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Welcome the Challenges and Imaging the Sky Town

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Abstract

Safety, livability, and efficiency are the three prominent problems of tall buildings, which are also the severe challenges to designers. We proposed the idea of building the sky town to solve these problems, which can be summarized in two sentences, one is tall building multi-storised, and another one is vertical facilities municipal-infrastructurised. The tall building can be horizontally cut into several multi-storey buildings by some large platforms. The platform extends a certain width to block the fire from spreading. Tall buildings are connected together as a group. One of them is a traffic core, which is used for vertical transportation and MEP. It connects to traffic center such as metro, while most of the other tall buildings' cores can be very much released, so as to achieve maximum efficiency of floor usable area and to give good traffic organization. By combining traffic core, platforms, and multi-storey buildings' inner traffic, a transportation network is formed. Finally, we refer to the design of Raffles City Chongqing to make a sketch of sky town.

Keywords: Sky town, Tall building multi-storised, Vertical facilities municipal-infrastructurised, Traffic core, Transportation network, Mega frame, Mega truss, Damping device

1. Introduction

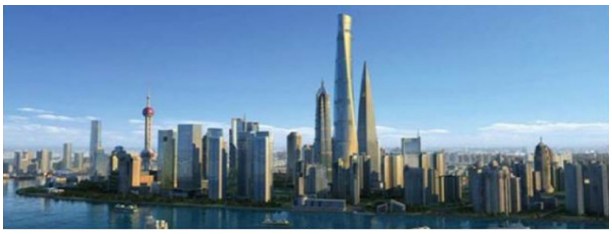
What attracted me is the theme of the international conference held in Chongqing, "Challenges of super high-rise building design and construction". The word "challenges" inspires me to face the challenge! Also the program of visiting the Raffles City project particularly interests me.

First of all, I am in favor of the construction of tall buildings. It can solve the shortages of construction land problem. Comparatively speaking, it is cheaper and safer than underground development. Certainly, it is much better than using farmland. In one word, it is beneficial to the national economy and the people's livelihood.

However, as huge number of tall buildings being built, its problems are becoming more and more severe. Mainly speaking, there are three.

First, safety issue. We have been paying great attention to the safety of structure on tall buildings. However, the actual situation is that, the fire disaster to tall building is even more serious, many buildings were burned by fire, such as fires on CCTV tower, on Shanghai Jiaozhou Road, and on the London apartment tower and so on, which caused many people died. There are too many lessons on it!

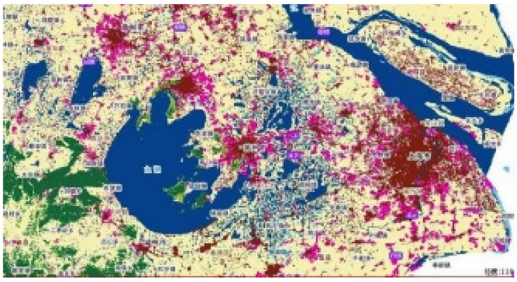
Second, the low comfort level. It causes isolation and social barriers. The elevator failures which is quite common keeping people from going up or down. It is difficult to feel relaxed at home due to renovation happening one by one.



(a) Borrowing land from sky (Pudong Shanghai)



(b) Undergroud development (Qianhai Shenzhen)



(c) City spreading (Shanghai and Lake Tai)
(the pink is after 2010)

Figure 1. Three ways of solving the shortage problems of construction land.

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(a) Fire of CCTV Beijing (20090209)*

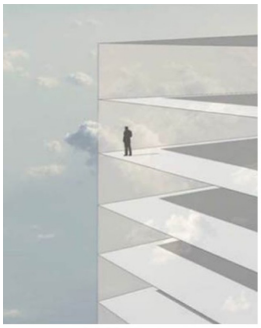


(b) Fire of Jiaozhou road Shanghai (20101115)*



(c) Fire of the apartment London (20170614)*

Figure 2. Fire accidents of buildings.

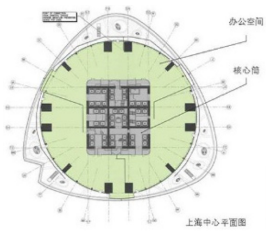


(a) Isolation



(b) Noise

Figure 3. low comfort issues.



