SPECIAL STUDY.

CONSTRUCTIONS FOR BUILDING OVER WATER.

THESIS FOR B. ARCH.

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CONTENTS.

CONSTRUCTIONS FOR BUILDING OVER WATER.

(With particular relation to the proposed Anglers' River Resort.)

1. INTRODUCTION.

Building over water presents a certain major problem. This problem is concerned with the foundations, which are, in the case of the proposed Anglers' River Resort, to be in the Kromme River Bed. The construction of the superstructure presents no special problems, being the same as those encountered on land. Thus this study will be concerned with the type of foundation required to support the building over the water.

2. CONDITIONS ENCOUNTERED IN RIVERS AND THE KROMME RIVER IN PARTICULAR.

The Kromme River is tidal, but there are no strong currents to contend with, the mouth is always open to the sea, but has become "barred" by silt. The chances of the river flooding are unlikely in the extreme, as the upper reaches of the river were brought under control when the large Churchill Dam was built to supply water to Port Elizabeth. The remote possibility of combined flood conditions, an outgoing Spring-tide and a North-Westerly wind could cause build-up of the water and this must be considered.

Although there is a certain amount of "scouring" of the river bed, caused by outgoing and incoming tides, this is negligible as the tides have no great "pull" in that area.

The maximum normal tidal range in the river is six feet.

The greatest depth of the river in that area is twenty feet.

The composition of the river bed (as accurately as could be ascertained for this thesis) is of river sand, with the possibility of encountering limestone at some depth.

Wind is the cause of almost all troubles which beset the construction of sea-works, being the generator of ordinary sea waves, but in the River there is not so much of a problem: firstly because the River is not very wide, and secondly the site is fairly protected from the prevailing North-West and South-East winds.

Although the South-Easter causes storms at sea, there is no recorded instance of storm inundation from the sea affecting the river to any extent.

3. FOUNDATION SYSTEMS.

There are two common systems of foundations for constructions over water.

(i) Piling

(ii) The use of Caissons.

Piling is the term applied to all columnar members driven vertically, or nearly so (or cast in situ, as with some proprietry reinforced concrete systems) into the ground to form a foundation for constructional purposes.

The word "Caisson" is derived from the French word meaning "case", and, as applied to engineering construction, may be defined as a large water-tight box used to exclude water or other fluid and semi-fluid material during excavation of foundations and the construction of sub-structure, and ultimately becoming an intigral part of the same.

Caissons are generally used in the construction of some large bridges, and in harbour works and would not be suitable for the scale of building proposed. Caissons are only economical if the loads anticipated are a minimum of four-hundred tons. Thus piling is the most profitable solution; also piling is more suitable for the conditions that exist in the river, and is the quickest solution.

Research on piling in water includes the study of jetties, which term covers structures "thrown out", or built into water from the shore. Piled jetties form the greater part of those constructed.

4. <u>PILING</u>.

There are three types of piles.

(a) Timber piles.

(b) Steel piles.

(c) Reinforced Concrete piles.

(a) <u>TIMBER PILES</u>. (and timber for sea works generally.)

Timber piles have certain advantages over other materials for water-front structures.

(i) Economy both in construction and in years of service.

(ii) An inherent ability to absorb impact, matched by no other material.

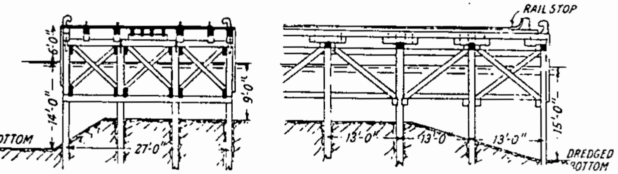
(iii) A comparatively large bulk for ground bearing and relative stability.

(iv) An ability to "give" and adjust and thus to absorb or cushion tremendous forces without damage.

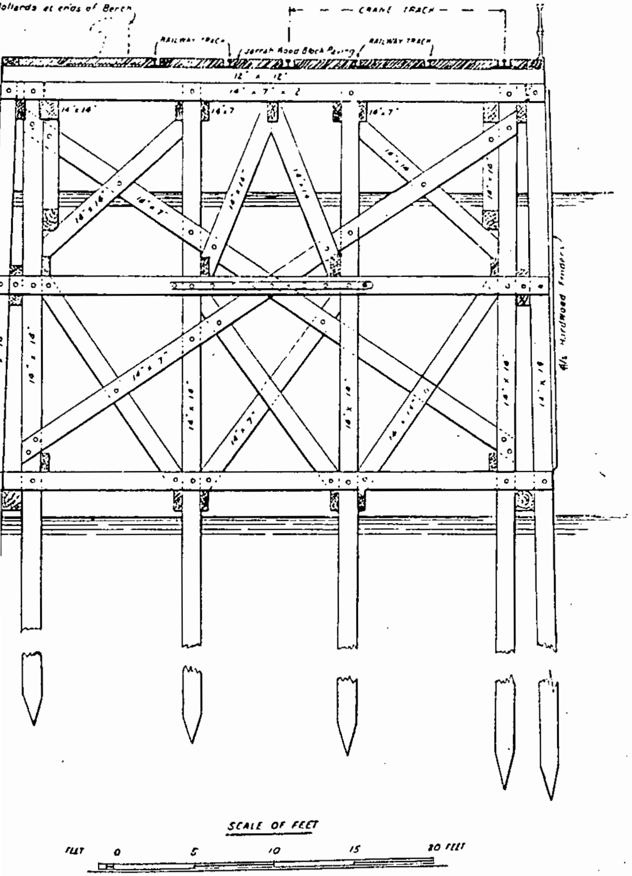
The different kinds of timber which are more or less commonly used in sea-works are as follows.

