

MAINTENANCE PERFORMANCE EVALUATION OF THE BUILDINGS IN THE DESIGN PHASE

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ABSTRACT: As the importance of building maintenance is being emphasized, studies regarding the efficient building maintenance focus on the evaluation of the maintenance plan, implementation and its cost only while the evaluation of the maintenance performance is nearly ignored. At this point when the importance is placed on the performance design we need to have methods to improve maintenance performance of the buildings in Design Phase.

The purpose of this study was to set the design evaluation items to improve the maintenance performance of the buildings. Through the review of the existing literature, we set the concept of the maintenance performance and suggested evaluation items to evaluate the maintenance performance through the analysis of domestic and overseas certification and design guidelines.

Key words : Maintenance Performance, Evaluation Items, Design Evaluation

1. INTRODUCTION

1.1 Background and Purpose of the Study

Since the studies of POE (Post-Occupancy Evaluation) on government driven public construction projects were started in 1960s, the studies regarding the building performance evaluation have been gradually activated. As the importance of the building maintenance emerged, many studies regarding maintenance performance have been performed. However, existing studies have emphasized the plan, implementation and cost only and have not paid enough attention to the easiness of the building maintenance. At this point when more importance is placed on performance design including the legislation of acts regarding the building performance¹⁾ the design that can secure high maintenance performance and its evaluation is required.

Accordingly, we tried to set the concept of maintenance performance as a basic study to evaluate the building maintenance performance in design phase, and to propose the evaluation items of the maintenance performance.

1.2 Scope and Methods of the Study

The evaluation of building maintenance performance has been done emphasizing the plan, implementation and cost of the maintenance. This study was to propose the items to evaluate the maintenance performance in the design phase that influence maintenance after the completion of the building.

This study was performed using the following methods.

(1) Establish the concept of the maintenance performance in the design phase through literatures review

(2) Analyze the performance design method of existing design standards, guidelines and evaluation items of domestic and overseas certifications and literature

(3) Propose the items which can evaluate the maintenance performance in the design phase based on the concept of maintenance performance

2. THEORETICAL REVIEW

The maintenance performance in design phase²⁾ means the performance of the design required to improve the maintenance of the buildings.

2.1 Analysis of Previous Studies

(1) Evaluation Related

We investigated the evaluation items for the building maintenance that existing domestic and overseas certifications and literatures proposed as a basic study to set the maintenance performance evaluation items.

The 'Green Building Rating System' integrating the existing environmental certification systems³⁾ evaluate 'Systematic construction site control', 'Efficient building management', 'Facilitation of system change' in the maintenance field among the 9 evaluation fields such as land use and indoor environments. The 'Prefabricated House Performance Certification (Ministry of Construction and Transportation, 1992)' classifies the performance of the

house as safety, housing and durability and evaluates the maintenance performance in sub criteria under durability. The 'Intelligence Building (IB) Certification⁴⁾' deal with 'Preparation of maintenance space for facilities' in general construction items of 'Construction Environments and Facilities' field. Article 21.2.1.3 of Housing Act (Apartment Housing Performance Indication System⁵⁾) specify the 'structure related grade such as changeability and repair easiness for remodeling'. GBTool⁶⁾ which evaluate 7 fields such as 'Resource Consumption' and 'Environmental Load' of aggregated houses, office buildings and schools deal with maintenance related items in 'Facility Level' field. In Environment Friendly House(Japan)⁷⁾ which consists of 'Requirements' and 'Proposal Types' there are evaluation items such as 'Durability' and 'Employment of Change Response'. In 'House Performance Indication System (Japan)⁸⁾ 'Maintenance easiness of facilities for plumbing pipes and gas pipes' among the nine evaluation items such as structure and fire safety (among 28 sub-items) is evaluated. Additionally, In 'A Basic Study on the Performance Indicator criteria for Remodeling and Maintenance Management of Multi-family Housing (Seok-ho Lim's, 2004)' and 'A Study on Extracting Process of the Evaluation Indices of Building Sustainability (Gang-hee Lee's, 2002)' maintenance related performance evaluation items are proposed. Table 1 shows the major contents of maintenance performance related evaluation items proposed in Domestic and Overseas Certifications and Literatures.

