REFERENCES


Professor Gosaburo Miki is presently Chairman of EPS Construction Method Development Organization, and Professor Emeritus of Tokyo University, Japan. He graduated with B.Eng., and was awarded the degree of Doctor of Engineering from Tokyo University. From 1951 to 1981, he was Assistant through full Professor of Civil Engineering at Tokyo University. Between 1981 and 1986, he was Professor at Yokohama National University. Professor Miki was President of the Japanese Society of Soil Mechanics and Foundation Engineering between 1980 and 1982.
EPS Construction Method in Japan

Gosaburo Miki
Chairman of EPS Construction Method Development Organization

ABSTRACT: The Expanded Polystyrol (EPS) construction Method was introduced for the first time into Japan in 1985. In the following year, the Expanded Polystyrol Construction Method Development Organization (EDO) was established in Tokyo, which has since been taking the lead in the advancement of the construction techniques employed using EPS. Consequently, in the last 10 years, Japan has become the largest user of EPS for construction works in the world. The original range of its application has been in embankment constructions on the weak ground. In Japan, it has increasingly expanded into road widening works in landslide areas, back filling works of the retaining wall, self-supporting high fill works, and so on. Now, the relatively new EPS construction method has been recognized as an excellent technology, and the international information exchange on it has become increasingly active.

INTRODUCTION

The EPS construction method refers to a procedure for the superlight banking which employs large EPS blocks with specific gravity of 0.02 or so-approximately 1/100 of that of the earth, with the aim of reducing the load applied to the foundation ground. It was brought to the practical use for the first time in Norway in 1972, and before long its application spreads from Nordic countries to the rest of the world. Soon, the EPS block was proven to have the superb self-supporting capability beyond its lightness. So, it has been often used in back filling works of retaining walls, and a self-supporting vertical high fill as tall as 15m was already constructed. Moreover, the EPS block has other advantageous properties. So, many different forms of its application have been developed and employed, especially in Japan.

At a time when just the 10th anniversary of the introduction of the EPS construction method into Japan has been experienced, the author will describe how it was introduced into Japan and how it established its position here. The author will then analyze its outstanding predominance in Japan, where the greatest amount of EPS has been used in the world. Finally, the author will present his opinion as to the future of the EPS construction method.

INTRODUCTION OF THE EPS CONSTRUCTION METHOD INTO JAPAN

In 1972, the first attempt at building a non-subsidence road with large EPS blocks instead of the earth was successfully implemented in a marshland in the suburb of Oslo in Norway. Subsequent results of the EPS construction method in the same country were presented in many different research reports. With only referring these documents, an EPS embankment as large as 470 m² was implemented in Sapporo in August 1985. This was the first EPS fill in Japan.

In June of the same year, the Norwegian Road Research Institute held the one day international conference in Oslo, in an attempt to publicize the EPS construction method to the world. The author and other one concerned happened to attend this conference, where they were convinced of the future potential of this unique construction method. They groped for how to spread this method in Japan, and established the Expanded Polystyrol Construction Method Development Organization in July 1986. This is a group of companies which carries out activities for the technical establishment and the diffusion of the EPS construction method (EDO, 1994). Fig. 1 shows the organization chart of EDO.
TOWARD THE ESTABLISHMENT OF THE EPS CONSTRUCTION METHOD

For the safe usage of fragile-looking EPS blocks in civil engineering works, it is essential to gain a clear picture of its material characteristics. For this purpose, the laboratories of companies affiliated with EDO as well as several universities, have been pursuing research into engineering properties of EPS. The principal items studied were compressive, creeping and frictional characteristics, and behaviors against dynamic and repeated loads. Also, its water resistance and corrosiveness as well as its durability against organisms have been researched (Miki, G., 1995).

The compressive characteristics of EPS are proportional to its density, and are elasto-plastic. Based on the Japanese Industrial Standard (JIS), the compressive strength is rated as the uniaxial compressive strength for a strain of 5%, but EDO establishes the uniaxial compressive strength for a strain of 1% as the allowable compressive strength (Table 1). At present, 6 types of EPS are utilized in Japan, as shown in Table 1.

