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Lessons from a failure case of an excavated floodway supported by precast cantilever pile walls

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ABSTRACT

The Gangweigou floodway, across the Quiren and Rende districts in Tainan, Taiwan, was designed to bypass partial discharge in the Gangweigou River during heavy rainfall events for the purpose of flood control. This floodway was an excavated open channel supported by single or double rows of precast RC cantilever pile walls on each side of its banks; these piles were installed by the jetting-assisted method. Twenty days after the completion of the floodway, it was put to work for the first time during a heavy rainfall. Unexpectedly, the cantilever pile walls in several sections failed and caused the collapse of the slope behind the walls. This paper explores the failure mechanism and the real causes of failure in this case. Based on the conditions of hydrology and hydraulics, failure processes and the results of stability analyses, it was concluded that ignoring a possible bed incision or bank erosion was likely the primary problem with the improper design. The most critical condition was when the water level in the floodway quickly dropped, which resulted in rapid drawdown. The failure of the case could have been avoided if both the rapid drawdown condition and the potential of the channel bed incision were considered.

1. Introduction

Cantilever pile walls often serve as retaining structures for various civil engineering or hydraulic engineering purposes. The use of precast reinforced concrete (RC) piles interconnected with adjacent units is a feasible technique for the formation of a cantilever pile wall. The tops of these jointed wall units can then be connected with a continuous RC girder as a pile cap. Compared with cast-in-situ piles, precast RC pile walls may have several advantages, including better quality control, shorter construction time and lower cost. To work as a flood protection structure, the use of installed walls can avoid large amounts of excavation. Therefore, the use of precast RC walls is a good choice for flood protection when the groundwater table is high and when the available land is limited.

The Gangweigou River is one of the main tributaries of the Erren River in southern Taiwan (Fig. 1). To mitigate repeated flooding in the midstream region of the Gangweigou River, the River Management Office commenced a flood control plan by building the Gangweigou floodway to bypass partial discharge exceeding the flood design in the upstream Gangweigou River directly into the Erren River.

The Gangweigou floodway was constructed by excavating the existing canal; the earth material is mainly composed of silty sand with clay and silty clay with sand. The channel banks were supported by one to two parallel series of precast RC cantilever pile walls on both sides (Fig. 2). The geometry of the floodway was an open channel with a compound rectangular section. The precast RC cantilever pile walls were used as the retaining structure for flood protection in the Gangweigou floodway. The precast RC piles were installed by the jetting-assisted method to drive them to pass through the soil-containing cobbles occasionally. Very soon after the completion of the floodway, a heavy rainfall event occurred, and the floodway was put to work for the first time. Unexpectedly, the cantilever pile walls in a few sections failed and caused the collapse of the slope behind the walls. This paper attempts to explore the failure mechanism and the real causes of failure in this case. The understanding of the failure causes in this case study may help improve the design of flood protection works using cantilever pile walls in the future.

2. Failure modes of the cantilever pile walls and methods for analysis

Sheet pile walls can be either cantilever pile walls or anchored pile walls, depending on whether the anchors are used. Usually, a cantilever pile wall is driven into the soil to provide lateral support below the excavation bottom; the wall has to resist both overturning and sliding. In

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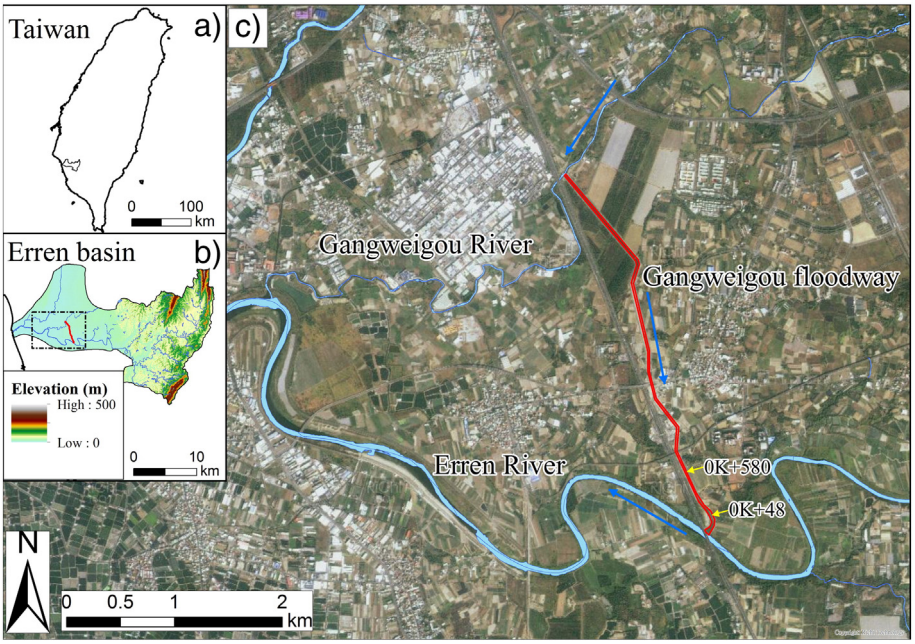

