DEVELOPMENT OF CAFM SYSTEM FOR LCM ON BUILDING MAINTENANCE AND MANAGEMENT

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Abstract. The purpose of this study is to develop a Computer Aided Facility Management (CAFM) system to assist the optimal Life Cycle Management (LCM) business, especially in the repair and renewal planning works of the inhabited building Life Cycle Cost (LCC). This system is also useful for annual, mid and long term facility maintenance budget planning. Major steps of this study are as follows: (1) A Study on the actual process of the LCM business was undertaken to determine the required functions of the CAFM system. (2) We surveyed the calculation process of the LCC and examined the data processing method in order to determine an efficient LCC calculation method for the CAFM system. (3) Based on the above result, we developed each function required for the CAFM system. (4) The CAFM system was developed by unifying the above functions in a network browser environment such as data transaction management between database, LCC calculation and graphical representation applications. (5) We evaluate the CAFM system by using case studies of LCM works on actual buildings. This system contributes to the efficient maintenance works of the LCC, and is able to support the appropriate scheduling of LCM works.

1. Background and purpose of the study

In recent Japanese economic conditions, prolongation of the building life cycle and efficient utilization are required for effective facility management. Life Cycle Management (LCM) of whole building areas at any stage of building construction and maintenance is desirable. Facility managers have to exercise proper decision-making based on exact details on their current facility condition. To provide this data to facility managers in appropriate time and accuracy, a high volume database should be maintained in an effective way. It allows making comparisons between several alternative plans of constructions, repairs and renewal works by using an efficient CAFM system. The system must also facilitate the functions of the Life Cycle Cost (LCC) calculation on any building areas and the graphical representation of the results for easy understanding of the characteristics of each alternative.

This paper shows the development of the CAFM system for the LCM corresponding to the network. The system we proposed is the CAFM system that we presented at the past CAADRIA conference (Kazuhisa IKI and Sadayuki SHIMODA, 1998; Sadayuki SHIMODA and Kazuhisa IKI 1999; Kazuhisa IKI and Sadayuki SHIMODA 1999).

2. Analysis of the LCM business

To undertake a maintenance and preservation examination of the LCC of an important LCM business, we calculate on a trial LCC for the customer service office buildings of an electric power corporation.

2.1. THE SITUATION SET FOR THE CALCULATION

The LCC is calculated by the adjustment method. We used the relevant, indispensable BELCA public database to calculate the trial LCC of the building. (Unit price of the cost of construction, repair and renewal, the assumed lifetime, mending rate of on the building parts). Because a long-term forecast is difficult, we set the capital interest rate and the price change rate to 0% based on the present unstable Japanese economy.

We also set the number of years of planned usage at 65 years, considering the longer-life tendency of the facilities. In the current calculation using this research, we focus on the internal areas of the building for the examination. The structural body and the outside of the building are not calculated in this trial.

2.2. ACTUAL CALCULATION OF LCC AND ARRANGEMENT OF THE PROCESS FOR THE LCM BUSINESS

To arrange the LCC for the LCM business in the maintenance and preservation facilities, we total the calculation result using the following three methods - "Calculate intended LCC as a whole", "LCC calculation by each item of expense", and "LCC calculation by each part. "

The transition of the passing year for each portion of the investment is shown in Figure 1 as an example of the calculation result. The time forecast of when a large amount of the investment is needed can be determined by totaling each costs and displaying in figures.

We arranged an actual LCM business based on the process of an actual LCC calculation, and made the chart as shown in Figure 2.

We did a survey on the calculation processing of the LCC and examined the data processing method for arranging an efficient LCC calculation method for the CAFM system. The complex content of the LCM business was achievable from the aspect of the LCC calculation by the following five phases.

