Intern rapport nr. 1511

SEMINAR ON THE USE OF EPS

IN ROAD CONSTRCTION

JUNE 21st 1991, LYSEBU OSLO

JULI 1991

VEGLABORATORIET

INTERN RAPPORT

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Vegdirektoratet

Veglaboratoriet

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TITTEL

Seminar on the use of EPS in road construction.
June 21st 1991, Lysebu Oslo

SAKSBEHANDLER

Navn	Institusjon
	EPS Development Organisation,
	Japan
T. E. Frydenlund	Norwegian Road Research Laboratory

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SAMMENDRAG

I et seminar arrangert fredag 21. juni 1991 på Lyseby i Oslo ble eksempler på bruk av Ekspandert Polystyren (EPS) som lett fyllmasse i Japan og Norge presentert. Rapporten gir en dokumentasjon av nevnte eksempler.

Proceeding foam a seminar on the use of Expanded Polystyrene as a light fill material in Japan and Norway held at Lyseby in Oslo on June 21st 1991.

FAG-OMR.	IRRD kode
Stabilitet og setninger	42.1

NØKKELORD	
Fylling	2801
Stabilitet	5930
Ekspanderte materialer	4502
Polystyren	7422
Setning	5792

*) N - ny O - oppdatert

**) FoU - forskning og utvikling K - konferansebidrag O - oppdrag
F - forskrifter/normaler A - artikkel

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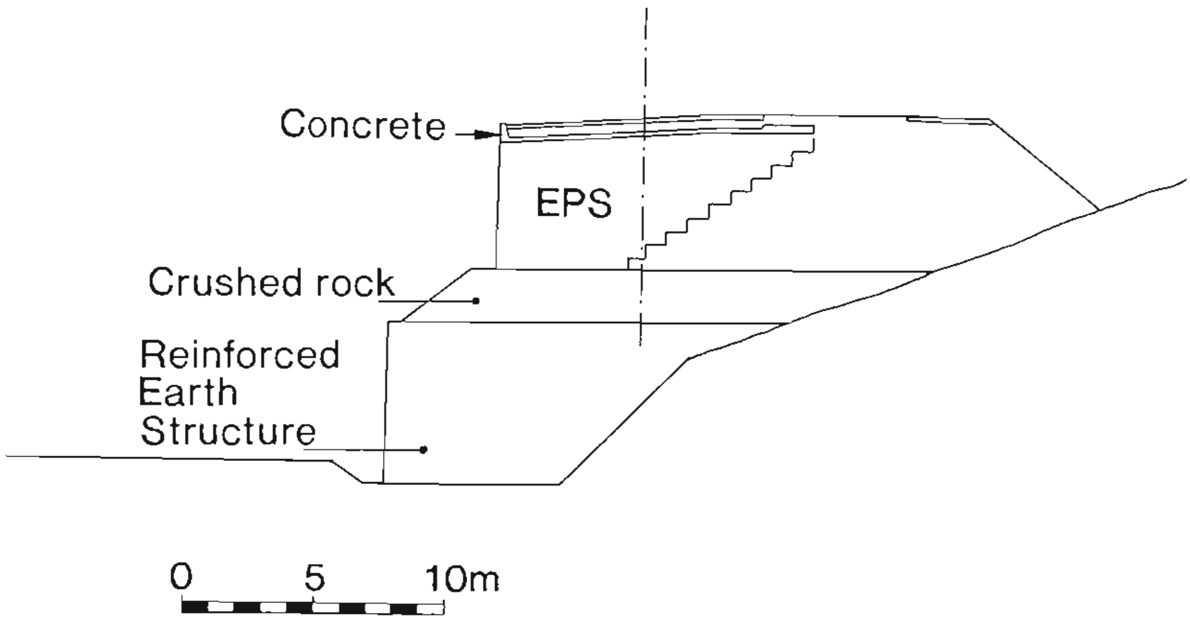
Norwegian Road Research Laboratory

SEMINAR ON THE USE OF EPS IN ROAD CONSTRUCTION
JUNE 21st 1991 LYSEBU, OSLO



Combined Reinforced Earth and EPS-structure

SEMINAR ON THE USE OF EPS IN ROAD CONSTRUCTION

JUNE 21ST 1991, LYSEBU OSLO

09.00 - 09.15	Opening of seminar	Dr. K. Flaate Mr. Okuzuno
09.15 - 09.25	CEN-specifications	T.E. Frydenlund
09.25 - 09.50	Løkkeberg intersection	R. Aabøe
09.50 - 10.10	Railway underpass at Bøle	T.E. Frydenlund
09.10 - 10.20	Euroroad E 18 in Vestfold	R. Aabøe
10.20 - 10.45	New highway 181 at Eidsvoll	E. Hagen
10.45 - 11.00	Coffee break	
11.00 - 12.30	Presentation by EDO members	
	Enlargement of road by EPS on steep slope	
	Enlargement of platform by EPS at Haijima station	
	Embankment of road by EPS in the landslide area	
12.30 - 13.30	Lunch break	
13.30 - 17.00	Field trip to Eidsvoll by bus to visit EPS site.	

Standardisation activities within CEN

T.E. Frydenlund
NRRL

1991-06-19

Standardisation activities within CEN

By senior engineer Tor Erik Frydenlund
Norwegian Road Research Laboratory

Within the European community (EC) and EFTA (European Free Trade Association) countries rather hectic activities are presently taking place regarding standardisation of products and equipment. This is in part connected to the time schedule set for the opening of the internal market within the EC countries in 1992. The activities are coordinated through CEN = Comitė Europėen de Normalisation and the work is carried out through Technical Committees (TC), Subcommittees (SC) and Working Groups (WG). Standards approved through the CEN system will automatically become standards in EC and EFTA countries respectively.

Within the road sector the following technical committees are of special importance.

TC 19	Methods of tests and specifications for petroleum products
TC 154	Aggregates
TC 226	Road equipment
TC 227	Road construction and maintenance materials for roads, airfields and other trafficked areas.

Within TC 227 a Working Group Liason (WGL) has been established in order to keep an update on road related activities in other TC's and make an assessment of the collected information (drafts of standards) to check that it meets the requirements of CEN/TC 227. WGL should also recommend any additional requirements needed for road application as a basis for extension of the drafts or the standards by the relevant liason-TC.

In relation to TC 88 on "Thermal insulating materials and products" the WGL will review the requirements for roads. In this connection the standardisation of polystyrene blocks used as a light fill material has been raised. A memorandum has been put foreward from Norway to be discussed by the WGL. Here various material requirements and testing methods which may be standardised are pointed out. A copy of the memorandum is enclosed.

In addition to the CEN activities, the present specifications for EPS used as a light fill material in roads in Norway are presently beeing reviewed by the Norwegian Road Research Laboratory. This work is not completed, but major changes in the present specifications are not expected.

MEMORANDUM For: CEN/TC 227/WGL

May 3, 1991

REGARDING POSSIBLE STANDARDIZATION OF POLYSTYRENE BLOCKS

CONTENTS

Memorandum prepared by:

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Abstract

CEN/TC 227/WGL has determined to prepare a paper regarding the possible standardization of polystyrene blocks intended for light weight road fills (Resolution 18, Stockholm, March 21-22, 1991).

This memorandum discusses the aspects of polystyrene blocks for super light road embankments, with regard to testing methods and standardization of the material. As far as possible, this should be in accordance with the CEN regulations for similar materials, but should also take into consideration the properties that are of particular interest for road applications.

Background

Expanded Polystyrene (EPS) blocks have been used for nearly 20 years to build super light road embankments. To our knowledge, it is being used in Norway, Sweden, U.K., Ireland, France, Netherlands, Canada, USA, and Japan. Due to the low unit weight characteristics, EPS blocks may both technically and economically provide advantageous solutions to stability and settlement problems often encountered in soil mechanics engineering.

So far, product standardization, testing methods (quality control) and design guidelines for the use of EPS blocks have been handled by each user country individually. Occasionally, there have been incidents where the material requirements have not been fully understood, neither by the customer nor by the contractors and the EPS manufacturers.

There is a certain amount of EPS trade between countries, consistent testing methods and product standardization should therefore be brought into existence.

Past and present use of EPS in road fills

A very rough evaluation of past and present EPS use for light weight road fills is shown in the accompanying table.

Country	Previous use, total (approx.)			Current use (approx.) 1991	
	Number of projects	Volume EPS m3	Period	Volume m3	
Norway	150	250.000	1972-90	30-40.000	
Sweden	> 25	150.000	-90	30-50.000	
Finland	1				?
United Kingdom	> 3		-90	35-50.000	
Ireland	2		(1990)		?
France	20 ?	> 15.000	1984-90 ?	5-10.000	?
Netherlands	20 ?	> 55.000			?
Canada/Br.Col.	?	45.000	(1985)		?
Japan	150	130.000	1985-89	100.000	

Standardization

In general, standardization of polystyrene blocks could include the following items:

A - product standardization and material requirements
B - testing methods and quality control
C - design guidelines for the appropriate applications

Product standardization and material requirements (A)

Polystyrene blocks for light weight road fills ought to be standardized, or at least it should be checked that the material requirements for road fill applications are not in conflict with any existing product standards for polystyrene products. Specific descriptions may be worked out for:

TYPE OF CHARACTERISTICS	IMPORTANCE
- compressive strength category (nominal)	Primary
- nominal dimensions (block size)	Primary
- tolerances for shape and dimensions	Primary
- fire resistance (chemical composition)	Primary
- density category (nominal density)	Secondary
- other parameters	Secondary

Material requirements, as part of current design guidelines for light weight fill EPS blocks, apparently vary from one country to another, and so do the testing methods.

In each of the EPS characteristics mentioned above, several requirements, test procedures, and tolerances, exist today. Some requirements and test methods may be quite specific for the type of application in question, namely light weight fills. This would certainly include tests that are not among the proposed tests in CEN/TC 88 (thermal insulation).

Design guidelines (C)

Each user country seems to have their own design guidelines for the use of EPS blocks in road constructions. In general, the design will depend on the type of construction considered, and it may be argued that the coordination of design guidelines should not be included in the present CEN standardization work. Items that could be considered for design standardization are, however:

i) Permissible stress level in EPS blocks
ii) Design criteria for type and thickness of pavement construction on top of the EPS fill
iii) Protection against fire hazards and chemical dissolving agents
iv) Laying pattern for blocks in multi-layer fills
v) Use of temporary anchoring (timber fasteners) during the construction period

In any case, national design guidelines in "CEN countries" will have to be adjusted to any new CEN standards regarding material requirements and testing procedures for EPS products.

Proposed items in a standardization programme for EPS blocks

In the initial phase of this work, efforts should be focused on product standardization/material requirements (A) regarding:

- chemical composition (including additives in fire resistant EPS)
- compressive strength
- geometric requirements

Specific tests and procedures possibly being involved (B)

- sampling procedure (samples for compression test)
- density and density distribution (the material may be non-homogeneous)
- dimensional shape and tolerances
- compressiive strength test
- creep test
- fire resistance test
- other tests and requirements?

Løkkeberg intersection

Roald Aabøe
NRRL

Temporary overpass bridge founded on expanded polystyrene

Pont de passage temporaire fondé sur du polystyrène gonflé

HARALD SKUGGEDAL & ROALD AABØE, Norwegian Road Research Laboratory, Norway

ABSTRACT: A new temporary one lane steel bridge has been built across Euroroad E6 at the Løkkeberget intersection in the County of Østfold.

The bridge and adjoining embankments are located in an area with soft clay deposits. In order to solve stability and settlement problems in the embankment a light fill material, expanded polystyrene (EPS) which is 100 times lighter than ordinary fill materials, was used. This provided an opportunity for placing the bridge foundation directly on the 4,5 m high EPS fill.

The EPS material below the bridge abutment has been instrumented in order to measure the stress distribution and the deformation of the EPS blocks.

RÉSUMÉ: Un pont temporaire à une voie, en acier, a été construit sur la E6 à un croisement de routes.

Le pont et ses remblais sont situés dans une zone de dépôts d'argile tendre qui recouvrent l'assise rocheuse. Pour résoudre les problèmes de stabilité et tassement dans les remblais on a utilisé un matériau léger de remblayage, du polystyrène expansé (EPS), ce qui a permis de faire reposer les fondations du pont directement sur un remblayage d'EPS de 4,5 m de hauteur.

Des instruments ont été placés dans le polystyrène expansé sous les butées du pont pour mesurer la répartition des charges et la déformation des blocs d'EPS.

INTRODUCTION

The County of Østfold Highway Authority have constructed a bridge across Euroroad E6 at the Løkkeberg intersection close to the Swedish border. Here left turning traffic on National Road 21 from the City of Halden going south on E6 is provided with a flyover in order to improve traffic safety at the present at-level intersection. This is a temporary solution pending the completion of a new E6 motorway to the Swedish border in five to six years. A plan view of the intersection is shown in fig. 1:

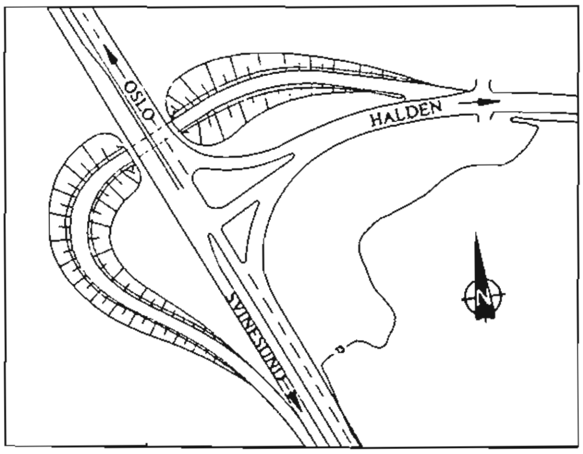

Fig. 1 Plan view of Løkkeberg intersection

SITE CONDITIONS

The bridge and adjoining embankments are located in an area with soft clay deposits overlaying rock. Beneath a drying crust of about 1,5 m the soil layer has a thickness from 6 to 16 m and consists mainly of quick clay. Oedometer tests indicate that the clay is somewhat overconsolidated. The preconsolidation effect, which is of the order of 60 - 70 kN/m^2, coincides well with the maximum bearing capacity of 60 kN/m^2. Settlements in the order of 20 - 30 cm are therefore expected, even if the bearing capacity is fully utilized.

DESIGN SOLUTIONS

A one lane Acrow steel bridge with a span of 36,8m and width 4,1 m has been used. Design live loads are according to the Nordic Load Specifications BK 10.

In order to provide a safe design in relation to bearing capacity and settlements, the use of expanded polystyrene (EPS) as a light fill material in the embankments adjoining the bridge was considered in the early planning stages. Since the bridge is only a temporary solution, the EPS blocks may be reused in later projects. This will also reduce the total project costs.

In Norway we have almost 20 years experience using blocks of expanded polystyrene (EPS) as a fill material to reduce stability and settlements problems when roads are constructed across soft clay deposits or peat bogs.

The unit density of polystyrene is about 100 times lighter than ordinary fill material, and the material properties match the load conditions in a road structure. Today, close to 150 road projects involving the use of polystyrene blocks have been successfully completed in Norway with volumes varying from a few hundred to 12000 cubic metres. The total volume of EPS used in road constructions in Norway is approaching 250000 m^3 .

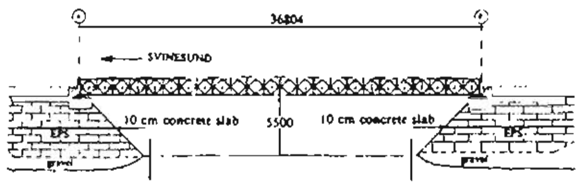

Fig. 2 Longitudinal profile Løkkeberg bridge

This project provided an opportunity to investigate the possibilities for placing the bridge foundations directly on the EPS fill, fig. 2. The alternative would be to support the bridge on end bearing piles to bedrock.

Design calculations showed that the bridge foundations could be supported by the EPS fill provided the EPS blocks could sustain a load of 60 kN/m² exclusive live loads and material factors. Fill geometry and the bridge abutments have been designed so that both vertical and horisontal loads including braking forces will be accomodated. In the design a value of $\mu = 0.7$ have been used for the coeffcient of friction between the EPS-blocks. The same value has been utilized for friction between blocks and the layer of noncohesive soil beneath the blocks.