Table 1  Criterion for EPS’s allowable compressive strength and compressive strength under quality control

<table>
<thead>
<tr>
<th>Type</th>
<th>Density (kg/m³)</th>
<th>Producing method</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unit</td>
<td>In-form foaming</td>
<td>Extrusion foaming</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D-30</td>
<td>D-25</td>
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<tr>
<td></td>
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<td>D-20</td>
<td>D-16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D-12</td>
<td>DX-29</td>
</tr>
<tr>
<td>Type</td>
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<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>29</td>
</tr>
<tr>
<td>Density</td>
<td>kg/m³</td>
<td>90</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>140</td>
</tr>
<tr>
<td>Allowable compressive strength</td>
<td>kPa</td>
<td>Compressive elastic limit</td>
<td></td>
</tr>
<tr>
<td>Compressive strength under quality control (JIS)</td>
<td>kPa</td>
<td>180</td>
<td>140</td>
</tr>
</tbody>
</table>
The first experience on the piling up of EPS blocks occurred with the trial construction work at a material manufacturer’s factory. EDO experienced it for the first time in the ground formation work of a parking lot in Nakatsu-gawa in September 1986, and the block connector tried out there still remains in practical use until now.

In December 1986, EPS as large as 680 m³ was employed in the embankment work of a national highway on a weak ground in Numazu, under the supervision of Public Works Research Institute, Ministry of Construction. Spurred on by this, the application of EPS started expanding into various fields. In October of the following year, EDO itself constructed a 3m high testing road embankment using 350 m³ of EPS, and conducted running tests using dump trucks (Miki, G., 1995). At these construction sites, field observations were always exercised to study the characteristics of EPS embankment, and these contributed greatly to the design and execution practice of the EPS construction method in subsequent years.

After that, the EPS construction method continued to expand in applicable fields, while increasing the actual using volume of EPS year by year.

EPS as large as 17500 m³ constructed as the bank work behind the abutment of Kasai Nagisa-Bridge in November 1988, still remains as the top volume used in one site in Japan (Wano, N., 1996). After that, there came a series of park embankment works that used EPS of greater than 10,000 m³ per site, including one in Kasai Park (Ishihara, K., 1996). The construction work executed in Senmaida area in Ishikawa Prefecture in August 1988, demonstrated the effectiveness of the EPS construction method for the road widening work in areas prevalent to landslides (EDO, 1994). The self-supporting capability of the EPS block is a significant feature, as well as the lightness that it offers. The EPS blocks used at the back of retaining walls have proved to be critical aids in the reduction of earth pressure. Not only that, EPS blocks have also attracted considerable attention as an effective method for self-supporting high fills that have no retaining walls. This year, a fill as high as 15m has been completed at Akagawa Bridge in Hokkaido (Takamoto, A. et al., 1996).

The EPS construction method, which employs pre-fabricated materials produced at factories, is also noteworthy for its excellent workability. In 1990, it gave people much to talk about when a widening work of the railway platform was completed in only midnight 5 hours between the last and the first train. In a construction work of the large scale abutment for a bridge in the sea area, large amount of EPS blocks was buried in the concrete to accelerate the construction work, by taking advantage of the ultra-lightness at the same time (Yoshihara, S. et al., 1996).

Likewise, the EPS method has shown its utility in various types of back filling, construction of temporary roads, as well as embankment buildings in disaster reconstructions. Furthermore, EPS, which has a favorable cushioning feature, has been put to practical use as the cushioning material for roofs over rock fall protection tunnels.

In its early stage, the general design and construction procedures that use EPS had to be partially dependent on Norway, with which Japan had a technical tie-up (Brattensborg, G. A. 1984). Before long, however, EDO itself set up various working groups, through which it has been endeavoring to prepare “the construction manual” and “Price Data for Construction Cost Estimation” applicable to existing conditions in Japan.

In particular, with regard to the earthquake-resistance of EPS, EDO has been using its own budget to devise such measures by exercising laboratory experiments and field measurements (Yamazaki, F., 1996), and to our great satisfaction, it has been shown that EPS construction works suffered nearly no damage in the huge earthquake disasters of Hokkaido and Kobe (Hotta, H., 1996).

The EPS itself is combustible, though, only incombustible blocks are employed in actual construction sites in Japan. It has on occasion, caused a fire in the ground formation work of a park in Kiba, Tokyo. The fire broke out during the covering work on the top surface of blocks that were piled up at 3 or 4 stages, and fire pillars blew up at 46 locations. This accident could be explained as follows: blocks with a curing time of only 3 days or so after forming were used at the site. As a result, the combustible gas used in the block forming process leaked out from inside the blocks and filled the gaps among the EPS embankment joints. The gas then ignited by a spark from the grinder that was being used on the surface area of blocks. To prevent reoccurrence of such accidents, it is now determined that EPS blocks cured for at least 7 days or longer after forming shall be used at construction sites, and more stringent anti-fire managements during construction works have been implemented (Miki, G., 1995).
SPREAD OF THE EPS CONSTRUCTION METHOD

The EPS construction method had been used for construction works at about 1,900 locations throughout Japan by the end of June 1996, and the quantity of EPS employed reached about 1,120,000 m³. Figure 2 shows the shift in the number of times EPS was employed as well as the quantity in every fiscal year.

