

WORLD'S TOWER - NAMELY, HOW TO BUILD A 1200 METRE TALL HOUSE

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ABSTRACT

The purpose of the paper is to discuss the idea of the construction of the World's Tower – a vertical town that, at the same time, symbolizes human brotherhood. The idea is to build the facility consisting of four towers joined from above with an arch structure that has the same cross section as the towers. The building, thanks to the top arches, constitutes the symbol of the unity of south and north, east and west. Moreover, at the height of 900m there is a batten plate (thanks to which the building is 1200 m high) and the fifth component – the spherical structure with a diameter of 220 m. The outlines of the continents are placed on the elevation of the spherical structure. The whole building symbolizes the mankind that has taken under its wings the planet earth.

Key words: top arches, symbol of unity, truss structure, mass damper, spherical structure, hurricanes, tower corners, heat recovery, photovoltaic, swimming pools, parks

1 INTRODUCTION

This article is concerned with the idea that originated at the beginning of 2002 in response to the destruction of World Trade Centre (WTC) by the terrorists in 2001 [1]. The author of the article as a young man was a great enthusiast of the WTC construction and as a Chairman of the Students' Science Club at the Faculty of Civil Engineering at Gdansk University of Technology made a speech on the WTC construction [2] for the academic staff of the above faculty in 1974. Therefore, the ruthless destruction of the WTC twin towers affected the author deeply and made him conclude that the best lesson for the terrorists would be to construct something at least twice bigger and far more impressive, instead. The building should symbolically oppose terrorism constituting the symbol of human brotherhood.

2 GENERAL DESCRIPTION - IDEA

The idea is to construct the building consisting of four towers connected at the top which allows to make it much higher than so far (even up to 2000 m; the height 1200m and 320 storeys have been assumed for the building). This is achieved thanks to the batten plate connecting the towers at the height of 900 m. The use of the batten plate makes the building function as a 450-metre-high single tower. The opposite towers are joined with the arch structure having the same cross-section as the towers 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 (the distance between the two opposite towers is 250 m) is placed on the batten plate. The spherical structure has the outlines of the continents on its elevation. Therefore, the whole building symbolizes the mankind that has taken under its wings the planet earth. The spherical structure constitutes a very important factor contributing to the equilibrium of the whole building as it can move on the batten plate changing the position of the centre of gravity of the whole building during hurricanes or earthquakes. Thus, the building works as a tuned mass damper (its prototype was the

damper used in the Taipei 101 Tower in Taiwan, where this kind of solution was applied for the first time).

This article is concerned with the possibility of the construction of the multipurpose building which is 1200 meters high and which, because of its symbolism and particular architectural form, is called the “World's Tower”. The 1200-metre-high building consists of four towers whose square bases are 75 m each. Two of the towers are located along the north- south axis while the two others along the east-west one. The height of the building is attributed to the batten plate joining the towers at the height of 900 m (the building functions as a 450-metre-high single tower). The opposite towers are joined with the arch structure having the same cross-section as the towers 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 (the distance between the two opposite towers is 250 m) fig. 1 is placed on the batten plate. The spherical structure has the outlines of the continents on its elevation. The whole building symbolizes the mankind that has taken under its wings the planet earth. The spherical structure constitutes a very important factor contributing to the equilibrium of the whole building as it can move on the batten plate changing the position of the centre of gravity of the whole building during hurricanes or earthquakes. Thus, the building works as a tuned mass damper (its prototype was the damper used in the Taipei 101 Tower in Taiwan, where this kind of solution was applied for the first time [3]). The construction of such a big structure with an over ground cubic volume reaching nearly 45 mln cubic meters requires activities that will be undertaken in advance and which will prepare the city (precisely the city centre) to incorporate this type of building into its tissue. Indeed, this building complex may be called a vertical city - new in the city's old tissue - which has to be incorporated by the existing city.



Fig. 1 Visualization of the architectural concept of the designed building.

To be able to compare the scale of the buildings we show the WTC twin towers which were destroyed.