Fig. 1. Maps of the location.

addition, the material stresses in the wall must be within acceptable values. Among possible applications, the functions of the cantilever pile walls may include the following: 1) to maintain the stability for deep excavation as a retaining wall; 2) to reduce underground flow as a seepage barrier wall; 3) to replace a levee for flood protection; and 4) to serve as a bulkhead wall in a waterfront (Dutta and Vaidya, 2003).

When a cantilever pile wall system is used in a waterfront, either along riverbanks or in a harbor, the cantilever pile wall must maintain stability and prevent the failure and excessive settlement of the ground behind the wall. The loading on the wall should consider the lateral earth pressure, the water pressure acting on the wall, and the surcharge on the ground surface. In general, the penetration depth of the

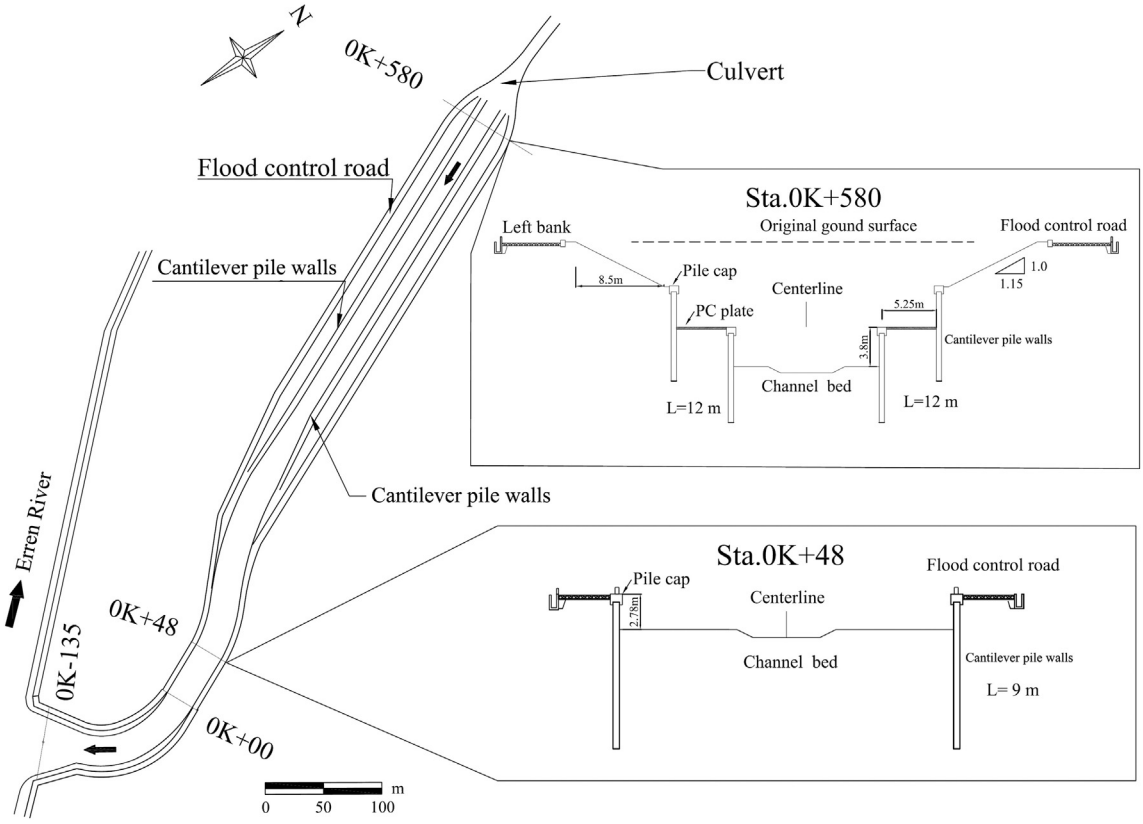

Fig. 2. Plane view and typical cross sections of the site.