Case History of EDO-EPS method in Japan

Tatsuro Kubota
CPC, Inc., EDO Technical manager
3-23-1 Takadanobaba Shinjuku-ku
Tokyo 169-0075 JAPAN
e-mail : kubota@cpcinc.co.jp

Abstract

I would like to report here some typical cases in which EDO-EPS method (later in this report, shortened to EPS method) has been applied in Japan in the last five years. The EPS method constructions executed during the same period amount annually on an average to 276,000 m² by area, and 760 cases by number. Application for road construction accounts for 85% and the rest varies as such as shake prevention, platform widening, railway, greening, etc. I might do well here by reporting two cases using EPS method for road widening on steep slopes as its application instance to road construction. Then, such seven unique applications are introduced as: light-weight tunnel gate, railway embankment, platform widening, shake prevention measure, green space furnishing, easy make walls.

1. PREFACE

Since introduction of the technology to Japan, application of EPS method to construction projects reached 5,315,562 m³ in 2010 by cumulative total construction volume, and 11,100 cases by number of applied constructions. The figures during one year 2010 resulted in 281,000 m³ and 656 cases respectively. Fig.1 shows in bars the progress of the yearly EPS application volume in each year from 1986 up through 2010. Fig.2 shows in segments the purposes of the EPS applied for road embankments.

According to recent classification by application purpose, road construction shares by far the great majority of the cases, accounting for 85%, followed by airports, buildings, parks, etc. in order of frequency. In EPS application to roads, use for widened embankment shares 50%, followed by back fill of bridge abutment and general embankment both by 20% each, with the rest shared by ground raising, embankment with vertical side walls, etc.
2. RECENT CASES OF EPS APPLIED CONSTRUCTION

Tab.1 lists unique cases recently executed in Kansai district; Fig.3 points their locations on the map.

<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
<th>Purpose</th>
<th>Length(m)</th>
<th>Height(m)</th>
<th>EPS Vol.(㎥)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Miyoshi City, Tokushima Pref</td>
<td>Road embankment widening (Landslide site)</td>
<td>276</td>
<td>6.5</td>
<td>2,400</td>
</tr>
<tr>
<td>2</td>
<td>Hita City, Oita Pref.</td>
<td>Road embankment (Slope)</td>
<td>185</td>
<td>7.0</td>
<td>2,500</td>
</tr>
<tr>
<td>3</td>
<td>Unnan City, Shimane Pref.</td>
<td>Weight decreasing of large culvert embankment</td>
<td>96</td>
<td>13.0</td>
<td>8,820</td>
</tr>
<tr>
<td>4</td>
<td>Kitakyushu City, Fukuoka Pref.</td>
<td>Rail track embankment</td>
<td>44</td>
<td>3.0</td>
<td>300</td>
</tr>
<tr>
<td>5</td>
<td>Nishinomiya City, Hyogo Pref.</td>
<td>Platform widening</td>
<td>60</td>
<td>1.0</td>
<td>110</td>
</tr>
<tr>
<td>6</td>
<td>Fukuoka City, Fukuoka Pref.</td>
<td>Shake Prevention</td>
<td>12</td>
<td>2.5</td>
<td>30</td>
</tr>
<tr>
<td>7</td>
<td>Amakusa City, Kumamoto Pref.</td>
<td>Greening of slope</td>
<td>130</td>
<td>7.0</td>
<td>900</td>
</tr>
<tr>
<td>8</td>
<td>Matsuyama City, Ehime Pref.</td>
<td>Abutment embanking (Easy assemble type)</td>
<td>47</td>
<td>3.5</td>
<td>1,190</td>
</tr>
<tr>
<td>9</td>
<td>Kyotanabe City, Kyoto Pref.</td>
<td>Stepping embankment (Easy assemble type)</td>
<td>22</td>
<td>3.8</td>
<td>700</td>
</tr>
</tbody>
</table>

Fig.3 Location Map of EPS Used Cases

3. CASE HISTORY OF EPS METHOD IN JAPAN

[Case Report No.1][1]

■Location: Miyoshi City, Tokushima Prefecture ■Purpose: Widening of prefectural road embankment (landslide) ■Length: 276m ■Height: 6.5m (Max) ■EPS volume: 2,400 ㎥ (EPS : D-20, D-25)

<Background of EPS Application>
This district is situated at the steep slope in the mountains where it was very difficult to carry in large-sized heavy construction vehicles to operate there and, in addition, the site was situated in an area liable to cause landslide. The EPS method was therefore adopted seeing its advantage of lightweight work and manual work execution. Also, the application of EPS method served to reduce the total cost of the construction work by efficiently minimizing the landslide prevention work, which might otherwise cost a substantial amount. Fig.4 shows the cross-section drawing

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[1] Case Report No.1: A detailed report on the application of EPS method in Miyoshi City, highlighting the unique challenges and solutions implemented to successfully complete the project.
of the site. Fig.5 shows the whole view of the construction site. Fig.6 shows the work effect of the wall panels. Fig.7 shows the concrete slabs and H-beam joined by an anchor that slides up and down to release excessive stress on the unit. Fig.8 shows the condition before casting concrete slabs. Fig.9 shows the completed condition of EPS embankment.