Baltic Red-wood	(Pinus sylvestris)
Pitch Pine	(Pinus rigida)
Oregon Pine	(Obies douglaisi)
English Oak	(Quercus robur)

TYPICAL TIMBER JETTY.



RAIL STOP
6'0"
14'0"
9'0"
27'0"
OTTOM
13'-0"
13'-0"
13'-0"
15'-0"
DREDGED BOTTOM



ollards at ends of Berth
CRANE TRACK
RAILWAY TRACK
Jarrah Wood Block Paving
RAILWAY TRACK
12" x 12"
14" x 7" x 2
14" x 14"
14" x 7"
4/6 Hardwood Fenders
SCALE OF FEET
FEET 0 5 10 15 20 FEET

American Oak	(Quercus alba)
Teak	(Tectona grandis)
Greenheart	(Nectandra rodiaci)
Janrah	(Eucalyptus marginata)
American Rock Elm	(Ulmos racemosa)

In addition to ,these timbers Black Iron-wood (Olea laurifolia) and Sneeze-wood (Ptoeroxylon utile) have been used locally. Greenheart is most oftten used overseas.

All of these woods are in a greater or less degree, subject to attack from marine animals - commonly known as"sea-worms" - and their value for use in marine works depends greatly upon their power to resist injury or destruction by them. Owing to the proximity of the site to the mouth of the river and the sea, these animals will also be present in the river.

The family of Pholadidae may perhaps be considered the worst enemies of timber structures in the sea; but the attacks of their smaller relatives, Limnoria terebrans and Chelura terebrans, are by no means to be despised.

Of the Pholadidae, Pholas dactylus, although pre-eminently a rock-homer, is often found in timber. It is, however, the Toredo navalis or common ship-worm, of the same family, which most frequently assails and is most destructive to structures in the sea.

These molluscs resemble worms , and they bore into the hardest kinds of timber, with apparantly as much ease as they do into the softer kinds.

Although the Toredo attacks submerged timber at all moderate depths, it, like other timber pests, is most active between low water of Spring-tides and high water of Neaps.

The Toredo, as with Limnoria terebrans, Chelura terebrans, is very fond of getting into timber through joints and bolt-holes.

Various methods have been adopted for protecting timber from the ravages of these marine marauders.

Covering with copper sheathing has been tried, but with only partial success, as the worms, when young, are so small, that they can penetrate between the joints of the copper and so find access to the wood. It is, moreover, rather a costly expedient, and liable to cause rapid decay of any submerged iron that may be about the structure.

Studding the surface of the timber with large-headed iron nails, driven close to each other, appears to answer fairly well. These rust and form a casing of iron oxide, which repells the attacks of the Toredo etc. This is, however, an expensive process, and somewhat reduces the strength of the timber.

Some timbers, in their natural state, resist the attacks of sea-worms much better than others. This is not in any way due to their texture, but to the fact that they contain poison or pungent oils, which are distasteful to these creatures. Of these, Greenheart, Sneeze-wood and Jarrah are the best, Teak and Oak being also fairly good.

In many situations, well-creosoted Baltic Red-wood timber, containing at least ten to twelve pounds of creosote per cubic foot, will be found to answer fairly well.

As the cost of creosoted timber does not usually much exceed one-third that of Green-heart, it is well worth while to consider whether, in positions where the worm is not very active, it may be used with advantage. This point like many others, resolves itself into a question of expediency.

In order to arrive at a correct decision, it is necessary that reliable data should be forth coming respecting the site where it is intended to use the timber; otherwise the estimated life of the timber may be very wide of the mark.

The only satisfactory information on

this subject, is that derived from a careful examination of various kinds of timber, which may have been in the water for some considerable time at the site of the proposed works. This evidence is lacking with regard to the site in question.

It cannot be argued that, because the worm is very bad or does not exist in one place, similar conditions will be found to obtain in another locality, although the places may be only a mile or two apart.

At Port Elizabeth, before the building of the present harbour, the timber used to construct the jetties was examined. The types of timber used, included that of creosoted Baltic Pine and Greenheart. The creosoted timber was badly eaten, both by Limnoria and Toredo, but the Greenheart was untouched, although it had been in the sea for many years.

All the timber structures in the Port

having been removed, others of iron were substituted. The fenders of these latter were all made of Greenheart, of exellant quality. Nevertheless, to the astonishment of everybody - Greenheart being generally considered proof against worm - they were very quickly attacked by the Toredo etc., and in less than seven years they were so badly eaten, that in many cases they required renewal.

In view of the foregoing it would appear desirable to keep experimental types of timber far apart from each other, otherwise the worms may be attracted to those they prefer and leave the others untouched, as was undoubtedly the case in the above instance.

Baltic Red-wood. (creosoted) may, with some advantage be used in some localities.

It is readily available in logs up to twelve or thirteen inches square and fourteen inches in length. It is fairly strong and is easily worked. After creosoting, the surface of the timber should be disturbed as little as possible, because it contains by far the largest share of the creosote.

Where practicable all notching and cutting should be done before the timber is creosoted. When this cannot be done, the newly exposed surfaces should be well served with hot creosote, and the joints should be made as close as possible.

Pitch Pine and Oregon Pine, are valuable chiefly on account of their great length and large scantling of the logs, or masts, which can be obtained. They are generally employed in the construction of staging, and are exellent, strong timbers; but they are quickly attacked by sea-worms. Staging in which they are used, ought therefore, to be examined periodically.