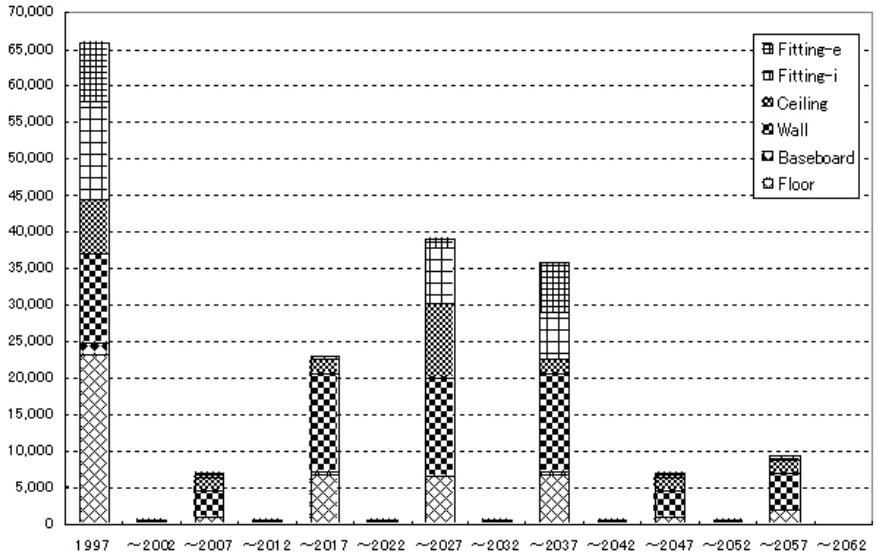


Figure 1. Total of each part of the LCC

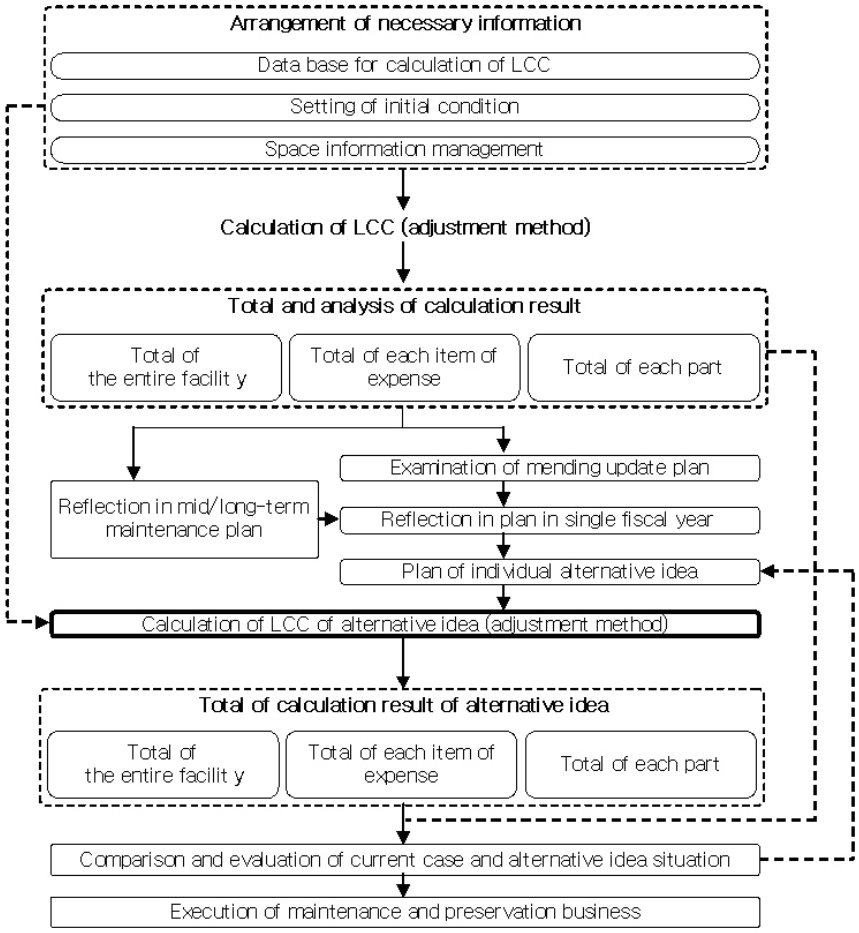


Figure 2. The LCM business arrangement based on the process of this calculation

1) Information collection and arrangement of facilities

The required, indispensable information to calculate the trial LCC of the building is collected, including the unit price, lifetime and volume of floorage and the area on any building parts.

