BUILDING AN ENGINEERING DATABASE AND INTEGRATED INFORMATION SYSTEMS IN CONSTRUCTION INDUSTRY

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ABSTRACT

We, a general contractor, is operating on the management principle of integrated system from designing to Construction, and is directed toward an engineering contractor. In 1965, large general-purpose computers were installed to start reorganization of the job processing systems, and the environments of use have been emproved ever since, from batch processing to interactive process, host operation to multifunction terminals, and combined with use personal computers. At the present, computer processing of key jobs in the technical fields is indispensable, including the planning and designing, structural design, and estimate of structural materials. This trend will be further expanded in the future.

On the other hand, there is a movement toward unification, CAD/CAM integration, and sharing of data. From the conventional use aiming at individualization of tasks and optimization of parts, the direction is turning toward the efficiency of the whole system, and effective use by the whole company.

1. Introduction

More than two decades have passed since the computers were first introduced in the building design and construction fields in Japan. The initial structural calculations and estimates of structural materials were how to replace the manual calculations by automatic processing, and the purpose was labor saving in computation. Afterwards the applications of computers have spread widely, including CAD, CAM, CAE. Today, the computer can build up a three-dimensional model of building, simulate the scenery, compare the designs, decrease the numer of operations for fabricating models, shorten the designing cycle, and enhance the quality, and the computer is now indispensable as an auxiliary means for intellectual production.

As a result of development of computer technology, supercomputers and various work stations are realized, and the environments for using the computers have been drastically changed, such as freedom of communications. What was conventionally impossible can be now achieved by the technical progress.

It should be the attitude of the information system organization to effectively utilize the hardware, softward and other properties accumulated in the company by reorganization and unification while correctly understanding the trend of the rapid developing computer technology and information processing engineering.

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This paper introduces the present situation of the construction of the engineering data base in the building industry as the nucleus of the information system unification.

2. History and Present Status of Information System

The history of development of Takenaka's information system is as shown in Fig. 1. It was started with simple calculations such as frame analysis and calculation of soil settlement due to consolidation, and was promoted to structural calculations and estimates of structural materials. In the 1970s, it was advanced to an interactive man-machine system such as planning and designing system. All of them are host side systems, and are established in the company in the online network connecting all branch offices.

In the latter half of the 1970s, commercial CAD systems were introduced, and were applied in the two-dimensional drafting processing mainly, and then the application fields of the three-dimensional CAD system began to be expanded owing to the enhancement of the performance of hardware and improvement of functions of the three-dimensional CAD system.

In the early 1980s, personal computer systems were developed, and they instantly invaded into every corner of the company as the inexpensive and easy-to-use tools. They are now used in automation of designing department and other offices and construction sites, and also in technical computations.

Thus, at the present, the computers of various types are used in various applications and purposes, including the host side application, the CAD system using minicomputer, and personal computer systems using microcomputers.

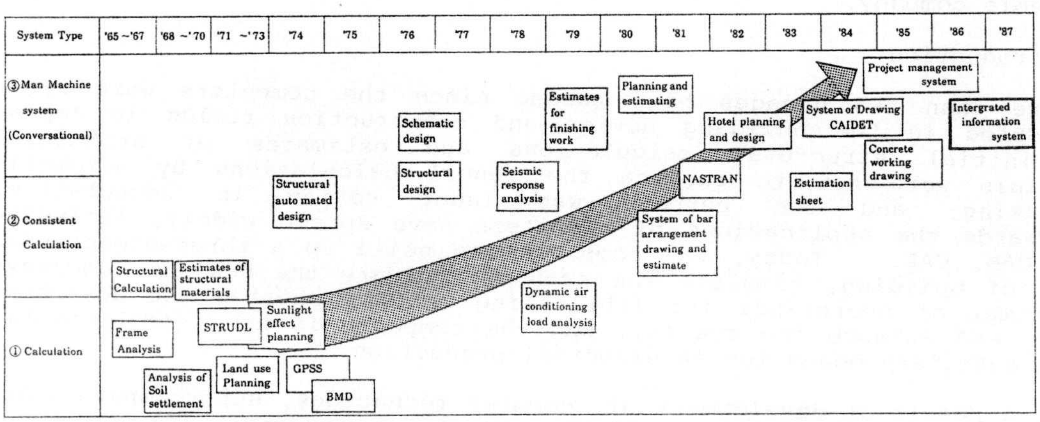

Fig. 1 Development of Utilization of Computers

3. Data Correlation Fixing Plan

In computer processing in the engineering field of building industry, complicated and abundant data including graphic data are handled. For this purpose, enormous skill and manpower are required for data entry, and at the present data entries are made by individual jobs, and duplications and contradiction of data, and time lag are caused.