- **Architecture** – the building complex where could coexist even one million people should fulfill the same functions as the town which is home to that many people. It means that except for residential, office and hotel functions there should also be nursery schools, schools of different levels, museums, cinemas, theatres and other facilities serving cultural purposes, environment friendly business activities (e.g. 3D printing) gym halls, swimming pools, parks, local and regional authorities buildings, and so on. In the underground part there could be a big shopping-mall. Summing up, this type of building complex can comprise absolutely everything, under one condition, it has to be wisely planned and laid out.
- **Construction** – the towers are designed in the form of four vertical flat truss structures joined with each other into the spatial structure which is fixed into the walls of the underground part. The trusses cooperate with the building core to intercept the load from the roof slabs of a 21.5 metre span and they also intercept horizontal wind loads. To diminish the wind load the 3/3 m tower corners have been canted, which significantly reduces the wind impact on the towers.
- **Energy saving** – the use of heat recovery, photovoltaic curtain wall elevation, wind energy and rainwater recovery systems.

3 URBAN SOLUTIONS

The construction of such a big structure with an aboveground cubic volume reaching nearly 44,9 mln cubic meters requires activities that must be undertaken in advance and which will prepare the city (the very city centre) tissue to incorporate this type of building. Indeed, this building complex may be called a vertical city - new in the city's old tissue - which has to be incorporated by the existing city.

However, one cannot exclude the reverse process in which the existing city will be subordinated to the vertical town. The basic conditions with regards to the urban solutions involve good city transport. Therefore, under the "World's Tower" there should be at least two subway lines with stations under each tower. The structure should have its foundations on the same plate situated directly on the rock or on the pillars on the assumption that the upper edge of the plate will be situated at least 160 m below the ground level. This will allow to have a 40-storey underground parking area with the entrances into particular storey sections from the immediate and more distant vicinity of the towers. The individual parking area floors should be bigger and bigger as they get closer to the ground level. This will result in the increased capacity of the parking area and it will resemble an inverted ziggurat in its vertical cross-section. The volume of the parking area is 107,6 mln m³ and its capacity is 220 thousand passenger cars. While planning the building complex location and the development of its nearest vicinity it is worth considering the solutions applied to large football stadiums as there are similar issues to be solved regarding, among others, handling large numbers of people and providing security to them.

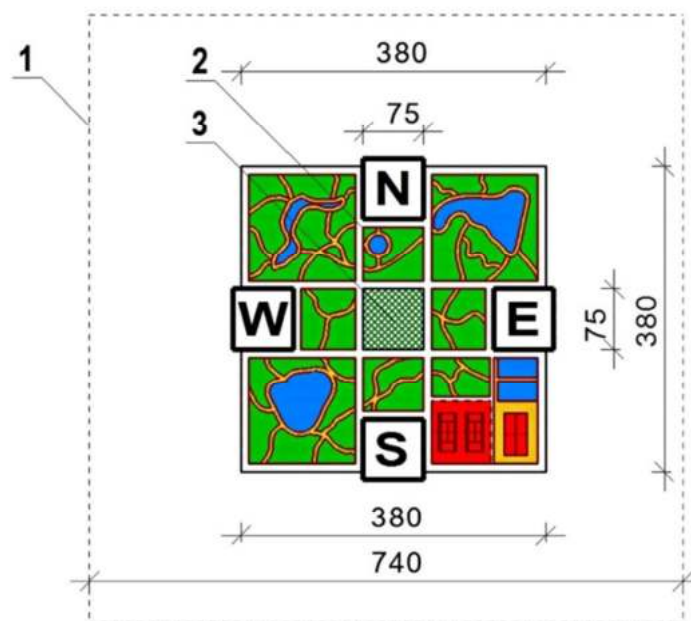


Fig. 2 The architectural concept of the designed building – the floor plan of the low part of the building seen from roof top.

- 1 Underground parking area outline, 2 Park on the roof of the low part of the building - 11,93 ha, swimming pools and sports grounds, 3 Atrium providing light to the low part of the building.



Fig. 3 Park on the roof of the low part of the building.



Fig. 4 Parks in upper parts of the building.