2) Calculation of the LCC which assumes that the current specification is used continuously

To plan the maintenance and preservation plan, it is necessary to understand the amount of the investment compared to the passage years when the current specification is continuously used.

Therefore, the LCC was calculated by the adjustment method, and "Amount of the investment of a mid/long-term passing age" and "Mending

and update time" were determined by "The entire facility", "Each item of expense", and "Each part".

3) Reflection of the maintenance and preservation plan

Based on 2)、 the maintenance and preservation plan in a mid/long term and single fiscal year was planned.

4) Making Individual alternative ideas and evaluation of LCC for the repairs and renewal business

Based on 3)、It is necessary to propose alternative ideas for the required repairs and renewal plan in the fiscal year concerned. The LCC of each alternative idea is calculated. Each quality was judged while comparing the alternative ideas with the current idea on each estimated LCC.

If we cannot produce a satisfactory plan from these alternatives, we should be able to make other alternatives by applying the process again. Therefore, the execution plan and the budget plan for the maintenance and preservation were decisively planned.

5) Execution of the maintenance and preservation plan

The proposed maintenance and preservation plan obtains the approval of the manager and the financial affairs section prior to execution.

3. Development of the CAFM system

3.1. REQUESTED FUNCTION FOR THE CAFM SYSTEM

According to the analysis results in Chapter 2, we arrange the functions requested in the CAFM system that supports the LCM in the maintenance and preservation business.

a) Clarification of object items evaluated based on the LCC

As for the LCC evaluation object at the maintenance and preservation stage, not only the examination of the entire facility but also the examination of repairs and renewal parts of the building is needed. Therefore, the person who evaluates an alternative plan selects a required room and the part to examine the LCC from the entire facility, and the examination object is clarified, and the person is able to examine the maintenance and preservation plan in consideration of the evaluation of the LCC.

b) Making the LCC calculation highly accurate

It is necessary to plan the repairs and renewal plan for the fiscal year concerned more decisively at the maintenance and preservation stage. First of all, it is necessary to arrange to calculate the LCC information with the highest accuracy. However, the information of an enterprise with many facilities is huge, complex, and the arrangement of the information is not easy. The method of achieving this is to manage the huge volume of

information by batch, the information is efficiently collected and easily prepared for inspection.

To do this, a container, which arranges the facilities huge volume of information, is needed. It is necessary to construct a database with the function to arrange the information, for this purpose we have developed the CAFM system.

c) Efficiency improvement of LCC evaluation

During the calculation of the LCC by this research, the numbers of calculations were huge and required a lot of time, though it was a simple calculation method. The effectiveness of achieving automatic processing using the system for the repetition of simple calculations is large. In the frequently held reviews of the plan concerning repair/renewal plan, mid/long term plan and fiscal year plan, we should calculate the LCC of various project plans, and evaluate the plan based on the result.

In addition, it is necessary that we immediately compare and examine the calculation result of the LCC of the alternative idea calculated by all conditions. Decisively, the variable by which sensitivity like the capital interest rate and the prices change rate, etc. should be considered and included in the calculation of the LCC. Moreover, it is necessary to change the material setting and the amount variant to calculate the LCC in the examination of alternative ideas. Therefore, the CAFM system with an efficient simulation function for LCC comparisons that can be easily achieved is needed in various cases.

d) Sharing of information on the LCC evaluation results

It is necessary to reflect the opinion of many sections, not only those of the "Architectural person in charge" but also the "Manager", the "Person in charge of financial affairs", the "Person in charge of the Supplies Department gate", and "Those who offer FM service" in the maintenance and preservation plan. The information sharing by two or more people should easily develop into a possible system.

e) Expression of the LCC evaluation results

As shown above, it is necessary to express the LCC evaluation results in a way that can be understood by not only the person in charge, who has highly developed expertise, but also by others who have little knowledge of the process because they are not part of the relevant section.

