Elimination of the Rayleigh Wave Effect on Low Strain Integrity Test Results

(Part 2: Rayleigh Wave Elimination Technique)

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ABSTRACT

Following the experimental investigation, a technique was subsequently proposed to eliminate the effect of Rayleigh Wave on low strain integrity test results. The technique involves simultaneous measurements of the horizontal and vertical velocities during low strain integrity testing. By measuring the horizontal velocity of Rayleigh waves, the vertical velocity of Rayleigh waves could be deduced by applying an appropriate factor and subsequently be eliminated from the vertical velocity responses. It is shown that this technique can eliminate the effect of Rayleigh Wave. However, a limitation of the technique is that the 'net' velocity response applying the technique does not seem to indicate the reliable profile consistently.

Keywords: surface waves, Rayleigh waves, sonic echo method, integrity testing

1. PROPOSED TECHNIQUE

Some understanding on the behaviour of Rayleigh waves reflecting back and forth along the pile top was achieved based on the experimental work done. It was found that there was a correlation between the horizontal velocity and vertical velocity of Rayleigh waves. It is postulated that the velocity responses obtained from sonic echo tests contain the vertical velocity component of both compression waves and Rayleigh waves. It is essential to obtain only the vertical velocity component of the compression waves for a reliable interpretation of the test results. If the vertical velocity component of Rayleigh waves can be eliminated from the velocity responses, then a pure response due to only compression waves can be obtained.

A technique was subsequently proposed to enable the elimination of the vertical velocity of Rayleigh waves from the vertical velocity responses. The key aspect of the technique is the simultaneous measurements of the horizontal and vertical velocities during low strain integrity testing. By measuring the horizontal velocity of Rayleigh waves, the vertical velocity of Rayleigh waves could be deduced by applying an appropriate factor and subsequently be eliminated from the vertical velocity responses.

2. VALIDITY OF THE PROPOSED TECHNIQUE

In order to investigate the validity of the proposed technique, the technique was applied to velocity responses of selected piles with intentionally built-in defects. The summary of the pile profiles is presented in Table 1. A medium sized hammer of weight 450 g was used as a hammer impact. Sonic echo

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tests were performed on the two piles with three different locations of hammer impact and accelerometer. The locations are:

- A@edge F@edge
- A@edge F@centre
- A@edge F@other edge

Figure 1 illustrates a schematic diagram of locations of the hammer impact and the accelerometer.

Table 1: Profiles of piles

Test pile	Pile Length (m)	Defect		
		Thickness (mm)	Depth from top (m)	Area (%)
4	12.10	300	10.10	26.0
5	11.89	300	9.89	18.0

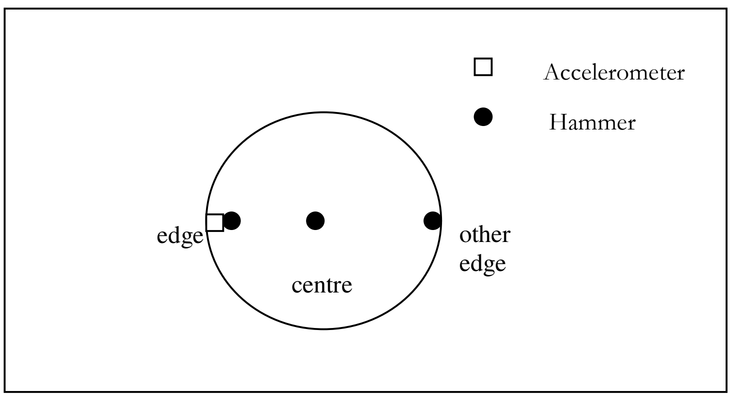

Figure 1: Schematic diagram of locations of the hammer impact and the accelerometer

A magnification factor of 2 and a wavelet length of 1.0 m were applied to all velocity responses for consistency and to enhance the presentation of the velocity responses. No low pass or high pass filter was used as it was found to be unnecessary.