Taking notice of this point, the data correlation fixing plan is being promoted, paying special attention to the data base construction and preparation of related information systems for the purpose of shared use of data among the key engineering jobs, especially by (1) improving the data correlation, (2) improving the man-machine interface, and (3) setting up the rational mangement system (see Fig. 2).

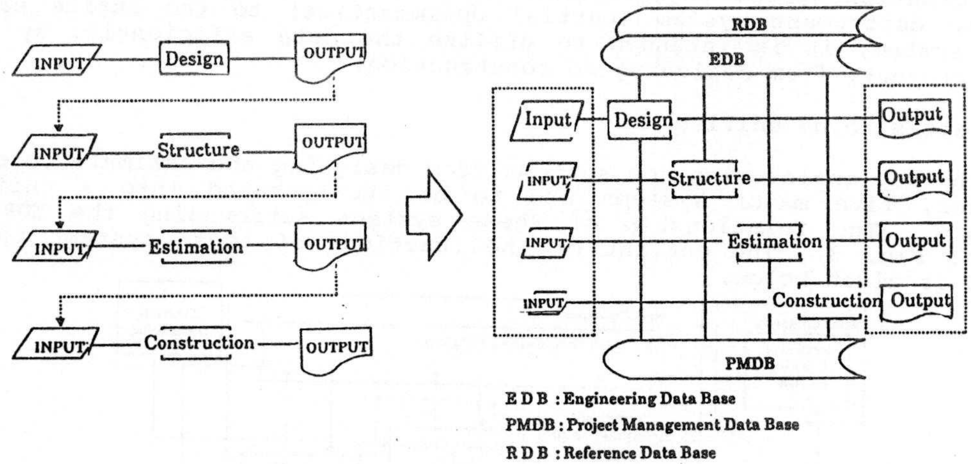

Fig. 2 From Individual Department Systems to Total Efficiency System

3.1 Improvement of Data Correlation

Data correlation is the exchange of mutually related data among the applied job systems through the computer. For this purpose, the engineering data base as its kernel is built up, and data correlation is effected among the job systems through it.

The designers and engineers of individual fields can exchange information accurately and promptly by sharing the data, and labor saving in data input operation and quick access to necessary data are expected.

3.2 Improvement of Man-machine Interface

In order to make the computers more familiar and easier to use for the designers and engineers, it is necessary to improve the man-machine interface. Accordingly, it is needed to advance into a system of high productivity as man-machine system by making use of engineering work station (EWS) having advanced interactive function, automatic drawing reading equipment, etc.

3.3 Setting of Management System

As the characteristic feature of the engineering jobs, repetitive processings such as comparative designs and design changes are frequently required and are also diversified. Besides, when transferring the data from one process to next, validation procedure for data guarantee, and synchronization for parallel works, and other considerations in management are necessary. The processing history and revision control in the individual jobs should be also important, and it is required to consider a practical method of clever control and management of data by utilizing the interactive functions by the engineering work station, centralizing the initial inputs and drafting processes, and specializing the data processing operations.

4. Construction of Engineering Data Base, and Unification of Information Systems

The engineering data base (EDB) of our company is the unified data base of the information used in the key engineering jobs for the purpose of uniform support of the design and construction works. By setting up the information system organization centered on the data base, to shift from the department system (partial optimization) to the entire efficiency system, it is intended to utilize the data efficiently, by the entire project, from designing to construction.

4.1 Systems to be Unified

Of the key engineering job systems from designing and estimate to construction, five major systems are to be incorporated into a unified structure. The relationship of these systems surrounding the EDB is shown in Fig. 3. The outlint of the functions of these systems to be unified is given below.

