Widening and bulk-up work for the replacement of a JR line overhead bridge
(DX-29 + D20 hybrid)

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1. Introduction

When replacing a heavily deteriorated railway overhead bridge, construction of a temporary road was difficult, as the existing road ran across the railway and crossing parallel to the national highway. No road was available for use as a detour in the vicinity of the site, therefore it was decided to carry out construction work in stages without interrupting traffic. The background to this decision is explained here, and a review conducted of specific aspects of the construction work.

2. General description

As the existing road had been in use for over 60 years, it had deteriorated to such an extent that heavy vehicle traffic was strictly controlled. The clearance under the bridge was also insufficient to meet railway standards. While replacement of the bridge was urgently needed, doing so would become more difficult when the construction work on the Shinkansen ("New Trunk Line" or "Bullet Train") line in progress near the bridge was completed. For these reasons, it was decided to carry out the replacement work in parallel with the construction work on the Shinkansen line.

This decision was made on condition that the work would take into account the following.

1) Plan to replace an overhead bridge crossing a JR line.
2) The impracticality of long term interruption of traffic in the vicinity of the construction.
3) No detour route available in the vicinity.
4) The planned road would require bulk-up of around 3.0m and widening of around 5.0m.
5) Alluvium layers of N=4 – 10 distributed in a complex fashion down to GL-25 m of the ground.
6) The work includes a temporary road, bridge construction and improvement work on the road. The time allotted for the work was around 25 months.

Another prerequisite was the need to allow one-way traffic and temporary interruption of traffic when necessary in the planned area of the work, due to convergence with the national highway at the end of the planned section, and traffic control near this location had the potential to cause serious congestion of traffic on the national highway.

2. Plan

Show Fig.2

2.1 Comparative study

The process was selected following consideration of several issues involved in the work, including the possibility of work with a lane of existing road for one-way traffic, parts which should be removed when the work was completed (e.g. ramp).

1) Inverted T wall + supporting pile

2) Reinforced earth wall process
3) EPS process
4) FCB process

Excavation in processes 1) – 3) leaves barely any room for a traffic lane, while the slope may be expected to disintegrate in process 4). For these reasons we took another look at the combined processes 1)- 3) and the earth supporting pile, then decided to carry out the work using process 2), the reinforced earth wall. A detailed investigation of the temporary road and landfill works revealed however that a temporary road of only barely sufficient width would be available at several sections during the landfill work over the temporary road, and that the increased load of landfill would most likely cause compaction settlement (road center of land-filled section Sc=198 mm), with the possibility of adverse effects on the railway tracks. Accordingly, we decided to carry out a study using 3) the EPS process.

2.2 Plan using EPS process

The EPS process is extremely lightweight and mobile. While it may be installed or removed without difficulty when the height of the temporary road is changed, it is unable to endure soil pressure. Accordingly, we used arc sliding calculations to calculate the excavation gradient at which soil pressure to the back of the EPS would not be not generated. As a result, we found that the work should be conducted with a gradient at the back of the EPS equal to 1:1.5, which is also the stable gradient of the landfill. Working with this gradient however not only results in a large volume of excavation and a costly structure, but also makes it difficult to secure sufficient width for a temporary road. For this reason, we decided to plan the work in combination with the soil supporting work, which was also one of the plans investigated in the aforementioned comparative study. We also decided that sufficient room for a temporary road is provided by the mobility of EPS material, even in a work plan that exceeds the height of the temporary road during step-by-step construction.

However, in the temporary road surface plan we chose to apply simplified pavement over concrete floor plates, for the reason that traffic directly on the EPS as the temporary road may result in wheel load exceeding the allowable stress of the EPS, and sliding wear of the longitudinal gradient. We chose the thickness of pavement to be simplified pavement and 18 cm thick from the design CBR 8%, because it is desirable to keep the pavement as thin as possible in terms of the ease of removing it at the next stage of work (Basic samples of simplified pavement, Japan Road Association).

Floor plates become completed intermediate floor plates when the pavement is removed in the next stage of work, and additional EPS material is installed on top of these plates.

