Development of steel sheet pile - concrete composite for conservation of corroded agricultural canal

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Abstract: A large number of steel sheet pile canals have been widely used in an agricultural infrastructure of Japan. In recent years, the relationship between the durability and the corrosion of the steel sheet pile has been discussed as a technical problem. In this study, development of conservation method for corroded steel sheet pile canal is going to be performed, applying steel sheet pile - concrete composite. The experiments were conducted in model tests and existing structure. In the monitoring, the bending properties of the composite are evaluated based on displacement measurement and acoustic emission (AE) method. Thus, the mechanical properties of steel sheet pile - concrete composite could be evaluated by comparing a moment with a displacement behavior. The AE generation behavior is correlated with fracture process in bending test, and thus the covering effect of concrete is quantitatively estimated.

Keywords: Steel sheet pile, Corrosion, Concrete coating, Bending test, Acoustic emission

1. Introduction

For effective conservation of irrigation system, it is necessary to be protection of degradation effects of structural materials by repainting materials. In recent years, the relationship between the durability and the corrosion of the steel sheet pile have been discussed as a technical problem (Photo. 1).

2. Materials and methods

Tested specimens

These samples of 1500 mm in length and 700 mm in width were prepared used steel sheet pile in all tested specimens (Fig. 1).

Table 1. Experimental conditions (Laboratory experiment)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Material composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>Existing steel sheet pile</td>
</tr>
<tr>
<td>Case 2</td>
<td>New steel sheet pile</td>
</tr>
<tr>
<td>Case 3</td>
<td>Existing steel sheet pile – concrete</td>
</tr>
<tr>
<td>Case 4</td>
<td>New steel sheet pile – concrete composite</td>
</tr>
</tbody>
</table>

Experimental procedure

In the experiments, the mechanical properties of composites were evaluated based on characteristics of displacement due to fracture during bending test. The characteristics of displacement were evaluated based on AE (acoustic emission) and load - displacement relations. (Table 2)

Table 2. Loading conditions (Laboratory experiment)

<table>
<thead>
<tr>
<th>Load level (kN)</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>40</td>
<td>30</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
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</tr>
</tbody>
</table>

Analytical procedure

AE signals were detected by AE sensor (R15α: resonant frequency = approx 190 kHz), which was located in center of specimens (Fig. 3). To count the number of AE hits, the threshold level was set to 42 dB with 40 dB gain in a pre-amplifier and 20 dB gain in a main amplifier. AE measurement was conducted with eight channels.

3. Results and Discussion

Characteristic of residual displacement

1. Existing steel sheet pile in Case 1 was detected large residual displacement behavior as compared with new steel sheet pile in Case 2.

2. Existing steel sheet pile – concrete composite in Case 3 was detected small residual displacement behavior as compared with new steel sheet pile – concrete composite in Case 4.

New steel sheet pile in Case 2 was detected uneven displacement behavior (Fig. 5).

After bending test in Case 4, concrete crack was detected (Fig. 6) and concentration of AE source in cracked part (Fig. 4) during unloading of 39 kN-m.

These results suggest that the mechanical properties, such as strength, may not be a key factor for the durability, while AE parameters are really sensitive to fracture process.

4. Conclusions

For quantitative estimation of bending properties in steel sheet pile with concrete coating, AE monitoring is applied to the bending test of composite samples.

● The mechanical properties of steel sheet pile - concrete composite could be evaluated by comparing a moment with a displacement.
● AE generation behavior is correlated with fracture process in bending test, and thus, the covering effect of concrete is quantitatively estimated.
● It is quantitatively demonstrated that concentration of AE hits is detected in cracked part in composite sample.

【References】
2) El-Shamy AM, Moya SSU, El-Diin HS, Shaaban HF and Mustafa SAA (2012) Torsional effect on steel - concrete composite sections subjected to negative moment. Materials and Structures 45: 393-410

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