Since the bridge is temporary and possible deformations may be adjusted during the period of operation, it was decided to carry out the project as a full scale test.

CONSTRUCTION DETAILS

The construction began in September 89 and was finished in Desember 89. Both bridge abutments are supported on 4.5 m high EPS embankments.

In the upper EPS layer just beneath the bridge abutment a compressive strength of at least 200 KN/m² was specified corresponding to a unit density of about 40 kg/m³ for the EPS blocks. Further down in the remaining upper half of the fill, blocs wih a compressive strength of 150 KN/m² was applied. For the remaining lower half of the fill and also for the embankments leading up to the bridge the ordinary EPS quality of 100 KN/m² was used. A total of 4600 m³ of EPS was used at the Løkkeberg intersection.

In the middle of the EPS fill a 10 cm concrete slab was cast. On the embankments leading up to the bridge abutments another slab was placed.

The geometry of the abutment is 7.4 * 7.5 meter. The foundation is 1.0 m thick directly under the bridge support and 0.5 m on the remaining part as shown in fig. 3.

Shotcrete was sprayed on the front slopes of the EPS while ordinary soil protection was provided on the side slopes.

The total pavement thickness constructed on top of the bridge abutments is 80 cm.

FIELD OBSERVATIONS

In order to observe the stress distribution in the EPS material below the bridge abutment during construction and on long term basis, 10 hydraulic earth pressure cells (Gløtzl) have been placed at different levels in the fill. The location of, and results from, the cells are shown in fig. 5.

Observations indicates that cell boundary effects may have influenced stress results, especially in the first loading stage. This is probably due to the installation tecnique of the cells between the blocks.

Deformation is being monitored by a system of telescopic rods through the entire EPS fill and through various layers of EPS. Precision levelling is being performed both on these rods and on bolts in the bridge abutment during and after construction. In addition settlement tubes were installed at two levels to monitor vertical deformation in the cross-section of the embankment. Observations will continue as long as the bridge is in operation.

EXPERIMENTAL RESULTS

So far, 10 months after the completion, the observations show encouraging results. There are no signs of cracks or deformation of the construction.

Small deformations have been measured in the EPS fill, totally approx. 1 % of the EPS height. About half of the deformation, 3.8%, is found in the lowest cm layer of EPS, fig. 3. This may be explained by the
high stress values measured at this level during and soon after the construction was finished, fig. 4.

The deformation came rather immediately and there are no signs of creep effects in the EPS so far, fig. 4, although the static load is about 60% of the compressive strength.

Compared to laboratory tests on 5 cm specimens of EPS carried out by the BASF company (supplier of EPS) the creep deformation should have been at least 2-3 %.

Results from the pressure cells are shown in fig. 5. They correspond well with the deformation measured

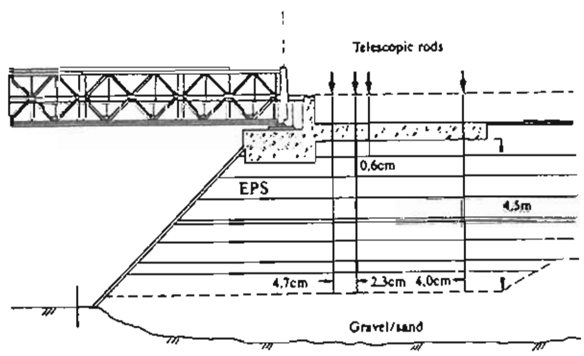

Fig. 3 Deformation of the EPS layers.

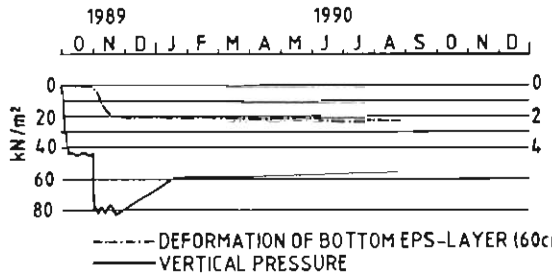

Fig. 4 Creep effect of EPS

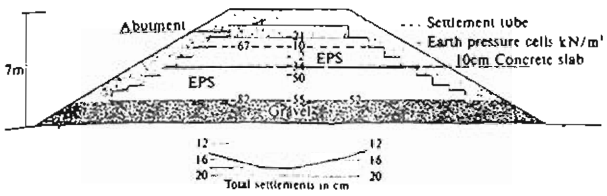

Fig. 5 Stress distribution and settlement conditions in the EPS fill

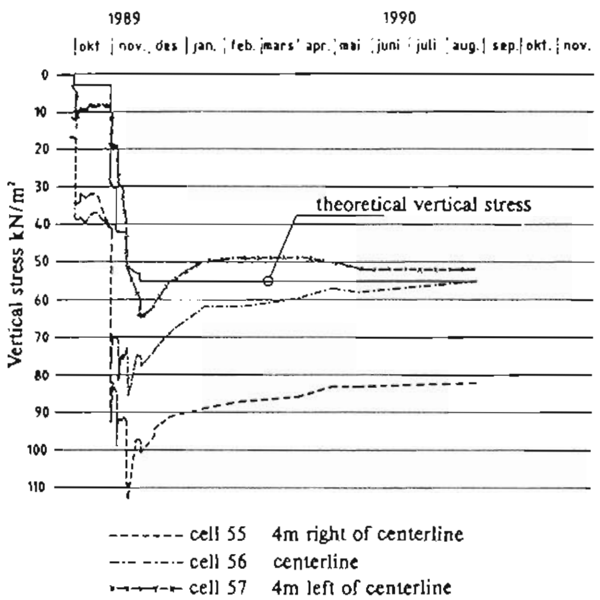

Fig. 6 Long term stress results measured on stress cells in the bottom of the EPS fill.

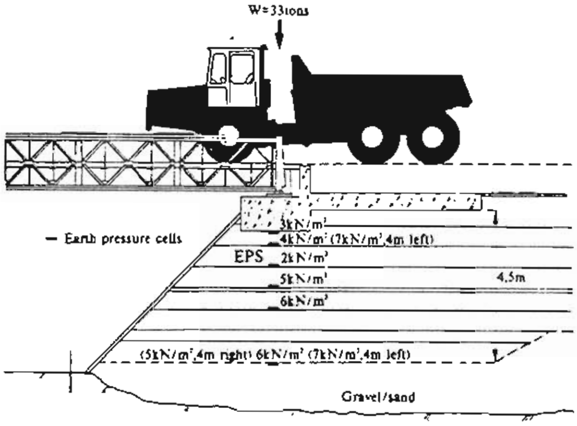

Fig. 7 Stress distribution from an additional load.

on the EPS blocks , especially in the lower part of the fill. In the EPS layers above the concrete slab we have measured lower vertical stress than should be expected under the center of the abutment. One pressure cell placed beneath the edge of the abutment gives higher stress than estimated.

Results from the settlement tubes indicate larger deformations in the centerline, fig. 5.

Both the stress distribution and settlement results indicates that the pressure is considerably reduced in a zone beneath the abutment. Based on this observation it would not have been necessarry to use a higher EPS quality directly under the abutment.

Stresses are also monitored on a long term basis, and a stress decrease has been observed in the EPS fill of about 15 to 30%.

Another test was done to check the stress result. A dumper with a weight of 33 ton was placed at different distances from the abutment. In the case when it was placed directly upon the abutment, fig. 7 (the stress spreading through the pavement was transferred to the abutment), it teoretically indicates an increase of about 6 KN/m². As shown in fig. 7 the results from the pressure cells correspond well with the teoretical stress. The same tendency to reduced vertical pressure in a zone beneath the abutment is also observed. After unloading the abutment the pressure cells immediately went back to the initial stress.

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Railway underpass at

Bøle

T.E. Frydenlund
NRRL

1990-01-20
TEF

RAILWAY UNDERPASS AT BØLE

Plans to reconstruct national road 36 at Bøle near the City of Skien in Telemark included building a new railwaybridge at a road underpass (see fig. 1). In order to increase the free height at the underpass, the road level was lowered and the railwayline elevated somewhat.

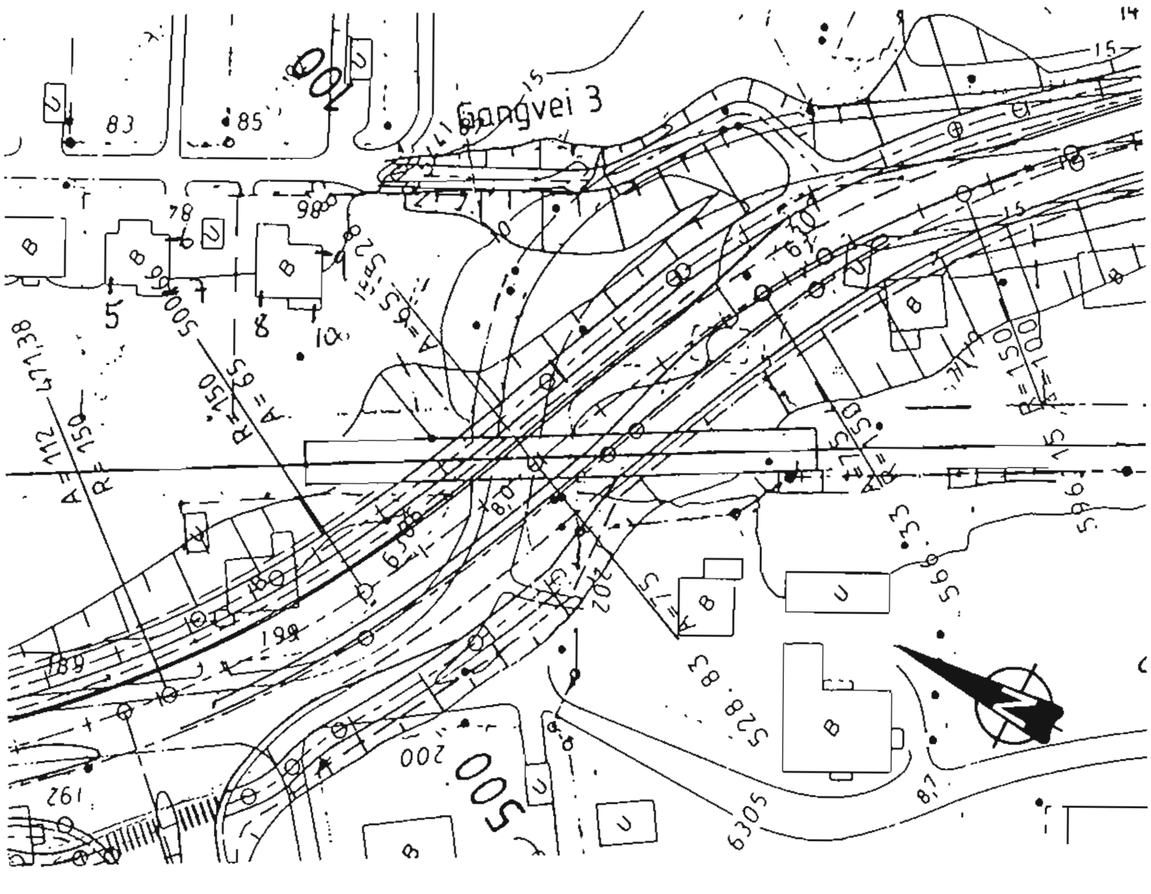

Fig. 1. Plan view of underpass

At the underpass the depth to bedrock is at least 38 m, and the soil consists of interchanging layers of clayey silt and silty clay on top, changing to fine grained sand further down.

The new bridge is constructed on footings in the sand layer. With the wider road and lowered road level, the upper clayey soil caused, however, stability problems, and the use of Expanded Polystyrene (EPS) as a superlight fill material against the northern bridge abutment was suggested and adopted. Since this solution had not been used in connection with railway bridges previously, it was decided to take some precautions.

One problem to consider was that the loads from trains on the EPS material might create intolerable deflections close to the bridge, thus creating hammer effects on the bridge. In order to minimize such effects, it was decided to use EPS-blocks with unit density 30 kg/m³ (compressive strength 150 kN/m²). Furthermore the total layer thickness of EPS was reduced somewhat towards the abutment. An approx. 1 m thick slab of Leca-concrete (Leca = Light Expanded Clay Aggregate) was cast on top of the EPS, being both fairly light and providing a platform for further load distribution. A longitudinal section of the arrangement of EPS-blocks is shown in fig. 2 while a cross section in fig 3 shows how proper drainage is obtained. Clay is used on the inside ditch in order to prevent surface water from percolating into the system. Note that a 15 cm thick reinforced concrete slab is cast on top of the EPS-blocks.

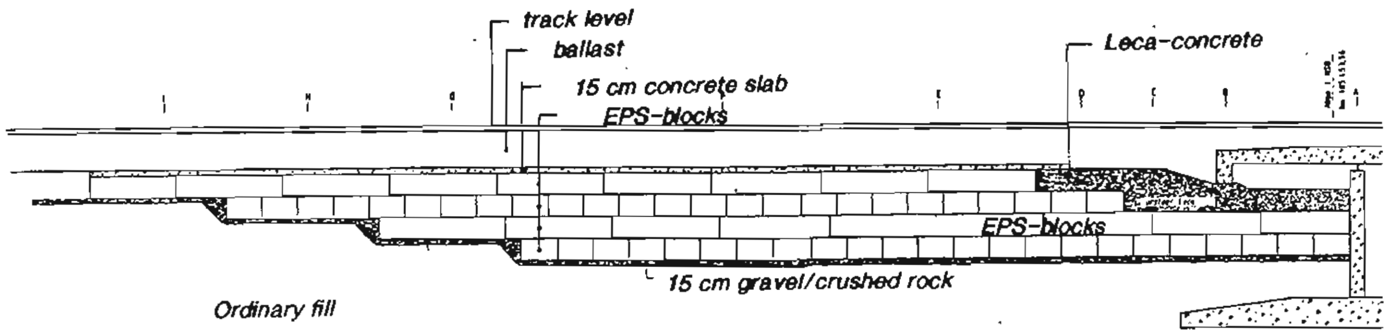

Fig. 2. Longitudinal section

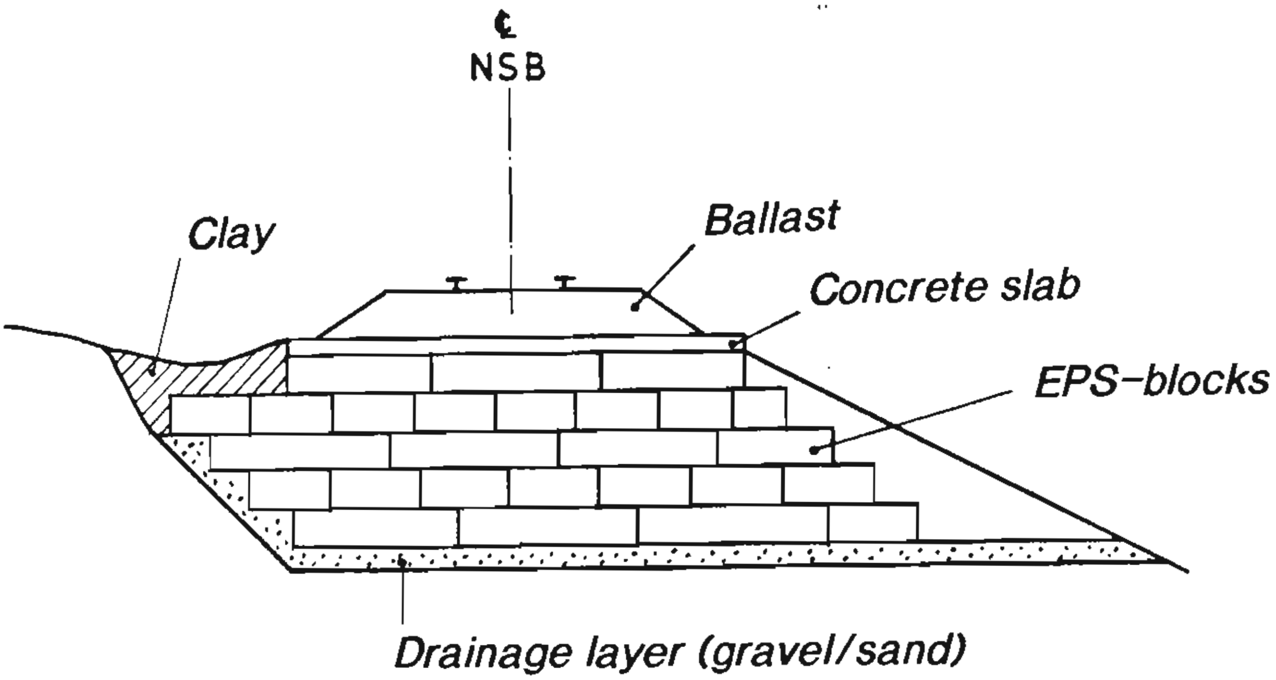

Fig. 3. Cross section

For fire safety the outer blocks (see fig. 4) were specified as made of selfextinguishing EPS. The thickness of EPS-blocks used was 0,6 m.

