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Considerations on Proper Usage of Design Programs

Considérations sul l'usage correct de programmes de calcul

Uber die richtige Anwendung eines Entwurfsprogramms

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Summary
The correctness of program usage is as important as the correctness of programs themselves, especially in such a case that programs are offered to unexperienced users. This paper describes a data error check system and some materials for avoiding improper program usage in a building structure automated calculation system. These materials include a program application checklist and a guide on the preparation of structural calculation sheets.

Résumé
L'utilisation conforme de programmes est aussi importante que l'exactitude des programmes eux-mêmes, surtout quand ils sont utilisés par des usagers inexpérimentés. Cet article expose un système qui permet de vérifier des erreurs de données et quelques mesures à prendre contre de faux usages de programmes pour le système de calcul automatisé de structures. Ces mesures comportent un tableau vérificateur pour l'application de programmes, ainsi qu'un guide pour la préparation des fiches de calcul de structures.

Zusammenfassung
Die Richtigkeit der Anwendung eines Programms ist genauso wichtig wie die Richtigkeit des Programms selbst. In diesem Aufsatz wird ein Kontroll-System zur Erfassung von Datenfehlern beschrieben und auf Dinge hingewiesen, die ungeeignete Programmanwendung in einem automatisierten Kalkulationssystem zur Baukonstruktion vermeiden sollen. Diese Materialien beinhalten eine Checkliste zur Programmanwendung und Richtlinien zur Vorbereitung von Blättern für die konstruktionsberechnung.

1. INTRODUCTION

This paper deals with several considerations on avoiding improper program usage concerning building structure automated calculation programs.

Just like the correctness of programs, the correctness of program usage is important, especially in such a case that programs are offered to anyone without regards to his ability or his experience. It is a regrettable fact that users are not always experts or excellent engineers. It is a matter of deep concern, especially for building officials, that unexperienced engineers use automated calculation programs blindly and design structures directly under instruction from computers. Possibly there are some mistakes in input data, or some misunderstandings regarding user's manuals. Undue reliance upon computers can lead engineers to catastrophe.

Throughout Japan, several hundreds of building engineering firms subscribe to a time sharing system called DEMOS-E offered by Nippon Telegraph and Telephone Public Corporation, whereby many subscribers are frequently carrying out building structural design by using library programs through the telephone network. In this case, much attention has to be paid to ascertainment of proper program usage within its application range and to correctness of input data.

DEMOS-E BUILD is a series of building structure automated calculation library programs from preparatory calculation and stress analysis to member design. The design methods adopted herein are based on structural standards of the Architectural Institute of Japan (AIJ). Compared with manual calculation, engineers can treat in these programs more complex structural calculation, such as space frame analysis, with resultant reduction in necessary design manpower.

With a view to inspect and evaluate building structure automated calculation programs and to promote their correct usage, an official committee called Evaluation Committee of Structural Analysis by Computer has been organized in The Building Center of Japan (BCJ) since 1973. An outline of the committee is shown in the Appendix.

DEMOS-E BUILD programs were the first programs submitted to the committee. Under demand from the committee regarding DEMOS-E BUILD, a program application check-list and a guide on the preparation of structural calculation sheets to be submitted to officials for building permits were devised.

In this paper, an outline of DEMOS-E BUILD is described first, and then techniques to avoid improper program usage are presented.

2. DEMOS-E BUILD OUTLINE

2.1 BUILD Function

DEMOS-E BUILD is a series of building structure automated calculation programs which are furnished to DEMOS-E subscribers as library programs [1], [2]. In Japan, reinforced concrete structures are generally adopted for low buildings (20 meters high or less), steel-reinforced concrete structures are adopted for fairly high buildings (50-60 meters high) and steel structures are adopted for low buildings as well as for high buildings. BUILD covers these three types of building structures, having regular rectangular frames composed of columns and girders. Calculation and design methods used in BUILD are based on AIJ's structural standards.

