THE INVESTIGATION OF SYSTEMATIZATION FOR PERFORMING MORE EFFICIENT DESIGN AND COST ESTIMATION IN SEWER CONSTRUCTIONS

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Project period: 2002-2004

OBJECTIVES

The civil engineering project estimation system has been formulated for systematizing the method, and the volumes on contract and cost estimation, in order to enhance the accountability and define the contents of the contract conditions of public works, and to perform more efficient estimation. In sewer projects, the parts which compose a construction structure has been systematized, which forms the core of the civil engineering project system, and the standard of cost estimation, the commom specification, and the definiens of the terms etc. have been formulated. But the standard of construction supervision, and the manual and the format for quantity survey are not formulated yet.

In order efficiently to reduce construction cost, it is necessary to keep promoting cost reduction of component parts that the ratio which construction expense occupies is large, preponderantly, and therfore it is effective to analyze the cost constitution ratio of each component parts and machines, labors, and materials, etc.

This investigation is, as a part of these systematizations for sewer public works, to formulate the standard of construction supervision, and the manual and the format for quantity survey, and to analyze cost constitution on the basis of the data of cost estimation results.

RESULTS

(1)The way to formulate the standard of construction supervision for sewer public works

As the common specificaton formulated previously, the composition of this standard is based on the standard for civil engineering, Minstry of Land, Infrastructure and Transport(MLIT standard), and formulated as an addition to MLIT standard. In addition, this standard concerning sewer public works is published in a separate volume to be able to be used independently. This content consists of the description on supervision of process, measure of figure and quality of constructions, and supervision by photo.

(2) The way to formulate the manual and the format for quantity survey for sewer public works

As the standard of construction supervision, the composition etc. is based on the standard for civil engineering of Minstry of Land, Infrastructure and Transport.

Pipe works are generally divided into 4 work units, excavation, small-diameter hole drilling, hole drilling, and shielding, that are located at level 4 at the systematized parts. Each unit consists of standard manhole, special manhole, fitting pipe, drainage pit, soil improvement, and vertical holing etc. Therefore, we will make the 4 files in this standard.

(3)The way to analyze cost consutitution of sewer public works

It is necessary, for analyzing construction cost of sewer public works, to divide the cost of each construction structure into the cost of some composed parts, machines, labors, and materials, and to define systematically what kind of cost each part's

cost for estimating is composed of. The standard of cost estimation for sewer public works was systematized at 2001. Therefore, it is the fist step to analyze the data of cost estimation results at 2001, to investigate how the cost ratio of the each component at level 4 is, and how the cost ratio of the machine, labor, and materials of the each component is.

SURVEY OF THE DEVELOPMENT OF RUNOFF AND INUNDATION MODELS FOR URBAN REGIONS

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Project period: 2002–2005

OBJECTIVES

It is becoming increasingly important to implement countermeasures that link rivers and sewerage systems in drainage basins to promote effective inundation protection measures in urban regions. Inundation simulation models that account for sewerage systems and other inner waters are needed in order to provide more realistic predictions of inundation phenomena in drainage basins.

This survey is a study of an inner water simulation model of a sewerage system that should be incorporated in existing inundation simulation models in order to simulate inundation throughout drainage basins , and at the same time, to develop a model (NILIM: New Integrated Low-land Inundation Model) that can more precisely represent the effectiveness of urban rain countermeasures by improving the prototype urban runoff and inundation model (PWRI model) that has already been developed so that it will more accurately clarify the effectiveness of facilities built to control rainfall, drainage, and runoff.

RESULTS

Analysis results were compared with the water level in trunk pipelines measured in 2001 and with past inundations in the actual city shown in the left of Figure 1 where urbanization has advanced and where a natural flow type combined wastewater system has been provided. Figure 2 shows a hydrograph and height graph and analysis results for a point at almost the center of the drainage basin. Unusually good results were obtained for the start-up and peak values, verifying the model's ability to reliably track the water level inside sewerage pipes.

Figure 1. Actual drainage basin analyzed
Left: Actual inundation Areas
Right: Analytical results

