Vertical Cities

by Fynn Thompson

Submission date: 04-Jul-2019 09:45PM (UTC+0100)
Submission ID: 109311401
File name: CW2_-_Vertical_Cities.docx (476.05K)
Word count: 3631
Character count: 20215

VERTICAL CITIES

Fabric and Services Management

ABSTRACT

A theoretical discussion of vertical cities, and fire safety strategies for supertall buildings

Fynn Thompson

166682541

1. A theoretical discussion of vertical cities and the challenges posted to a facilities manager.

For millennia humanity has strived to construct great edifices, monuments to civilisation. The mighty pyramids and ziggurats used as centres of religion or governance in ancient South American and Middle Eastern civilisations, or the castles and cathedrals of Christian Europe. Some societies also constructed vertically for mercantile or residential uses, for example in the Roman Empire. Of course, human ambition is always limited by the technology and quality of material available at the time; Roman Emperors felt the need to pass legislation limiting the height of *Insulae* to 5-6 stories several times to prevent the collapse of tenements[1].

In the late 1800's, Chicago and New York began constructing skyscrapers. The first widely recognised skyscraper was the (now defunct) Chicago Home Insurance Building, designed by William Le Baron Jenney and completed in 1885. The Home Insurance building was revolutionary for the time. Prior to its construction, the taller a building was, the more masonry had to be used in the construction of the walls to hold the weight of the upper floors. Jenney's design used a steel frame to reduce the overall load of the building, allowing him to construct up to 10 floors; this started a whole new movement in architecture. No longer confined by height constraints, buildings started to get taller and more complex. In the modern era we now construct supertall skyscrapers, which have multiple uses; vertical cities.

The general consensus of what constitutes a supertall building is one over 300m[2]. The Shard for example is 306m tall, constituting 95 storeys[3], and is a prime example of what the current definition of a vertical city is; The Shard being a mixed use vertical development constituting 26 floors of office space, 3 floors of restaurants, a 19 floor hotel and 13 floors of residential apartments. However full use of buildings such as The Shard are generally reserved for high earners or corporations, and currently are socially divisive; developments reserved solely for residential use, such as the 396m 432 Park Avenue in New York are prohibitively expensive at approximately $40,000,000 for an apartment[4]. But the concept of vertical cities could transform the urban landscape within our lifetimes.

As the human race continues to expand, the concept of a vertical city could become invaluable to managing the ever increasing population and its needs. Between 1950 and 2018 the global urban population has increased from 451 million to 4.2 billion; by 2050, the U.N predict 68% of the worlds population will live in urban areas[5]. This puts an increasing strain on space and resources, which we must deal with to survive. A true vertical city would be just that; an entire self contained urban environment in which communities can exist without ever perhaps feet touching the earth. The concept of giant, hive like structures stretching into the lower atmosphere isn't new; it has long existed in fiction, from the hab-blocks of Judge Dredd's Mega-City 1, to the dystopian vision of L.A posited by Blade Runner. In the real world, architects have designed concept buildings in response to exploding populations in Japan and China; the X-Seed 4000 is a theoretical design by , a 4km tall structure designed as a fully functional city to house 500,000 to 1,000,000 inhabitants[6]. By

[1] Gregory S. Aldrete (2004). *Daily Life in the Roman City: Rome, Pompeii and Ostia*. Greenwood Publishing Group. pp. 78–80
[2] Al-Kodmany, K. The sustainability of tall buildings; a conceptual framework (University of Illinois, 2018).
[3] www.the-shard.com
[4] www.432parkavenue.com
[5] https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html
[6] https://inhabitat.com/self-contained-tokyo-highrise-eco-city-x-seed-4000/

building up, we can solve the problem of overpopulation in urban areas, ensuring the housing needs for 21st century society and beyond are supported. As new, desirable vertical developments are built, land will be freed up as people migrate into them, allowing further development of additional blocks utilising space already given up for urban development.

