

# **CONSTRUCTION OF HIGH EPS EMBANKMENT IN HEAVY SNOWFALL REGION**

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## **ABSTRACT**

A report will be made for high EPS embankment construction work in winter in heavy snowfall in Japan. This construction work was a part of YAMAGATA EXPRESSWAY construction, and the site was located in one of the heaviest snowfall region in Japan. It was one of the highest EPS embankments among constructed in a landslide area. Further despite the site was located in the heavy snowfall region, the construction work was required to be done in a winter season due to its rather short construction period. Therefore, the first time in EPS construction works, a roofing system which covered all the construction site was introduced. The roofing system was consisted of 5 units of membrane structure with steel support components so that the height of the roof was easily adjusted as the construction work proceeded. The less friction resistance membrane material was chosen so that snow on the roof could easily slide down to reduce snowplowing works. As a result, a good construction environment was kept even in a severe winter season and the construction was achieved in a shorter period.

**KEYWORDS:** EPS, Expanded Polystyrol, Tent, Lightweight Embankment, Embankment, Landslide.

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## 1. INTRODUCTION

YAMAGATA EXPRESSWAY is about 160 km in total length between MURATA junction, MIYAGI Pref. of TOHOKU EXPRESSWAY and SAKATA city, YAMAGATA Pref. Japan. A section of about 16 km on this expressway between NISHIKAWA and GASSAN has been in-service since October 1998. Many landslide zones in this area have been found and reported since planning of the expressway line (Mochida, 2000 and Tamaki, 2001). Although a 16m high embankment was planned in ISHIKURA construction site in the area, several landslide behaviors were found while the construction was on its way. Therefore construction work had to be done in winter due to pre-determined time for completion.

A landslide task force (Expressway Technical Center, 1999) was organized to study construction methods for restraining and controlling these landslides, and also for a rapid construction.

After its overall study, the task force decided to adopt the EPS (Expanded Poly-Styrene) method. The amount of EPS used was about 15,800m<sup>3</sup>. This paper will report on this high EPS embankment construction work covered with overall working area by a tent structure to make the construction possible in winter in heavy snowfall area in Japan.

## 2. COUNTERMEASURES FOR LANDSLIDES

Typical section of the area has 15 – 18 degree of slope with 8 – 15 degree of moderate slope in some parts. Colluvial deposit due to landslides and detrital deposit were seen on the moderate slope. In August 1997 as the construction of the embankment was in its halfway, deformations on landslide blocks at the roadside area of National Road No. 112 were found. Removing of the surface ground soil of vicinity area and lowering of the ground water level were the countermeasures for this landslide. However, in snow melting season just after the completion of these countermeasures, about 0.2m of swell was found in rice paddy, which was located about 100m lower sides of those landslide blocks. More detailed investigation showed that there was another deeper landslide. The aspect of both landslides were, for shallow landslide; 25m in depth, 80m in width, and 150m in length, and for deep landslide; 70m in depth, 250 in width, and 600m in length.

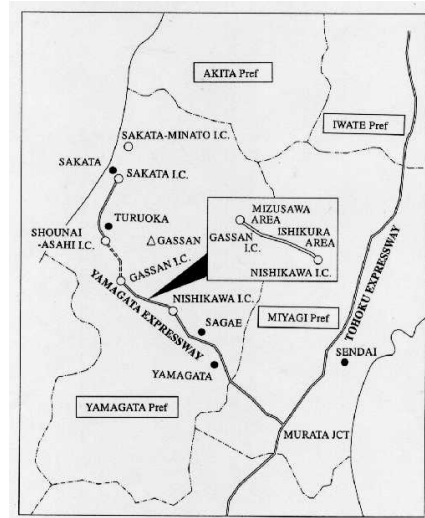


Fig.-1. Location of the site (YAMAGATA EXPRESSWAY in JAPAN).

