Earth Reinforcement Practice, Ochiai, Hayashi & Otani (eds) © 1992 Balkema, Rotterdam. ISBN 90 5410 093 1

Application of geosynthetic-reinforced soil for bridge abutments

A. Kasugai
Central Japan Railway Company, Tokyo, Japan

M. Tateyama
Railway Technical Research Institute, Kokubunji, Japan

ABSTRACT: At Nagoya depot yard of the Tokaido Shinkansen operated by Central Japan Railway Company, to construct the new roadbed for the additional pool tracks, we adopted the geosynthetic-reinforced soil retaining wall(GRS retaining wall). Especially, in this construction site, we first placed the abutment supporting the over-road bridge for the Shinkansen on the GRS retaining wall. Therefore we set up instruments in the embankment under the abutment and observe its behavior to confirm the safety of this new method, and to establish the rational design. In this paper, we report the construction outline of the GRS retaining wall and the measurement results until now.

1 CONSTRUCTION PLACES

Fig.1 shows the outline of Nagoya depot yard. The place using the GRS retaining wall method is three work section as follows:

1. A work section ・・The embankment for three additional pool tracks.
   (Length 700m, Average height 5m)
2. B work section ・・The embankment for the track of maintenance car.
   (Length 130m, Average height 4.4m)
3. C work section ・・The embankment for the warehouses of track material.
   (Length 120m, Average height 4.4m)

Especially, at the over-road bridge in A work section, we used the new method setting the abutment on the GRS retaining wall.

2 SELECTION OF THE METHOD

The most of the roadbed section in this construction site are close to private houses and face the road local people often use. Therefore we couldn't construct pile foundation which can cause the problem of

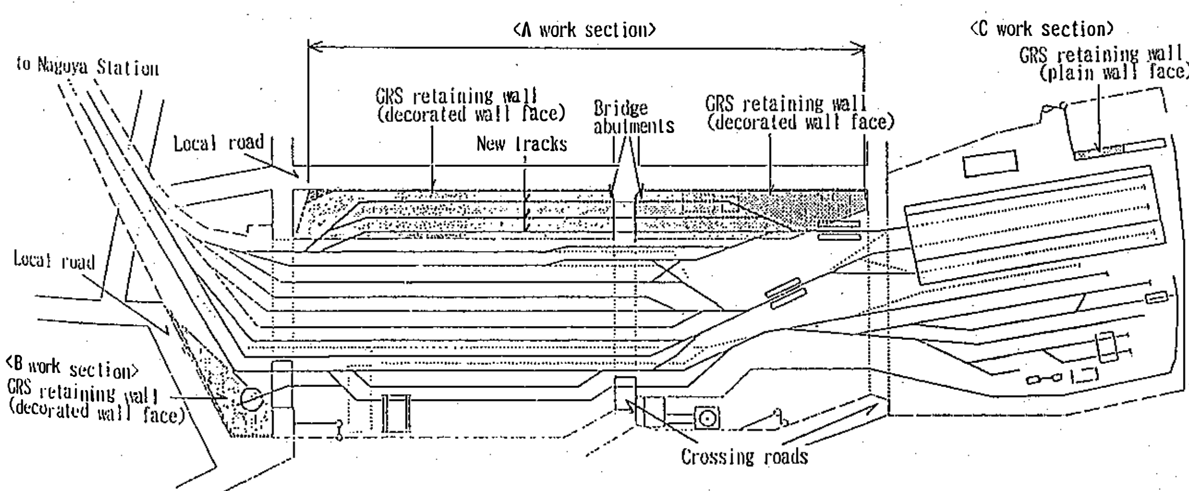

Fig.1 Plan of Nagoya depot yard site showing the places using the GRS retaining walls