As the population increases, so do the requirements for food, water and goods. Although in the future hydroponic technology may allow us to produce sufficient resources to feed the expanded population, the majority of food will likely still require agricultural land. By building up, we can reduce the urban sprawl encroaching onto valuable arable land, ensuring the supply chain of food is well maintained and not interrupted. Furthermore, the natural habitat will not be destroyed, reducing the environmental impact of construction and settlement by exploiting the existing natural habitat. However there is debate over whether the reduction in use of resources and energy long term is offset by the energy and resources required for the initial construction of a vertical development. In addition, the local habitat could be adversely impacted by the construction, by dominating the landscape in terms of sunlight, and creating microclimates by affecting windflow; modern supertall buildings are designed with wind vorticies in mind.

Another environmental consideration is pollution. At present the topic of environmental pollution is very much in the public eye, with a focus on C02 emissions. The needs of a vertical city in terms of energy use would be considerable; as such on-site generation of renewable energy would be a prerequisite for mass adoption of vertical cities as an urban norm. Although we are making strides in reducing the carbon footprint through use of renewable energy sources, and rapid implementation of electric vehicles, our use of energy for transportation with conventional vehicles is still significant, with no real way to reclaim excess or waste energy. With an integrated vertical city we can reuse energy, materials and resources through efficient design and management of the environment. Utilising automated systems, a vertical city could be a sustainable endeavour by reclaiming, recycling and redistributing resources. By constructing vertically we can reduce energy use for transportation and services in the urban environment, by using energy efficient technology, reclaiming energy where able, and reducing the travel times for our workforce.

From a social perspective, living and working in vertical cities would reduce the travel times between the home and the workplace. This would free up more time for social activities. In a true vertical city, places of leisure, worship, recreation and commerce would be easily accessible, giving people more freedom to pursue their own interests, promoting and improving the general wellbeing of the workforce. Inherent in the design and objective of a vertical city is it being a 24/7 hub of activity. As such employment opportunities are improved with an increase in services both public and commercial, and the requirements of such related business. However the employment opportunities in vertical cities would be limited to tertiary and quartertiary industries given the associated environmental impact of the resource extraction and manufacturing being at odds with the concept of a sustainable vertical city. Additionally, the needs of human society develop over time. The advantages offered by a vertical city to deal with our immediate growth prospects may be eclipsed by our ever evolving civilisation in the future, perhaps invalidating the argument for preserving the natural habitat as we may require its use in the future regardless. Horizontal growth of human settlements is tried and tested, however repurposing of vertical developments is not; indeed vertical developments of the 20th century are usually demolished rather than being repurposed, as evidenced by ongoing redevelopment within London. There is no precedent for redeveloping or repurposing developments of stature such as The Shard or Burj Khalifa.

Although as evidenced there are many benefits to accepting vertical cities as the primary mode of human habitation in the urban landscape, there are challenges for the facilities manager in maintaining such buildings. In terms of access for people and to physical resources such as food or cleaning consumables, buildings must employ a network of high speed elevators and sky galleries to connect the myriad floors of the building. 13 of The Shard's 32 elevators are dual-deck lifts, allowing them to carry more people or goods in a smaller space. The Elevators use in-shaft hoisting technology negating the requirement for a machine room, thus saving space[7]. Because access to the upper floors of a supertall building is only possible using these elevators, the building must have sufficient access elevators included in the design to ensure access is possible when one or more are down for reactive or planned maintenance.

Getting resources and people in to a supertall skyscraper is one challenge, but getting waste out of a skyscraper is another. A Facilities Manager for a high rise building must use the tools available ensure there is sufficient storage and frequent collections to remove different types of waste from the building in good time. Waste services such as disposal chutes must be well signed to reduce the chance of cross contamination between waste streams. Tenants should be regularly trained or reminded (without being overbearing) of their obligations to adhere to the waste hierarchy to further reduce non-compliance and contamination between waste streams. Waste disposal areas should be regularly checked to ensure they are clean and tidy, and any additional waste is removed in short order[8].

