Analysis of Architectural Design Scheme of "Pit City"

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Abstract. The paper aims to employ emerging technologies to recycle the abandoned mining pits, and build urban complex to recycle the space, thus improving the local natural environment and creating a livable environment. The paper intends to explore the direction of urban construction in the future.

Introduction

In the 1760s, the first industrial revolution brought human beings to the age of industrial civilization. Through the lengthy course of history, coal-mining industry, as a key economic engine, has developed and witnessed the transformation, exploitation and destruction of the natural environment by human beings—stripping surface vegetation and violent changes of the landform. After centuries, excavated mining pits have become the scar of the cities. Habitat fragmentation is ubiquitous in human settlements. Meanwhile, owing to the constant expansion of population and urban land, as well as the increasingly refined pursuit for the living environment of human beings, mining pits are gradually incorporated into the planning scope of construction land. Its land use value and function potential are gaining attention by degrees. Therefore, it has become an urgent realistic issue to carry out creative reconstruction and recycling of these abandoned mining pits.

Across the entire globe, it's rare to see any research and comprehensive use of the abandoned mining pits. One of the successful cases is the "Garden of Eden"—the largest plant exhibition greenhouse in the world, the new millennium celebration project built nearby St Austell, Cornwall County of Britain in 2000, based on an abandoned old clay pit [1]. Other traditional solutions: 1) make it a reservoir for easing water shortage; 2) use it for landfill of domestic wastes from the nearby cities; 3) build it into unique tourist destinations by combining with local cultural characteristics.

With the progress in urban design and regional planning philosophy, the concept of sustainable development is put onto the paramount position, comparing with the traditional ideas, which emphasizes people-oriented design and elevation of life quality, and vigorously supports the advances of knowledge industry and technological innovation. Traditional solutions for the abandoned mining pits cannot further meet the new social demand. Therefore, it raises a more serious challenge to the designers in the new era regarding how to dig out potential resources in the abandoned mining pits[2-3].

Based on the survey of the existing abandoned mining pits, the paper innovatively proposes to construct a highly modern urban complex on the abandoned mining pits. The key points include circulation system design, day lighting and ventilation system design, water supply and drainage system design, green system design, and energy system design.

Overall Structural Design of "Pit City"

The study aims to build a "Pit City" on the pit space, which serves as the satellite city of the mining district. The concept of "smart city" is also introduced, with a view to improve the living environment in the mining district and recycle the spatial resources. The entire city can be roughly divided into three parts of functions. The 40 floors above the ground are for public use, including cultural education, activity, and information management, etc. The 23 floors under the ground are for residential space and supply station of living resources. The whole complex has an independent

integral information network. It is feasible to record all the information necessary for living into the cloud and manage it. It can also be connected to the primary city district.

The design is mainly comprised of a core tube and the ring space around it. For the core tube above the ground, its diameter reduces 2m by every floor from the 1st floor to the 10th floor, and reduces 1m by every floor from the 11th floor to the 20th floor, and reduces 0.5m by every floor from the 20th floor to the 30th floor. The floors above the 30th floor keep the same diameter. Thus, a smooth curved shape and a stable building system are both guaranteed. The ring space clings to the pit wall floor by floor. A stable structural system is created based on the natural characteristics of the mining pit.

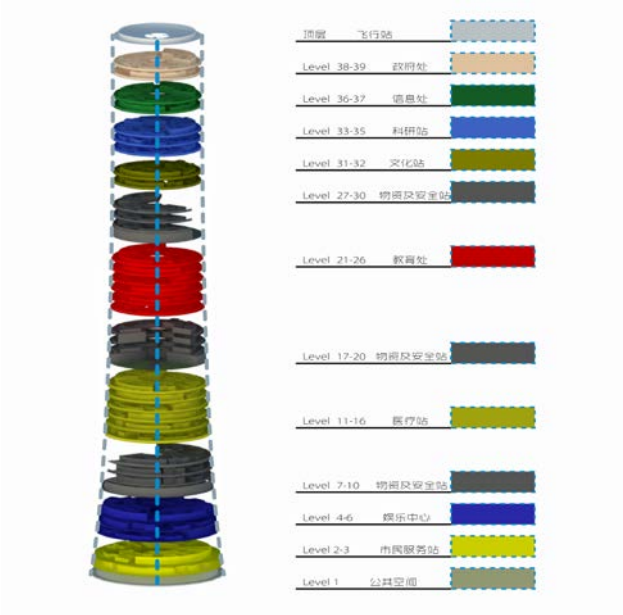

Fig.1 Overall structure of "Pit City"

Circulation System Design of "Pit City"

Vertical Circulation.

