in Vietnam

3.2.1 Safety principles

- The refuge space must be positioned in the safest possible location, in close proximity to two open building sides, at least one of which has access to the main highway, and it must be positioned at the head of the primary wind direction. religion. A smoke-proof, pressurized, and fireproof rescue route must also be designated from the outside in the direction that firemen and rescuers should approach the scene from.

- Shelter space must be provided for all super-high-rise structures (those that are 100 meters or above). Structures that provide refuge spaces must adhere to the restrictions related for materials and construction.

- The number of occupants and the building's security are taken into account when determining the size and area of the escape space. The area needed is between 0.3 and 0.5 square meters per resident in the building.

3.2.2 Technical principles

- To enable the ability to escape safely or to support a safe escape, the refuge space needs access to the technical space (elevators, emergency ladders) and ensure a secure connection to rescue elevators, vertical and horizontal escape routes, emergency exits, and ladders... For apartment buildings, corridors must be separated into segments no longer than 30 and no longer than 60 meters includes another collection c mixed-use homes above 5 meters in order to evacuat people in time an unobstructed, protect peopl on the way to escape.

The capacity to facilitat rescue from the outside is improved by the refuge

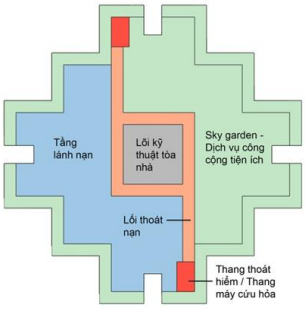


Figure 3: Principles of layout of the refuge space

space's direct access to the outdoors. It's essential to use open areas like rooftops, outside walls, and podium gardens for ultra high-rise buildings.

- For multi-function ultra high-rise buildings, it is necessary to divide into separate functional blocks, each of which has its own exit and refuge space, or divided by buffer compartments that prevent smoke and fire spread.

3.2.3 Multi-Functional Principle

- In addition to functioning as a place of refuge, it can also serve other purposes, making it a popular destination for building users. These additional purposes include providing green space, access to public services, entertainment, and health.

- It is possible to locate the refuge area outside the structure. For instance, a sky roof on a super-high rise building or a block of sky bridge corridors (skybridge). ensuring urban flora, aesthetics, landscape, material structure, and infrastructural planning. The ultra-high-rise structure, which combines a pure refuge space, is regarded as a hallmark of the city and the surrounding area. The combination of technical and safety elements with trees, landscape architecture, and overhead bridges will produce the best results in terms of technical, aesthetic, and economic efficiency.

3.2.4 Principles based on calculation and construction of escape scenarios

Travel time in the stairwell:

It is possible to preliminary calculate the number of people in the building & the corresponding refuge area (with the average distance of 15 floors and the norm of 0.3-0.5 m2/person) - for comparison and further work relevant aspects.

+ For apartment buildings: Snơ = 0,23F - 0,38F (~ 0,25F - 0,4F)
+ For office: Svp = 0,6F – F

Build the escape script:

Simultaneous Evacuation - Phased Evacuation

3.3 Systematize design methods of refuge space according to foreign experience

3.3.1 Vertical refuge zoning ensures safety and continuity in building operations

(Experience of Japan and China)

3.3.2 Design of the refuge space as a stop of the emergency ladder to support vulnerable people

(Experience of Hong Kong and Singapore)

3.3.3 Design of the refuge space integrated with the technical floor

(Taiwan experience)

3.3.4 Design of refuge space in the direction of dispersion

3.3.4.1 Dispersion at every 7th layer (Indian Experience)

3.3.4.2 Dispersion at each floor (American National Fire Association Experience)

3.3.5 Lessons on calculating the escape of people in super-high-rise buildings in some countries around the world

- It can be classified into two groups of factors that have an impact on the issue of human escape: architectural factors and human factors.