3.2. SPECIFICATION OF THE CAFM SYSTEM

The specification of the CAFM system is examined based on the functions demanded by the system arranged in the preceding clauses.

1) Use of Intranet

The information sharing between multiple sections is indispensable for efficient communications. Because the information is important in-house,

the upgrade of security is important. Therefore, this system took on the technology of an Intranet.

2) Classification of the database for the CAFM System

We propose that the information needed in the LCC evaluation at the maintenance preservation stage be classified into two databases. One is a database of facilities information classified into "Static information" such as "Facilities information", "Space information", and "Materials information". Another is a database for the maintenance and preservation plan classified into "Dynamic information" which should frequently be modified according to various cases in the evaluation of the project plan making and the comparison.

When we make the project plan,

Information needed to calculate the LCC is extracted from "Static information", it is added to "Dynamic information", and an alternative plan is made while modifying the information.

In the comparison and the evaluation of the LCC, the current LCC calculation result based on "Static information" and the alternative LCC calculation result based on "Dynamic information"

are compared and evaluated.

The differences in the character of information which is assumed to be handled in the LCM business is clarified and classified.

3.3. CONSTRUCTION OF THE SYSTEM

The system is constructed by using the following development environments.

1) Development environment of client system

- Hardware

CPU: PentiumⅢ 550MHz RAM: 768MB

- Software

OS: Microsoft Windows 2000 professional（SP2）

Editor: Microsoft Visual InterDev6.0（Service Pack 5）

Database: Microsoft Access 2000（SR-1）

Browser: Microsoft Internet Explorer 6.0

- Programming language

・ HTML + VBScript、 JavaScript、SQL

2) Development environment of the server system

- Hardware

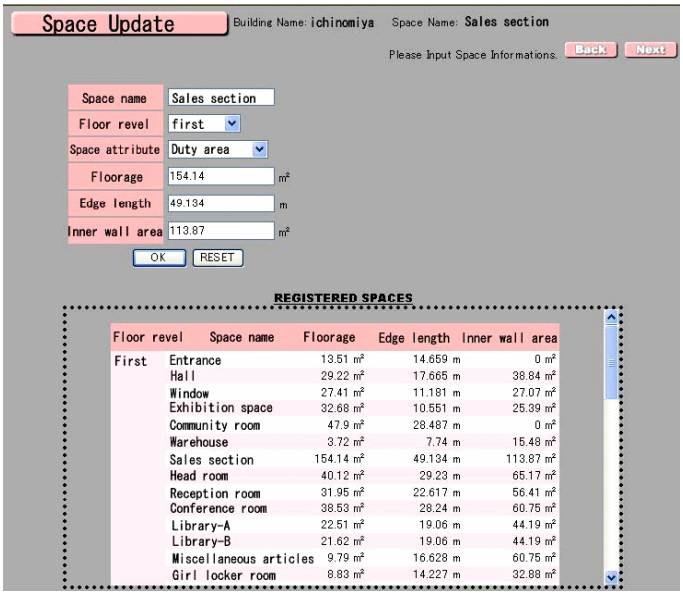
CPU: PentiumⅢ 500MHz RAM: 256MB

- Software
OS: Microsoft Windows 2000 Server（SP2）
Web Server: Microsoft Internet Information Service 5.0（IIS5.0）
Database: Microsoft Access 2000（SR-1）