4 ARCHITECTURE OF THE BUILDING

4.1 Numerical data

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. A tower single storey useful area is $69 \cdot 69 = 4761 \text{ m}^2$. The total area of the above ground part is 11,97 mln m^2 and of the underground one is 26,9 mln m^2 .

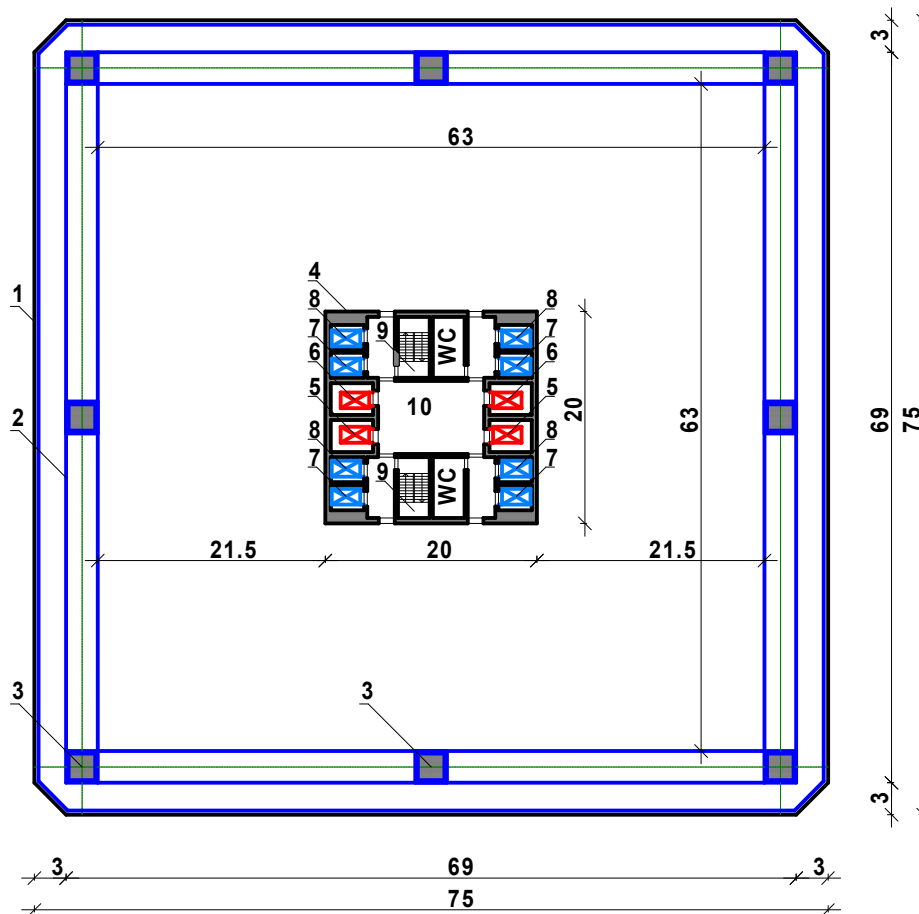


Fig. 5 The floor plan of a typical storey of one of the four towers along with a vertical subway station.

1 Elevations - tower glass curtain walls 3 m before 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.

4.2 Functions of the building

The building where could coexist even one million people should fulfill the same functions as the town which is home to that many people. It means that except for residential, office and hotel functions there should also be nursery schools, schools of different levels, museums, cinemas, theatres and other facilities serving cultural purposes, environment friendly business activities (e.g. 3D printing) gym halls, swimming pools, parks, local and regional authorities buildings, and so on. In the underground part there could be a big shopping-mall. Summing up, this type of building can comprise absolutely everything, under one condition, it has to be wisely planned and laid out.

4.3 Elevation

The buildings have double skin facades. Energy efficient triple glazed glass curtain walls constitute the external elevation. The internal elevations, main vertical trusses with (if required) an additional glass curtain wall, are 3 metres away from the external elevations. Therefore, it is possible (but it is not compulsory) to have a walking area around the tower.

