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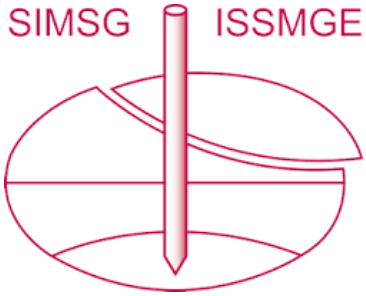

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Arrested Steel Sheetpile Bulkhead Failure—Cause and Correction

Suppression de l'instabilité d'une cloison étanche de palplanches. Cause et reconstruction

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Summary

An anchored steel sheetpile bulkhead was built as a dock along a dredged inlet in swamp alluvium area. As land access to this area, a road fill was built and caused internal unbalance of the subsoil sufficient to cause bodily movement of the entire bulkhead structure. Movements were aided by the sloping bed rock surfaces, acting as a sliding plane for the soil deposits. Reconstruction of the anchorage system proved to be sufficient correction, no further movements of serious dimensions have occurred in several years later use of the bulkhead.

Sommaire

Une cloison étanche ancrée de palplanches a été construite pour aménager un bassin le long d'un passage dragué dans un marais alluvial. Un remblai, exécuté pour servir de chemin d'accès, avait provoqué une instabilité du sous-sol, suffisante pour occasionner un mouvement de la structure entière. Ce mouvement avait été facilité par l'inclinaison de la surface des roches souterraines sur lesquelles les couches susjacentes avaient glissé. La reconstruction du système d'ancrage s'est avérée suffisante car, après plusieurs années, aucun mouvement important n'a été observé dans la cloison étanche.

This report concerns the displacement of an achored sheet pile bulkhead built as part of a waste disposal unloading plant at the east shore line of Fresh Kills, a tidal estuary separating Staten Island from the New Jersey mainland. The bulkhead was located just off shore from a spit of dry land surrounded by marsh and open water (Fig. 1).

The site is within the area of glacial coverage and near the southern end of the Lake Hackensack as it existed in glacial times. Under the marsh alluvium are banded layers of silts and fine sands extending to a gently sloping surface of serpentine.

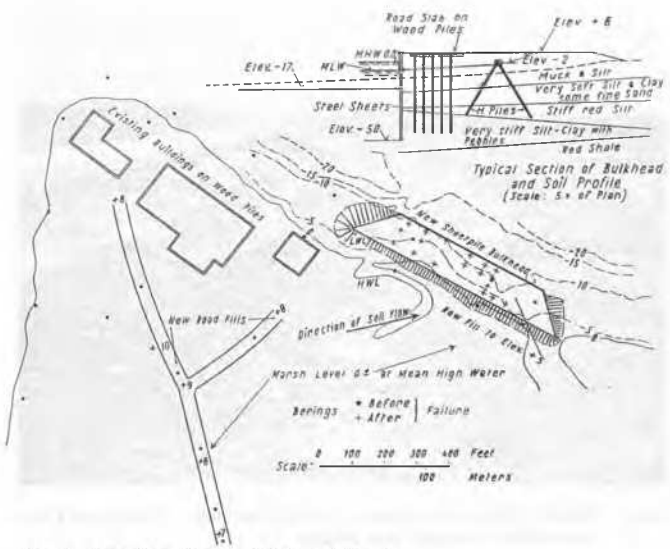

Fig. 1 Location Plan and Ground Level
Plan de l'emplacement et coupe du sol

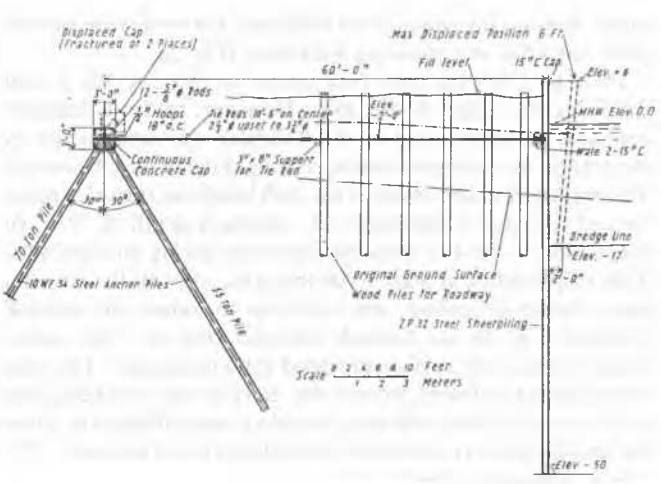

Fig. 2 Typical Bulkhead Section
Coupe typique du système d'arrimage de la cloison de palplanches