Oak and Teak, are good timbers for pile-work and for many other purposes. They are not so freely attacked by sea-worms as those of the Pine family and in many situations they are very durable. They may be obtained, without difficulty, in logs from twelve to twenty inches square and from twenty to thirty-five feet in length. English Oak however, is a very scarce wood.

Greenheart, is the wood, of all others, upon which engineers rely for durability in sea-works. Although it sometimes fails - as has already been pointed out - it is generally proof against sea-worms of all kinds, and in exceptional localities, where Greenheart will not stand, no other timber will.

It is very strong and tough, but piles are liable to split when being driven. They should, therefore, be afforded temporary support during this operation, by bolting on strong iron bands or cramps, not only near the head, but also at intervals of say six or eight feet throughout their length, as circumstances may indicate this much easier to prevent a split than to stop one once started.

The usual immunity enjoyed by Greenheart from the attacks of sea-worms is due to the poisonous oil which it contains. A wound caused by a splinter of this wood almost invariably festers.

Logs from twelve to fifteen inches square and up to forty feet in length may easily be obtained.

Jarrah. The quality of this timber is much influenced by the nature of the soil upon which it is grown. The best, and the only kind servicable for sea-works, is that obtained from the summit of the granite and ironstone ranges South of Perth, in Western Australia. That grown upon the sand-flats in the same district is of inferior quality.

The best Jarrah effectively resists the attacks of sea-worms, and may be obtained in large size, viz. from forty to forty-five feet in length and from three to four feet in diameter at the large end, tapering to twelve or eighteen inches in diameter at the smaller end.

A serious objection to the wood is its extreme liability to split, not only by exposure, but also while being driven as piles. In driving piles, it is necessary to hoop them in the same manner as Greenheart.

This tendency to split is, however, much more pronounced than in Greenheart, and, notwithstanding all the precautions which may be taken piles often split so badly as to necessitate their being drawn and cast aside.

In driving piles, of this timber, or of Greenheart, a ram weighing not less than 25 cwt. should be used, and a short fall - say three to four feet - should be given.

In Jarrah decay usually commences at

the heart.

American Rock Elm, is very tough, and is chiefly used for"fendering". It is durable in water if not attacked by sea-worms, which it cannot resist.

Black Iron-wood, was extensively used in sea-works in the Cape Province, before the building of new Reinforced Concrete quays.

It is very hard, tough and heavy, and possesses great strength. Notwithstanding these qualities, the Toredo attacks it freely, and out of water it is liable to decay somewhat rapidly. It is not, therefore, a very suitable wood for sea-works. It may be obtained in logs from twelve to fourteen inches square, and up to thirty-five or forty feet in length.

Sneeze-wood, is as strong and as hard as Black Iron-wood, and it contains an essential, pungent oil, which renders it equally as good as Greenheart in resisting the ravages of sea-worms.

Unfortunately, Sneeze-wood trees do

not attain a large size, and it is very rare indeed to find a straight one. Hence scarfing becomes necessary if piles of even moderate length and scantling are required, and the structure in which they are used presents an unsightly appearance.

(b) STEEL PILES.

When steel piles are employed in sea-works, a very important factor has to be considered; this concerns their durability, or power to resist the corrosive influences of the saline constituents of the water, aided, as they are, by carbonic acid gas, oxygen, and, under certain circumstances by galvanic action, arising from various causes.

Laboratory tests and practical investigations extending over a long period of years have been carried out in many parts of the world. (These tests generally were performed on steel sheet piling.) The most elaborate and reliable of these, is the series of fifteen year tests carried out by the Sea Action Committee of the Institution of Civil Engineers. In addition, various steel structures, some of which are more than fifty years old, have been examined.

The conclusions reached are that the

useful life of a steel pile retaining wall in Great Britain can be based on an average rate of under-water corrosion of 0.003 inches per year in sea-water, and 0.002 inches per year in fresh water. Corrosion of the rear surface of a wall in contact with soil is usually negligable. From These figures the effective life of various sections may be calculated generally by assuming that the permissable loss is half the thickness of the original section. This corresponds to a useful life of forty to one-hundred years or more, depending on the conditions and the section.

Piles should be coated with prepared acid-free tar before driving, the tar being obtained from the high temperature carbonization of coal in horizontal retorts. The coating should be renewed on the exposed parts of the piling from time to time.

<u>Steel Bearing Piles of Screw Shape</u>, have been used to a limited extent in the past: more rec-

ently structural H-sections have been used where the penetration is in hard material.

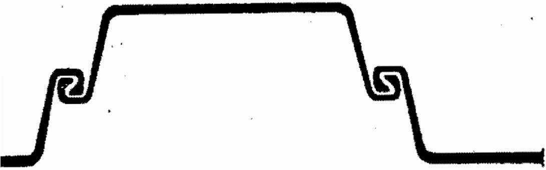
A modern development of the metal screw-shaped piles, are "Screwcrete" piles, but this type of pile is only used where the superstructure imposes very heavy concentrated loads on the piles.

Steel-cylinder piles, also have been used. These consist of steel cylinders up to sixteen inches in diameter which may be driven by means of a pile driver through ordinary soils to rock or other solid stratum, the enclosed soil pumped or blown out by air, and the cylinders filled with concrete. Such piles afford a means of resting a structure on a deep-lying stratum, with a minimum of excavation, and soil disturbance and constitute really a transition type of foundation between piles and piers.

Steel-sheet piles and Steel-box piles, (most commonly used steel piles today.)

SECTIONS OF TWO TYPES OF STEEL SHEET PILES.

