Investigation of the formulation of the estimation system to improve the efficiency of design and estimation for sewer construction

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Project period: 2002-2005

Objectives

The new estimation system of civil engineering work is a form to improve the transparency, the objectivity, and the adequacy of estimation and contract system of civil engineering work, and to reduce the workload. In sewer construction, the components of the works, the standard of estimation, the common specification, etc. have been formulated, but "Standard of Performance Management", and "Procedure for Surveying Quantities and Form for Totaling Quantities" are not yet formulated.

It is necessary, for improving the efficiency of cost reduction, to reduce the cost of works that occupies large parts of construction expense. For that, it is effective to analyze the ratio of expense of each component, for example, piping work, excavation, materials, labors, etc.

This study is to formulate "Standard of Performance Management for Sewer Construction", and "Procedure for Surveying Quantities and Form for Totaling Quantities for Sewer Construction" as part of this project, and to analyze cost structure of sewer construction based on estimation results.

Results

(1) Proposal of "Standard of Performance Management for Sewer Construction"

As Common Specification for Sewer Construction formerly formulated, the composition of "Standard of Performance Management for Sewer Construction" is based on that of "Common Specification for Civil Engineering, Ministry of Land, Infrastructure and Transport", and formulated as an addition to this standard. However, it is compiled so that it is easy to be used independently. It is composed of four contents, the standard of performance management of schedule, figure, quality, and photo.

(2) Proposal of "Procedure for Surveying Quantities and Form for Totaling Quantities for Sewer Construction"

As "Standard of Performance Management for Sewer Construction", its policy of compilation, contents, etc. is based on "Procedure for Surveying Quantities and Form for Totaling Quantities for Civil Engineering, Ministry of Land, Infrastructure and Transport".

Procedure for Surveying Quantities is composed of four contents, the items of surveying quantities, the division of surveying quantities, unit code, and method of survey of quantity.

Form for Totaling Quantities is composed of files of four "Level 2" components of piping works, that are excavation work, small diameter hole drilling work, hole drilling work, and shielding works. Each level 2 work is composed of standard manhole work, special manhole work, fitting tube work, drainage pit work, ground improvement work, incidental work, and vertical holing work.

(3) Analysis of cost structure in sewer construction

The ratio of each type of piping work in sewer construction is analyzed based on estimation results in 2001.

In piping work by excavation, the expense of "Earth works" occupies the largest part of the whole construction expense, that is 25%. The following are "Protection works from earth collapse", "Precast manhole works", "Restoration works of pavements", "Fitting works of pipes", "Removal Works of pavements", "Foundation works of pipes" and others. The 7 works occupy about 90 %. In piping work by hole drilling, the expense share of "Hole drilling works of small diameter pipes" is about 25%, that is the largest. The following are "Hole drilling works with temporary pipes", "Hole drilling works of small diameter pipes with water", "Protection works from earth collapse" and others. The 4 works occupy about 60 %. Therefore, if the cost of these works is reduced, the cost reduction of piping work in sewer construction will be promoted effectively.

Keywords: the new estimation system of civil engineering work, cost structure, cost reduction

Survey of the Development of Runoff and Inundation Models for Urban Regions

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Project period:2002 - 2005

OBJECTIVE

The Flood Disaster Division's ultimate objective in developing the NILIM model was to release it to the public so that it is effectively used and applied throughout Japan. There is a high probability that the NILIM model will be used for analysis, because inundation analysis of urban regions is essential in order to prepare a map of districts where inundation is predicted in designated urban river basins in particular.

When a model is released to the public, the organization releasing it permits users to assess the model's usefulness by also giving a guarantee of the reliability of the analysis results generally provided by the model. So before a model is released, the model's precision must be verified to confirm the reliability of the analysis results. And users require that when generally similar models already exist, differences between the properties, strong and weak points, and applicable regions of existing models be clarified in advance in order to simplify users' selection of a model.Therefore, the purpose of this survey is to accompany the public release of the NILIM model by an evaluation of the reliability of the analysis results of the model to clarify the properties of the NILIM model based on a comparison with other similar models.