Fig. 2  Shift in the number and quantity of EPS construction in each fiscal year

![Graph showing the shift in the number and quantity of EPS construction in each fiscal year.]

Fig. 3  Quantity of construction according to application fields of EPS (1995)

![Diagram showing the quantity of construction according to application fields of EPS (1995).]

Fig. 4  Quantity of construction according to using purposes (1995)

![Diagram showing the quantity of construction according to using purposes (1995).]

Figure 3 and 4 show the quantity of construction according to the application fields and according to the using purposes in 1995 respectively. With these figures, we can see various examples of the utility of this method. In addition, Table 1 describes the type of EPS used with the EPS construction method in Japan. To utilize relatively expensive EPS economically, we are trying to use different types of EPS according to using purposes, and also in a field, we are trying to properly use different types of EPS with consideration to the stress occurrence. In connection with this, EDO itself is implementing indoor and field loading tests concerning the
load dispersion characteristics of EPS banking, now.

To popularize the EPS method, which is a totally new construction technique, improving the technical level of EDO members themselves and publicizing this method to the public are both important. With regard to the first point, EDO sent a group to inspect the conditions of this method in Europe on three occasions, and invited a technical engineer from Norway in 1990 to lecture on the EPS construction method. Moreover, EDO distributed research expenses to the development of new techniques and field observations every year, and held meetings to exhibit those results. For the latter point, EDO has requested that members report on EPS construction techniques in research conferences of such as the Geotechnical Society, and EDO itself has also distributed printed materials which introduce construction examples, as well as holding technical meetings in each major region in Japan. In 1993, a textbook concerning this method was published by EDO.

After this method, which is a superlight filling method, was practically introduced into Japan in 1986, various other lightweight filling methods which were largely ignored until then, started to gain the research attention and some of them came to practical use. In the future, the lightweight filling method including the EPS construction method will maintain his positions as one of the important technical field in soil improvement procedures.

The spread of the EPS construction method is no longer not only of interest within Japan. Large-scale construction examples have begun to be reported in North America as well as in advanced European countries. In 1994, international symposiums were held in Hawaii (Pacific Allied Products, Ltd., 1994) and Seoul (Korean Geotechnical Society, 1994). In 1995, a Japanese general construction company implemented an EPS banking in Singapore. The future aims of EDO is to contribute to developing this method in South East Asia.

FUTURE OF THE EPS CONSTRUCTION METHOD

The EPS construction method is, as mentioned above, still creating various examples of its utility to be proud of. However, if compressive characteristics of EPS itself can be improved, it could be more widely used as the roadbed for railways and runways. At the beginning of the 1990s, a compound material made of EPS with embedded reinforcement, was proposed. This will be a subject of future study.

To achieve the integrity of EPS banking, the frictional resistance on the block surface and many block connectors are used now. In contrast, composite blocks combining C and H shaped EPS blocks were finally brought into practical use (Kurose, M., 1996). A method which sets a strip fiber reinforced sheet of approximately 0.3mm thick to the adjacent block surface is also being studied.

With particular attention to the fact that EPS can be used for the self-supporting high banking without a retaining wall, the author has proposed the reduction of cutting into mountainsides as much as possible, and mainly creating EPS bankings in the valley side for the road which is crossing steep mountain slopes. It is excellent as an environmental countermeasure to preserve the nature, and also the cost of construction can be estimated at less than the cost of the conventional cutting and banking balance-type.

When EPS is used for temporary roads, its reuse will be a problem. As the investigation results of EDO prove, there is no degradation of the material under use, and it is recommended to reuse the blocks when they can be collected in their prototype. However, when dismantled by machines, blocks often become damaged, and as EPS directly below the cast-in-place concrete slab is excellent in adhesion, it can not be collected in prototype. We have just recently started to develop a resource preserving technique to reuse EPS blocks which can not be reused as it is, as well as damaged EPS pieces.

CONCLUSION

The EPS construction method is essentially an outstanding method and we think it will further develop in the future. Therefore, in order for this method to be increasingly utilized both inside and outside Japan, regular information exchanges are recommended. It is especially significant that we have had the opportunity to introduce the impressive Japanese EPS construction methods in English, and also to learn about foreign construction methods in this international symposium.