Aboveground part: As the design considers ten floors as a vertical unit, circulation system varies according to different floors. Take the 1st floor to the 10th floor as the example. From the 1st to the 8th floor, the primary circulation relies on the central circulation tube and three separated auxiliary circulation tubes. Because the function space for education and medical treatment requires dedicated nonstop circulation, two nonstop circulation tubes are designed exclusively for them. For satisfying the demand of the fire escape, an escape elevator is designed beside each of the three auxiliary circulation tubes. Between the eighth and tenth floor, owing to the reduction of one third of the floor area, and the requirements of the escape elevators, the escape elevators are relocated to the other side of the auxiliary elevators. Other vertical circulation systems stay the same. One thing to be noted: for the sake of circulation flexibility, the central circulation tube stops every three floors (both directions) from the first floor underground (B1), while the auxiliary circulation tubes stop at every floor. The elevators dedicated for medical treatment and education end at the 15th floor and 24th floor.

Underground part: The underground building has 23 floors. From B1 to B10, the central tube connects to the aboveground part, while the three auxiliary circulation tubes are staggered with the aboveground ones. B1 serves as the circulation hub. People can interchange elevators at B1 to the aboveground part, which largely enhances circulation flexibility. Owing to the particular characteristics of the industrial floor, it possesses an independent circulation system—connection to the aboveground part through the central circulation tube and an auxiliary circulation tube.

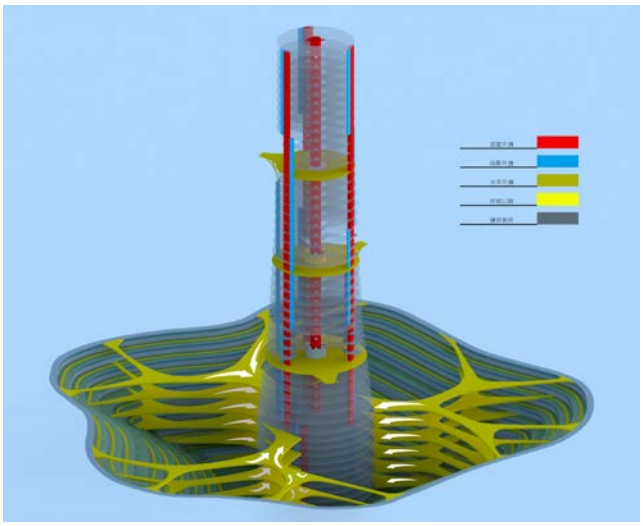

Fig.2 Circulation System Diagram of "Pit City"

Horizontal Circulation.

Aboveground part: The primary horizontal circulation is to connect the central tube with the auxiliary tubes. As the indoor space is module-based, the secondary circulation is subject to the indoor structure.

Underground part: The pit wall and the core tube are linked through six horizontal circulation belts at each floor. The indoor circulation is up to the floor arrangement. On the isolation floor between the energy station and the residential zone, an underground rail circulation system is designed, so as to connect to the major city of the mind district, and reinforce the subsidiary nature of the satellite city.

Day Lighting and Ventilation System Design of "Pit City"

Day Lighting System.

The urban complex adopts the natural day lighting and artificial lighting combined design. As the underground space is totally isolated from the outside, it is impossible to realize natural lighting through the side windows and skylights. Thus, we use the active sunlight system to transit the natural light to the isolated underground space through duct, conduit and optical fiber, etc. The active sunlight system calculates the sun positions according to the season and time. Heliostat tracking system is adopted as the sunlight collector. Besides, efficient light guide systems will transmit natural light to the deep underground space where light is needed. The employed active natural lighting methods include direct reflection, light pipe, and prism group.

Direct reflection lighting method: use flat or curved mirrors to reflect sunlight one or several times until light is transmitted to the area where necessary.

Light pipe lighting method: the method varies according to the types of system equipment and locations. The entire light guide system comprises of sunlight collection, sunlight transmission, and sunlight illumination. The sunlight collector is made up of heliostat, collecting lens and reflector. There are many methods of transmitting sunlight, including air, mirror, light pipe, and optical fiber, etc. For sunlight illumination, materials such as diffusion panel, pervious prism or specially made illumination material, so on, are adopted, so that the light coming out from the light pipe should have different light distribution characteristics. Corresponding materials should be selected based on the requirements of the space [4].

