CHAPTER 3

MATERIALS, TEST PROGRAMMES, AND METHODS

3.1 Introduction

Foundations are the most important members for any structure. For instance, loads first are transmitted to a slab. Then they are further transmitted to beam, if there is any. Next, they are transmitted and supported by a column and continue to do so to a foundation post. Finally, all of the loads, including both dead and live loads, are supported by a foundation, either shallow or deep one. They are then transmitted and dissipated to the underlying- and surrounding soil. From this short explanation, it may be concluded that all loads are supported by foundations and soil.

This research emphasised on the deep foundation employing driven piles because it is most popular in Thailand. One particular problem has been causing doubts concerning their integrity after installation to civil engineers. This is because when installed it is very difficult to correct if it has been found that the pile has an unacceptable integrity. Another problem that has not been mentioned is when there are more than one locations of defect the current pile integrity testing techniques.

This chapter presents the materials, testing equipment, testing techniques, and analysing techniques concerning the pile integrity test when encountering more than one location of defect. It begins with the explanation for building model concrete piles for being integrity tested using a conventional accelerometer and commercial equipment. Then, it is followed by the description of all of the equipment and tools employed. Techniques and methods for the interpretation of test results are also included in this chapter. Finally, it also shows the entire test programmes conducted. Figure 3.1 provides the steps taken to finish this research project.
3.2 Model piles

To achieve the purpose of this research, a total of two model concrete piles having the cross sectional area of 0.15 by 0.15 m and 5.00 m long were constructed. Then, two defects were intentionally created at 2.50 m and 3.50 m from the pile top. The former defect was by means of removing some pile material such that the cross sectional area was left about 40% (60% extracted). The latter defect located at 3.50 m from the pile top, however, was created by gradually extracting the pile material from 0, 5, 10, 15, 20, 35, 50, 65, and 80 %, resulting in the $\beta$ values of 100, 95, 90, 85, 65, 50, 35, and 20%. Figure 3.2 displays the main tools used to create such defects, including an electric grinding machine with different sizes of grinding blade and protective gears during extracting the concrete. In the meantime, figure 3.3 displays the additional tools and equipment used for preparing the model concrete piles as well as for aiding the testing processes.

Figure 3.4 gives the details concerning how the model concrete piles were intentionally made to have the defects. Figure 3.5 displays the steps for creating the
defects. Basically, a circular saw was first employed to cut the pile at a specific depth. To obtain a desired cross-sectional area the pile was essentially cut several times; then, an extractor was employed to finalise a defect shape.

Figure 3. 2 (a) and (b) grinning machine (c) ear noise reduction (d) safety glasses

Figure 3. 3 (a) steel hammer (b) chisel (c) steel square (d) vernier (e) vernier in operation (f) hand pulley
3.3 Equipment and testing devices

The pile integrity testing equipment employed in this study was obtained from PILETEST. The model was PET (Pile Echo Tester) which has been built according to ASTM D5882-07. It comprises a specially-made accelerometer with USB cable and a nylon hammer, as shown in figure 8. The accelerometer has a sensitivity of 100 mV/V, resonant frequency of 30 kHz, sampling solution of 24 bit, and sampling frequency of 50 kHz, as shown in figure 3.6.

Plasticine is customarily employed for attaching the accelerometer to the pile top. A moderate force from the nylon hammer was generated at the pile top several times, resulting in stress waves travelling from the pile top and reflecting back when encountering an abnormality or pile toe. The signals were transmitted from the accelerometer via the USB cable connected to a portable computer or tablet having been
installed a program for monitoring and recording the testing signals for further analysis. The modules used to collect the test data were from National Instruments, as shown in figure 3.7. Basically, they comprised a module connected to an accelerometer. Then, it was housed in a chassis connected to a computer for monitoring and recording the test signal in terms of velocity records.

