A case study on the construction of reinforced earth wall using I-type connection system

Han, J.G. & Hong, K.K.
Department of Civil & Environmental Engineering, Chung-Ang University, Korea

Lee, K.W. & Cho, S.D.
Geotechnical Engineering & Tunnelling Research Division, Korea Institute of Construction Technology, Korea

Moon, H.J.
Dae-Sung Concrete Corporation, Korea

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ABSTRACT: The reinforced earth wall system with geogrid has been increased rapidly since 1990's in Korea, because of the economical efficiency, the convenience of installation and the graceful appearance. Therefore, the various connection systems between the wall facing and geogrid are developed for stability increase of the reinforced earth wall. In this paper, the behavior of the reinforced earth wall using I-type connection system was analyzed with field monitoring. The analysis results confirmed that the horizontal displacement of the wall facing and the maximum strain of geogrid are in a stable condition. Therefore, the reinforced earth wall using I-type connection system will be able to apply in field.

1 INTRODUCTION

The reinforced earth wall, which is unified with backfill soil, reinforcement and wall facing, resist against the external force and the earth pressure. Therefore, the connection between wall facing and reinforcement is very important in stability of the reinforced earth wall. However, there have been increasing numbers of crack and local failure in wall facing, because there are so many cases that an evaluation of the connection strength is overlooked(Hong et al., 2008). The connection between facing block and reinforcement is located in reinforcement between the blocks and fixed reinforcement to the blocks by using shear key or shear pin. However, the existing connection type could be cause damage to reinforcement during construction(Figure 1) that is caused by crack of facing block and excess horizontal displacement of the wall.

This study developed new connection system to make up for the weak points in the existing connection type. A case of field construction and monitoring was conducted in the reinforced earth wall using new connection system.

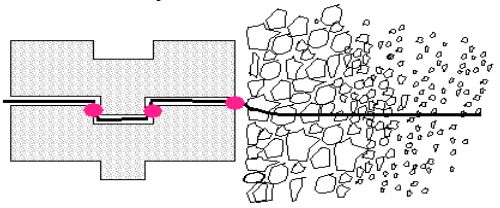


Figure 1.Damage between facing block and reinforcement

2 I-TYPE CONNECTION SYSTEM

In order to improve the problems of the existing connection system, new connection system was developed as shown in figure 2. The I-type connection equipment in the new connection system is located in the facing block directly as shown in figure 3. The developed connection system is able to reduce a length of the used geogrid because geogrid is not located between the facing blocks and to protect from a local damage, which occurred between upper and lower blocks. It also has advantage that the damage of geogrid is protecting due to simultaneous settlement of geogrid, backfill soil and drainage layer behind the facing blocks.

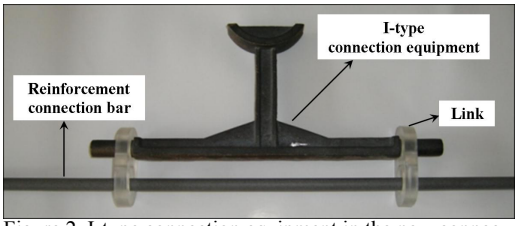


Figure 2. I-type connection equipment in the new connection system

3 FIELD TEST AND MONITORING

3.1 *A plan of construction and measurement*

The construction and measurement on the reinforced

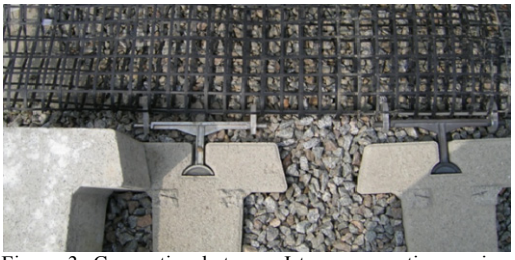


Figure 3. Connection between I-type connection equipment and facing block

Table 1. Property of backfill soil

Water content (%)		9.88
Gran size Distribution (%)	Gravel	23.53
	Sand	71.78
	Silt	4.69
Plastic Index		N.P
Gs		2.64
Compaction test results	$\gamma_{d\,max}$ (kN/m^3)	19.55
	O.M.C (%)	10.98
USCS		SW