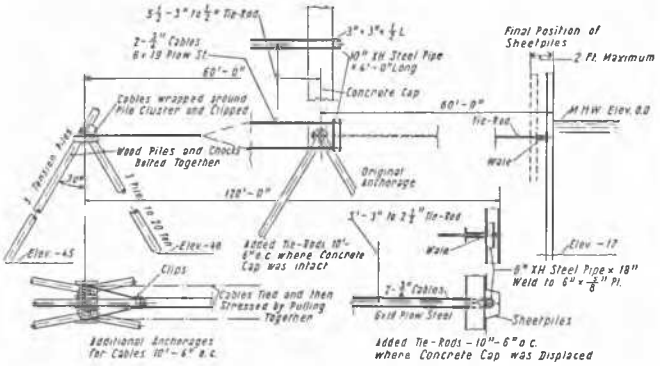

Fig. 3 Typical Bulkhead Anchorage Additions
Tiges additionnelles typiques du système d'arrimage

Some pockets of compact red clay and shale are found in contact with the bed rock. Borings made prior to construction indicated the existence of fine sands and silts, becoming firmer with depth and underlaid by a shale surface sloping downward to the west on a 5% slope, located just below elevation —50 (zero being mean high water).

Construction consisted of driving interlocking deep section steel sheets weighing 32 lbs./sq.ft. of wall, 56 ft. long, to elevation —50, tied back to a parallel concrete beam encasing pairs of batter piles of structural *H* section. The piles in each pair were driven with opposite batters, the tension member to 70 tons indicated resistance by the Engineering-News formula and the compression member to 55 tons. All anchorage piles went to approximately elevation —50. The tops of the piles were not connected to each other but were encased together into the concrete cap which in turn was connected by steel tie rods to the sheet-piling (Fig. 2 for details and dimensions).

The work was substantially completed before October 1, 1947, the water side had been dredged to elevation —17, and the land side had been filled partly by floating derrick dredge and partly by crane from storage piles of river silty sands almost to final grade elevation +6. Quite suddenly, on October 3, the sheet piles started to move outwards, in varying amounts from zero at the ends of the bulkhead to almost 6 ft. near the middle of the length. The concrete anchorage cap tipped towards the river and moved upwards, fractured into several sections and the piles rose with the cap. The ground surface in back of the sheeting assumed a typical curvature of a "mud-wave", disturbing the piles driven for the roadway and structures. Beyond the limits of the bulkhead, the mud-wave pushed piles, catwalks and mooring walkways (Fig. 5).

Prior to 1947, the only land access to this site was a trail following the ridge of the spit. However, under a separate contract, an access road to the bulkhead was constructed by excavation of the higher land and filling directly into the marsh. The main fill headed towards the bulkhead was started August 19 and completed September 23, placing a depth of 10 ft. of silty sands on the 4 ft. thick meadow mat resting on loose silts. This strip load of at least 1,000 lbs/sq.ft., over 60 ft. in width, quite suddenly applied, was sufficient to induce the internal movement in the soil towards the river (Fig. 6). The underlying sloping rock surface provided little resistance. The mud wave fanned outward beyond the ends of the bulkhead, but at the middle of the bulkhead, the force was sufficient to cause the anchorage to rise and the sheet piles to move outward. The sheets remained substantially vertical, since they were not driven into the rock. Some small settlements of the road fill had occurred, and the shoulders and slopes were refilled to

Fig. 4 Repaired Sheet-Pile Bulkhead; Excavation for Additional Tie-rods Being Backfilled; Piles are for Roadway Structure
Cloison de palplanches réparée. Les excavations pour tiges additionnelles d'arrimage sont remblayées. Les pieux sont destinés à la construction de la route

Fig. 5 Effect of mud-Wave on Temporary Pile and Plank Structure; End of Bulkhead at Right
Effet d'une vague de vase sur pilotis et coffrage provisoires; à droite: extrémité de la cloison de palplanches

Fig. 6 Road Fill and Beginning of Soil Movement; Telephone Poles Have Been Plumbed and Braced
Remblai de la route et début du mouvement du sol; les poteaux téléphoniques ont été remis d'aplomb et contreventés

shape, but no additional movement has been noted. The road is floating on the submerged meadow mat. Borings taken after the movement of the bulkhead and after the completion of repairs showed that the original black muck layer had been squeezed downward and had blended along both surfaces with the silts below and the sand fill above. All designs and borings for this work were by the New York Department of Public Works.

Following the investigation to determine the cause of the movement, reconstruction consisted of redriving many of the anchorage piles, adding anchorage piles and cables and by partial removal of backfill, the bulkhead was pulled back to a maximum deviation of 2 ft. from the original line (Figs. 3 and 4). In the four years use since the correction, no apparent movement has occurred and if no additional disturbance of the general marsh area is made, there seems to be reasonable assurance of continuing stability.

The conclusions to be drawn from this incident are:—

(1) Sheetpiles must be installed so as to provide a positive reaction resistance at the lower end.
(2) Inclined soil or rock surfaces below grade are just as conducive to movements as exposed slippery ramps and must be so considered.
(3) Soils in fluid condition obey all the laws of fluids and transmit imposed pressures in all directions, loss in intensity being very little for marsh areas.