DESIGNING AN ASSESSMENT SYSTEM OF BUILDINGS FOR ALL LIFECYCLE STAGES BASED ON THE CONCEPT OF ECO-EFFICIENCY

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ABSTRACT CASBEE (Comprehensive Assessment System for Building Environmental Efficiency) is an environmental labeling method for buildings, based on assessment of the environmental performance of buildings. In CASBEE, BEE (Building Environmental Efficiency) was developed as a new indicator for assessment following the concept of eco-efficiency. With the increasing BEE value, the total environmental performance of buildings is labeled from the highest performance. The framework of basic and extended CASBEE tools as a structured assessment system is called the "CASBEE family". CASBEE consists of a set of four basic assessment tools, namely "CASBEE for Pre-design" (CASBEE-PD), "CASBEE for New Construction" (CASBEE-NC), "CASBEE for Existing Building" (CASBEE-EB) and "CASBEE for Renovation" (CASBEE-RN). These correspond to the individual stages of the building's lifecycle. There are also needs for detailed assessment targeting specific environmental aspects. "CASBEE-HI," as an extended tool, assesses efforts made in buildings to alleviate the heat island effect. A new tool called "CASBEE for Urban Development" (CASBEE-UD) is developed for assessment of a group of buildings. In Japan, approximately 500,000 detached houses are constructed every year. In order to improve the quality of houses, "CASBEE for Home" was introduced in 2007. Some local authorities introduced CASBEE into their building administration as assessment methods for their sustainable building reporting systems. This requires building owners to submit a planning document assessing the environmental performance of their buildings to the authorities. In April 2004, the city of Nagoya introduced "CASBEE Nagoya". Introduction of CASBEE followed in the city of Osaka, Yokohama, Kyoto, and other municipals. These local systems require some modification in CASBEE to reflect their local characteristics, such as climate and prioritized policies.

Keywords: CASBEE, Building Environmental Assessment, Environmental Efficiency, Environmental Labeling, Environmental Policy, Building Administration, Sustainable Building Reporting System, Information Disclosure

1. INTRODUCTION

After the increase in the consciousness of global environmental problems in the 1990's, a number of methods are developed for comprehensive assessment of building environmental performance, including BREEAM, LEED™ and GBTool. The development of the Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) was started in 2001 with the assistance of Japanese Ministry of Land, Infrastructure and Transportation (MLIT). To date, a series of CASBEE tools have been elaborated and released for the wide range of building types. This paper presents the concept and framework of the assessment method and its application.

2. ECO-LABELING BASED ON THE CONCEPT OF ECO-EFFICIENCY

It is well-known that Weizsacker, Schmidt-Bleek and others are advocating concepts such as 'Factor 4' and 'Factor 10' to proceed reform in the resource productivity of the developed countries, based on their conclusions that the sustainability of the earth's eco-system cannot be maintained without an increase by a

factor of 4 or a factor of 10 in resource efficiency [1]. The principle of resource efficiency is expressed in the following formula;

$$\text{Resource Efficiency} = \frac{\text{Asset and Service Production}}{\text{Resource Input}}$$

An index similar to resource efficiency is utilized by organizations such as the WBCSD (World Business Council for Sustainable Development) and the OECD (Organization for Economic Co-operation and Development) based on the eco-efficiency approach. This is defined as follows;

$$\text{Eco-Efficiency} = \frac{\text{Quality of Life}}{\text{Impact on the Environment}}$$

These approaches are attempts to coordinate and unify the various and different aspects involved in environmental assessment and express them in terms of efficiency. They are excellent approaches for the remarkable clarity and simplicity of the principles. CASBEE is the first attempt in the world to apply the eco-efficiency approach to this sort of system. Specifically, the eco-efficiency approach has been applied to issues of environmental assessment of buildings, producing an index of Building Environmental Efficiency (BEE), defined by the following equation;

$$\text{BEE} = \frac{\text{Q (Building Environmental Quality)}}{\text{L (Building Environmental Load)}}$$

In order to define the terms Q and L used in the BEE definition, the new concept of hypothetical boundary at the site boundary is introduced as shown in Figure 1. In Figure 1, Category “Q” is assessed as the improvement of environmental quality within the virtual enclosed space. Category “L” is assessed as the negative impact on the environment outside the virtual enclosed space.