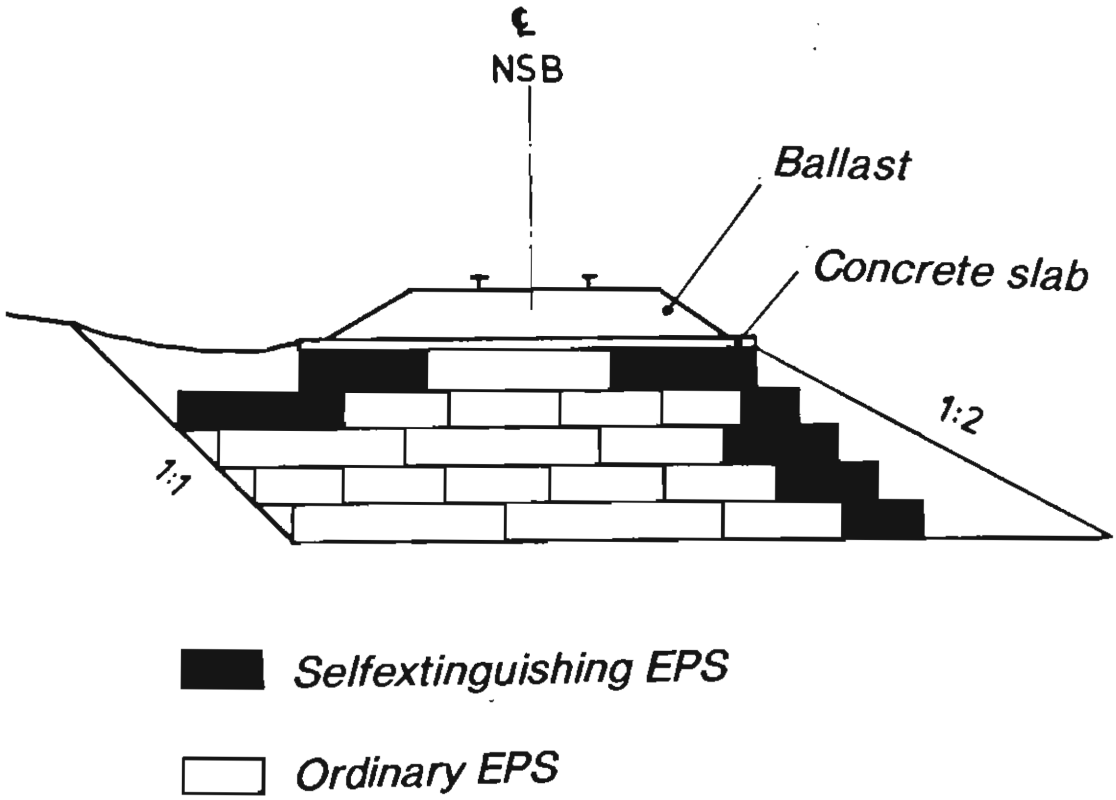

Fig. 4. Cross section showing type of EPS-material used.

After the new bridge was completed, load tests were carried out in order to measure deformations due to train live loads. For that purpose a locomotive with wheel configurations as shown in fig. 5 was used. Locations with various thicknesses of EPS along the railway track were selected and deformations measured with the 155 kN axle load at each location (see fig. 6). Deflections were measured (1988-08-31) both on the sleepers and on bolts in the concrete slab above the EPS-blocks. The results obtained are shown in table 1.

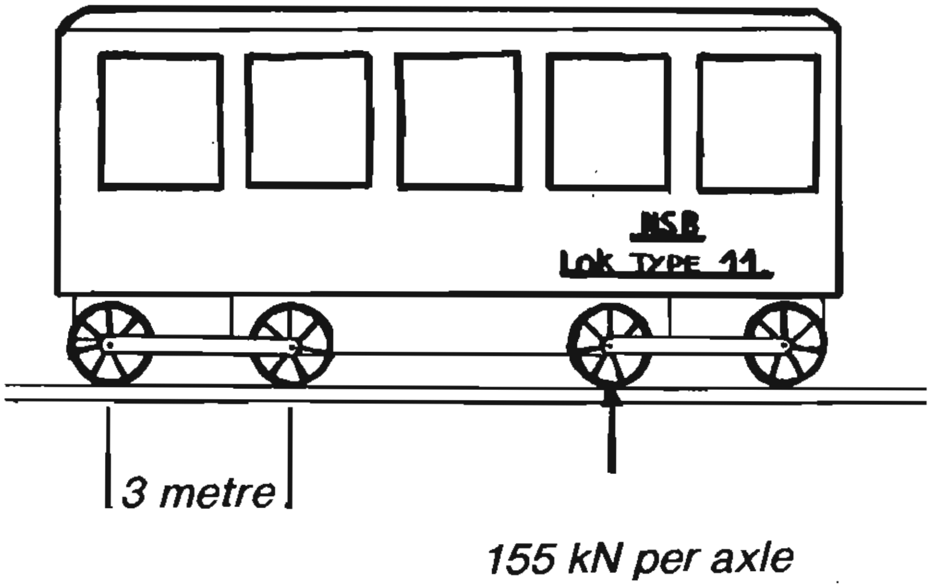

Fig. 5. Load configuration.

From the table it is apparent that deflections in the EPS-material are minor compared with deflections measured on the sleepers. The design adopted for the bridge is considered satisfactory, and trains are now passing the bridge daily.

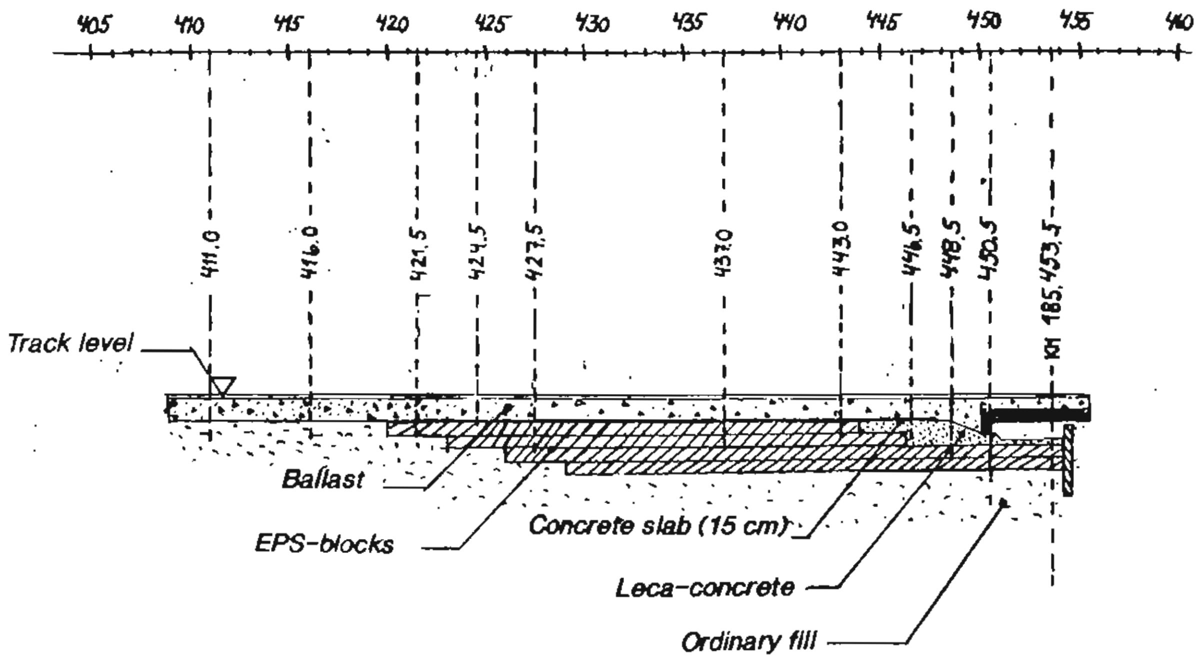

Fig. 6. Location of load for deflection measurements

Profile no	East		West	
	Bolt in concrete slab	Nail in sleeper	Bolt in concrete slab	Nail in sleeper
185.411,0		- 3 mm		- 3 mm
416,0		- 1 mm		- 4 mm
421,5		- 4 mm		- 5 mm
424,5	0 mm	- 4 mm	- 3 mm	- 6 mm
427,5	0 mm	- 4 mm	- 2 mm	- 5 mm
437,0	- 1 mm	- 5 mm	- 3 mm	- 7 mm
443,0	- 1 mm	- 2 mm	- 3 mm	- 5 mm
446,5	- 1 mm	- 3 mm	- 2 mm ?	- 1 mm
448,5		- 2 mm		- 3 mm
Bridge end	0 mm	- 1 mm	0 mm	- 3 mm
Axis 1	0 mm	- 1 mm	0 mm	- 2 mm

Tasble 1. Resulting deflections from train loads

Euroroad E 18 in Vestfold

Roald Aabøe
NRRL

NEW EUROROAD 18 THROUGH THE COUNTY OF VESTFOLD

INTRODUCTION

Euroroad 18 through the county of Vestfold is presently being realigned to bypass urban areas. It has been built in two stages. The first one was opend in June 1990 and the second will be opened in November 1991. The total length of the new motorway system is 13 km and includes 10 underpasses and overpasses and 3 river crossings.

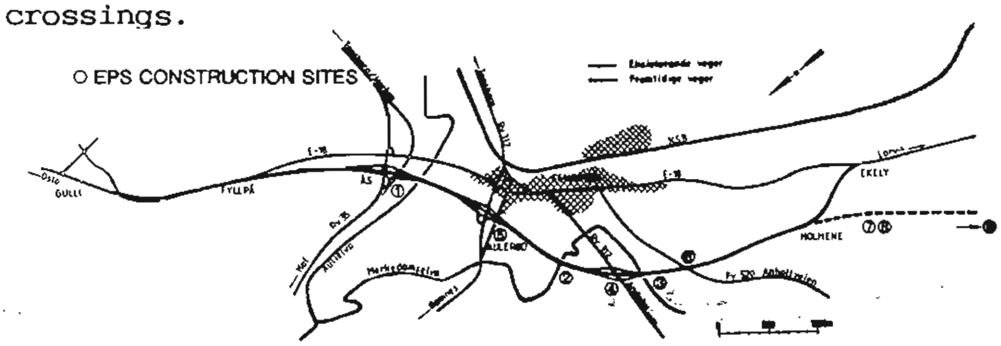

Fig 1. Situation plan **E-18. (first stage)**

SITE CONDITIONS

E-18 is mainly constructed on large deposits of very soft, normally consolidated clay with a shear strength as low as S_u = 10 kN/m^2 in some places, but rock outcrops, moraine and overconsolidated clay deposits are also present in some areas. Where the road runs along the foot of a moraine ridge the soil profile is rather complicated with local changes in soil composition.

CONSTRUCTION

The road was planned with a concrete surface (24 cm concrete with a minimum C70 quality) and therefore only minor settlements could be accepted.

Calculations showed large settlements and also stability problems for embankments higher than 2-3 meter on soft clay deposits. Special solutions were therefore required in order to keep loads within the bearing capacity of the subsoil and minimize settlements.

The EPS method was chosen for most of the critical sites. A total of 60 000 m^3 has been placed with a price tag of about NOK 25 million.

One manufacturer was chosen for the entire delivery after an open tender in 1987. The EPS prices were very low at that time due to the low oil prices. This has proved to be advantageous for the project and the Public Roads Administration.

A flammable EPS quality has been chosen for all construction sites due to short construction time (working 2 to 3 shifts in periods). This has given a cost reduction of 5-10 %. Trained workers have also kept construction time and costs down. One man can install 100 m^3 EPS during one shift giving an installation cost of about 1.5 $ per m^3.

THE SITES WHERE EPS BLOCKS HAVE BEEN USED ARE LISTED BELOW:

1) Bispeveien bridge:

EPS was used as backfill material against the abutment om Bispeveien bridge. The bridge was completed in spring 1987. The total volume of EPS placed in the fills adjoining the bridge and in nearby ramps was 12 000 m^3.

A full scale test to monitor possible horizontal stress transfer from the EPS fill to the vertical concrete abutment was carried out.

2) and 3) Søndre Hesby bridge and Nordre Tem Bridge (simplified bridge design)

E-18 is twice passing a small erosion valley with a river at the bottom. Steel sheet pile culverts with a thin concrete deck and EPS blocks on top were constructed on both sites.

At Nordre Tem bridge a layer of 4 m EPS (3000 m^3) was placed on top of the bridge deck resting on the sheet pile walls. Along the road the EPS fill was terminated in vertical walls and covered with corrugated steel panels.

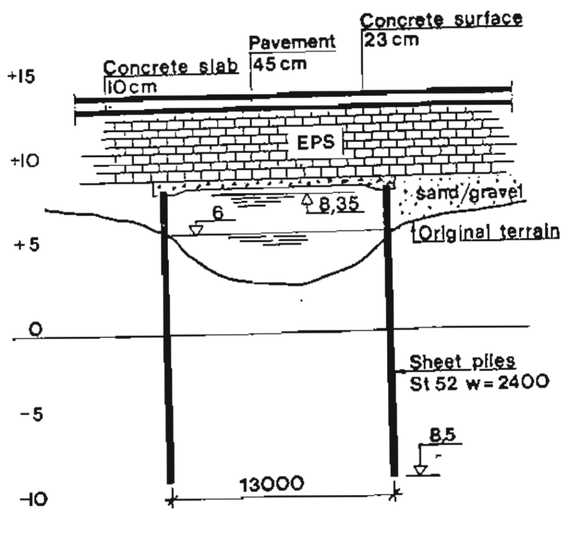

Fig. 2 Nordre Tem bridge. details of sheet pile wall with EPS on top.

At Søndre Hesby bridge the road alignment has a lower elevation and only a layer of 1.2 m EPS was required giving a total volume of 1200 m^3.

4) <u>Hesby bridge</u>

An intersection with two roundabouts for local roads on each side of the bridge has been built with a total volume of 10700 m^3 EPS.

5) <u>Ramnesveien</u>

A local road is crossing E-18. Total volume of EPS used in the bridge embankments is 9600 m^3.

6) <u>Østre Åmot bridge</u>

A local road is crossing E-18. The subsoil consists of very soft quick clay. A total volume of 4400 m^3 EPS has been used in the embankments.

7) and 8) <u>Borge</u>

E-18 is passing 2 small valleys with a river in the bottom. The valleys have been filled up for agricultural purposes. The road embankment has been preloaded for 1.5 year. The surcharge is now replaced with an embankment of EPS.Totally 10000 m^3 of EPS has been used with an embankment thickness of 3.5 m.

9) <u>Gjennestadmyra bridge</u>

E-18 is elevated about 6 m above ground level passing for 500 m an area with soft clay, somewhat overconsolidated. Over a stretch of about 200 m a bridge on piles has been built. The remaining part consists of an embankment with 2m rock fill, 2.5 m EPS and a pavement (100 cm). A surcharge of 2 m has been added on top of the embankment for 1/2 year. Due to a shorter construction time than planned, one year reduction , the surcharge was not allowed to function as long as intended, and settlements are still in progress. Totally 12000 m^3 EPS has been used on Gjennestadmyra bridge.