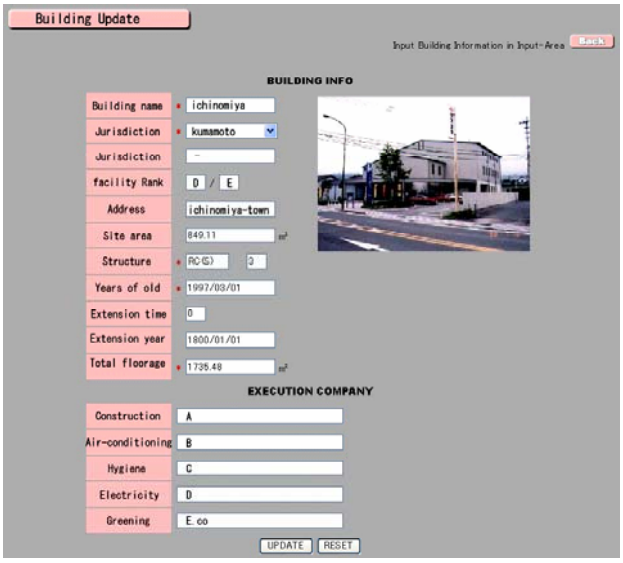
3.4. CASE STUDY OF USE OF THE CAFM SYSTEM

We selected the customer service office buildings of the electric power corporation as the case study. The CAFM system was examined on the repairs and renewals works of five office buildings. The system, which was developed by this research, is introduced and the case study which assumes an actual business operation is introduced. The operation example is shown in Figure 3, 4, and 5.

First, we prepared the LCC database of these buildings at the completion time, then adding repairs and renewals data up to the present. Then we extract required repair / renewal works by using the function of this system. On these parts, we plan alternative specifications of repairs / renewals works and make comparison and evaluation among projects based on each estimated LCC. If we cannot get a satisfactory plan from these alternatives, we will be able to make other alternatives and apply the process again. Finally, we can produce the minimum investment repairs / renewals plan of LCC.



Registration of information for a new building
When the building is completed, facilities information is registered in the database.

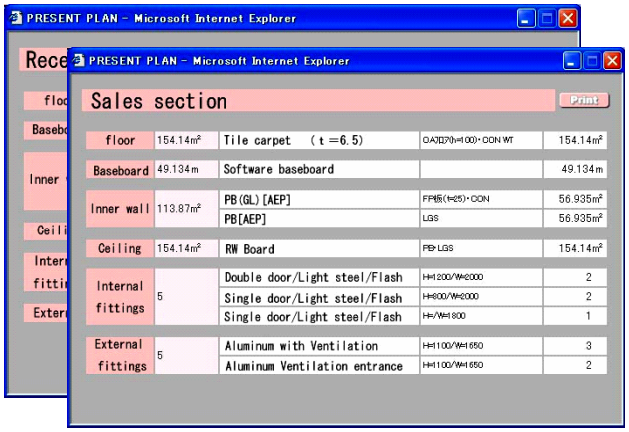


Change in facilities information

(1)The situation change by the execution of the maintenance and preservation business is registered.

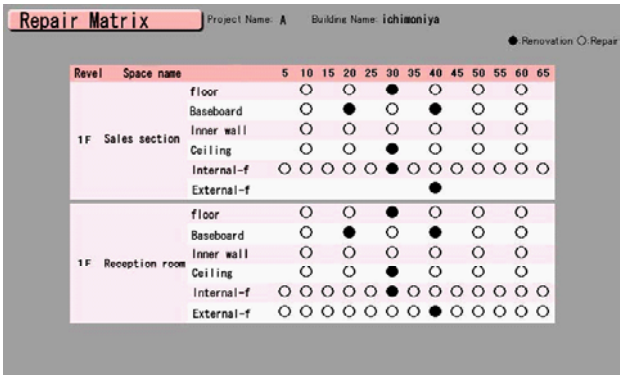
(2)Information in the database is repeatedly changed, and the current facilities information is managed.