Loading stress acting on the EPS material was calculated using the following equation:

$$\mathbf{s}\ z = \frac{P(\mathbf{1}+\mathbf{i})}{(B+2\ ?Z\ ?\tan ?)(L+2\ ?Z\ ?\tan ?)}$$

where, **s** z: Stress on the top surface of EPS

P: Wheel load (P=100.0 N)

i: Impact coefficient (i= 0.3)

Z: Depth from road surface to top surface of EPS

B, L: Wheel load application width (B=0.5m, L=0.2m)

? : Load dispersion angle (? =45- when concrete floor plate is used)

(Design manual 2nd edition: Foamed Polystyrene Construction Process Development Corporation)

The thickness of the EPS for under the floor plates was 10 cm, taking into consideration sliding wear over the longitudinal slope. Stress on EPS material was investigated taking into account the minimal influence of dead load and the multiplication factor (1.5), assuming the position of the center of the section (-5 cm) as the long term load and the top of the section (-0 cm) as the short term load. Results are shown below.

Live load: Wheel load 100 KN x 1.3 = 130.0 kN
Dead load: Case 1- Pavement not considered
Case 2- Simplified pavement
Surface layer 4cm, crushed stone 14cm

Case 1 Wheel load directly applied to floor plate:
Top of section: 466.736 kN/m^2 (/1.5 = 311.16 kN/m^2) N.G.
Center of section: 327.464 kN/m^2 N.G.

Case 2 Wheel load directly applied to pavement:
Top of section: 167.520 kN/m^2 (/1.5 = 111.68 kN/m^2) DX-29.
Center of section: 136.477 kN/m^2 DX-29.

It was decided that a temporary road could be constructed using DX-29, which has a high level of allowable stress, when simplified pavement (18 cm) is applied to the floor plate.

3. Carrying out work

Using an EPS installed surface as the temporary road allows work to be carried out without interruption of traffic flow. Removal of temporary roading is not necessary as the EPS is laid up to planned height over the EPS layers used as the temporary road in the next stage of work. The temporary roads and work sections are shown below:

? Right lane of existing road 1st stage of work (Left lane: Widening to the height of existing road)
? 1st temporary road (surface of 1st application) 2nd stage of work (Right lane: Widening to the height of temporary road, installation of ramp)
? 2nd temporary road (surface of 2nd application) 3rd stage of work (Left lane: Widening to the planned height)
? 3rd temporary road (surface of 3rd application) 4th stage of work (Left lane: Widening to the planned height)

Photograph of work

4. Conclusion

It was made simple to change the temporary road by application of EPS material with high strength. EPS is also applicable to works of approaches to jetty, which led to reduced section length of jetty, reduction of construction period and improved economic advantage. It also resulted in, however, increased complexity in the planning and work as EPS with different strength has to be allocated to individual phases of the construction. Further review is required on the structural strength allocation with the economic aspect and ease of planning/work taken into consideration.

References

Foamed Polystyrene Construction Process Development Corporation: Design manual, April 1993

1) Foamed Polystyrene Construction Process Development Corporation: Construction and cost estimation manual, November 1990
2) Foamed Polystyrene Construction Process Development Corporation: Materials manual, April 1992
3) Foamed Polystyrene Construction Process Development Corporation: EPS Process Riko Tosho, February 1993