The method of labeling based on BEE is shown in Figure 2. BEE values are represented on the graph by plotting L on the x axis and Q on the y axis. The BEE value assessment result is expressed as the gradient of the straight line passing through the origin (0,0). Here the criteria for assessment items are decided so that the buildings on the diagonal line (BEE=1.0) are indicated as ordinary buildings. The higher the Q value and the lower the L value, the steeper the gradient, and the more sustainable the building is. With an increasing BEE value, total environmental performance of buildings is labeled as either; C rank (poor), B-, B^+, A, or S (excellent).

CASBEE is based on the eco-efficiency approach, and has an advantage over the many building assessment systems around the world due to this clear concept [2][3].

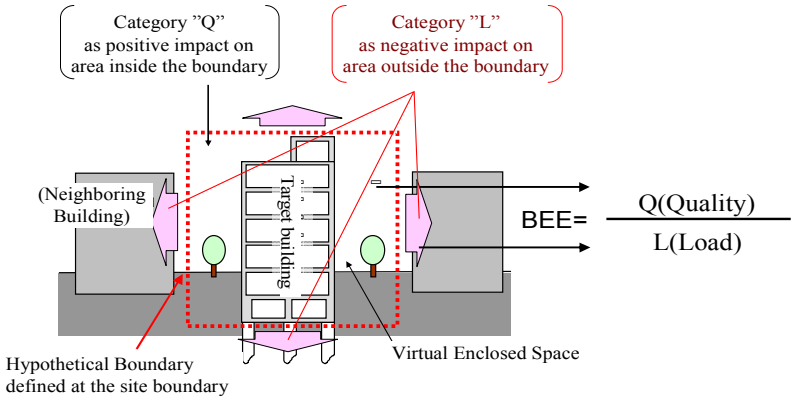

Figure 1. Definitions of Q, L and BEE based on virtual enclosed space>

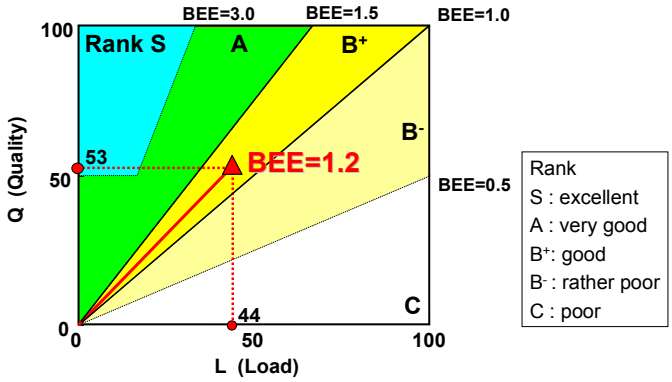

Figure 2. Environmental labeling of buildings utilizing BEE (Example)

2. BASIC CONDITIONS FOR DEVELOPING CASBEE

2.1 Three Major Concepts for CASBEE

The development and extension of CASBEE is based on three major concepts. Firstly, CASBEE is designed for assessment of buildings, which corresponds to their lifecycle. Secondly, it is based on the concept that clearly distinguishes environmental load (L) and quality of building performance (Q) as the major assessment targets. Thirdly, CASBEE applies the concept of eco-efficiency as BEE (Building Environmental Efficiency). Given L and Q, BEE is defined as Q/L to indicate the overall result of environmental assessment of buildings.

2.2 The basic approach to CASBEE Development

CASBEE has been developed in accordance with the following principles:

(1) It should be a positive assessment tool for designs with superior environmental consideration, rather than simply a negative checklist, in order to motivate designers, clients and others to be more interested in using the tool.

(2) The assessment system should be kept as simple and comprehensible as possible.

(3) It should be a general-purpose tool, able to evaluate buildings with wide-ranging types and sizes. To ensure widespread use, it should have a flexible structure able to reflect innovative initiatives taken by users based on their organizational circumstances.

(4) It should take into consideration issues and problems particular to Asia and Japan.

3. APPLICATIONS OF CASBEE

CASBEE is intended to serve applications for both public use and private use. It can be described according to the three major uses of CASBEE.

3.1 Application in public sector

(1) Application to building administration

Some local authorities introduced CASBEE into their building administration as assessment methods for their sustainable building reporting systems. This requires building owners to submit a planning document assessing the environmental performance of their buildings to the authorities. In April 2004, the city of Nagoya introduced “CASBEE Nagoya”. Introduction of CASBEE followed in the city of Osaka, Yokohama, Kyoto, and other municipals.