- Exiting people from the building is built into 2 evacuation scenarios when incidents occur:

+ Simultaneous evacuation; + Phased evacuation

3.4 Proposing a model of refuge space integrating utility functions in the architecture of super high-rise buildings in VN

3.4.1 Green space refuge model

The sanctuary area and the roof garden together (Sky Garden)

There are three types of above gardens that are frequently seen in extremely tall buildings:

+ Rooftop garden
+ Intermediate-level garden
+ Podium garden

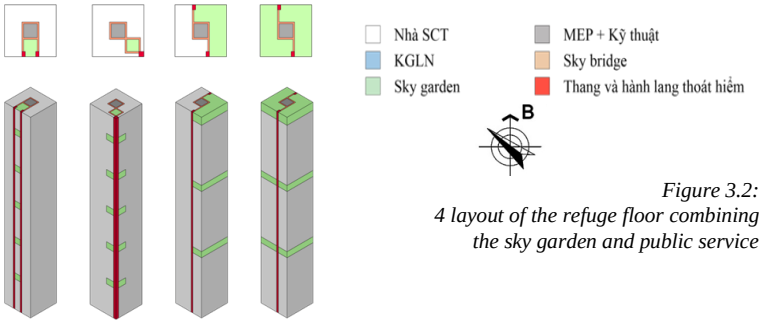


Figure 3.2:
4 layout of the refuge floor combining the sky garden and public service

In order for building occupants to quickly evacuate to the closest refuge floor in the case of an emergency, the overhanging garden and refuge area together improve awareness (sense of familiarity). A vertical green urban landscape is created by connecting the urban garden chain in layers up to the roof of the super-high-rise skyscraper. The air intake gaps that make it easy for fire and smoke to spread must also be considered when designing overhead gardens since they also produce gaps that lower wind pressure on the building's surface. Therefore, establishing fire-blocking compartments with water screens, fire partitions, and trapdoors in accordance with fire protection regulations will produce a green and secure refuge space in addition to fire-resistant ladders (Figure 3.2).

Depending on the size and area of the building, the refuge floor combined with the overhanging garden may make the full floor area or just a portion of it. Although it is still recommended to organize the primary wind direction and face the main road, it is also possible to provide variety to the facade of extremely high-rise buildings by adding various types of hanging gardens.

The height of the refuge floor should be more than the typical height of one level when paired with the overhanging garden (greater than 4.5 meters). The refuge space's area exceeds 50% of the floor plan's area, however the trees should only take up 15% of it and should form the refuge space's outside perimeter. No trees block the refuge space's view of the outer world (Figure 3.3).