New highway 181 at Eidsvoll

Eivind Hagen
NRRL

1991-06-19
EiH

NEW HIGHWAY NO. 181 AT EIDSVOLL

Use of Expanded Polystyrene in two embankments

By senior engineer Eivind Hagen
Norwegian Road Research Laboratory

A new bridge is being built across the river Vorma at Eidsvoll. The bridge is 320 metre long and with connecting roads the total length of new highway is 1 km. In addition the project includes 1.5 km of local roads and 1.2 km of pedestrian/bycycle paths. Total costs amount to 90 mill NOK. An aerial view is shown in figure 1.

Two large embankments of Expanded Polystyrene (EPS) are included in the project.

1. Western approach embankment for the new bridge

The road is to be carried by a 13 metre high embankment at the foot of a high ridge. The areas in front of the ridge slope belongs to the Norwegian railway system and is needed for future railway use. The subsoil consists of firm, overconsolidated clay with shear strength $S_u = 80\ KN/m^3$.

In order to limit the area required for the road embankment, it was decided to use a Reinforced Earth structure consisting of two vertical walls, one on top of the other and slightly retracted. Calculations showed, however, that the subsoil did not have sufficient bearing capacity to support such a structure.

The problem was solved by employing the reinforced earth concept in the lower half of the embankment while using EPS blocks in the upper half. By this approach the load on the subsoil was kept within permissible levels and at the same time maintaining the vertical front walls.

Typical cross sections of the embankment are shown in figures 2 and 3.

The EPS-fill was terminated against the vertical wall of the bridge abutment. In addition to reduceing the vertical load on the subsoil, this solution also reduced the horizontal load against the abutment, see figure 4.

2. "Kastellvegen" - local road

Part of the road was planned as a 7 metre high embankment close to a factory. The subsoil consists of loose, sandy silt.

For this embankment it was decided to use EPS for two reasons:

- The factory close to the new local road rests on raft foundations in the subsoil. In order to prevent building damage due to settlements, additional loads on the subsoil had to be avoided.

- The distance from the road edge to the building was so small that the embankment had to be terminated sideways with a vertical or very steep slope.

These conditions added up to a solution with EPS-blocks and vertical termination sideways, figure 5.

A special feature of this EPS-structure is that for the first time shot-crete has been used to protect a vertical EPS-wall on a permanent basis. The shot-crete was sprayed on a net of reinforcing bars and thin, close grid wire mesh, figure 6.

This embankment has already been completed and figure 6 shows the fill before spraying with shot-crete. The picture in figure 7 is taken while spraying of shot-crete was in progress.

Figure 1.   Aerial view

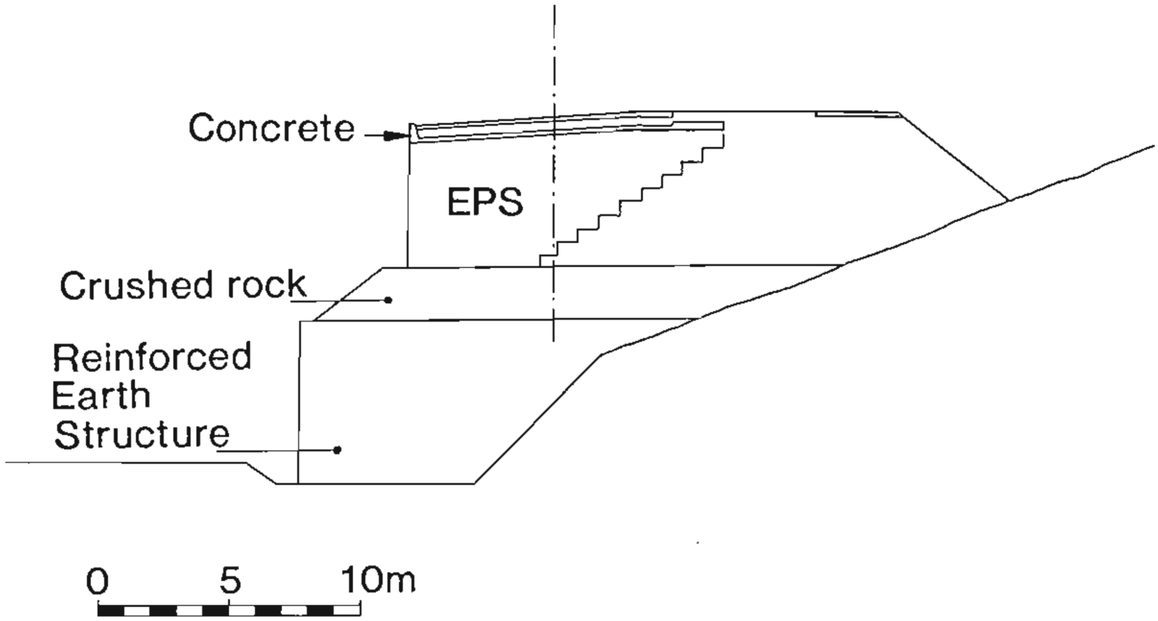

Figure 2. Typical cross section of embankment in front of ridge slope

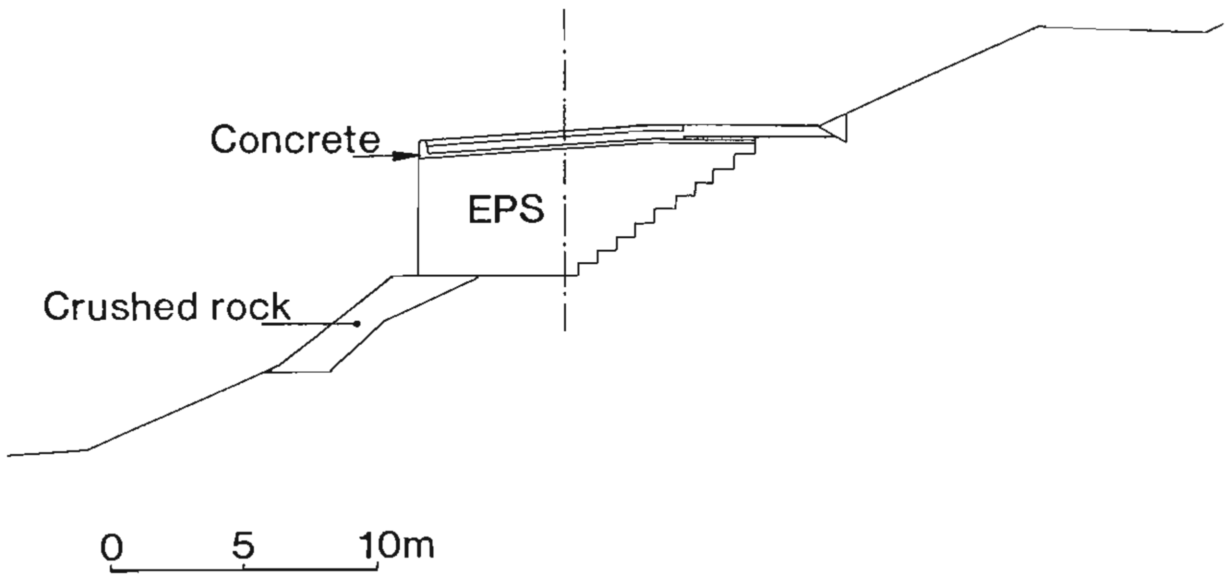

Figure 3. Typical cross section of embankment on ridge slope.

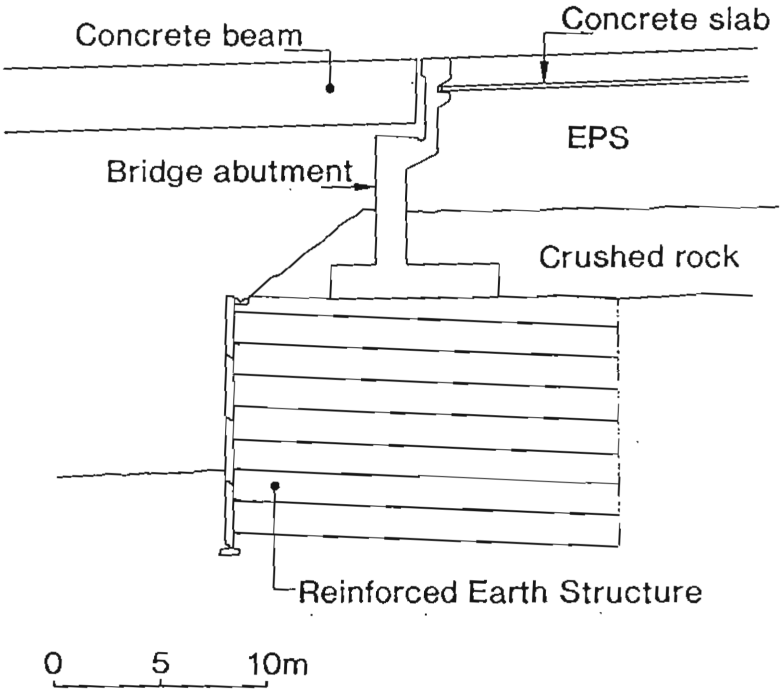

Figure 4. Cross section through bridge abutment

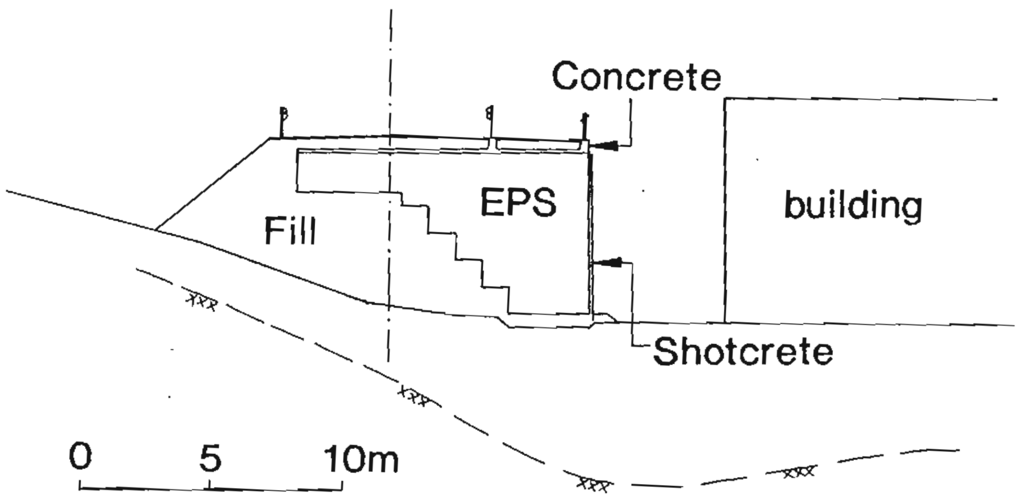

Figure 5. Typical cross section of local road.

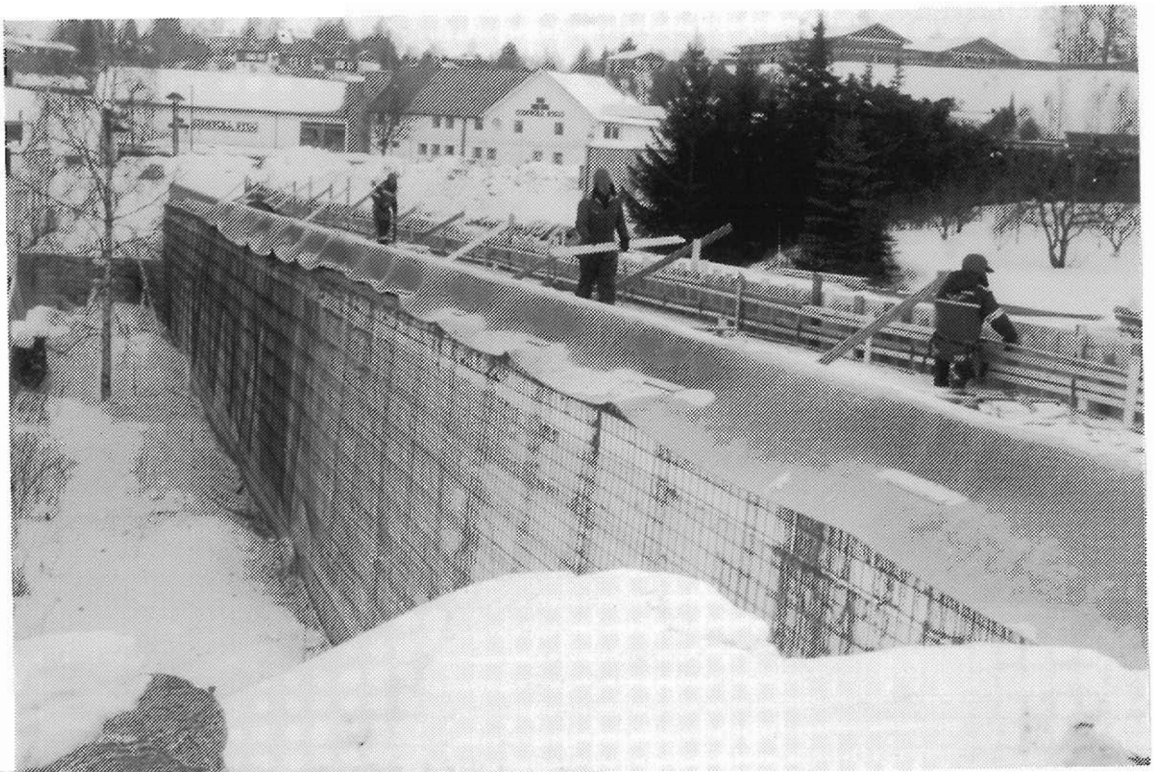

Figure 6. Placing of EPS-blocks completed.

Figure 7. Shot-crete spraying in progress.

TECHNICAL REPORTS OF CONSTRUCTION METHOD

USING EXPANDED POLYSTYROL

EXPAVDED POLYSTYROL CONSTRUCTION METHOD
DEVELOPMENT ORGANIZATION

1991. TOKYO , JAPAN

-CONTENTS-

1 USE OF EPS BlOCKS FOR LANDSLIDE COUNTERMEASURE

1 Introduction

As one of the arterial roads in Hokkaido, National Highway Route No. 274 is used for the transportation of fishery, agricultural and forestry resources from the eastern Hokkaido to other areas in and outside Hokkaido. The road also carries tourists, greatly contributing to the industries in the eastern and central Hokkaido, and is thus positioned as an intercity road as a part of the road network of Hokkaido.

The job site is at an extensive landslide site. Although the road had been protected by piling works and temporary embankment, about four meters more of embankment was still needed to meet the design height requirement. Prior to the embankment, stability analysis was conducted again using data taken from the existing piling works. As a result, it was thought that embankment causing a further load increase would be dangerous. Evaluation of alternatives followed, and the EPS method was adopted.

The EPS method uses large-sized, expanded polystyrol blocks (2.0m x 1.0m x 0.5m) which are piled up as filling material. The method takes advantage of the extreme lightness, high compressive strength, water resistance and self-supporting capability of EPS blocks.

This report outlines the design, construction, and construction management of a correctional treatment at a landslide site using the EPS method.

A

3 Outline of the Work

(a) Type of structure: Type 3, Class 2; arterial road; Type D district
(b) Design speed: v=60km/h
(c) Traffic volume: Class B
(d) Total length: L=400m (EPS section L=110m, EPS volume $V=8,480m^3$)
(e) Period: from March 31, 1991 to December 13, 1991 (period of EPS placement: from early June to late October)

4 Analysis of Landslide Countermeasures

4.1 Data Taken from Existing Piling Works

The existing piling works along the river behind Block b were designed in 1984 as two-layered shear piling. The construction of the piling works in 1986 was followed immediately by temporary embankment, and the road was opened for traffic. While four meters of embankment was yet to be done, strains in steel pipes used in the upper layer of piling were measured. The measurement revealed two slip surfaces (upper and lower). It also revealed that although bending moments of steel pipes on the lower slip surface were small, bending stress on the 10m deep upper slip surface was $2,270kgf/cm^2$ while the allowable stress and yield stress of the pile were $1,900kgf/cm^2$ and $3,200kgf/cm^2$, respectively.