2) Performance Design Method

To investigate design methods to improve maintenance performance, design standards and guidelines in domestic and overseas literature were analyzed.

In 'A Study on Institutional Foundation to activate Building Remodeling (Architectural Institute of Korea/ Korea Institute of Construction Technology/Construction and Economy Research Institute of Korea, 2001) and 'A Study on the Design Method for the Long life Multi-family Housing(Korea Institute of Construction Technology, 2003)' which are representative study to improve the building performance the factors inhibiting remodeling and long life of the buildings are mentioned as 'uniformed space configuration', 'wet construction method', 'burial construction of the facilities and integrated construction method', and 'common plumbing and inappropriate location and size of dedicated space'. They defined the basic functions of the buildings for remodeling and long life as 'durability', 'space Flexibility', 'maintainability', and 'renewability'. In 'SI House Design Guidelines' of the Ministry of Land and Transportation in Japan, the guidelines to secure durability, seismic-resistance, facilitation of maintenance, flexibility of the equipments and residence performance are proposed to build houses that can respond to the changeable requirements of the residents and the improvements of residential level and maintain the value as quality house stocks. Table 2 shows the design standards and

guidelines for remodeling and long life apartment houses specified in previous studies.

According to the analysis results of the existing materials, we concluded that a good construction plan, and the durability, modular coordination, flexibility and maintainability of design, structures, equipments and finishing would be needed to improve the maintenance performance of the buildings. In this study, it was defined as maintenance performance in the design phase.

Table 1. Maintenance performance related evaluation criteria of domestic and overseas certification and research literatures

Content	Examples of maintenance performance related evaluation items	
Green Building Rating System	Facilitation of the System Change	
Prefabricated House Performance Certification	Design for easy maintenance of each component of a house	
Intelligence Building (IB) Certification	Secure maintenance space for equipments	
	Floor plan development and application such as convertibles and mergeables	
Apartment Housing Performance Indication System	Structure related grade such as flexibility and maintainability for remodeling	
'House Performance Indication System (Japan)	Maintenance easiness of water and gas supply pipes	
Environment Friendly Houses (Japan)	Application of tools and construction methods for durability and change response type	
GBTool (Canada)	Flexibility, applicability, system controllability and performance maintenance	
Seok-ho Lim (2004)	Space convertible plan	Flexibility, modular coordination and compatibility
	Maintenance Plan	inspection, alternation and repair
Kang-hee Lee (2002)	Space Flexibility according to life cycle materials and structuring method easy to maintain	
	Structure providing long life	
	Design method for facility components, pipes and cables easy to maintain	

Table 2. Major Contents of Design Standards and Guidelines of Existing Literatures

Content	Major Contents
Design considering Remodeling	Application of modular coordination
	Establish spatial flexible plan
	Structure design considering building expansion and purpose change
	Structural design considering the space flexibility
	facilitation of the inspection and maintenance
	Enough space for equipments
Long-life Apartment Housing Design Standards	Durability of the materials and components
	Space flexibility
	Renewability of construction components
SI Housing Design Guidelines(Japan)	maintainability of structure and materials
	Durability and seismic-resistance of the structures
	Facilitation of maintenance, repair, alternation and renewal
	Flexibility of interior equipments
	Amenity

3. EVALUATION ITEMS FOR MAINTENANCE PERFORMANCE IN DESIGN PHASE

3.1 Classification of Evaluation Items

In this section, evaluation items for maintenance performance in design phase proposed in Chapter II (durability, modular coordination, flexibility, and repair and alternation possibility) were discussed.

The evaluation fields were building design, building structure, finishing and equipment referring to 'Checklist for each Design Phase' of Ha-kyu Baeck (2005). The evaluation items were set as durability, modular coordination, flexibility and maintainability and the size and location of each space, the location, shape, size, dimension of components and accessories, and the construction methods and techniques are selected as sub items for the evaluation.