BUILD is composed of 7 package programs, as shown in Figure 1. Outlines of these programs are:

(1) BUILDCK (Input data check): Input data are checked by real time processing.

(2) BUILD-P (Preparatory calculation): Loads, such as fixed end moments of girders, axial forces of columns, and lateral forces caused by earthquakes, are calculated. Quantities of members are also covered.

(3) BUILD-S (Stress calculation): Stresses and displacements of frames are calculated, either by plane frame analysis or by space frame analysis. In the former, vibrational characteristics of buildings are obtained which can be analysed in detail by using DYNA (earthquake response calculation library program).

(4) BUILD-M1 (Reinforced concrete member calculation): Reinforcing bars of girders, columns, and walls are calculated for bending and shearing forces.

(5) BUILD-M2 (Steel-reinforced concrete member calculation): Reinforcing bars and steel structures embedded in concrete of girders and columns are calculated.

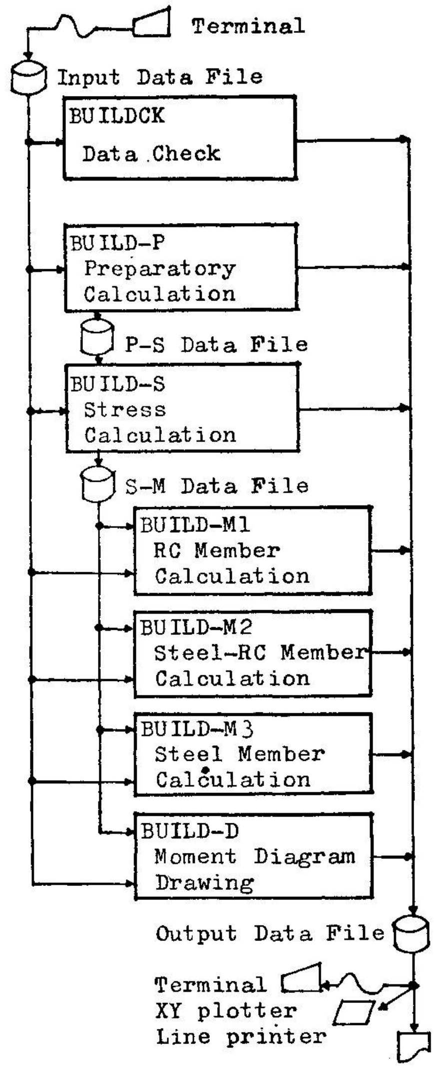

Fig. 1 BUILD Composition

(6) BUILD-M3 (Steel member calculation): Stresses are checked or suitable profiles are selected for various steel profiles of girders and columns.

(7) BUILD-D (Drawing moment diagrams): From the stress data output by BUILD-S, X-Y plotters draw moment diagrams for girders and columns.

In the case of simple structures, BUILD-P, S, and M1/M2/M3 are automatically processed in sequence, and required output can easily be obtained. In the case of complex structures, engineers use BUILD-P, S, and M1/M2/M3 repeatedly, as shown in Figure 2, by changing, for example, the sizes of structural members, or rigidity of walls. As input data are already stored in files, it is sufficient to transmit updating data only, thus reducing the engineer's work. By such repetition of calculation, more suitable sizes of members and arrangement of reinforcing bars are obtained.

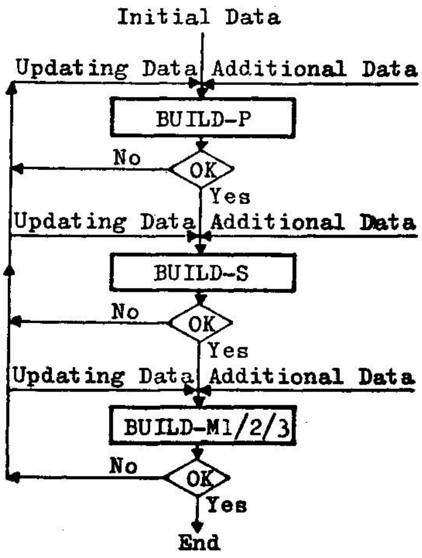

Fig. 2 Processing Flowchart

In 1973, when BUILD made its début, it was composed of 4 packages, namely BUILDCK, -P, -S, and -M1. Its size was 40K statements (mainly FORTRAN), but later its function was englarged and new programs were developed. At present, BUILD program size amounts to 110K statements.

