COMPARISON OF SEISMIC STRENGTH OF COMPOSITE PIPE MATERIALS

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1. INTRODUCTION

Currently, cracks and breakages are likely to occur due to the low toughness of the backfill material of the sewerage rehabilitation method using mortar. Seismic analysis is essential to guarantee the safety against the load during level 1 and level 2 earthquakes of the rehabilitated Hume pipes. It is requisite that the existing pipes, rehabilitation materials and surface members are integrated into the composite pipe to form a composite structure with predetermined seismic performance due to seismic motion. In order to check the seismic resistance strength of the composite pipes of each material, the limit state design method that can evaluate the crack resistance and cross-sectional force of each rehabilitated pipe is used to perform level 1 and level 2 ground motion.

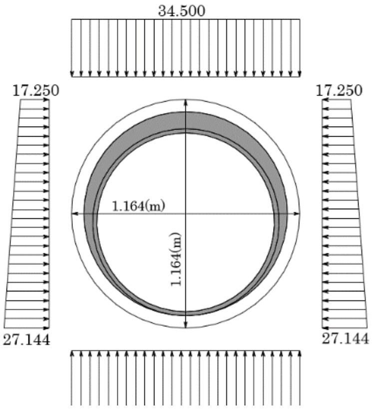

Fig. 1 Distributed load

2. ANALYSIS

2.1 Loading conditions

For seismic analysis, before applying the seismic load of level 1 and level 2 ground motions, the self-weight condition and soil water pressure condition are set, and the dead load and soil water pressure are applied to the peripheral surface of the pipe as distributed load as shown in Fig.1. The ground displacement during an earthquake, which is considered in the seismic design of, is applied to the sewer pipe.

2.2 Characteristics of materials

Table 1 shows the material properties.

Table.1 Characteristics of materials

Characteristics		Elastic modulus (N/mm²)	Compression strength (N/mm²)	Tensile strength (N/mm²)	Poisson's ratio
Existing pipe	Concrete	20000	40	4.00	0.2
Rehabilitation pipe	Mortar	6600	21	1.83	0.2
	SFRC	30000	35	2.46	0.2
	HPFRM	40000	115	6.00	0.2
	Ductal	50000	180	8.80	0.2

3. ANALYSIS RESULTS

3.1 Analysis results of level 1 ground motion

The analysis of level 1 ground motion is to summarize the results under the design load at the usage limit state of the pipe. In the analytical model, after reaching the design level 1 seismic load, the existing pipe produced only small cracks in the right outer part, and the composite rehabilitation pipe have no cracks. It turns out that the design flow capacity is secured against the level 1 seismic motion, judging from the facts that the existing pipe and the composite rehabilitation pipe caused slight deformation and the members failed to yield

3.2 Analysis results of level 2 ground motion

The analysis of level 2 ground motion is to summarize the results under design load, crack occurrence and maximum load at the ultimate state of the pipe. According to the results, it can be safely concluded that a large number of cracks which occur in the three stress concentration locations of the existing pipe after the motion load reaches the level 2. Crack deformation under design load be checked to determine whether the design flow function could against level 2 ground motion.

In addition to the design load, the maximum load on the side cracks of existing pipe and the composite pipe with level 2 ground motion is also considered. The crack deformation diagram of the pipe and the enlarged view of the inner part are shown in Fig. 2 and Fig. 3. Set the design load of level 2 ground motion to 1 and match the ratio of the load when cracks occur, the results are shown in Table 2.

Keywords: Rehabilitated pipe, Seismic resistance, HPFRM, Mortar
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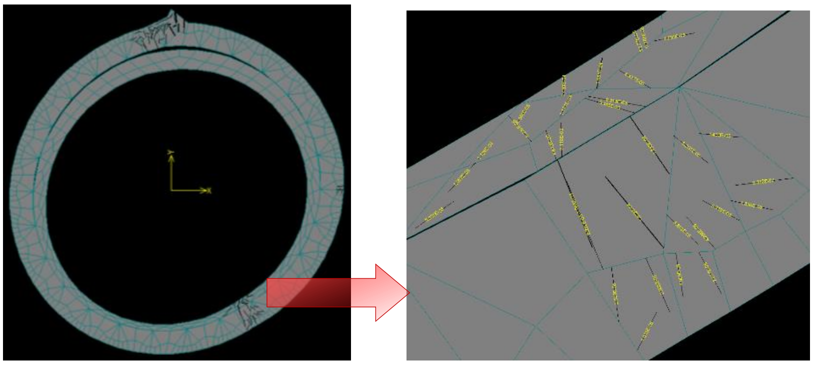

Fig. 2 Mortar rehabilitation pipe crack deformation diagram

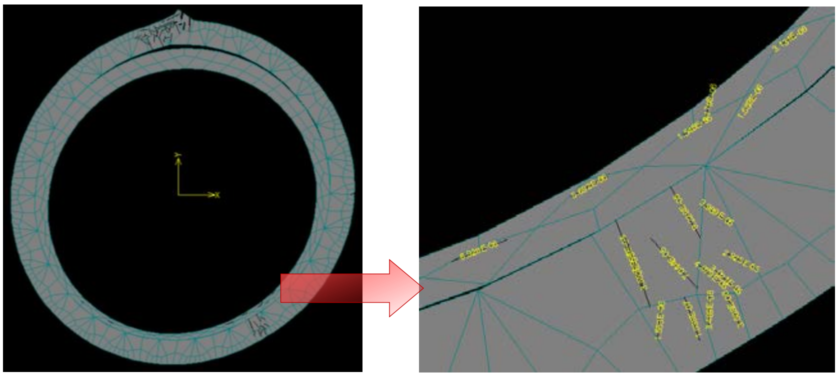

Fig. 3 HPFRM rehabilitation pipe crack deformation diagram

Table 2 Level 2 ground motion analysis results

	Existing pipe	Mortar	SFRC	HPFRM	DUCTAL
Moment at design load (KNm)	-3.909～2.508	-7.521～1.826	-6.979～2.070	-6.276～1.566	-7.642～2.135
Shear force at design load (KN)	-33.090～21.270	-19.500～31.450	-20.410～28.680	-21.970～19.090	-21.760～43.560
Ratio of load to design load when cracks occur inside the pipe	0.900	1.100	1.000	1.100	1.200
Maximum crack width when cracks occur inside the pipe (mm)	0.164	0.146	0.001	0.004	0.001
Ratio of maximum load to design load	1.100	1.200	1.400	1.500	1.600

4. CONCLUSIONS

As for the seismic capacity against level 1 ground motion, the existing pipe alone has sufficient seismic resistance in the usage limit state because there merely exist few cracks. However in level 2 ground motion, the existing pipe is destructed. On the other hand, the reinforcement of the rehabilitation pipe do not reach the usage limit state. However, it is separated from the existing pipe when level 2 seismic motion acts. Moreover, when the material of the rehabilitation pipe is mortar or SFRC, the crack width has reached the rupture state, resulting in insufficient seismic performance. Besides, when it is HPFRM or Ductal, only minute cracks occur even when level 2 ground motion acts. In short, HPFRM and Ductal have sufficient seismic performance.

REFERENCES

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