Deep Underground Usage for Effective Executing of City Facility Construction

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ABSTRACT

It is very difficult to construct new city facilities in a high-density big city. We performed underground law revision on 2000 and 2001 to ease the difficulty for the facility construction in Japan. One is the revision for existing city planning law to enable multi-level planning. The other is making new law to limit the right of building owner to construct proper city facilities in deep underground in big cities. A ring road of Tokyo that was a long-time pending problem has begun to execution using these laws.

1. BACKGROUND FOR THE NEW LAW

Lots of the population and economic activity of Japan concentrate on three mega-cities, Tokyo metropolitan area, Chubu area and Kinki area. In the principal cities of these areas, Tokyo, Nagoya and Osaka, land is used in high density and that increase land price. The highly risen land prise sometimes disturbs smooth execution of public projects. In addition, the underground is a saturated condition against the new construction needs of subways, underpass roads and sewages that arises corresponding to expansion of area and higher utility. On this account newly built facilities such as subways are in a deeper underground year by year. The construction cost tends to rise as deepened. From such a viewpoint, 20 years have passed since the necessity of the city planning of the underground was advocated.

2. LAW FOR MULTI-LEVEL CITY PLANNING

2.1 Outline of the low

The plane areas for city planning facilities were subject to limitations on construction both below and above the surface to facilitate development of certain facilities. Permission was therefore required for construction even if it did not affect facility development. The city Planning Law was accordingly amended in May 2000 to enable integrated development of city facilities, having external benefits, and structures in city planning areas and give more freedom to developers by clearly defining multi-level dimensions of city facilities. The city facilities specified under the cabinet order include roads, city rapid transit, water supply, power supply facilities, and rivers. The amended City Planning Law provides that “concerning roads, rivers and other facilities specified in the cabinet order, the three-dimensional space and dimensions of construction can be specified in a city plan for the development of city facilities.” According to the amended law, if the vertical range is to be defined underground, a minimum separation distance and maximum loading (including that specified in response to the separation distance) have to be specified.

The revised law promotes construction of roads under buildings and roads integrated with them (Fig.1).
2.2 Technical examination for defining “a minimum separation distance and maximum loading”

When we construct an underground facility, average pressure of the total loading from the upper side is used for designing. This design condition was applied to the definition for multi level city planning. Minimum separation distance and maximum loading was specified, therefore, any building must be built so as not to bias the load for the facility extremely.

The necessary figure of a minimum separation distance changes with structures of facilities and soil quality. Generally, separation distance has 1~1.5 times as much distance as the diameter (long side of rectangle) of a facility in response to a subterranean distributed angle (approximately 30 degrees). Maximum loading have to be specified in consideration of the earth pressure, the underground water pressure, and the loading caused in the facilities in the subterranean, and the construction and the maintenance of facilities are appropriately done (Fig.2).

![Diagram 1](https://via.placeholder.com/150)

**Fig.1. Example of a multi-level city plan.**

![Diagram 2](https://via.placeholder.com/150)

**Fig.2. Relation of separation distance and loading.**

3. EFFECT OF DEEP UNDERGROUND UTILIZATION LAW

3.1 Outline of the law

Enacted in April 2001, the Deep Underground Utilization Law focuses on the metropolitan areas of Tokyo, Osaka Nagoya and their environs to promote utilization of deep underground spaces. It is based on the premise that if public facilities are constructed in space categorized as “Deep Underground,” they will not affect existing aboveground buildings, including their foundation piles and basements. Therefore, according to this law, when railway or road companies such as some in the Japan Railway group and Metropolitan Expressway Co., Ltd. seek to build a tunnel in a space 40 meters or more under the ground, they are no longer required to receive the consent of parties owning or renting the land above the tunnel, nor are they required to pay them any compensation.
3.2 Definition of the deep underground

Deep underground is defined as deeper space of following two cases:
   i) Space normally not utilized to construct basements. (Deeper than 40 meters from the surface)
   ii) Space normally not utilized for foundation piles. (Deeper than the 10 meters from surface of the bearing layer)

Because of much rain, subsurface water digit is high, and the use of basement is not so popular. In Tokyo where the land use is highest-density, more than 99.9% of buildings are equal to or less than underground the fourth floor. The digit of “40 meters” is calculated as the summation of following three factors; the maximum depth of a basement was set to 20 meters (5 meters per floor), the thickness of the foundation slab (5 meters) and the safety width (15 meters).

