

RETHINKING ON THE COLLAPSE OF WORLD TRADE CENTER IN NEW YORK

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ABSTRACT

Since the collapse of the World Trade Center (WTC) in New York in 2001 what should we learn from the miserable event is still considerable. According to the construction background in China, the author would discuss it from both the urban planning and structural vulnerability point of view in the present paper. Facing the new 21st Century and the IT Era is it really necessary to build more and more lower Manhattans in the world? It seems absolutely true that the buildings intensive mean people intensive, the people intensive mean treasure intensive, which means the risk intensive. According to the collapse mechanism of the WTC the structural vulnerability, which is defined as the ratio between the local damage and the consequences of that damage in a structural system, should urgently be considered by a quantitative calculation instead of experienced qualitative evaluation.

1. INTRODUCTION

It seems that the urbanization is an irreversible trend in the world. At present the urbanization ratio in China is close to 36%. By prediction the ratio will become 50% in 2020, which is similar with average urbanization ratio in the world at that time (Liu 1997). For developing countries it seems true that when the urbanization ratio is close to 30% around the development of projects on buildings construction and infrastructure systems will increase rapidly. The urbanization ratio at 30%, to some extent, seems a turning point with respect to both state income and personal income (Figure 1). In another words, China is located at the beginning of the economic acceleration. In this case, the government investment in infrastructure is almost 15% of the Gross National Product (GNP) (Table 1). China almost becomes the biggest construction site in the world. In the new century, some largest cable-stayed bridges, some largest arch bridges, almost all of highest concrete dams in the world will be or have been built in China.

On the other side, however, it is well known that there are four serious problems existing in China, which are population, education, energy resources and pollution. For example, China possesses 22% population in the world, but only has 7% freshwater and plowland, 3% forest, and 2% petroleum resources. Besides, some natural disasters happen frequently in China. The annual direct loss from natural disasters is almost 3~5% of GNP

in recent years. 74.5% cities and 85.7% big cities with more than one million people are located in the earthquake region. There are almost 500 counties suffered severe geological disasters in China. Some of them were caused by construction. It is very necessary for China to learn from others, especially from developed countries. From their developing process, not only the successful experience but also the negative lessons should be learnt.

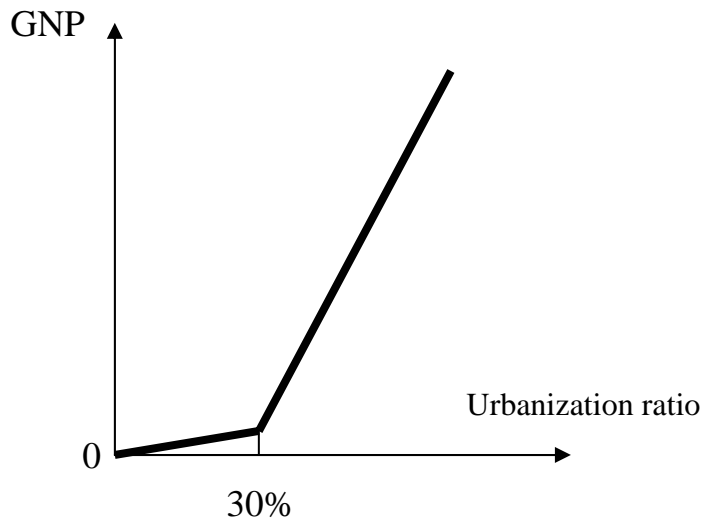


Figure 1: Urbanization ratio vs. GNP for developing countries

Table 1: Infrastructure investment in China (Unit: 1 billion RMB)

	GNP	Infrastructure investment	%
1997	7477.24	991.70	13.26
1998	7955.30	1190.43	14.96
1999	8680.00	1444.00	16.64
2000	8940.36	1342.73	15.02
2001	9593.30	1456.70	15.18
2002	10360.00	1588.00	15.33

Since the collapse of the World Trade Center (WTC) in New York in 2001 two years has passed. What should we learn from the miserable event is still considerable. According to the construction background in China, the author would discuss it from both the urban planning and structural vulnerability point of view in the present paper.

2. ON URBAN PLANNING

After the September 11 Incident, people have come to realize a problem caused by the density of tall buildings. The more concentrated the tall buildings, the more people there will be, and so there will be more

wealth, and in the end, more risks (Liu, 2002). Manhattan in New York is a historical product, which has grown out of the development of capitalism since the 19th century (Figure 2). Unfortunately, however, more and more people like to have the Manhattan style in their own country (Figure 3). In the 21st century, people have entered into the information age. Is it still necessary for thousands of people to work in one building? Is it still necessary to show economic strength by super high-rise building? We need to give it a thought.