Window cleaning is another unique challenge in supertall buildings. Traditional skyscrapers may use hoist systems to access exterior windows, however there are an increasing number of unconventional building shapes such as the Shard or Shanghai Tower which pose an additional challenge. The Shard, for example, uses specialist teams to abseil down the side of the building and clean as they go. Fallsafe systems must be maintained to ensure the health and safety of specialist cleaners in the event of an accident. The cost implications can be significant given the complexity of the task, and must be planned well in advance to ensure availability. The need for regular cleaning can be mitigated by using self cleaning glass in the design, however this still needs to be cleaned periodically.

Mechanical, Electrical and Plumbing systems in supertall buildings must be maintained to ensure maximum efficiency. Sustainable and efficient skyscraper design includes service floors which serve a block of usable floors. For example, Greenland Tower in Chengdu has 5 compartments of 3 service floors to every 10 usable floors[9], which contain structural elements, as well as mechanical, electrical and fire protection. Service floors also allow HVAC units to draw in fresh air from the outside ventilating the building. By stacking services inside the technical/service floors the requirement for regular access into commercial, residential or leisure areas of the building Is reduced, allowing the tenants to enjoy uninhibited use of the building, which could be impaired by engineers having to access plant on each floor.

In conclusion vertical cities are a major consideration for future high density human habitation which could drastically improve society while also reducing the human impact on the environment. Supertall buildings are complex structures which pose significant challenges in the field of maintenance, which must be overcome through good management and efficient design.

---

[7] https://www.buildingcentre.co.uk/case_study/lifts-and-escalators-for-the-shard
[8] "OPDC Waste in Tall Buildings Study", June 2018 (https://www.london.gov.uk/sites/default/files/57._waste_in_tall_buildings_2018.pdf) pp.33-36
[9] Designing high performance MEP systems for supertall buildings; a review of challenges and opportunities. Burton, C (2017)

General Fire Evacuation Assessment – The Shard

1. Description of the site
2. Identification of fire hazards:
    a. Sources of ignition
    b. Sources of fuel
    c. Sources of oxygen
3. Identify people at risk
    a. People in and around the premises
    b. Fatalities Risk
4. Evacuation Strategy
5. Design Elements
6. Conclusion

1: Description of the site

The Shard London Bridge (also known as the Shard of Glass) is a mixed use skyscraper next to London Bridge Station in Southwark. It is to the south of London Bridge which crosses the River Thames from the City of London to the north. The Shard has 72 habitable floors and at 310 metres (1016 feet) is the tallest building in the European Union. The building was completed in 2012.

2: Identification of Fire Hazards

Fire hazards vary between the different zones of the development. Fire hazards in each zone can be classed as either I (potential sources of fuel) or II (potential sources of ignition). Oxygen present in the surrounding space will also fuel a fire.

Zones	**Type I fire hazards**	**Type II fire hazards**	**Fire characteristics**	**Relevant parties**
Office	Office appliance, electrical devices, furniture and furnishing materials, paper	Smoking, rubbish fires, electrical faults, use of naked flames during maintenance	Easy to form three dimensional fire, potential to grow and spread, difficulty for evacuation and extinguishing	Tenants, office staff
Hotel	Bedding and mattress, soft furnishings, curtains, carpets, electrical appliances, kitchen areas, gas, hotel storage	Smoking in bed, electrical faults, careless use of cooking utensils, use of naked flames during maintenance	Easy to form three dimensional fire, potential to grow and spread, difficulty for evacuation and extinguishing	Hotel manager, accommodation staff, guests
Residential	Bedding and mattress, soft furnishings, curtains, carpets, electrical appliances, kitchen areas, gas	Smoking in bed, electrical faults, careless use of cooking utensils, use of naked flames during maintenance	Easy to form three dimensional fire, potential to grow and spread, difficulty for evacuation and extinguishing	Tenants
Shared areas	Furniture, combustible goods, clothing, soft furnishings	Careless Smoking causing rubbish fires, electrical faults, naked flames during maintenance	Easy to form three dimensional fire, potential to grow and spread, difficulty for evacuation and extinguishing	Public, tenants,