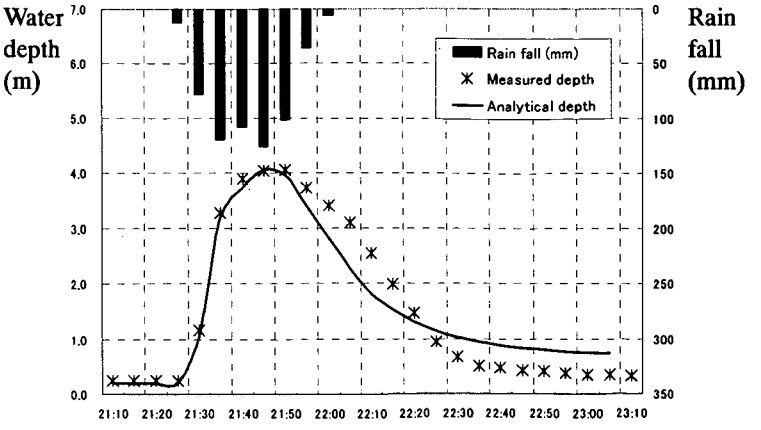

Figure 2. Hydrograph and Height Graph at the Center Point of the Basin

The right side of Figure 1 shows the results of an analysis accounting for surface inundation. The inundation of the land near the downstream end shown in the bottom of the figure covers an area that is a little larger than the actual inundation. Considering that it is possible that this occurred because inundation of approximately 0.2m to 0.3m is not recorded, it can be concluded that relatively good results were obtained. In the upper and middle parts of the basin, inundation areas that differ from actual inundation appear. It is suspected that this occurred because the analysis was done uniformly using data obtained by rain gauges installed on the downstream side, and this data are larger than actual rainfall in the upstream area.

In the future, models for more drainage basins must be verified to study the impact of input, geographical features, and other conditions on the effectiveness of the models and differences in their characteristics to improve their reliability.

STUDY ON RATIONAL METHODS OF EVALUATING AND SELECTING SEWAGE PIPE CONSTRUCTION METHODS

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Project period: 2000-2002

OBJECTIVES

Methods of constructing sewerage pipes can be broadly categorized as cut and cover methods, drilling methods, and shield methods, but recent technological development has provided new technologies that contribute to cost reduction and environmental conservation. These include drilling methods that can perform long distance drilling and can be applied under various ground conditions, and fast and safe cut and cover methods featuring lightweight temporary structure materials and pipe material and backfill using fluidized soil, and so forth. And it is now important to consider the noise, vibration, traffic congestion caused by work on street, disposing of by-products of construction, and other impacts of pipeline work on the surrounding environment. And in addition to laying new pipes etc., pipe maintenance and replacement technologies have become important issues as the existing stock has deteriorated. For these reasons, when sewerage pipe construction methods are selected in the future, the candidate methods must be comprehensively evaluated by accounting not only for the construction cost and other initial costs, but also for external costs such as the impact of the work on the surrounding environment and maintenance costs that account for future repair and reconstruction of the pipe.

This study was carried out to propose a rational method of selecting a sewerage pipe construction method that encompasses the external cost and the life cycle cost of each method.

RESULTS

This year, a case study of external cost items and their impacts was carried out focusing on sewerage work on an existing road. The impacts of maintenance and repair work on life cycle costs were studied by performing an analysis of the present state of pipe maintenance accompanied by a trial calculation of life cycle costs.

(1) Study of external costs of sewerage pipe work

The impact on the external environment of sewerage pipe work on an existing road was trial calculated by selecting traffic congestion caused by the work—a factor that has a high degree of impact when converted to cost and which is relatively easy to measure and predict—as the external cost factor.

The trial calculation assumed that the work was done on a two-lane road with traffic closed on one lane as automobiles traveled on the other lane alternately in two directions. The trial calculation obtained the following results.

- As the traffic volume increases, the external cost of traffic congestion rises sharply.
- The external cost varies widely according to the length of road that is closed and the closure method (signal light pattern alternating traffic flow direction etc.).
- The impact on traffic congestion also increases under the effects of the width of the road's traffic lanes and its shoulders and of roadside conditions.
- It is possible to greatly lower external cost by simple improvements such as narrowing the width of the road closed,

delaying the start of closure, etc.

(2) Life cycle cost study

Trial calculations were performed to study differences in the life cycle cost resulting from differences in the pipe selected at the design stage and in the maintenance and repair planning. The design working life was set as 100 years with reference to the state of existing sewerage pipes and design standards for various kinds of structures. The maintenance cost was set according to the age of pipes based on the results of a survey of the way that maintenance is done. The following are four trial calculation cases.

Case 1: The design working life is satisfied by repeatedly carrying out minor repairs before the strength properties of the pipe begin to decline.

Case 2: The design working life is satisfied by performing a major repair when the strength properties of the pipe have declined over a period of years and have approached the lower limit values of its required performance.

Case 3: The design working life is satisfied by reconstructing the pipe to improve its durability when the strength properties of the pipe have declined over a period of years and have approached the lower limit values of its required performance.

Case 4: Case where the frequency of repair work was reduced by laying pipe with improved durability.

There are only small differences between the results of the trial calculations for all cases 50 years after construction, but a comparison of life cycle costs over a period of 100 years revealed that results were more economical in two cases: repeated small repairs before maintenance costs rise (case 1) and laying high performance pipe despite its higher initial cost (case 4).