Figure 2: lower Manhattan in New York



Figure 3: Lu Jia Zui in Shanghai

It seems that the development of a city can be divided into three stages (Figure 4). The first stage is the “cooked egg” mode, that is, surrounding the city is a “hard cover”, namely, the city wall. The second stage is the “fried egg” mode. Like in Beijing, after the city wall was pulled down, the “second ring road”, “third ring road”, “fourth ring road”, and more ring roads have

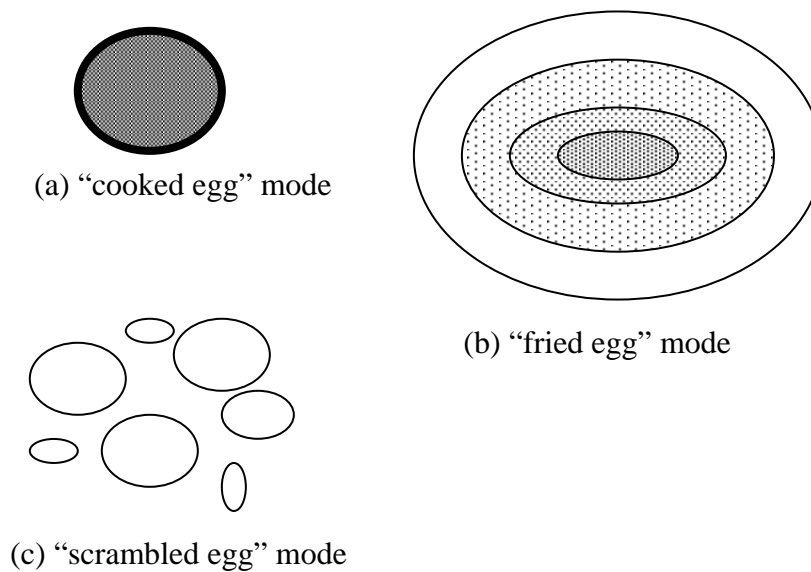


Figure 4: Three stages of city development

been constructed. Because the basic principle is still observed that the flow of people and the flow of vehicles should be concentrated towards the city center, the traffic problem remains unresolved. It is said that a car in the city center of London now travels almost at the same speed as a horse-drawn carriage did a hundred years ago. Today, as the third stage, people hope to take the "scrambled egg" mode that is, dissecting the functions of a large city and trying best to combine the urban and rural areas. Since things are developing in this trend, why should we continue to follow the old path of the western countries? Ray Anderson, former co-chairman of President Clinton's Sustainable Development Council, wrote a very good book entitled *Mid-Course Correction*, which introduces the lessons drawn from the development of the American society. From this booklet, we can not only learn many experiences and lessons, but also feel many things that are nobler and more valuable beyond "the drive of economic interests".

As mentioned previously there are four serious problems existing in China, from strategic point of view the development of middle or small towns has been considered in the majority in China. Even for Shanghai, as a Mega-City in China, people prefer not to build a network system focusing on a certain metropolis with surrounding satellite cities, but a multi-centered regional urban agglomeration emphasizing the integrated regional development.

3. ON STRUCTURAL VULNERABILITY

On the principals in structural design, people are very familiar with adequate safety factors and the adequate control of the design and construction process but they are not very familiar with the adequate

structural robustness (Figure 5), which was considered in practice by expertise from senior engineers. However, the collapse of the World Trade Center, even for most of senior structural engineers, showed an unfamiliar collapse mode. In some special case, the upper part of building becomes a very critical heavy hammer to hit the lower part and makes the building totally collapse. Similarly the consideration on structural vulnerability is also needed in other cases, which can be given as follows.

