Comprehensive Assessment System of Building Environmental Efficiency in Japan (CASBEE-J)

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1. INTRODUCTION
As the trend towards sustainable buildings becomes widespread, many environmental assessment systems for buildings have captured considerable attention worldwide; these include BREEAM (Building Research Establishment Environmental Assessment Method), LEED (Leadership in Energy and Environment Design), and GB Tool (Green Building Tool). To be nationally authorized in Japan, a governmental and academic project has been launched to establish a new system named the Comprehensive Assessment System of Building Environmental Efficiency (CASBEE-J).

2. FRAMEWORK FOR A NEW ENVIRONMENTAL ASSESSMENT OF BUILDING
2.1 A historical review of the environmental assessment of buildings
2.1.1 Stage 1 The oldest form of environmental assessment of buildings in Japan is the performance assessment of building environments, mainly indoor environments, which is basically aimed at improving living amenities or enhancing convenience for occupants. This can be thought of as Stage 1 in the evolution of the environmental assessment of buildings. At this stage, since the local environment surrounding the building concerned and the global environment were generally considered as open systems, environmental assessments paid no attention to the fact that buildings simply discharged their environmental loadings into their surroundings. In this sense, the philosophy behind environmental assessments was very clear, but opposite to today’s approach.

2.1.2 Stage 2 The growth in public concern over air pollution problems in urban areas such as Tokyo in the 1960s led to the establishment of environmental impact assessment in developed societies. This was the time when environmental loadings started to be incorporated into building environmental assessments. This can be thought of as Stage 2. Here, only the negative effects that buildings have on their surrounding environments, such as urban pollution, are considered as environmental impacts, i.e. environmental load. In Stage 1, the environment mainly suggests a private space or property, whereas in Stage 2 it is a public space, although both Stage 1 and Stage 2 deal with the environment.

2.1.3 Stage 3 Stage 3 in the evolution of environmental assessments of buildings began after the rise in consciousness of global environmental problems in the 1990s. These systems
include BREEAM, LEED and GB Tool. The main issue in assessment at this stage is the negative impacts, in other words, the environmental loadings, the buildings have on the environment through their lifetime. In addition, building performance was also included as an object in some assessments, as in Stage 1. Notably, none of the assessment tools mentioned above clearly distinguish between these two basic assessment objects (in Stage 1 and Stage 2). Also, the scope (or the boundary) of the assessment objects is not clearly stated. In this sense, the concept of environmental assessment in Stage 3 lacks the clear underlying philosophy found in Stage 1 and Stage 2.

2.2 New stage in the environmental assessment of building: Stage 4

2.2.1 The boundary for assessing closed ecosystems and environmental capacity Stage 3 in environmental assessment began when it was recognized that the capacities of local environments, or the earth as a whole, were reaching a limit. As a result, the concept of closed ecosystems became essential for determining environmental capacities when conducting environmental assessments.

Therefore a hypothetical enclosed space bounded by the borders of the building site, as shown in Figure 1, is proposed here in making environmental assessments of buildings. This concept may be missing in Stage 3 assessments. The environmental loadings can thus be defined as “the negative environmental impact that extends outside to the public environment beyond the hypothetical enclosed space.” The improvement of environmental performance within the hypothetical enclosed space is defined as “the improvement in the living amenities for building users.” Dealing with both factors, Stage 4 environmental assessments clearly define these two factors, and distinguish between them as defined by BEE in Equation 1 of the following section. This makes the philosophy of assessment much clearer, and it has been used to form the framework of CASBEE-J.

