NON-DESTRUCTIVE EVALUATION OF THE CONCRETE PREFABRICATED PILE LENGTH USING IMPULSE RESPONSE S'MASH

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1. INTRODUCTION

Currently very popular is the application of the concrete prefabricated piles. In modern geotechnics generally the piles range 0,30 m x 0,30 m (length 6 – 18 m) and 0,40 m x 0,40 m (length 6 – 12 m) with pointed or pointless base are using [1]. The most significant element of the project work is to control the bearing capacity, continuity and length of piles [2-4].

The measurement of bearing capacity of the concrete prefabricated piles are performed using mainly static and dynamic methods. On the other side the most useful method to determine the continuity and length of measured pile are the non-destructive stress wave methods.

In the following article the testing of the quality of the piles and the results of the measurement of the pile length using nondestructive Impulse Response method has been presented. The measurement have been performed on the pylon foundations of the overpass on the district of one of the largest cities in Poland.

2. LENGTH TEST OF THE CONCRETE PREFABRICATED PILE

Opposite to the bearing capacity measurement of concrete prefabricated piles very important is to control the continuity and length of a pile. The most popular of these methods in construction practice are stress waves methods like Cross-hole Sonic Logging or Pile Integrity Test (PIT) which have been shown on the figure 1a and 1b. The most popular application of these methods is to measure the length, cross-section area change, cracks and even changes of the geotechnical layers.

To measure the continuity and the length of concrete prefabricated piles the non-destructive Impulse Response s'Mash test method is applied.

a) b)

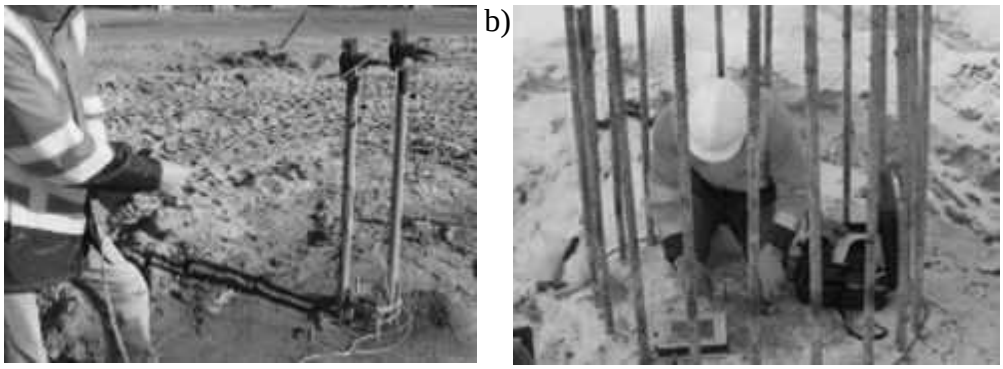

Fig. 1. Methods applied to measure the continuity and length of concrete prefabricated piles [1, 2]: a) Cross-hole Sonic Logging, b) Pile Integrity Test (PIT)

The non-destructive Impulse Response test method belongs to stress waves method and can be used to determine the length, cross-section area and quality of concrete prefabricated piles [5-7]. This method has been first applied in aerospace engineering [8] and after that in testing of concrete structures [9]. It is proper to note that this method is fully non-destructive and can be used to analyze the quality of concrete slab [10]. The impulse response method is frequently using in USA and has been described in American Concrete Institute report [11]. The concept of this method has been shown on the figure 2.

a) b)