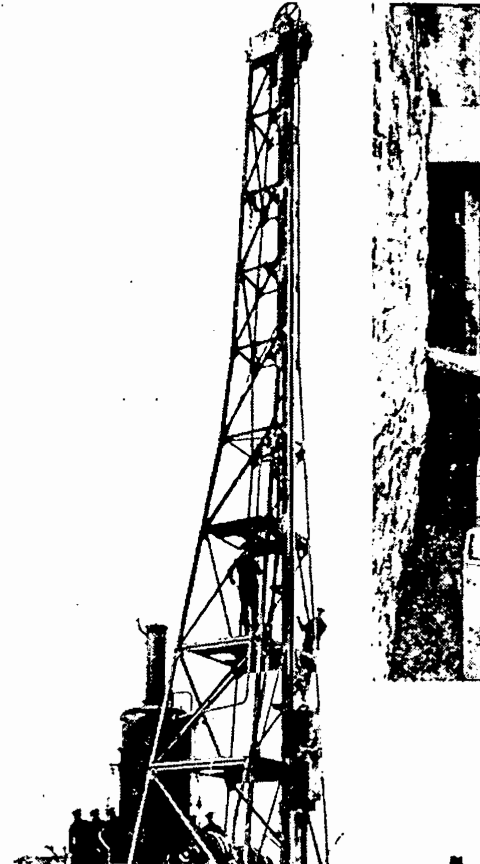
NGHAM SHEET STEEL



EN SHEET STEEL

DRIVING STEEL SHEET PILING.

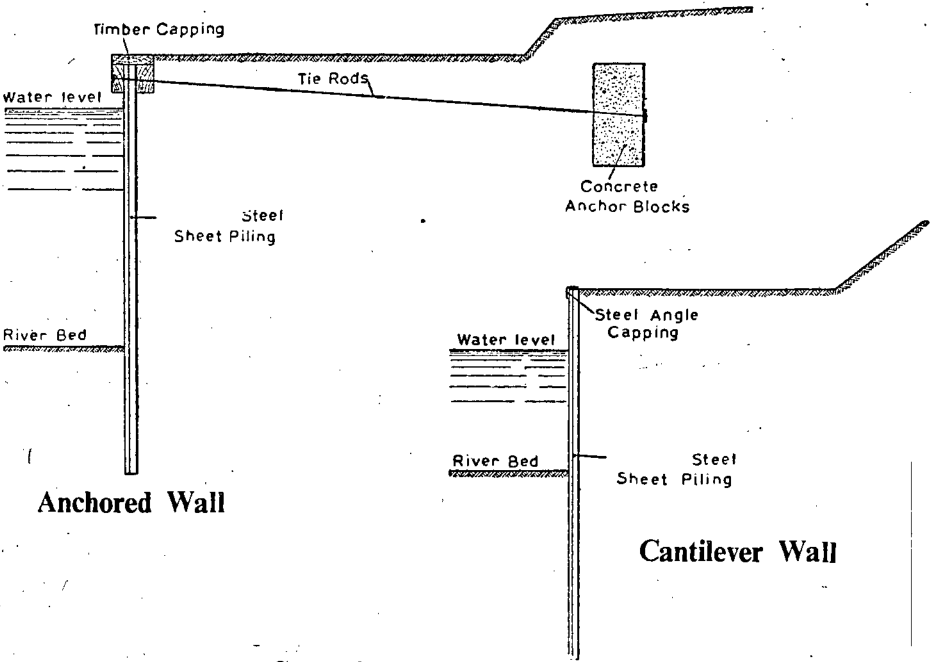
Driving Steel Sheet Piling.



Standard steel frame with McKiernan-Terry hammer.

McKiernan-Terry hammer operating in deep trench.

EXAMPLE OF STEEL SHEET PILING USED TO RETAIN SMALL RIVER WALLS.

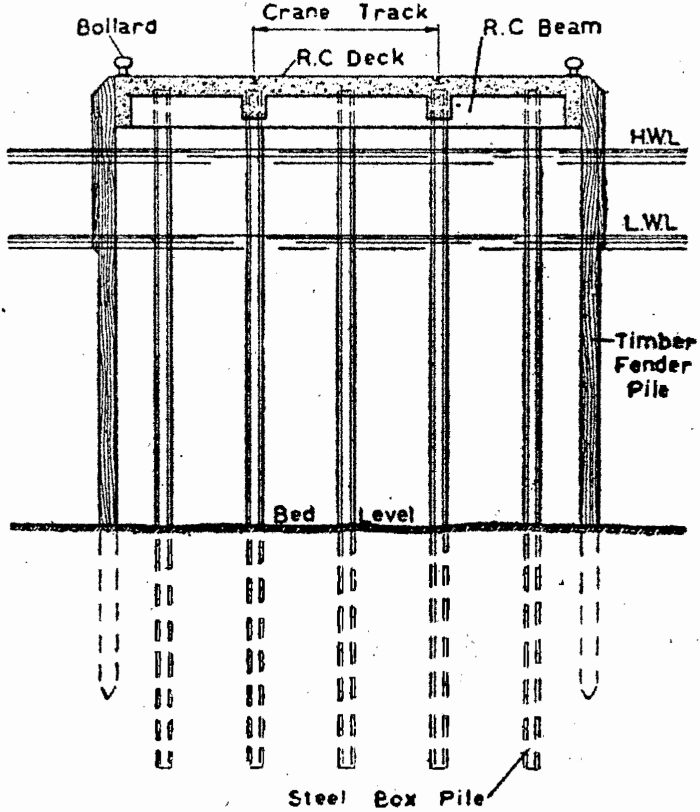


Small River Walls.

