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Reinforcement effect of composite earth retaining wall system on releasing strut

S. Saji & K. Numakami
Tokyu Construction Co., Ltd, Tokyo, Japan

ABSTRACT : In this paper,we propose to discuss a Composite Earth Retaining Wall (CERW) system used to control displacement of an earth retaining wall when a strut is released. The CERW is composed of a soil cement wall and a concrete underground wall which are unified by stud bolts. The behavior of the earth retaining wall on releasing the strut was estimated by analytical calculation. The estimation closely matched the measured.

1. INTRODUCTION

It is one of the problems in the ground work of buildings constructed on a soft ground in a city to control the displacement of an earth retaining wall during an excavation. It is also a serious problem to control that when the strut is released if the basement floor height of the building is high. The increment of the earth retaining wall is great because two or three stage struts are released at once.

In general, raker and buttress system have been used. However, the constructions of these systems are time-consuming, and these systems need to be removed after the strut is released.

In this paper, the author proposes a new system, which requires less time to construct than conventional systems and does not need to be removed. This system is named 'Composite Earth Retaining Wall '(CERW) .

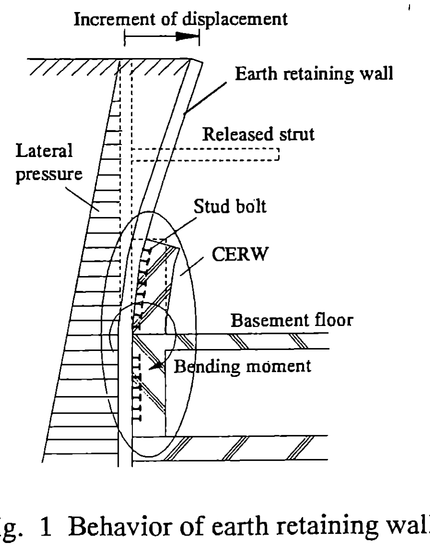

Fig. 1 Behavior of earth retaining wall

2. COMPOSITE EARTH RETAINING WALL

Fig.1 shows the behavior of an earth retaining wall when the strut is released. The reaction of the released strut results in an increment of displacement and bending moment.

Fig.2 shows details of the CERW and distribution of the strain in CERW. The CERW is composed of a soil cement wall and a reinforced concrete wall. At the first, stud bots are welded on the H-shaped steel of a soil cement wall. Next, a part of the concrete wall is placed next to the soil cement wall. These two elements are unified by the friction between stud bolts and the concrete.

Tensile strain and compressive strain occurs in the CERW. It is necessary to control the tensile strain of the concrete below the concrete crack strain.

Neutral axis is the boundary between a compressive strain area and a tensile strain area. The position of neutral axis can be calculated using the convergent method.

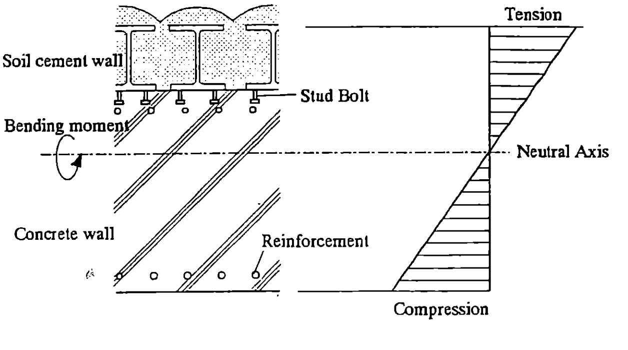

Fig. 2 Detail and distribution of strain of CERW

3. GENERAL OUTLINE OF THE CONSTRUCTION SITE

The construction site is in a suburb of Tokyo and is located topographically in the Meguro terrace.

Fig.3 shows the earth retaining wall plan and measuring items. The plan is bounded by A zone and B zone. Soil cement wall was used for the earth retaining wall (except the boundary between A zone and B zone). Berlinoise method wall was used for the boundary. The excavation of B zone started after the basement floor of A zone was constructed. A CERW was used for the soil cement wall of A zone. Displacement of the earth retaining wall, reaction and temperature of the struts and strain of CERW were monitored by an automatic measuring system.