Table 2. Measurement plan of the reinforced earth wall

Contents	Measurement location
Horizontal earth pressure	1.1m, 3.0m and 5.4m from the bottom of the wall
Strain of geogrid	0.5m, 1.0m, 1.5m, 2.0m, 3.0m and 4.0m from behind the block (Measurement geogrid : 2nd, 3rd, 5th, 6th, 8th and 9th from the bottom of the wall)
Horizontal displacement of wall facing	0.8m, 1.4m, 2.6m, 3.4m, 5.0m and 5.8m from the bottom of wall facing

Table 3. Characteristics of geogrids and blocks

Classification	Contents			
Geogrid	Max. Strength (kN/m)	60	80	
	Materials	PP/PET		
	Elongation (%)	13	13	
	Strength at 2% Elongation (%)	15	20	
	Strength at 5% Elongation (%)	30	40	
Block	Size (B*L*H, m)	A	B	C
		0.5*0.5*0.4	0.5*0.5*0.3	0.5*0.5*0.2

earth wall using I-type connection system was conducted to evaluation in field application as shown in Figure 4. The reinforced earth wall was 20m in length and 7.0m in height and was designed based on the design guidelines specified by FHWA(Elias & Christopher, 1996). Table 1 shows the property of weathered soil using backfill soil.

In order to evaluate behavior of the reinforced earth wall using I-type connection system, the horizontal earth pressure, the tensile deformation of geogrid and the horizontal displacement of wall facing are measured. The contents of measurement are planned as shown in table 2, figure 4 and figure 5.

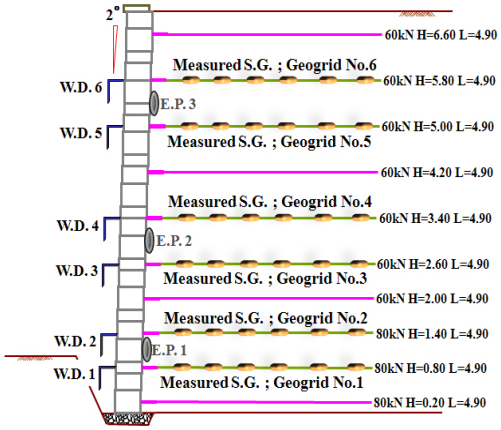


Figure 4. Measurement location of the reinforced earth wall

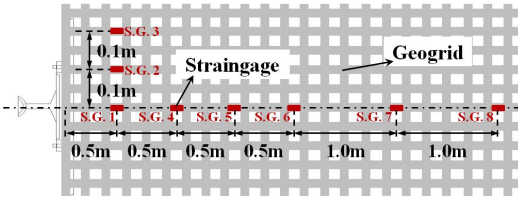


Figure 5. Strain measurement location of geogrid

3.2 *Results of measurement*

The measurements of the horizontal earth pressure, the strain in the geogrid and the horizontal displacement of the wall are conducted to evaluate behavior characteristic of the reinforced earth wall using I-type connection system during 5 months after the end of construction.

The measurement result confirmed that horizontal earth pressure increased as close to the bottom of the wall and the maximum earth pressure indicated 7kN/m^2 at EP1. It was less than the predicted earth pressure by Rankine's theory, 17%.

3.2.1 *Horizontal displacement of the wall*

The measurement results on the horizontal displacement of the wall with the elapsed time are shown in Figure 6. The horizontal displacement was rapidly increased at the early stage of construction. However, the displacement was decreased according to increasing of backfill height and was almost fixed after the end of construction. That is, the horizontal displacement occurred during construction of the