RESULTS

To prepare for the release of the NILIM model, in 2003, an actual river basin and a virtual river basin were analyzed to compare the compatibility of inundation and water level measurement values etc. with a market model, to perform a verification in order to assure their functional reliability. The implementation of a designated urban river inundation damage countermeasure method must be accompanied by the preparation of a map showing districts where urban inundation is predicted in a designated urban river basin, but the analysis model used to do this was chosen by studying the optimum analysis method including market models.

According to a comparison of the quantity discharged inside pipelines and its maximum value in the virtual river basin, although some discrepancies are caused by differences between the calculation procedure of the NILIM model that performs a hydraulic calculation inside the pipeline based on the physical quantities of the water balance and that of the market model that is done using the energy balance based on the hydraulic gradient, generally roughly equivalent results are obtained.

Focusing on the results of inundation analysis (max. inundation depth of the virtual open channel in each mesh), shows that the market model that set a virtual channel on a road in the inundation area obtained deeper results than the NILIM model that set the inundation area in 50m meshes.(Table 1) It is hypothesized that this is a result of differences between the surface areas whose inundation is allowed according to the inundation water, and that as a result, the overtopping water quantity is divided by the allowed inundation area, creating differences when the inundation depth is calculated. This shows that it is extremely important to set the area of the ground surface where inundation is allowed, and that when using the NILIM model, it is necessary to pay close attention to the setting of the surface area where inundation water is removed in addition to the surface roughness, and when using the market model, to the setting of the virtual road width that includes the surface area where inundation is allowed. This survey has shown that in a case where inundation analysis in an urban region is done accounting for sewage pipelines, if full attention is paid to setting the area of the ground surface that is inundated, whether the NILIM model or the market model is used, similar results are obtained with few differences between them.

Table 1 - Results of Analysis of a Virtual River Basin

Analysis model name				NILIM	InfoWorksCS	MOUSE	XP-SWMM
River basin name				Virtual river basin			
Rainfall				Virtual trapezoidal rainfall hydrograph (max. intensity: 200mm/hr)			
Water level condition				Free discharge			
Pump; Yes/No				None			
Pipeline flow volume	Peak volume	Upstream P1	(m^3/sec.)	3.06	4.12	3.95	3.55
		Mid stream P2	(m^3/sec.)	15.30	14.41	16.40	16.53
		Mid stream P2	(m^3/sec.)	61.90	72.12	68.65	68.18
	Total volume	Upstream P1	(m^3)	14,585	13,010	19,190	15,835
		Mid stream P2	(m^3)	84,195	64,821	86,056	82,985
		Downstream P3	(m^3)	376,803	390,325	407,457	389,066
Overtopping volume	30 min. after rainfall starts		(m3)	4,500	3,444	2,284	3,763
	60 min. after rainfall starts		(m3)	79,400	85,130	72,747	72,615
	90 min. after rainfall starts		(m3)	119,000	107,954	80,239	100,338
	120 min. after rainfall starts		(m3)	68,800	25,693	20,552	34,357
	150 min. after rainfall starts		(m3)	29,200	5,201	5,425	9,446
	Max. overtopping (m3) -Time of max. overtopping (after rainfall starts)			117,000	118,290	92,988	105,946
Calculation time			(Minutes)	5.0	0.1	3.5	3.8

Evaluation of earth pressure acting on a buried pipe in renewing sewerage facilities

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Project period: 2001-2004

Objective:

In considering the renewal of sewerage pipes after several tens years from the construction, it is questioned that the earth pressure originally considered based on Marston-Spangler theory may be over-estimated due to the time-dependent behaviour of ground such as earth pressure stabilisation or ground ageing etc. In this study, the long term behaviour of ground around a buried pipe was investigated and the evaluation of time-dependent earth pressure, if any, was aimed at to propose.

Results:

The possible causes for time-dependent behaviour of earth pressure acting on underground structures can be categorised mainly into the following three patterns; a)the ground is subjected to external force, b)due to the deformation of underground structure, the surrounding ground deforms as a result, c)the mechanical properties of the surrounding ground change with time. Mechanism of the interaction between underground structure and the surrounding ground has been investigated by a long-term monitoring of earth pressure around buried pipes and a series of trap-door tests.

1. Long-term monitoring of earth pressures acting on buried pipes

   The strain-gauged pipes (rigid and flexible pipe) were laid in the model sand ground in a soil chamber. During burying, earth pressure acting on the flexible pipe noticeably decreased due to the development of ground arching, after which there was no systematical change for more than one year observation period.