2.2 State of Usage

BUILD programs are used considerably among building engineering firm subscribers throughout Japan. As an example, BUILD-P program is used several hundreds times in every month. Statistics indicate that frequencies of using other BUILD programs are, in comparison with BUILD-P usage frequency, 1.4 times in BUILDCK, 0.84 in BUILD-S, and 0.76 in BUILD-M programs (M1, M2, and M3).

An investigation regarding how BUILD programs were used among building engineering firms was held in 1976 [3]. Forty firms were chosen in Tokyo, Osaka, and Fukuoka for this purpose. Major results from the investigation are as follow:

(1) Main reasons why BUILD programs are used are: No. 1 — Shortening design time. No. 2 — Manpower reduction. Manpower reduction, in case of simple structures, amounts to 50% in preparatory calculation (BUILD-P), 50-90% in stress calculation (BUILD-S), and 20-50% in member calculation (BUILD-M programs).

(2) An investigation was made on how many times BUILD programs were operated in one case of structural designing because of data error or calculation modification (cf. Figure 2). Fifty cases were investigated. Results are shown in Figure 3. Major reasons for repetitive operation are: data error in BUILD-CK, data error in 50% of the cases and calculation modification in 50% of the cases in BUILD-P, and modification of calculation in BUILD-S and -M programs.

(3) 40% of the total stress calculation cases in BUILD-S are calculated as plane frames, whereas 60% are calculated as space frames.

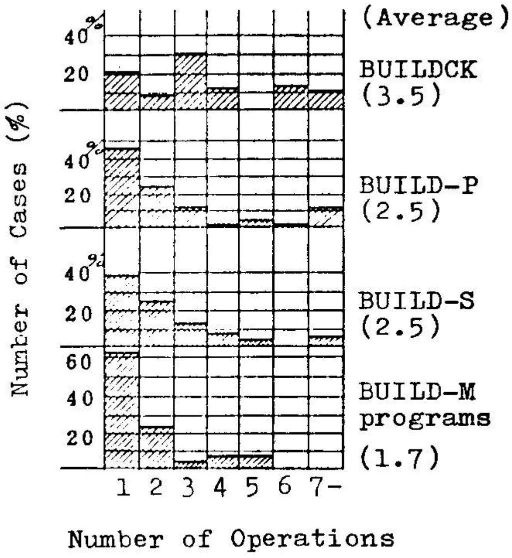

Fig. 3 Histogram on Number of Operations

3. PROPER DEMOS-E BUILD USAGE

3.1 Outline

It is desirable for users that program designers and suppliers prepare good input forms and output presentation, strict data check system, and good user's manuals. Moreover, in case of a building structure automated calculation program, it is recommended by BCJ's committee (cf. Appendix) that the program suppliers furnish a "Program Application Check-List", by which users can ascertain problems within the program application range, and a guide on structural calculation sheets preparation by which building officials can easily understand the contents of the structural calculation sheets submitted by users.

In DEMOS-E BUILD, several techniques to avoid improper program usage are considered, including a program application check-list and a guide on preparation of structural calculation sheets. By these techniques, users are considerably relieved from misuse and misunderstanding of BUILD programs.

3.2 Program Application Check-List

Purposes of this Check-List are:

(1) To ascertain that the structure concerned is within BUILD application range.

(2) To describe modelling of the structure to meet the requirement of BUILD, when the structure or a part of the structure is beyond the BUILD application range.

(3) To clarify and express important design conditions such as loads, materials, shape of the building, and foundations.

(4) To decide calculation methods, such as space frame analysis, consideration of foundations settlement, and consideration of rocking motion in earthquake resisting walls.