According to Kolsky(1963), the path of any particle is an ellipse and the its major axis is normal to the surface. For particles at the surface ($z = 0$), the ratio between the major and minor axes of the ellipse is 1.468. This suggests that the ratio of the maximum amplitude of vertical velocity to horizontal velocity component of Rayleigh waves should be 1.468. Therefore, in the analysis, a constant 'correction' factor of 1.468 was applied to the horizontal velocity to deduce the vertical velocity of the Rayleigh waves. This deduced vertical velocity response of Rayleigh waves was then subtracted from the vertical velocity response of the individual pile to eliminate the effect of Rayleigh waves.

Figure 3 shows the velocity responses of piles 4 and 5 before the correction factor was applied while Figure 4 shows the velocity responses of piles 4 and 5 after the correction factor was applied. As can be seen from the graphs, the general shape of the 'corrected' velocity responses of pile 4 and 5 is similar and consistent. However, from the analysis, it was found that the correction factor to eliminate the effect of Rayleigh waves varied for different locations (see Table 2). The difference in the correction factor applied may indicate that there is a superposition effect of the multiple paths travelled by Rayleigh waves upon reaching the accelerometer as shown in Figure 5.

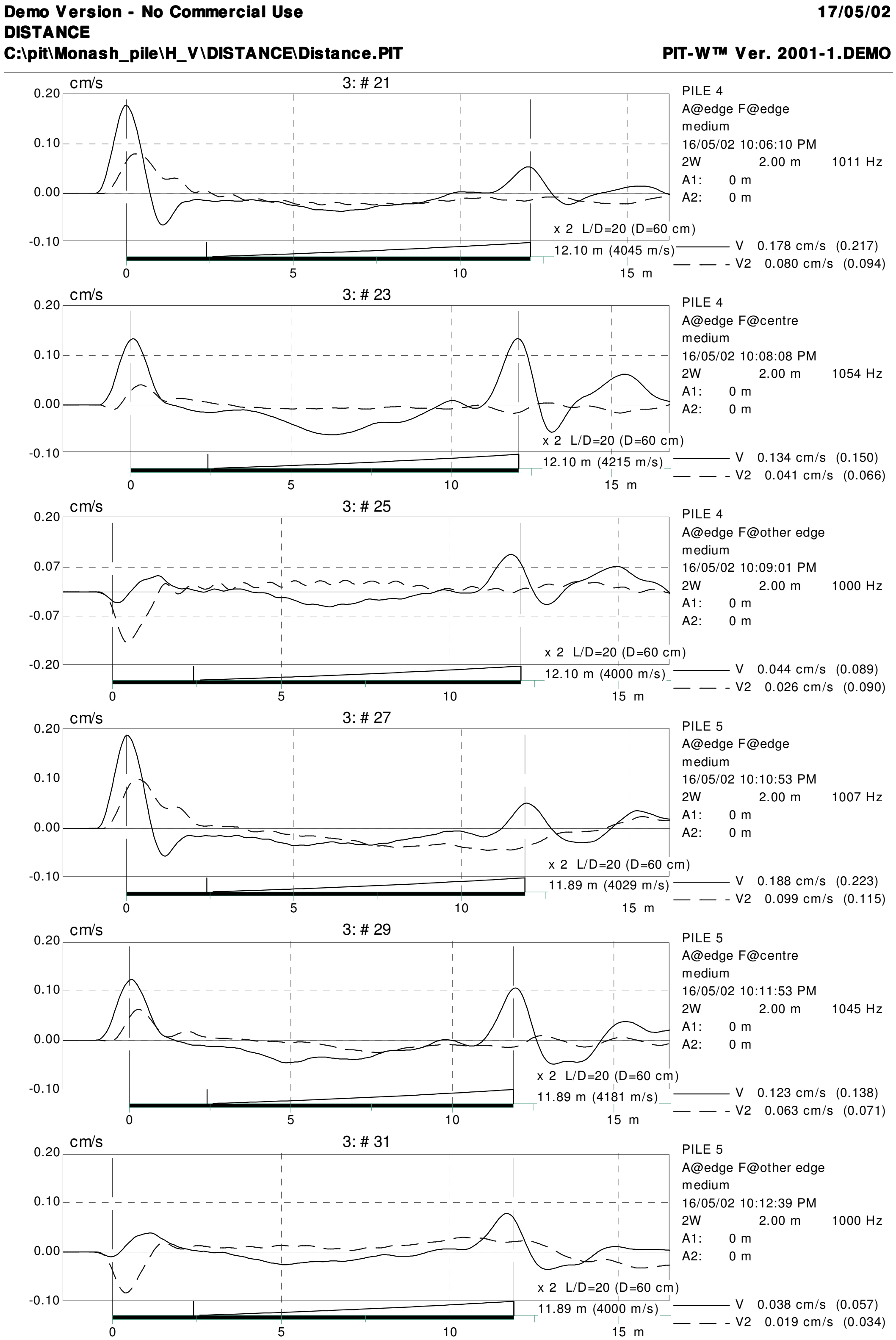

Figure 2: Horizontal-Vertical velocity responses for piles 4 and 5