(2) Use in selection of design competition proposals, and of PFI project operators

It is anticipated that CASBEE will be used for grading design competition proposals, selecting PFI project operators and checking environmental performance of buildings at the design stage. The CASBEE rating can also be used between building clients and designer, or between owners and occupants, to determine environmental targets.

(3) Certification by a third party

The CASBEE rating is now subjected to third-party certification. A training program is also available to become an accredited assessor for CASBEE. Public use of CASBEE demands a higher level of fairness and confidence in the assessment results. Those systems are expected to become popular, although assessment by CASBEE is primarily a voluntary activity.

3.2 Application in Businesses

(1) For designers to employ design for the environment (DfE)

CASBEE can serve as an assessment tool that designers can use to check the environmental performance of buildings at the design stage by themselves, and provide their clients and others with objective information on environmental considerations.

(2) Environmental labeling that can be used in the asset valuation of buildings

Environmental labeling of buildings is also possible through certification by a third party, when buildings are valued as assets. Organizations can improve their corporate image through such labeling activity for the environment. Furthermore, CASBEE can be used as a tool to generate proposals for building operation monitoring, commissioning and upgrade design with a view to ESCO (Energy Service Company) projects and building stock refurbishment. CASBEE has the potential to be utilized in several stock management situations.

3.3 Application in Education

For specialized education, such as university and college courses of architecture, CASBEE can be used as a teaching resource. It is also useful as training material for professional CPD programs.

4. FRAMEWORK OF CASBEE: THE CASBEE-FAMILY

4.1 Building Lifecycle and CASBEE-Family

CASBEE consists of a set of four basic assessment tools which include, “CASBEE for Pre-design” (CASBEE-PD), “CASBEE for New Construction” (CASBEE-NC), “CASBEE for Existing Buildings” (CASBEE-EB) and “CASBEE for Renovation” (CASBEE-RN), which correspond to the individual stages of a building’s lifecycle as shown in Table 1. These tools can be applied for many types of buildings, such as offices, schools, retail stores, restaurants, halls, hospitals, hotels and apartments. These tools are basically designed to assess single buildings.

“CASBEE Family” is the collective name for these four tools and the extended tools for specific purposes. Figure 3 presents the relationship between these tools and the corresponding lifecycle of buildings. Figure 4 shows the scope of the CASBEE-Family.

Table 1. CASBEE’s four basic assessment tools

Names	Abbreviation	Tool No.	Development schedule
CASBEE for Pre-design	CASBEE-PD	Tool-0	not completed
CASBEE for New Construction	CASBEE-NC	Tool-1	completed in July 2003
CASBEE for Existing Building	CASBEE-EB	Tool-2	completed in July 2004
CASBEE for Renovation	CASBEE-RN	Tool-3	completed in March 2005