Using printed forms, users examine and check items and, if necessary, write their points of view in the forms. The Check-List is easily read by others and effectively used as a part of calculation sheet. Numbers of check items in BUILD's Program Application Check-List are, according to the above four categories, 13, 7, 27, and 39, respectively.

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3.1 Stress Analysis

(1) Stress analysis as ——— ○ plane frames
　　　　　　　　　　　　　　Ⓥ space frames

(2) Floor slabs can be assumed as rigid bodies for horizontal displacement. ——— Ⓥ Yes
　　　　　　　　　　　　　　○ No

In case of 'No', describe the structural model to be used in BUILD.

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Fig. 4 Example of Program Application Check-List (originally written in Japanese)

Figure 4 shows an example of the Check-List translated into English from Japanese. In the near future, users will obtain BUILD's Program Application Check-List forms directly from BUILDCK program through user's terminals.

3.3 Error Check System in BUILD programs

There are three kinds of error check in BUILD programs, initial check at input data processing phase, intermediate check during calculation, and check after calculation.

(1) Initial check: Responding to each input record, syntax check, attribute check and limit value check are performed in the early stage of processing. Later, after all data are input, they are mutually checked to isolate contradictions between themselves. They are compared with building codes and structural calculation standards.

(2) Intermediate check: During structural calculation, the occurence of some irrational performances is watched for.

(3) Final check: Calculation results are usually checked to meet the requirements of building codes and structural calculation standards, especially in case of structural member design.

When input data or calculation results are found not to comply with the requirements of building codes and structural calculation standards, warning messages are output, such as: "Slenderness ratio of the steel column exceeds 200", and"Breadth thickness ratio of the flange plate exceeds limit value". Important warning messages, which have been output at proper places, are gathered and listed again in the last part of output to make them conspicuous. BUILD programs include 110 prepared warning messages of above mentioned type and 260 other error messages.

Besides warning and error messages, BUILD calculates key values to express characteristics of structures such as each floor area and space volume, total weight and weight per unit floor area, quantities of concrete and steel per unit floor area, center of gravity and rigidity at each floor, slenderness of members, etc. By examining these values, users can verify the structural model, as well as check the input data comprehensively.

3.4 Input Data Abstract

The whole input data are output arranged into tables or appropriate forms. These arrangements aim at good documentation and are not always suitable for input data checking by users. Moreover, input data tables sometimes amount to a fairly great volume, in case of large structures.

"Input Data Abstract" is a summary of input data compiled in several pages by BUILDCK real time program using the whole input data for BUILD-P, -S, and -M1/2/3. It is useful for input data checking by users, as well as for concise description of the building structure, design conditions and calculation methods.

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  *  ﾒﾝｾｷ A = 252.0 M2
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Fig. 5 An Example of Input Data Abstract (Floor Plan)

Several output items are as follow:
- -Figure 5 shows a concise floor plan with floor area.
- -Sizes of girders and columns are not output individually. Instead, maximum and minimum sizes and depth-length ratios in each story are output.
- -When member sizes are altered among BUILD-P, -S, and -M programs, old and new member sizes and altered member positions are shown.

3.5 Graphically Arranged Output

Even in case of printers, graphically arranged output is more easily read and understood than lines of mere characters. On the recommendation of BCJ's committee, many graphically arranged output forms are introduced into BUILD programs, such as member arrangement plans (slabs, girders, columns and walls), column axial force list, member rigidity list, earthquake induced horizontal loads distribution in columns and walls, frame stress diagrams, and reinforcing bar schedules for girders and columns.

Figure 6 shows an example of a frame stress diagram.

3.6 Guide to Preparation of Structural Calculation Sheets

To use computer output alone as a formal document often arouse troubles for non-users, especially for building officials. Major causes for such troubles are:

(1) Usually, descriptive statements in the output are few in quantity and inferior in quality.

(2) Knowledge regarding the program's calculation functions and methods is needed.

(3) Often output amounts to a large volume, in case of a large structure.