Fig.4 shows a general outline of the soil and a section of the soil cement wall of A zone. The final excavation depth is 27m. The total stage number of the struts is 7. A CERW system was used for the ground wall of basement 5th floor (B5F) on the 5th stage strut releasing (5SR), and B3F on 3rd stage strut releasing (3SR). The height of the concrete walls is 3.7m and 2.2m respectively.

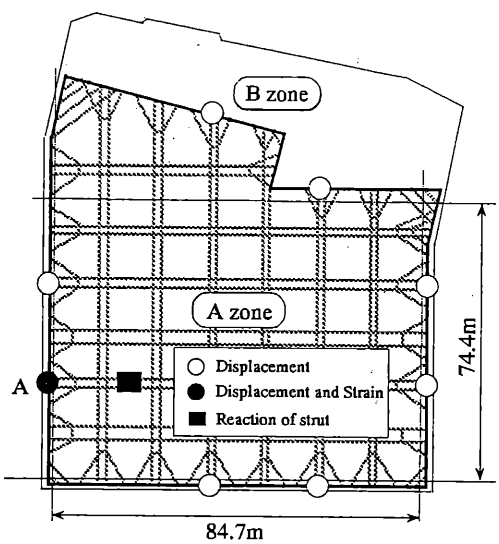

Fig. 3 Plan of earth retaining wall and measuring items

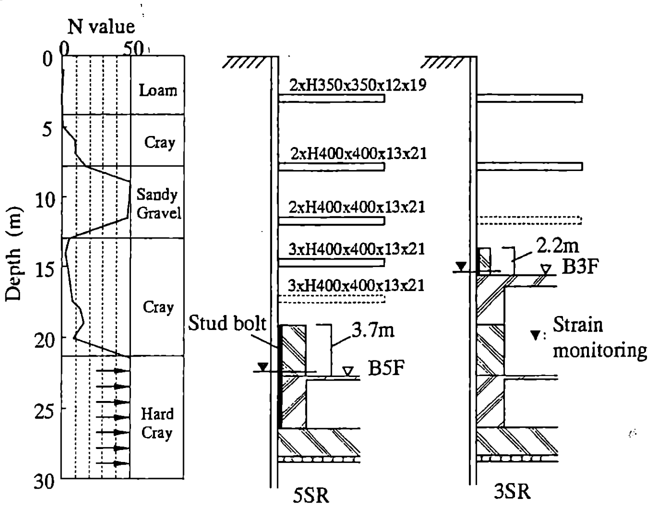

Fig. 4 Soil profile and Sention of earth retaining wall

4. DETAIL AND RIGIDITY OF CERW

Fig.5 shows sectional details of CERW(B5F,B3F). The thickness of the concrete walls is 180cm and 100cm respectively. The size and the interval of the stud bolts were decided based on the calculation proposed by the Architectural Institute of Japan. The neutral axis exists in the concrete. The distance from the edge of the H-shaped steel is 68cm (B5F) and 34cm (B3F) respectively. Strain meters were set in CERW at the floor level (shown in FIg.4) to monitor the distribution of the strain when the strut was released.

Fig.6 shows elastoplastic properties of the bending rigidity of the CERW. The rigidity of the CERW is calculated using parameters of the strength and

