SECTION VII

PILE FOUNDATIONS, PILE LOADING TESTS

SUB-SECTION VII a

SETTLEMENT AND BEARING CAPACITY OF PILES

VII a 1 THE USE OF LONG SPLICED PILES DRIVEN THROUGH SOFT SILT TO FIRM FOUNDATIONS

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PROBLEM.

The problem consisted of the complete renewal of a wharf comprising portion of Central Pier, Victoria Dock, Melbourne. The new structure was required to provide a wharf apron 35 ft. in width, a cargo shed 80 ft. in width, and the widening of the existing roadway at the rear of the shed from 60 ft. to 90 ft. The live loading for which the structure was designed consisted of -

a) a distributed load of 5 cwt. per square foot;
b) vehicles weighing 44.000 lbs. and having a rear axleload of 30.000 lbs. (no impact);
c) electric level luffing wharf cranes of semi-portal type, capable of lifting 3 tons and travelling along the wharf apron.

From other considerations a longitudinal pile spacing of 10 ft. was adopted, and calculations showed that a transverse spacing of 9 ft. would create unit pile loads of 35 to 40 tons.

The foundation conditions were investigated by sinking bores along the front and rear of the proposed structure at 100 ft. intervals. These bores disclosed fairly uniform conditions averaging as follows:

25 ft. of water at low tide
40 ft. of soft silt
8 ft. of firm silt
gravelly sand proved to 20 ft. depth.

Samples of the soft silt when tested showed the following characteristics:

cohesion, 250 lbs. per sq. ft.
angle of internal friction, 2 degrees.

Samples of the firm silt and gravelly sand could not be obtained with the apparatus available.

Investigation of costs indicated that a reinforced concrete structure carried on timber piles would be the most economical if piles of the requisite length were obtainable. It was desired that the timber exposed to sea water should be Turpentine (Syncarpia laurifolia) in view of its immunity from the attack of Toredo and the satisfactory condition of piles of this timber in an adjoining structure after 33 years' service. Trees of this species, however, were not available in lengths exceeding 75 feet, whereas it was obvious that piles to support a wharf at 10 ft. above L.W.O.S.T. would require to be about 100 ft. in length.

The problem therefore resolved itself into determining whether piles 100 ft. long, consisting of two lengths spliced together, and driven through the silt into the gravelly sand, would be capable of withstanding safely a working load of 35 to 40 tons.

TESTS.

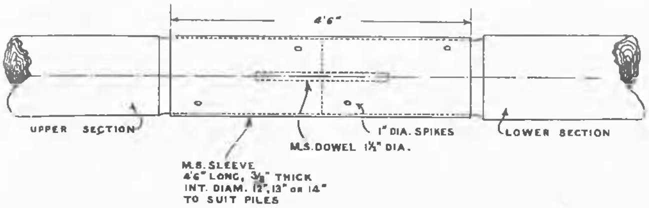
It was decided to use plices consisting of steel sleeves 12" to 14" in diameter (according to the size of the timber), 4'6" in length and⅝" in thickness. A sample splice was made up and submitted to a transverse loading test, which indicated that the splice had a transverse strength equal to 75% of that of a continuous log of the same diameter. The pile ends for the above mentioned test were prepared by hand, but it was contemplated that the 700 piles required for the work would be turned in a special machine.

In order to determine if possible the ultimate bearing value of long spliced piles used with the foundation conditions described above, sample piles were prepared, driven and submitted to static load tests. The samples were as follow:

	No.1 Pile	No.2 Pile
Top length, Turpentine.	61 ft.long, 21" dia. at head, 15½" dia. at toe.	56 ft. long, 21½" dia. at head, 14" dia. at toe.
Bottom length,Messmate.	42 ft. long, 15" dia. at head, 11½" dia. at toe.	46'6" long, 15¼" dia. at head, 12¼" dia. at toe.
Splice, steel sleeve.	5'0" long, 14" int. dia.	4'6" long, 12¼" int.dia.
Pile shoe	Cast iron	Cast iron
Estimated total weight	41 tons	3.63 tons.