(a) Big core



(b) Line up for elevator

Figure 4. Low efficiency issues.

Third, the low efficiency. The area of the core occupied more than a quarter of the floor area. The elevator is not very efficient, which lead to long lines of waiting for the elevator during rush hours but less used during working time.

I think these three problems are the severe challenges to designers for tall buildings. They are much more critical than many of the other problems we are studying, such as the vibration control of structure and the limits of structure acceleration, etc.



(a) Forest city of BiGuiYuan



(b) Link bridge among tall buildings

Figure 5. Efforts by designers.



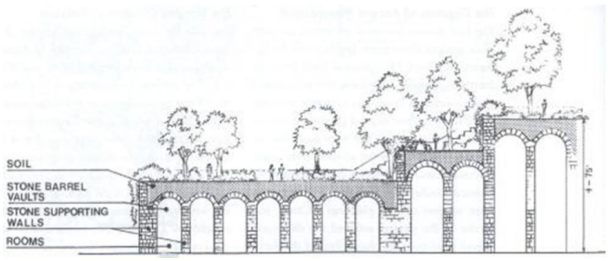


Figure 6. Babylon sky garden.

2. Dreams

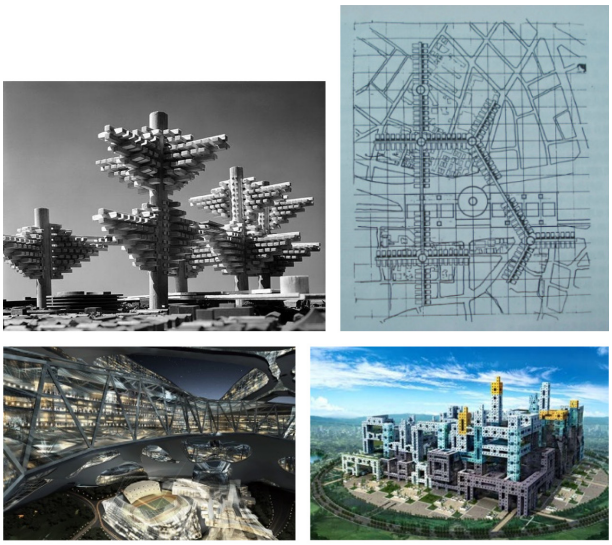
In order to solve these problems, designers have made a lot of efforts, such as designing the link bridge, greens on balcony, etc. But they are merelly a few of local improvement, or just for good-looking. Therefore, it is necessary to make some great changes in the building system to solve the problems of tall building. And that is the sky town I'm dreaming.

There are many people who have dreamed or are dreaming to build the sky city.

As far back to 2600 years ago, there was the story of Babylon sky garden in the country Iraq. The princess



Figure 7. Mountain city of Fulin.



(a) Great City of Wantong Group



(b) Sky City of Yuanda Group

Figure 8. Attempt on sky city.

missed her life in the mountain village and the king built a sky garden for her.

Coincidentally, I have visited Fuling, a city belongs to Sichuan province China, the birthplace of ancient country "Ba". I admire people's wisdom there. They built a lot of platforms along the mountain slope. People play and communicate with each other on the platform, living a very happy life. The scene is so similar to the sky Gardens of

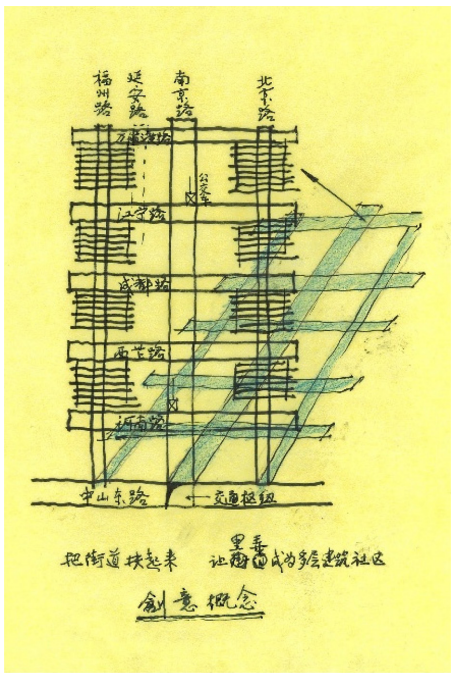


Figure 9. Inovative concept of Sky Town.

