ANALYSIS OF REFLECTOGRAMS OF PILE INTEGRITY TEST USING IMAGE PROCESSING TECHNIQUE

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Abstract

Pile foundations are typically used for major constructions and in cases when the soil at shallow depths is insufficient to withstand excessive settlement, uplift, and so on. Integrity testing identifies areas with reduced cross-sections or poor material qualities. Minor faults, such as microscopic cracks, can often be predicted, but their nature must be confirmed through visual inspection. The main objective of this thesis work is to identify the condition of the cast-in-situ pile and to identify the faulty piles. From recent studies, Sonic Integrity Testing (SIT) is a type of low-strain testing that is an effective instrument for detecting faults and estimating pile length in SKS LPG Mongla, Bangladesh.

As highlighted in the ICE manual handbook, CIRIA 144 (1997), proposes a taxonomy of different types (Type 0, 1, and 2) of reflectogram signal responses. Here, MATLAB is used to create an image-based analysis that digitally represents the signal type. After that, the data is sorted in an Excel file for numerical analysis. The created method was used on 204 signals of 68 piles at SKS LPG Mongla, with 2 piles classified as Type 0, 171 piles classified as Type 1, and 31 piles classified as Type 2. The image-based algorithm and expert judgment were found to be almost identical. Since the analysis has been so good, it seems to make more sense to utilize it instead of regular pile examinations.

Research Objectives

A pile integrity test is a non-destructive method that assesses a pile's response to physical scanning methods, evaluating its construction integrity, gauging concrete homogeneity and uniformity. The research aims to develop an MATLAB algorithm for interpreting Single Integrity Test reflectograms, validation of its effectiveness through visual inspection, establish a standardized data analysis format, and classify signals according to the CIRIA Classification. The ultimate goal is to improve the efficiency and accuracy of pile integrity testing, maintaining high quality control standards and ensuring the safety and reliability of construction and engineering projects.

Design Methodology

- The analysis begins with a site test conducted by SIT Apparatus, where pre-cast piles are hammered and signal reflections collected three times for each pile. Data is stored in the device's memory, processed with filtering and amplification, and converted into a single PDF for further analysis. The PDF file was converted to an image file in jpg format, with a pixel size of 3509 by 2480. The MATLAB 2018a version was used for simulation. The position of reflectograms within the picture was determined using the "imread" function, and three distinct plots were cropped using coordinate points (Figure 1).

- The result is a binary picture made up of 1's and O's, showing all spots in the image where the gradient is greater than the threshold value. The RGB color value of a particular reflectogram is determined, and the mean line is deducted from the line by thresholding between pixels. The binary picture is stored as a one-dimensional matrix array variable, and several Y values are discovered when visualizing the matrix with the plot function (Figure 2).