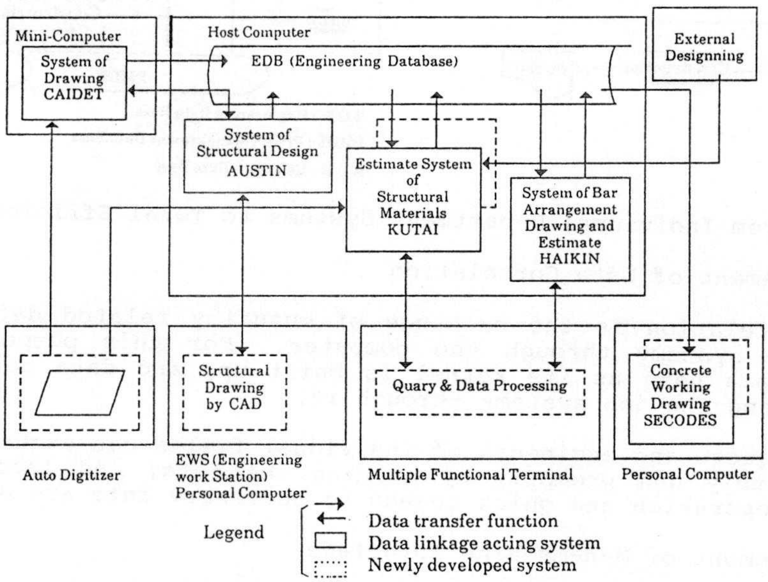

Fig. 3 Relationship of Systems to be Unified.

4.1.1 Design Drafting System (CAIDET)

This is a multifunctional CAD system having three-dimensional color modeling and drafting function. It broadly supports the design job, from the study of shape and appearance in the basic planning stage to the drafting work in the detail designing stage.

4.1.2 Structural Designing System (AUSTIN)

This is a continuous processing system of structural calculation of a building.In order to cope with the seismic resistant design that has been complicated and increased in precision as a result of revision of the law, and diversified building styles, and complication of structural types, use of computer is now essential in the structural designing jobs. Our system has a particularly wide range of applications, including the RC, SRS or mixed structure with S, and irregular structures such as inclined system and multiple-story high ceiling, and it is used in more than 90 percent of the design projects of the company.

4.1.3 Structural material estimate system (KUTAI)

Simultaneously with the structural designing system, this is the oldest computerized system, and estimates of the quantity of reinforcement of RC and SRC, forms and concrete are all done by this system. As for the calculation of S, there is an independent steel frame estimate system.

4.1.4 Bar arrangement drawing drafting and meter estimate system (HAIKIN)

This is a system for drafting the bar arrangement drawing to express the shape of bar arrangement based on the design drawings and construction conditions, and for estimating the specific quantity of reinforcement corresponding to it.

4.1.5 Concrete working drawing system (SECODES)

Only by entering the basic dimensions and attributes of the building members according to the procedure of drafting by the conventional manual job, drafting of drawings (plans, sectional views, developments, etc.) and estimates of quantity (forms, concrete) are carried out by the interactive system using personal computers.

4.2 Application Range of EDB and Building Steps

For construction of EDB, there are still many technical and management problems, and it takes time until it is completed as an established system. That is, the following points must be taken into consideration for building up the EDB.

(1) Characteristics of designing job
To promote the design studies while the design information is not established yet, and to establish the information while feeding back. To control and manage flexibly to design changes.

(2) Handling of varied data formats and structures
To handle numerical data and graphic data uniformly, and also deal with complicated data structures. To efficiently cope with dynamic changes of the structure.

(3) Load on computer
As the function of EDB system is advanced, the system resource is required more, and the efficiency becomes worse. And therefore, it is necessary to pay attention to the response and processing cost.
From this point of view, we limited the building steps and application range as shown in Table 1, and decided to expand gradually while observing the circumstances.

4.3 Data Analysis

It is important to extract data items that should be kept in the EDB out of the enormous quantity of design data and technical information. Accordingly the data were analyzed on the basis of the input data of key job systems, processing step data and output data.

In the designing stage, it is important what should be left over as the achievements. In the construction stage, it depends on who and where the data should be used, and how fat the data can be managed by the single principle. Considering these points, the main aims of data analysis may be summarized as follows.