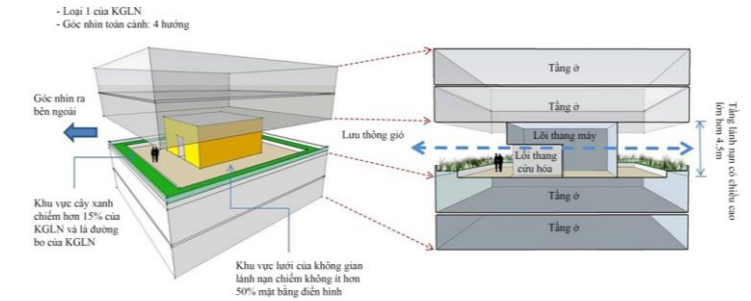


Figure 3.3: The height of the refuge floor and the allowable percentage of trees

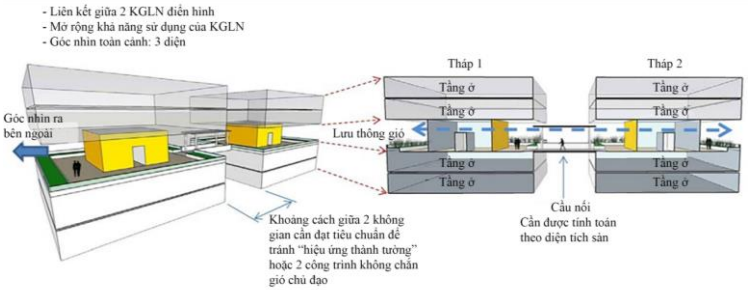


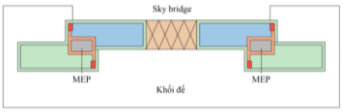
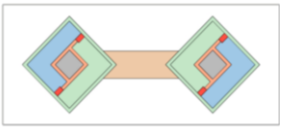
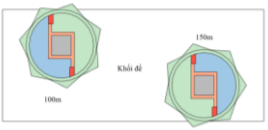
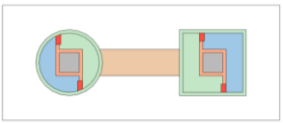
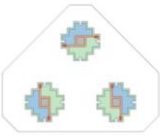
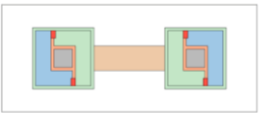
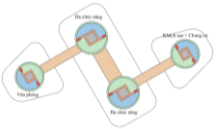
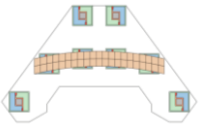
Figure 3.4: Allowable height and distance between 2 shelter floors of the same height

The distance should be estimated to avoid the effects of the wind or to cover the dominating wind of the adjacent building if the two refuge levels are the same height when paired with the overhead garden (Figure 3.4).

The flexible combination of overhead gardens with green roofs and skybridges creates an ideal safe and green refuge for buildings. The investor can reduce 1 floor of refuge according to the regulations on the height of the house, still ensuring compliance with QC, TCXD.

The plan structure of super high-rise buildings, tower houses are usually rectangular, square, circular and developed forms of those basic shapes such as hexagons, octagons, ovals, etc. plate house, 2-wing, 3-wing house in the shape of L, U, T... (Table 3.1: Proposed types of structure of super high-rise buildings with arrangement of refuge space)

Table 3.1: Proposed types of super-high-rise building with refuge space

	
Thin plate tower	Twin tower with skybridge
	
Twin tower with the same base	Twin tower with skybridge
	
Multi-tower with the same base	Twin tower with skybridge
	
Multifuctional complex tower with skybridge	Multifuctional complex tower with the same base

3.4.2 Refuge space combined with technical layer MEP (Mechanical,Electrical, and Plumbing)

Depending on the size and volume of super high-rise buildings, technical floors (MEP) with super high-rise buildings typically synchronize 4 parts (Ventilation and air conditioning system; Water supply and drainage and sanitary equipment; Electrical system; Fire alarm and fire fighting system) located in each of 8–15 floors.

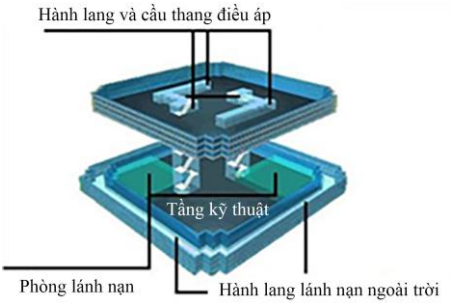


Figure 3.5: Refuge area layout on technical layer (MEP)

One or two emergency rooms that follow to fire prevention, such

as shelters, can be set up on each technical floor (connected by an outdoor evacuation corridor, to ensure that each evacuation room has 2 escape routes). Firefighting elevators can be arranged from the cellar to the top floor and stop only at the selected floors, in addition to at least two pressurized, fire-resistant escape stairs (Figure 3.5).

3.4.3 The model of organizing the refuge space with the architectural form of the super-high-rise building.(The refuge space combines the roof garden)

When deploying the rescue helicopter, the rescue force will approach from above and use the roof as a means of escape. Ultra high-rise buildings structures frequently reach heights of 100 meters or higher, well above what fire trucks can access (elevators in Vietnam are only up to 56 meters). Because of their height, super-high-rise structures are thought of as having a refuge floor on the roof. The investor has saved one floor of refuge thanks to the roof garden and the refuge space.

