埋設 RC 管の劣化状態と埋設深度が荷重－変形量の傾きに与える影響評価
Assessment of the Influence of the Deterioration States and Burial Depth of Buried RC Pipes on the Load-Deformation Slope

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1. Introduction

Reinforced concrete pipes (RC) are essential structures for agriculture and sewage etc... However, these vital conduits are susceptible to deterioration from physical stress and aging, compromising their structural integrity. Simultaneously, the surrounding soil, while providing support, exerts varying pressures that influence pipe behavior. Traditional assessment methods, involving costly and disruptive excavations, highlight the urgent need for non-destructive evaluation techniques.

This research addresses these challenges by developing a diagnostic chart for buried RC pipes. We investigate how different deterioration states (original, minor, medium, major) and burial depths (ground, 30 cm, 60 cm) affect the pipe's load-deformation behavior using the Internal Loading Device (ILD). By quantifying the relationship between pipe health, burial depth, and resulting load-deformation behavior, we aim to establish a standardized, reliable assessment method. This standardization ensures consistent evaluations across different locations. The development of such a diagnostic tool is crucial for efficient, in-situ assessments, reducing maintenance costs and minimizing disruptions.

2. Material and Methods

The experimental setup was designed to evaluate the load-deformation behavior of an RC. Pipe under controlled deterioration and burial conditions. An RC pipe Fig.1, with Length 500mm and inner diameter of 250mm and thickness 30mm in JSWAS A-1, and modulus of elasticity 29,866 N/mm^2 taken from previous research[1)], is chosen to represent typical buried pipeline. The pipe's inner surfaces were smoothed to ensure uniform contact with the Internal Loading Device (ILD), and strain gauges were attached to measure axial and bending strains.

To simulate deterioration levels, the pipe was subjected to four distinct states: original, minor, medium, and maximum. Deterioration was induced using a compression testing machine Fig.2, with load magnitudes corresponding to crack load (16.7 kN/m) as a minor state, fracture load (25.6 kN/m) as a medium state, and yield load (36.6 kN/m) as a maximum state. Burial conditions were simulated using a steel model filled with decomposed granite soil, representing different burial depths. The soil was compacted in layers to ensure consistent density, **Fig.3**. An average deformation value calculated at a 2,000 N load to minimize errors. In this report, Original, Minor and Max states are discussed due to space limitations.

Fig.1 Used RC Pipe

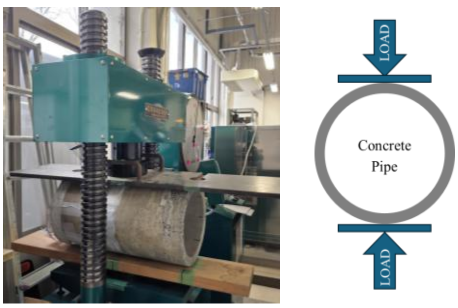

Fig.2 Compression testing machine

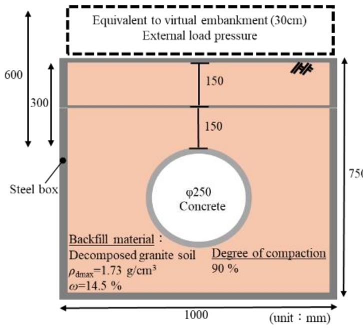

Fig.3 Burial Soil Model

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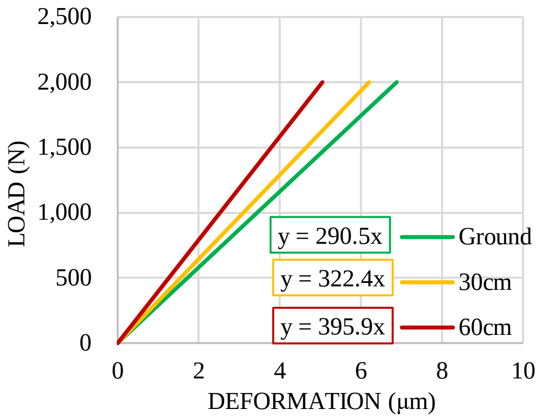