[Case Report No.2]
■ Location : Hita City, Ooita Prefecture ■ Purpose: Widening of Prefectural Road Embankment on steep slope ■ Length: 85m ■ Height: 7m (Max) ■ EPS volume: 2,500 m$^3$ (EPS : D-20, XPE : DX-24, DX-35)

< Background of EPS Application>
The site was situated along a very narrow road in the mountains; besides, its horizontal alignment was very winding. As it had no detour available during the road improvement work, EPS Method was adopted in view of its capability to ensure that the work could be carried
without hindering the current traffic along the road. The slope was as steep as over 60° that stress concentration on the bottom EPS layer was inevitably to occur at the site. It was, accordingly, decided to apply 3 types of EPS blocks, as: DX-24 (XPS, 0.24kN/m$^3$) to the top 1m thick layer, D-20 (EPS, 0.20kN/m$^3$) to the middle 3m thick layer, DX-35 (XPS, 0.35kN/m$^3$) to the bottom 3m thick layer.

Fig.10 shows the cross-section drawing of the site design. Fig.11 shows the base ground excavation work employing a large diameter boring machine. Fig.12 shows the laying condition of EPS blocks. Fig.13 shows the improvement of the horizontal alignment condition before and after EPS method execution.*Upper red circle showing the traffic lane currently in use, secured without being disturbed during the on-going improvement work. *Lower red circle showing the talus (approx. N=10) serving to ease the local stress concentration.
[Case Report No.3]
- Location: Unnan City, Shimane Prefecture
- Purpose: Reduction of overhead load on the arch culvert
- Length: 96m
- Height: 13m (Max)
- EPS volume: 8,820 m$^3$ (EPS: D-12)

<Background of EPS Application>
A large-scale precast concrete arch culvert box (C-Box) was projected to be built under the embankment of an expressway. Planned to be built under the lower part of the embankment slope, the C-Box was left to sustain an unsymmetrical earth pressure along its crown. In order to prevent such a biased ground earth pressure, EPS blocks were applied to the sloping side of the embankment thereby to equalize loads acting on the C-Box. Given the fact that there was no overhead load acting from above, the lowest density D-12 (EPS, 0.12kN/m$^3$) was applied there. Fig.14 shows the area where EPS blocks were applied to prevent the biased pressure. Fig.15 (photo) shows the condition of EPS blocks laid on along the crown line.

![Fig.14 EPS laid zone](image1.png)

![Fig.15 EPS laid along C-Box’s summit line](image2.png)

[Case Report No.4]$^2$
- Location: Kitakyushu City, Fukuoka Prefecture
- Purpose: Railway Embankment
- Length: 44m
- Height: 3m (Max)
- EPS volume: 300 m$^3$ (EPS: D-25)

<Background of EPS Application>
Along with a project to widen a national highway, it turned out necessary to remove the place of an iron works’ industrial railway thatchanced to be located in the way of the road widening work. The embankment under the widening project was originally planned to be completed by the Reinforced Earth method. However, EPS method, which uses such light and ready-to-handle blocks, was adopted in this case, considering the site’s soft ground nature that would affect the existing retaining walls. Due to the strict restriction imposed on retaining the level of railway tracks, the structural design was composed of EPS blocks and concrete piles in order to enhance the total resistive rigidity of the whole EPS embankment against compressive stress. The design also included a 20cm thick concrete slab applied to the base structure of the EPS embankment while 20cm dia. cylindrical shafts were bored in the EPS blocks in two rows for every 2.5m span. The shafts were ten filled with concrete piles of the same dia. Also 40cm thick concrete slabs were placed on the top layer of the EPS structure.

Fig.16 shows the cross-sections of the railway track shift plan. Fig.17 shows the condition of the EPS placed in the embankment. Fig.18 shows the concrete piling work.
[Case Report No.5]
■ Location: Nishinomiya City, Hyogo Prefecture ■ Purpose: Widening of Railway Platform
■ Length 60m ■ Height: 1m (Max) ■ EPS volume: 110 m$^3$ (D-20)

<Background of EPS Application>
Platforms at the railway stations in urban districts are always very crowded with commuters to and from offices, schools, etc. who change trains on the platforms. In Japan, railway station platforms, mostly some 1m high, are in a way dangerous places from where passengers might possibly fall down to the railway track. Repair works of such platforms, therefore, must be carried out speedily during holidays when less passengers move around there. It is for this reason that EPS method was adopted here in view of EPS block’s lightness and use readiness. The EPS blocks, elaborately prefabricated in factory based on the pre-surveyed site condition and dimensions of the installation spot, were transported to the site for on-site assembling so as to help maximize the work efficiency. Such EPS blocks as pre-united with mortar wall, called “wall block”, was also employed to serve to complete the wall at the same time the EPS blocks were installed, so as also to enhance the work efficiency here. Fig.19 shows the site condition before start of the work. Fig.20 shows the condition during the work with EPS. Fig.21 shows the condition after completion of the work with EPS.
[Case Report No.6][3]
■ Location: Fukuoka City, Fukuoka Prefecture ■ Purpose: Road and Vibration Proof Wall (1m wide, 2.5m deep) ■ Length 12m ■ EPS volume: 30 m$^3$ (CD-14: Chip-Drain type)