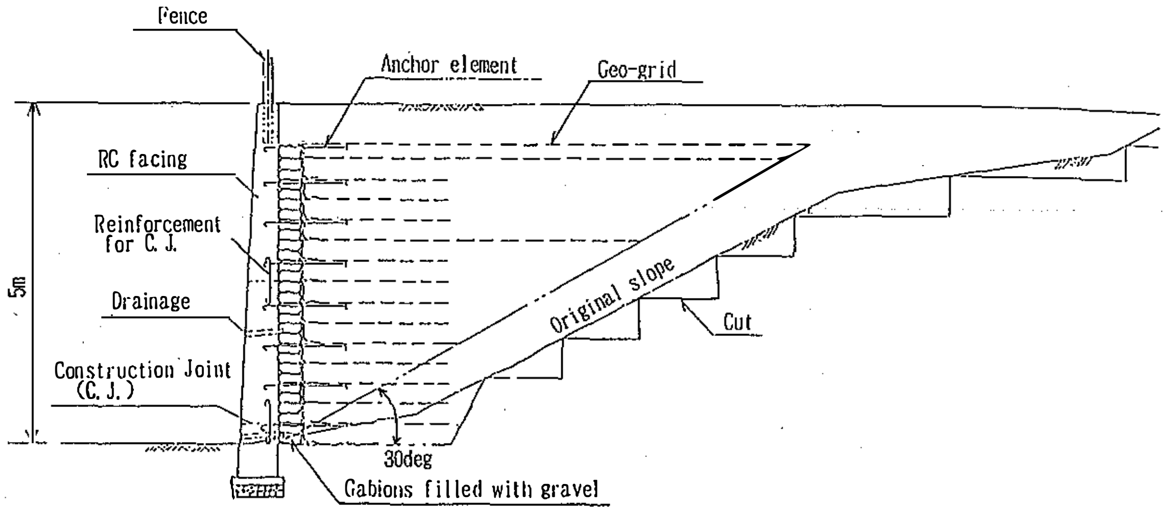

Fig. 2 General cross-section of the GRS retaining walls

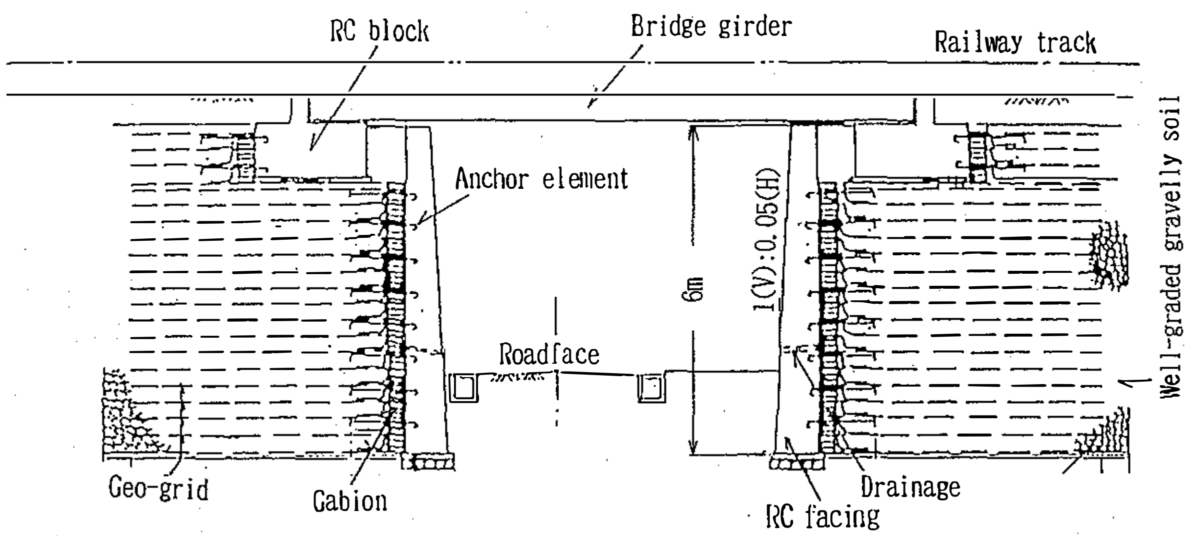

Fig. 3 Cross-section of geosynthetic-reinforced soil bridge abutments

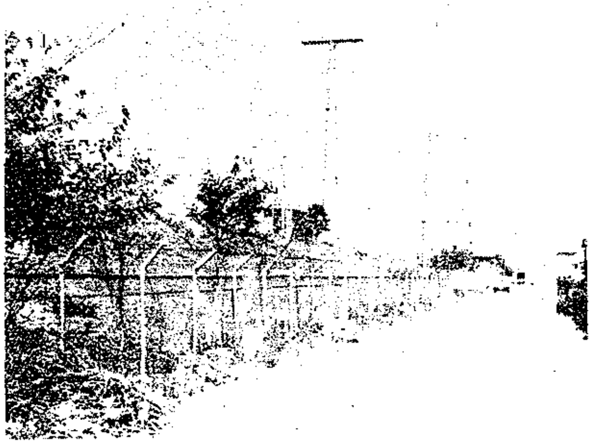

Plate 1 View at the beginning stage of re-construction of the existing slope

noise and vibration and couldn't use the crane which occupy the road for the local people. So we decided to adopt the GRS retaining wall method which has advantages as follows:

1. Compared with the conventional reinforcing method, the length of the new reinforcement required for resisting the earth pressure can be much shorter because of planar reinforcements and the use of a continuous rigid facing. If the length of reinforcements should be on the order of the wall height as employed for the conventional reinforcing method, some sheet piling work together with anchoring work into the existing slopes, to excavate large part of them, would be necessary in order not to unstabilize the existing slopes on which trains are running nearly.

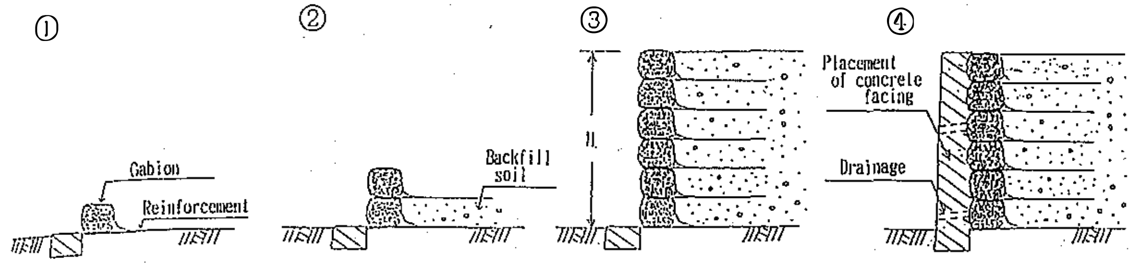

Fig.4 Construction sequence of the GRS retaining wall method

2. The possible damage to the connections between the rigid facing and the reinforcing members due to the subsidence of the backfill can be less avoided because a facing structure is built after the compression of the back fill is completed. Furthermore gabions are used as a buffer to smooth the relative settlement between them.

3. Because of not using the crane like the conventional reinforcing method, the construction in narrow space is possible.

4. The waste material is effectively used since it is possible to use cohesive soil as the backfill soil.

And at the over-road bridge in A section which is next to the box girder, the additional bridge couldn't be constructed by using a box girder, since the construction of this type of structure required closure of the road, which wasn't allowed. Therefore the GRS retaining wall system was adopted to construct the bridge abutment.

3 CONSTRUCTION SEQUENCE OF THE GRS RETAINING WALL METHOD

Fig.4 shows the construction sequence of the GRS retaining wall method.

1. At first the foundation of rigid facing is constructed, and the reinforcemento are laid. Then the gabions are piled up and they are rolled by the reinforcements. After that the reinforcements are fixed tightly.

2. After the material of the embankment is strewed and compacted, laying reinforcements and piling up gabions are repeated.

3. The above progress of work is repeated till prescribed height "H".

4. After construction of the drainage, the concrete of the rigid facing is placed.

3.1 Making and piling up gabions

The material of the bag of a gabion is fibrous, which has good nature of penetration of water and the enough strength. The bag of a gabion is filled with gravel to fulfill the function as a drainage.

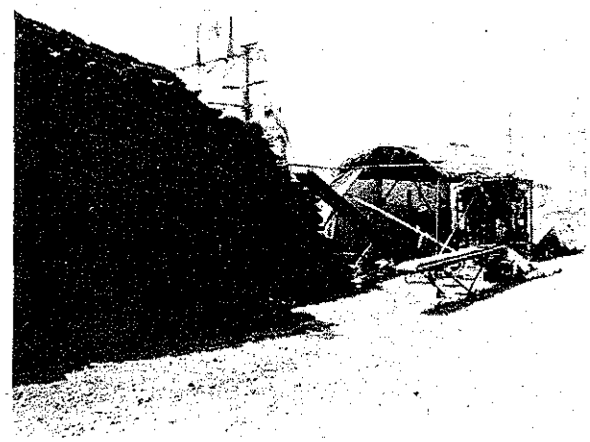

Plate 2 Making gabions by machine

Plate 3 Piling up gabions

At first the gabions were made by man power. But workers were very tired and the efficiency of making gabions was bad. So the contractor devised the making machine of gabions which consists of the weighting instrument of the gravel, the belt conveyer and the industrial sewing machine to sew the bag of gabions. By using this machine, it came to be possible to make about 600 gabions per a day(see Plate 2).

