SUCCESSION REVIEW ON VERTICAL TRANSPORTATION IN TALL BUILDINGS

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Abstract

The main motive of this paper is to stress the concept of evolution of tall buildings in conjunction with advanced vertical transportation. The objective is to understand the parameters of planning and deigning and selection criteria of various lift system and to know the various types of advanced elevators and their efficiency.

A detail research emphasising on planning considerations of service core, elevator configurations, and types catering to various heights of the building is to be highlighted. Functioning of elevators in tall buildings where in sky lobby, shuttle lifts and express lifts are discussed with relevant case examples. The criteria's of selecting a particular type of elevator and typology of elevator will be discussed in detail.

For the purpose of understanding of above statement it is imperative to understand: What is the history of tall buildings? Which type of structure initiated the concept of going high? Classification of tall buildings, as per the height and concepts of service core and planning considerations of lifts.

Key Words: Elevator Technology, Vertical Circulation in Tall Buildings

1.0 Introduction

1.1 Tall buildings are basically the product of today's need, mostly to cater the needs of rapid urban growth by supplying commercial and residential spaces. For instance, in an underdeveloped country more than 10 million people are expected to move into urban areas. As per 2015 survey done by a reputed research group 4 billion people worldwide will be living in urban settlement. Tall buildings are solution to this growing demand of habitable spaces and thus the need of rationalised services solution arises.

1.2 Origin

Tall structures evolved as monuments and the first impression of tall structures was the Ziggurats of Mesopotamia (now Iraq), during Babylonian reign remained the tallest structure. Many churches and cathedrals were built during the gothic and Renaissance period, the tallest of them was built in 1890. Ulm Minster was begun in Gothic era and not completed until the late 19th century. It is the tallest church in the world and 4th tallest structure built before the 20th century, with a steeple measuring 161.5 meters.

Fig.1 Ziggurats of Mesopotamia

Fig.2 Ulm Minster, Ulm, Germany

However, though all of these are structures are not buildings which provide habitable spaces. As the non profit international organisation Council of Tall Buildings and Urban Habitat (CTBUH) defines buildings as "*a structure that is designed for residential, business or manufacturing purpose" that has "floors".*

1.3 Historical Evolution of Tall Buildings

A period of major Industrialisation that took place during the late 17th century and early 18th century which not only has massive impact on social, cultural and economic conditions but also revolutionised construction industry and vitalised the process of manufacturing, material production and construction technology.

This resolved the fundamental requirement of advancement of vertical transportation system to make high rise structures "tall".

In the mid of 19th century Elisha Otis introduced the safety elevators, allowing convenient and safe passenger movement to upper floors. Industrial revolution brought revolution in construction materials allowing usage of steel frame instead of stones or bricks. It expanded the scope of high rise shafts housing high speed elevators.

Following are the details of buildings which evolved due to possibilities in material, technology and construction system.

Oriel Chambers in Liverpool Architect : Peter Ellis in 1864. First office building with curtain wall.	 *Fig.3*
Insurance Building in Chicago, built in 1884–1885 Architect:-William Le Baron Jenney.	 *Fig.4*
Louis Sullivan's Wainwright Building in St. Louis, Missouri, 1891, First steel frame building	 *Fig.5*

40 Wall Street, New York The world's tallest building from April 1930 to May 27, 1930 [283 m spire and 70 floors].	 *Fig.6*
Chrysler Building, New York The world's tallest building from 27 May 1930 to 1931 (282 m roof, 319 m spire, 77 floors].	 *Fig.7*
Empire State, New York [381 m roof, 449 m spire, 102 floors] was the World's Tallest Building for 41years.	 *Fig.8*

Table (table 01) shows a list of tallest buildings in context with the material used and typology.