<Background of EPS Application>
Traffic of large vehicles increased in this district along with the road improvement work started in the neighbourhood. This then caused increase of the ground vibration level, making the local inhabitants complaining to the municipality about the vibration nuisance. Traffic of vehicles in the neighbourhood was 15,000 cars a day on an average. The city government then decided to install EPS applied vibration-proof walls along the ground of the road in question that ran in front of the houses of those who complained. A special type of EPS blocks, called “chip-drain” which is porous and made of compressed products of recycled chips, was applied for the task. Part of such EPS, buried underground, was specially treated on both sides with soil cement that resists buoyancy. Data obtained by measuring the vibration levels before and after construction of such EPS walls indicated a reduction of vibration by 10dB and also that of amplitude by 50%. Fig.22 shows the installation of the EPS wall. Fig.23 shows the result of measuring vibration levels before and after installation of EPS walls.

[Case Report No.7][4]
■ Location: Amakusa City, Kumamoto Prefecture ■ Purpose: Green Space Enclosure Wall ■ Length 130m ■ Height: 7m (Max) ■ EPS volume: 900 m$^3$ (D-16)
<Background for EPS Application>
EPS method was applied to refurbishment work of a museum, seeing the advantage of its capabilities in reducing the earth pressure on the existing walls as well as to its green furnishing effect that would be obtained at the same time. EPS blocks were piled up step on step along the steep slope (1:0.4) and against a 7m high existing wall. Then sodding was done along the EPS steps to complete greening of the wall surface. Sodding is a sheet material spread with seeds on it and united with lightweight earth unit. Fig.24 shows the cross-section of the work site. Fig.25 shows the scene installing the greening units after application of EPS parts. Fig.26 shows the condition of the completed work.

[Case Report No.8][5]
■ Location: Matsuyama City, Ehime Prefecture ■Purpose: Embankment for Abutment Construction ■Length 47m ■Height: 3.5m (Max) ■EPS volume: 1,190 m³ (DX-24H, D-25)

<Background of EPS Application>
Heavy traffic congestion, with the line of cars as long as even 3km in rush hours, used to take place constantly at the site in a provincial city, where the national roads made an at level crossing. In order to resolve the problem, at first, a two-level crossing construction was planned to replace the existing at level crossing. However, the EPS method, with its high workability ensuring prompt ‘start and finish’, came in focus and was finally adopted when further congestion was envisaged to take place once construction work was started at the crossing. Also, ‘Wall-block’, a type of prefabricated EPS block pre-coupled in one body with a mortar wall unit, was applied to the vertical outer walls of the EPS embanked abutment. In consequence, it succeeded in shortening the execution work period by 11 months. Fig.27 shows the position of the EPS embankment for the abutment. Fig.28 shows the completed embankment with EPS wall-blocks.
<Background of EPS Application>

Construction of a bus terminal was planned for a location striding over an underground type expressway (on the upper concrete slab level) where an embanked slope was originally designed to be built as the access for wheelchairs to and from the neighbourhood. Since an ordinary slope embankment made of earth, if built there, was estimated to substantially increase the overhead load on the upper concrete slabs layer, the EPS method was adopted with a view to minimizing the increase of pressure on the upper slabs layer. Simple knockdown EPS Wall was then applied as EPS Wall could be made complete very easily by just joining each knockdown piece with the thin concrete slab counterpart by screwing 4 points at the built-in metal part on the EPS unit (i.e. 4-point screwing assembly). Fig.29 shows the condition of Simple knockdown EPS Wall. Fig.30 shows the completed Simple knockdown EPS Wall.

4. CONCLUSION

I have so far introduced here some of typical application instances of the EPS method in the western Japan for the last five years. Recent trend found out goes that the EPS method applied for road widening embankments on steep slopes is on the increase, and that structures using prefabricated walls such as easy-make walls or wall-blocks are also on the increase.

When it comes about road widening construction works in the steep slopes, meantime, stress concentration on the bottom layer comes up as a problem if the widened embankment becomes higher than a certain level. In such a case it is important to apply high density, strengthened EPS blocks to the bottom layer as well as to give special care for reinforcing treatment on the slope surface to stabilize it.

In Japan, besides these case instances, there are quite a few unique application instances such as preventive use of EPS blocks against falling rocks or rockslide, or protective use of the blocks for historical remains. What with its excellent aseismic property of EPS and what with the high workability by virtue of its light weight nature, EPS method is a construction technology that has
still more application potentials. It is therefore expected to serve as many unique applications as well in the future.

REFERENCES