EXAMPLE OF A JETTY CONSTRUCTED BY USING STEEL BOX PILES.

Steel-sheet piles are designed for the construction of permanent retaining walls in docks, harbours and river-bank protection etc. and are thus not strictly relevant to the problem of constructions over water, except perhaps in relation to the protection of the river-bank which is illustrated in the accompanying diagram.

Steel-box piles may be fabricated from two sheet piles of suitable shape welded together at intervals along the interlocks and also from other rolled steel sections. They have a very large carrying capacity in comparison with timber or reinforced concrete piles, provided the ground can develop a correspondingly high bearing resistance. As a rule box piles are driven with the bottom end open, but if the soil is not firm enough to develop the necessary resistance, a shoe may be provided. They can be driven into very compact ground or soft rock and there is no risk of damaging or cracking the piles when it is necessary



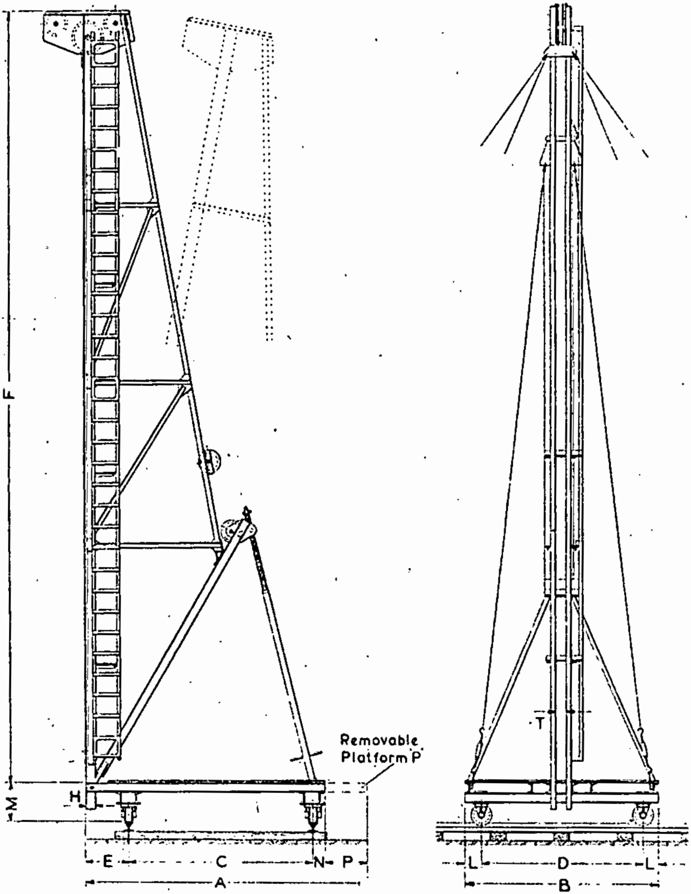
Crane Track
Bollard
R.C Beam
R.C Deck
H.W.L
L.W.L
Timber
Fender
Pile
Bed Level
Steel Box Pile

Jetty

to drive them through or into hard stratum. If the piles are driven open-ended, the displacement of the soil, which may be particularly undesirable with soft clays, is almost entirely eliminated. The cost of driving box piles is likely to be much lower than that of driving timber or concrete piles as the necessary bearing capacity can generally be developed with a Mc - Kiernan-Terry hammer of moderate size. This also permits the piles to be driven with the hammer suspended from a crane, the use of a pile-frame being frequently unnecessary.

Box piles require no special care in handling and are therefore more economical than pre-cast concrete piles when the piles are long, as concrete piles have to be heavily reinforced to withstand handling and driving stresses. When a considerable length of pile is exposed above ground level the strength of box piles against buckling as columns is an important adavantage.

TYPICAL LIGHT TYPE FRAME.



F
M
H
Removable Platform P
E
C
N
P
A
T
L
D
L
B

Light Type Pile-driving Plants.

The introduction of light sections of steel piling, created a demand for a specially light type of pile-driving plant. It is designed for economy in operation and in transport and also possesses the special feature of being self- erecting with the aid of its own winch. This plant is also suitable for driving light timber, steel and concrete piles weighing up to 2½ tons and for use with automatic and semi-automatic hammers as well as drop hammers. The standard heights are 23, 35 and 50 feet.

Selection of Length and Section.

The section of piling selected for any particular purpose is governed by the strength required to resist the anticipated bending moment, the cross-sectional area of metal necessary to withstand the driving stresses and other factors. The length of the pile is mainly dependent upon the type of construction, the depth of penetration and the material through which it will be driven. The section of piling is also dependent on the length and as a rough guide the following lengths should not be exceeded.

Very light sections, weight up to fifteen pounds per sq.ft.	15 feet
Light sections between fifteen and twenty-two pounds per sq.ft.	15-30 feet
Medium sections between twenty-two and thirty-five pounds per sq.ft.	30-60 feet
Heavy sections over thirty-five pounds per sq.ft.	As required

Each case, however, must be considered on its own merits, in accordance with past experience and local conditions.

A rather amusing comment, for the modern world of 1963, on the matter of increasing the permanance of steel-work in the sea, from a publication of 1928 is as follows:- "The desired result, however, has been achieved by the ingenious expedient of enveloping the metal in concrete, and this brings us to the system of combined steel and concrete which now generally goes by the name of reinforced concrete."

(c) <u>REINFORCED CONCRETE PILES</u>.

Reinforced Concrete Piles are today the most commonly used type of pile. They have many advantages over other types:-

(i) They are not subject to oxidation, decomposition, or decay.