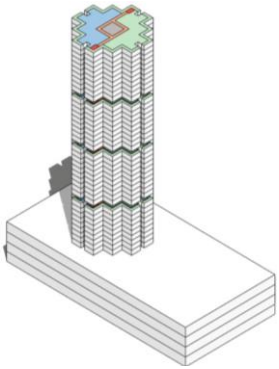


Figure 3.6: Refuge space combined with roof garden

This solution brings great benefits to investors and residents in the building. A communal garden on the roof is advantageous for the residents, and the investor can minimize the total investment by one level or improve the building's aesthetic appeal. Solar panels and the HVAC system for the building are frequently installed on super-high-rise rooftops. It is quite likely that the system will no longer be fire safe. It is advised to offer solutions that can be integrated with the building's technical system. Additionally, research is being done

on rooftop gardens to suggest water-retentive species and plants that thrive in hot, windy, and sunny conditions. Rainwater collection system to supplement the amount of water for watering plants, miniatures and cooling the roof when needed. The rainwater collection system through the settling tank for treatment also contributes to saving water resources in the future.

3.5 Proposing solutions to organize the refuge space in super high-rise buildings in Vietnam

3.5.1 Green refuge space solution

The green refuge space solution is applied to the following types of super high-rise buildings:

+ Single-functional super high-rise buildings such as houses, offices, hotels

+ Multi-functional super high-rise building in 1 building, twin towers or multi-towers sharing the same base.

This solution is arranged according to the following principles:

- The refuge space is arranged in common with an elevated garden or alternately with an elevated garden with a refuge space for every 1 refuge space. The refuge space combines public services to ensure sufficient refuge area and combines other applications such as skygardens, roof gardens and utility public services (community rooms, gymnasiums, swimming pool, library).

- The skygarden can only be arranged at the roof of the podium, the middle floor and on the roof. In this case, a refuge space should be arranged with an MEP or other public utility service.

- For super high-rise buildings with large podiums, the emergency ladders should run down to the roof of the podiums and at the same time allow the emergency exits to approach here and closest to the main traffic axis.

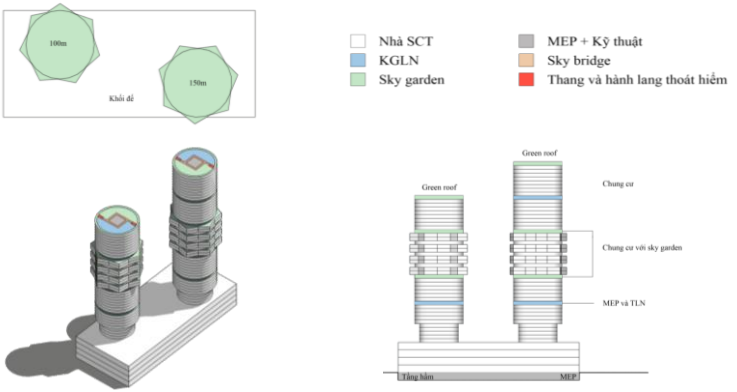


Figure 3.7: Indoor green shadow space with tower and double super-storey house

+ For the mixed use complex, it is advisable to arrange a refuge space combining the skygardens and the skybridges.

- Multi-functional super high-rise buildings need to be divided into independent functional blocks, have separate refuge and escape spaces, buffer compartments and fire-proof partitions.

- If it is a twin tower, the working functions (offices, shopping centers) should be separated from the residential functions (apartments, hotels) by an intermediate refuge space. At floors with public services, the skybridge should be made to coincide with the refuge space of the residential block. This solution makes it the fastest to escape when there is an incident in one of the two super high-rise buildings, supporting each other.

- If multi-tower should group functions to work together, or separate working function, residential function, commercial function and public service into 3 groups, skybridges will connect group 1 with 3 or 2 with 3 because the number of people using the refuge space when there is an incident of these 3 groups is different.

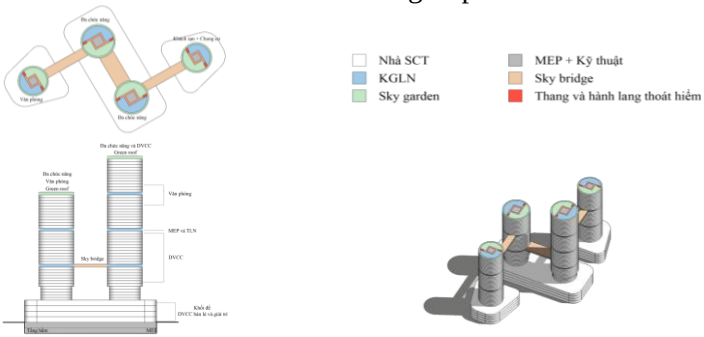


Figure 3.8: Indoor concentrated refuge space with multi-tower super high-rise buildings and complex of functions

The skybridge allows for flexible vertical and horizontal escape, which can have multiple exit directions and exit scenarios.