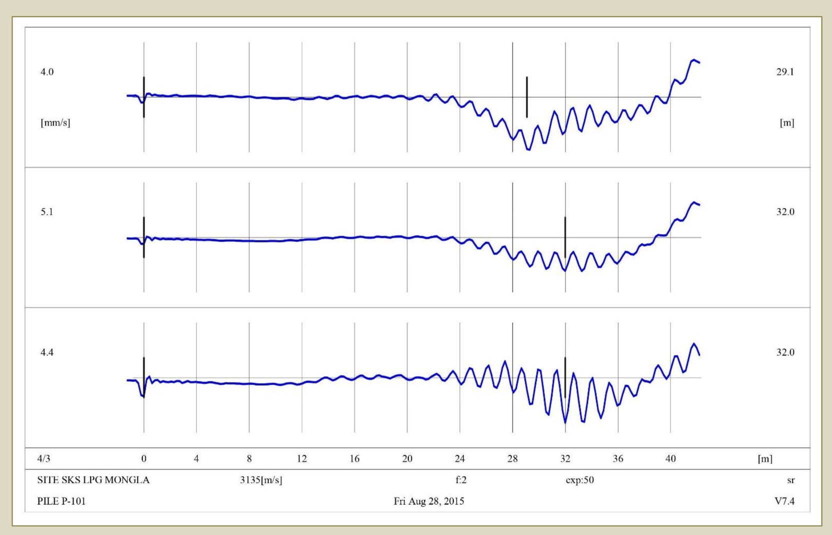


Figure 1: Raw Images from SIT Apparatus

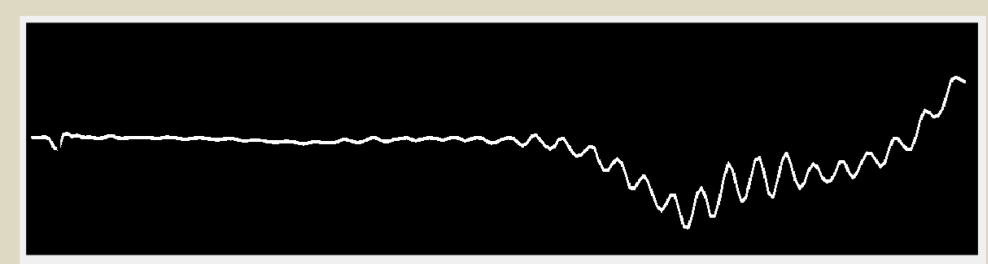


Figure 2: Binary Image After Simulation

- To begin, the RGB color value of a particular reflectogram is determined. In the cropped picture, the value is 0,0 and 255 (i.e., Red=0, Green=0, and Blue=255). The image file's pixel values greater than 128 and less than 128 are selected separately for the line (Figure 3).

- The dataset is plotted to get an image file with the mean value line as a red line. The axial lengths of the reflectograms are calculated, and the offset value of the individual cropped image is determined again from the 'impixelinfo' function. A rescaled plot is named "Scaled Plots" (Figure 4).