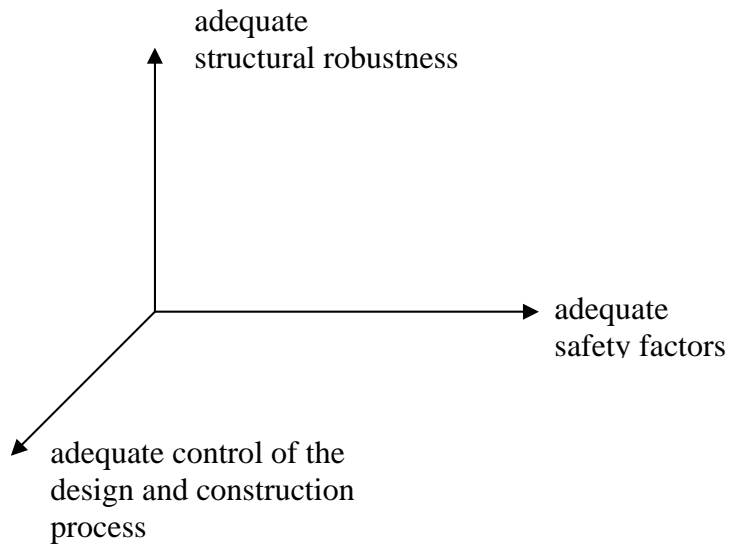
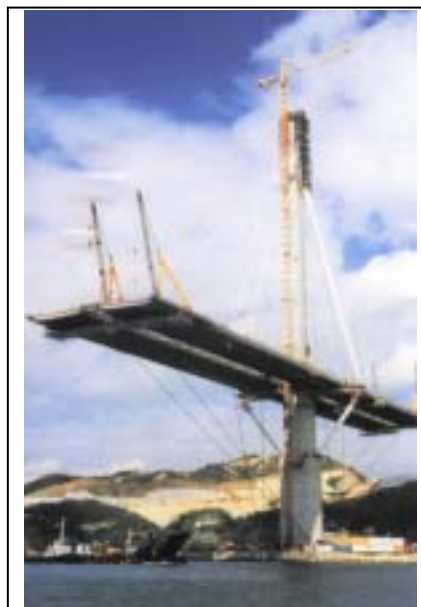


Figure 5: Principals in Structural Design



(a) Cable-stay Bridge



(b) Suspension Bridge

Figure 6: Cable-Supported Bridges during Construction

For Example, according to structural vulnerability during bridge construction the cable-stay bridge in Figure 6(a) is not as robust as suspension bridges in Figure 6(b). For the cable-stay bridge, if some part of

the deck crushes during construction the whole bridge totally fails. But for the suspension bridge it should be better.

Similarly, some sky-lobby in supper high-rise buildings should be very attractive (Figure 7). But from fireproofing point of view it may not a reasonable scheme. It means if the ignition point is just on the deck of the sky-lobby the upper part of the building will perform as a big chimney.

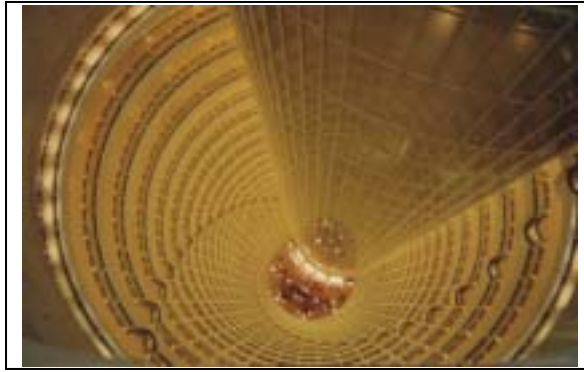


Figure 7: Sky-lobby in a Supper High-rise Building



(a) Bridge Failure after Earthquake



(b) Very Long Bridge across a Bay Area

Figure 8: Long Bridges and the vulnerability

Some long bridges across bay areas, shown as Figure 8 (a) (b) are not robust either. They are typical serial structures. If earthquake, impaction or collision happens and a local part of the structure damages the whole bridge will fail.

The structural vulnerability can be defined as the ratio between the local damage and the consequences of that damage in a structural system. It should be determined by a quantitative calculation instead of experienced qualitative evaluation. The research on structural vulnerability has started for more than ten years. There are several indexes to describe the ratio between the local damage and the consequences of that damage in a structural system. At beginning people like to introduce an index to purely describe the topologic relations between structural elements without considering loading condition (Xin Wu, et al, 1993; Z. Lu, et al, 1999). Now people have recognized that the loading condition of structures, especially the regular dead loads, life loads, even wind loads should be considered. Besides, it is also very important to simulate the collapse process of structures under some unpredictable conditions. In this case, not only some special impacts, such as fire, collision, explosion should be considered, but the calculation models should be improved also. In the new model the non-linearity of materials, the non-linearity of geometry, the dynamic behavior and the discontinuity of displacements should all be considered (Leiming Zhang, Xila Liu. 2000).

4. CONCLUSIONS

- (1) Facing the new 21st Century and the IT Era we have to rethink is it really necessary to build more and more lower Manhattans in the world? It seems absolutely true that the buildings intensive mean people intensive, the people intensive mean treasure intensive, which means the risk intensive.
- (2) According to the collapse mechanism of the WTC the structural vulnerability, which is defined as the ratio between the local damage and the consequences of that damage in a structural system, should urgently be considered by a quantitative calculation instead of experienced qualitative evaluation.

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