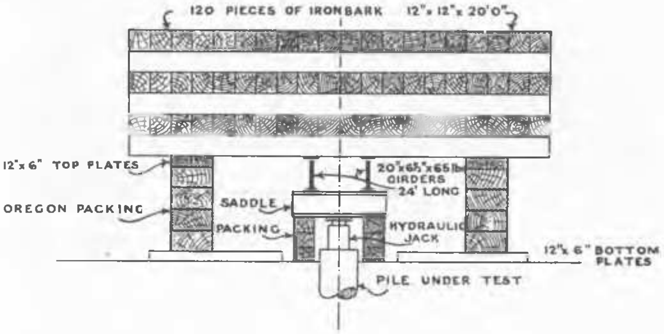
Messmate logs used as bottom lengths are only a third of the cost of Turpentine, but are of equal strength and are quite durable below the mudline.

The piles were driven in the old wharf structure, at the site of a bore which indicated foundation conditions corresponding with the average for the site as described above. Each pile was driven about 20 ft. into



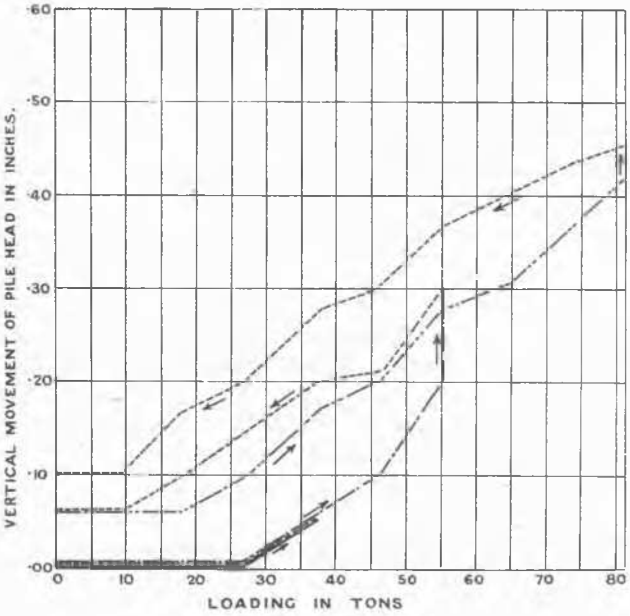
Detail of pile splice.

FIG.1



Arrangement of apparatus static load test.

FIG.2



Record of static load test no.2 pile.

FIG.3

Pile-turning machine.

FIG.4

Pile-turning machine. Close view.

FIG.5

the gravelly sand, by means of a 3-ton drop hammer. The nature of the soft silt is indicated by the fact that the spliced pile penetrated the silt to a depth of 15 ft. under its own weight, and with the 3-ton hammer resting on the head of the pile a further penetration of 7 ft. occurred.

The load was applied by erecting over each pile in turn a stack of timber weighing 80 tons, supported on a system of steel beams; a hydraulic jack was introduced between the steel beams and the pile head. The latter was prevented from moving laterally by shoring from the old wharf structure. No. 1 pile was tested 3 weeks after being driven, and No. 2 pile 2 days after being driven.

Vertical movement of the pile head was measured by fastening a scale to the pile and taking readings on this scale with a dumpy level resting on solid foundation near by. The load was applied in increments of about 10 tons; after each increment the load was maintained for a period of 30 minutes in order to detect any continuity of settlement. After loadings of 37, 55 and 80 tons the load was removed and the recovery of the pile observed. After the 55 ton load was removed, No. 1 pile showed a permanent settlement of 0.25" and No.2 pile 0.06". This is believed to have indicated a closing up of the bearing surfaces at the splice. Each pile was loaded in stages up to the maximum possible, viz.- 80 tons; after this load was removed both piles showed a further permanent settlement of 0.04". Both piles were then reloaded to 80 tons for 5 hours and showed no further inelastic settlement.It was apparent that the ultimate load-carrying capacity of each pile as driven was at least 80 tons.

The pile-driving records were as follow:

No. 1 pile, 3 ton hammer on winch cable, 7 ft. drop, final set 7/12" per blow.