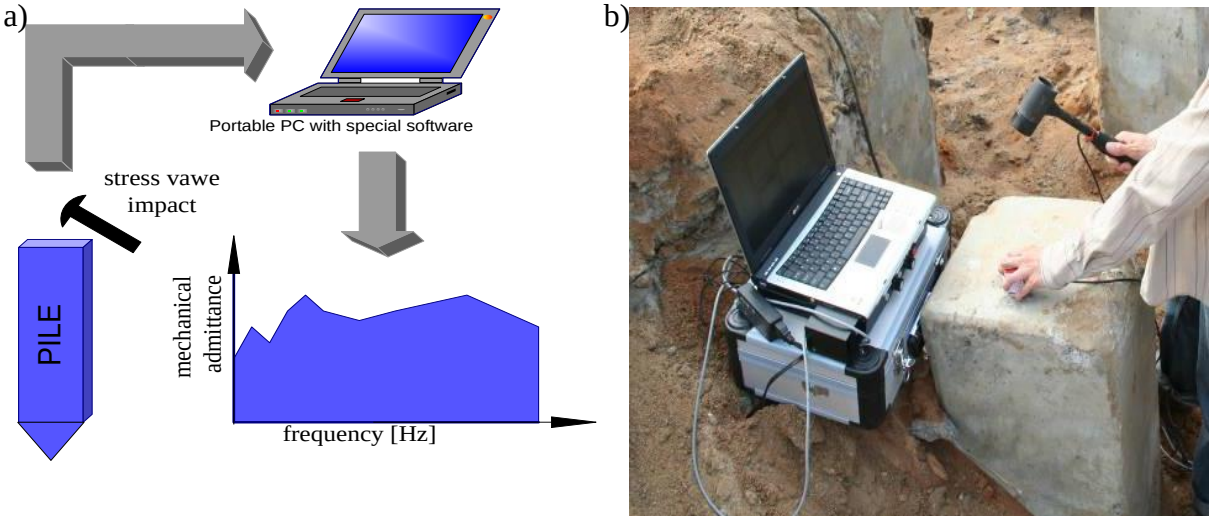

Fig. 2. Impulse Response test method: a) the concept, b) example of using in practice

On the figure 3a the view of the Impulse Response s'Mash equipment has been presented. The concept of the impulse response method is to generate the stress wave in the top of the concrete prefabricated pile using calibrated hammer with rubber head (fig. 3b). At the same moment the stress wave signal is registering using the geophone (fig. 3c) and the intensification is generated by the amplifier which has been presented on the figure 3d. The frequency of generated wave is range from 1 to 800 Hz.

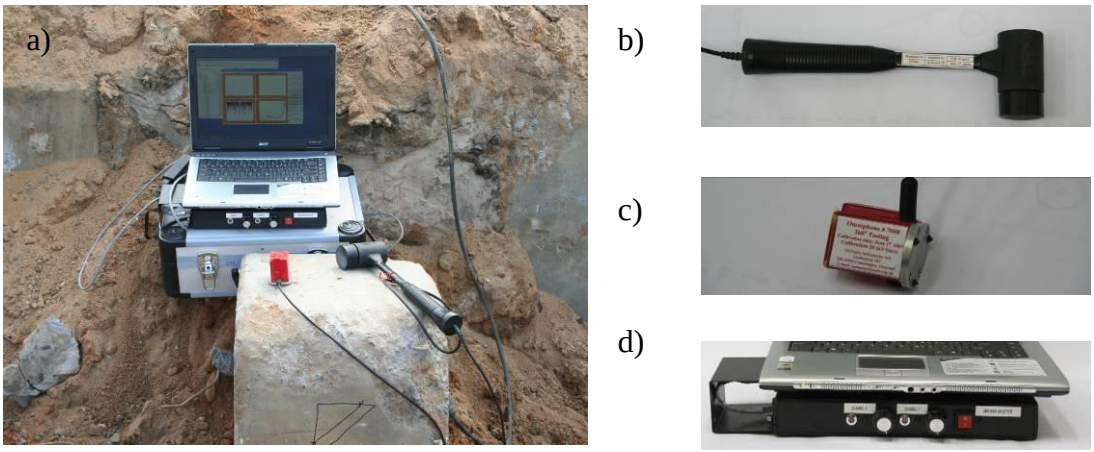

Fig. 3. The view of the : a) impulse response equipment: b) hammer, c) geophone, d) amplifier

3. TEST RESULTS

The measurements have been performed on 25 concrete prefabricated piles with cross-section area about 0,40 m x 0,40 m and designed length 12,0 m. The piles have been applied on the pylon foundations of the overpass on the district of one of the largest cities in Poland. The view of measured piles has been shown on the figure 4. The nondestructive impulse response test method has been applied. After preliminary inspection in selected points the stress wave using calibrated hammer has been generated. The aim of these measurement was to find the length of tested piles. The visual mobility chart, which has been used to analyze the results, has been shown on figure 5. On this chart the manner to generate characteristic parameters like: stiffness, velocity of stress view impulse and important frequency sections. The chart can be used in interpretation when in a range between 1 and around 2500 Hz the mobility value is increasing and at the end of this section there is the maximum value of this parameter. Starting from this point three the nearest local extreme values should be marked.