Further countermeasures for each landslide were planned. A combination of lowering of the ground water level to deep layer, removing of the surface ground soil of vicinity area, and installation of the counter embankment was the countermeasure for the deep landslide. Four catchments-wells into 40 – 50m deep layer, removal of 90,000m<sup>3</sup> of surface ground soil, and counter embankment of 65,000m<sup>3</sup> were made. For the shallow landslide, steel piles were installed as a countermeasure after the lowering of the ground water level. And to decrease the expense of pile installation, surface ground soil was also removed. Further, a lightweight embankment method was adopted for an embankment of the expressway itself to reduce the surcharge on the sliding surface.

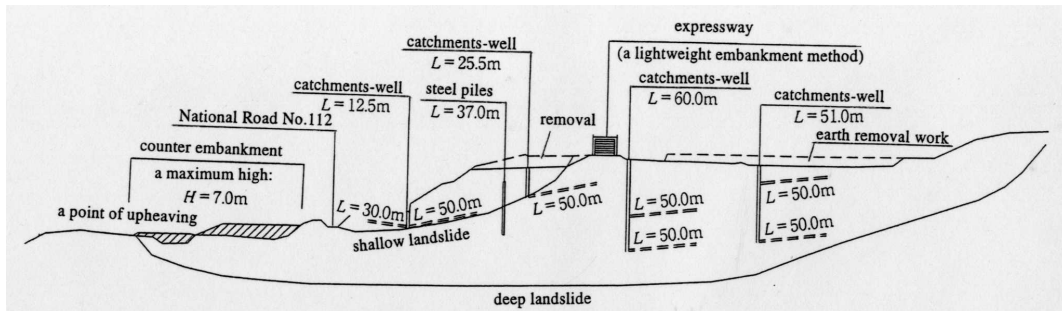


Fig.-2. Countermeasures for the shallow and the deep landslides.

### 3. SELECTION OF THE LIGHTWEIGHT EMBANKMENT METHOD

FCB method and EPS method were both studied and compared. EPS method was adopted because it fulfilled the following requirements,

- 1, the work should be completed in rather rapid construction period because the EXPRESSWAY should be in-service at pre-determined time,
- 2, a 16m high embankment should be achieved with the method, using rather stable material even in a snow falling season,
- 3, the material should reduce the weight of embankment itself to decrease the effect on the landslide activities
- 4, the method should be with good operationabilty to decrease the construction period,
- 5, the work should be done in winter season of heavy snow fall area, and
- 6, the total expense should be reasonable.



Photo -1. Overview of the site.

Although the requirements of 1 to 4 were fulfilled with EPS method, the requirement 5 could not be fulfilled with the method itself. Therefore a tent structure was also adopted as a roofing system

for the construction site to get a large working space even in snow falling season with a reasonable expense.

#### 4. EPS EMBANKMENT

The height of the EPS embankment was about 16m at the highest point. The EPS material used for the embankment was DX-29 (density = 29kg/m<sup>3</sup> and allowable maximum compression stress = 0.14N/mm<sup>2</sup>) for 0.5m of the most upper layer of the embankment and D-20 (density = 20kg/m<sup>3</sup> and allowable maximum compression stress = 0.05N/mm<sup>2</sup>) for the rest of the embankment. The typical section of the embankment is shown in Fig.-3.

Prestressed concrete panels with cavities were used for the facing material of the embankment. Panels were fixed to H-steel stanchions with specially designed clips. A detail for the fixing of panel to H-steel stanchion is shown in Fig.-4.

To avoid the H-steel stanchions to be vibrated, the anchors were used and were fixed into concrete slab. The anchor was fixed to the H-steel stanchion via a sliding fixing device to follow the elastic deformation of EPS material due to the surcharge. A detail for the fixing of the anchor to the H-steel stanchion is shown in Fig.-5.