Figure 1 Hypothetical Boundary in Assessing Building Environmental Quality & Performance and Building Environmental Loadings

2.2.2 Definition of Building Environmental Efficiency (BEE) The definition of Building Environmental Efficiency (BEE) makes the concept of Stage 4 environmental assessments simpler and clearer. BEE is an indicator calculated according to equation 1 below.

\[
\text{Building Environmental Efficiency (BEE)} = \frac{\text{Building Environmental Quality & Performance}}{\text{Building Environmental Loadings}} \\
\text{(1)}
\]

The numerator is Building Environmental Quality & Performance, which represents the condition of the living environment being assessed in terms of amenities for building users;
The denominator is Building Environmental Loadings. This idea refers to the eco-efficiency indicator that is normally defined as “values of products or service per environmental load unit.” (Ministry of Environment of Japan, 2001)

3. ESTABLISHING A COMPREHENSIVE ASSESSMENT SYSTEM OF BUILDING ENVIRONMENTAL EFFICIENCY IN JAPAN (CASBEE-J)

3.1 Project outline: Stage 4 and CASBEE-J

Designated over three years, the project for developing CASBEE-J is currently being undertaken by the governmental administration concerned in collaboration with academic, industrial and public sectors. CASBEE is entirely based on the philosophy addressed in Stage 4 of environment assessment that the authors have elaborated in this project. A major objective in developing the system is to meet both the political requirements and market needs to achieve a sustainable society throughout building lifecycles. CASBEE-J comprises the following assessment tools:

a) **The Pre-design Assessment Tool** (Tool-0), which supports owners and planners in identifying the basic context of the project. This may suggest proper site selection and the primal impact of the project. (This tool is not covered in this three-year project)

b) **The DfE (Design for Environment) Tool** (Tool-1), which is a simple self-evaluation check system for designers and engineers to improve the BEE of relevant buildings during the design process

c) **The Eco-labeling Tool** (Tool-2), with which buildings are rated in terms of BEE after completion. This could be used to determine the basic property value of the labeled building in the market.

d) **The Sustainable Operation and Renovation Tool** (Tool-3), which provides building owners and managers with information concerning how to improve the BEE of their own building property during the post-design process

Each tool has its own purposes and target users. These tools are designed for use along with the building design processes, beginning with the Pre-design phase, and followed by the Design and Post-design phases. CASBEE-J covers the assessment of different types of buildings including offices, schools, and multi-unit residential buildings. Following extensive review of existing national and international assessment systems, CASBEE-J covers four assessment aspects, Energy Consumption, Cyclical Use of Resources, Local Environments, and Indoor Environments.

3.2 The DfE (Design for Environment) Tool

3.2.1 Design Framework for the DfE tool  This paper explains *The DfE (Design for Environment) Tool* (Tool-1) designed as a simple self-evaluation check system for designers and engineers, as described above. The tool is planned for use in assessing buildings of any type or size. Assessments should be carried out at three design stages: the basic design stage, the design development stage, and the construction completion stage. To operate the system, the assessor fills out two assessment forms at each design stage: the Assessment Result Sheet and the Score Sheet shown in Figures 2 and 3. Figure 2 describes the basic structure of the forms for the DfE Tool, and a detailed illustration of the forms is shown in Figure 3, in which the Assessment Result Sheet is shown in front of the Score Sheet.

3.2.2 Assessment Result Sheet  The Assessment Result Sheet mainly displays the result of the assessment of a building using CASBEE-J as shown in Figures 2 and 3. “(1) Project Outline” on the Assessment Result Sheet summarizes the main features of the building being assessed, such as its name, size, and structure.
Below “Section (1) (Project Outline),” (2)-1 and (2)-2 in Figures 2 and 3, graphically summarize the assessment results for each category given from the ratings for each item in the Score Sheet. They are displayed in the form of bar graphs and numerical values in (2)-1. The assessment results for the “Q; Building Environmental Quality & Performance” category are displayed in the upper panel, while the results for the “L; Reduction of Building Environmental Loadings” category are shown in the lower panel. Here the indicator L represents not the building environmental load itself, but the level of performance in minimizing building environmental loadings imposed outside the hypothetical boundary. The better a building performs in reducing the environmental load, the higher the score it receives for this indicator L. Furthermore, the assessment results for Q are broken down into the categories of “Q-1 Indoor Environment,” “Q-2 Quality of Service,” and “Q-3 Outdoor Environment on Site.” Similarly, the assessment results for L are categorized into “L-1 Energy,” “L-2 Resource & Materials,” and “L-3 Off-site Environment.” Section (2)-2 displays information on BEE, as calculated from the results for Q and L. The left side of the panel shows the value of BEE as shown in Figure 3. On the right side there is a graph of Q against (6-L), where the gradients of the lines represent the BEE values. This visually shows the relative environmental sustainability of the assessed building. Details of this section and BEE are described in the following chapter.