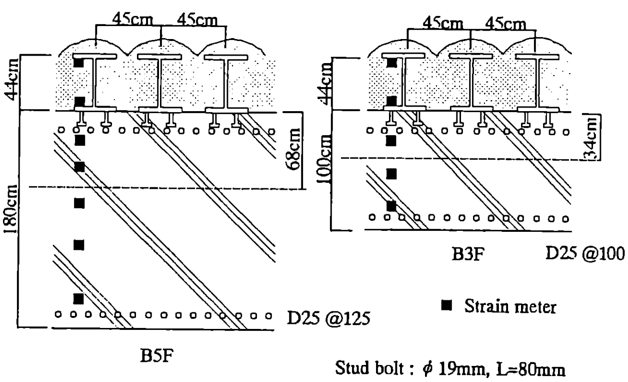

Fig. 5 Details of CERW

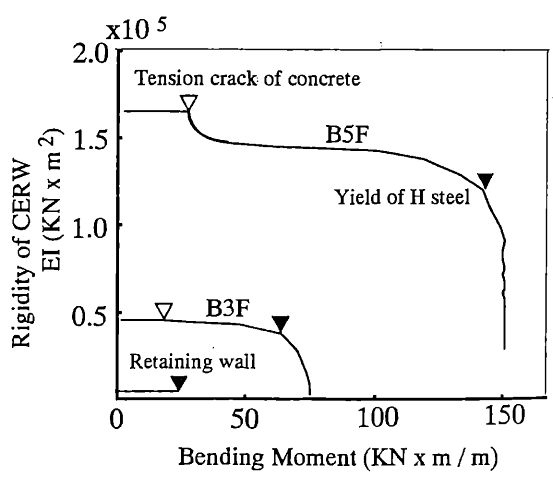

Fig. 6 EI(M) - M curve

thickness of the concrete wall, the size and pitch of the H-shaped steel and reinforcement. The compressive strength and the tensile strength of the concrete used for the analytical calculation is 102KN/m^2 and 18.4KN/m^2 respectively. The rigidity of the CERW is 63 times (B5F) and 17 times (B3F) higher than that of unreinforced retaining wall respectively. The yield bending moment (yield of H-shaped steel) is also 9 times (B5F) and 4 times (B3F) higher than that.

5. ESTIMATION OF THE BEHAVIOR OF THE EARTH RETAINING WALL

Fig.7 shows the analytical model of 5SR and 3SR. It is a two dimensional elastic model. A retaining wall is displaced to a beam,and struts are displaced to springs. The lowest floor is the fixed bearing in this model. Spring stiffness of the struts k are obtained by the next equation.

$k = AE / L$ (A: sectional area of the strut, E: Young's coefficient, L: strut length)

A load is the reaction of the strut measured before released. It is clear that releasing a reaction of the strut is equal to putting the load on the retaining wall from the back side. In this model, it is assumed that the lateral pressure is unchanged by releasing the strut.

Fig.8 shows a flow chart of analytical calculation (5SR). The displacement, stress of the beam and the reaction of the springs were calculated using this analytical model. These values are equal to the increment of the displacement and the stress of the earth retaining wall, reaction of the upper stage strut. Adding these increment values to the measured values before 5SR, the behavior of the retaining wall after 5SR is estimated. If the estimated bending moment is over the elastic limit (tensile crack develops in a concrete), the design of CERW must be changed and calculated again.

