INDUSTRIAL REPORT:
THE CONSTRUCTION OF PILE FOUNDATION FOR HALL SEVEN, UNIVERSITY OF DAR ES SALAAM.

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1. General

The report is based on Pile Foundation Construction of two four storey blocks for a Hall of Residence at the University of Dar es Salaam. The project is being carried out by

(i) George Boorer & Sons Ltd as General Contractors
(ii) Solanki and Chohan as Consulting Engineers
(iii) B.J. Amuli - Architect.

The pile construction was done by Mowlem Construction Company based in Nairobi. On completion, the hall will accommodate about 150 students.

2. Introduction

Foundations pass the total load from a structure to the ground by direct contact. The load carried or contained within the superstructure reaches the foundation by means of a number of individual members or units of construction such as walls and columns. It is therefore of utmost importance that the foundation is of such a structural design that is able to distribute the load in such a manner that the ground is not overstressed or caused to settle beyond the ability the superstructure can afford. As such in foundation design, a knowledge of the underlying ground together with the superstructure must be clearly understood as well as their effect on each other.

In the subject case, after site investigation and soil tests, it was found out that the type of soil was predominantly clay of rather low bearing capacity. It was therefore not suitable to start the foundation on such soil, instead, the hard stratum found at a depth of 12-15 metres below the ground was sought.

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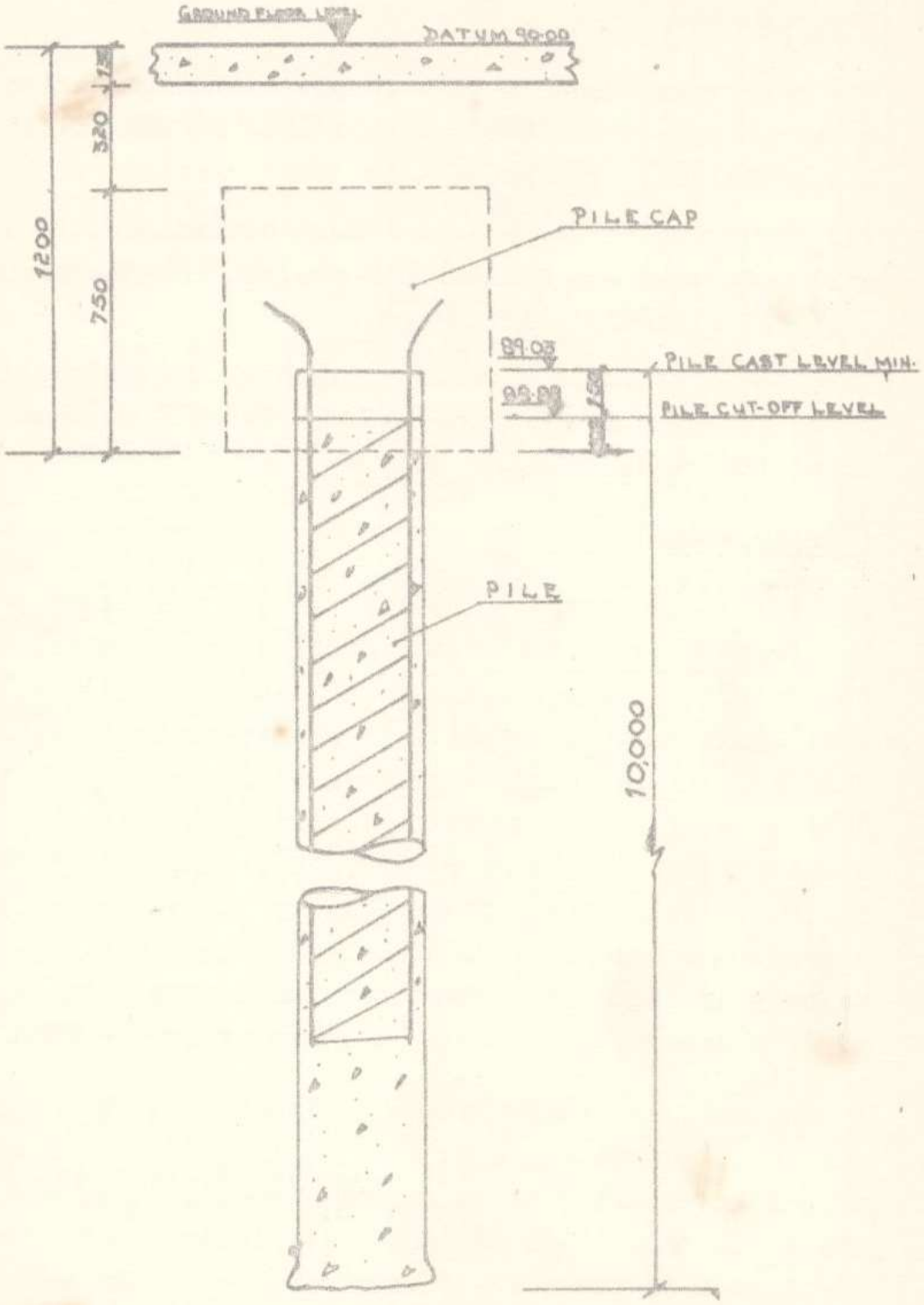

Figure 1: DRAWING OF A TYPICAL PILE

It is not economical to excavate the earth to such great depths and Pile Foundation was found to be the most satisfactory and economical design. In this case Bored Cast In Situ Piles were used. A typical bored-cast in situ pile is shown diagramatically in Figure 1.