3: Identification of people at risk

The Shard comprises separate commercial, hotel and residential spaces. Each section of The Shard has a different level of minimum and maximum occupancy at any given time. Occupancy levels can be determined using guidance from the Regulatory Reform (Fire Safety) Order 2005, and Approved Document B;

Number of persons = <u>total M2 / occupant density</u>

Floor Space Factor	
Occupied Area Type	Typical Occupant Density m²/person
Standing spectator/audience area or *bar area	0.3
Assembly area, public house, dance floor or hall etc	0.5
Dining area or restaurant	1.0
Sports area	2.0
Shop sales area	2.0
Display, production or workshop area	5.0
Office	6.0
Shop (bulky goods) sales area	7.0

Figure 1: Floor Space Factor (Approved Document B)

Using this guidance the assumed occupancy rate of the shard would be as follows:

Floor	Designation	Sq M (Source: *The Shard Brochure*)	Typical Occupant Density	Occupancy rate
73-95	*Spire*	N/A	N/A	N/A
68-72	*Observatory (Assembley Area)*	758	0.5	1516
53-65	*Residential Apartments (10)*	N/A	N/A	20 (Max)
52	*Spa*	N/A	N/A	N/A
34-52	*Hotel*	16198	0.3	53993
31-33	*Restaraunts*	5945	1	5945
2 through 30	*Offices*	54488	6	9081
1	*Lobby (Assembley Area)*	2102	0.5	4204
			Total:	~75000

This would suggest a maximum possible fire fatalities risk of approximately 75000. In reality this figure is much lower due to the use of space within the building, and the fire redundancy features of the structural design.

4: Fire Evacuation Strategy

The Shard must utilise a phased/staged fire evacuation hybrid given the mixed use nature of the building.

- At the basement level a simultaneous evacuation would take place. In the lower levels of offices and retail units, a phased evacuation would take place using fire protected stairwells up to level 28.
- The levels above the offices hold a 3 floor restaurant and two levels of public and conference facilities. In this section of the building occupants would be evacuated simultaneously via emergency evacuation lifts.
- Between hotel floors 36 and 52 a phased evacuation 2 floors at a time would be used again using emergency evacuation lifts.
- The 14 levels above the final hotel floor comprise residential apartments. The fire safety system in the residential zone is capable of raising a simultaneous alarm. Occupants would

use protected fire escape routes to the restaurant levels, where emergency evacuation lifts are available.

- The highest levels of the shard comprise a viewing gallery, which is also served by evacuation lifts.
- Service levels at periodic stages throughout the shard act as a fire barrier. There are refuge points at the restaurant level allowing emergency services to target vulnerable people during an evacuation.

5: Design elements

In addition to emergency evacuation lifts, three firefighting shafts are built into the core, which include a lift and stairwell. Level 37 acts as an interface point for firefighters at the midpoint of the building which allows protected transfer of personell and equipment.

Uniquely The Shard's water storage system is double the requirement under BS EN 12845, providing ample water for firefighting teams. The pumps feeding wet risers have a capacity of 1500l/m, providing an indefinite supply for firefighting jets. In at risk service areas, gas suppression systems are used to mitigate electrical fires.

6: Conclusion

In conclusion The Shard is a complex building which uses some innovative building techniques to reduce the risk of fatality in the event of a fire, such as emergency evacuation lifts, which are uncommon in the western hemisphere. A hybrid phased/staggered evacuation strategy taking into account occupancy levels in the different zones, and strategic placement of evacuation lifts at higher occupancy areas significantly reduces the fatalities risk for the building.