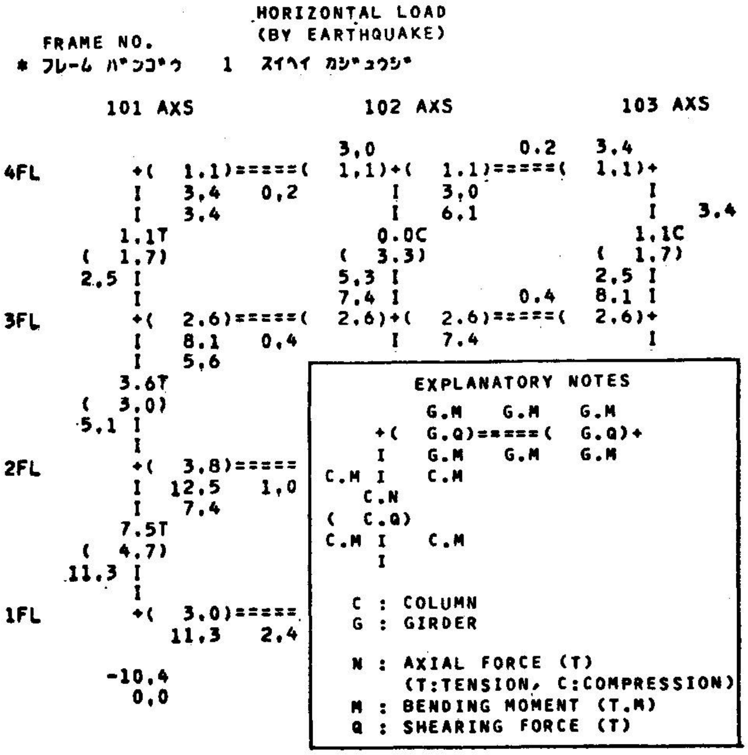

Fig. 6 Frame Stress Output

On the recommendation of BCJ's committee, a Guide on the preparation of structural calculation sheets was devised. According to the Guide, structural calculation sheets are composed of two parts, main text and supplementary data. Computer output is treated as the latter. The main text, written by hand, must contain the following items.

a) Structural modelling description.

b) Main or representative values from the output, in order to understand the calculation outline.

c) A summary of structural design and calculation, as well as remarks on structural safety, especially for earthquakes.

4. CONCLUSION

This paper describes several techniques for avoiding improper usage of programs adopted in DEMOS-E BUILD, such as error check system and other means, namely, program application check-list, output of input data abstract, graphically arranged output, and a guide on the preparation of structural calculation sheets. The program application check-list and the guide are furnished by the service supplier and are expected to be fully utilized by subscribers.

Considering the tendency for computer programs to become increasingly extensive and complicated with the progress of computer hardware, it is important to develop proper methods for ascertaining the correctness of program usage so as to promote reliable and pertinent computer application to the structural designing.

ACKNOWLEDGEMENT

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APPENDIX

Evaluation Committee of Structural Analysis by Computer in The Building Center of Japan

Several papers regarding this Committee, written in Japanese, have been published [4], [5], [6]. The following is a brief on the Committee using these papers.

The Committee was organized in 1973, and more than ten programs have been examined since then. Programs to be examined by the Committee are, for the time being, limited to building structure automated calculation programs. Members of the Committee are university professors, govermental institute researchers and building officials.

At the request of an applicant, the Committee examines the program concerned and the way of using it, regarding the following points:

(1) Within the application range of the program, are there any errors regarding methods of analysis and calculation as well as programing?

(2) Is there any possibility of the program being used erroneously? What is the pertinent precaution method?

(3) Is there any possibility of output data being used erroneously? What is the pertinent precaution method?

(4) When input and output data are used in structural calculation sheets to be submitted to officials for building permit, are styles of these data suitable for this purpose?

(5) In order that users master the program and its usage, are there any training courses available for users?

The result of examination is publicized and delivered to building officials. Users are recommended to use the program according to the way proposed by the Committee. Building officials are no longer required to check the program by themselves.

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