Table 1 Application Range of EDB and Building Steps

Scope	Planning		
	1 st. Step	2 nd. Step	3rd. Step
Structural Type	RC part of RC and SRC	S part of SRC and S	
Shape of Building	Arbitrary quadrilateral		
Composition of Data	Structure	Finish	Mechanical and Electrical
Type Of Data	Numerical Text	Graphics	Image

(1) Extraction of data items that can be exchanged between key job systems
(2) When, where and by whom the data input, updating or processing should be done
(3) Assembly of modeling of building and data structure
(4) What are new problems occurring due to data exchange as result of data analysis and improvement plans

These points must be clarified. As a result of this data analysis, data items to be left over in the EDB are extracted, and the data contents are defined. The results are summarized in the Data item definition format (See Table 2.).

Table 2 Sample of "Data Item Definition Format"

SEQ	Item. Variable Name	Description	Classification	Length Array Unit	Input Division	Update Division
001 ≑	Member Name	Member Name	Structure Member Attr. Column	TEXT 4		
002 ≑	Direction of Member	Direction of Member X dir. Y dir.	ditto	INT 1		
003 ≑	Direction of cantilever	Cantilever 'S', 'E', '1' – '4'	ditto	TEXT 1		
004 ≑	Coordinate X	X - Coordinate	ditto	INT		
005 ≑	Coordinate Y	Y - Coordinate	ditto	INT		
011	Material of Member	Material of Member 'S', 'SRC', 'RC' etc.	ditto	TEXT 3		
012	Shape of Section	Shape Type '1' – '8'	ditto	INT 1		
013	Section 1	Length of X-direction Array 1 for Bottom,Array 2 for Top	ditto	RVEC 6.0 2 mm		

4.4 Contents and Composition of EDB

The data in the EDB is built in tree constructure as shown in Fig. 4. Data items are classified in three strata, that is, major classification, division, and subdivision, and a simple data structure is set up.

In consequence, modeling of building is made easily, and data retrieval, processing and other handling can be also done easily.

The EDB contains the following data items.
(1) Outline of building (name of the building, location, etc.)
(2) Shape of building (nominal appellation, scale of building, etc.)
(3) Arrangement of structural materials (arrangement and location information of building members)
(4) Member attributes of structural materials (sectional shape and material of building members, etc.)
(5) Finishing information (finishing standard, specification number, etc.)
(6) Information of facilities (unit numbers of piping, wiring and other facilities)

All these data items are registered in the Data item definition format. The data of material arrangement and material attributes are defined by the members to compose the column, beam, floor and other building components at each node point, and have the retrieval key, position information and attribute information.

As for the data base control system, the relational DBMS is used which is said to be relatively easy in retrieval and processing and is flexible in data base definition.

5. Practical Approach of System Unification

In the flow of jobs for building production, the establishment rate of design data and the data combination range between key job systems become higher in the later processes (See Table 3.).

Table 3 Data Combination Possibility Rate

Major Application		Data combination possibility rate (with post-process)
Pre-Process	Post-Process	
Design and drafting (CAIDET)	Structural design (AUSTIN)	(%) 20 ~ 30
Structural design (AUSTIN)	Estimates of structure materials (KUTAI)	30 ~ 40
Estimates of structural materials (KUTAI)	Concrete working drawing (SECODES)	50 ~ 60
Structural design (AUSTIN)	Concrete working drawing (SECODES)	30 ~ 40

Therefore, since effective use of data and labor saving in data input work can be expected, it was first attempted to couple the data of KUTAI system in the estimate field and SECODES in the construction field.

5.1 KUTAI-SECODES Combined System

The KUTAI data stored in the host computer is transferred to SECODES of personal computer. As a result, almost all input data necessary in SECODES are entered, and only by slight additional data, drafting is possible, and the input time can be notably shortened.