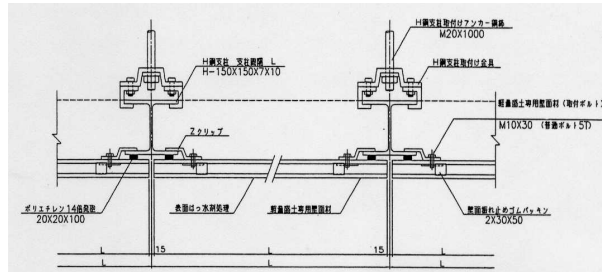


Fig.-4. Detail of fixing the facing panel.

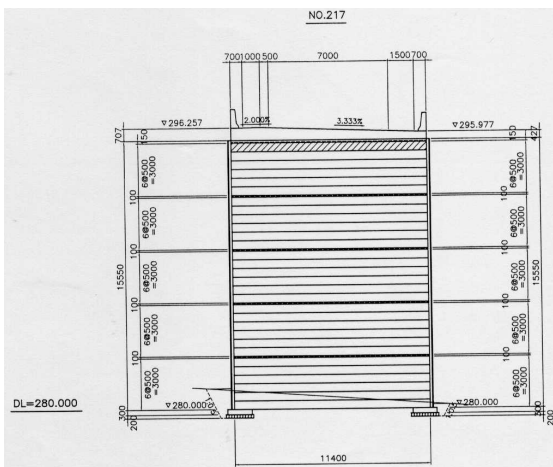


Fig.-3. Typical section of the EPS embankment (No. 217)

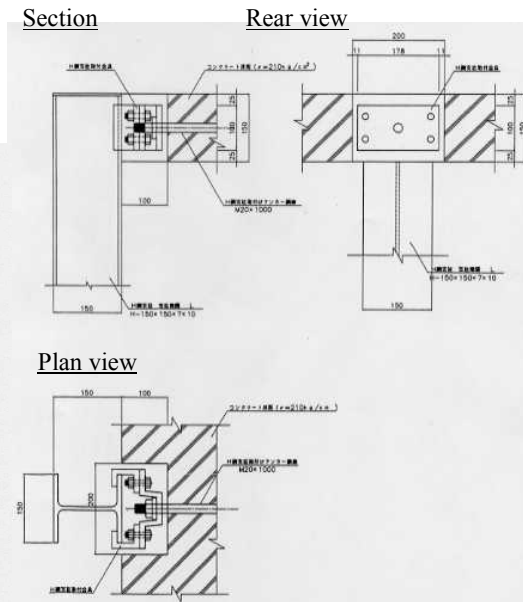


Fig.-5. Detail of fixing the anchor to the concrete slab.

## 5. ALL- WEATHER ROOFING SYSTEM

Because of rather short construction period and requirement for construction work in winter season, a roofing system was set to cover all of the working area of the embankment to get all-weather working area. The advantages of using the roofing system were;

- 1, the construction work could be done in rain or snow,
- 2, the color of the tent membrane was white and transmitting the sunlight to the working area so that no other lighting systems were needed,
- 3, the snow on the roofing system could be easily slide down because the tent membrane was coated with fluorine coating to decrease the friction resistance, and
- 4, the roofing system was so light that it was easy to change its height as the embankment construction work proceeded.

### 5.1 DESIGNING CONDITIONS

Maximum wind velocity: 40m/sec, and

Maximum snowfall load: 1kN/m<sup>2</sup>.

### 5.2 ASPECTS OF THE ROOFING SYSTEM

#### < STRUCTURAL STEEL >

Dimensions:

Width 12.15m X Length 13m / unit X 5 units,

Slope of the roof: 30 degree, and

Weight: 45kN/unit.

#### < MEMBRANE >

General name of the material :

PVC-Polyester fabric with fluorine coating,

Tensile strength :

machine direction X cross machine direction

> 1.25kN/3cm X 1.25kN/3cm, and

Weight of membrane: 625 (+40, -40) g/m<sup>2</sup>.



Photo-2. All-weather roofing system.



Photo-3. Installing the EPS blocks.