6. COMPARISON OF ESTIMATION AND MEASUREMENT

Fig.9 shows the measured displacement before 5SR

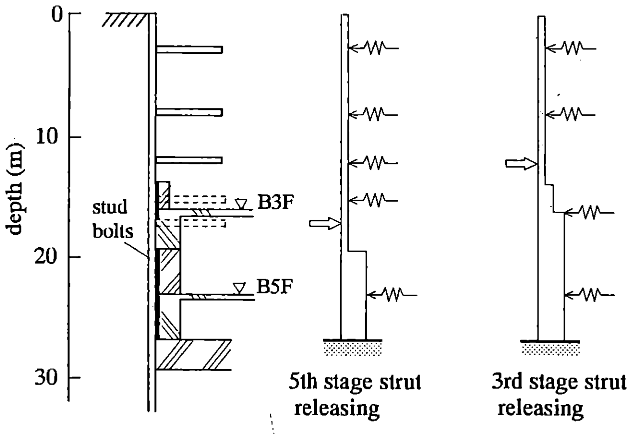

Fig. 7 Analytical model

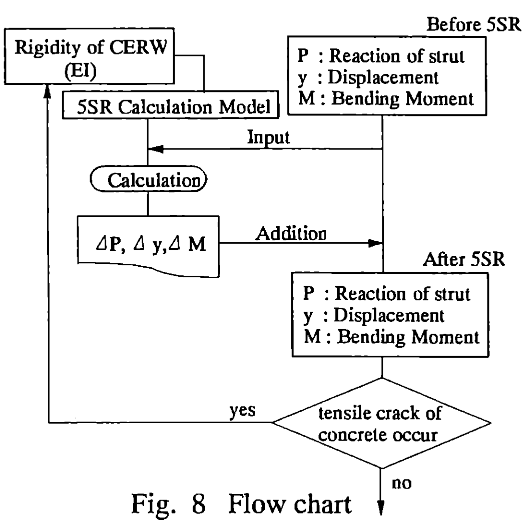

Fig. 8 Flow chart

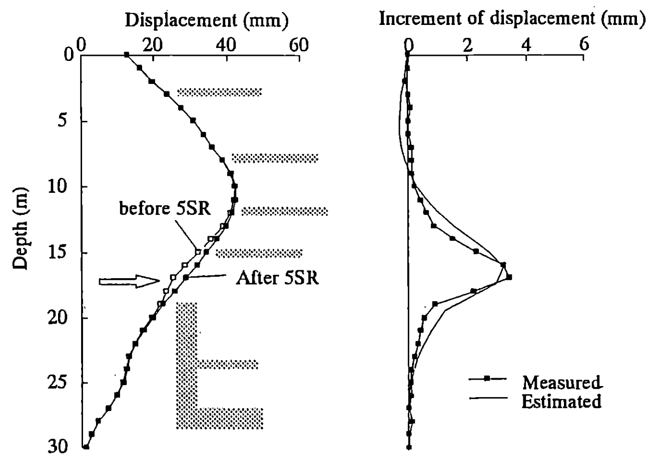

Fig. 9 Behavior of retaining wall (5SR)

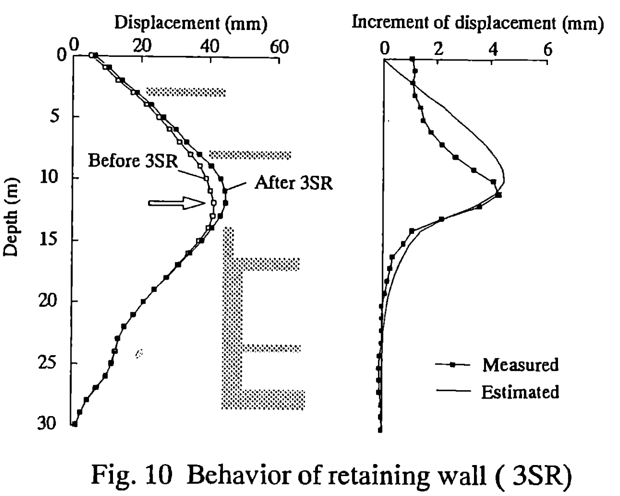

Fig. 10 Behavior of retaining wall (3SR)

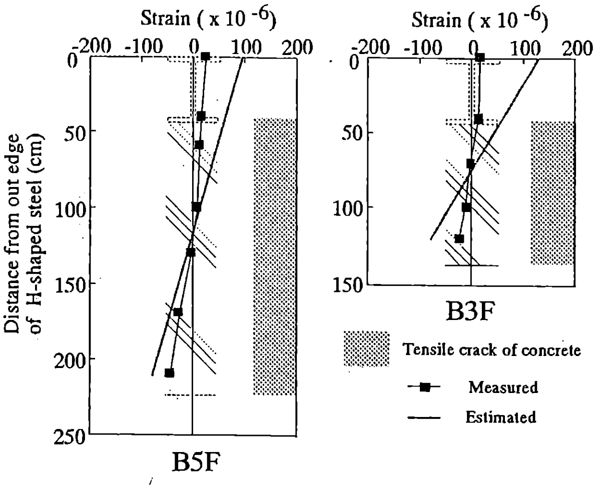

Fig. 11 Distribution of strain

and after 5SR at point A. The displacement of the earth retaining wall increased between the top of the CERW and the upper stage strut. There was little increment of the displacement at CERW.

A comparison of measured and estimated increment of displacement is shown in Fig.9. Estimation closely matches the measured properties.

Fig.10 shows the displacement of the earth retaining wall before 3SR and after 3SR. The form of estimated displacement is a little different from measured. However the estimated maximum increase of the displacement is nearly equal to the measured.

Fig.11 shows a comparison of measured and estimated distribution of the strain when the strut is released. Tensile strain measured in the concrete was smaller than tensile crack strain. Estimated position of the neutral axis is nearly equal to the measured one. The measured strain is smaller than estimated. The cause is that the rigidity of the beam which crosses CERW is ignored in this model.

7. CONCLUSION

The rigidity of the CERW is much higher than that of unreinforced retaining wall. Measured distribution of the strain showed that a soil cement wall and a reinforced concrete was unified. The behavior of the retaining wall on releasing a strut is able to be estimated by the analytical method proposed in this paper.

8. REFERENCES

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