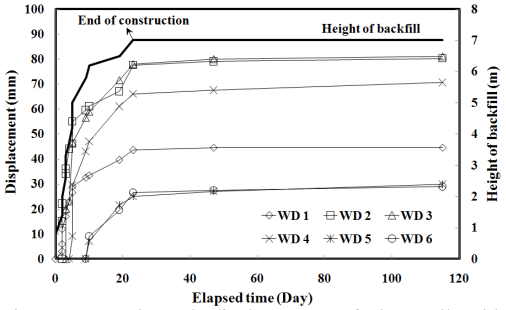


Figure 6. Horizontal displacement of the wall with elapsed time

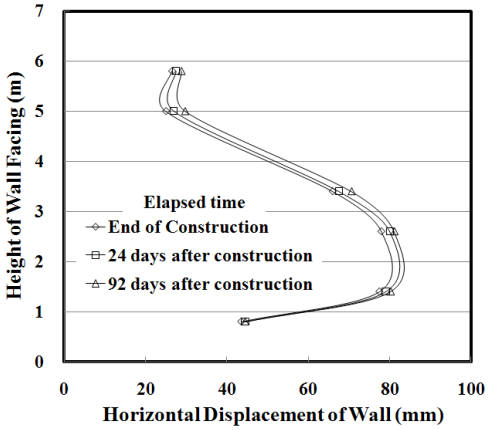
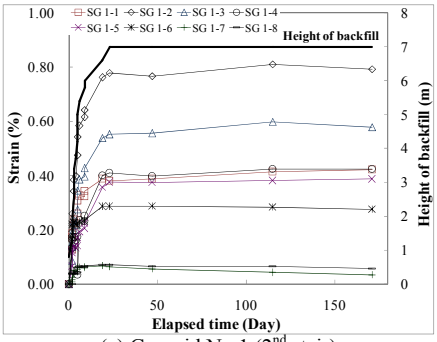


Figure 7. Horizontal displacement with the wall height

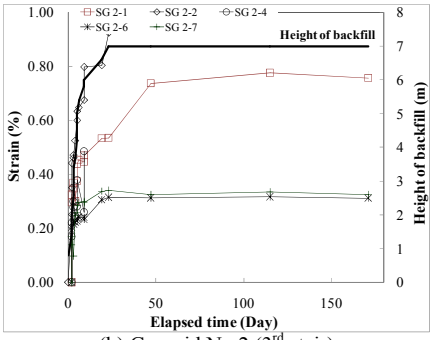
wall and it is stabilized as end of the construction. Figure 7 shows the horizontal displacement with the height of the wall. The maximum horizontal displacement occurred 81.1mm until 92days after end of the construction; it was about 1.2 % on the height of the reinforced earth wall.

3.2.2 *A tensile variation of geogrids*

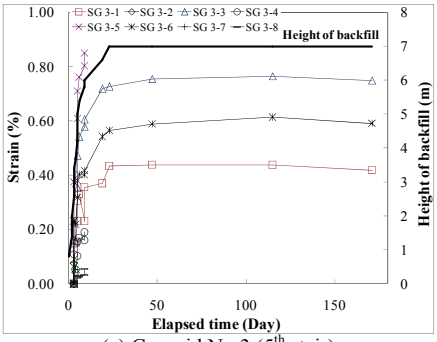
The strain measurement results of geogrid are presented as shown in Figure 8 and Figure 9. The strain in the geogrids is increased by increasing of the wall height during construction of the wall, and then the strain was fixed or decreased after the end of construction. The maximum strain of geogrid is measured less than 1.0% until 5months after end of the construction. Therefore, the reinforced earth wall using I-type connection system can be evaluated to the stabilization. The measurement results confirmed that the I-type connection system is able to decrease the strain of geogrid in the connection section between geogrids and facing blocks because of a simultaneous settlement of geogrids, backfill soil and drainage layer behind the facing blocks.



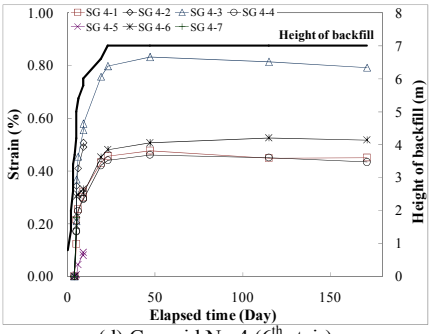
(a) Geogrid No.1 (2nd stair)



