Rehabilitation of Ferry Docks in Southwestern Ontario

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Summary

Three ferry docks are part of a ferry service which connect mainland Southwestern Ontario with Pelee Island, a 10,000 acre island situated in Lake Erie, approximately 30 km south of the mainland. A number of structural and operational deficiencies were identified at each of the ferry docks, and a rehabilitation strategy was developed to address these deficiencies. The existing sheet pile walls at the docks required strengthening to maintain their stability and structural integrity. To determine the strengthening requirements for the sheet pile walls, a mobilized earth pressure coefficient analysis was conducted. The strengthening and rehabilitation strategy developed through this analysis consisted of the installation of a caisson wall in front of the toe of the existing sheet piles below the dredge line, connected by a caisson cap beam. The rehabilitation of the ferry docks included providing scour protection and lowering the dredge line elevations.

Keywords: sheet pile walls, caisson wall, strengthening and rehabilitation, mobilized earth pressure coefficients

1. Introduction

Three ferry docks are part of a ferry service which connect mainland Southwestern Ontario with Pelee Island, a 10,000 acre island situated in Lake Erie, approximately 30 km south of the mainland. The Ministry of Transportation of Ontario and their operator, Owen Sound Transportation Company, operate two vessels, the M.V. Jimaan and the M.V. Pelee Islander to carry passengers, vehicles and freight on a seasonal schedule. A number of structural and operational deficiencies were identified by the Ministry at each of the ferry docks, and a rehabilitation and strengthening strategy was developed to address these deficiencies, and maintain the operation and structural integrity of the docks in the future.

Initial analyses of existing conditions indicated that the existing dock walls do not have sufficient resistance to toe kick-out. The scope of work for the rehabilitation of the ferry docks included improving the stability of the walls as well as providing scour protection to prevent undermining of the existing sheet pile walls and lowering the dredge line elevations to prevent grounding of the ferry vessels. The existing sheet pile walls at the docks required strengthening due to lower dredge line to maintain the stability and structural integrity of the sheet pile walls.

2. Sheet Pile Rehabilitation and Strengthening

2.1 Evaluation of Wall Stabilization Alternatives

Evaluations of the existing sheet pile walls utilizing geotechnical parameters based on conventional

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methods indicated that the dock walls do not have adequate capacity against toe kick-out for existing conditions. Further excavation in front of the walls to lower the dredge line would increase the requirement for stabilizing the walls against toe kick-out, and necessitate strengthening the sheet pile walls in bending. The initial evaluation of existing conditions showed that the factor of safety against toe kickout was less than 1.0 at the Kingsville and Pelee Island sites. As the existing sheet pile walls did not show signs of distress or instability during recent inspections, it was determined that the initial geotechnical design parameters were too conservative, and a mobilized earth pressure coefficent analysis (MEPC) was conducted to determine realistic geotechnical design parameters.

2.2 Recommended Wall Stabilization Alternative

Based on the results of the comparative evaluation of a variety of wall stabilization alternatives, and the structural analyses conducted to assure the modified dock wall systems have adequate resistance to both instability and bending moment when dredge levels are lowered, a wall stabilization alternative consisting of reinforced cast-in-place concrete caissons extending from the proposed dredge line and socketted into bedrock was selected as the recommended alternative.

This system increases wall stability by use of caissons which cantilever structurally from the underlying soil strata and bedrock to offer support to the toe of the sheet piles for the incremental load change as dredge depth is lowered. The structural analysis of the recommended wall stabilization alternative included a staged loading to account for the net additional loading applied to the caisson support system. This is assessed by:

1. Analyzing the existing case (loading to the present dredge depth);

2. Analyzing the future case with the incremental net loading difference from the present dredge depth to the proposed dredge depth;

3. Combining the above two cases to ascertain the wall stresses.

As the concrete caisson system utilizes both the passive pressure resistance of the surrounding soil strata and the structural capacity of the reinforced concrete section to support lateral forces transmitted from the steel sheet pile wall, computation of a factor of safety against kick-out of the sheetpile/caisson system is not applicable.

The concrete caisson wall stabilization system consists of 914 mm diameter concrete caissons spaced at 2.5 m centres, linked by a continuous reinforced concrete beam located at the proposed dredge line. The link or “cap” beam provides continuous support for the individual sheet piles at the level of the dredge line, preventing potential toe kick-out due to the reduced pile embedment and additional lateral forces which will occur when the dredge line is lowered. The concrete caissons were designed as vertical cantilever supports, transferring the additional lateral forces to the competent till and bedrock strata.

The proposed sheet pile wall rehabilitation and stabilization alternative provided a cost effective solution, while minimizing disruptions to ferry operations serving Southwestern Ontario. Rehabilitation of the ferry docks commenced in November 2007, and will be completed in the summer of 2009.