(ii) Experience has demonstrated that steel bedded in concrete does not rust even when immersed in water, and that a rusty bar so treated manifests no increase in corrosion.

(iii) Reinforced concrete piles do not offer the least incentive or attraction to sea organisms or insects.

(iv) They are fire-proof as well as water-proof.

(v) Their durability is beyond question.

(vi) They cost less than long Greenheart piles, and little, if anything more than creosoted Pitch Pine.

(vii) They can be jointed, lengthened or shortened at will.

(viii) Their compressive strength and supporting power is very great.

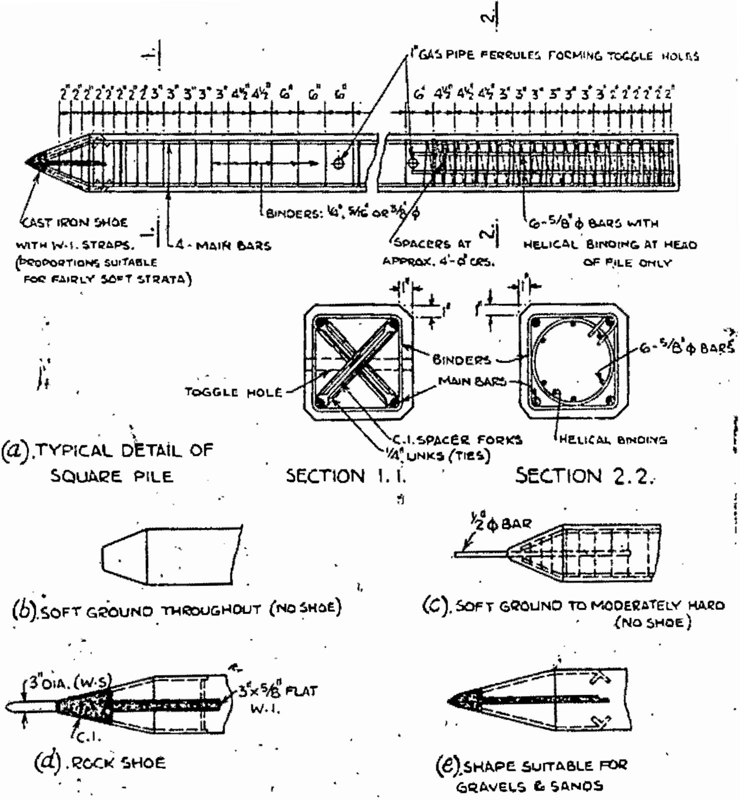
Reinforced concrete piles vary considerably in design, according to the individual ideas of numerous inventors. It will be necessary, however, to refer to a couple of the better known examples, which are distinctly applicable to piling in water. The circumstances of foundation piles for inland structures and for piers and jetties and for any other structure over water, are by no means identical. It cannot fail to be evident that a pile driven wholly into the ground, as in the former case, need not possess the same lateral stiffness which must essentially appertain to a pile only partially buried, and subject, moreover, to the incidence of forcible impact throughout a very considerable part of its length.

Thus, for landwork, concrete piles may

be formed by simply drilling or boring a hole within a steel shell or tube, and filling the latter with concrete, the shell in many cases being withdrawn as the work proceeds. This is in-situ piling, and is quite inapplicable to piling in water. Precast piles have to be adopted. Prestressed precast piles are now also available, made in short lengths and assembled on the site. These piles are hollow and their light weight makes them easy to drive; but no proprietry brand prestressed pile suitable for building in water was encountered. Even if one were designed specifically for the type of building proposed, precast piles would still be more economical.

Precast Piles:- These are either square or octagonal in section and are from eight to eighteen inches wide, and are sometimes tapered towards the toe. They have been driven in lengths exceeding one-hundred feet, although when more than sixty feet long it is necessary to give special

TYPICAL PRECAST REINFORCED CONCRETE PILES.



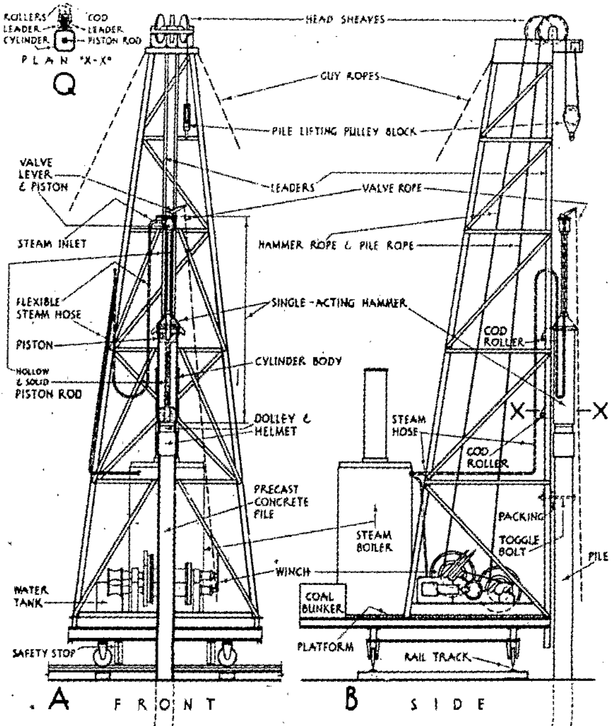
-Precast Reinforced Concrete Piles.

consideration to the design of the pile and of the lifting and driving plant. Piles less than fifteen feet are seldom economical. For their support, piles depend either on direct bearing on a firm stratum, or a frictional resistance in soft strata, or more often on a combination of both resistances.