The reason for the stress increase was considered to be an unexpected increase in sliding load on the upper slip surface. Since further embankment was expected to

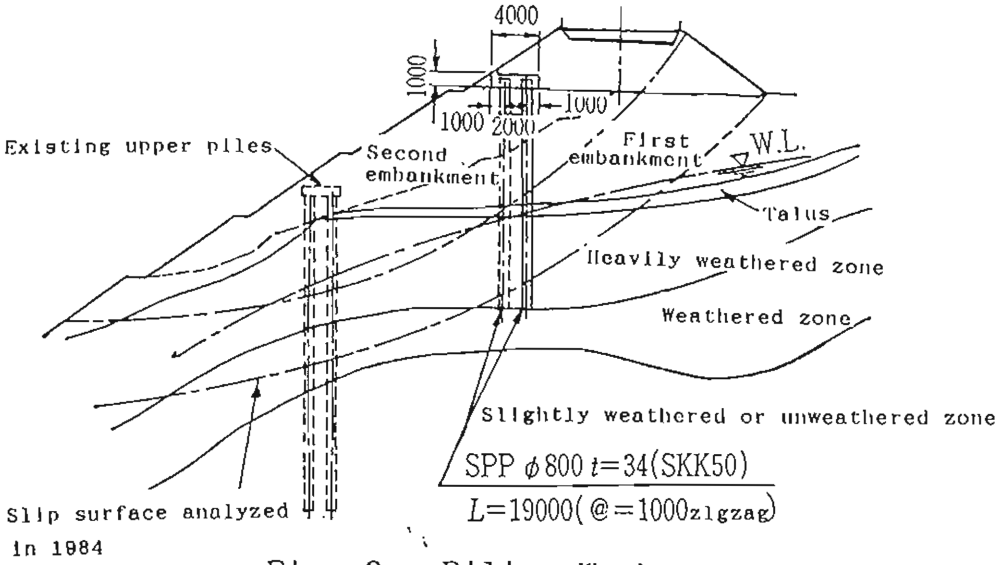

Fig. 2. Piling Works

(2) Light-weight Embankment Method Using EPS Blocks

Fig. 3 shows a cross section of embankment made by this method. Loads equivalent to the loads from the earth cover, base course, pavement, expanded polystyrol and intermediate slabs are reduced by replacing part of existing embankment with EPS blocks so as not to produce a greater load than the one with the temporary embankment. Workability during the construction period, including a detour, was evaluated, too.

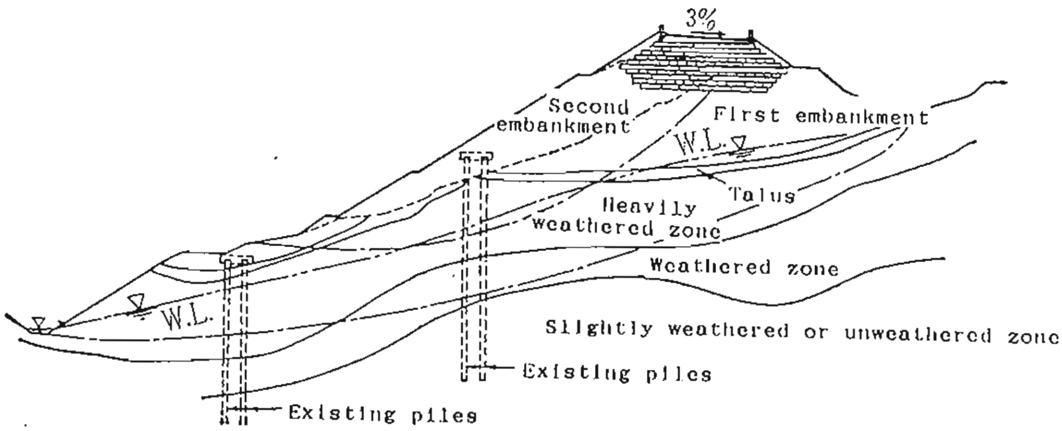

Fig. 3. Light-Weight Embankment

part of the subbase course. Class B traffic, T_A=24cm, and total thickness II=49cm were also assumed, and the pavement structure shown in Fig. 5 was adopted.

Hydraulic shovels (0.6m³ class) were used for excavation. After excavation, a stone-filled drain was made on each side, and the drains were covered with anti-clogging sheets. Then, paving sand (t=10cm) which was to serve as a leveling layer was laid, and expanded polystyrol blocks (2,000mm x 1,000mm x 0.500mm) were placed on the sand layer. Usually, a layer of concrete slabs to disperse load evenly is placed every four to six layers of EPS blocks and on the top. In this particular 6m high embankment, therefore, a layer of concrete slabs was provided on 3m thick layers of EPS blocks. Reinforcing bars (D6-150mm x 150mm) for the slabs were arranged in a grid pattern, and concrete (maximum coarse aggregate size 25mm, slump 8cm, standard strength 210kgf/cm²) was placed. Another set of EPS blocks (H=3m) was placed on the concrete slab layer, and another layer of concrete slabs was put on top of the embankment so as to achieve structural integrity.

Since the improvement of adjoining areas with 6% slopes had already been completed, the same gradient of 6% was adopted. Thus, for reasons of workability, EPS blocks at the lowest level were piled up like 10m-run steps, and ones at the highest level were placed like 4m-run steps (see Fig. 6).

A detour necessary during the excavation of the existing road section was located where the influence of landslides was minimal. Near the upper end of EPS embankment area, however, extra space for the detour was not available. Hence, a part of the embankment was performed by stages, and a temporary base course (t=50cm) was laid on some of the intermediate slabs for bypassing. In view of Class A traffic to be handled and the service period of 12 months, the thickness of pavement was set at 4cm, and the tbickness of the base course was set, based on the allowable compressive stress of EPS blocks, at 50cm.

6 Results of Observation

During the process of EPS block placement, the behavior of the EPS blocks was observed for the following purposes:

(1) To observe the long-term (five years from now) influence of further landslide movement and earthquakes on EPS
(2) Relative settlement or sloping of EPS blocks within the embankment

Purposes of measuring instruments used are summarized in Table 1.

After the measuring instruments were installed, measurements were taken each time a layer of blocks has been placed. So far, readings on the strain gauges have shown no changes in any cross sections. Displacements of the blocks measured by the inclinometers were around 0.1° at most in all cross sections. Measurements from the earth pressure gauges show that earth pressure continued to rise througbout the period from the placement of the blocks to the completion of pavement and leveled off thereafter. Lower temperatures in higher layers measured by the thermometers suggest that the heat retaining property of EPS was high. Since only one and a half month or so have passed since the

7 Summary

The length of the road section covered by this work was 400m, of which only 110m was done by the EPS method. Thus, the work was completed within the same year, and the road was put into service by early December. Results of field observation during the construction period and the first one month after completion show only small changes. However, measurements from the earth pressure gauges indicate that the expanded polystyrol blocks contributed to load distribution. It can be concluded, from these results, that the use of the expanded polystyrol blocks had a significant load-reducing effect.

Partly because only one and a half months or so have passed since the opening of the road and partly because the site is now in a dry season, influence of the EPS embankment on the existing piling works has not yet been observed.

8 Concluding Remarks

This report outlined results of observation conducted during the construction and the first one month after the road was put into service. Observation will be continued for a period of five years from now. Results of this observation will be reviewed in evaluating the applicability of the EPS method as a countermeasure against landslides.

EPSを用いた地すべり対策工事例

Use of EPS Blocks for Landslide Countermesure

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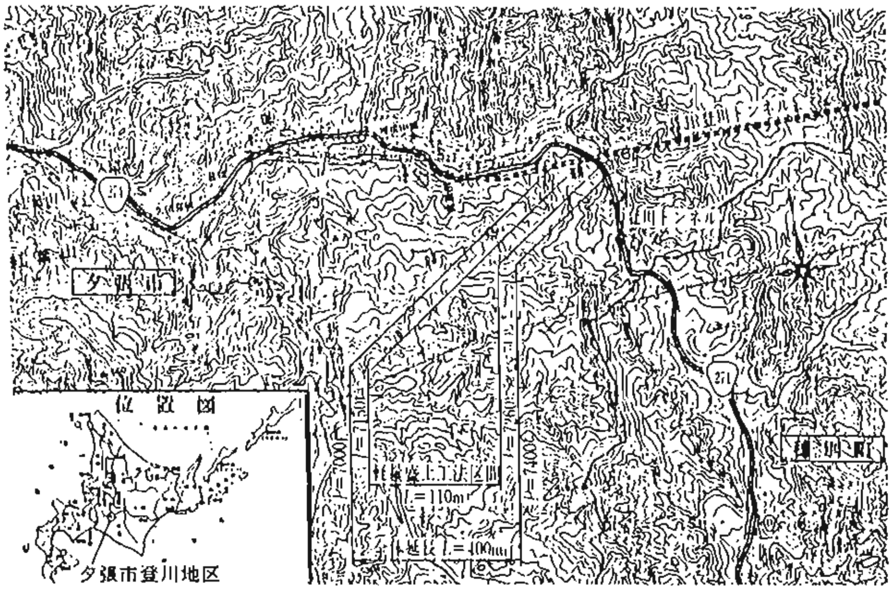
1. まえがき

一般国道274号は，北海道の160万都市，札幌を起点とし広島町・夕張市・日高町を経て上川郡清水町において，一般国道38号に接続する延長177.5kmの幹線道路である（図—1参照）。当路線は，道東圏の水産農林資源を全道各地および道外へ搬出し，また，観光客の輸送など道東と道央との産業経済の振興に大きく寄与するための，全道道路ネットワーク体系の観点からも都市間幹線道路として位置付けられている重要路線である。



図—1 位置図

本工事箇所は，夕張市登川地区に位置し，松竹沢川に沿った大規模な地すべり地形箇所であるため，抑止杭を施工し，暫定盛土で交通を開放していたが，計画高まで約4mの盛土が必要となっていた。本工事を実施するにあたって既設抑止杭による現場計測値を用いて，再度安定解析をして，検討した結果，これ以上の荷重増加となる盛土が困難と判断された。これを受け各種工法について検討を行い，EPS土木工法を採用することにした。

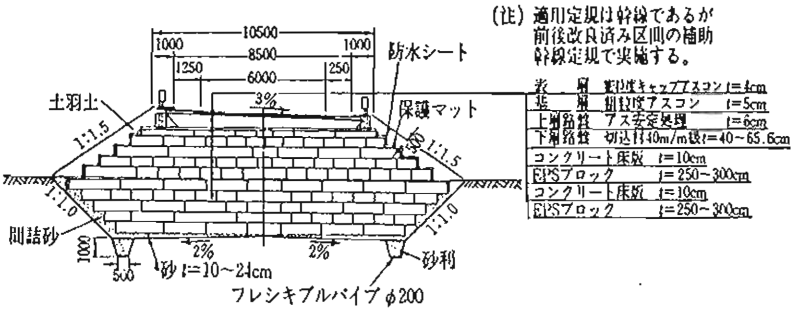
EPS土木工法は，大型の発泡スチロールブロック（2.0m×1.0m×0.5m）を盛土材料として積み重ねていくもので，材料の超軽量性，耐圧縮性，耐水性および積み重ねた場合の自立性等の特長を有効に利用した工法である。

本報告書は，地すべり箇所でのEPS土木工法の設計・施工・施工管理についての結果を報告するものである。

2. 地形，地すべり概要

工事箇所の周辺地形は，標高が300～500mと比較的緩やかな丘陵性山地形を呈しており，松竹沢川の河床付近では，洗掘により45°前後の急崖となっている。また，地すべり地に多く見られる緩急入りくんだ地形が特徴的である。当区間の地質は，白亜紀函淵層の砂岩を基盤とし，これを覆って第四紀洪積世の段丘堆積物や沖積層，崖錐堆積物，崩積土などが分布している。基盤岩である函淵層は砂岩を主として，泥岩および凝灰岩薄層を挟有し，起点側に椀状に開いた地質構造となっている。図—2に示すように，大規模な地すべり地形を呈すAブロックに含まれ，地形また過去の経緯からa・bブロックに大別され，aブロックについては，地すべり調査解析において，後段（4.地すべり対策工の検討）での報告

は最適と考えてここで検討した。図—4に断面図を示す。暫定盛土時の荷重状態より増加荷重を発生させないように覆土・路盤工・舗装・発泡スチロール自重・中間床版などの増加荷重に相当する荷重は盛土を掘削し発泡スチロールに置換し対処する。工事期間中の迂回路など施工性の検討も同時に行った。



図—6 土工定規図

3) 概算経済比較(延長110m)

○抑止杭工法(SKK 50, t=34 mm, L=19 m, 1 m間隔) 直接工事費 364 000千円

○軽量盛土工法(発泡スチロール,最大盛高 6 m, 体積 V=8 480 m³) 直接工事費 237 000千円

この結果,既設抑止杭への影響が小さく経済的である発泡スチロールを使用した軽量盛土工法を採用することとした。

5. 設計の考え方および施工方法

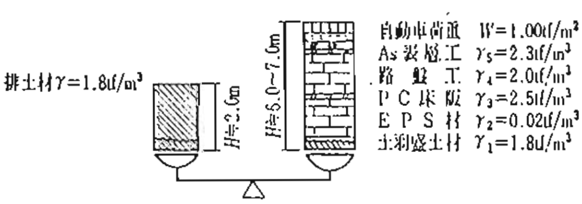
地すべり対策工の検討で,これ以上の荷重増加が困難となり,既設杭にこれ以上荷重負担をかけずに計画盛土を完成させる工法として,EPS土木工法を採用した。施工基面高が現況の暫定盛土より4mも高いため,発泡スチロールの超軽量性(土の単位体積重量の1/80~1/100)を利用し,掘削前の土かぶり厚に等しい分だけ発泡スチロール材による置換盛土を行い,盛土荷重(交通相当荷重を含む)により,地盤内に発生する応力増加を無くするようにした(図—5参照)。

舗装構成については,ノルウェーでの実績や国内の実験的研究の結果をもとに検討した。すなわち,発泡スチロールのCBRを4としてコンクリート床版も下層路盤の一部として計算し,交通区分B交通,T_A=24 cm,合計厚 H=49 cm とし,図—6の舗装構成とした。

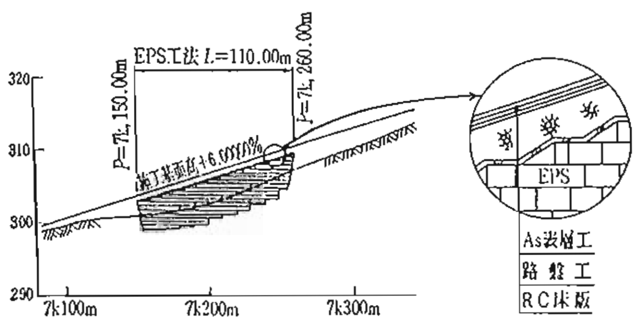
施工方法については,油圧ショベル0.6m³級にて掘削を行い,端部に盲排水溝を設置し,その上に目詰まり防止用としてシートを設け,次にレベリング層となる敷砂(t=10 cm)を施工し,発泡スチロールブロック(2.000×1.000×0.500m)を設置する。本工事では発泡スチロールの高さが H=6mの高盛土となるが,通常最上部および4~6段ごとに荷重伝達を均等に分散させるためにコンクリート床版を設置することから H=3m積み上げ,その上にコンクリート床版を設けている。床版は鉄筋を格子状に配筋(D6-150×150 mm)してコンクリート(最大粗骨材 25 mm,スランプ 8 cm,基準強度 210 kgf/cm²)を打設し,その上に発泡スチロールブロックを H=3m積み上げ,その上面にもコンクリート床版を設置し,盛土体として一体化している。

縦断勾配については,前後の改良が完了していることから,その勾配(6%)に合わせている。したがって,最下段は,施工性より,10mごとに階段状にし,最上段についてはもう少し細かく,4mごとに階段上に発泡スチロール材を設置した(図—7参照)。

また,工事区間の現道部を掘削するために必要となる迂回道路は,地すべりにあまり影響が無い位置に選定したが,EPS工法終点部で,そのスペースが無く,一部段階施工を行うこととし,中間床版上を仮設の路盤工(t=50 cm)を施工し交通の切回しを



図—5 当工事におけるEPS土木工法使用の考え方



図—7 縦断図

14

2 Example of Construction of Upright Retaining Walls on a Slope

1. Overview

In order to relieve traffic congestion as much as possible, one traffic lane and a sidewalk were added to an existing two-lane road. In the widening of this road, upright retaining walls of light and highly self-supporting expanded polystyrol (EPS) were built on a slope in wetland.

