Engineering

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FAILURE INVESTIGATION OF A COFFERDAM FAILURE

This project consisted of rehab construction of an about 15,000 ft. long earthen levee which was bound by water on one side. Therefore, in order to carry out construction along the levee surface on the west side, successive cofferdams had to be constructed along the existing levee in order to dewater the face for the rehabilitation work to proceed. The cofferdam cells were constructed in phases as the work proceeded. Each cofferdam cell consisted of a brace steel sheetpile wall which is anchored on both ends into earthen dikes which rested on the sides of the levee. See Figure 1. The bracing system was designed to provide lateral support near the top of the wall, in addition to the sheetpile embedment at the bottom wall against the retained water pressure. Inclined or battered steel piles (rakers) were driven into the ground to provide the horizontal support to the top of the wall.

The breach occurred after the second cell was constructed and dewatered and occurred in the second cofferdam cell which was 3,000 ft. long (the first cell was 2,000 ft long, therefore 5,000 ft. of cofferdam had been completed). The breach in a localized area was rapid without fore-warning and was a result of underseepage. A video of this failure can be seen in Figure 2. The video shows the severe upward boiling in the dry side of the sheetpile and the associated loss of ground and embedment.

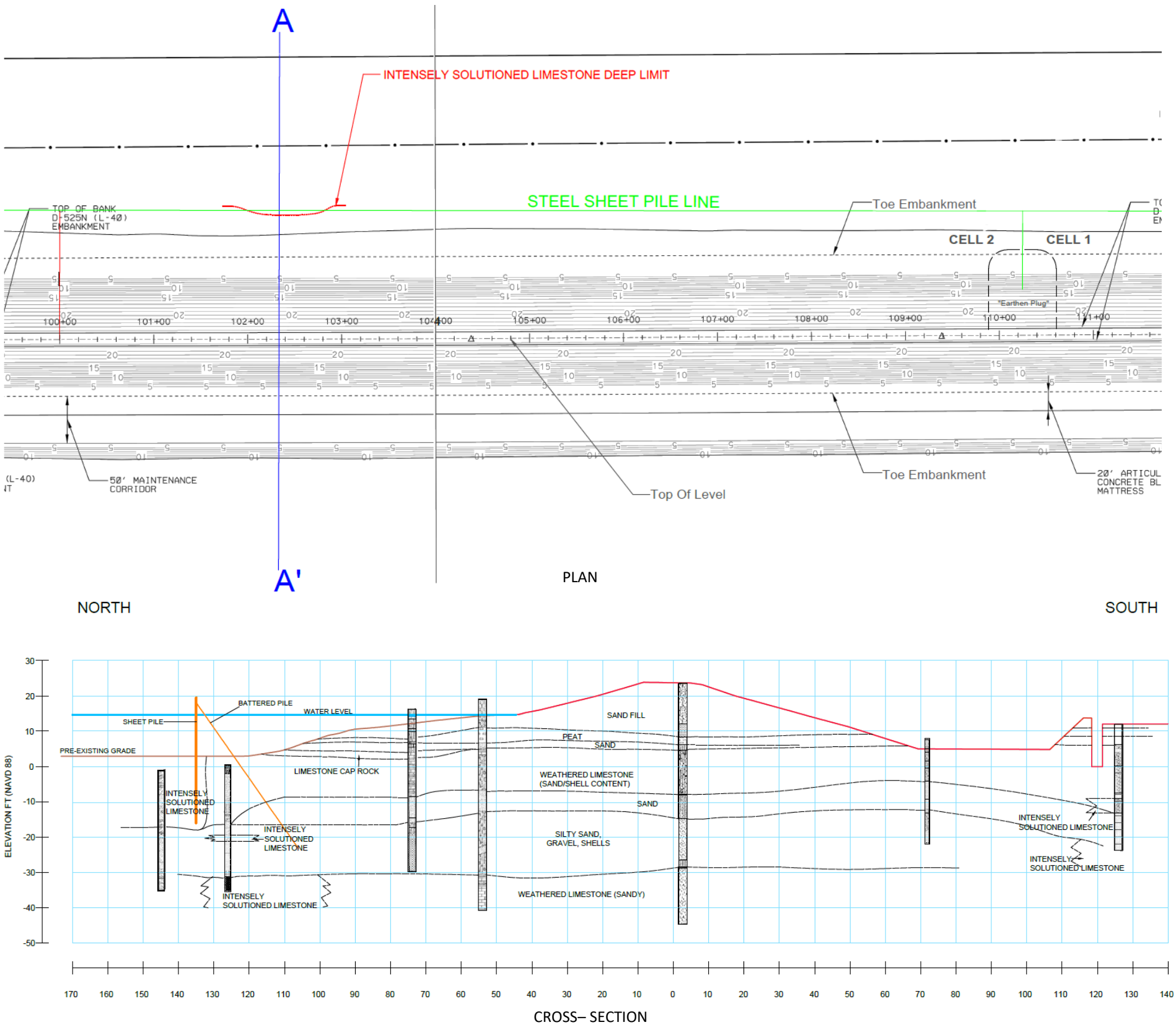

FIGURE 1 COFFERDAM CONSTRUCTION A -A' ALONG THE EXISTING LEVEE

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FIGURE 2 VIDEO OF ONGOING BREACH OF THE COFFERDAM DUE TO UNDERSEEPAGE

http://meacorporation.com/wp-content/uploads/095.mov

As a result of the loss of ground, the sheetpile moved inward causing the corresponding rakers to bend backward to practically vertical and in turn rotate upward uplifting the steel sheetpile wall.