Babylon!

In 1960s, the famous architect, Arata Isozaki wanted to set up a number of big columns between dense buildings. They are connected together by imitating branches and leaves and forming a sky city.

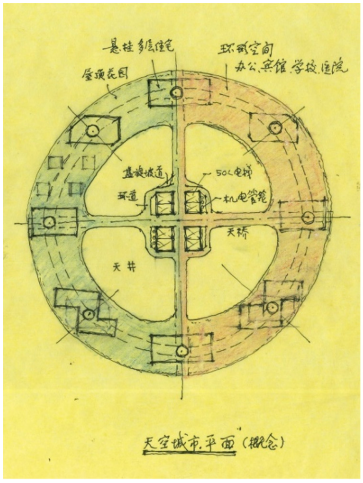
Wantong Group, Yuanda Group and some other companies in China also have made a lot of efforts on sky city. However, those ambitions have become Utopian, and failed to come true, and received a lot of criticism instead.

3. Make Dreams Come True

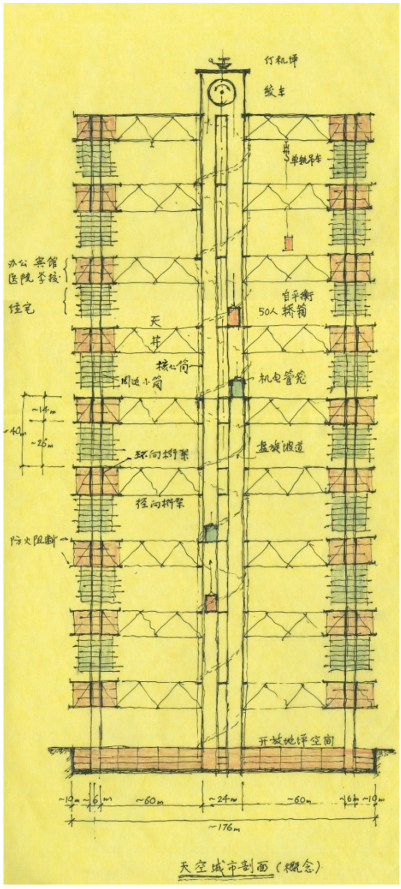
Taking the risk, I have been giving speeches many times around China in recent years. I advise to take the construction of sky town as the contribution to the "National Strategy of Innovation-Driven Development" from the traditional industry. Let the sky town dream come true. It received many positive responses, and some people even said it is a revolution of tall buildings.

The innovation points of mine can be summarized in two sentences: first, tall building multi-storised. Second, vertical facilities municipal-infrastructurised. The words of multi-storised and infrastructurised might be the English words I invented.

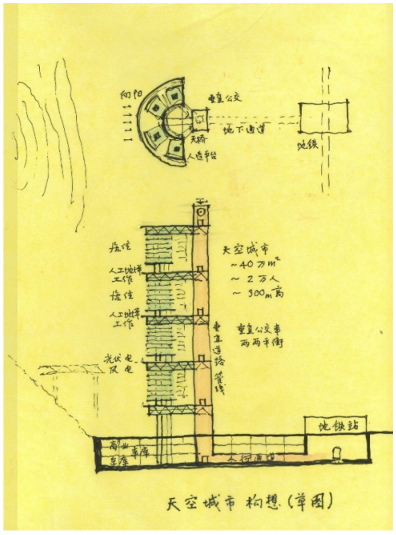
First, I hope that the high-rise building can be horizontally cut into several multi-storey buildings by some large platforms, upon which the sky garden is established. People living in multi-storey buildings, can easily go up and down to the platform, enjoying the garden with happiness and having community activities. The inner space of the platform structure is utilized for the public facilities, such



