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Vertical Subway, Namely, an Internal Transport System in 1200 m Tall Building

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Abstract

This article deals with the topic of designing an efficient internal transport system in a 1200 m tall multifunctional building called the "World's Tower" due to its symbolism and specific architectural form. The building comprises four towers whose bases are 75 m/75 m long each and whose height is 1200 m. Two of the towers are located along the north-south axis while the two others along the east-west one. The towers are joined at the top which makes the building higher than ever before (even up to 2 km). It has been achieved with the help of a batten plate joining the towers at the height of 900 m. The opposite towers are joined with the arch structure thanks to which the building constitutes the monument – the symbol of the unity of south and north, east and west. Additionally, the fifth component – a spherical structure with a diameter of 220 m has been placed on the batten plate. There are outlines of the continents on the elevation of the spherical structure. Thus, the whole building symbolizes the mankind that has taken the planet Earth under its wings. The internal transport system in the building has been called by the author a "vertical subway" due to its similarity to the actual subway system. The system consists of 40 elevator cars connected with each other and which, in a given shaft, move only in one direction, for example, they all move up and then they move one by one into the other shaft in which they go down. It creates so far unknown possibilities of using the internal transport systems in very tall buildings, as the "vertical subway" of this type can take a few thousand people at the same time and it can operate every three minutes at peak times. Two sets of these "trains" plus eight traditional elevators can work in the tallest buildings in the world while taking up only a small fraction of their area. It is a new quality in the vertical internal transport because of its efficiency which is several times bigger than the one of the vertical transport systems used so far.

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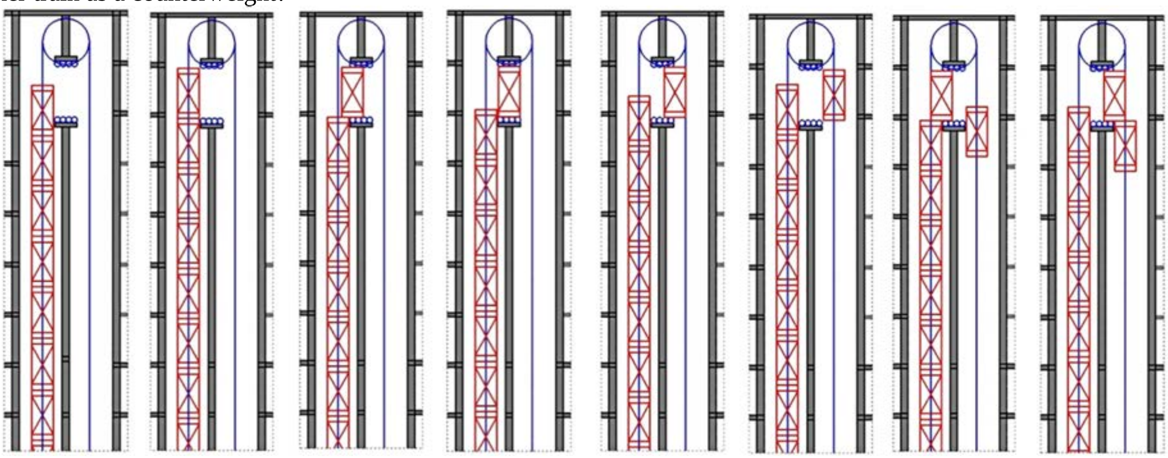
1. Introduction

This article deals with the topic of an efficient transport system in a 1200 m tall building. The vertical transport seems to be the biggest concern in case of tall buildings because the elevators take a major part of the usable area of the building. In the building complex described here the use of typical elevators is out of the question as no matter what they will never be efficient enough. Therefore, a new type of vertical transport of a great efficiency has been created. The author has given it a working name: a "vertical subway". It is a 40 storey high-speed elevator which reminds of a vertical train. At the same time, 1 000 people can get on or off at 40 stations of each elevator on forty floors of e.g. the parking area. Assuming that there are 10 trains of this type in every single tower, it turns out that 40 000 persons can use the vertical subway simultaneously, not to mention the local elevators. The vertical subway should stop at least every 80 floors where it will be possible to change to the local elevators. However, it should be emphasized that the whole system must be controlled by the central computer which will not only direct people to the appropriate elevators and identify who they are but also find the most optimized route for them and the vertical subway stations. Therefore, there is a need for each tenant, worker or a visitor to be allocated to a parking lot and the parking level (a visitor has to register its visit at the reception or online in advance).

2. Vertical Subway

2.1. A vertical subway as a solution to the transport system problems in tall buildings

The height of the building complex is a factor that questions the use of counterweights as the cables would have to reach the length of 2,5 km (although there are mines over 1 km deep where there are elevators using such long cables). On the other hand, a vertical train with its own drive without the counterweights contradicts the principles of the sustainable development due to an immense amount of power necessary to operate it. However, why not use the other train as a counterweight?



a) b) c) d) e) f) g) h)

Fig. 1. The operating principle of the vertical subway. The left shaft – the trains go up, the right shaft – the trains go down. The operating scheme of the upper station of the vertical subway is shown. The operating principle of the bottom station is the same, where:
a) the subway goes up and reaches the upper station, b) the subway waits at the upper station,
c), d), e) the first and uppermost car goes into the other shaft,
f) the uppermost car is in the other shaft as the first car of the train going down,
g) the uppermost car gets down and the second car takes its place,
h) the second car goes above the first one and within seconds the train consisting of 40 cars going down has been formed.