And piling up two gabions(15cm× 2) per a

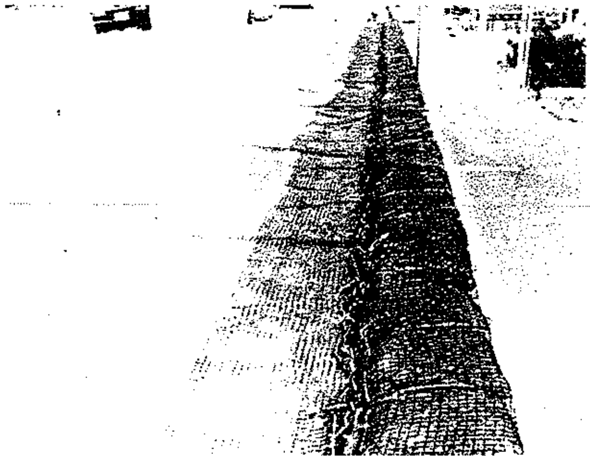

Plate 4 Laying reinforcements

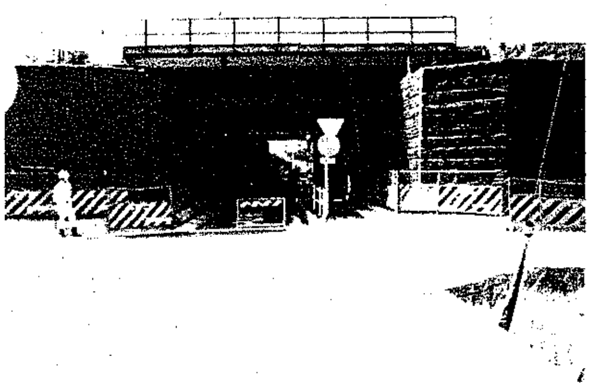

Plate 5 After the construction of a temporary girder

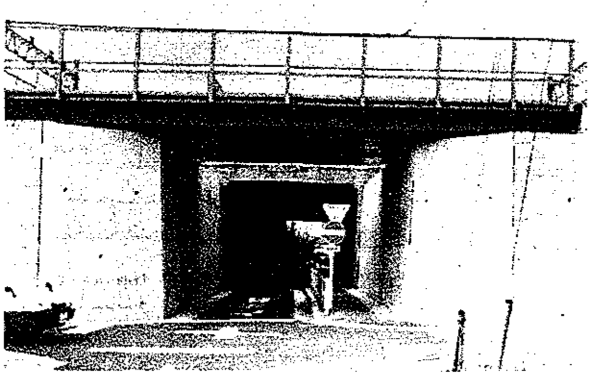

Plate 6 After the construction of the permanent over-road bridge

layer which is 30 cm thick was planed in the beginning. But the gabions piled up was unstable and it was need to squeeze the mouth of the bag of gabions by man power to round it. Therefore we changed into piling up three gabions(10cm × 3) per a layer.

3.2 Laying reinforcements

The material is Vinylon covered with soft vinyl chloride.

The gabions often overhanged when the backfill soil was compacted, because the reinforcements which rolled the gabions couldn't be fixed tightly. In order to improve this state, after compacting the gabions piled up for a layer and the backfill soil of the back of the gabions which is rolled by the reinforcements, using a plate rammer, we piled up the main body of the backfill soil and compacted them by a compaction machine.

To minimize the transformation after construction, about twice strong reinforcements with a rupture strength of 6tonf/m, compared with the general embankment section, was used in the embankment under the abutment.

3.3 Embankment

The total volume of the backfill soil is about 36,000m³ and about 17,000m³ of them are the waste material.

Near the shoulder of wall, a small compaction machine was used and a heavy compaction machine was used to compact the main body of the backfill soil. And the compaction was managed by a plate loading test.

In the embankment under the abutment, to minimize the subsidence by passing of the Shinkansen, a high-quality selected well--graded gravel was carefully compacted to a dry density as high as about 2.2 g/cm³. Besides before placing a delayed cast-in--place concrete facing, a temporary girder was constructed and the embankment was enough made accelerate its transformation by passing of the dump truck carrying the material of the embankment(see Plate 5).

