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A new methodology for evaluating a new construction technology from the viewpoint of constructability

東京大学　学正員　申鉉穣
東京大学　正員　渡邊法美
東京大学　正員　國島正彦

1. Introduction

Many construction technologies have been developed in Japan to overcome the chronic labor shortage problem, improve the competitiveness of the Japan construction industry, and make public investment efficiently. In order to meet these social demands a new construction technology is desirable, however, it has been considered so far that it is difficult to evaluate a technology itself on public acceptance basis.

The purpose of this paper is to present a methodology to evaluate a new construction technology from the viewpoint of constructability with a shorter time, less manpower, and more objectivity.

In this paper, a technology is defined as the means and knowledge used to accomplish a desired aim necessary for human sustenance and comfort. Accordingly, construction technologies also have special aims which are to obtain better constructability during construction and to obtain better serviceability during service. Constructability in this paper is defined as its capability to optimize resources such as manpower, time, quality, environmental condition of labor and neighborhood during construction.

2. Decomposition of the constructability

Since the constructability includes many aspects, it is decomposed into a hierarchy with three levels: components, elements,and attributes. The hierarchy is shown in Table 1.

3. A methodology for evaluating a new technology

The main problems here are how the individual attributes at the lowest level of the hierarchy are rated and how strongly these individual attribute influence the constructability at the highest level of the hierarchy. Since this influence will not be uniform over all components, elements, and attributes, it is necessary to express the level of them by determining weighting factors. This section shows a rating technique of each attribute and a general equation for the total evaluation points associated with a new technology.

Table 1: A hierarchy of the constructability

No	COMP.	ELEMENT	ATTRIBUTE
1	Save manpower	1. Decrease workers	1. Number of workers
		2. Lower level of skill	1. Req. level of skill
		3. Improve working motivation & conditions	1. Future promise of occupation 2. Wages 3. Work value 4. Working speed 5. Heaviness 6. Learning time 7. Frequency of maintenance work 8. Maintainability 9. Working height
2	Save time	1. Decrease task's time	1. Learning time 2. Adverse weather 3. Accessibility
		2. Decrease failure time	1. Reliability 2. Frequency of maintenance work 3. Sudden breakdown
		3. Omit work tasks	1. Standardizability 2. Modularizability 3. Simplicity
		4. Decrease risk	1.Operation falseness 2. Slow-down 3. Material shortage 4.Natural calamity
3	Save resources	1. Save material	1. Req. material
		2. Save equipment	1. Required equipment
		3. Equip more functions	1. Applicability
		4. Save land	1. Required land
		5. Lower technical cost	1. Required technical cost
4	Obtain better working environments	1. Reduce danger	1. Heaviness 2. Communication 3. Noise 4. Working area 5. Working height 6. Arresting device 7. Slip

No	COMP.	ELEMENT	ATTRIBUTE
		2. Alleviate hardship	1. Heaviness 2. Boredom 3. Noise 4. Working area 5. Working speed 6. Frequency of maintenance work 7. Maintainability
		3. Reduce dirt	1. Closed or opened 2. Waste gas 3. Oil based or electric 4. Directly touch or not
5	**Obtain better quality**	1. Get better durability	1. Simplicity 2. Standardization 3. Modularizability 4. Accessibility 5. Adverse weather 6. Reliability 7.Learning time
6	**Do not damage neighboring environment**	1. Do not damage neighboring environment	1. Noise 2. Vibrations 3. Waste gas 4. Number of workers required
		2. Not to occur hazardous happening	1. Arresting device 2. Heaviness

Construction technologies are extremely complex and various. Therefore, the concept of the standard technology is introduced. This aims to clarify the nature and evaluate the worth of a new construction technology, by comparing it with the standard technology.

Then, a procedure of rating is described as follows:
1. Select the standard technology.
2. Give 3 as rating values to all attributes of the standard technology.
3. Compare the new construction technology with the standard technology and rate the new construction technology on all attributes.

The rating scale is shown as follows.

5: much better
4: better
3: same
2: worse
1: much worse

The next concern is how to obtain the total evaluation points of both technologies. The equations give total points of both technologies.

$$R_0 = 3$$

$$R = \sum_{i=1}^{n} \sum_{j=1}^{n_i} \sum_{k=1}^{n_{ij}} W_i W_{ij} W_{ijk} r_{ijk}$$

Where:
- R_0: total evaluation points of the standard technology; R_0=3
- R: total evaluation point of the new technology
- r: rating point of a attribute
- i: index for components
- j: index for elements
- k: index for attributes
- W_{ijk}: weighting factor for the k^{th} attribute of the j^{th} element of the i^{th} component
- W_{ij}: weighting factor for the j^{th} element of the i^{th} component
- W_i: weighting factor for the i^{th} component
- n: the number of components
- n_i: the number of elements in the i^{th} component
- n_{ij}: the number of attributes in the j^{th} element of i^{th} component

The effectiveness of the new technology can be judged based on the value difference between R and R_0. It should be noted that R_0 is always 3 irrespective of the weighting factors.

4. Conclusions

A methodology for a evaluating a new construction technology from the viewpoint of its constructability has been proposed. The applicability of the methodology has been examined in the case study concerned with concrete technology. It will be necessary to express the attributes and/or the constructability index in monetary terms to incorporate the methodology into Cost and Benefit analysis.

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