No. 2 pile, 3 ton hammer on winch cable, 6 ft. drop, final set ⅓" per blow.

The resistances as calculated by Hiley's formula were

No. 1 pile - 84 tons.
No. 2 pile - 96 tons.

CONCLUSION.

As a result of the tests it was considered that the required working load of 35 to 40 tons could be safely employed with piles of the kind tested, in the foundation conditions obtaining at the site.

DESCRIPTION OF PILE TURNING MACHINE.

The following is a description of the apparatus which was designed and manufactured for turning the ends of the piles to a circular section to fit the steel sleeves: - The pile is held at the outboard end in a circular steel trunnion turning on rollers which are mounted on a flanged-wheel truck. At the other end, which is to be turned down, the pile end is inserted in a similar trunnion which is mounted on the machine proper and is turned by an electric motor through reduction gearing at the rate of 12 revolutions per minute.

The machine carries a revolving cutter head having four blades 4" in length, and this can be travelled about 3 ft. longitudinally along the pile or fed into the pile diametrically. The cutter head is vee-belt driven from an electric motor which is mounted on the same carriage as the cutter. As the pile revolves the cutter head is travelled slowly along the length of the cut, removing about 3/16" of timber in each passage, back and forth until the desired diameter is reached. The shavings are removed from a hopper beneath the machine into a raised storage bin by means of a compressed air ejector. After being turned the lower length is reversed on a hydraulic turn table (truck-hoist) and the two lengths are then brought together and spliced. Throughout the operation the piles are handled on flanged-wheel trolleys running on rails. When spliced the piles, now in approximately 100 ft. lengths, are lowered over the face of the wharf in slings under the control of a pair of crab winches, and loaded on to a barge which transports them to the wharf under construction. Here they are lowered into the water, whence they are picked up and placed into position in the driving leads by means of a line from a spare head - wheel in the pile driving frame.

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VII a 2

PREDETERMINATION OF THE RESISTANCE OF A PILE ON BASIS OF FIELD SHEAR AND LOADING TEST VALUES

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SUMMARY.

In a heavy stratum of homogeneous Yoldia-clay (of., section III a) 6 tests piles were driven in 3 lines out from a concrete dolphin resting on 3 sloping piles, to 3 single supporting piles 8 m from the centre. The 6 piles were test loaded and pulled, and the skin friction, τ_p , and point resistance, σ_p determined. From accompaying borings the corresponding values of τ_v^m and σ_v^m were determined by a loading test sampler (sect. III a) and the transition coefficients $\alpha = \frac{\tau_p}{\tau_v^m}$ and $\beta = \frac{\sigma_p}{\sigma_v^m}$ were determined for different pile types and point areas. The measured values τ_v^m and σ_v^m were graphically referred to the average values τ_a and σ_a for the whole area by determining $\mu_1 = \frac{\tau_v^m}{\tau_a}$ and $\mu_2 = \frac{\sigma_v^m}{\sigma_a}$ by interpolation from the τ_v^m and σ_v^m values from the nearest borings.

The predetermined static pile resistance P_p is thus $P_p = \alpha \mu_1 \Sigma \tau_a \cdot O \Delta h + \beta \mu_2 \tau_a \cdot \frac{\pi d^2}{4}$ (= ultimate test pile load P_u). Here O is the pile periphery, Δh thickness of stratum, d point diameter, and τ_a and σ_a taken from the average graph.

The ultimate test pile load, P_u, is compared with the Eytelwein-Rausch pile-driving formula, $P_E = \frac{Q^2}{Q+q} \cdot \frac{h}{\frac{1}{2}e + s}$ (e = elastic set and s = permanent set for h cm drop of a Q^t hammer on a pile with weight = q^t). For friction-piles is found that $P_u = \frac{n \cdot K_3}{K_1} \cdot P_E$, where K_3 and K_1 is the cone-weight, that gives a 10 mm deep impress of a 60° steel cone after a 10 mm drop in a clay sample in natural and in kneaded state, respectively, n is a recovery coefficient.