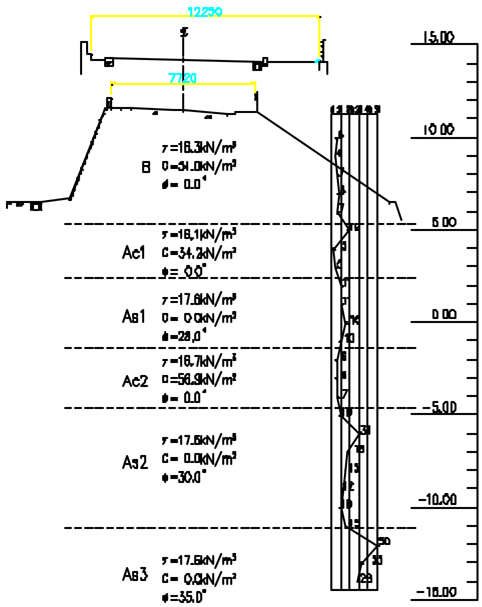

Fig. 1 Cross-sectional view of plan

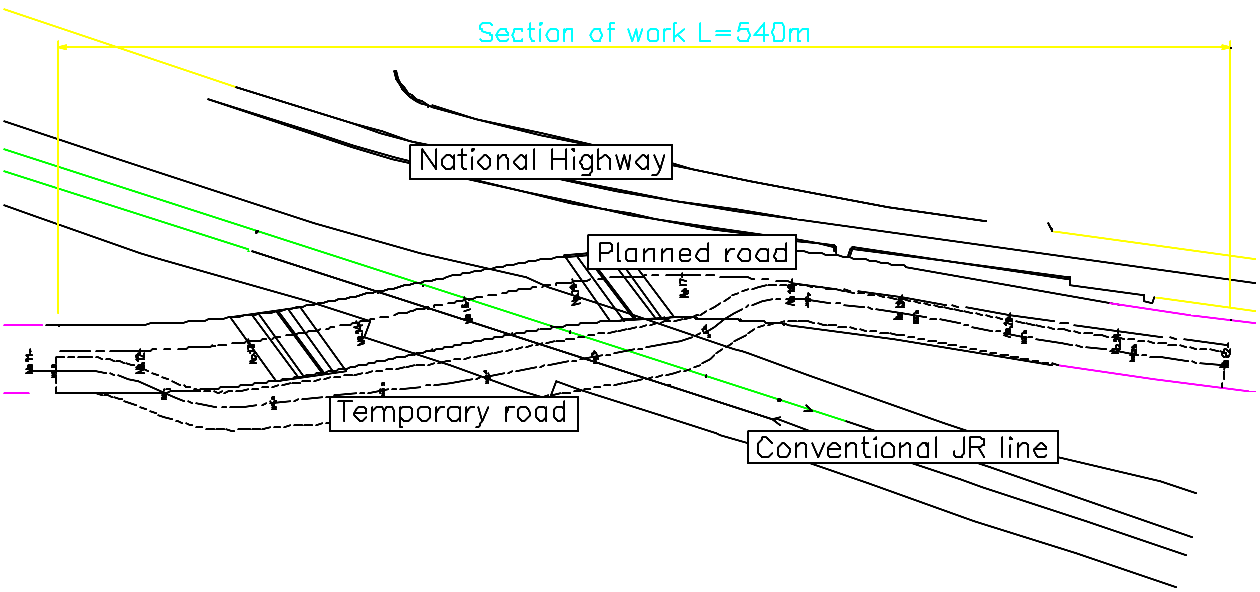

Fig.2 Horizontal view of plan

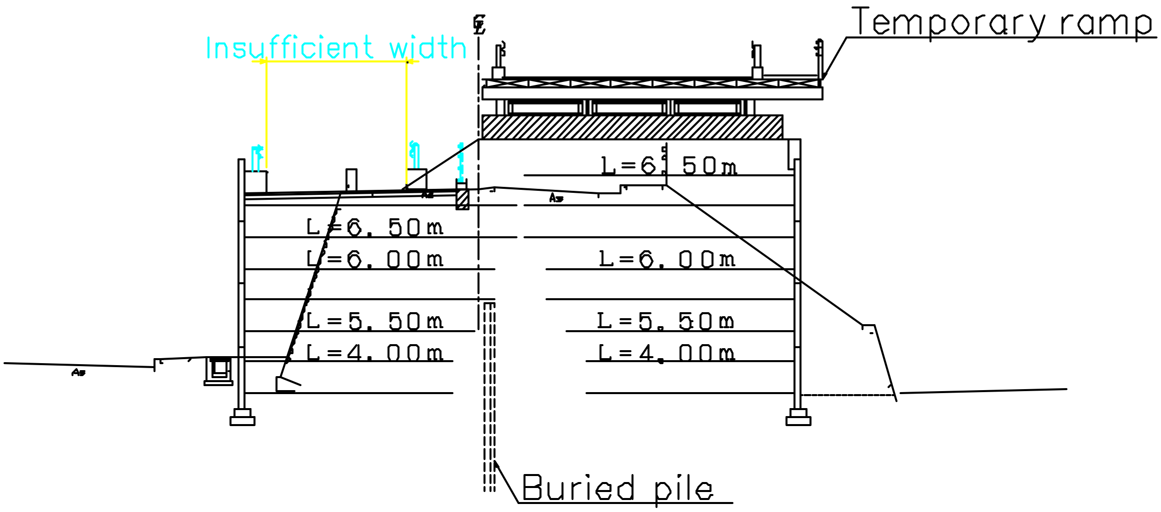

Fig.3 Step-by-step work using reinforced soil

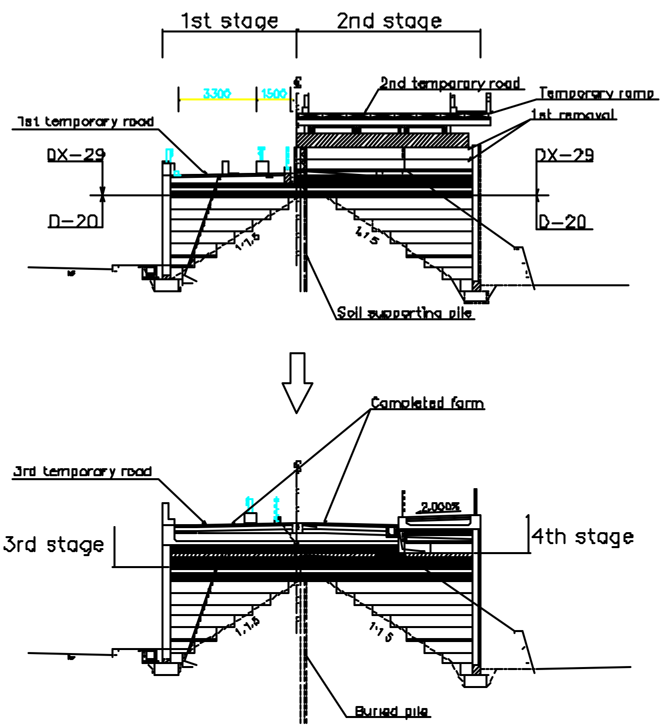

Fig.4 Step-by-step work using the EPS process