The parameter $3\Delta f$, which has been presented on the figure 5, is given by this three section. To generate the pile length the most important is the average parameter Δf using following equation:

$$L = \frac{C_p}{2 \cdot \Delta f} \tag{1}$$

where:
L – pile length,
C_p – stress wave velocity [m/s].

Fig. 4. View: a) of the building site of the overpass, b) embedding the piles into the ground using swingle, c), d) of the pylon foundations, e), f) detailed view of tested concrete prefabricated piles

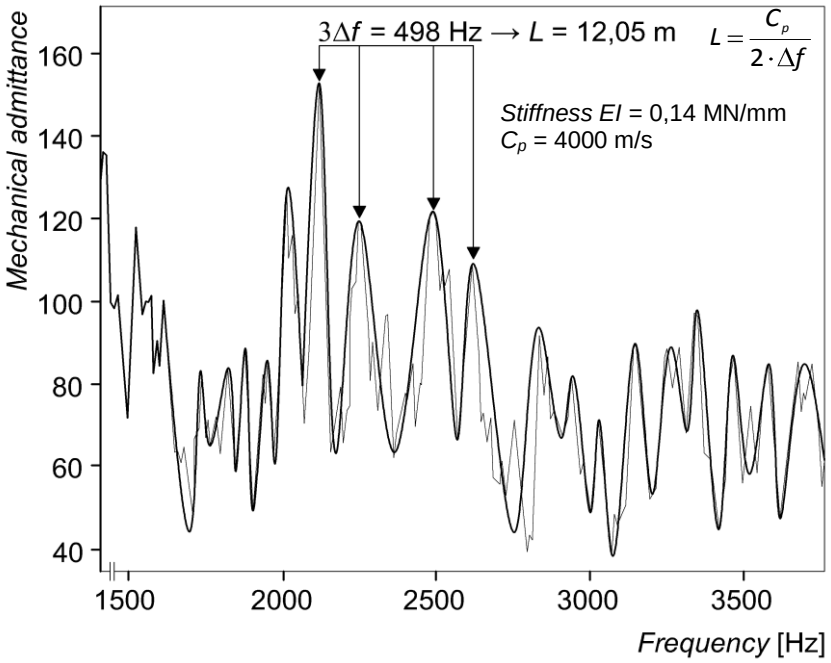

Fig. 5. The visual mobility chart with marked parameters to determine the length of concrete prefabricated piles

On the pictures 6 – 8 three typical mobility plots registered by the Impulse Response method for tested piles no. 9, 11 and 23 have been presented. On the other side in the table 1 the parameters given from these plots for the signals from the pictures 6 – 8 and the calculation of the pile length have been presented.