3.4 Construction of the rigid facing

After certifying the subsidence of the embankment came to an end, the cast-in-place concrete facing was placed. The average settlement at the crest for a period of about eight months between the end of the construction of the wrapped-around wall and the placement of concrete facing was about 7cm.

And most part of the facing was decorated by using a special framework for concrete which can give an illusion of piled-up natural stones, as shown in Plate 8. This is because the wall is located next to private residences separated only by a narrow two-lane local road.

4 OUTLINE OF MEASURE MANAGEMENT

As stated above, because the application of the method placing the abutment on the GRS retaining wall to the Shinkansen's permanent important structures, is the first, the construction needs enough safety management. From this point of view, we set up instruments in the embankment under the abutment and observe its behavior to confirm the safety of this new method.

Fig.5 shows the arrangement of the instruments in measure cross section. Main instruments are the earth pressure gauge, the strain gauge of the reinforcement bar, the inclination gauge of the rigid facing, the strain gauge of the reinforcement, the hydraulic gauge of the gap and the rain gauge.

In this construction site, four types of measurement as follows, are done:

1. The measurement in the process of construction.
2. The long-term behavior measurement after construction.
3. The static loading test by a dump truck.
4. The dynamic loading test when the Shinkansen passes the bridge for the first time.

5 MEASUREMENT RESULTS

Among above-stated measurement, 4. is planed to do after October 1992 and 2. is measuring till March 1993 over one and a half year. So in this paper we report the measured results.

5.1 Measurement results in the process of construction

Figs 6. and 7. show an example of a time series curve of the earth pressure and the strain of the reinforcement.

The earth pressure rises according to the height of the embankment, and the measurement value is stable after a temporary bridge is constructed.

The value of the strain gauge doesn't respond well to the height of the embankment. It is not regular that some of them are compressive strain. It seems that it is

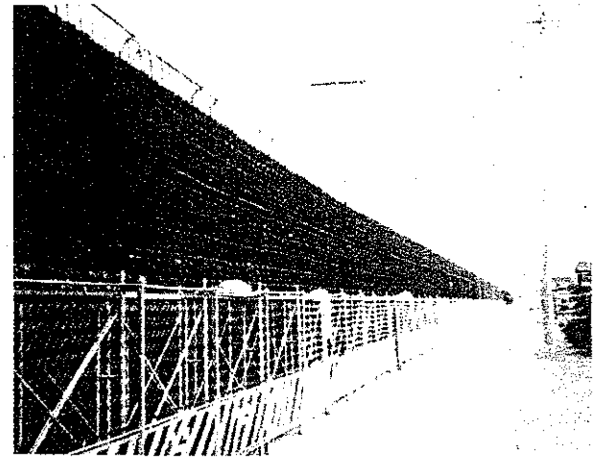

Plate 7 View of completed wrapped-around wall prior to placing a cast-in-place concrete facing

