モルタル充填前後における RC 管の荷重—変形量の基礎的評価
Basic Evaluation of Load-Deformation of RC Pipes Before and After Mortar Filling

モスタファ　エルカッサール* 兵頭正浩** 緒方英彦***
MOSTAFA Elkassar※, HYODO Masahiro※※ and OGATA Hidehiko※※※

1. Introduction

The total length of sewer pipes in Japan reached 490,000 km at the end of FY 2021, with 30,000 km exceeding the stipulated 50-year service life. The excess ratio is predicted to rise annually, potentially reaching 18% of the total extension in 10 years and 40% in 20 years[1).
In contrast to Japan's situation, Egypt is currently constructing large-scale national projects, such as the Bahr El-Baqar Wastewater Treatment Plant and the "Future of Egypt" initiative, and projects with daily water capacity of 30,000 cubic meters[2), involving extensive pipelines. Therefore, future rehabilitation and evaluation measures are crucial for long-term sustainability and performance.

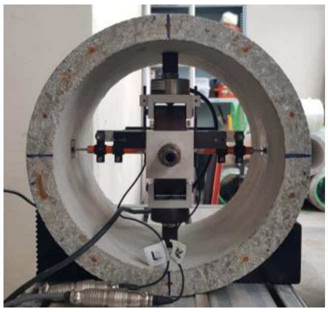
Fig.1 Internal Loading Device

Research and development on pipe rehabilitation techniques is being carried out in Egypt and Japan to repair and reinforce the huge number of sewers and agricultural pipelines. However, pipeline rehabilitation methods are basically constructed on site, with management of the amount of material used during construction and visual checks after implementation. However, this is not sufficient, and a quantitative evaluation method is required. In this study, it is verified whether changes in the proof stress of RC pipes before and after the installation of mortar filling can be evaluated.


Fig.2 Pipe Steel Mold

2. Material and Methods

The internal loading method was employed to assess the effect of adding a mortar layer on the stiffness of a pipe, as shown in **Fig.1**. The test pipe used for the experiment was an RC pipe of type B with an inner diameter of 250 mm and a pipe thickness of 28 mm in JIS A 5372. The length of the pipe is 2430 mm, but the straight section was cut to 200 mm for experimental purposes. noted that the inner surface of the pipe is considered rough to ensure full contact between the pipe and the mortar layer. As shown in **Fig. 2**, a steel mold with an outer diameter of 232 mm was inserted into the RC pipe, and the 9 mm clearance on one side was filled with mortar that is non-separable in water. After the mortar filling, the pipe was wet cured for three days, and the steel mold was removed using a jack with hooks. The rehabilitation pipe produced is shown in **Fig. 3**. It can be seen that the inner surface of the RC pipe is filled with 9 mm of mortar. Loads and deformations were measured using an internal loading device, and the third of three repetitions of data was obtained. Noted that the same RC pipe was used to collect data for both before and after rehabilitation.


Fig.3 Pipe after Rehabilitation

*鳥取大学大学院持続性社会創生科学研究科，Graduate School of Sustainability Science, Tottori University
**鳥取大学農学部，Faculty of Agriculture, Tottori University
***鳥取大学大学院連合農学研究科，The United Graduate School of Agricultural Sciences, Tottori University
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Table 1 Specifications of used pipes.

Pipe Description	Length L (mm)	Pipe thickness, center diameter D (mm)	Pipe thickness. t (mm)	Modulus of elasticity E (N/mm^2)	Ring stiffness. EI/D^3 (kN/m^2)
Original	200	278	28	29,886[3]	2544.6
Rehabilitated	200	269	37	Measuring	Calculating

3. Results and Discussion

The studied RC pipe and its post-rehabilitation properties are shown in **Table 1**. The modulus of elasticity of the RC pipes was taken from previous research[3], as they were obtained from the same manufacturer. The modulus of elasticity of the mortar used as filler is currently unknown and under measurement. The load-deformation relationships before and after mortar filling are shown in **Fig. 4**, the original pipe exhibited a slope of Y = 81.0 (N/µm), while the slope increased to Y = 92.0 (N/µm) after adding the mortar layer. Therefore, the increase in slope observed after adding the mortar layer indicates that the pipe has become stiffer. And it can now withstand a lower deformation for the same load compared to the original pipe; the stiffness is an approximately 13.6% increase.

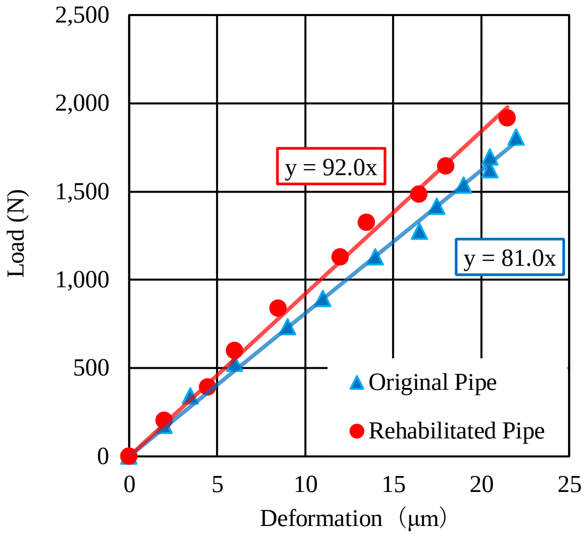

Fig. 4 Load-Deformation Graph (After/Before)

Calculated as $\left(\frac{92.0-81.0}{81.0}\times 100\right)\%$

It's observed that the stiffness increases with pipe thickness, but the modulus of elasticity of filler material remains unknown, making it unclear how 9mm increase contributes to the 13.6% increase in stiffness. Therefore, the study will further clarify and discuss the modulus of elasticity of the in-water, non-separable mortar used.

4. Conclusion

It remains challenging to evaluate the functionality of pipe rehabilitation techniques in the field, despite increasing demand for them. This study aimed to evaluate an RC pipe in terms of load and deformation by comparing the results of the original pipe with the same pipe after applying mortar filler. With the aim of applying the method in the field, the results showed that the slope of load-deformation increased by 13.6% for the specimen pipe after filling with mortar (9 mm thick) (assuming post-rehabilitation).

As a result, the internal loading device proved to be a valuable tool, offering a sustainable and efficient method for evaluating proof stress compared to traditional destructive testing methods. However, the modulus of elasticity of the filler used in this study has not yet been measured, so these values will be clarified in the future, and it will continue to be verified whether the inner surface loading method can adequately assess pipe stiffness after rehabilitation.

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