In the future, we must set rational repair standards for sewerage pipes, establish degree of damage evaluation methods, and clarify changes in the performance of pipes under varying conditions to establish rational and economical construction method selection method.

DEVELOPMENT OF PRACTICAL TECHNOLOGY RELATED TO NEW MATERIALS FOR SEWERAGE TREATMENT FACILITIES

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Project period: 2001–2003

OBJECTIVES

In order to efficiently construct sewerage systems, their corrosion resistance performance must be enhanced by improving the reinforced concrete that has been used in the past. It is expected that technologies that permit the use of new materials with superior corrosion resistance in sewerage systems will be developed. This paper describes the search for new materials of this kind and a survey of their corrosion resistance and applicability in sewerage systems and reports on improvements and new technology development performed to permit their use as corrosion proof materials in sewerage systems. In recent years, the corrosion resistance of newly constructed structures has been improved by the provision of corrosion resistance guidelines for sewerage system structures. And because the sewerage system penetration rate reached 62% by 2000, the importance of maintenance of existing structures is growing. The object of the research is materials used to repair concrete in sewerage systems.

A joint research project with 12 private companies capable of developing materials and repair technologies that satisfy the required performance levels began in 2002 in order to conduct research in this area more efficiently. In 2002, the following three technological items related to sewerage treatment system repair materials were studied to establish the required performance and methods of evaluating their performance. Preliminary tests related to part of this research have been done.

(1) Applicability of acid resistant mortar

(2) Improving the reliability of coating type lining materials

(3) Developing new sheet lining materials

RESULTS

(1) Applicability of acid resistant mortar

The use of acid resistant mortar as section repair material can control deterioration of coating type lining materials caused by pin holes. And in relatively gentle corrosion environments, it can be used without a coating. This means that the acid resistance of acid-resistant mortar must be appropriately evaluated, but a problem with testing by soaking it in a sulfuric acid solution as has been done in the past was that environmental conditions were actually far different. A sulfuric acid dripping method has been proposed as a test method that mimics the sulfuric acid formed on walls by microorganisms. The results of the preliminary test have revealed that this test method can be applied as an acid resistance evaluation method: for example, it can measure the depth of corrosion by sulfuric acid.

(2) Improving the reliability of coating type lining materials

A conventional coating type lining material is susceptible to swelling caused by inadequate bonding with the concrete, but this can be mitigated by improving the primer, etc. Because it was difficult to evaluate such bonding with the BRI (Building Research Institute) bonding test used in the past, the applicability of the peeling method as a new evaluation

method will be studied to improve its correlation with its swelling control performance.

(3) Developing new sheet lining materials

There are two problems with conventional sheet lining materials: they are relatively expensive and difficult to install. Therefore, these materials will be improved to develop new sheet lining materials. Work began on the development of [1] sheet lining material made of FRP drawn formed material and [2] sheet lining materials made of titanium plates (film) and detailed studies of execution methods and connection methods etc. were carried out.

EVALUATION OF EARTH PRESSURE ACTING ON A BURIED PIPE IN RENEWING SEWERAGE FACILITIES

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Project period: 2001-2004

OBJECTIVES

In considering the renewal of sewerage pipes after several tens years from the construction, it is questioned that the earth pressure originally calculated 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 are investigated and the evaluation of time-dependent earth pressure, if any, is 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. From 2001, the mechanism of the interaction between underground structure and the surrounding ground (pattern b) has been investigated by a long-term monitoring of earth pressure around buried pipes and a series of trap-door tests. In 2002, those experiments were performed in more precise and detailed manner. In addition, patterns a) and c) were also considered in the monitoring and the trap door testing.

[1. Long-term monitoring of earth pressures acting on buried pipes] The strain-gauged pipes were laid in the model sand ground in a soil chamber. The earth pressures in the surrounding ground and the deformation of the pipes were measured during and after laying. The measured earth pressure on the flexible pipe was significantly smaller (nearly equal zero) than the overburden pressure due to the small deformation of the pipe. Noticeable change was not observed both in the earth pressures and pipe deformation for one year. Lightly cemented sand was then used for the model ground and the similar monitoring is currently being continued to evaluate the effects of ageing (cementation) of the ground on the earth pressure changes.

[2. The observation of ground arching by trap-door testing] A series of trap-door tests was carried out on Toyoura sand to investigate the rate effects of moving pedestal. The pressure acting on the moving pedestal dropped rapidly with displacement and stabilised at about 20% of the initial value. It was found that the pressure-displacement relationship was not strongly affected by the displacement rate but when the displacement rate was temporarily changed by up to 100 times the pressure changed by several percent. Test results on clayey sand showed that the drop of pressure in the overall pressure-displacement curve was less steep but the temporal change of pressure was more sensitive to the rate change.

[3. 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. The degree of disturbance was less significant in the case of clayey sand.