Prism lighting method: the primary principle is rotating two flat prisms to generate four times of refraction. The illuminated face always keeps the direct light coming vertically. The control mechanism is rotating flat prisms on the horizontal plane when the solar azimuth and elevation angle change. According to the sun position, the optimized rotation angle is determined for the two flat prisms, so as to control the direct sunlight with elevation angle of 10-84 degrees coming vertically. The collected light is diffused by the light distribution panels. In order to track the sun,

parameters like time, latitude and longitude are defined. The operations are conducted by the wireless remote control. The power for driving and controlling is supplied by solar battery instead of municipal power grid. [4]

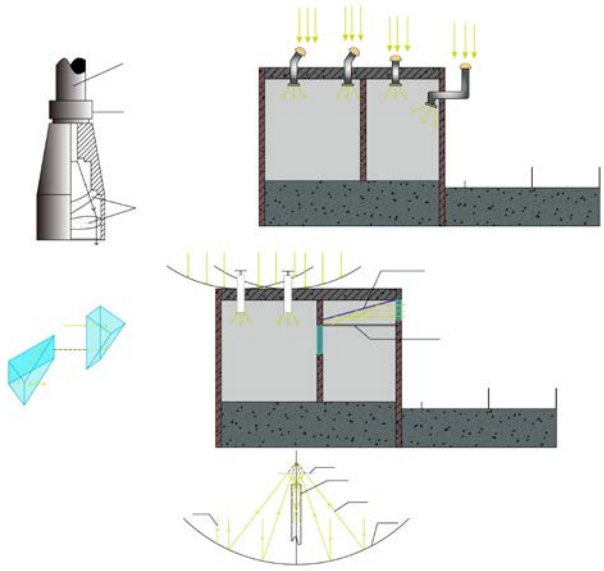

Fig.3 Day lighting system diagram of "Pit City"

Ventilation System.

The ventilation system is mainly comprised of natural ventilation, and supported by mechanical ventilation.

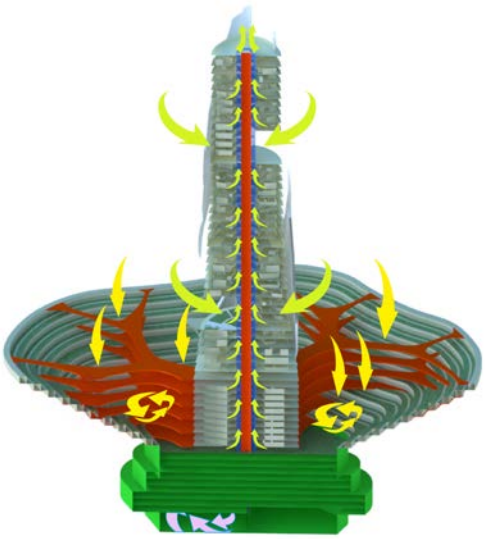

Fig.4 Ventilation system diagram of "Pit City"

Natural ventilation mainly adopts the combined way of wind pressure and thermal pressure. Shaft space is designed inside the building to accelerate airflow. Atrium is utilized for ventilation. The principle of funneling effect of thermal pressure ventilation is employed to intensify air circulation and hot air going up, thus creating the environmental wind tower that is able to suck airflow of various directions by the prevailing wind and stack effect. Finally, the disadvantageous influence of the local climate is reduced. A really comfortable artificial environment is created.

The atrium around the core tube is designed of reduced volume from the bottom up, similar to a funnel. This is because of the presence of funneling effect in thermal pressure ventilation. In accordance with the second law of thermodynamics, heat is transmitted from the hot zone to the

cold zone. This law is also applicable to the funnel space. Actually, the funneling effect will help to push the hot air to go up.

Environmental wind tower is an approach of environmental regulation. Taking the surrounding environmental wind field and the requirements for user's comfort into account, architects allocate the environmental wind tower into the position closest to human activity, namely, the evacuation floor. The bionic shape of the wind tower also beautifies the environment. The environmental wind tower is able to suck airflow of various directions by the prevailing wind and stack effect. Finally, the disadvantageous influence of the local climate is reduced. A really comfortable artificial environment is created. To increase the air supply into the core tube is a way of comprehensive utilization of natural resources to realize efficient ecological architectural standard.