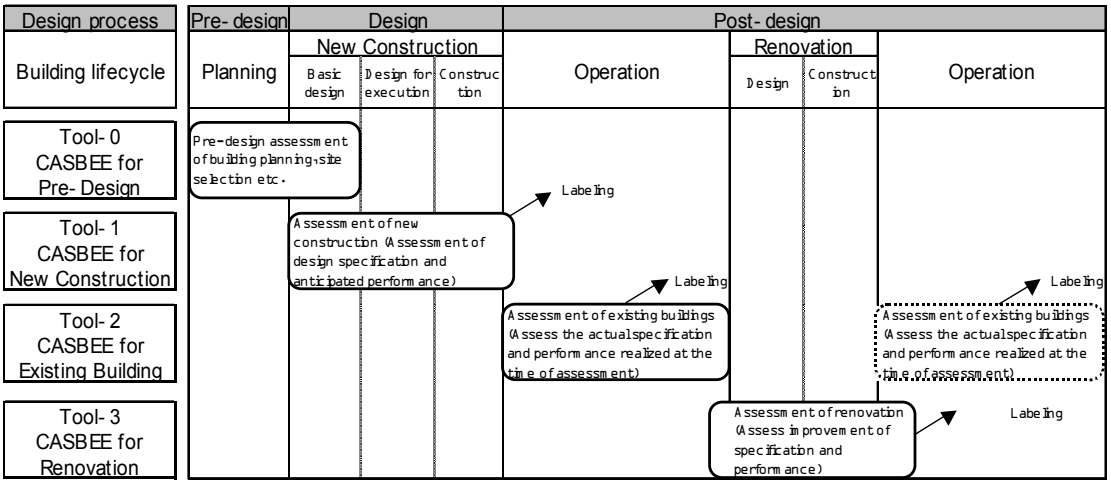

Figure 3. Building Lifecycle and the Four Assessment Tools

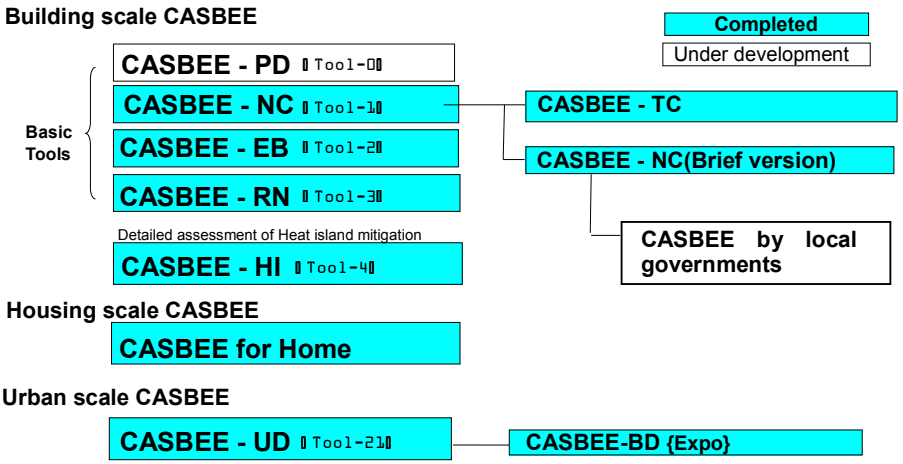

Figure 4. Scope of CASBEE-Family

4.2 Outline of the Basic Assessment tools

CASBEE for Pre-design (CASBEE-PD) — This tool aims to assist the owner, planner and others involved in the planning (pre-design) stage of the project. It can be

used to assist in grasping issues such as the basic environmental impact of the project, in selecting a suitable site, and to evaluate the environmental performance of the project in the pre-design stage.

CASBEE for New Construction (CASBEE-NC) — This is used by architects and engineers to increase the BEE value of a building during the design process [4]. This can be used as a design support tool as well as a self check list. This tool, formerly named DfE (Design for Environment) tool, makes assessments based on the design specifications and the anticipated performance. Rebuilding projects are assessed by CASBEE-NC. At the Preliminary Design, Execution Design and Construction Completion phases, the environmental quality and performance of the building and its load reduction performance are evaluated. As environmental performance and assessment criteria change over time, the results of assessments under "CASBEE for New Construction" only remain valid for three years after the completion of construction.

CASBEE for Existing Building (CASBEE-EB) — This assessment tool targets existing building stock, based on operation records for at least one year after completion [5]. The tool was also developed to be applicable to asset assessment. This assessment tool evaluates achieved performance or installation when the assessment is made. The result is valid for 5 years, and requires revision using the latest version of the assessment tool, because the condition of the building may change over time.

It can be used as a labeling tool to declare the environmental performance of buildings. CASBEE-EB is also utilized to support building maintenance. Building owners, such as the real estate sector and large enterprises, may use it as a self-evaluation tool for mid-term and long-term management plans.

CASBEE for Renovation (CASBEE-RN) — CASBEE-RN is designed to evaluate the performances of existing buildings based on predicted performance and specifications with renovation [6]. It can be used for building-stock renovation, and to generate proposals for building-operation monitoring, commissioning and upgrade design with a view to ESCO (Energy Service Company) projects. It is valid for three years after completion of the renovation work, and assessment must be made with the latest version of CASBEE-RN at the point of assessment. This tool can be used to evaluate the degree of improvement (increased BEE), relative to the level that preceded renovation. The example of CASBEE-RN's result (version year 2006) is

presented as shown in Figure 5.

CASBEE-RN may also assess improvement of specific performance in relation to the purpose of the renovation. For instance, the BEE for energy saving can be presented, that is determined by the scores for assessment categories especially related to energy saving renovation, such as Energy(LR-1) and Indoor environment(Q-1).