From this solution, it is just a step to a kind of paternoster (paternoster or paternoster lift is a passenger elevator which consists of a chain of open compartments, each usually designed for two persons, that move slowly (0.30 – 0.45 m/s) in a loop up and down inside a building (without stopping); when one part moves up, the other one goes down. namely an elevator where there are two integrated shafts that operate in a loop. What makes it different from a paternoster elevator is that these are two or more vertical subways that stop at particular stations and have doors in the cars, therefore, handicapped people can use them, too. In the building complex as big as the one in question they cannot be called on demand, they have to operate like a real subway - every 3 minutes at peak times and every 6 minutes at other times. The efficient and fluent shift of an individual car into the other shaft constitutes the biggest technical challenge of the "vertical subway". A single car after reaching the highest level is moved horizontally into the other shaft in which it goes down one stop only and waits for the next car to arrive and so on – as it is shown in fig. 1. Once "the whole train has been formed", it goes 80 floors down to the first stop. The time needed for the cars to shift horizontally on the upper and bottom level is a key issue here.

2.2. Architecture of the building

The dimensions of the floor plan of the towers are 75/75 m, and the dimensions of the floor plan of the main cores are 20/20 m (fig. 3). The total area of the aboveground part is 11.97 million m^2 and of the underground one is 26.9 million m^2.

Fig. 2. The visualisation of the designed building.

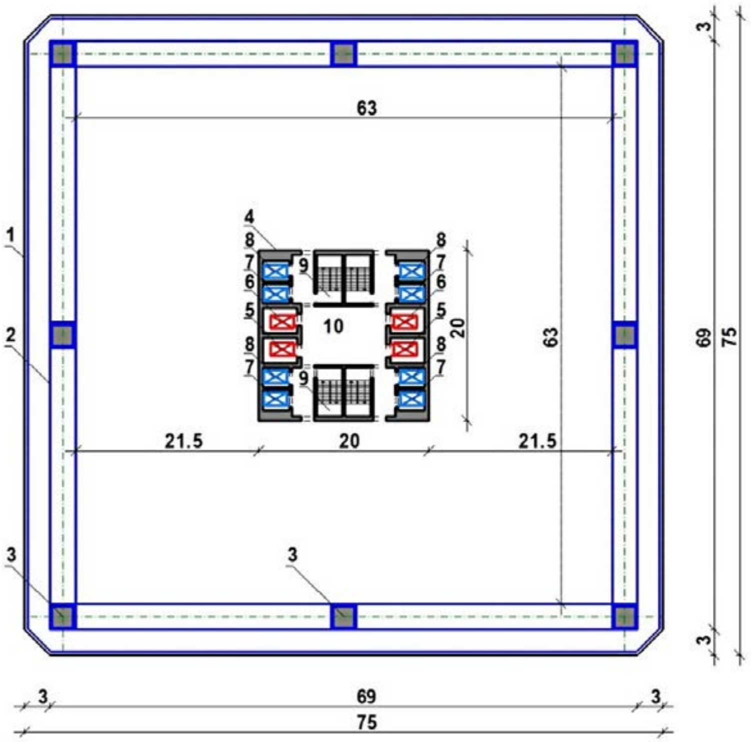


Fig. 3. The floor plan of a typical storey of one of the four towers along with a vertical subway station.

On the figure 3 description of tower utilities:

1. Elevations - tower glass curtain walls located 3 m in front of the main vertical truss structures of tower walls.
2. Vertical truss structures of tower walls hidden 3 m behind the glass elevations.
3. Main load-bearing pillars of cross-sectional dimension 3/3 m; steel, filled with reinforced concrete.
4. Core 20/20 m; steel, filled with reinforced concrete.
5. Vertical subway, 40 cars 26 persons each, 2000 kg load, KONE MonoSpace 700, it only goes 360 floors up.
6. Vertical subway, 40 cars 26 persons each, 2000 kg load, KONE MonoSpace 700, it only goes 360 floors down.
7. Elevator; 26 persons, 2000 kg load, KONE MonoSpace 700, it only goes 80 floors up.
8. Elevator; 26 persons, 2000 kg load, KONE MonoSpace 700, it only goes 80 floors down.
9. Staircases - 4, for evacuation purposes.
10. Vertical subway station.

3. Results and Discussions

The building presented here with the volume of nearly 44.9 million m3 may be called, without exaggerating, a vertical town. However, the basic condition of its efficient operation is to solve the issues concerned with the vertical transport system. It turns out that the only solution is the use of a vertical subway whose efficiency is, in comparison with traditional elevators, several dozen times bigger.

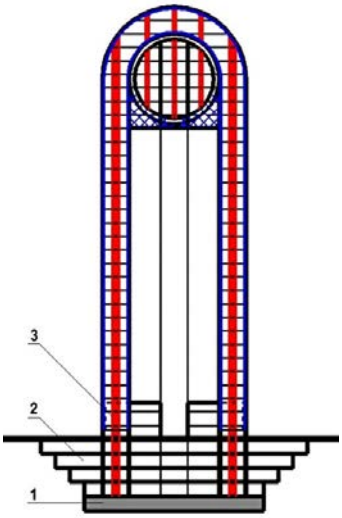


Fig. 4. The architectural concept of the designed building – a vertical cross section, only every 10th storey is shown to have a clearer view
The description: 1-Foundation slab; 2-Underground parking area for 220 000 cars, 40 floors. The volume – 107.6 million m^3;
3-Transport system shafts – marked red.

4. Conclusion

The vertical subway operating principles seem to be the only possible solution of the efficient vertical transport system in very tall buildings that will be constructed in the nearest and farthest future. Therefore, the concept of the vertical subway should be further developed so that it can be used in such mega- constructions of the future.

Finally, it should also be emphasized that the photovoltaic cells located on the building elevation would greatly contribute to the power supply system of the facility. Moreover, the experience coming from the aviation technology especially with regard to composite materials and carbon fibres should be applied to the construction of the modern means of transport of this kind.

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