In August 1985, the first EPS-based, light-weight embankment for road construction in Japan was carried out in Sapporo, Hokkaido. The total volume of EPS used in 150 light-weight embankment projects to date exceeds 130,000m³. However, although in several projects EPS has been used as light-weight filling material at the back of L-shaped retaining walls, only a few project took advantage of EPS's lightness and self-supporting capability.

This report describes the method of designing upright retaining walls, taking advantage of the self-supporting capability of EPS, used in the widening of National Route No. 9.

2. Topography and Selection of the Construction Method

This area consists of relatively steep hills at elevations of 100m-200m and dissected swamps.

The work involved the widening of the traffic lane and the sidewalk of about 3.5m and 2.8m, respectively. In selecting the construction method, an inverted T-shaped retaining wall method and an EPS-based, upright wall method

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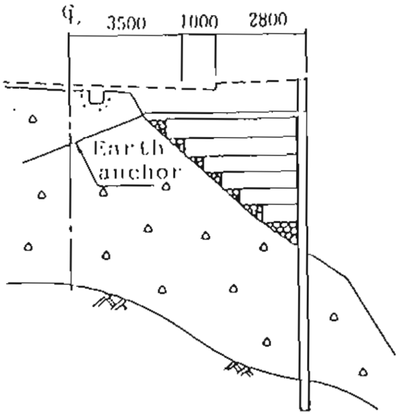
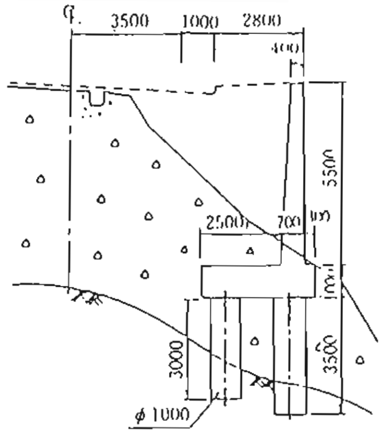
Table 1. Comparison of Construction Methods

Method	EPS Method	Retaining Wall Method
Sectional View		
Evaluation	(1) Large construction equipment is not necessary. (2) The existing road is not affected even during piling. (3) The construction period can be shortened. ○	(1) Large-scale temporary structures are needed during foundation piling and wall construction. (2) Loose grounds created by excavation during foundation piling could affect the existing road. (3) Excavated ground created by bed excavation for the wall necessitates one-way alternate traffic regulation. (4) In order to avoid one-way alternate traffic regulation, large-scale temporary earth retaining works, such as sheeting, at the back of the wall are necessary. ×

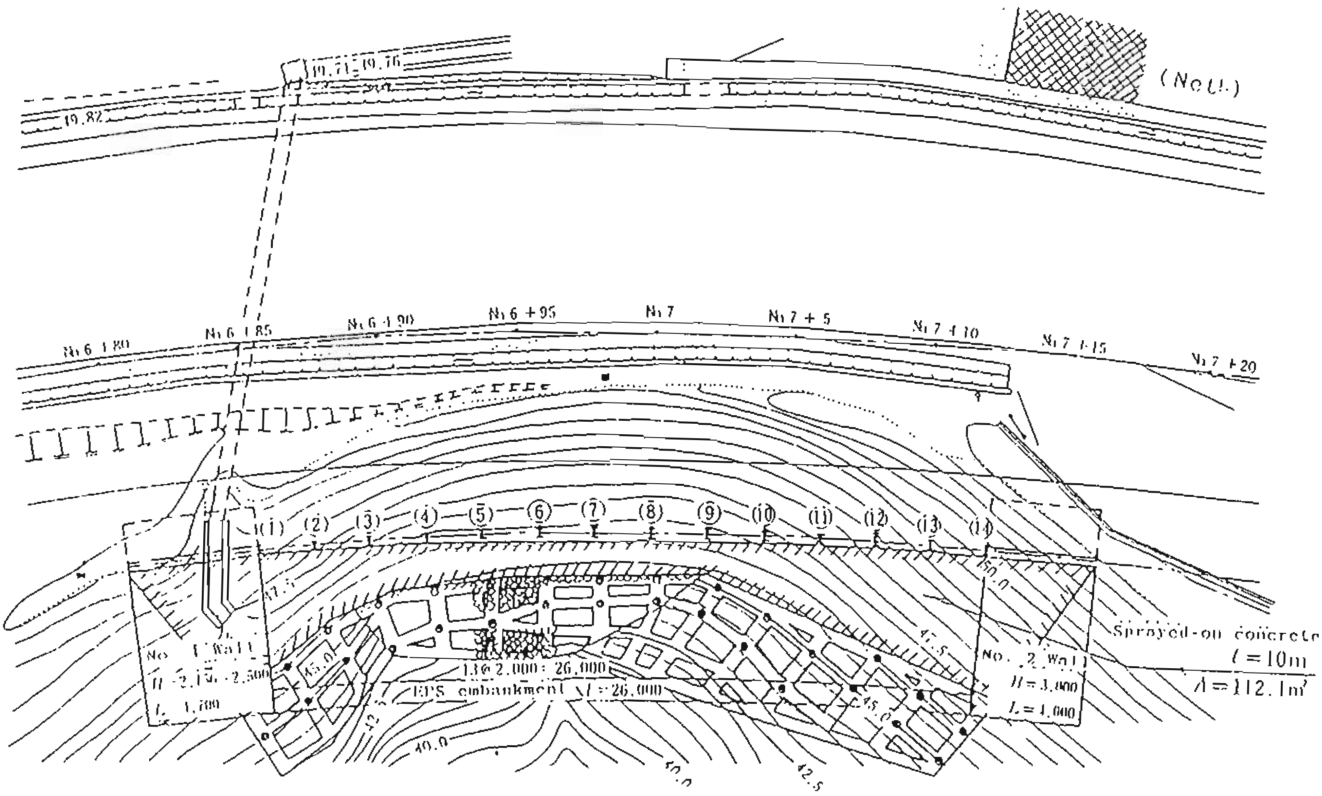


Fig. 3. Plan View

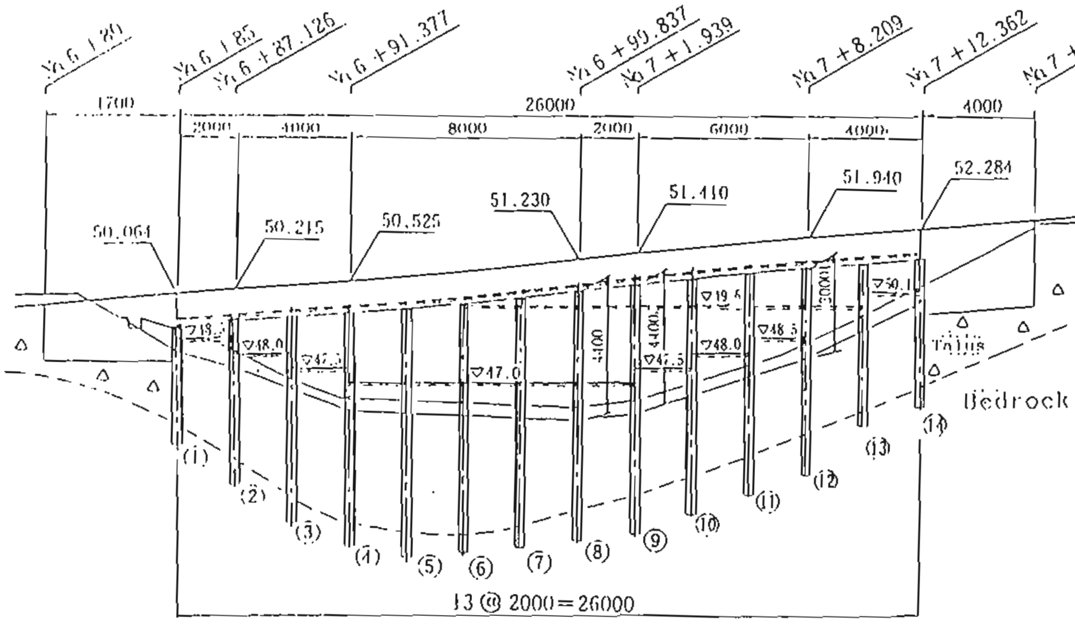


Fig. 4. Side View

3.1.1 Under Normal Conditions

Based on results of a large model test, external horizontal force acting on the H beams, between their tops and the bottoms of EPSs (top of adjusting concrete), was assumed to be 1/10 of surcharge including live load. Poisson's ratio of EPS is said to be 0.1 or so, which supports the assumption that when EPS was used as elastic body, 1/10 of vertical load moved horizontally. It was also assumed that horizontal earth pressure acted through backfill (crushed stone) under the adjusting concrete.

Thus, 1/10 of surcharge on the surface of EPS and horizontal earth pressure of underlying backfill were assumed as horizontal load acting on H beams on under normal conditions. It was also assumed that earth pressure from backfill at the back of EPS did not exist since the width of backfill at each level was small for its height.

3.1.2 During Earthquake

From inertial force during an earthquake obtained from response analysis by the finite element method using a model of EPS upright wall built in 1989 about 200m to the east of this area, a modified horizontal seismic factor for the EPS block of 0.17 was adopted.

As external force acting on H piles during an earthquake, the following loads were considered:

(1) horizontal external force on the surface of EPS equal to 1/10 of surcharge excluding live load
(2) earth pressure of backfill under the adjusting concrete at the bottom during an earthquake

3.2 Stability of Upper Slabs

In this design, sealing material was put between the H piles and the upper floor slabs so that inertial force of the upper slabs during an earthquake was resisted by anchors and load distribution between the slabs and the H piles in the structural system was clear. Since only vertical load exists under normal conditions, tension does not occur in the anchors. With respect to inertial force during an earthquake, a modified seismic intensity at the upper slabs was determined as 0.27, from results of the response analysis mentioned earlier. The response magnification ratio at the upper slabs was higher than at the EPSs.

To be on the safe side, 100% of force acting on the anchors during an earthquake was assumed to be inertial force due to dead load of pavement and others above the upper slabs. The anchors were designed in accordance with the criteria of Japan Society of Soil Mechanics and Foundation Engineering. Fig. 6 illustrates the structure of the anchor system.

3.3 Stability of Entire Structure

Since the structure was to be built on talus accumulation with N values of 5 or so located in a relatively steep wetland, the total stability of a structure on a talus layer functioning as slip surface was analyzed by the circular arc method. As a result, in order to achieve the design safety factor, cast-in-place concrete frames which also served as anchor works were provided below the H beams. Rock bolt anchor works were also adopted so as to prevent shallow slips along the talus layer at the back of EPS.

3.4 Foundation for Safety Fences

Impact load of collision with vehicles was analyzed using a model shown in Fig. 7. If the foundation is assumed to be a 60cm wide continuous concrete, overturning moment arising from the collision is

$$Ms = 1.6 \times 1/2 \times 1.6$$
$$= 1.28 t \cdot m \text{ (safety fences at 2m intervals)}$$

Resisting moment due to the foundation concrete is

$$Ms = 0.6 \times 1.0 \times 2.5 \times 0.6 \times 1/2$$
$$= 0.45 t \cdot m$$

The design was such that the difference between these moments, that is

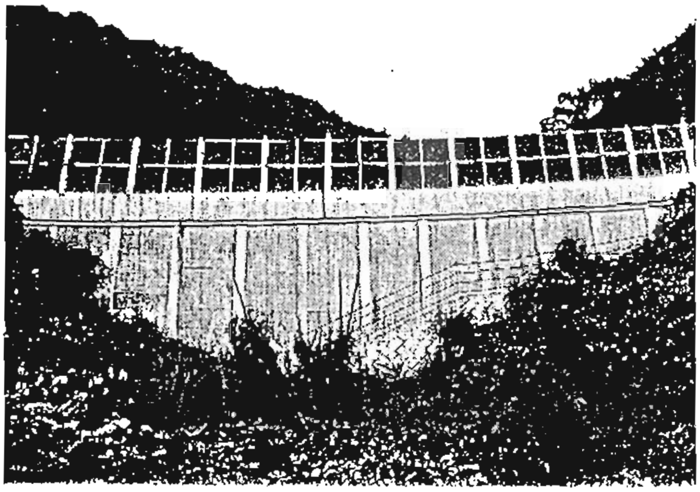


Photo 1. Side Wall of the Completed EPS Upright Wall

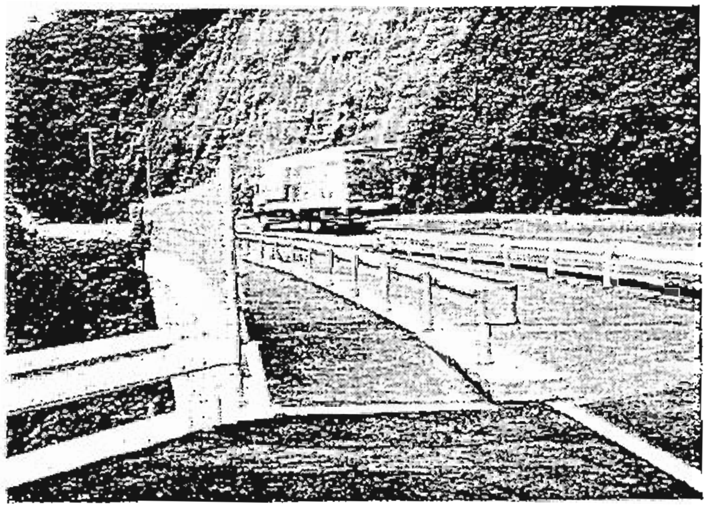


Photo 2. Completed Widening

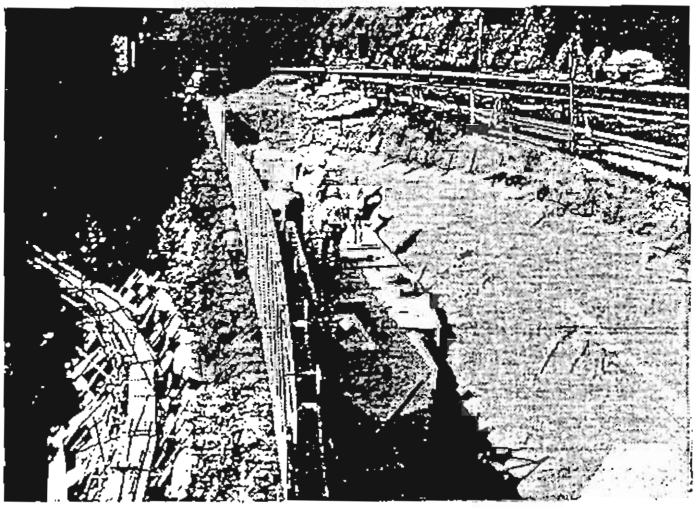


Photo 3. Wall Under Construction

2. Example of Construction of Upright Retaining Walls on a Slope

報文　発泡スチロールによる直立壁の施工例

嘉本　安夫*　福本　一明**　篠崎　亘***　古市　求****

1. まえがき

一般国道9号は京都市を起点として，山陰地方の日本海沿岸の主要都市を結び，下関に至る延長673 kmの路線である。図-1に示す鳥取市から西へ約20 kmに位置する船磯地区は，日本海に面した急峻な地形を呈しており，その山腹を国道が通過している。このため，この地区の延長900mは曲線部の連続で，道路縦断勾配も8％と急な勾配となっている。