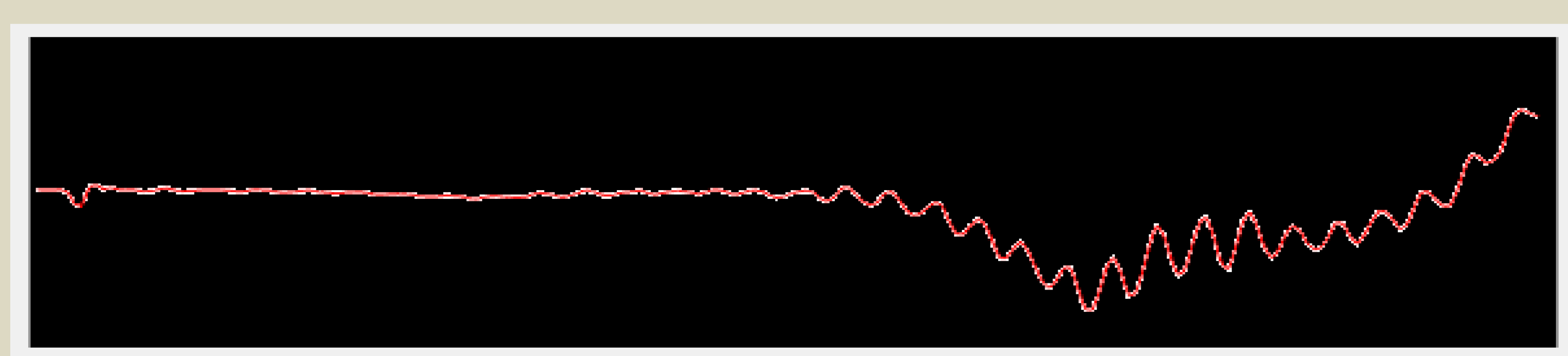
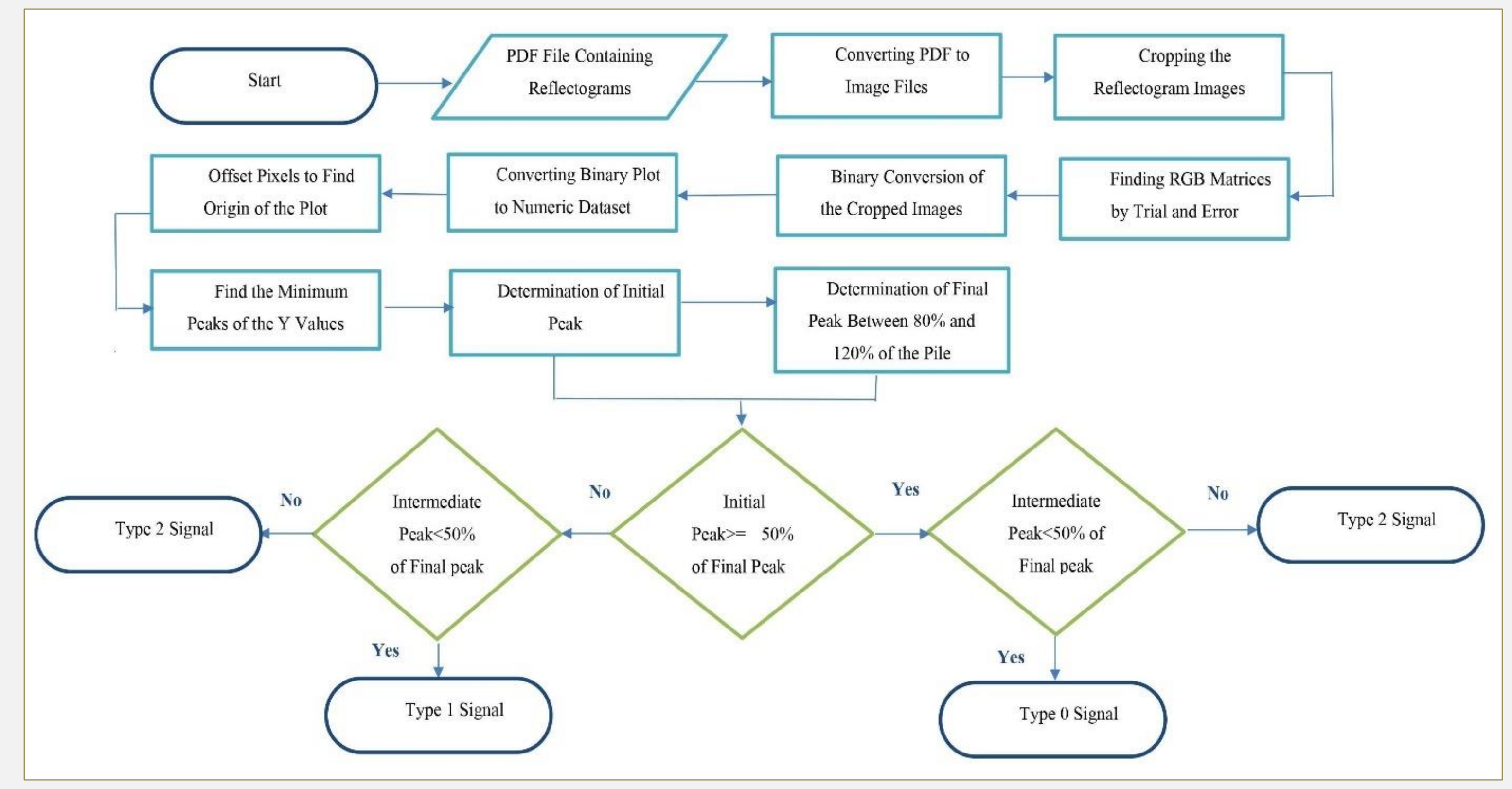


Figure 3: Numerical dataset finding demonstration

Figure 4: Irregularities lost after meaning line insertion

Analysis Flowchart



Experimental Findings

This test was conducted on 68 Cast in situ RCC Piles in the SKS LPG Mongla Project, Bangladesh using data collected by a SIT device. Signal types were determined using MATLAB and Excel files. Out of 204 signals, 2 were Type 0, 171 were Type 1, and 31 were matched with Type 2 signals. The results were presented in tabular and 3D bar charts (Figure 5).