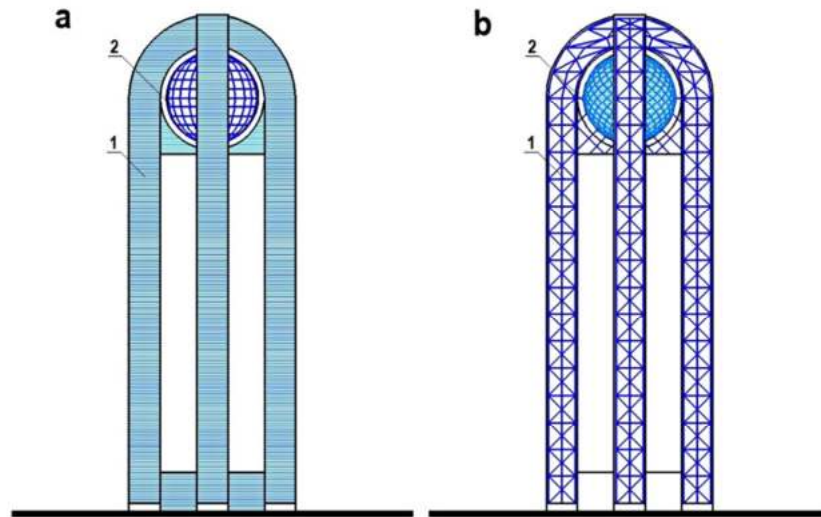


Fig 6 The architectural concept of the designed building:

a) external elevations - glass curtain walls in the towers and the main construction skeleton on the spherical structure. 1 Elevations -tower glass curtain walls 3 m before the main vertical truss structures of the tower walls, 2 The main truss structures (longitudes and latitudes) on the spherical structure 3 m before the glass elevation.

b) internal elevations - wall vertical truss structures hidden 3m behind the external elevations in the towers and glass curtain walls on the spherical structure 3 m behind the main construction skelet.

1 Tower wall vertical truss structures hidden 3 m behind the glass elevation, 2 Glass elevation and cross braces on the spherical structure hidden 3 m behind the main truss structures (longitudes and latitudes).

4.4 Conservatories

There are conservatories for relaxation purposes located on three mezzanine areas and there is a real park called NCP (New Central Park) of 11,93 ha area over the low part of the building. Apart from the tall and low greenery, lakes and walking paths to relax there are also two swimming pools (25/50m) and two tennis courts and one basketball pitch in the park. The usage of the park must be limited with the help of entrance cards valid for a specific time of the day according to the schedule available online (there is no possibility for the park to be used by a million people at the same time).

4.5 Vertical transport

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 are like they will never be sufficient enough. Therefore, a new type of vertical transport with a great efficiency has been created. The author gave it a working name "vertical subway". It is a 40 storey high-speed elevator which really reminds of the vertical train. At the same time, 1000 people can get on or off at 40 stations of each elevator on forty floors of eg. the parking area. Assuming that there are 10 trains of this type in each single tower,

it turns out that 40 000 persons can use the vertical subway at the same time, not to mention the local elevators.

The vertical subway should stop at least every 80 floors where it is possible to change to the local elevators. However, it should be emphasized that the whole system must be controlled by the central computer which directs people to the appropriate elevators, identifies these people and finds the most optimised 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 online in advance).

4.5.1 *The paternoster in favour again?*

The height of the building complex is a factor that questions the use of the counterweights as the cables would have to reach the length of 2,5 km (although there are mines over 1km 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 a huge amount of energy necessary to operate it. However, why not use the other train as a counterweight? 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 goes down) namely an elevator where there are two integrated shafts. The first one is used only to go up and the other only to go down. The elevator works 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.

5 CONSTRUCTION OF THE BUILDING

5.1 Foundations

The necessity of making a very deep underground parking area (40 storeys) resulted in placing the foundation plate at least 160 m below the ground level. The plate of 500 m side and 40 m height has been assumed for the building (the concrete volume is 10 mln m³). The plate should be placed directly on the rock. In case the bedrock is deeper, the plate should be supported on the bedrock with the help of pillars. The calculation of their number and radius should be made on the basis of the construction project.