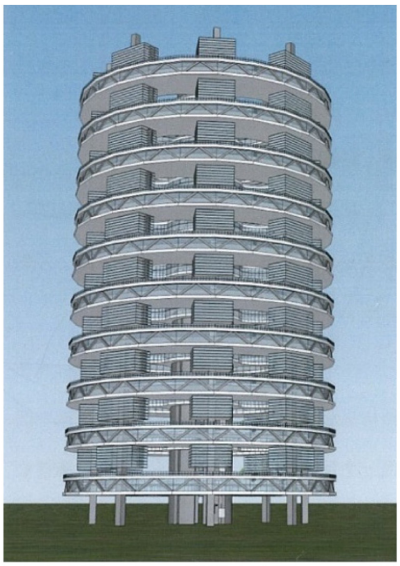
(a) Conceptual plan



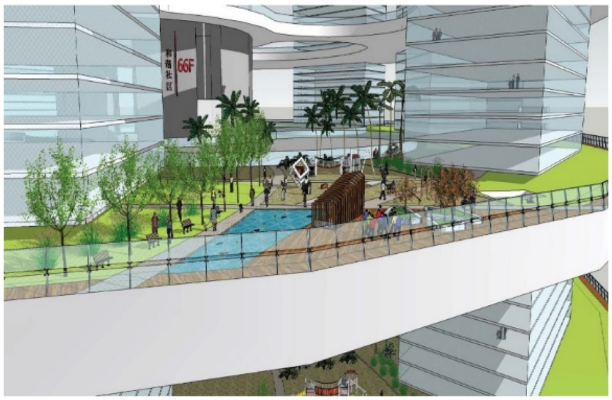
(b) Conceptual section



(c) Connecting to metro



(d) Perspective



(e) Platform

Figure 10. Concept of Sky Town.

as schools, hospitals, clubs, scientific research institute, and office, etc. People are living and working nearby. The platform extends a certain width to block the fire from spreading.

Secondly, tall buildings are connected together as a group. One of them is a traffic core, which is used for vertical transportation and MEP, connecting to the transportation center such as metro, while most of the other tall

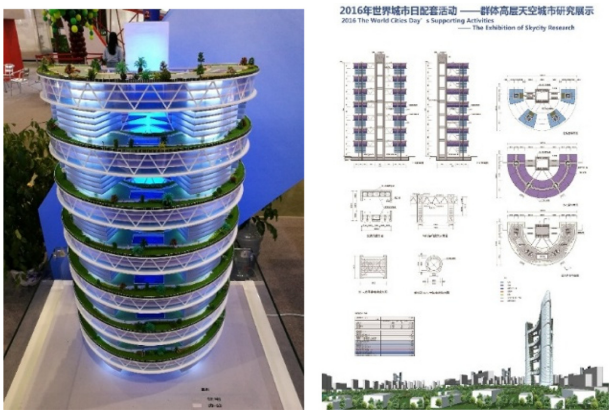


Figure 11. Model of Sky Town on "world city day".

buildings' cores can be very much reduced, so as to achieve maximum efficiency of floor usable area and to give good traffic organization. As everyone knows, the municipal roads are always busy with high efficiency, while other tall buildings only retain a small amount of elevator and stairs. The platform is walk way for pedestrians. All of these form a transportation network.

In order to illustrate my intentions, I have drawn some plans, sections and some details of the innovation. Such as self-balancing large elevator, sky crane, helipad, utilization of high-rise wind energy, photovoltaic power generation by the breast board, using hanging floors to let roof garden free, also hanger is cheaper than column without buckling, using Pillar-Supported Dwelling to return the land to the public, to the nature and so on.

At the end of October 2016, the "world city day" International Forum and Exhibition held in Xiamen, the model of the sky town we made attracted many peoples' attention.

4. The Structure of the Sky Town

After the majority of cores of the tall buildings have been stripped off and merged into a vertical traffic core, the stiffness of a single tall building has apparently become small. So the structure system of this group must be a mega structure. It is like a space bridge. Each building sets on one or several big columns or bridge piers, and the mega structure is formed by them and steel trusses of the large platform. The structure system can be a mega frame or a mega truss, preferably with damping device. As a mega structure, the support of platform truss is not movable, the internal force caused by temperature deformation can be calculated. The temperature stress would not be very big because the column stiffness is not so big.