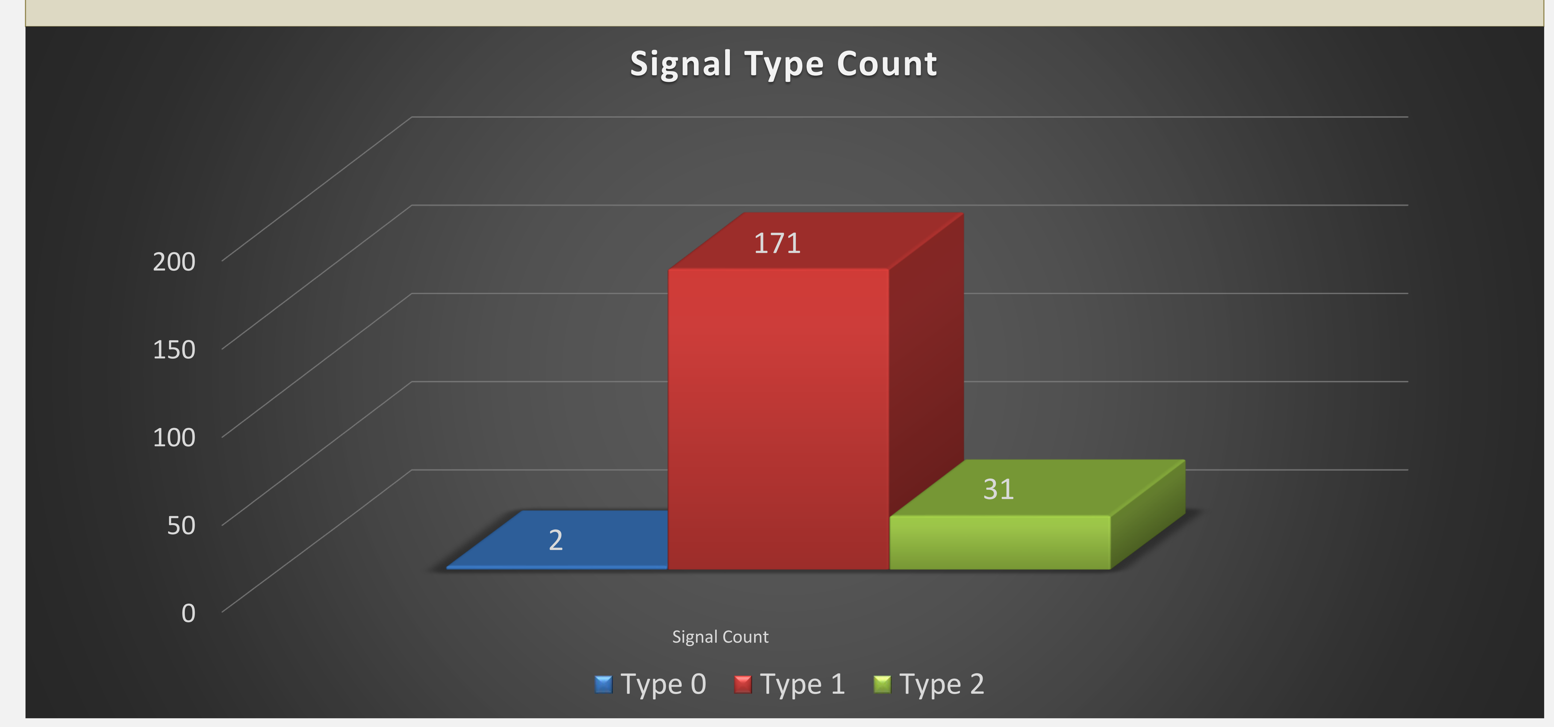


Figure 5: Type and Number of Each Signals

Conclusion and Practical Implications

Pile Integrity Testing is a common method for inspecting underground piles, but may not be 100% accurate due to visionary flaws. Computer software can help identify anomalies, minimize mistakes, and be used indefinitely for any pile configuration. Assessing pile construction continuity and homogeneity optimizes foundation design and construction processes, reducing potential failures and costly repairs.

Key References

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[2] Fathalla M. El-Nahhas & A. A. Hossam-Eldin. (2008). ASSESSMENT OF PILE INTEGRITY UTILIZING NON-DESTRUCTIVE TESTING OF MODEL CONCRETE PILES. Journal of the Egyptian Geotechnical Society, 18(1/2).