In the case of very large contracts, precast piles are frequently cast on temporary beds set up on the site, subject, of course to space being available. This generally reduces cartage charges: but for medium or smaller contracts, similar in size to the proposed Resort Scheme, it is more economical to have the piles delivered to the site from the nearest pre-casting yards, provided, of course they are not too distant.

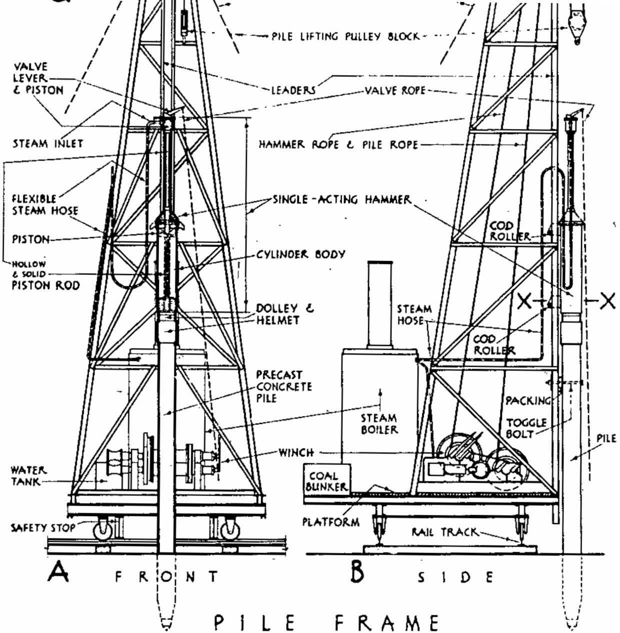
Precast piles are driven into the ground using a pile frame with a heavy weight, called a monkey, which is lifted a specified height, and then allowed to fall freely onto the

TYPICAL PILE FRAME.



ROLLERS
COD
LEADER
LEADER
CYLINDER
PISTON ROD
PLAN "X-X"
Q
HEAD SHEAVES
GUY ROPES
PILE LIFTING PULLEY BLOCK
VALVE LEVER & PISTON
LEADERS
VALVE ROPE
STEAM INLET
HAMMER ROPE & PILE ROPE
FLEXIBLE STEAM HOSE
SINGLE-ACTING HAMMER
PISTON
COD ROLLER
CYLINDER BODY
HOLLOW & SOLID PISTON ROD
X
X
DOLLEY & HELMET
STEAM HOSE
COD ROLLER
PRECAST CONCRETE PILE
PACKING
STEAM BOILER
TOGGLE BOLT
WINCH
PILE
WATER TANK
COAL BUNKER
PLATFORM
SAFETY STOP
RAIL TRACK
A
FRONT
B
SIDE

PILE FRAME


PILE LIFTING PULLEY BLOCK
VALVE LEVER & PISTON
LEADERS
VALVE ROPE
STEAM INLET
HAMMER ROPE & PILE ROPE
FLEXIBLE STEAM HOSE
SINGLE-ACTING HAMMER
PISTON
COD ROLLER
HOLLOW & SOLID PISTON ROD
CYLINDER BODY
DOLLEY & HELMET
STEAM HOSE
X
X
COD ROLLER
PRECAST CONCRETE PILE
PACKING
STEAM BOILER
TOGGLE BOLT
PILE
WINCH
WATER TANK
COAL BUNKER
PLATFORM
SAFETY STOP
RAIL TRACK
A FRONT
B SIDE

PILE FRAME

pile head (which is protected by a helmet with suitable packing) or by a steam hammer. Driving is continued until either:-

(a) The toe of the pile reaches a definite level, such as rock, or,

(b) until a "set" is reached, i.e. a specified penetration for a given number of blows.

Thus a pile might be specified to be driven a set of one inch for ten blows with a three ton monkey, falling four feet. From the set per blow an estimate can be made, using the many "piling" formulae, of the carrying capacity of the pile, although to do this considerable judgement and experience are required.

For heavy driving precast reinforced concrete piles are provided with cast iron shoes. The stresses induced in driving are heavy and therefore the concrete must be good and the reinforcement adequate.

When driving precast piles into sand, it is sometimes found advantageous to use a water jet from the shoe of the pile. This system is especially suitable for marine and ancillary work, as it is not usually practical on inland or city sites.

The following are two patented precast piles that have been used for marine works overseas:-

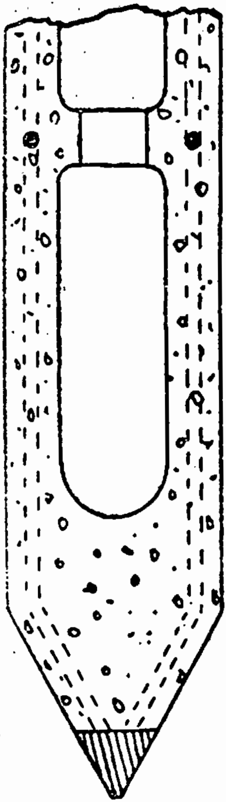
(i) The Hennebique bearing pile is square, without taper, and is reinforced with bars at the corners.

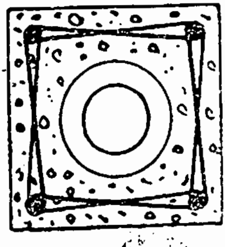
(ii) The Chenowith pile, is formed by rolling dry concrete on a mesh of wire netting about a small tube and embedding longitudinal bars near the surface.