The data flow of data base and individual systems is shown in Fig. 5,

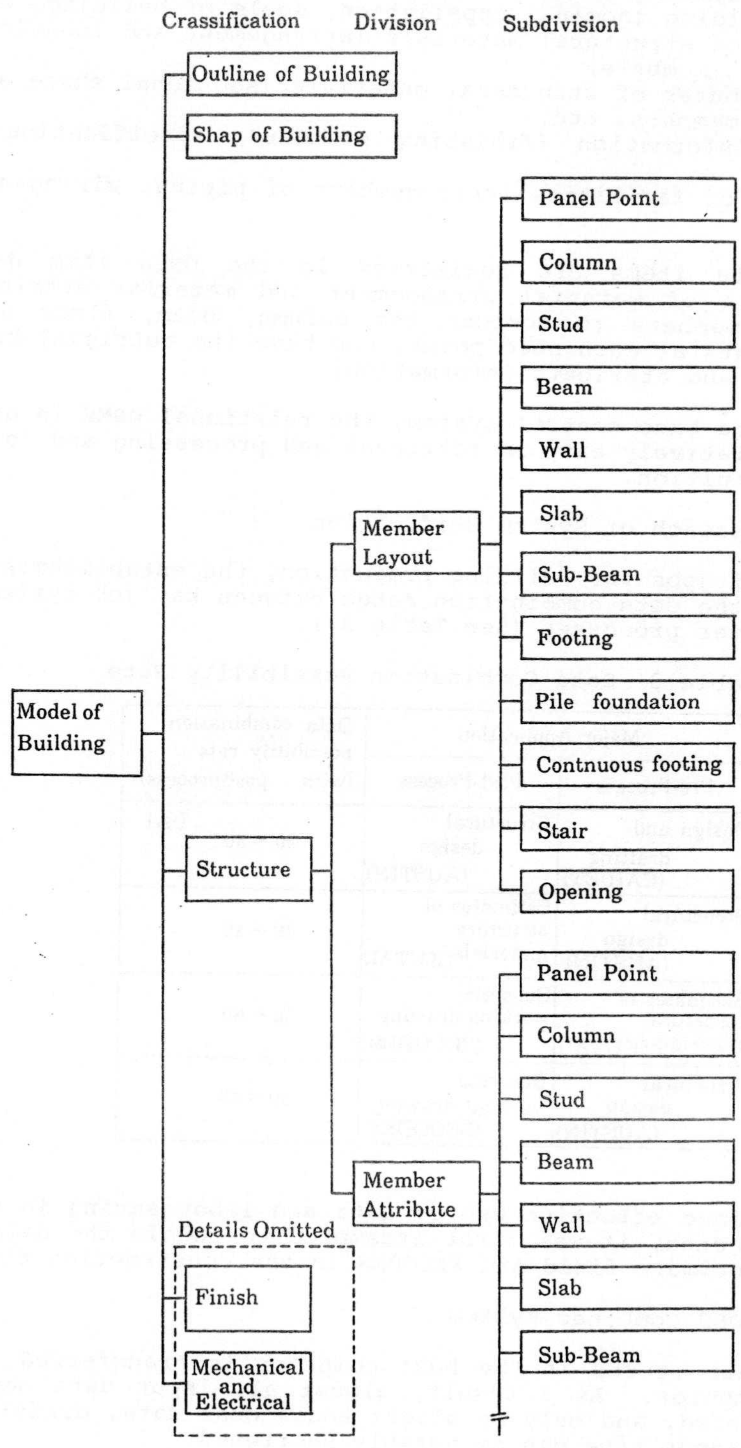

Fig. 4 Data Composition of Building Model

and the configuration of the KUTAI, SECODES combined system is given in Fig. 6.