Table 1 Compressive strength of EPS material

Type	Unit	Mold method		Extrusion method
		D-20	D-25	DX-29
Unit weight	N/m^3	196	245	284
Allowable compressive stress	KN/m^2	50	70	140

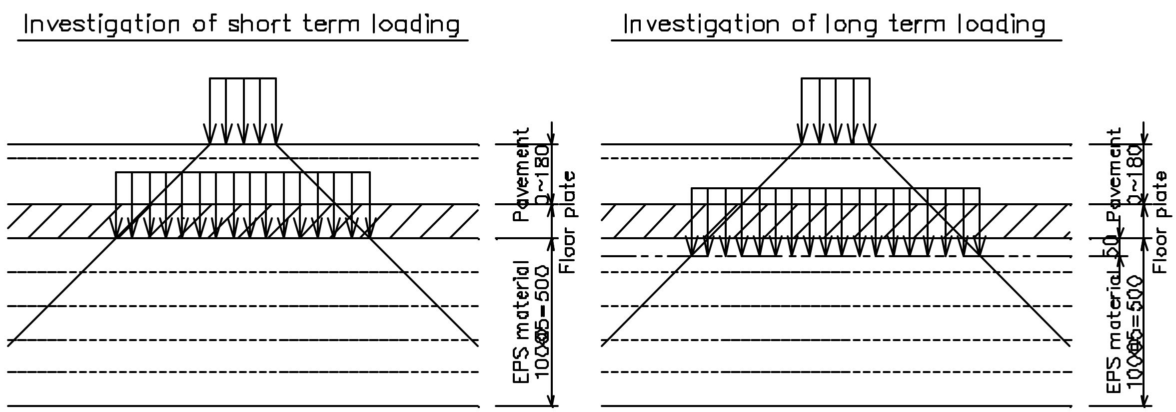

Fig.5 Model for examining EPS stress

Photo.1


Photo.2


Photo.3