Section (3) in Figures 2 and 3 presents optional assessment items. (3)-1 shows the Quantitative Values of indicators that are not included as part of the comprehensive assessment (2), but which are still useful for the environmental assessment of the building. These indicators may include the amount of primary energy consumption, the water consumption in operation, and LCCO2 emissions. Design Process Assessment (3)-2 assesses important environmental consideration items relating to the environmental management of the building.

3.2.3 Score Sheet  The assessment results for each assessment item are given as scores on the Score Sheet. The sheet is divided into sections representing the various categories of assessment. Scores are given based on the scoring criteria for each assessment item. These criteria applied to assessments are determined in consideration of the level of technical and social standards at the time of assessment. A five-level scoring system is used, and a score of level 3 (i.e. three points) indicates an “average” assessment. The scores for each assessment item are multiplied by a weighting coefficient, and aggregated into the sub-total scores for sub-categories. Total scores can then be calculated for each category.
Figure 3 Details of The DfE (Design for Environment) Tool
(Draft sample for design development stage assessment)
4. CONCEPT OF BEE (BUILDING ENVIRONMENTAL EFFICIENCY)
In CASBEE-J, the assessment scale for Q and L is from 1 to 5. The building environmental loadings can be given by (6-L), where L represents the level of reduction of the building environmental loadings. Equation 1 can then be expressed by the following formula.

\[
\text{BEE} = \frac{Q}{(6-L)}
\]  

(2)

The reason for using 6 is to avoid making the denominator zero. If Q is plotted on the vertical axis against (6-L) on the horizontal axis, the assessment results can be displayed on a graph, as shown in Figure 4 below. BEE values, calculated using Equation 2, are represented on the graph by the gradients of the lines connecting the assessment results and the origin (0,0). The triangular symbol on the graph shows an example. The higher the value of Q and the lower the value of (6-L), the larger the gradient, which means that the building is more sustainable. In contrast, the smaller the gradient, the less sustainable the building. In this approach, it becomes possible to graphically present the results of building environmental assessments using areas bounded by these gradients (environmental labeling). Figure 4 shows how the assessment results for buildings can be labeled on a diagram as Poor, Fair, Good, Very Good, and Excellent, in order of increasing BEE values. To make this approach more reliable, it is desirable that the methodology to determine Q and L values is continuously revised through the accumulation of assessment results. For further investigation, such revision may consider a quantitative approach to assessments; for instance, using the LCA process on buildings to give the L value.

Figure 4 Graphical expression of Environmental Labeling based on BEE

5. CONCLUSIONS
• The concept of CASBEE-J is presented following the concept of Stage 4, based on a historical review of the environmental assessment of buildings.
• A concept of hypothetical boundary for the building site is proposed in establishing CASBEE-J, and this is used to define assessment categories Q (Building Environmental Quality & Performance) and L (Reduction of Building Environmental Loadings).
• BEE (Building Environmental Efficiency) is proposed for expressing the assessment result clearly by CASBEE-J in a simple form.
• CASBEE-J comprises a variety of assessment tools designed along with the building design processes. Details of the DfE Tool are presented.
• A graphical expression based on BEE suggests that BEE can be applied to the environmental labeling of a building.

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7. REFERENCES