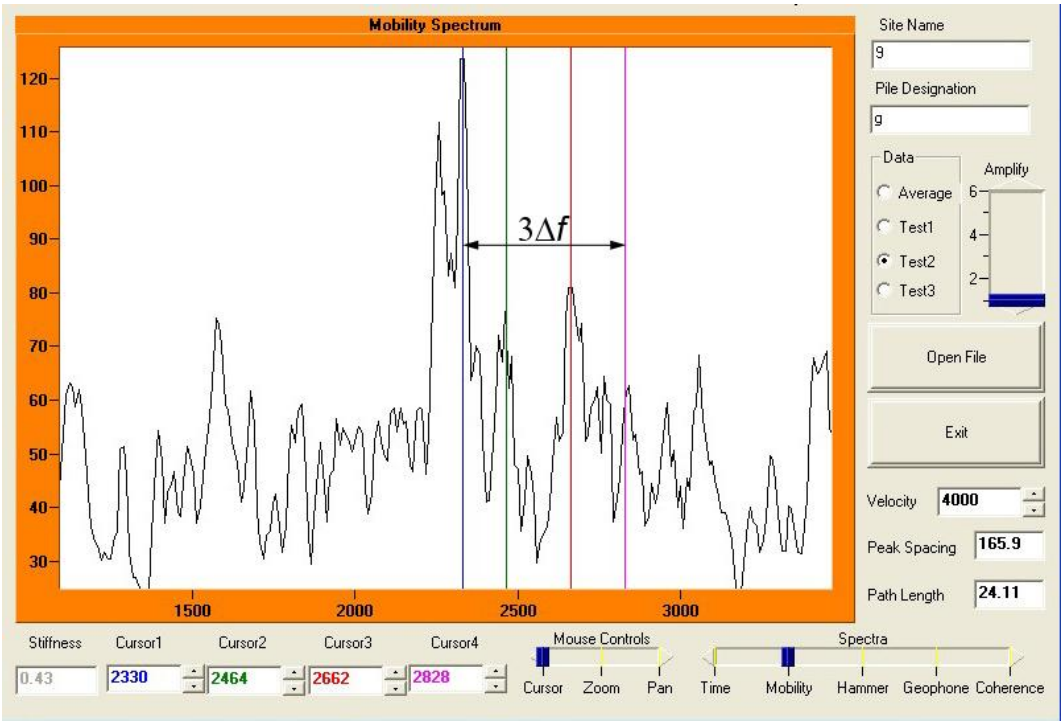

Fig. 6. The mobility plot registered by the Impulse Response method for the pile no. 9.

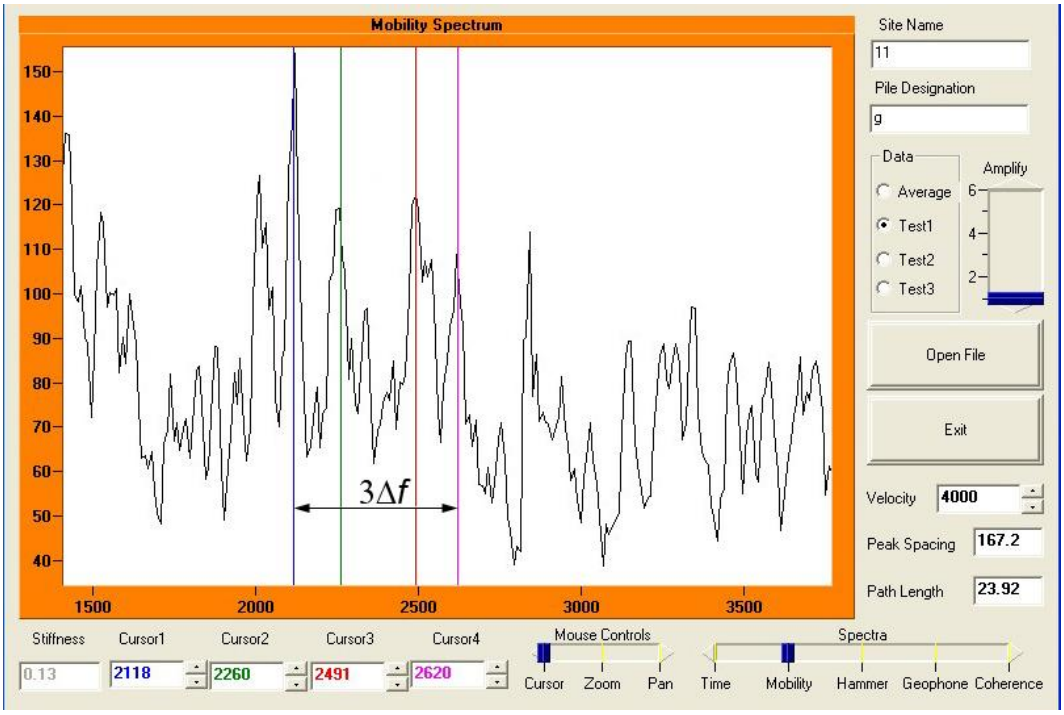

Fig. 7. The mobility plot registered by the Impulse Response method for the pile no. 11.