Spacing Of Piles. Piles to be effective should not be so closely spaced that the earth included between them loses its supporting capacity. The supporting capacity of a group of piles can actually be diminished by driving additional piles, if such additional piles cause the group to act as a unit instead of each pile acting separately, because the friction of the periphery of the group will be less than the sum of the peripheries of the piles taken separately. A mimimum effective spacing is frequently stated to be about three feet for piles of ordinary size or perhaps three diameters centre to centre. In the design of the spacing, it is important to have a uniform bearing on all the piles, so that in the event of any settlement occuring it may be uniform and cause a minimum of damage. Special care must be exercised to secure uniformity of bearing for continuous structures.

Groups of Inclined and Vertical Piles. The accompanying diagrams relate to the loads on piles in a group that project above the ground, as in a wharf and jetty. For each probable condition of

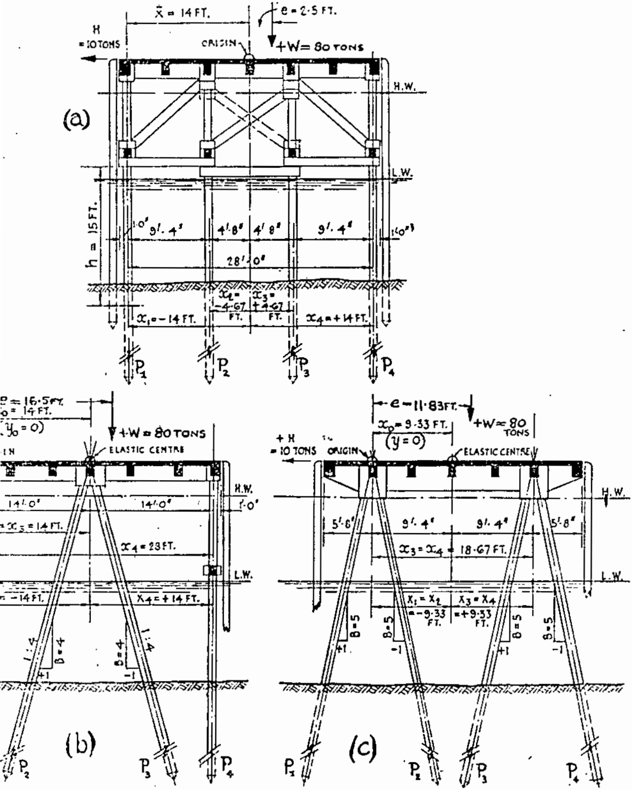
THE HENNEBIQUE PRECAST CONCRETE PILE.





load, the external forces are resolved into horizontal and vertical components H and W, the points of application of which are determined. It is assumed that the piles are surmounted by a rigid pile cap or superstructure. The effects on each pile when all the piles are vertical are based on a simple, but approximate statical analysis. Since a pile has little resistance to bending, structures with vertical piles only, are not suitable when H predominates. The resistance of an inclined pile to horizontal force is considerable. In groups containing inclined piles, the bending moments and shearing forces are negligible. However, as the proposed building is to be located on a river, without any strong currents or tidal pull, and will not have to suffer any severe buffeting from large ships as would a jetty, vertical piling should be adequate.

EXAMPLES OF GROUPS OF VERTICAL AND INCLINED PILES.



x̄ = 14 FT.
e = 2·5 FT.
H = 10 TONS
ORIGIN
+W = 80 TONS
H.W.
(a)
L.W.
h = 15 FT.
1'·0"
9'·4"
4'·8"
4'·8"
9'·4"
1'·0"
28'·0"
x_1 = −14 FT.
x_2 = −4·67 FT.
x_3 = +4·67 FT.
x_4 = +14 FT.
P_1
P_2
P_3
P_4
+W = 80 TONS
ELASTIC CENTRE
H.W.
14'·0"
14'·0"
1'·0"
x_4 = 28 FT.
L.W.
x_4 = +14 FT.
1:4
B=4
+1
B=4
1:4
−1
(b)
P_2
P_3
P_4
e = 11·83 FT.
x_0 = 9·33 FT.
(y = 0)
+W = 80 TONS
+H = 10 TONS
ORIGIN
ELASTIC CENTRE
H.W.
5'·8"
9'·4"
9'·4"
5'·8"
x_3 = x_4 = 18·67 FT.
L.W.
x_1 = x_2 = −9·33 FT.
x_3 = x_4 = +9·33 FT.
B=5
+1
B=5
−1
B=5
+1
B=5
−1
(c)
P_1
P_2
P_3
P_4

5. CONCLUSIONS.

After the careful study of the foregoing timber, steel and precast reinforced concrete piles it seems evident that concrete piles have the greatest durability, are more economical and are most suited to the type of structure proposed.

The precast reinforced concrete piles would be specially designed and manufactured in Port Elizabeth and transported to the site. Owing to the fact that only light loads will be imposed on the piles (in the region of fifty tons) they would probably be of section of 12" x 12" and they would not be of great length; so should cause no difficulty in transport. A light pile-driving plant should be sufficient.

With regard to the actual pile-driving operations, the piles nearest the bank would be first driven, and then the pile-driver would move further out over the river on rails mounted on the piles previously driven. Another method would be to bulldoze an arm of sand out into the river, the pile driver moved out along the arm and the piles driven, through the sand, into their correct positions; the sand would then later be removed.The piles can be driven accurately into their positions, allowing a latitude of an half inch.

The superstructure would provide sufficient bracing to the piles, as a pile may be quite easily designed to stand completely alone, without any form of bracing.

The spacing of the piles for the proposed Resort could be dictated by the spacing of the main supports of the superstructure, as there will be no great point loads imposed on the piles.

The building should be located five feet above mean river level, which allows for the greatest extreme conditions possible.

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