General Fire Evacuation Assessment – Burj Khalifa

1. Description of the site
2. Identification of fire hazards:
    a. Sources of ignition
    b. Sources of fuel
    c. Sources of oxygen
3. Identify people at risk
4. Evacuation Strategy
5. Design Elements
6. Conclusion

1: Description of the site

The Burj Khalifa is currently the worlds tallest building at 829m. Completed in 2010, the tower comprises a mixed use development over 160+ floors, with a total floor space of 310,000 m/2. The Burj comprises 1.85m sq/ft of residential space and 300,000 sq/ft of office space, in addition to shops, restaurants, viewing galleries and the prestigious Armani Hotel.

2: Identification of Fire Hazards

Fire hazards vary between the different zones of the development. Fire hazards in each zone can be classed as either I (potential sources of fuel) or II (potential sources of ignition). Oxygen present in the surrounding space will also fuel a fire.

Zones	**Type I fire hazards**	**Type II fire hazards**	**Fire characteristics**	**Relevant parties**
Office	Office appliance, electrical devices, furniture and furnishing materials, paper	Smoking, rubbish fires, electrical faults, use of naked flames during maintenance	Easy to form three dimensional fire, potential to grow and spread, difficulty for evacuation and extinguishing	Tenants, office staff
Hotel	Bedding and mattress, soft furnishings, curtains, carpets, electrical appliances, kitchen areas, gas, hotel storage	Smoking in bed, electrical faults, careless use of cooking utensils, use of naked flames during maintenance	Easy to form three dimensional fire, potential to grow and spread, difficulty for evacuation and extinguishing	Hotel manager, accommodation staff, guests
Residential	Bedding and mattress, soft furnishings, curtains, carpets, electrical appliances, kitchen areas, gas	Smoking in bed, electrical faults, careless use of cooking utensils, use of naked flames during maintenance	Easy to form three dimensional fire, potential to grow and spread, difficulty for evacuation and extinguishing	Tenants
Shared areas	Furniture, combustible goods, clothing, soft furnishings	Careless Smoking causing rubbish fires, electrical faults, naked flames during maintenance	Easy to form three dimensional fire, potential to grow and spread, difficulty for evacuation and extinguishing	Public, tenants,

3: Identification of people at risk

The Burj comprises separate commercial, hotel and residential spaces. Each section of The Burj has a different level of minimum and maximum occupancy at any given time. In the 28,000 sq/m of office space we can assume a maximum occupancy of 4,666 on the basis of a typical occupancy rate of 6 persons per sq/m. The Burj contains 900 apartments, comprising a mixture of 1,2 and 3 bedrooom residences. Assuming an occupancy rate of 2.5 persons per apartment in the absence of a publicly available breakdown of the types of residence, approx. 2250 people could reside in the Burj. Space information regarding the hotels and other areas is not available

4: Fire Evacuation Strategy

The Burj must utilise a phased/staged fire evacuation hybrid given the mixed use nature of the building, and its height, utilising fire protected stairwells, pressurised and air conditioned refuge points, and emergency evacuation lifts.

- At the basement level a simultaneous evacuation would take place. In the lower levels of Armani Hotel and Residences, a phased evacuation would take place using fire protected stairwells up to level 19.
- Level 19-108 consist of residental apartments, with sky lobbies on level 43-44 and 76-77. Residents could evacuate to the sky lobbies, and use the double cab designated fire evacuation lifts to phase their evacuation to the ground floor. Residents who are unable to reach the evacuation lifts can seek refuge in pressurised, air conditioned refuge points situated every 25 floors.
- For the corporate suites on levels 112-124, a phased evacuation of the lower then upper levels to the evacuation lifts in the lobby/lounge area on floor 123 would allow everyone to escape in short order.
- In other zones such as the viewing galleries and restaurants, evacuees would proceed to the nearest evacuation lift when the signal is given.