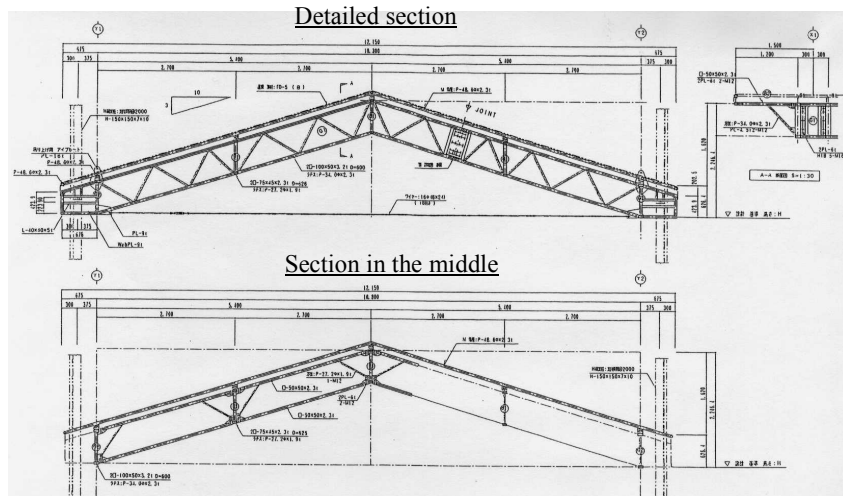


Fig.-6. Typical section of the roofing system.

## 6. CONSTRUCTION OF THE ROOFING SYSTEM

As shown in Fig.-7, EPS installation and all-weather roofing system setting were conducted as follows. After placement of concrete footing and installing the H-steel piles, the all-weather roofing system was set on top of the H-steel piles. Hydraulic cylinders, which were set on the roofing system, were used to fix the roofing system to the H-steel piles. Thus working space for all-weather condition was obtained. As the construction work proceeded with installing of facing panels and EPS blocks, the height of the working space would get shorter. Then before the distance between the top of embankment and the roof got too short for the work, the roofing system was removed temporarily using a crane. And again the roofing system was set to top of the H-steel piles, which were longed with new H-steel piles. By continuous work of the above, the roofing system was removed after the completion of the embankment. And final pavement was made.

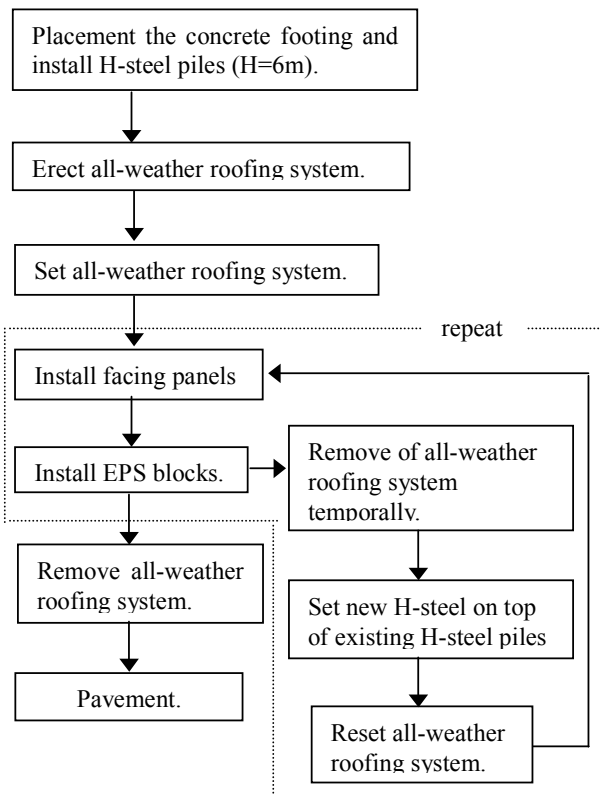


Fig.-7. Construction procedure.