Water Supply and Drainage System Design of "Pit City"

Water Supply System.

Water supply system has two sources: underground rivers and rainwater harvesting. As to the underground water collection, it will be introduced into the Energy Floor and treated, and distributed to two directions, one is directly supplied to the upper floors after purification; the other is supplied to the outside of the reactor for cooling the heat generated by nuclear fusion reaction. And the heated water will be processed and supplied to the upper floors as domestic hot water.

As to rainwater harvesting, there are two methods. The first method is to design a ring of green belt around the pit for harvesting rainwater, and transit the rainwater after sedimentation back through pipes. The second method is to install pipes at each floor on the pit wall to harvest rainwater, and gather all the rainwater to the water treatment floor. After treatment, the water will be supplied to users by the main pipes.

The entire system is considered as an internal rainwater recycling system.

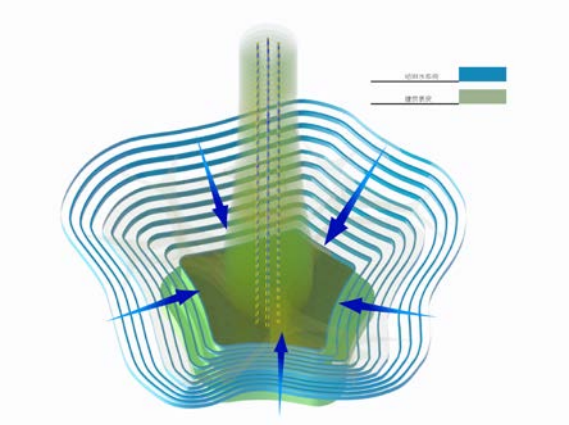

Fig.5 Water supply system diagram of "Pit City"

Wastewater Treatment.

All the wastewater is recycled or discharged to the underground rivers before verification of zero contaminant. Recycled water should be fully used in irrigation and toilet flushing, etc.

Green System Design of "Pit City"

A vertical forest is designed for the building. A great number of trees of different varieties are planted on each floor, thus creating a vertical forest. This green system has the following advantages [5].

It creates a large area of green environment which serves as the green lung of the city. It thus improves the surrounding climatic environment of the mining pit, and provides fresh air and a good view for the residents. The building becomes capable of purifying the air by itself and features more diversified colors.

It introduces nature and forest into the city, creating a livable environment for human beings,

and fully reflecting the green design philosophy of harmony between people and nature.

Currently, Chinese cities are facing severe problem of smog, which is caused by exceeding particulate matters in the air. Actually, plants are able to absorb particulate matters in the air, and reduce dust loading in the air, thus creating a good respiratory environment. In addition, plants are capable of effectively blocking the outside particulate matters. The green space becomes the second skin of the building which efficiently guarantees air quality.

It perfectly resolves the problem of urban heat island effect. As the thermal radiation amount of the city is much higher than that of the surrounding regions, this causes heat aggregation effect and makes the temperature in the city stay at a high level. However, thanks to the following functions of plants, including evaporation, transpiration, shading, and relief of the greenhouse effect, heat island effect is evidently alleviated.

Seasonal changes of plants also correspond to the urban demand for lighting and heat storage. In summer, luxuriant branches and leaves shade and protect the building from heat, while in winter, bare trees are beneficial to lighting and heat storage. The trees also form a vertical landscape that offers a marvelous view from spring to winter. [5]

Fig.6 Green system diagram of "Pit City"

Energy System Design of "Pit City"

"Artificial Sun": nuclear fusion reaction features zero radiation, enormous energy efficiency, and absolute zero pollution in energy supply. The reactor is placed at the bottom of the building. The energy is processed and transmitted to the entire building by pipes, and stored in the Energy Station[6].

Solar power: as a technically matured clean energy, it has been widely used in green buildings nowadays. Solar panels are mounted on the belt envelope of the building. After processing by the Energy Processing Floor at the high level, the energy is stored for building consumption. [6]

Conclusions

The design takes advantage of the abandoned mining pit to re-plan based on the concept of smart city. The abandoned pit space is sufficiently utilized by building an urban complex. And the complex will improve the local natural environment. It perfectly resolves the tricky problem of recycling mining pits and elevates the lifestyle nowadays.

The road to the future architecture is ecological architecture, while the development direction of the city is the smart city. A smart city will provide us both convenience and a better living environment. How to take advantage of new technologies to solve the problems we are facing? This is what the design aims to achieve.

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