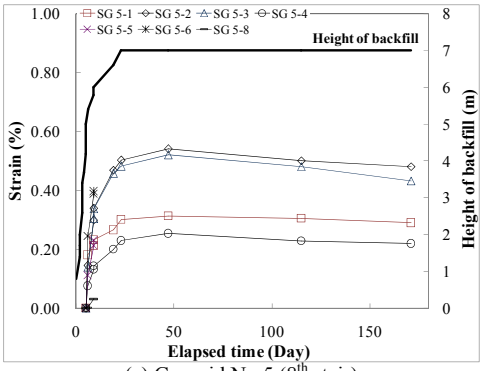
(b) Geogrid No.2 (3rd stair)



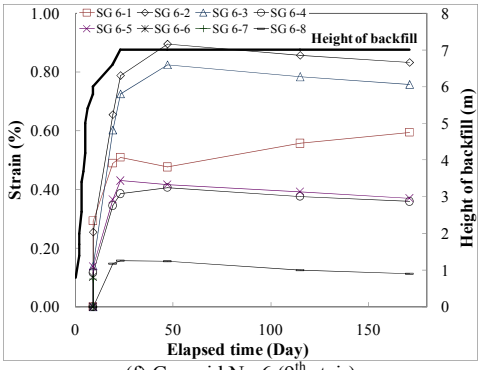
(c) Geogrid No.3 (5th stair)



(d) Geogrid No.4 (6th stair)



(e) Geogrid No.5 (8th stair)



(f) Geogrid No.6 (9th stair)

Figure 8. The strain in geogrids with elapsed time

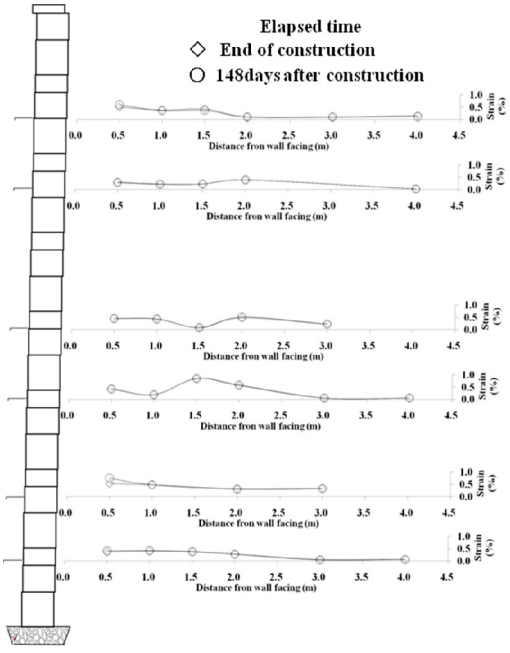


Figure 9. The strain in geogrids with the wall height

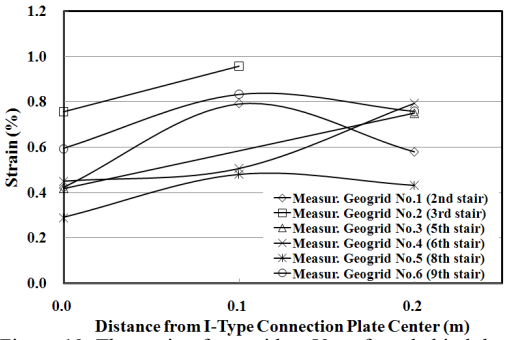


Figure 10. The strain of geogrid at 50cm from behind the wall

Figure 10 shows the measurement results of the strain at 50cm from behind wall facing, there is result at 5 months after the end of construction. The measurement results confirmed that the strain in the geogrid presented the maximum value at 10cm from a center of the I-type connection equipment; it means that the maximum tensile force occurred at the point.

4 CONCLUSIONS

The new connection system is developed to prevent from damage which could be caused at the connection between geogrids and the facing blocks. A field experiment and monitoring was conducted in the reinforced earth wall using new connection system.

The reinforced earth wall was constructed 7m in height. The measurement results confirmed that maximum horizontal displacement of the wall and the maximum strain of geogrid are evaluated 81.1mm (0.012H) and 0.96% until 5months after the end of construction, respectively. Therefore, the reinforced earth wall using I-type connection system is good in field application because it is evaluated in stabilization.

REFERENCES

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