- For multi-tower complex and common podium, multi-function use, it is recommended to arrange refuge space at a distance of every 15-20 floors.

- All super high-rise roofs should be covered with greenroofs. It is possible to connect an skybridge with all these green roofs, in addition to the function of an skybridge for traffic, it is possible to

combine public services, swimming pools, sports, parks, commerce, restaurants ... take advantage of the elevated view overlooking the city, creating a destination impression for the building. This type of complex should be located in beautiful landscape locations such as rivers, lakes and seas to create attractiveness for tourism. (Figure 3.9)

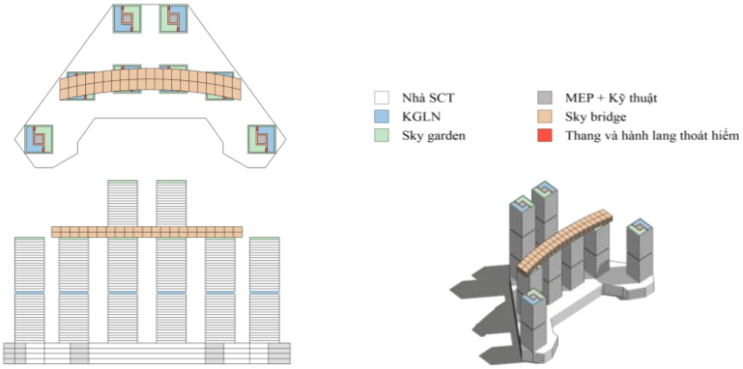


Figure 3.9: Green refuge space with large complex super high-rise buildings

3.5.2 Solutions for concentrated refuge spaces inside and outside the house

The solution of outdoor refuge space is usually applied to the following cases:

+ Connecting the concentrated refuge spaces indoors with the outdoor refuge spaces of the same elevation by means of an sky bridge or an outdoor corridor;

+ Connecting the refuge space of super high-rise buildings with twin towers or multi-towers with multi-functions including crowded elements such as commercial centers and offices by skybridges.

There are two proposed types of skybridges:

- The skybridge only functions as a traffic bridge

- The skybridge combines the function of a traffic bridge with other utility public services. Both forms must satisfy the following rules

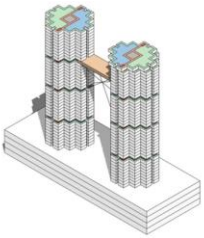


Figure 3.10: Skybridge with the function of a traffic

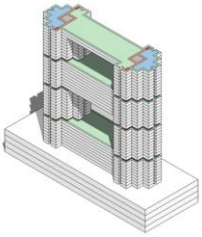


Figure 3.11: Skybridge with the function of connecting traffic and public services

+ Connecting the top-level refuge spaces between the super high-rise buildings by an skybridge or an outdoor corridor at the height of the refuge space. The layout of the elevated bridge must be chosen to ensure maximum traffic efficiency and subsequently benefit evacuation (fastest exit time).

3.5.3 Solutions for indoor dispersed refuge space

This solution is applicable to single-function super high-rise buildings with small ground area, multi-faceted lines, or low concentration of people, which can be divided into shelters. Technical floors or a part of technical floors can be used as shelters when meeting the same general regulations as for shelter floors.

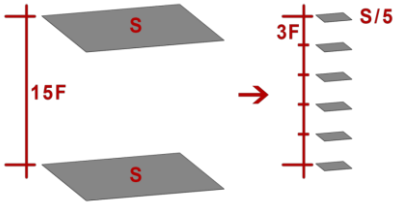


Figure 3.12: Refugee area(dividing the refuge floor)

Figure 3.13: Dispersed refuge space

The dispersed refuge space is a refuge space, part of the elevator lobby or building technical area arranged for users to move there. It is possible to arrange a shelter on 1 floor (one wing on the ground with a fork, a T), also arrange 2 shelters on a floor at 2 ends of the building in case the house has a long floor plan, narrow, or the number of users in the building is small. (Additional recommendations to QCVN 06-2020, apartments can be arranged on the refuge floor).