This cofferdam failure required extensive investigation as there were a number of potential causes, which could have resulted in this failure. The areas of investigation are listed below:

- Insufficient steel pile pullout resistance to battered pile upward reaction force.
- Potential for downward plunging of battered support piles due to inadequate foundation capacity.
- Insufficient embedment depth of the sheetpiles against underseepage
- Possibly inappropriate deepened excavation or drainage along the sheetpile wall and in the dry side resulting in excessive piping from underseepage.
- Unknown subsurface condition susceptible to underseepage potentially resulting in a piping failure.

Based on the subsurface investigation, laboratory testing, and engineering analyses, MEA determined that the cofferdam failure was the result of the concentrated and localized underseepage induced piping. This was the result of localized intensely weathered sandy limestone zone which had greater permeability and lower dry density due to solutioning over time. This condition was 3D modeled in FLAC which indicated failure due to piping. This is illustrated in the output from the FLAC model which indicated unstable soil heave adjacent to the sheetpile in the intensely weathered zone. Figure 3 shows the model output at different stages of numerical iteration showing the progression of the failure by the change in color intensity in the area of solutioning along the wall. This model run did not reach a solution as the flow condition was unstable.

In summary, an about 5,000 ft. of sheetpile dam was installed and dewatered with only a small isolated area failed due to underseepage. It was determined that the relevant subsurface conditions encountered in this area were significantly different than in the remainder of the site. The failure conditions and analyses performed by MEA indicate that this differing site condition was the cause of the cofferdam failure.