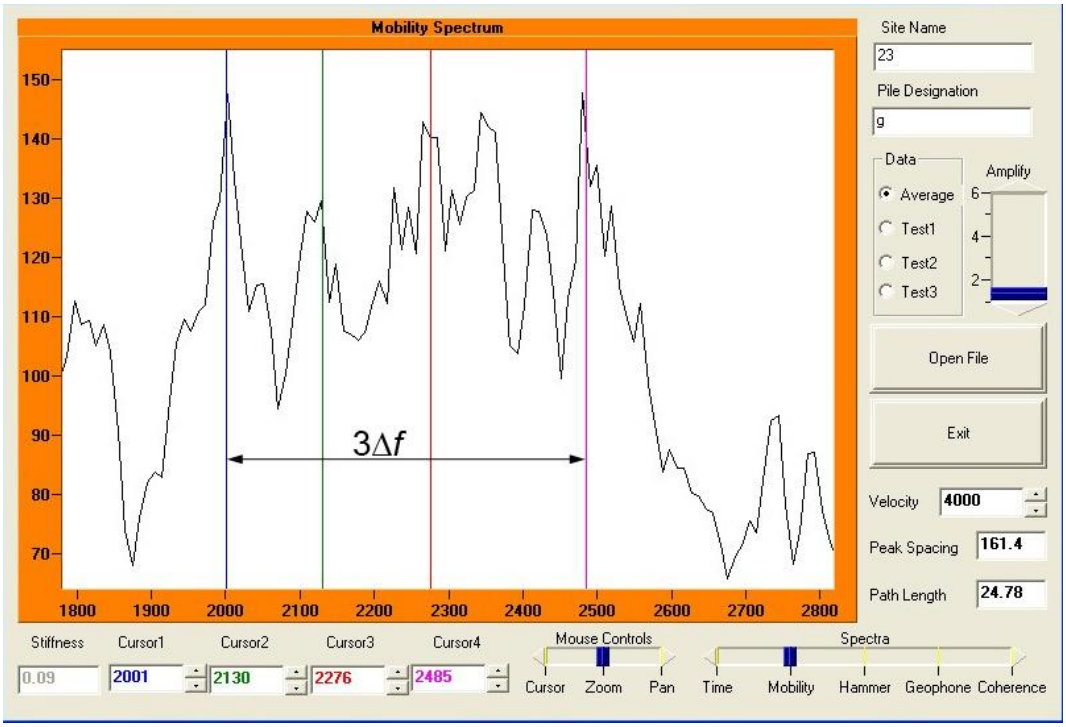

Fig. 8. The mobility plot registered by the Impulse Response method for the pile no. 23.

Table 1. Parameters given from the mobility plots for the signals showed on the pictures 6 - 8

Pile no.	*Stress wave velocity* C_p [m/s]	*Stiffness* EI [MN/mm]	*Increase of the frequency*		*Pile length* L [m]
			$3\Delta f$ [Hz]	Δf [Hz]	
9	4000	0,43	498	165,9	12,06
11	4000	0,13	502	167,2	11,96
23	4000	0,09	484	161,4	12,39

The measurements of the concrete prefabricated piles performed by non-destructive Impulse Response s'Mash method clearly showed that the pile length is around 12,0 m which is similar to designed length. For the number of piles e.g. pile no. 23 the results showed higher pile length. Probable the stress wave impulse has been gone outside to the pile. The reason of this situation was apparent very strong consolidation of the ground under the pile head or even the existence of the big size stones.

For the few piles the analysis of registered signal can suggest the presence of existed void on some deepness. Following signals need to be further analyzed and described.

4. CONCLUSION

The measurements of continuity and length of concrete prefabricated piles can be successfully carried by non-destructive stress wave methods especially the Impulse Response s'Mash test method. The measurements presented in this paper clearly shows that method is usable to determine the pile length in quick and direct manner. The measurements of the concrete prefabricated piles used to build the pylon foundations of the overpass of the district in one of the largest cities in Poland given by non-destructive impulse response method clearly showed that the pile length is around 12,0 m which is similar to designed length.

The conclusion is that the Impulse Response s'Mash method can be successfully used in the engineering practice. It is proper to note that the professional must be fully experienced in analyzing stress waves signals and it can be important disadvantage of this method. In a case of a few piles the presence of existed void on some deepness have been noted but this case must be first analyzed and optimistically published in the next paper.

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