Sr.No.	Building Name	City	Meters	Year	Material	Use
1	Burj Khalifa	Dubai (AE)	828	2010	Steel-Concrete	Hotel/Residential/ Office
2	Taipei 101	Taipei(TW)	508	2004	Composite	Office
3	Shanghai WFC	Shanghai (CN)	492	2008	Composite	Office/ Hotel
4	International Commerce Centre	Hongkong	484	2010	Composite	Office/ Hotel
5	Petronas Tower1	Kuala Lumper	452	1998	Composite	Office
6	Zifeng Tower	Nanjing	450	2010	Composite	Office/ Hotel
7	Willis Tower	Chicago	442	1974	Steel	Office
8	Guangzhou IFC	Guangzhou	439	2010	Composite	Office/ Hotel
9	Trump IHT	Chicago	423	2009	Concrete	Hotel/Residential

Table-01 -Ten tallest buildings in the world adapted from CTBUH

In the early 20th century structural engineer **Fazlur Khan** realized the need of rationalised and flexible structural systems of tall buildings. These advances in the fields of structure, construction techniques, building services, material and transportation allowed for a steady increase in building height.

This has brought a revolution in "freedom of design", designers had an opportunity to use materials which are lighter in weight, needs less time to execute, building multi floors in a stipulated time and above all experimenting tall structures with innovative forms, facade treatment.

2.0 Planning considerations and functioning of elevators

2.1 Importance of vertical communication system in tall buildings

Any multistory building requires ways to get people and objects from one floor to another. Staircase are the most basic means of vertical transportation and are included even in very tall buildings as secure exits in the event of fire accidents .Tall buildings would have not been possible without elevators innovation.

Staircase, elevators are the basic requirements of the tall buildings which need discreet attention in planning and execution considering the economic and safety factors.

This topic further will emphasise in planning and design considerations of elevators.

2.2 Service core

Strategically planning of service core of lift is an integral part of design. Economical constraints, safety factors are considered as the number of service core are decided as per the footprint of the building and occupant.

Speed of an elevator is a concern with respect to safety as it has to cater to occupants of various floor in a considerable waiting time not more than 60-90 seconds to begin their journey. A service core is a whole system consists of multiple individual components which has different functions like HVAC, elevator systems, stairs, storage rooms, and toilets and housing other sub-services like ducts, pipes etc.

2.3 Core layouts: Two components size and location of core is vital in tall building**,** which plays a major role in deciding the form and planning as stated by Ar. Ken Yeang in 2002. The core area plays an important role of thermal mass and protects the building from gaining heat and develops the building form. Various types of layouts are i.e. 'central core', 'double core' or 'single-sided core', the double core is to be preferred.

Below are various arrangements of core, a peripheral placement of core helps in cross ventilation and allows light into the space, it also protects the main spaces from heat gain and thus reduces energy comsumption.

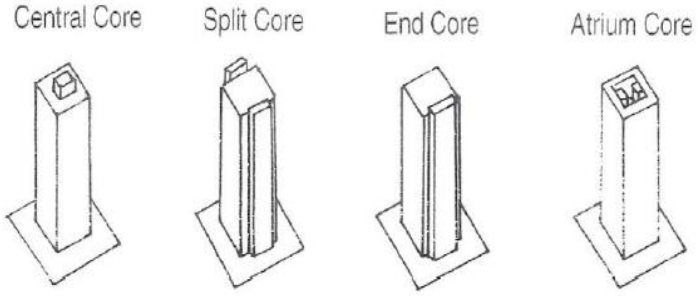


Fig.09 (Google Image)

2.4 Selection Criteria of elevators

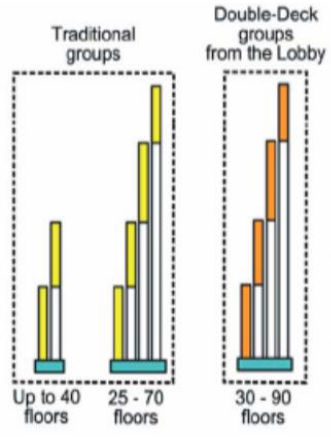
Size and type of elevators depends on various factors like average waiting time and handling capacity which depends on the typology of the building. Apart from the performance criteria there are four major variables which needs to be considered, they are Travel Distance, Elevator speed, elevator capacity, and building population. The lifting design is a major determinant of the core size and other aspects of efficiency, including space planning. Elevators consumes about 6-12% of a buildings construction cost and account for up to 8% of a buildings total energy consumption.