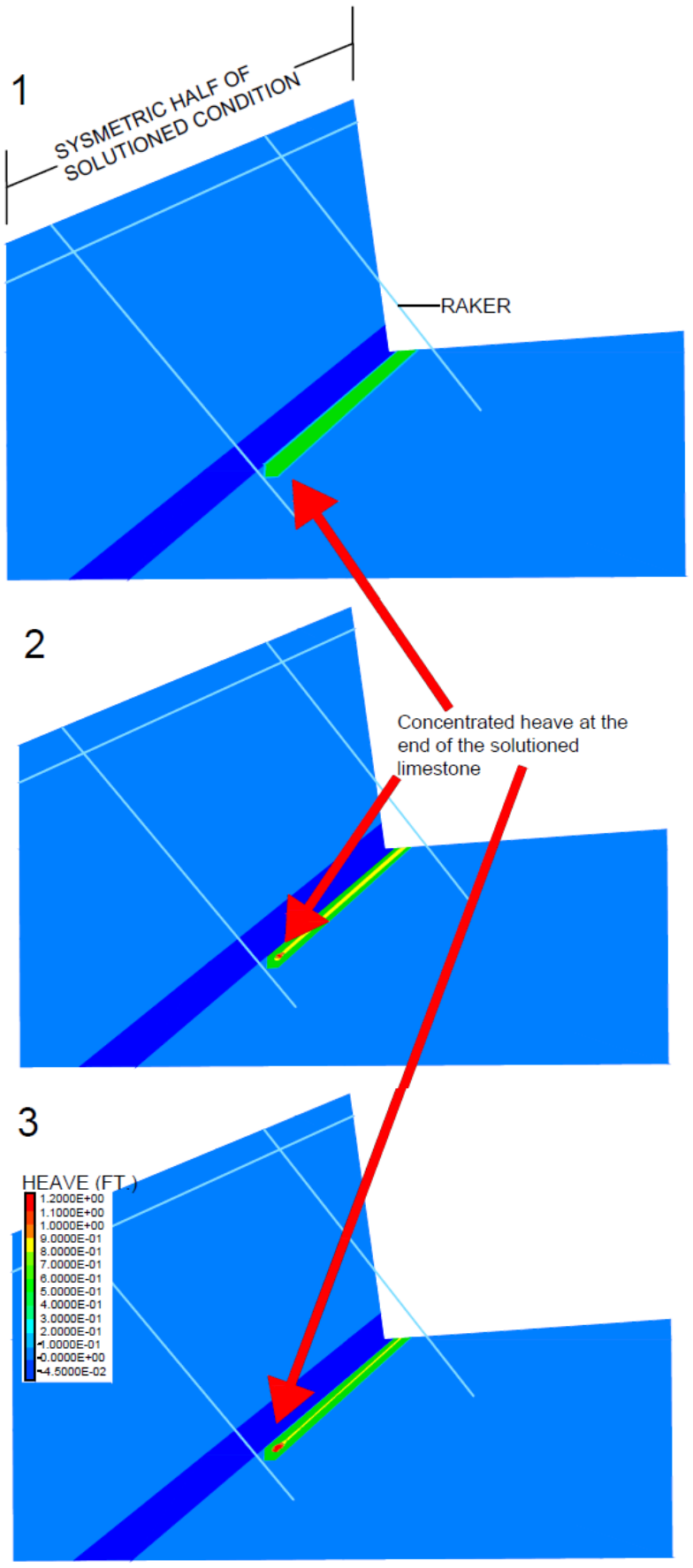

FIGURE 3 OUTPUT OF 3D FLAC MODEL SHOWING THE UNSTABLE PROGRESSION OF UNDERSEEPAGE FAILURE IN THE INTENSELY WEATHERED LIMESTONE ZONE

Other MEA Publications that may be of Interest:

Engineering Update #23: Anatomy of Canal Geo-Construction Difficulties

Engineering Update #39: Using Reinforced Soil for Construction of Retaining Structures and Earth Slopes

Engineering Update #43: Catastrophic Failure of an Underground Dam

Engineering Update #47: Improved Methods of Cofferdam Design

Engineering Update #52: MSE Wall Failures From Use of Non-Durable Backfill

ABOUT MEA: Marino Engineering Associates, Inc. focuses on engineering research, practice and expert evaluations and is licensed in 30 states in the U.S. Our projects primarily have an emphasis on Geotechnical Engineering, however, we also have significant experience in projects involving transportation, subsidence engineering, laboratory testing, training, and geophysical exploration. To obtain additional information on MEA, one can also visit our website at www.meacorporation.com.

FOR MORE INFORMATION: There is a significant amount of additional information that is available on the above subject. For more information, please contact MEA at the address listed below.

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