Figure 3. Example of operating system1

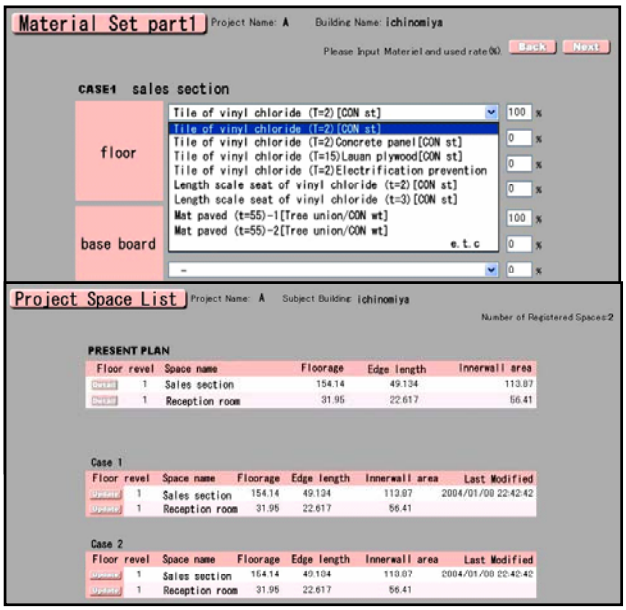


(1)To examine the mending update plan, the current state is determined.

(2)The material used in each target space for the mending update plan is confirmed.

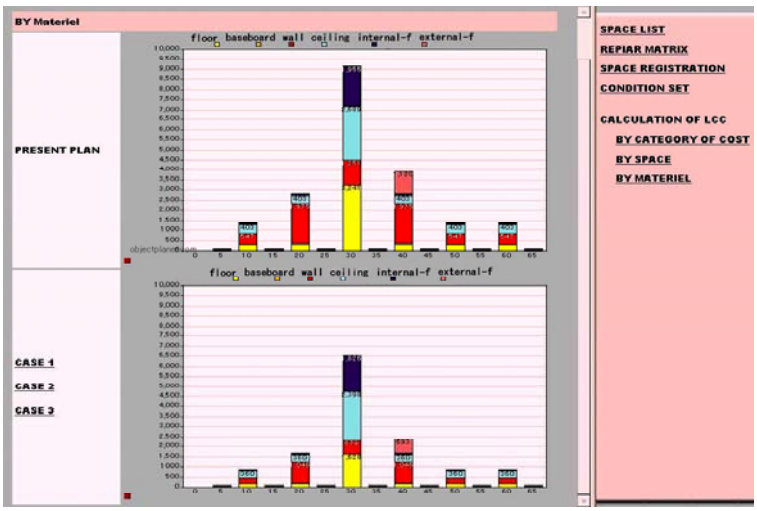


(3)The time when the mending update is required for each part according to space displayed, is easily understood.



(4)Alternative ideas for each space are selected.
(5)Construction materials are selected from the list.
(6)Various cases with the alternative ideas for the project are registered.

Figure 4. Example of operating system 2



Comparison and evaluation of alternative ideas
(1)LCC at current maintenance is displayed.
(2)LCC of two or more alternative ideas are displayed.
(3)The best idea is examined and selected by doing a comparative study.

Figure 5. Example of operating system 3

4. Evaluation of the System

We obtained the following evaluation results from a case study using the above system.

1) Maintenance of latest facilities information

By using this CAFM system, the efficiency of the information management business is increased, and database maintenance work is reduced. Therefore, we will be able to reduce the facility manager's burden in maintenance of the newest facility information**.**

2) Highly developed LCC simulation

To utilize this system, LCC planning can be managed by each project in different planning situations and economical conditions. Therefore, the quality of repairs / renewals planning work is improved by the quick comparison and evaluation among several alternative projects.

3) Efficiency improvement of maintenance and preservation planning

To show the matrix indicated by the time and element of repairs / renewals objects, we can grasp the required amounts and positions of repairs

/ renewals works easily. This helps with decision-making on the long-term-investment planning of building maintenance.

4) Efficient calculation of LCC and strategic decision-making

As described in (2)(3), mending and the update time were easily understood, and it was possible to make a comparative study of the LCC substitution idea by various patterns by using this system, it is possible to do complex work to derive the best alternative idea efficiently.

From these results, this system contributes to the efficient maintenance works in consideration of the LCC, and is able to support the appropriate scheduling of LCM works.

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