According to QCVN 06, for buildings with a height of 100 meters or more, a refuge floor must be arranged, no more than 20 floors must have a refuge floor (S), for a shelter, it can be divided by the number of floors, such as about 3 - 4 fl have 1 shelter (s) (Fig.3.12).

3.6 Proposing criteria to evaluate the organization of refuge space in super high-rise buildings in Vietnam

3.6.1 Developing criteria for assessing the refuge space

The evacuation time of the entire building ranges from 1 to 3 hours, depending on the number of floors. The most important parameter when evaluating the safety and effectiveness of the escape plan is the maximum number of people who can escape from the building in 1 hour (exit rate). That depends on many factors like:

+ Number of floors; + Number of floors of refuge; + Distance between floors of refuge; + Arrange the escape ladder…

Studies show that optimizing the layout of the refuge floor is very important in escaping people.

The refuge space when designed meets the requirements of the current Design Standards. In addition to the criteria according to the Design Standards, it is possible to propose improved criteria to evaluate the effectiveness of the layout of the refuge space (table 3.2)

Table 3.2: Proposed scorecard to evaluate the effectiveness of the refuge space

No	**Evaluation criteria**		**Score**
I	**Criteria according to Design Standards**		**50/100**
II	**Advanced Criteria**		**50/100**
1	Safeness	Escape safety	5/100
		Health safety	5/100
		Location safety - Reasonable function	5/100
		Safety Rescue	5/100
2	Technology	Ventilation - Light equipment	5/100
		Information equipment - Accurate fire alarm	5/100
3	Economical	Optimizing the functional space to reduce costs	5/100
		Kết hợp tầng kỹ thuật, dịch vụ công cộng	5/100
4	Green refuge space	Connecting urban green space, sky garden	5/100
		Community, humanity	5/100

3.6.2 Application in typical super high-rise building

Take examples from 3 super high-rise buildings completed at different times to apply the score (According to the proposed scoreboard to evaluate the effectiveness of the refuge space in Table 3.2). The score achieved for each super high-rise building should be announced as an outstanding advantage for the investor to comply with QCVN, TCXD and improve the attractiveness of the building. Secondary investors, home buyers will have the habit of first paying attention to the safety and utility of the building.

Evaluation criteria are applied objectively for 3 super high-rise buildings in 3 different geographical locations; completed 3 different times before and after QC06/2020; Various design consulting (foreign consultant and domestic consultant); Different architectural forms (plate tower houses, twin tower houses with skybridges, skyscrapers); Different investors.

Comments and reviews:

+ Lotte Building: The 68-storey building has a planar structure; There are 2 refuge areas located near the core of the ladder on the 33rd floor. The refuge space has been added in the later stage of completion to ensure fire prevention, but has not yet created a refuge space connected to the rescue route. , the area is very small, only enough for about 10 floors above the 33rd floor. Reach 75/100 points.

+ Landmark 81 Building: 81-storey building with 4-wing ground structure, technical core in the middle. There is a refuge floor at the 21st, 46th and 65th floors in direct contact with the outside. Support for escape with fire elevator. The refuge floor is combined with the MEP. Get 90/100 points.

+ Ha Dong Millennium Building: The 44-storey building consists of 2 towers connected by a garden bridge on the 17th floor. There is a refuge floor on the 17th floor in both towers. The refuge floor of each building consists of 2 exit ladders at the core. The entire evacuation floor is empty, connected by a bridge on the 17th floor, which is a 4-storey skybridge with apartments from the 14th to the 16th floor. This bridge can support the escape between 2 people. the tower, exit to the garden on the 17th floor. Reach 85/100 points.

All 3 super high-rise buildings have complied with the current TCXD with a minimum score of 50/100 points, less than this score is a violation and is not allowed to be built. The higher the score, the greater the effect of the layout of the refuge space.