Figure 2 shows the concept diagram of maintenance performance evaluation system.

3.2 Maintenance Performance Evaluation Items in Each Field

The followings are the sub items in construction plan, structure, finish and facility fields based on the evaluation items specified in 3.1.

(1) Building Design

In building design, 'modular coordination' and 'space flexibility' are evaluated. In modular coordination item, dimension of construction space and materials and the modular coordination of component specification are evaluated and the flexibility of the space concerning the location and size of the space are evaluated in space flexibility field. Table 3 shows the maintenance performance evaluation items in building design field.

Classification	Evaluation Items	Sub-Items
Building Design	Modular Coordination	Size and Location of the Space
	Space flexibility	
Building Structure	Durability of the accessories, materials and construction method	Location, shape, size and dimension of the materials and accessories
	Convertibility of structure system	
	Easy maintenance	
Finishing	Durability of materials and accessories	Construction methods and techniques
	Easy maintenance	
Equipments	Durability of machinery and components	Construction methods and techniques
	Convertibility of facility system	
	maintainability	

Figure 2. Concept diagram of maintenance performance evaluation item configuration

Table 3. Maintenance performance evaluation items in the building design

Classification	Sub-items	Evaluation Contents
Modular Coordination	Dimension of building space and materials	Whether to apply 'Design Document Preparation Standards (Ministry of Construction and Transportation Notice)'
	Dimension of materials and components of the building	Whether to apply KS dimension
Space Flexibility	Location and size of core	location and size estimation to function and use change
	Size of dedicated space	Whether to secure the minimal dimension

(2) Building Structure

In construction structure field, 'durability of materials and accessories and construction methods', 'flexibility of structure system' and 'maintainability' are evaluated. In durability evaluation items, the durability of the structure accessories and materials are evaluated and in convertibility evaluation item the location and shape of the structure and the flexibility of structure load are evaluated. In maintainability item, the location and size of the inspection holes and the accessibility and workability of those holes are evaluated. Table 4 shows the maintenance performance evaluation items in building structure.

Table 4. Maintenance performance evaluation items in building structure

Classification	Sub Items	Content
Durability of materials, accessories and construction methods	Materials, accessories and construction methods	Durability of the structure components, materials, and the applied construction method
Flexibility of structure system	Location and shape of structure	Convertibility of structureal system
	load	Load design considering building expansion and use change
maintainability	Location and size of inspection holes	Accessibility and workability of personnel and equipments

(3) Finishings

In construction finishing, 'durability of materials and components' and 'maintainability' are evaluated. In durability item, service life of the materials and components are evaluated, and in 'maintainability' evaluation item, maintenance of connection methods and availability of the materials and components are evaluated. Table 5 shows the maintenance performance evaluation items in finishings.

(4) Building equipments

In buildings equipments, 'durability of equipments and components', 'Flexibility of facility system' and 'maintainability' are evaluated. In durability item, the service life of equipments and components are evaluated, in flexibility item the location and size of pipe is evaluated. In maintainability item, the location and size of inspection holes and maintenance according to the configuration and shape of the pipes are evaluated. Table 6 shows the maintenance performance evaluation items in building equipments.

Table 5. Maintenance performance evaluation items in Finish field

Classification	Sub items	Content
Durability of materials and components	Materials and components	Service life of materials and components
Maintainability	Connection methods	Service life of materials and components Application of dry structuring method
	Material and components	Availability of materials and componebts

Table 6. Maintenance performance evaluation items in building equipments

Classification	Sub items	Content
Durability of equipments and components	equipments and components	Service life of devices and components
Flexibility of equipment system	Zoning	Responsiveness to expansion and contraction of the space
	Location and Size of pipes	SI(structure and infill) separation Application of exposed pipes, pedestal floor and cavity walls
Maintainability	Location and size of inspection holes	Accessibility and workability
	Configuration and shape of the pipes	facilitation of assembly and installment (Application of dry structuring method)
	Equipments and components	Availability of materials and components

4. CONCLUSION

As the importance of the building maintenance emerged, many studies regarding maintenance performance has been performed. However, existing studies have emphasized the plan, implementation and cost only and have not paid enough attention to the facilitation of the building maintenance. At this point when more importance is placed on the evaluation on the maintenance performance of the buildings in the design phase should be evaluated.