![Image](a) Accelerometer (b) USB cable (c) plasticine (d) nylon hammer

Figure 3.6 (a) Accelerometer (b) USB cable (c) plasticine (d) nylon hammer

![Image](a) NI module for accelerometer connection (b) NI chassis for housing the NI module

Figure 3.7 (a) NI module for accelerometer connection (b) NI chassis for housing the NI module

![Image](a) Pile in the air (b) testing being carried out on the pile in the air (c) a computer

Figure 3.8 (a) Pile in the air (b) testing being carried out on the pile in the air (c) a computer

3.4 Methods and test programmes

The main objective of this study was to investigate whether when a major defect detected a defect located lower could still be detected. This is because it is possible for a pile having more than one defect locations. This resulted in the two defect locations intentionally created as previously given in figure 3.4 and table 1. In addition, the defected piles were tested under two conditions: (1) in the air, and (2) 30 cm under the ground. Note that for both conditions the piles were horizontally laid for ease of testing. It should also be noted that this technique would not alter the test results. Figures 9 and
10 illustrate the testing techniques carried out for the pile in the air and under the ground, respectively.

**Table 3.1 Details of defects made for pile integrity test**

<table>
<thead>
<tr>
<th>No.</th>
<th>No. of defect location</th>
<th>Status of tested pile</th>
<th>Percentage of reduced sectional area</th>
<th>Symbols</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None</td>
<td>A&lt;sup&gt;1&lt;/sup&gt;</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Defect</td>
<td>ND-A</td>
<td>Normal pile</td>
</tr>
<tr>
<td>2</td>
<td>None</td>
<td>U&lt;sup&gt;1&lt;/sup&gt;</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Defect</td>
<td>ND-U</td>
<td>Normal pile</td>
</tr>
<tr>
<td>3-11</td>
<td>2</td>
<td>A</td>
<td>60</td>
<td>2-A0, 2-A5, 2-A10, 2-A15, 2-A20, 2-A35, 2-A50, 2-A65, and 2-A80</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; and 2&lt;sup&gt;nd&lt;/sup&gt; defects located at 2.50 and 3.50 m from pile top&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>12-20</td>
<td>2</td>
<td>U</td>
<td>60</td>
<td>2-U0, 2-U5, 2-U10, 2-U15, 2-U20, 2-U35, 2-U50, 2-U65, and 2-U80</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; and 2&lt;sup&gt;nd&lt;/sup&gt; defects located at 2.50 and 3.50 m from pile top</td>
</tr>
<tr>
<td>21-28</td>
<td>1</td>
<td>A</td>
<td>5, 10, 15, 20, 35, 50, 65, and 80&lt;sup&gt;3&lt;/sup&gt;</td>
<td>1-A5, 1-A10, 1-A15, 1-A20, 1-A35, 1-A50, 1-A65, and 1-A80</td>
<td>The defect located at 3.50 m from pile top&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>29-36</td>
<td>1</td>
<td>U</td>
<td>5, 10, 15, 20, 35, 50, 65, and 80&lt;sup&gt;3&lt;/sup&gt;</td>
<td>1-U5, 1-U10, 1-U15, 1-U20, 1-U35, 1-U50, 1-U65, and 1-U80</td>
<td>The defect located at 3.50 m from pile top&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>1</sup>: The pile was horizontally laid over the ground

<sup>2</sup>: The pile was horizontally laid 0.30 m under the ground

<sup>3</sup>: The defect was by means of gradually sectional area reduction from 0 to 80%

<sup>4</sup>: 1<sup>st</sup> defect was constant at 60%; 2<sup>nd</sup> defect was by means of gradually sectional area reduction from 0 to 80%
A typical result obtained from the pile integrity test is simply a stress wave velocity versus pile length, as shown in figure 3.9. The $\beta$ concept has been adopted for assessing the integrity of a pile. For simplicity, it can be obtained by comparing the amplitude of a velocity record at a point $Z_2$ to the amplitude at the pile top $Z_1$, i.e., $(Z_2/Z_1) \times 100$. It should be noted that the pile top is assumed to have the $\beta$ of 100%. In the case of bored piles, however, the amplitude at a point may be negative thereby resulting in a negative $\square$. This means that the impedance at the point is higher than that of the pile top; in other words, there is probably bulging.