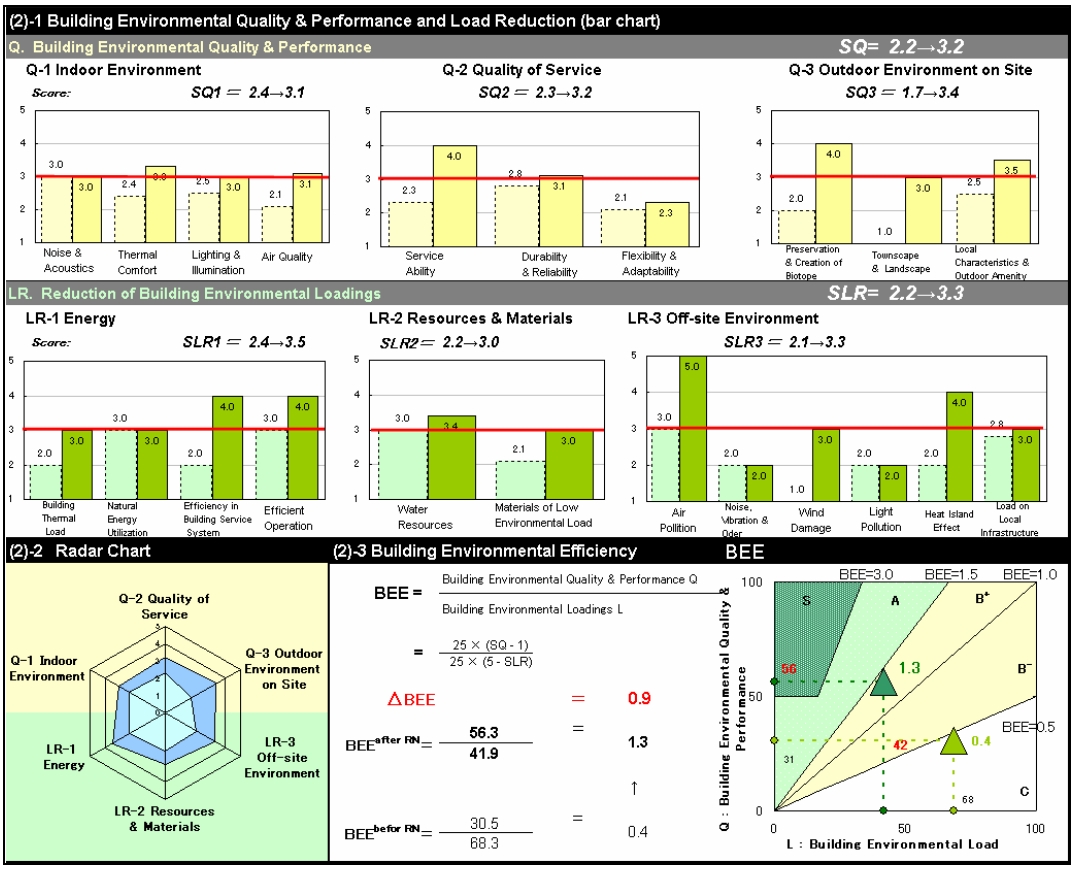

Figure 5. Example of assessment result by CASBEE-RN (version year 2006); comparison between before and after renovation

5. EXTENDED TOOLS OF CASBEE

The basic CASBEE tool suite is applicable to a diverse range of individual applications.

CASBEE for Temporary Construction — The tool called “CASBEE for Temporary Construction” (CASBEE-TC) was developed as an extension to CASBEE for New Construction for evaluating temporary buildings constructed specifically for short-term use, such as expo pavilions. Buildings of this type have short-term lifecycles, and therefore consideration must concentrate largely on material use and recycling in the

construction and the demolition phases. The scoring criteria and weighting reflect the features of this type of buildings. So far, the tool has been completed in a version limited to exhibition facilities [7].

CASBEE for New Construction (Brief version) — Assessment using CASBEE for New Construction may take 3~7 days, including the time required to prepare documents necessary as the basis for scoring. “CASBEE for New Construction (Brief version)” was developed to meet the growing need for a tool to handle objectives such as a simplified setting of the Building Environmental Efficiency level and preparation of documents for submission to government agencies. It makes a simplified, provisional assessment possible in around two hours (excluding time for the preparation of an Energy Saving Plan) [8].

Application of CASBEE by Local Governments — CASBEE is used by local authorities in construction administration, namely building- environmental reporting systems. They can tailor CASBEE for New Construction (Brief version) to local conditions, such as climate and prioritized policies. Examples are “CASBEE Nagoya,” “CASBEE Osaka” and “CASBEE Yokohama.”