2. Disturbance of ground arching

   Small ups and downs of the moving pedestal were given after stable ground arching was developed in the model ground in trap door testing. The pressure increased and decreased depending on the movement of pedestal. Small cyclic loads applied on the ground surface did not affect the ground arching.

Lightly cemented sand was also used for the model ground in the long-term monitoring of pipe to evaluate the effects of ageing (cementation) of the ground on the earth pressure changes. As the cementation developed, the cemented ground behaved in one body and some large pressure (more than the overburden pressure) probably due to the change of temperature was observed. But those changes appeared to be reversible. There seemed to be no serious disturbance occurred in the ground around a pipe once the cementation had developed.

Conclusions:

In the case of uncemented ground, the earth pressure acting on a buried pipe may change as a result of arching action due to the deformation of the pipe. Once the stress distribution in the ground was stabilised, noticeable pressure change was not observed. The ground arching was not disturbed easily by the load on the ground but the deformation of pipe changed the state of stress in the ground, implying that the breakage of the old underground pipe may cause possible failure of surrounding ground. Cemented material showed more stabilised behaviour.

Application of New Materials for Sewage Treatment Facilities

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Project Period: 2001-2004

Research objective

In order to manage sewage system efficiently, it is desired to develop more effective corrosion protection system for sewage with innovative durable materials. In this study, we have worked on seeking such materials applicable to sewage facilities, investigating the durability of them and developing the repair technique with them.

In the 2003 fiscal year, the repairing materials for sewage treatment facilities such as "acid resistant mortars", "resin linings", "FRP linings" and "titanium linings" were investigated. The main part of this study has been carried out by a collaboration of 11 private companies, and a public-service corporation and PWRI.

Results

1) We proposed the "sulfuric acid dropping test" in order to examine the corrosion behavior of acid resistant mortars in sewage environment. Corrosion characteristics of acid resistant mortars were summarized through this method. It was also confirmed that corrosion depth of acid resistant mortars was smaller than normal mortars. In addition, the relation between the concentration of sulfuric acid and corrosion rate of mortars was found out.

2) We carried out some experiments on adhesive quality of resin linings in order to improve the evaluation method for blistering performance of those materials. From these results, it was shown that the peeling adhesion test was a better method to evaluate blistering on resin linings than pull-off adhesion test (the method of Building Research Institute).

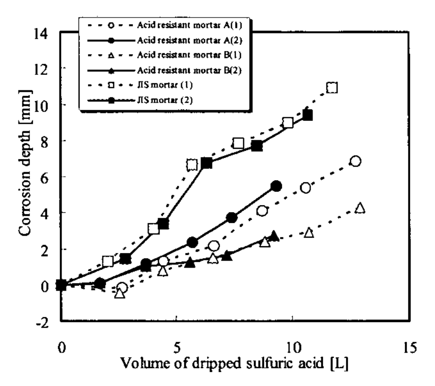
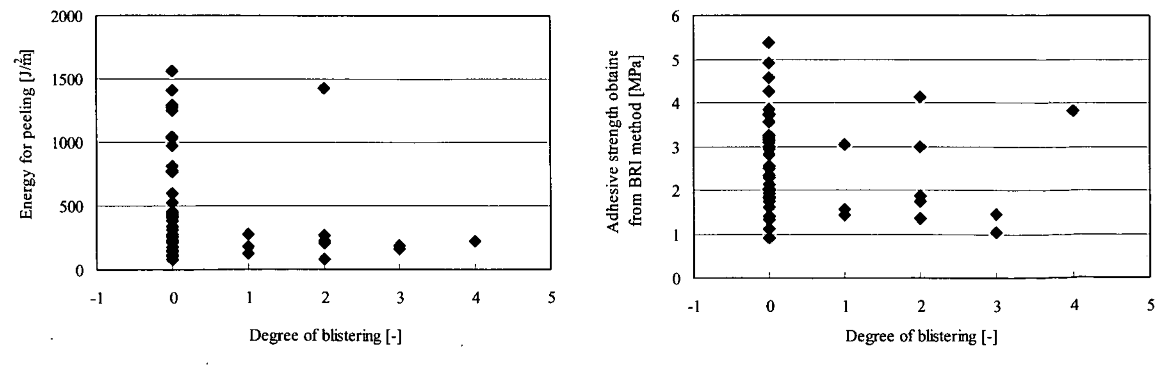


Fig.1 Relation between corrosion depth of mortars and volume of dripped sulfuric acid. (pH0, 40 degree C)



(a) (b)

Fig. 2 Comparison between the experimental results obtained from (a) the peeling adhesion test and (b) the pull-off adhesion test.

