Research on the detection and secondary utilization of the old piles of the re-building wharf at the original site

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Abstract. According to the test results of the appearance deterioration degree, concrete strength, reinforcement strength and pile foundation integrity of the old square piles of the original wharf, it is confirmed that the old square piles still have good performance and bearing capacity which can meet the requirements of the temporary support of the construction steel platform of the new wharf piles, and the old square piles have been successfully secondary used in the construction of the new wharf.

1. Introduction
BEIRA port is the second largest port in Mozambique. Due to the long service life and several natural disasters, some areas of the port have been seriously damaged and can only be operated with low efficiency. In order to restore and expand the fishery production capacity, the Ministry of Fisheries of the government of Mozambique has launched a new fishery wharf reconstruction project.

The new fishing wharf of BEIRA port adopts the high pile beam plate structure [1], which is rebuilt on the original fishing wharf coastline. During the demolition of the original wharf, it is difficult to pull out the original old piles, which are basically treated as reserved.

Based on the test results of old piles reserved, the feasibility of the secondary use of the old piles is analysed in the construction of the new wharf.

2. Test and detection of the old piles

2.1. General situation of the old wharf piles
The original fishing wharf of BEIRA port adopts the square pile with the size of 380mm and C20 concrete. The main reinforcement in the pile is four Φ32 mm grade I bars.

2.2. Observation on damage degree of appearance
Before the demolition of the old wharf, the appearance damage degree of the old square pile has been observed. As shown in Fig. 1, due to being in the splash zone, the pile within one meter below the top is seriously damaged with the concrete peeled off in a large area and the steel bar exposed and rusted, and basically lose the main performance. However, the pile below is in the water level fluctuation zone, without obvious damage, and the appearance is relatively complete.
In order to observe the internal concrete quality of the old square pile, the seriously damaged part at the top of the old square pile is cut off at the elevation of 5.5m. From the section of the old square pile after cutting, it can be seen that the concrete and reinforcement of the pile are in complete condition, the concrete appearance quality is normal, and the reinforcement is not corroded, as shown in Fig. 2.

![Figure 1. Appearance of square pile before demolition.](image1)

![Figure 2. Section of old square pile.](image2)

2.3. Laboratory test
In order to obtain the residual strength of the concrete and reinforcement after many years, the concrete core samples of the old square pile are drilled and the reinforcements in square pile are taken out for laboratory test. The core samples taken out are made into the test samples with the size of $\Phi 100\text{mm}\times 100\text{mm}$, as shown in Fig. 3. The surface of the sample is smooth and the concrete quality is good. Core samples are drilled for 7 piles, and three samples were made for each pile as a group.

The compressive strength tests shall be carried out for each group of samples. The average value of the compressive strength of three samples shall be taken as the representative value of the pile, and the test results can be seen from Table 1. Eight reinforcing bars are taken out from the old square pile and made into samples for tensile test, and the test results can be seen from Table 2.

According to the test results, the average concrete compressive strength of old square pile is 20.66 MPa, and the minimum is 18.76 MPa. The average yield strength of $\Phi 32\text{mm}$ round steel is 247.6 MPa, and the minimum is 235 MPa. The performance of concrete and reinforcement has not been reduced.

![Figure 3. Appearance of concrete core.](image3)
2.4. Low strain dynamic test of the old square piles

After cutting off the damaged part at the top, the integrity of the old square pile was detected with low strain dynamic test, and 14 piles were tested. The typical wave chart of the low strain dynamic test is shown in Fig. 4.

Due to the small excitation energy, the detection depth of low strain dynamic test for pile is limited. According to the existing experience and the ability of detection instrument, the detection depth is not more than 30m [2] [3].

According to the wave chart of 14 piles, there is no reflected wave within 30m of the old pile. In view of the above, it can be concluded that the length of the old square pile is at least 30m, and free from defects.
3. Calculation of bearing capacity of old square pile

3.1. Calculation based on concrete strength
The lowest representative value of compressive strength, 18.76MPa, is selected from table 1 as the concrete compressive strength for calculating the axial compressive bearing capacity of the old square pile. The design value of the axial compressive bearing capacity of the old square pile is 1747.7kN, as shown in Formula (1), in which, the side length of the old square pile is 0.38m and the partial coefficient is 1.55.

\[ Q_d = \frac{1}{1.55} (0.38^2 \times 18.67 \times 10^3) = 1747.7\,(kN) \]  

3.2. Calculation based on empirical parameter method
According to code for pile foundation of port engineering, the design value of axial compressive bearing capacity of driven pile can be calculated according to Formula (2) [4].

\[ Q_d = \frac{1}{\gamma_R} (U \sum q_f l_i + q_R A) \]  

The standard values of unit pile side resistance and unit pile end resistance recommended in the engineering investigation report of the reconstruction project are adopted [5], excluding the side friction resistance of block stone layer and silt layer. The pile length is considered as 30m, and the design value of axial compressive bearing capacity of single pile is 751.6kN.

| Soil name                        | Medium coarse sand | Clay | Total | Design value of bearing capacity (kN) |
|----------------------------------|-------------------|------|-------|--------------------------------------|
| Partial coefficient γR           | 1.55              | 1.55 |       |                                      |
| Perimeter of pile U (m)          | 1.52              | 1.52 |       |                                      |
| Length of soil layer l_i (m)     | 4                 | 13   | 17    |                                      |
| Standard value of unit ultimate side friction qf (kPa) | 45               | 40   |       | 751.6                                |
| Design value of side friction resistance (kN) | 176.5            | 509.9| 686.4 |                                      |
| Section area of pile A (m²)      |                   | 0.144|       |                                      |
| Standard value of unit ultimate end resistance qR (kPa) |                   | 700  |       |                                      |
| Design value of end resistance (kN) | 65.2             | 65.2 |       |                                      |

4. Secondary utilization of old square pile
According to the calculation results in the construction scheme of the steel platform of the construction company of the new fishing wharf, if the old square pile is used as the temporary support of the pile foundation construction steel platform, each square pile shall bear a load of 300KN.

Based on the test results of appearance deterioration, concrete strength, reinforcement strength and pile foundation integrity, the old square pile of the original wharf still has good performance.
According to the calculation results of bearing capacity, the axial compressive bearing capacity of single pile of old square pile is at least 751.6kN, which fully meets the requirements of temporary support of steel platform for pile foundation construction of new wharf.

5. conclusion
In the actual construction, the construction unit makes secondary use of the old square pile as the temporary support of the steel platform, which saves the project cost. At present, the pile foundation construction has been completed, and the steel platform is in good use. The experience of test detection and secondary utilization of the old pile in this project can provide reference for similar reconstruction projects in the future.

References
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