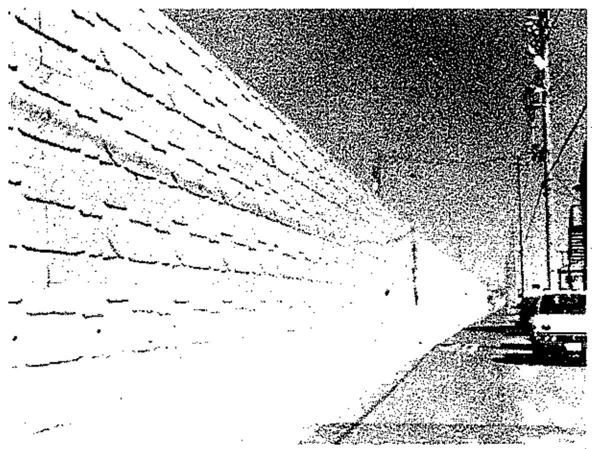

Plate 8 Decorated wall surface

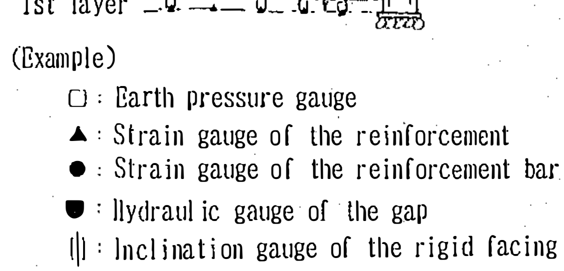

Fig.5 Arrangement of the instruments

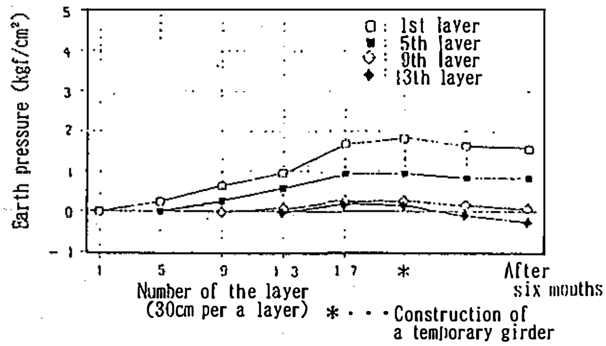

Fig.6 Earth pressure in the process of construction

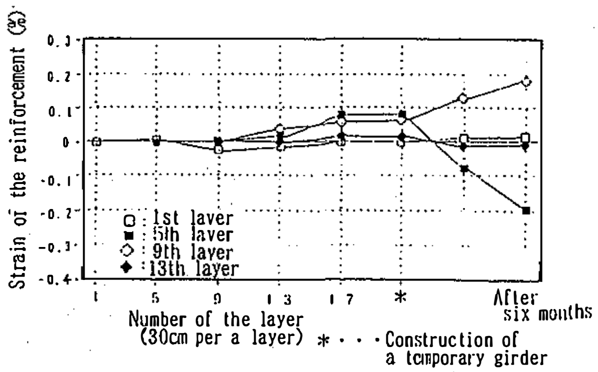

Fig.7 Strain of the reinforcement in the process of construction

caused by the irregularity and the unevenness of the reinforcement which happens when it is laid.

5.2 The result of the static loading test by a dump truck

The static loads which are a dump track(20 tf), fully loaded with earth and sand, and a tire roller(10tf) were gradually moved from end to end of a temporary girder.

It was found that the settlement of the concrete block which is an abutment of a temporary girder, was about 0.2 mm. Considering that the design load is 2.5 tf/m^2 when the train is loaded, this test is as same order as that one which is done by using the real train. If this transformation happens at the range of 2m from the top of the embankment, it seems that the risen strain of the earth is a minute order(about 10^{-4}).

Fig.8 shows an example of the process of the stress in the embankment and the strain of the reinforcement, accompanied with loading. The measured strain is minute(about $10^{-5}\sim10^{-4}$) and the process draw a loop, which returns 0 at last. By this results, it seems that the soil behaves elastically.

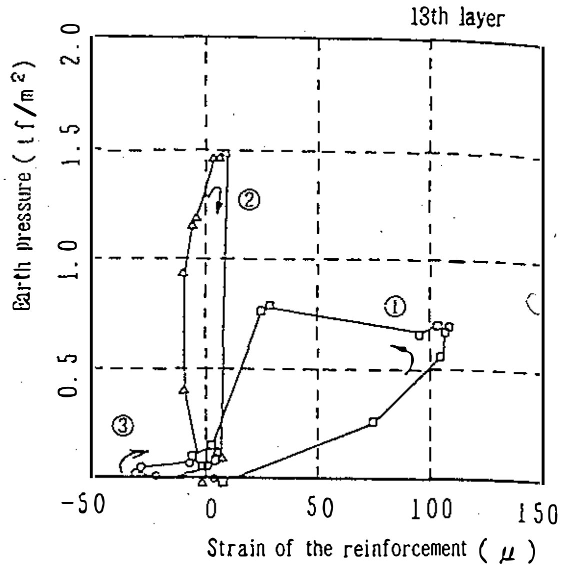

Fig.8 Process of the stress in the embankment and the strain of the reinforcement

6 FUTURE RESEARCH

From now on, we continue the long-term behavior measurement and observe the behavior of the embankment when the Shinkansen passes to confirm the safety of this method.

By this measurement results in site and the results of the large compressive test of three axles in Tokyo Univ., using the well-graded gravel under the abutment at this site, we plan to do the non-linear FEM analysis at the level of minute strain to establish the rational design.

REFERENCES

Tatsuoka, Murata and Tateyama 1991. Permanent geosynthetic-reinforced soil retaining walls used for railway embankments in Japan.

Watanabe, Aoki, Kachi, Kasugai 1991. A construction example of the geosynthetic-reinforced soil retaining walls in the depot yard of the Shinkansen. The foundation engineering & equipment, Vol.19, No.11, p.46-56