Most of all big cities in Japan are located in alluvial plains composed of the weak ground. Then many of buildings set up the foundation piles in the stiff bearing layer in the underground. Bearing layer was set if bearing capacity is more than 2,500kN/m², because many skyscrapers set the upper bound of the permissible bearing capacity degree of the foundation piles at that digit. With consideration of the length of the foundation piles and influence of the deep underground facilities, space normally not utilized for foundation piles was specified to 10 meters deeper than the surface of the bearing layer.

![Fig.3. Definition of deep underground.](image)

4. PROJECT RELATING TO CONSTRUCTION OF PUBLIC FACILITIES USING DEEP UNDERGROUND SPACES (TOKYO OUTER RING ROAD)

4.1 Outline of Tokyo outer ring road

Tokyo outer ring road, total length of about 85km, was planned at radius of approximately 15km from the city center of Tokyo more than 40 years ago. It is designed to divert and disperse traffic concentrate on the inner city. And it is desired to solve the heavy traffic jam in the central area of Tokyo, and makes a smooth traffic network between cities.

It is divided into four sections in the construction situation. The 30 km from Kanetsu Exp. to Jyoban Exp. in the Northern section is opened to traffic. The 20 km from Jyoban Exp. to Higashi Kanto Exp. in the Eastern section is now in progress. And the 20 km from Tomei Exp. to Wangan Exp. in the
Western is currently in the preparatory stage. The 16km from Kanetsu Exp. to Tomei Exp. in the Western section was authorized in city planning in 1966, but it has not been constructed until now.

4.2 Revised city planning from Kanetsu Exp. to Tomei Exp.

As mentioned above, the section from Kanetsu Exp to Tomei Exp was authorized in city planning in 1966, but it has not been constructed because of opposition for the project from the residents along this road. According to the original plan, elevated structure was adopted in this section. In the latter part of the 1960s, the pollution attendant upon the high rate of economic growth posed a major problem in all parts of Japan. In the case of this road, pollution is also an important issue, so this plan was not approved by the residents. In 1970, Minister of Construction said, “It does not have to construct the road until being possible to discuss it with the residents along the road.” According the statement the project was actually frozen.

Since 2000, the government began to try to discuss with the residents along the road again. They discussed 300 times or more about a necessity and a structural form of the road. The main focus of the discussion was about the environment along the road, air pollution, noise, and vibration, etc. As a result, the elevated structure changed to tunnel structure, and then the government could obtain understanding by the greater part of residents. Main part of this road was decided to use the deep underground spaces and connect with the existing trunk roads in junctions. Using multi-level city planning and deep underground utilization law in the section of the deep underground spaces, they ease the conflict between government and resident.

4.3 Effect of the project

After completion of Tokyo outer ring road from Kanetsu Exp. to Tomei Exp., the traffic concentrating on the inner city would decrease 10–20 percents. The effect in terms of environment improvement
due to the decrease in exhaust gas emissions resulting from reduced congestion and travel time is a sheet of Table-1. And the economic effect in Metropolitan area associated with the development of Tokyo outer ring road is estimated to amount to approximately 2 billions euros a year (1 euro = 150 yen).

<table>
<thead>
<tr>
<th>Exhaust Gas Emissions</th>
<th>Annual reduction amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide(CO₂)</td>
<td>Approx. 200,000–300,000 tons</td>
</tr>
<tr>
<td>Nitrogen oxides(NOₓ)</td>
<td>Approx. 300–400 tons</td>
</tr>
<tr>
<td>Suspended Particulate Matter(SPM)</td>
<td>Approx. 15–20 tons</td>
</tr>
</tbody>
</table>

Table 1. Environmental Effect due to Reduced Exhaust Gas Emissions.

4.4 Schedule for the future

The structure of this road was changed from the bridge to the tunnel by changing city planning in April 2007. We keep discussing continuously with the route resident about environmental measures around Junction with the existing road, and we want to start constructing at early time.

Fig. 5. Revised city plan of Tokyo outer ring road.

REFERENCES