3. The Working Process

After the site had been cleared, the positions of the piles were established in Grid System laid down in the Pile layout plan.

The piles were 92 in total and differed in depth and diameter depending on forces they were required to withstand.

3.1 Boring

Pile drilling was done by a "CALDWELD MACHINE" using buckets of different diameters depending on the pile diameter. This machine is made in the U.S.A., and for safety reasons it is unlawful to operate it within 6ft of high voltage lines.

3.2 Reinforcement or Caging

Piles are reinforced to increase their ability to withstand shear, compressive as well as bending forces. Structural specifications required 5 high tensile steel bars of 16 mm diameter in each pile and mild steel stirrups of 8 mm diameter.

The completed cages were lowered into the bores with some packing blocks attached to the bars so as to ensure that the reinforcement gets fully embedded in concrete to avoid chemical attack or corrosion which might lead to structural failure. It was required therefore that the reinforcement be covered by about 50 mm of concrete.

3.3 Concreting

The quality of hardened concrete largely depends on mix design of which material choice and quality are important.

3.3.1 Materials:

Cement:

It was ordinary portland cement from Tanzania Portland Cement Factory - Wazo Hill, Dar es Salaam.

Aggregate:

This was limestone aggregate of 20 mm overall maximum size obtained from Kunduchi quaries in Dar es Salaam.

Sand:

It was brown in colour and free from organic matter.

Water:

City Supply water to the University Campus was used.

3.3.2 Mixing, Transporting and Placing

Machinery:

The type of machinery used was 'Benford' Rotating Drum Concrete Mixer, made in Britain which had a scale upon which weight batches could accurately be determined.

Proportions:

The nominal mix ratio was 1 : $1\frac{1}{2}$: 3 by volume which on the weight batch was 100 Kg:140 Kg:300 Kg, and approximately the capacity of the mixer. The Engineer's specification required a water cement ratio of 0.45. The concrete prepared was to have a medium slump.

Mixing:

All materials were mixed dry before adding water until a rather homogeneous mixture, judged by the uniformity of colour, was obtained. Water was then added while the drum with the contents kept rotating until the whole mass was plastic and uniform in colour.

Transporting:

Dumpers were used for this purpose.

Placing:

Hoppers were used to place the concrete into the reinforced bores.

3.3.3 Test Cubes

As concreting proceeded, representative samples of concrete were taken randomly daily and three test cubes were prepared in accordance to BS 1881 : 1970. These were taken for crushing strength test after 7 and 28 days in Government's Material Laboratory, Pugu Road. From the design of the mix, the crushing strength should have been 18 and 28 N/mm^2 at 7 and 28 days respectively, and these minimum strengths were attained.

4. Pile Testing

This is very important in the design of pile foundations. Loading tests are usually made because of a number of reasons. The main reasons for such tests are:

a) to observe the load-settlement relationship at the working place.
b) To prove that no failure occurs for smaller loads than the expected working loads.
c) To determine the real ultimate bearing capacity of the soil.

The test therefore serves as a good reference for future work on the nearby area.

Theory of the Experiment

Test load is applied to a 'test pile' by jacking it against a beam which is tied to the heads of two anchor piles capable of withstanding an upward force as shown in Figure 2.

Procedure

After arranging the beam in place as shown in the drawing, initial gauge readings were taken. Loading was done in ten ton steps (using a hydraulic machine) always waiting for settling to cease before proceeding to a greater load.

Settlement of the test pile was measured after every five minutes by two gauges (precision 0.025 mm) fixed to two opposite sides of the tost pile and the mean settlement calculated.