Fig. 4 Original Pipe State

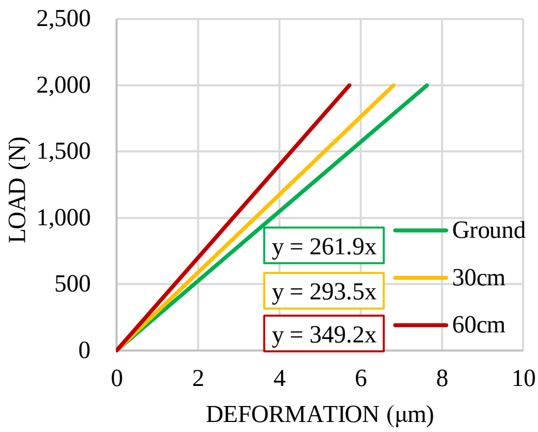

Fig. 5 Minor Deterioration State

3. Results and Discussion

The influence of burial conditions on the Load-Deformation behavior of the RC pipe was analyzed across three deterioration states: original, minor, and maximum. The results, presented in **Fig. 4, 5, and 6**, illustrate the Load-Deformation slopes for each burial condition (ground, 30 cm, and 60 cm) at each deterioration stage.

For the original condition, a significant increase in pipe stiffness was observed with increasing burial depth. Specifically, the slope of the load-deformation slope increased by approximately 11% at 30 cm burial compared to the ground condition, and further increased by 22% at 60 cm burial compared to 30 cm. This indicates that doubling the burial depth nearly doubled the increase in stiffness, though not at a perfectly constant rate.

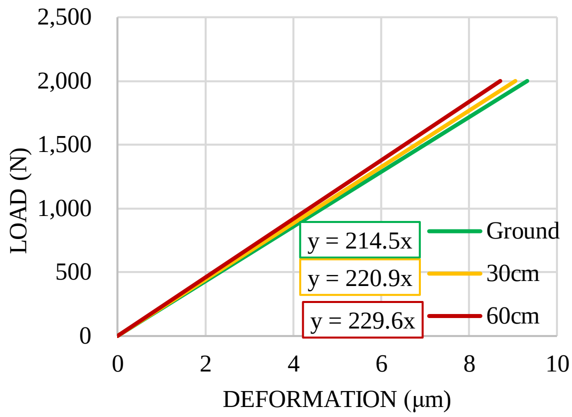

Fig. 6 Max Deterioration State

In the minor deterioration state, the rate of increase in slope is nearly the same in 30cm and became slightly less in 60cm. The slope increased by about 12% in the 1st time, and by 18% in the 2nd time. This suggests that the supporting effect of the surrounding soil was marginally reduced compared to the original condition.

However, in the maximum deterioration state, a clear drop in slope values was observed, and the slope values for ground, 30 cm, and 60 cm burial became relatively similar. The slope increased by only 2.9% at 30 cm burial, and by 3.9% at 60 cm burial compared to 30 cm.

This suggests that the impact of burial depth on stiffness decreased as the pipe suffered greater deterioration; in other words, highly damaged pipes are less affected by surrounding soil support.

4. Conclusion

This study established a correlation between pipe condition, burial depth, and structural stiffness, aiming for the development of a diagnostic chart. for quick, non-destructive pipe health assessments. Our findings indicated that progressive deterioration reduces pipe stiffness, while increased burial depth enhances it. However, the influence of burial depth disappears in severely deteriorated pipes. A key limitation of this study is its focus on a single pipe size and soil type, so structural variation should be considered.

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References:
1) OYAMA Koki, et.al, Behavior of Buried RC Pipe Loaded Locally from Inner Surface, IDRE Journal, 89-1, pp. I_53～I_61,2021