DEFORMATION-BASED DESIGN METHOD OF COUNTERMEASURES AGAINST LIQUEFACTION FOR SEWAGE FACILITIES

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Project period : FY 2002-2005

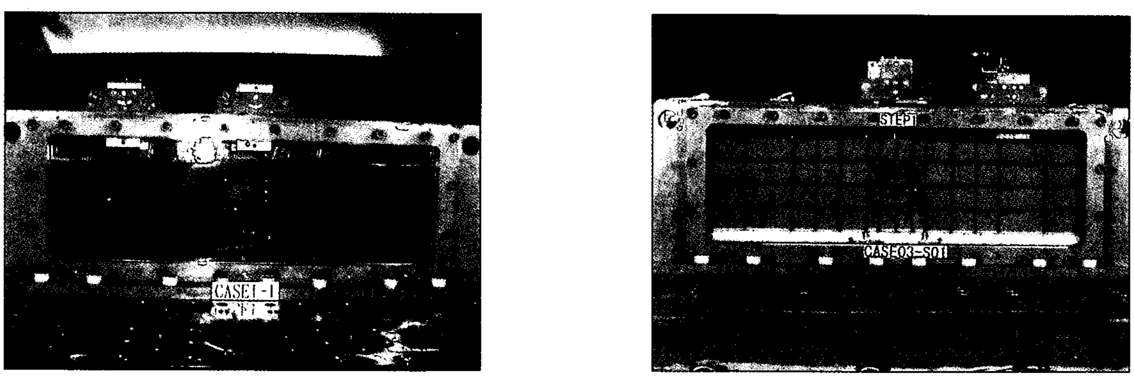
OBJECTIVE

Seismic damage of sewage facilities has been often caused by soil liquefaction. Many sewage pipes and manholes have been uplifted and damaged by buoyant force due to liquefaction. Development of countermeasures to mitigate such damage is required. In the research project, a series of dynamic centrifuge model tests of sewage pipes with and without a countermeasure using sheet piles was performed to reveal seismic behavior of sewage pipes and propose a deformation-based design method of countermeasures.

RESULTS

Figure 1 shows the deformations of the centrifuge models without and with sheet piles after shaking. It is clear that the countermeasure by sheet piles is effective to reduce uplift displacement of underground structure due to liquefaction.

The observed uplift displacements were caused by sheet pile bending and liquefied sand movement. We proposed a beam model to estimate the deflection of sheet piles, as illustrated in Figure 2 and a prediction method of uplift displacement due to liquefied sand movement. Figure 3 shows that the predicted uplift displacements by the proposed model agree quite well with the observations.



a) Without countermeasure b) With countermeasure

Fig. 1 Deformation after shaking

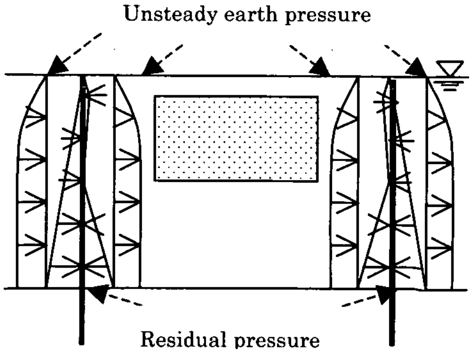


Fig.2 Model for design of sheet piles

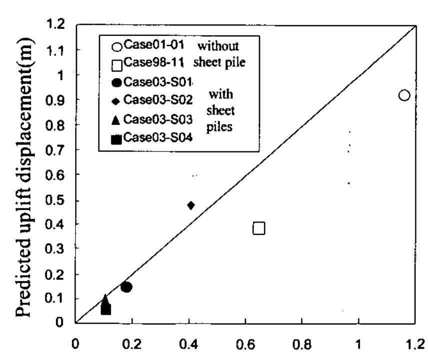


Fig.3 Predicted and observed uplift displacements