5.2 The underground part of the building complex

It should be monolithic, ferroconcrete (B 80 concrete). Individual parking area floor sections have bigger and bigger floor plans every 10 floors while getting closer to the ground level, which results in smaller pressure of the ground on the external walls of the building complex and the fact that the underground part of the building cooperates much better with the foundation plate with regards to the stabilisation of the whole buiding complex.

5.3 The aboveground, low part of the building complex

It should be monolithic, ferroconcrete (B80 concrete) and is 100m high.

5.4 The aboveground, tall part of the building complex

The individual towers have the form of four vertical plane trusses connected with each other into a spatial construction and anchored in the walls of the underground part. The truss structures cooperate with the building core in intercepting the load from the floor slab of the span 21,5 m and the horizontal wind loads. To reduce the wind loads the tower corners have been cut (3/3m), which has significantly decreased the wind effect on the towers.

5.5 The spherical structure

It is to be made of aluminium pipes. The spatial aluminum trusses of 36/36m span and 75 cm construction height form the ceiling slabs, the ceiling slabs are made from light concrete, only the shafts for vertical transport purposes are clad with aerated concrete. In case of the spherical structure the double skin facades are used in a reversed manner in comparison to the towers, that is, the external elevation consists mainly of pipes in the form of longitudes and latitudes while the remaining latticework and triple glazed glass curtain walls of high energy efficiency are moved 3 m inside. The experience coming from the aircraft industry may turn out useful whilst constructing the spherical structure. Additionally, the spherical structure constitutes a very important factor contributing to the equilibrium of the whole building as it can move on the batten plate changing the position of the centre of gravity of the whole building during hurricanes or earthquakes.

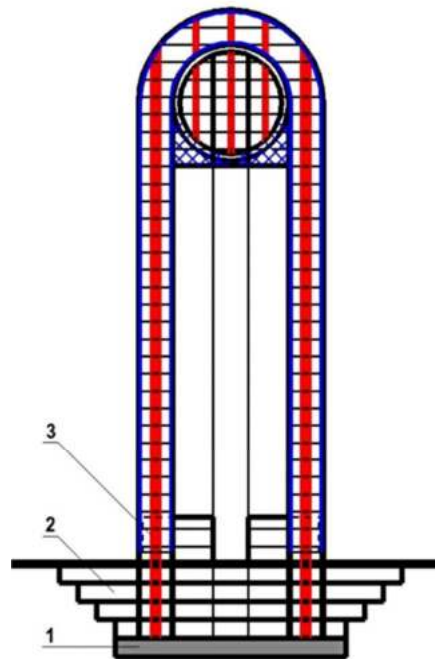


Fig. 6 A vertical cross section, only every 10th storey is shown to have a clearer view.

1 Foundation plate, 2 Underground parking area for 220 000 cars, 3 Shafts for vertical transport purposes – marked red.

6 ENERGY EFFICIENCY AND SELF-SUFFICIENCY

To facilitate the administration of the building complex and to implement energy saving solutions the whole building is divided into 10 storey sections. Each storey of the tower as a sub-section is divided into 5 parts (4 usable parts and the core).

6.1 Storm water

The storm water will be collected from the elevation on each floor and delivered to the central reservoirs and the water, after being purified, will be reused for household purposes.

6.2 Photovoltaic cells

Altogether they will be fitted on seven elevations of three towers at the height corresponding to the height of the railings + floor slab thickness, that is at 1,50 m on each storey. No solar collectors are foreseen for the building.

6.3 Recuperation

It will be used wherever it is possible.

6.4 Wind energy

In this case it is the most controversial renewable source of energy because of the noise coming from the wind turbin propellers. However, at the height over 100m above the sea level there are constant winds with the speed of around 120 km/h. It seems such a waste not to make use of it, especially, that any way the wind of this speed produces a lot of noise. On the other hand, modern window framing reduces the noise and the windows cannot be opened (mechanical ventilation). Instead of the huge wind turbin located on the building roof it would be a good idea to make through holes of the diameter up to 3 m in the highest parts of the elevation and which will be equipped in Venturi nozzles (accepted on the basis of the model study, therefore, they are not presented here).

Literature

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