CONCLUDE – SUGGEST

1. Conclusion

From the general analysis of the architecture and structure of super high-rise buildings in the world and in Vietnam, the advantages and disadvantages and experiences in the design of evacuation and escape as well as the trends that architecture should follow to suitable for sustainable development and response to epidemics and climate change globally. The thesis has contributed 3 proposals and solutions to organize the refuge space in the architecture of super high-rise buildings in Vietnam:

- Propose solutions to organize concentrated refuge spaces inside and outside super high-rise buildings, develop a strategy for evacuating people in the vertical and horizontal directions to optimally solve the problem of escaping people in super-tall houses. floors in the fastest time, thereby applying to the design of new architectural forms for super high-rise buildings combined with refuge outside the house when using skybridges.

- Proposing a solution to combine the functions of the refuge space to make optimal use of the area of the refuge floor such as combining the refuge floor with the technical floor, the refuge floor with combined public and utility services with community activities (humanity); The refuge floor combined with the sky garden, the roof garden, greening the super high-rise roof turns it into a green refuge floor, reducing investors and increasing benefits for users.

- Proposing solutions to arrange scattered refuge spaces instead of concentrated on the refuge floors for the cases of super high-rise buildings with small area, long and multi-faceted and multi-faceted ground.

- Develop criteria to evaluate the refuge space, thereby proposing criteria for evaluating the refuge space in super high-rise buildings including mandatory criteria and advanced criteria, scores to evaluate

the effectiveness of the evacuation. propose solutions to organize the refuge space in super high-rise buildings to ensure that the refuge space is both safe, sustainable and humane.

2. Suggestions

+ Fire safety for super high-rise buildings is an interdisciplinary issue, which needs coordination between the Ministry of Public Security, the Ministry of Construction and Urban Infrastructure. There are flexible instructions to suit the region's location and proper orientation.

+ Continue to study issues related to the refuge floor to recommend considering specific provisions in the Fire safety regulations for super high-rise buildings such as researching and proposing applications related to space refuge: Application of skybridges, skygardens, greening of super high-rise roofs.

+ Research and propose requirements on structure and materials for super high-rise buildings with mandatory use of refuge floors, mandatory technical requirements in sync with fire prevention, fire fighting and on-site fire fighting equipment .

+ Training of Architects and Civil Engineers at universities should be added to the curriculum of subjects on Fire Safety and Life Safety.

List of published scientific works of the author related to the thesis

1. Doan Minh Khoi; Tran Phuong Mai (2016) *"Some problems with the design of refuge areas in high-rise buildings". Construction Magazine*. ISSN 0866-0762

2. Doan Minh Khoi; Tran Phuong Mai (2017) *"Analyze the Dengers of Fire Hazard Events in High Density Areas of Hanoi".* Seminar for the 6th FORUM for Advanced Fire Education/ Research in Asia. Posted at Centrer for Fire Science and Technology. Research Institure for Science and Technology TOKYO UNIVERSITY OF SCIENCE.

3. Doan Minh Khoi; Tran Phuong Mai (2018) *"Fire Safety in Vietnam – Challenges and Overall Solutions". Proceedings of the International Conference: "FIRE SECURITY - EMERGENCY IN VIETNAM AND JAPANESE EXPERIENCE". Construction Publisher.* ISBN 978-604-82-2487-5.

4. Tran Phuong Mai (2020), *"Challenges of fire safety in spatial organization of high-rise buildings in Vietnam". Science Journal of Architecture and Construction - Hanoi University of Architecture. No. 37, Hanoi – February 2020. Page 18-22.* ISSN 1859-350X.

5. Tran Phuong Mai (2020), *"Safety solution for people escaping for high-rise buildings using skybridges". Vietnam Construction Magazine - Ministry of Construction, No. 625, Hanoi – June 2020. Page 189 - 192.* ISSN 0866-8762.

6. Tran Phuong Mai (2020), *"Architectural design solutions for green refuge spaces in super high-rise buildings in Vietnam". Vietnam Construction Magazine – Ministry of Construction, No. 648, Hanoi – May – 2022. Pages 84 – 89.* ISSN 2734-9888.