The ratio of height to width of a mega structure is not that big, such as less than 2:1, so overall stability is not a problem.

How much will the mega structure cost? That's what

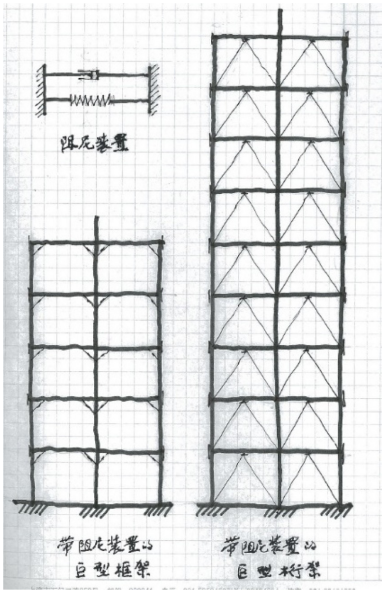


Figure 12. Strucutre of Sky Town.

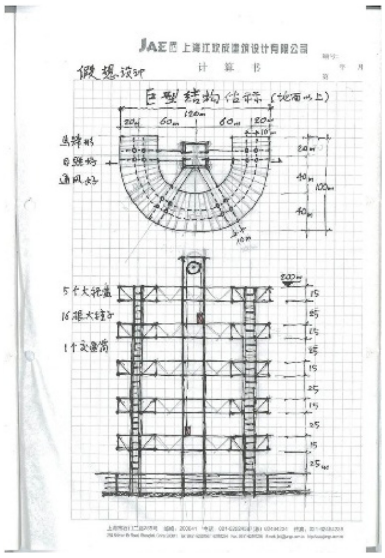


Figure 13. Assumed strucutre for calculating the structure cost.

everyone cares about. In order to know fairly well, I assumed a structure, as shown in Fig.15, which is a 160,000 m^2 complex, and covers a site area of 16,000 m^2, and has a floor area ratio of 10. It consists of 5 tall buildings with a 200 m height and a spacing of 60 m about. It is estimated that the structure cost is approximately 5000 yuan/m^2 (floor area). It fits in with the big concept that usually the steel amount of high-rise building is about 150 kg/m^2, which means that the structure cost is about 1500 yuan/m^2. In this example, the amount of steel is counted as 500 kg/m^2, which is about 5000 yuan/m^2. The mega structure certainly costs more than the ordinary structure, mainly bec-



Figure 14. Raffles City Chongqing.

ause of the large span and heavy load on the platform. Therefore, it is necessary to keep the depth-span ratio of the large platform bigger and to reduce the load on the platform, especially loads on the midspan.

It seems to be quite cost-effective even though it is more expensive than the common structure. Because it borrowed a lot of lands from the sky, and in this example it will be about 100,000 m^2. As land is the most valuable in big city, the land price is up to several tens-thousands yuan per square meter of floor area, while the whole structure is only several thousand yuan. So why not go ahead with it? And it gave a lot of land back to the citizens and to nature. Thus, as long as the government give a little compensation to the developer, such as reward building area of 1 m^2 when increasing 1 m^2 artificial land, developers will have enthusiasm, then the sky town will be settled. I hope my appeal will be supported by government and developers.

5. Refer to the Design of Raffles City Chongqing to Make a Sketch of Sky Town

I would like to say congratulations to Mr. Safdie Moshe for the good job of the Raffles City Chongqing been done when he is going to be 80 years old. Coincidentally, Mr. Moshe and I are the same age, that we were both born in 1938. I would like to take his plan as example to explain my idea.

Reducing the numbers of lifts and the area of all buildings' core, and building a traffic core among those buildings. All mechanical floors are linked together with large trusses, and connected to the traffic core. Each big lift in the traffic core can carry more than 50 people. It can also be combined with some different sizes of elevators just like buses and minibuses. Those elevators only stop at the platform level, and only pedestrian or small battery vehicles will be allowed on the platform. Multi-storey buildings on the platform use small amounts of little elevators for micro circulation. In this way, the floor sizes of each high-rise building are reduced, the efficiency is improved, and room orientation could even be better. The sketch is