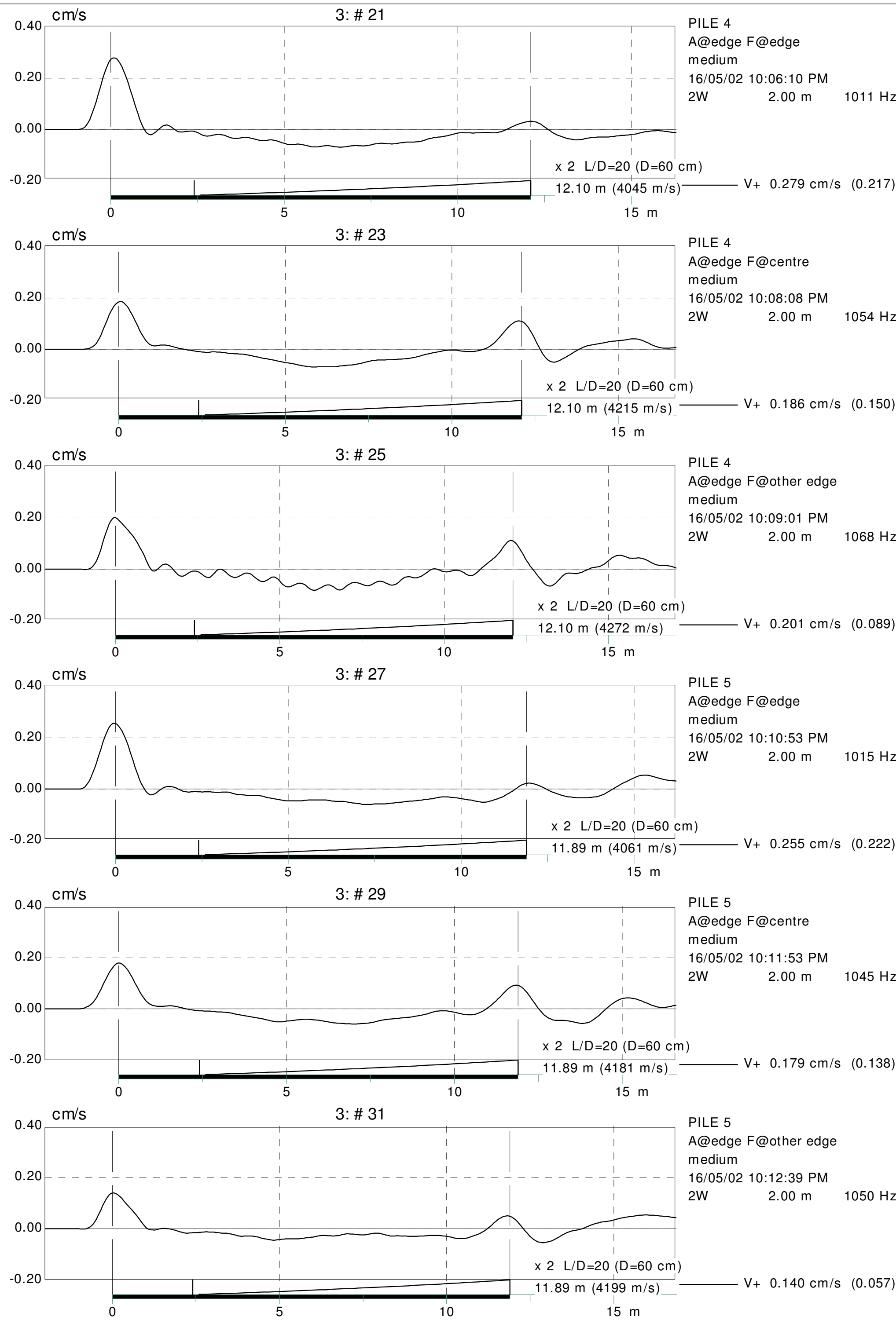

Figure 4: 'Corrected' velocity responses for piles 4 and 5

Although the technique is successful in obtaining a unique response which is location-independent, the 'corrected' velocity response does not seem to indicate the true profile of the pile reliably. As shown in Table 1, there is a defect located at the depth of 10.10 m in pile 4. However, there is no indication of this defect in the corrected velocity responses of pile 4 for all the three locations. Similar phenomenon is also observed in the corrected velocity responses of pile 5 for the location A@edge F@other edge. In pile 5, there is a defect located at a depth of 9.89 m. There is a barely discernible peak identified at a depth of approximately 10 m in the corrected velocity responses for locations A@edge F@edge and A@edge F@centre. However, the peak is not discernible in the corrected velocity response for the location A@edge F@other edge. These results suggest that the orientation of defects within the pile could possibly affect the velocity responses.

Table 2: Correction factor used on velocity responses of piles 4 and 5

Location	**Pile**	
	4	**5**
A@edge F@edge	0.80	0.80
A@edge F@centre	1.10	1.00
A@edge F@other edge	-1.20	-1.47

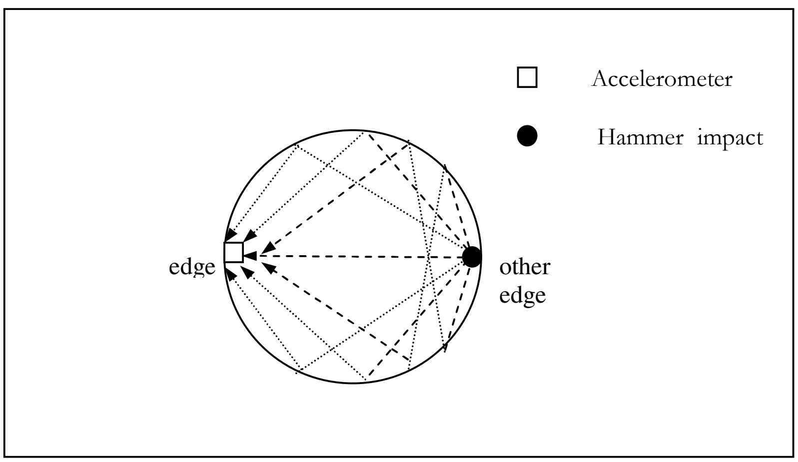

Figure 5: Possible travel paths of Rayleigh waves

3. CONCLUSIONS