The purpose of the study was to set the design evaluation items to improve maintenance performance of the buildings. Through the analysis of domestic and overseas certification and research literature, the concept of maintenance performance was established and evaluation items were

proposed in order to evaluate building maintenance performance in design phase.

The major contents of the maintenance performance evaluation items in each field are as follows;

(1) Building Design: It evaluates 'modular coordination' and 'space flexibility'. In modular coordination item, dimension of construction space and materials and the modular coordination of component specification are evaluated and the flexibility of the space concerning the location and size of the space are evaluated in space flexibility field.

(2) Building Structure: It evaluates 'durability', 'flexibility', and 'maintainability'. In durability evaluation items, the durability of the structure accessories and materials are evaluated and in flexibility evaluation item the location and shape of the structure and the flexibility of structure load are evaluated. In maintainability item, the location and size of the inspection holes and the accessibility and workability of those holes are evaluated.

(3) Finishings: It evaluates 'durability of materials and components' and 'maintainability'. In durability item, service life of the materials and components are evaluated, and in 'maintainability' evaluation item, maintenance of connection methods and availability of the materials and components are evaluated.

(4) Building Equipments: It evaluates 'durability', 'flexibility', and 'maintainability'. In durability item, the service life of equipments and components are evaluated, in flexibility item the location and size of pipe is evaluated. In maintainability item, the location and size of inspection holes and maintenance according to the configuration and shape of the pipes are evaluated

This study can be utilized as base dates to develop evaluation criteria and model evaluating the maintenance performance of the buildings in design phase and will contribute to the improvement of the building maintenance performance.

ACKNOWLEDGEMENTS

The study described in this paper is part of the "Research on the Repair/Rehabilitation of the Multi-Owned Buildings" that was funded through Ministry of Construction & Transportation in 2005. The writers would like to thank the members of research team on "Research on the Repair/Rehabilitation of the Multi-Owned Buildings" for their help and support throughout the course of this study.

APPENDIX

1. Article 21.2 of Housing Act (Display of House Performance Grade)

2. It is the performance to maintain the functions of the building without providing users with any inconveniences during the life cycle of the building. In this article, it means performance in broader perspectives including performance security such as inspection, repair, alternation and

reinforcement as well as life lengthening such as purpose change through remodeling.

3. KGBAC (Korea Institute of Energy Research prepared Green Building Performance Evaluation Criteria of business buildings through Green Building Challenge operated since 1998), KICTEAC(Korea Institute of Construction Technology proposed KICTEAC (Korea Institute of Construction Technology Environmental Assessment Criteria) in 1998 which is environment performance evaluation method of the residential buildings), GBRS (Building environment performance certification which GBC-Korea under Korea Management Association Quality Assurance modified GBTool by GBC(Green Building Challenge) according to domestic situations), KOEAM2000 (Environment friendly residential block Evaluation Model developed by Ministry of Construction and Transportation and Korea National Housing Corporation as an evaluation tool for high quality residential building certification in order to encourage to construct environment friendly apartment houses)

4. IBS Korea developed it as civil certification institution for intelligent buildings (the final proposal was published on October 22, 2001)

5. 'If the project owner wants to supply more houses than President Order specified, he shall get the authorization from the organizations designated by Ministry of Construction and Transportation regarding the house performance grade under 1 of each items and publish it on Subscription Notice.'

6. Green Building Tool, The Project that GBC(Green building Challenge) which is a Green Building related international organization composed of 20 countries such as Canada is developing

7. It was developed in June, 1996 based on the research achievements which Japanese Environment Friendly House Construction Association had developed for 6 years. It is an environment friendly house certification evaluation criteria to induce practical and sound environment friendly houses.

8. It was prepared based on "Laws regarding House Quality Assurance" in 2004. It evaluates house performance with objective standards by a third organization and then evaluates the results.

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