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1. Introduction

The objective of this study is to appraise construction works based on the technical and engineering difficulty. It is important in tendering to select a contractor having the required ability in construction works from the view point of quality construction. The aim is that the evaluated performance of a contractor will correspond to the technical characteristics of construction works. In this paper some results are described to develop measuring and analytical methods for technical and engineering difficulty, which is an important characteristics of construction works.

2. Technical difficulty of construction works

The technical and engineering ability required to attain quality construction depends on the characteristics of a construction work, such as size of contract and others. In this paper technical difficulty is defined as another characteristic of construction works beside a size of contract. We have tried to measure the technical difficulty of construction works by means of questionnaire survey on experienced engineers.

3. Outline of questionnaire survey

The perception of technical difficulty of a construction work varies across different experienced engineers. It was, however, expected that a general rule to perceive technical difficulty might be found by a statistical approach. A questionnaire survey was made on about 90 inhouse engineers, who are responsible to supervise and inspect construction works. A framework of technical difficulty and factors of construction conditions affecting the technical difficulty were proposed as shown in Fig.1 and Table 1 respectively. The perception of technical difficulty and construction conditions affecting technical difficulty in about 10 contracts were ranked by engineers, which resulted in about 900 samples.

The ranks of technical difficulty		typical examples	the structure of technical difficulty
IV	very difficult	new or specialized technology introduced	
III	difficult	required high design skill or better technique	
II	average	few design changes	
I	easy	no problem	
			$\boxed{\text{technical difficulty}} = A + B$ <p>A : technical difficulty based on types of construction work</p> <p>B : technical difficulty based on construction condition</p>

Fig.1 Framework of technical difficulty proposed in questionnaire survey

Keywords; construction works, technical difficulty, questionnaire survey, quantification theory

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Table 1 Construction conditions

Categories	Factors
1. structural	- scale, geometry, etc
2. technical	- construction method, etc
3. natural	- underground water, climate, etc
4. social	- neighboring construction, environmental conditions, etc
5. management	- schedule control, quality control, safety control, others, etc

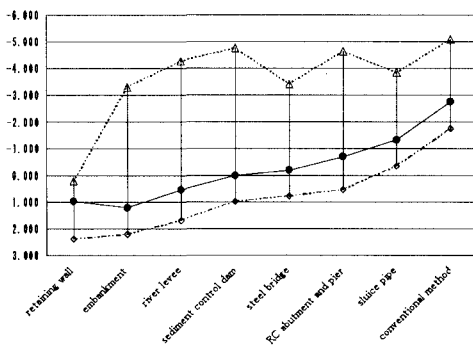


Fig.3 Score of technical difficulty among type of construction works

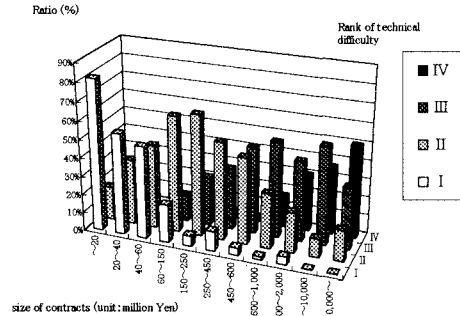


Fig.2 Ratio of each rank of technical difficulty in each size of construction works

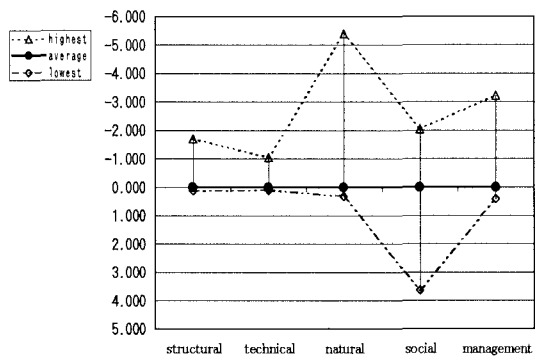


Fig.4 Score of technical difficulty among type of construction conditions

4. Analytical results and discussions

The ratio of each rank of technical difficulty in each size of contract is shown in Fig.2. High rank of technical difficulty is found with large sized contracts. Various ranks of technical difficulty are also observed in each size of contract.

The mechanism to perceive technical difficulty was analyzed by applying quantification theory. Average scores of technical difficulty in each type of construction work was computed by discriminate analysis on ranks of technical difficulty from I to IV. And gaps between the average score and score of each contract are analyzed by construction conditions of each work. Examples of results in representative types of construction works are shown in Fig.3 and Fig.4.

It is found that there are differences of scores of technical difficulty among types of construction works. It is also clarified that construction conditions affect scores of technical difficulty more than types of construction works.

5. Concluding remarks

The technical difficulty of construction works was measured based on the perception of site engineers. It is found that the technical difficulty can be appraised using factors on construction conditions as well as types of construction works. It is important to integrate more data on perception of technical difficulty in practical works and to proceed towards structural analysis for establishing an appraisal system.