Through the implementation of the technique, it was demonstrated that the horizontal velocity could be used to deduce the vertical velocity of Rayleigh waves despite the difference in the amplitude of the 'corrected' horizontal and the vertical velocity in the reflected Rayleigh waves.

A technique was subsequently proposed to enable the elimination of Rayleigh waves effect in a velocity response and hence to obtain a location-independent response. The key aspect of the proposed technique is the simultaneous measurements of the horizontal velocity and the vertical velocity and eliminating Rayleigh waves effect by applying an appropriate correction factor to the horizontal velocity. The technique was applied to the velocity responses of selected piles to assess the validity of the technique.

Through the implementation of the technique, it was demonstrated that the technique is capable of eliminating Rayleigh waves effect in a velocity response, which lead to a location-independent response. The successful application of the technique shows that Rayleigh waves are responsible for the location dependence effect. Although the technique is successful in obtaining a location-independent response, it has a limitation; the ‘corrected’ velocity response does not seem to indicate the true profile of the pile consistently. Future research needs to be carried out to investigate the causes for this occurrence and to improve the correlation of the ‘corrected’ velocity response with the pile profile.

References

Kolsky, H. (1963). Propagation in an extended elastic medium. Stress Waves in Solids. New York, New York Dover, Inc.: pp. 16-24