Performance criteria: Elevators need to clear common performance criteria of handling capacity of 5-15% within five minutes period and average waiting interval of not more than 30-90 seconds to begin their journey. *"The more people and the more floors, the greater the number of high speed elevators required"*

3.0 Innovation in elevator technology

Two lifting strategies in tall building are: number of lifts per group and number of lift zones. The whole building is divided into various zones and each zone is served by local elevators. The zones are termed as sky lobby and are connected by express elevators.

The maximum number of lifts in a group should not exceed eight, and each group can normally serve up to 16 floors.



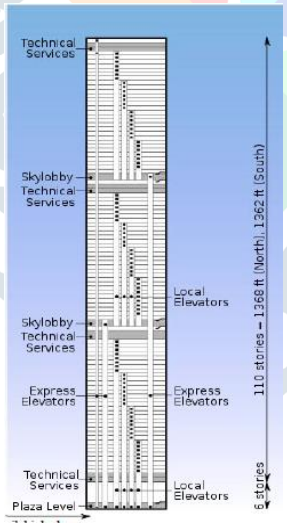


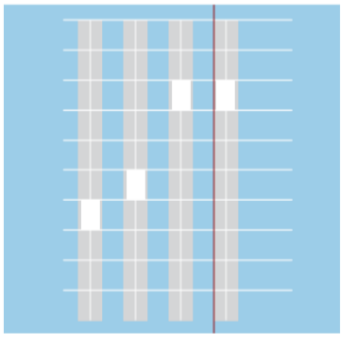
Fig.10 grouping of lifts *Fig.11 showing local, express lifts and sky lobbies*

3.1 Special elevators for super tall skyscrapers

Sky lobby concept is usually adopted to facilitate very high buildings as this also permits to restrict the size of core to a considerable size. Express elevators are used to take passengers from the ground level main lobby to a sky lobby. Passengers land at the sky lobby and service is then provided to further low, mid, high zones, etc.

using the sky lobby as an upper main terminal floor. Shuttle lifts are usually quite large and fast and provide an excellent service to the sky lobby. (Inserted Fig.7)

- Double deck lifts: These comprise two passenger cars one above the other connected to one suspension/ drive system. The upper and lower decks will serve two floors simultaneously.
- Twin elevators: A sophisticated and regular monitoring system is adapted in this system wherein two lifts travel in single shaft.



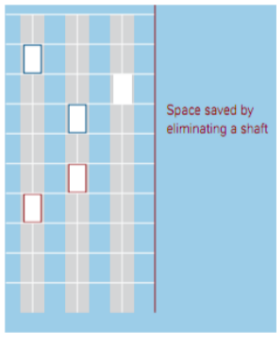


Fig.12 Benefit of twin elevators *Fig.13 Twin elevator in Frankfurt Main triangle Building*

4.0 Conclusion

To conclude, establishing huge monuments/ buildings to portray a sense of craftsmanship, power, dominance, recognition and need to accommodate people migrating from rural settlement to urban settlement has provoked the thoughts of providing habitable, affordable, cost efficient spaces and thus high rise buildings came into scenario.

Scarcity of land for construction initiating the demand of high rise habitable spaces, worldwide concept of maximum FAR is been practised considering the surroundings land use so that we can have Structure system and means of reaching various levels of buildings considering the safety and economic constraints is the need of the hour.

The modern technology has given a great prospect for infrastructure and housing development where in a project is designed and executed by using various available solutions. However, the technology has to be utilised in an efficient manner by appropriate selection of technology and technique. Tall buildings major component is the core which houses all the service loops and enclosed in a shear wall. The well with the shear walls also becomes a major structural component to support other ancillary elements and thus planning of these cores has to be legitimate. Selection of type and size of lifts also plays a vital role in tall building efficiency.

5.0 References

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