CASBEE-HI — Assessment of the heat island effect is essential in major urban areas, such as Tokyo and Osaka. CASBEE for heat island alleviation (CASBEE-HI) is a tool aiming for more detailed quantitative assessment of heat island relaxation measures in building design [9]. In CASBEE-HI, the criteria deal with more detailed conditions in the outdoor thermal environment and the heat island load to surroundings. (These are also addressed in CASBEE-NC.) CASBEE-HI is also evaluated with the concept of eco-efficiency. BEE_{HI} (Building Environmental Efficiency for Heat Island Relaxation), indicating efficiency in measures taken to reduce the heat island effect, as in the following equation;

$$BEE_{HI} = \frac{Q_{HI}}{L_{HI}} = \frac{\text{Improvement of thermal environment inside the virtual boundary}}{\text{Heat island load outside the virtual boundary}}$$

CASBEE for Home — The four basic tools are not applied to detached houses, although they are applied to apartments. In Japan, approximately 500,000 detached houses are constructed every year. In order to improve the quality of houses, CASBEE for Home was developed for detached houses in 2007 [10].

CASBEE for Urban Development — "CASBEE for Urban Development" is applied to projects including multiple buildings [11]. This tool considers the human efforts and effects of group of buildings, other than these of single buildings, which improve the environmental performance of the urban area as a whole. As a specialized tool, "CASBEE for District Neighborhoods (Expo) version March 2005" has been completed and was used to assess the site plan of the World Expo 2005 Aichi, Japan.

6. SUMMARY

CASBEE is intended to serve various applications for both public use and private use, namely application for public policies, business and education. Local governments seem to be the most active in introducing CASBEE for practical use. The scope of CASBEE is summarized as below.

(1) CASBEE consists of a set of four basic assessment tools: "CASBEE for Pre-design," "CASBEE for New Construction," "CASBEE for Existing Building" and "CASBEE for Renovation." They correspond to the individual stages of the building's lifecycle.

(2) In CASBEE, BEE (Building Environmental Efficiency) was developed as a new indicator for assessment following the concept of eco-efficiency.

(3) "CASBEE Family" is the collective name for CASBEE's four basic assessment tools and the extended tools for specific purposes.

(4) Some extended tools for specific purposes have been developed, such as CASBEE for Temporary Construction (exhibition facilities), CASBEE for New Construction (Brief version) and its variations reflecting local conditions, CASBEE-HI.

(5) "CASBEE for Urban Development" broadened assessment to cover efforts applied to areas including multiple buildings.

7. REFERENCES

[1] Schmidt-Bleek, Friedrich, *Wieviel Umwelt braucht der Mensch? MIPS __ das Mab fur okologisches Wirtschaften,*. Basel/Berlin, Birkhauser, 1994

[2] Murakami, S. et.al., 2002, Comprehensive Assessment System for Building Environmental Efficiency in Japan (CASBEE-J), Proceedings of Sustainable Building 2002 international conference

[3] Ikaga, T. 2004, CASBEE; New Labeling System Based on Environmental Efficiency, Proceedings of 6th Int. Conf. on EcoBalance, pp. 249-52.

[4] Japan Sustainable Building Consortium, *CASBEE Technical Manual 2006 Edition; CASBEE for New Construction,* Institute for Building Environment and Energy

Conservation, 2006

[5] Japan Sustainable Building Consortium, *CASBEE Technical Manual 2006 Edition; CASBEE for Existing Building,* Institute for Building Environment and Energy Conservation, 2006 (in Japanese)

[6] Japan Sustainable Building Consortium, *CASBEE Technical Manual 2006 Edition; CASBEE for Renovation,* Institute for Building Environment and Energy Conservation, 2006 (in Japanese)

[7] Japan Sustainable Building Consortium, *CASBEE Technical Manual 2005 Edition; CASBEE for Temporary Construction (for exhibition facilities),* Institute for Building Environment and Energy Conservation, 2006 (in Japanese)

[8] Japan Sustainable Building Consortium, *CASBEE Technical Manual 2006 Edition; CASBEE for New Construction (Brief version),* Institute for Building Environment and Energy Conservation, 2006 (in Japanese)

[9] Japan Sustainable Building Consortium, *CASBEE Technical Manual 2006 Edition; CASBEE-HI,* Institute for Building Environment and Energy Conservation, 2006 (in Japanese)

[10] Japan Sustainable Building Consortium, *CASBEE Technical Manual 2007 Edition; CASBEE for Home,* Institute for Building Environment and Energy Conservation, 2007 (in Japanese)

[11] Japan Sustainable Building Consortium, *CASBEE Technical Manual 2006 Edition; CASBEE for Urban Development,* Institute for Building Environment and Energy Conservation, 2006 (in Japanese)