Case Studies of Master Planning for Sustainable Urban Underground Space Utilization

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ABSTRACT

Underground space exploitation and utilization in many large cites in China began to get into fast developing stage in recent decade. Sustainable development of underground space is a strategy issue. This paper gives out some principles and construction of master planning of underground space development for several cities of China. Then it introduces case studies concerning the sustainability of underground space development of these cities.

1. INTRODUCTION

Economy growing stably, urbanization is increasing quickly in China. Urban sprawl crowded of people, traffic congestion, lack of parking space and environment problems etc., all these city sickness makes people and government of cities be obliged to find out more proper way for a sustainable developing of their urban space. Compact city is a feasible and necessary way for spatial developing of large cities of China. As a useful method enlarging spatial capacity of a certain area of urban land and a good alternative to solve traffic and environment problem, urban underground space exploitation and utilization began getting into a fast speed developing stage in recent decade in many big cites in China. Obviously urban underground space use is in status of enlargement and acceleration both in scope and in speed. Although there is a good phenomenon of transform from insolate construction of individual underground structures into a synthetically development at certain urban redevelopment projects, most of larger ratio of underground space projects are still in unconscious status without systematic planning and are occupying uninformed layers and locations, forming obstacles to important future infrastructures and losing benefits of integrated planning.

So, in recent years governments of several big cities in China have begun undertaking the master planning of underground space for sustainable developing goals. In cases the authors participated, they made some trials and thoughts about how the underground space could be planned and developed in a much more sustainable way. Investigation and assessment of the natural and human factor conditions relevant to urban underground space were made as fundamental factors for coincidence arrainment choice between qualified underground space resource and the demand of underground space.

2. PRINCIPLES FOR SUSTAINABLE UNDERGROUND SPACE DEVELOPMENT

Underground space exits below surface of urban ground which is the foundation of our city. So we can definite that urban underground space is not only natural resources which human is going to conquer

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and utilize, but also the environmental and base supporting matter of human beings and cities on the
earth. Development and preservation are both important leader factors in planning making and
decision making. In the underground, any modification is difficult and the return to the initial state of
the sub-soil is almost impossible (Besner, 2006). So some principles could be concluded as below for
benefits to sustainable underground space development:

- Proper site choice: suitable natural conditions and proper locations. Harmonic relationship
  between developing activities and resource preservation is the key point to a sustainable
  underground space resource use.
- Plenty of rational and sustainable resources. Investigation and appraisal of underground space
  resource before development and utilization are necessary.
- Integrated planning as a system—planning in a united system for controlling the rational
  resource use.
- Proper functions and utilizations down to subsurface
- Transport-oriented development (TOD) method to guide the renewal of old city and
  development of a new city
- Proper connection and entrance planning
- High quality of construction (structure, water proof, earthquake resistance, maintenance, etc.)

In China, land is owned by public and the country, so it is possible to make integrated planning and
easy to consider the long-time benefit for the city’s entire interesting of the society. For big cities in
China, sustainable underground space developing is an important issue and feasible by efforts.

3. MAIN CONTENT AND STRUCTURE OF MASTER PLAN FOR URBAN
UNDERGROUND SPACE DEVELOPMENT

Among the master planning for underground space development in case examples of cities which the
authors participated: Beijing, Qingdao and Xiamen, some content must be considered for a strategic
study as shown below:

- Study of the status quo of underground space development in case city;
- Investigation and assessment of underground space resource in case city;
- Strategy and steps of underground space development
- Goals of underground space development
- Demand study and possible scale predication
- General functions and planning layout structure type of the city’s total underground space,
  both at plane and at vertical layers divisions

Then in the specific systems of the planning, there are some important contents which consists the
main part of the city’s underground space facilities. Generally speaking, these are:

- Underground transportation systems
- Underground utility systems, including multi-purpose utility tunnels system
- Underground public spaces
- Underground warehouse systems
- Underground disaster space systems

In order to point out the proper direction guiding the underground space development for future, there
must be a perspective looking forward planning image. A set of certain planning index is also
important to request to be satisfied during the phase the planning is being carried out. Among those
factors in the strategy phase, conditions of underground space resources are fundamental data which
represents the influences of natural factors and economic-society factors on the resource’s value and
suitability when it to be developed. This is the objective effecting factor acting as guiding to decision
making in planning and could help to promote the degree of effective, reasonable and scientific
underground space use. In cases of Beijing, Qingdao and Xiamen city, the authors had made
investigations and assessment for their underground space conditions and accomplished their
underground space’ master planning by methodology of resource analysis.
4. INVESTIGATION AND ASSESSMENT OF URBAN UNDERGROUND SPACE RESOURCES

As a kind of natural resources, it is a must to investigate and assess the conditions, quality and quantity, potentials and capacity of the resource before the planning and construction phases. In tables 1 and 2, influence factors and index are assembled for investigation and assessment, and the fundamental relationship is shown between underground space resource layout and the planning demand and optimisation.

Table 1. Structure of investigation and assessment system.