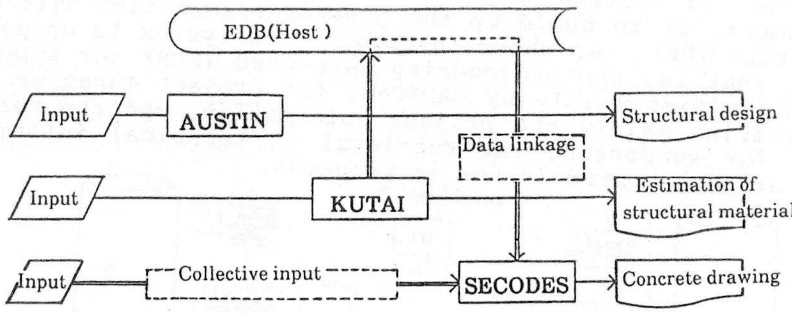

Fig. 5 Flow of Data of Data Base and Individual Systems

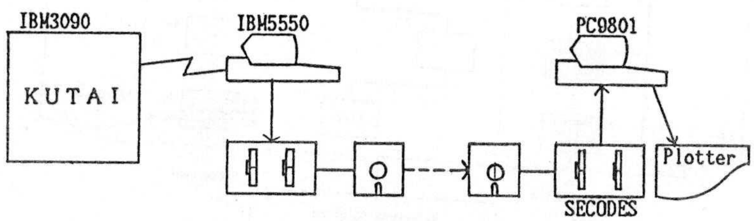

Fig. 6 Configuration of KUTAI, SECODES Combined System

5.2 Effects of KUTAI, SECODES Combined System

By sharing data between KUTAI and SECODES, the drafting time of a standard concrete installation drawing (A1 size) has been reduced from 7.1 hours to 3.7 hours, and about 50 percent of labor was saved. In addition to the labor-saving effect, since the design data can be transmitted accurately and promptly, it also contributed to the enhancement of efficiency of jobs (See Table 4.).

Thus, the EDB construction was attempted from the later processes, and practical achievements were obtained together with the users, and it is expected that the pace of building steps will be accelerated in the future.

Table 4 Labor-saving Effects by KUTAI-SECODES Combined System

Processing method	Required Time (Hours) 7 · 14 · 21 · 28
Previous method	Concrete working drawing · Estimation · 28 Hours
SECODES independent processing	7.1 Hours(about 1 day)
KUTAI,SECODES combined processing	3.7Hours(about 0.5 day)

6. Future Developments

The basic concept of systematizing the computer use in the engineering fields of our company is to build up the general information system making use of data base (DB). As shown in Fig. 7, the system is composed of three major DBS, that is, the engineering data base (EDB) for supporting the production activities mainly by CAD/CAM, the project management data base (PMDB) comprising mainly the project information, and the reference data base (RDB) for supporting the retrieval of technical information. The development of this system is now in progress.

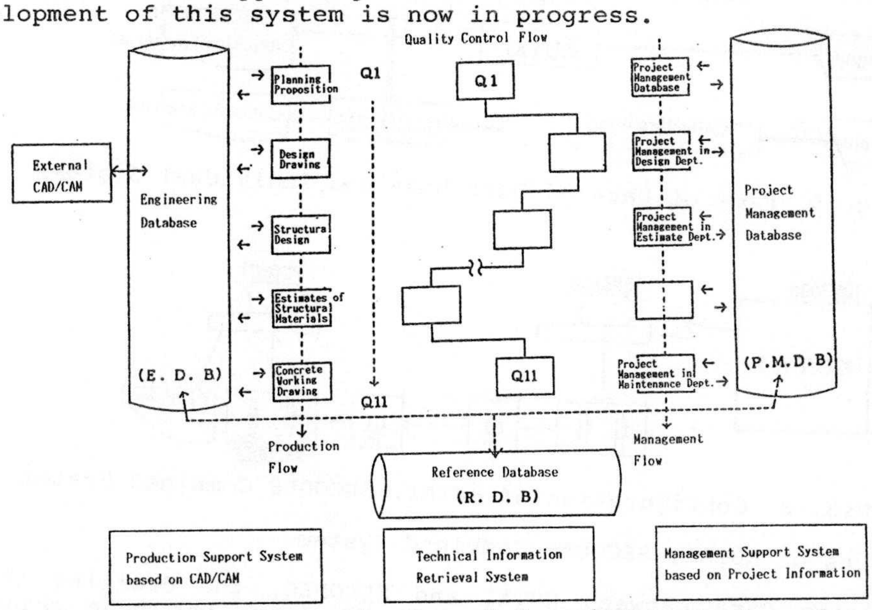

Fig. 7 Concept for Systematic Use of Computer in Engineering Field

7. Conclusion

The most important subject of enhancing the efficiency of the engineering enterprise henceforth seems to be unification of information system. And its kernel is the construction of engineering data base. As for construction of engineering data base, however, the present computer technology involves many problems such as modeling of building, handling of various data including numeric, graphic and image information, and DBMS to cope with flexibly dynamic changes of the data structure, and technical progresses in this aspect are highly expected.

It is estimated that the construction of engineering data base and unification of information system will be promoted by accumulating realistic approaches and efforts on the basis of the character of the enterprise.

References

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