本区間は，昭和38年に1次改築を完了したが，近年の交通量の増加，特に大型車両の増加による走行速度の低下による交通渋滞が著しい。さらに，夏期の観光シーズンには鳥取砂丘・白兎海岸などの海水浴場を控えているため，交通渋滞は一層著しいものとなる。また，冬期は降雪・凍結などによる気象条件がきびしく，交通のキーポイントとなっている。

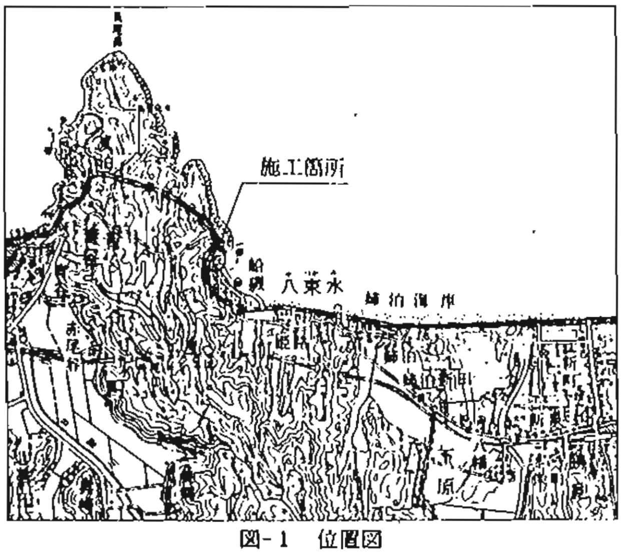


図-1　位置図

これらの交通渋滞をできるだけ解消するため，現在の2車線の現道を1車線と歩道部を設置するための拡幅工事を行うに当り，急峻な沢地形部に軽量で自立性のある発泡スチロール（Expanded Poly-Stylor，略してEPS）を用いた直立土留め壁を採用した。

EPS工法は，1972年，ノルウェーのオスロ市郊外で軟弱地盤における盛土荷重の軽減を目的とし，EPSが初めて盛土材に採用された[1]。その後，スウェーデン，カナダ，フランスなどで相次いで施工され，現在ではノルウェーだけでも120例を超える実績がある。一方，わが国においては，1985年8月，北海道札幌市において日本で初めてのEPSを用いた軽量盛土工法による道路盛土が施工され[2]，現在150件の施工事例，使用総体積13万 m^3 を超える実績がある。しかしながら，L型擁壁等の背面に土圧軽減のためにEPSを盛土材とした施工は数例あるものの[3]，EPSの軽量性および自立性の特徴を生かした工事例はきわめて少ない。

本報告は，上記のように国道9号の道路拡幅のため，EPSの自立性の特徴を生かした直立壁の設計方法について述べるものである。なお，船磯地区では昨年，本報告で述べる施工箇所の東側約200mの位置に同規模のEPS直立壁の施工を完了している[4]。

2. 地形地質と工法選定

当地区は，標高100～200mの比較的急峻な起伏

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*** SHINOZAKI Wataru	(株)建設企画コンサルタント 土質技術部 次長	大阪市西区靭本町3－5　25
**** FURUICHI Motomu	同　上　道路設計部 取締役部長	同　上

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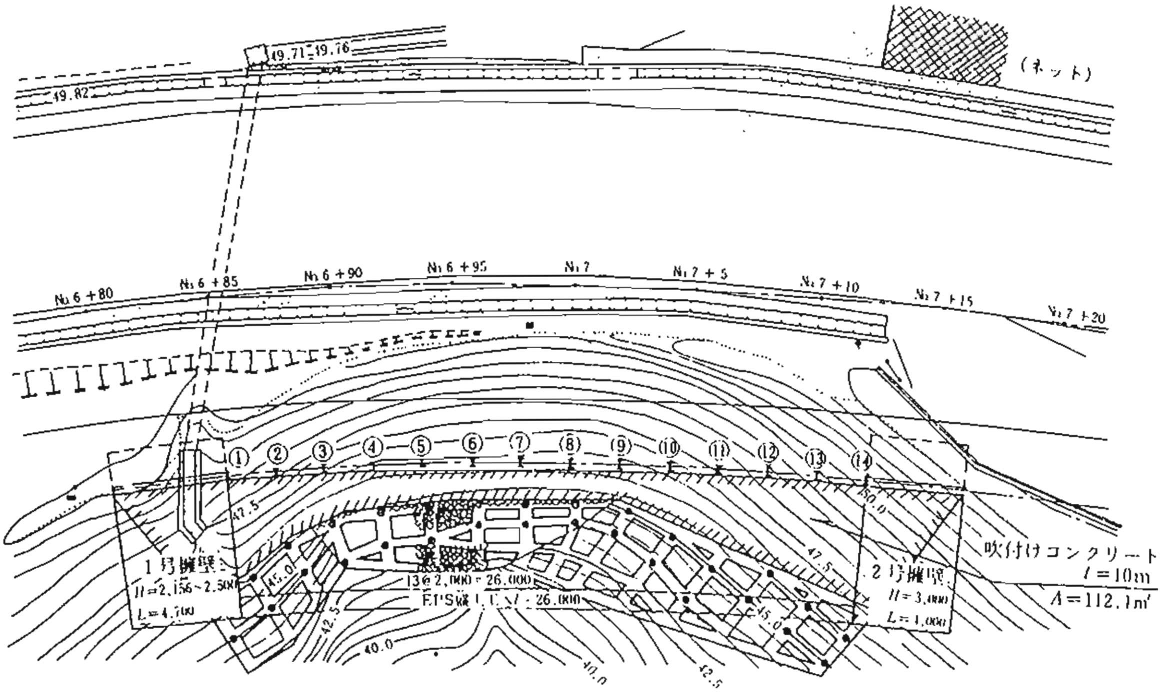

図-3　施工平面

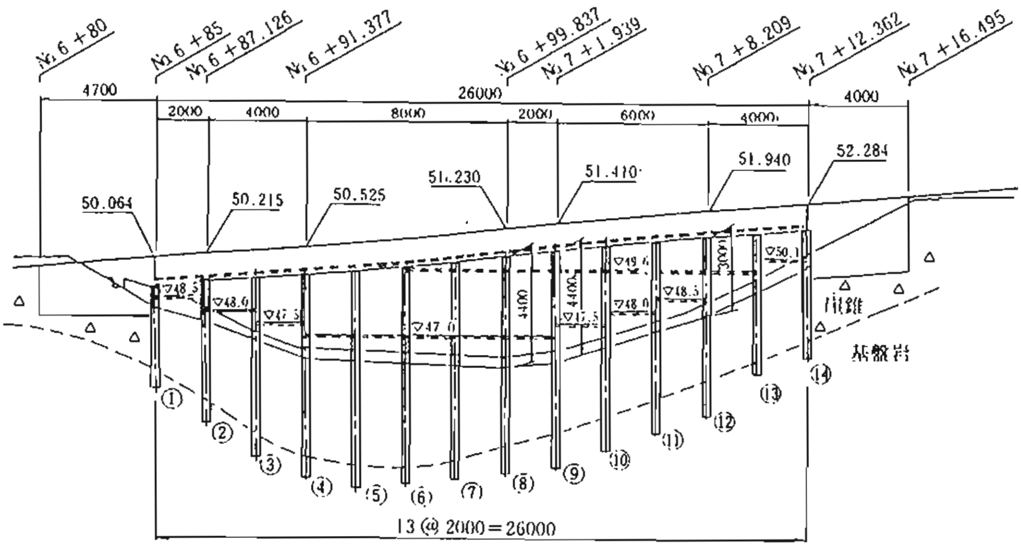

図-4　側面

設けて上部のコンクリート床版とは縁が切れた構造とした。H鋼の下方の法枠およびアンカー工，EPS背面の補強土工は崖錐性堆積物内を通るすべりに対する対策である。以下に，設計の基本的な考え方を述べる。

3．1　H鋼杭の応力度

H鋼杭は崖錐性堆積物下位の基盤岩を支持層として，岩盤部へは50～100cm程度の根入れとした。H鋼の応力度は表-2に示す荷重モデルによりフレーム計算により検討した。H鋼杭の打設間隔はEPSブロックの長辺が2ｍであることから，同一の寸法とした。したがって，H鋼杭1本当りには背面から2ｍの幅の外力が作用するものとした。

H鋼杭の根入れ部の横方向地盤反力係数は，当地区が傾斜地盤であるため，水平地盤での値を杭基礎設計便覧[5]に準じて補正した。次にH鋼杭に作用する外力を，常時並びに地震時に分けて述べる。

3．1．1　常　時

H鋼の天端からEPS最下段部（調整コンクリートの上面）までのH鋼に作用する水平方向荷重は，大型模型実験の結果[6]より，活荷重を含んだ上載荷重の1/10荷重を外力とした。EPSのポアソン比は

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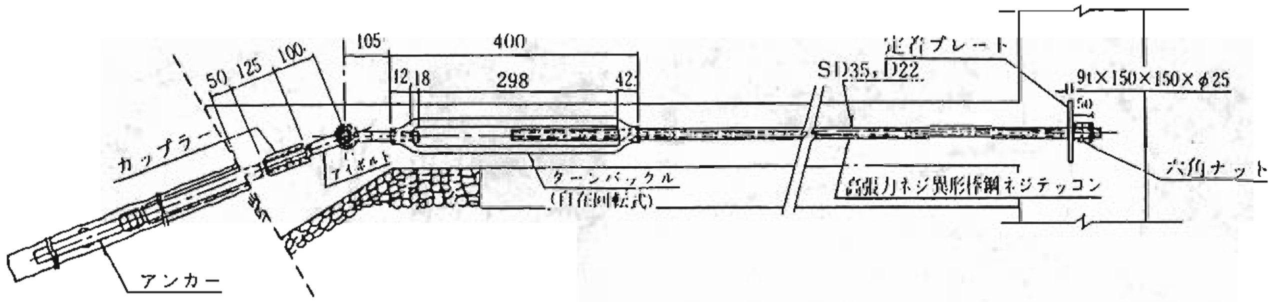

図-6 アンカー構造

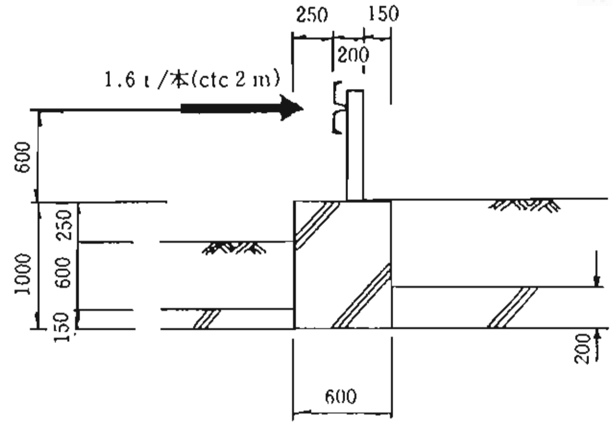

図-7 防護柵検討モデル

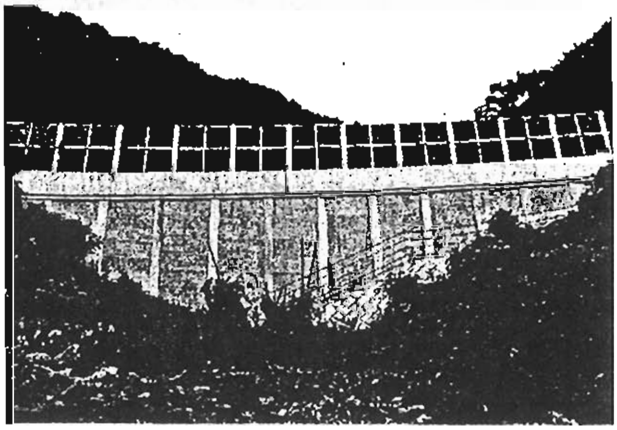

写真-1 既設のEPS直立壁側壁

壁）の慣性力

⑥ EPS，中間コンクリート床版，調整コンクリートおよび裏込め砕石の慣性力

以上の常時・地震時におけるH鋼の応力度および水平変位の照査を行った。

3．2 上部床版の安定性の検討

本設計では，H鋼杭と上部床版との境界に目地材を設けて，地震時の上部床版の慣性力はアンカーに負担させ，H鋼杭との荷重分担が明確となる構造系とした。常時は鉛直荷重だけが作用するため，アンカーには張力が発生しない。地震時の慣性力は，前述の応答解析の結果[8]より，上部床版での修正震度を0.27と決定した。なお，上部床版では，EPS部に比べて応答倍率は大きくなっている。

地震時にアンカーに作用する力は，安全側に考えて上部床版より上部の舗装等の死荷重による慣性力が100％働くものとした。なお，アンカー工の設計は，土質工学会の基準[9]に準じた。図-6にアンカー工の構造図を示す。

3．3 構造物全体の安定検討

当地区は比較的急峻な沢部の N 値が5程度の崖錐性堆積物上に構造物を築造するために，崖錐層をすべり面とする構造物全体の安定性を円弧すべり面法により検討した。その結果，設計安全率を満足できないため，H鋼下方にアンカー工併用の現場打ち法枠工による対策とした。さらに，EPS背面の崖錐層の浅いすべりに対しては，ロックボルトアンカーによる対策とした。

3．4 防護柵の基礎の検討

車両の衝突荷重は図-7に示すモデルで検討した。基礎形状を幅60cmの連続コンクリートとすると，衝突により生じる転倒モーメントは M_s＝1.6×1/2×1.6＝1.28t・m となる（防護柵は2mに1本）。基礎コンクリートによる抵抗モーメントは，M_s＝0.6×1.0×2.5×0.6×1/2＝0.45t・m となる。不足のモーメント $M＝M_s－M_r$＝1.28－0.45＝0.83t・m は，コンクリート床版の鉄筋によって受持たせた。

なお，防護フェンスに働く風荷重による基礎の検討は防護柵と同一の手法により行った。その結果として歩道部直下のコンクリート床版の厚さが20cmとなり，車道直下の床版の厚さ15cmより厚くなった。

4．施工状況

写真-1はすでに施工が完了した箇所の沢の下向から見たEPS直立壁の側壁面である。また，写真-2も同様に施工が完了した箇所の改良後の歩道・車道部の状況である（供用は来年度となるため，アスファルト舗装の施工および既設ガードレールの撤去

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3 Example of Implementation at a Station

Widening an existing platform overnight--can you believe it? It really took place in Tokyo at Haijima Station on JR Oume Line. The time available for the work was only about four and a half hours after the departure of the last train (12:15 a.m., January 27) and before the arrival of the first train next morning (4:52 a.m., January 27). What made the widening of the 210m long platform from 5.3m to 8.9m was now well-known expanded polystyrol (EPS). A platform can be made by simply heaping up EPS blocks.

A piece of cake

EPS blocks come in two sizes: 2m(L) x 1m(W) x 0.5m(H) and 2m(L) x 1m(H) x 0.4m(H). A 3.4m wide, 90cm high foundation was formed by arranging these blocks in three rows and two layers. Spaces between blocks were filled with adjusting blocks.

A flat concrete foundation had been prepared on the 160m section of the former up line where EPS blocks were to be laid out. The procedure was simple: arrange blocks neatly between the existing platform and retaining walls which had been prepared.

The work involved about 70 workers, which were divided into eight teams working on eight 20m subsections. The total weight of 50cm high blocks (with a volume of $1m^3$ each) was 16kg. The teams vied with one another in piling up about 60 blocks, each of which was carried by a team of two workers.