<table>
<thead>
<tr>
<th>Investigation and assessment system of underground space resource</th>
<th>Investigation system of underground space resource</th>
<th>Assessment system of underground space resource</th>
<th>Capacity estimation system of underground space</th>
</tr>
</thead>
<tbody>
<tr>
<td>investigation of underground space</td>
<td>unavailable underground space</td>
<td>serious bad geological structure and serious geo-disaster</td>
<td>active faults etc.</td>
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<tr>
<td></td>
<td>preservation of water source</td>
<td>water source region, ground water pulse</td>
<td></td>
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<tr>
<td></td>
<td>preservation of buildings</td>
<td>relics, important and normal buildings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>constructed underground space</td>
<td>underground buildings, pipelines, traffic facilities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>buried matter</td>
<td>relics, mineral</td>
<td></td>
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<tr>
<td>medium available underground space</td>
<td>green field, water, mountains</td>
<td>relative depth and coefficient</td>
<td></td>
</tr>
<tr>
<td></td>
<td>space below basement of buildings and structures</td>
<td>relative depth and scope</td>
<td></td>
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<tr>
<td>thoroughly available underground space</td>
<td>area planned to be removed</td>
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<tr>
<td></td>
<td>square and vacant space</td>
<td></td>
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<td></td>
<td>space below road</td>
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<td></td>
<td>newly planned areas</td>
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<tr>
<td>assessment of underground space</td>
<td>engineering difficulty; or resource quality</td>
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<td></td>
<td>engineering geological background suitability</td>
<td>geological stability</td>
<td></td>
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<tr>
<td></td>
<td>types and quality of soil &amp; rock</td>
<td>geological stability</td>
<td></td>
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<tr>
<td></td>
<td>hydрадryology suitability</td>
<td>ground water type and relative elevation; groundwater quality</td>
<td></td>
</tr>
<tr>
<td></td>
<td>depth of underground space</td>
<td>0<del>10m; 10m</del>30m</td>
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<td>potential value</td>
<td>space location in the city</td>
<td>centre district of authority and commercial ; Centro district of city landscape and culture</td>
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<td></td>
<td>transportation conditions</td>
<td>subway station; interchanges</td>
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<td></td>
<td>land value</td>
<td>basic land price</td>
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<tr>
<td>capacity estimation of underground space</td>
<td>medium available</td>
<td>green field, water, mountains</td>
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Underground space is difficult to be renewal and has bad reversible characteristic. For example, the rock space could be extended, stretched and maintainable, but could not be resumed for a new design. So, a long-term and long-range plan of underground space utilization is very important for the long-interest of the city. Different kinds of soil or rock are suitable to different types of underground shape, scale and exploitation methods. Constructed city has a lot of kinds of basement and piles in the foundation space below the surface. Different locations of land have different potential values, different functions demand and scales. Thus it can be said that a general investigation and assessment about the underground space resource is the analysing bases of resource conditions for urban underground space planning.

Figure 1 shows the layout of shallow stratum of underground space available for exploitation in Beijing central district; then figure 2 shows the assessment layout of potential value and demand of underground space.

Figure 3 shows the high class location layout and subway lines planning layout in Qingdao City, and figure 4 correspondently shows the assessment of potential value and demand of underground space.

Figure 5 shows the high class location layout and subway lines planning layout in Xiamen City, and figure 6 correspondently shows the assessment of potential value and demand of underground space.
5. COINCIDENT: PLANNING LAYOUT AND ASSESSMENT OF UNDERGROUND SPACE RESOURCE

According to investigation and assessment results for underground space, planners can find the suitable area of which the land block is in planning, including available layout and valuable potential layout of underground space resources. Then planners could make choices and decisions about where and which the mostly demanded areas should be arraigned for underground space use. Figures 7 and 8 show that the planning layout of main public underground space complex in Qingdao City and Xiamen City, were drawn according to and coincide with the assessment results of potential value and demand about each city’s underground space resources. The main centres of the city and most important interchanges of subway systems were assigned as first class target areas prepared for public underground space development, and subway stations are hoped to be the spreading sources of underground space development for each city. Fortunately, these planning results were taken as an especial part to each city’s master planning and will act as guidelines of underground space and regulation for city’s massive projects.
6. CONCLUSION: INTEGRAL MASTER PLANNING AND ORDERLY INDIVIDUAL DEVELOPING

Based on investigation and evaluation of rational and qualified underground space resource, these cases accomplished each city’s master plan for underground space development, including subsurface transportation system, municipal utilities, public facilities, warehousing and etc. Strategy study suggested that underground space should be exploited in chronological order and by layers order. Policy and legal system must be established as guiding and incentive tools. Conclusion shows that plenty of qualified resources, integrated planning, orderly exploitation and legal system are key factors for sustainable development of urban underground space resource. Adding the underground space planning to the city’s two-dimensional surface planning together, forming an integral plan assembling both surface and subsurface information, and inciting development by individuals orderly and chronologically as the policies and legal system set, is a good image for sustainable underground space utilization in China.

REFERENCES