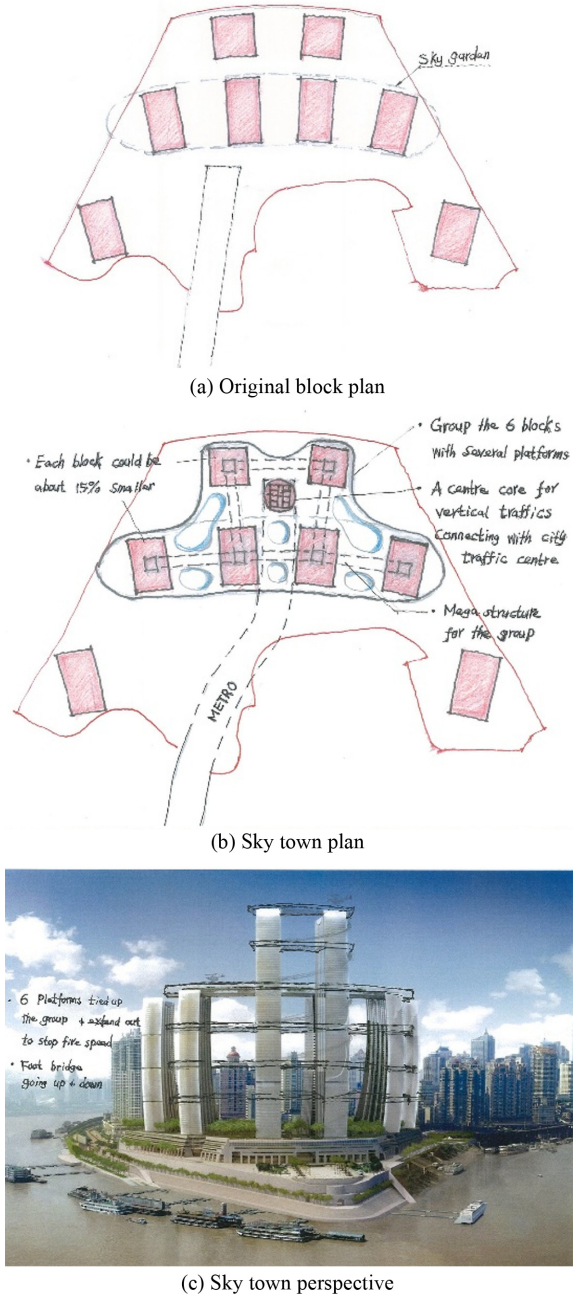


Figure 15. Sketch of Sky Town refer to Raffles City Chongqing.

illustrated as below.

6. Accept the Challenges of Innovation

The company JAE has tried a sky town design by using the project of "Zhenru City Deputy Center in Shanghai" we are recently working on. You may find that 75% of the land becoming the city garden.

Mr. Jiang Chun, Managing Director and Design Principal of JAE (Jiang Architects & Engineers), had used this



(a) Project under construction



(b) Idea of sky town

Figure 16. Comparison between project undergoing and idea of sky town.

concept to provide a design scheme for BiGuiYuan company, and won high evaluation by the experts judges, and received the honor award. He also gave a speech at the CTBUH forum at Shenzhen in 2016. The overall architectural effect of the building was completed very well, but it has not fully reflect my intentions. From the function point speaking, it is better to have two more platforms, and the platform should be extended to block fire and so on.

Any innovation will bring forth many new challenges, and I have listed a number of questions to be further studied, including psychology, sociology, urban planing, architecture, structure, MEP, land scaping, traffic, fire protection, material, energy saving, internet+, construction cost and so on. I am sure that engineers will get a lot of pleasure from the challenges!

7. Conclusion

To let tall buildings be stacking up multi-storey buildings and to combine vertical facilities of single building as the vertical infrastructure for public use are the main points of this paper raised. By this way, the dream of sky city may become true. Prospectively, it might be the direction of tall buildings' revalution.

However, Any innovation will bring forth many new challenges. A number of questions need to be further studied, including psychology, sociology, urban planing, architecture, structure, MEP, land scaping, traffic, fire protection, material, energy saving, internet+, construction cost and so on. Engineers will get a lot of pleasure from these challenges!

References

*Pictures are downloaded from internet.