By 1:00 a.m. all blocks had been put in place, and they

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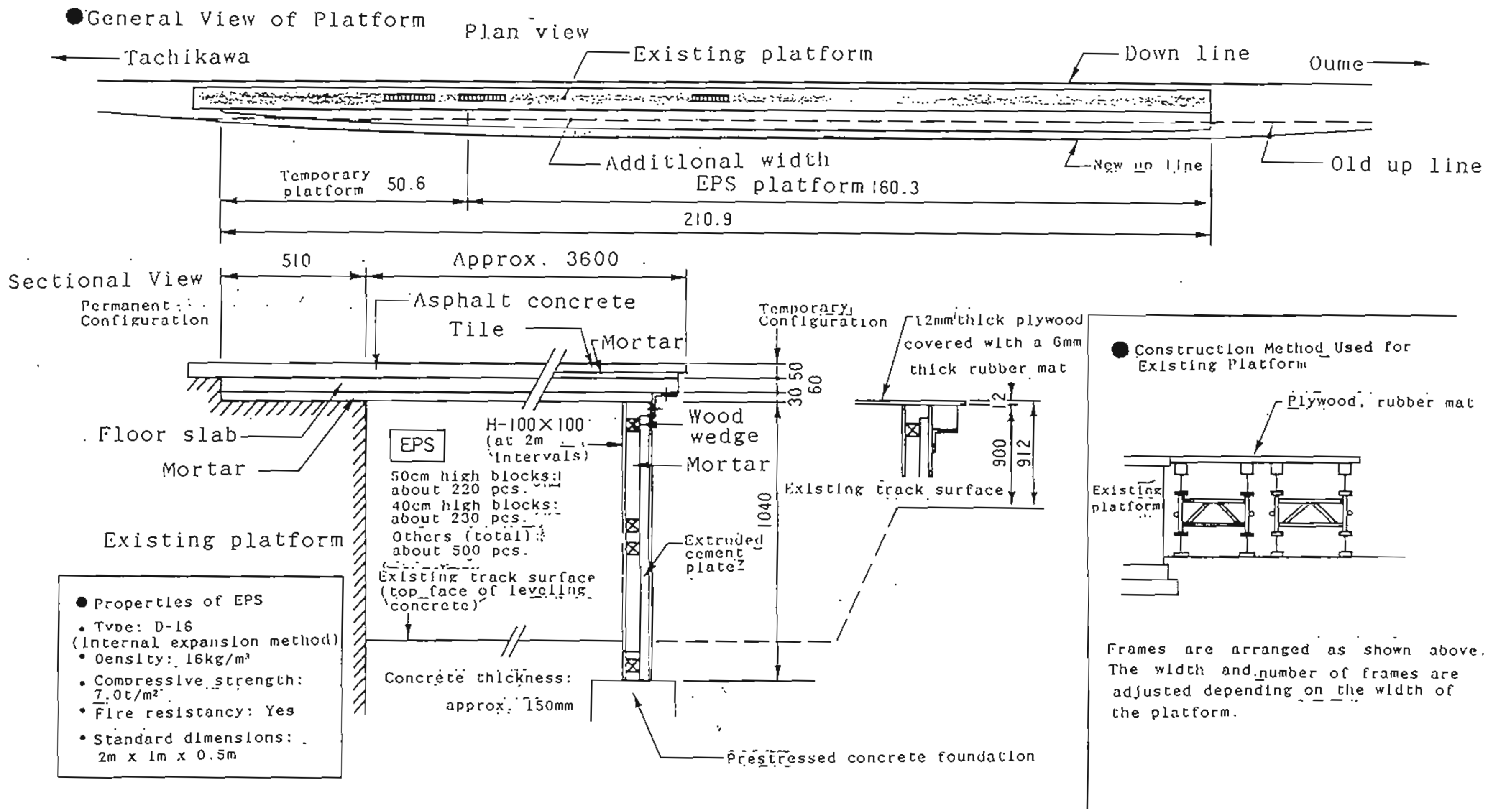


The allowable minimum compressive strength of EPS used was $3.5t/m^2$. The design load was $0.681t/m^2$, which is the sum of dead load and sidewalk live load.

3. Example of Implementation at a Station

一夜のうちに，既設のホームを拡幅してしまう——。こんな工事が東京都下，JR青梅（おうめ）線の拝島（はいじま）駅で行われた。工事に許された時間は1月26日の終電（27日零時15分発）から27日の初電（同4時52分発）までの約4時間半。全長210m，幅5.3mのホームを幅8.9mに拡幅する工事の主役は，おなじみの発泡スチロール（Expanded Poly-styrol=EPS）。そのブロックを積んでホームをつくり上げてしまうのだ。

1月27日（日）午前零時15分，上り最終電車が拝島駅を発車した。貨物線側で待機していた作業員が動き始める。切り替え後に上り本線となる線路上に積んであった発泡スチロールのブロックを，最終電車が行ったばかりの旧上り本線に移し変えるのだ。「あわてることはないよっ」と現場代理人，関谷厳氏（鉄建建設）の声がとぶ。

EPS部は楽々終わる

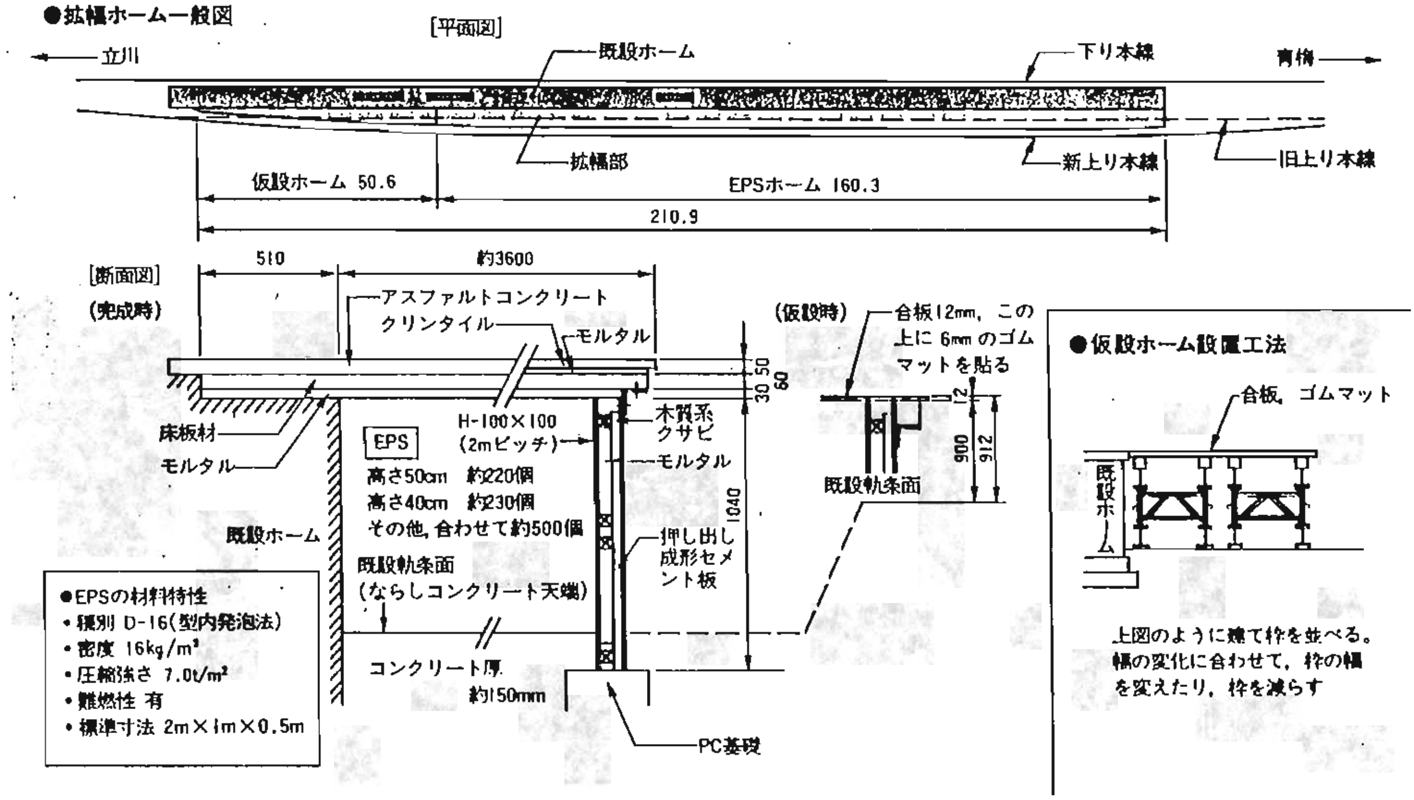
ブロックの大きさは，長さ2m×幅1m×高さ0.5mと2m×1m×0.4mの2種類だ。これを幅方向に3列，高さ2段に並べて，幅約3.4m，高さ90cmの基礎をつくる。隙間は，別に用意した調整用のブロックで埋める。

ブロックを並べる160mのEPS部には，旧上り本線のレール部分を除いてコンクリートが平たんに打設してある。作業は単純だ。ブロックを既設ホームと，当日までにつくった擁壁との間に規則正しく置いていけばよい。

作業員は約70人。施工区間を20mずつとして，8班に分けた。ブロックの重さは，高さ50cmのもの（体積1m³）が16kg。ほかの班に遅れてはならじと，二人一組で1班当たり約60個を次々と積み上げる。

午前1時にはブロックの設置を終え，その上に合板を敷く作業に取りかかった。既設ホームとの高さも調節する。1時半にはゴムマットを敷き出した班がある。EPS部の施工は，4時前にほぼ完了した。予定の時間を上回る早さだった。

しかし東京側の50mの部分では，



今回，使用したEPSの圧縮強さの許容値は3.5t/m²。設計荷重は死荷重，群集荷重の合計で0.681t/m²

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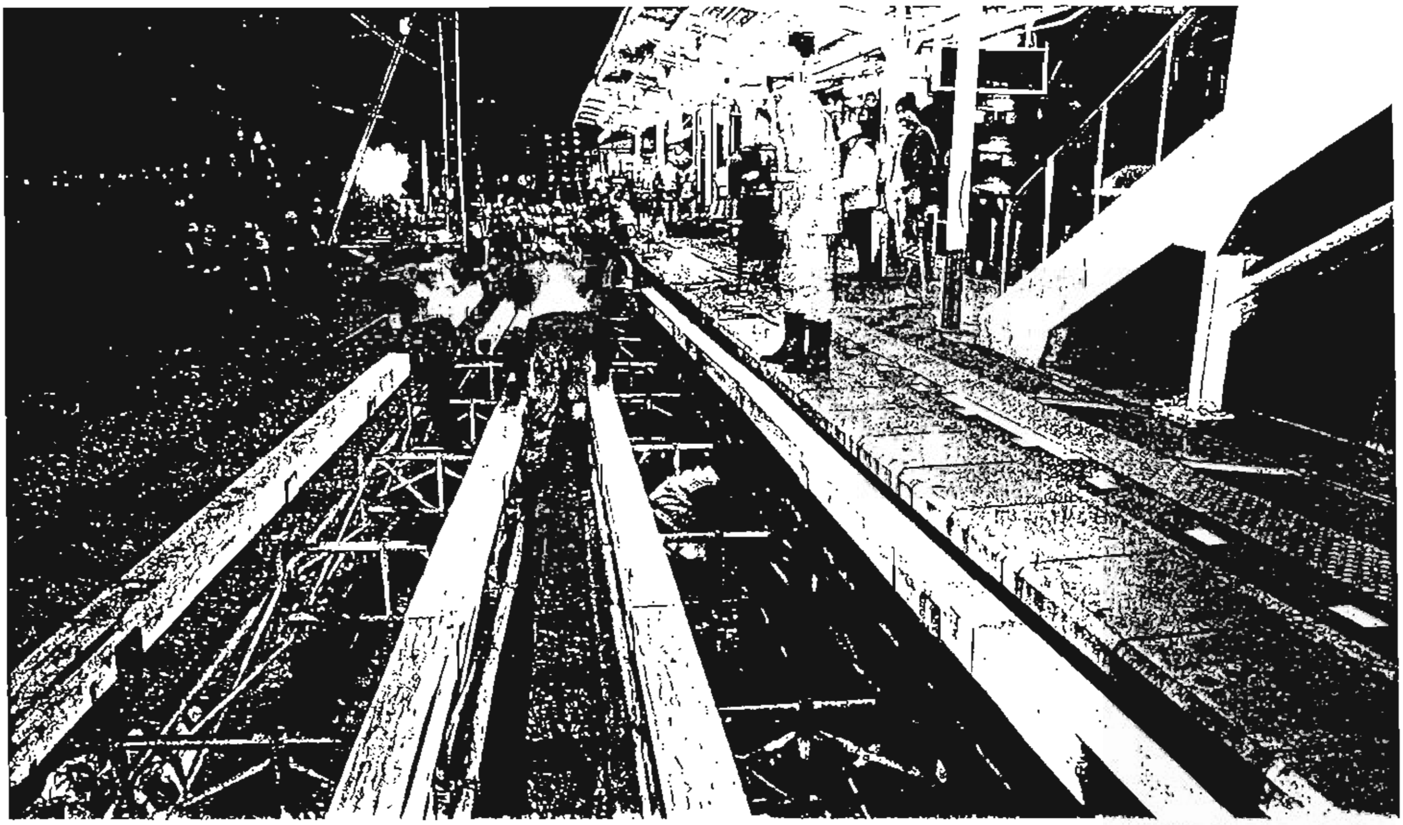
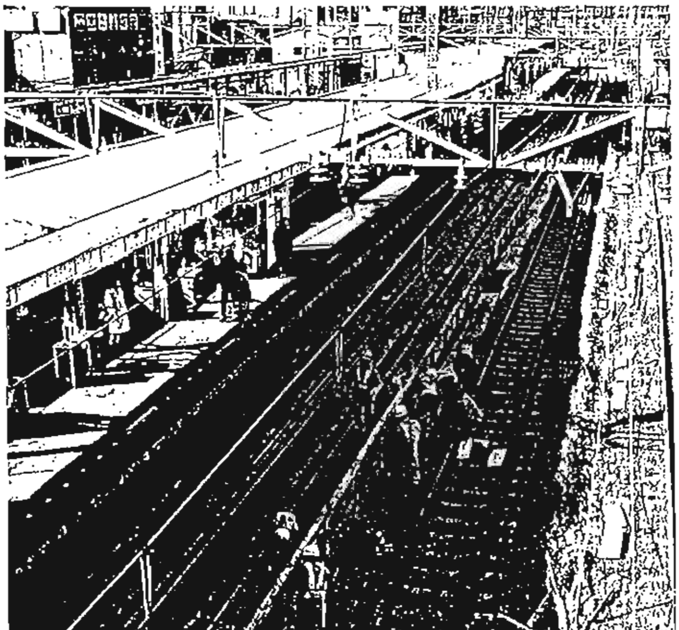
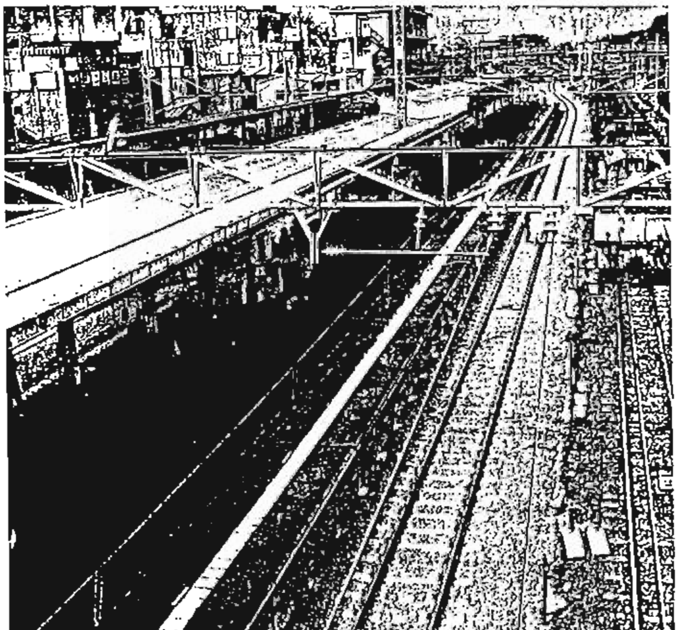


従来工法による施工。幅が狭くなる東京側50mの部分は，建て枠を組み合わせてそれに対応させる。この上に合板とゴムマットを敷く



拡幅3日前。擁壁を施工中だ。コンクリートは敷設済み(写真：本誌)



拡幅後の状況

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