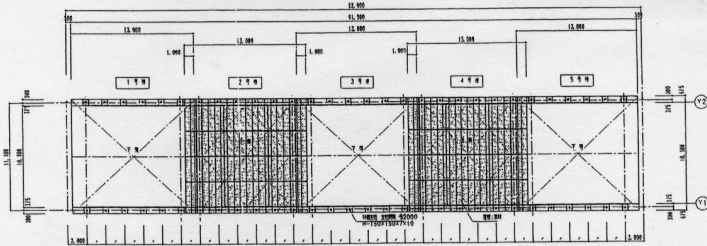


Photo-4. H-steel piles and facing

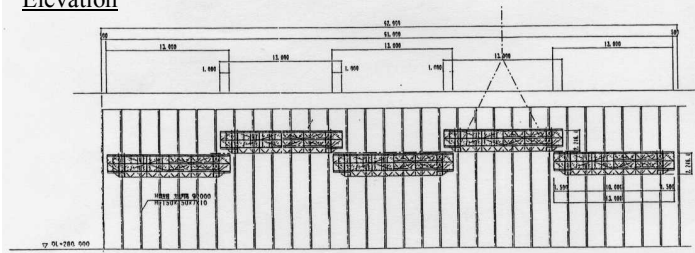


Photo-5. Stands for hydraulic

Plan view



Elevation



Section

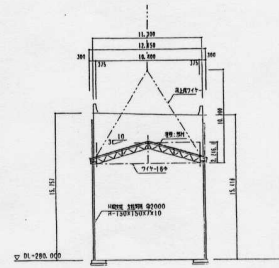


Fig-8. All-weather roof



## 7. CONCLUSIONS

This construction work was not only the case that was a large EPS embankment construction on landslide area, but also the case that showed a possibility of construction in a heavy snowfall region in winter by using the roofing system, which was fixed on top of H-steel piles. This construction method is effective not only for a construction in a heavy snowfall region in winter but also for a construction in a rainy season or region, because,

- 1, the EPS embankment can be easily constructed,
- 2, the working space for all-weather can be obtained, and
- 3, the roof itself is made of membrane material so that the roofing system is light weight and snow on the roof will easy to slide down.

Since snow could be “light” or “wet and heavy ” depending on the season or the region, there may be a period that snow will not so easy to slide down. Actually, the period when “wet” snow fell heavily, as it is typical in the Sea of Japan coastal region, we had to remove the snow on the roofing system since the snow on the roof did not slide down by its weight. Improvement on the roofing system, such as modification on a roofing slope or introducing a roof with double-layered membrane, should be made to meet the variety of environmental conditions.



Photo-6. Completion of the 1st-period construction.



Photo-7. Completion of entire construction.

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- Expressway Technical Center (1999) Report on the study of countermeasures for landslides at NISHIKAWA area of YAMAGATA EXPRESSWAY (in Japanese).



Fig.-1. Location of the site (YAMAGATA EXPRESSWAY in JAPAN).

Fig.-2. Countermeasures for the shallow and the deep landslides.

Fig.-3. Typical section of the EPS embankment (No. 217).

Fig.-4. Detail of fixing the facing panel.

Fig.-5. Detail of fixing the anchor to the concrete slab.

Section

Rear view

Plan view

Fig.-6. Typical section of the roofing system.

Detailed section

Section in the middle

Fig.-7. Construction procedure.

Placement the concrete footing and install H-steel piles (H=6m).

Erect all-weather roofing system.

Set all-weather roofing system.

Install facing panels.

Install EPS blocks.

Remove all-weather roofing system.

Remove of all-weather roofing system temporally.

Set new H-steel on top of existing H-steel piles

Reset all-weather roofing system.

Pavement.

Fig.-8. All-weather roof

Plan view

Elevation

Section

Photo -1. Overview of the site.

Photo-2. All-weather roofing system.

Photo-3. Installing the EPS blocks.

Photo-4. H-steel piles and facing panels.

Photo-5. Stands for hydraulic cylinders.

Photo-6. Completion of the 1st-period construction.

Photo-7. Completion of entire construction.