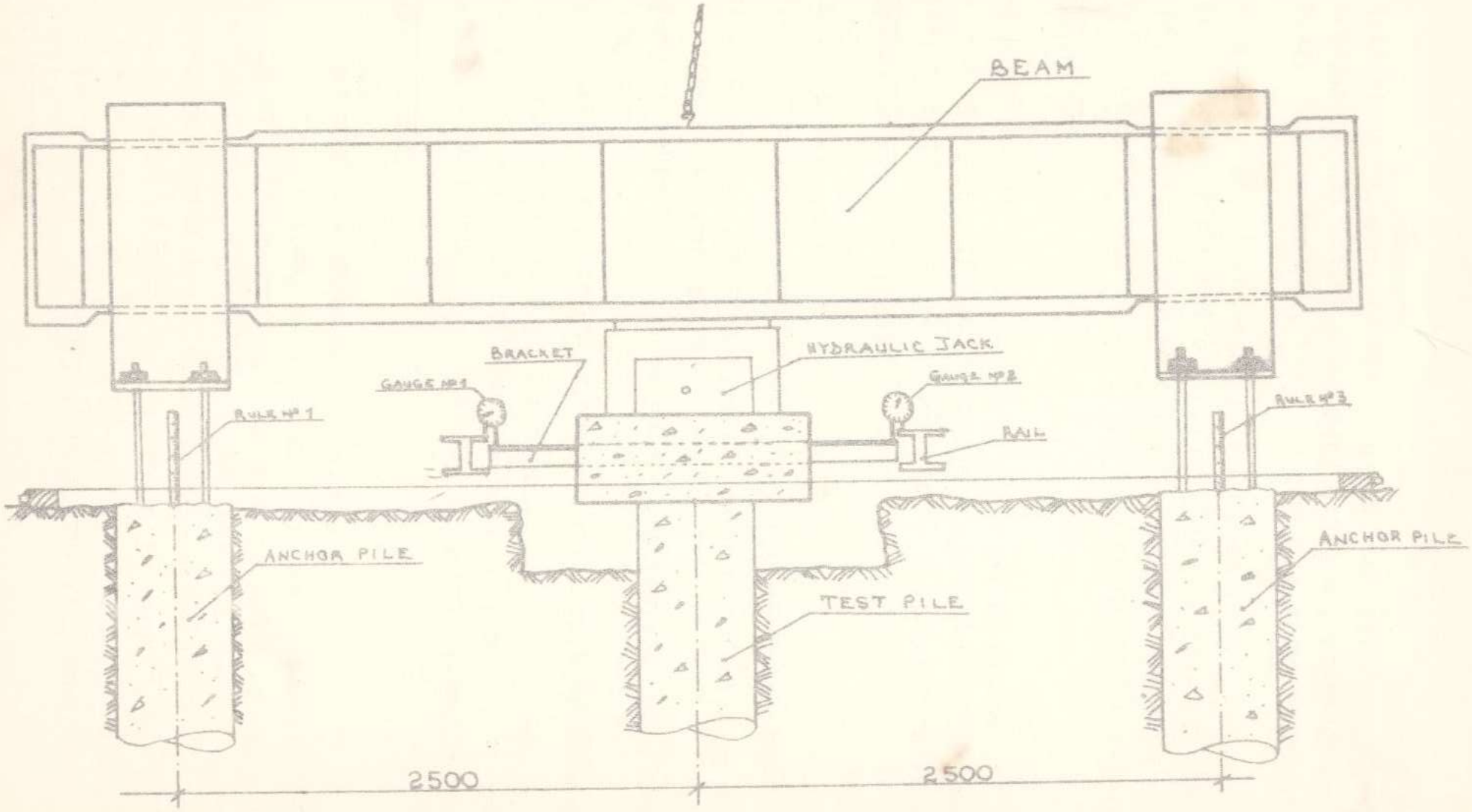

Figure 2: A CROSS-SECTIONAL DRAWING OF THE PILE TEST

After the expected working load (40 tons) was reached the load was maintained constant for 24 hrs while taking settlement readings. Then the pile was off loaded in 10 ton steps. The pile was left unloaded for 1 hour then loading was again repeated in 10 ton steps to a 60 ton load which was maintained constant for 48 hours while taking settlement readings.

Results

Some results of the settlement of the pile due to various loads are given in the table below. Most of the settlement took place immediately after the load was applied, and remained constant during the duration of the load, indicating stable conditions. The full load of 40 tons was maintained for 24 hours after which it yielded an average settlement of 0.081 inches.

Some results of the pile test

Load (tons)	10	20	30	40
Settlement (inches)	0.057	0.064	0.071	0.080
Duration of load (minutes)	15	15	15	60

There are different definitions of failure. We can say a failing load is that which causes a settlement equal to 10 percent of the pile diameter or failing load is that at which the rate of settlement continues undiminishingly without further increement of load, unless this rate is so slow as to indicate that settlement may be due to consolidation of the soil. In this test failure was considered to be settlement of 12 mm.

Precautions taken in the test

1) The ground around the T. pile must not be disturbed e.g. by heavy machinery because disturbance may lead to faulty settlement readings.

2) The anchor piles must be far enough so that any movement of soil up around them may not influence the settlement of the test pile. In this test the anchor piles were at a distance of 2,500 mm from the centre of the test pile.

5. Pile Caps

After stripping off the top soil a profile was prepared and pile cap trenches were excavated manually to the pile 'cut off level'. The bottom surface of the trenches was levelled, compacted and blinded with mortar ready to receive the pile cap reinforcement.

The pile cap reinforcement was prepared out of mild steel bars and stirrups bent cold on site.

6. Conclusion and Recommendations

On the average workmanship was satisfactory. A few areas, however, could have been improved especially in concrete mixing and placing. The water content was left to the mixer-drivers judgement and as a result concrete of very high slump was prepared. For this matter a more skilled operators should have been employed.

In placing the concrete, it was left to fall freely to depths as high as ten metres. To avoid segregation pipes should have been used for placing concrete at such great depths. Concrete should have been vibrated to make it more compact but unfortunately this was not done.

Acknowledgements

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