5: Design elements

In addition to emergency evacuation lifts, the central core contains a firefighting shaft including a lift and stairwell. The firefighting lift is capable of hoisting 5500kg of personell and equipment. The evacuation elevators themselves are double stacked, carrying 12-14 people per cab. The elevators travel at a speed of 10m/s. This allows a high capacity of evacuation per lift; from the observation deck on the 148th floor (555m), up to 28 people could travel to the base of the building in under a minute.

2

In the event evacuees are unable to reach the lifts, there are fire protected, pressurised, air conditioned refuge areas every 25 floors throughout the Burj.

6: Conclusion

2

In conclusion The Burj, being the tallest building in the world, poses a major risk to life in the event of a fire. Through phased evacuation via evacuation lifts the fatality risk can be mitigated. Travelling at 10 m/s and holding up to 28 people at a time, evacuation lifts allow ease of escape even from the tallest habitable levels, making the journey in under 1 minute.

Bibliography

Scholarly Articles

Gregory S. Aldrete, *Daily Life in the Roman City: Rome, Pompeii and Ostia*. 2004, Greenwood Publishing Group. pp. 78–80

Al-Kodmany, K, *The sustainability of tall buildings; a conceptual framework.* 2018, University of Illinois

Burton, C, *Designing high performance MEP systems for supertall buildings; a review of challenges and opportunities*. 2017. International Journal of High rise Buildings

Online Resources

"OPDC Waste in Tall Buildings Study", June 2018 (https://www.london.gov.uk/sites/default/files/57._waste_in_tall_buildings_2018.pdf) pp.33-36

"The Shard": (www.the-shard.com)

"432 Park Avenue": (www.432parkavenue.com)

UN Report on world urbanisation prospects: https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

X-Seed 4000: https://inhabitat.com/self-contained-tokyo-highrise-eco-city-x-seed-4000/

Case Study: Lifts and Escalators for The Shard: https://www.buildingcentre.co.uk/case_study/lifts-and-escalators-for-the-shard

Special Report: Total Fire Engineering at The Shard (https://www.ifsecglobal.com/fire/special-report-total-fire-engineering-at-the-shard/)

Statutory Documents

Fire Safety: Approved Document B (https://www.gov.uk/government/publications/fire-safety-approved-document-b)

Regulatory Reform (Fire) Order 2005

Vertical Cities

ORIGINALITY REPORT

18%	15%	6%	12%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	core.ac.uk Internet Source	4%
2	Submitted to University of Westminster Student Paper	1%
3	www.imvisitinglondon.com Internet Source	1%
4	www.ifsecglobal.com Internet Source	1%
5	www.surefiresolutions.co.uk Internet Source	1%
6	en.wikipedia.org Internet Source	1%
7	Submitted to University of Newcastle Student Paper	1%
8	Submitted to University of Derby Student Paper	1%
9	Submitted to University College London Student Paper	1%

10	kojokrom.com Internet Source	1%
11	docs.mipro-proceedings.com Internet Source	<1%
12	apolitical.co Internet Source	<1%
13	Submitted to Glasgow Caledonian University Student Paper	<1%
14	www.westcoastwindows.com Internet Source	<1%
15	Submitted to Coventry University Student Paper	<1%
16	www.skyscrapercenter.com Internet Source	<1%
17	arrolgellner.blogspot.com Internet Source	<1%
18	cdn.eco-chick.com Internet Source	<1%
19	www.safelincs-forum.co.uk Internet Source	<1%
20	seo.x0x.cz Internet Source	<1%
21	Submitted to University of Central Lancashire Student Paper	<1%

22	Submitted to University of Huddersfield Student Paper	<1%
23	www.firesafetyfirst.co.uk Internet Source	<1%
24	cdia.asia Internet Source	<1%

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	Off		

Vertical Cities

GRADEMARK REPORT

FINAL GRADE

75/100

GENERAL COMMENTS

Instructor

The report has demonstrated that comprehensive research has been conducted . You have been critical with the representation on your findings and drawn up some good conclusions.

The report has been structured in a professional manner.

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13