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Total Computer System for Bridges

Système global pour le projet de ponts au moyen de l'ordinateur

Integrales Computersystem für Brückenentwurf

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1. Optimum design and automated design

Automated design has been studied as a part of automation and labor saving problems by those who are engaged mainly in the practical design work, while the optimum design has been researched and developed by researchers who study mainly the mathematical decision method in connection with this design work. However, it is unreasonable to say that design by the automated design system does not have to be optimum design. If optimum design should be used for a practical application, its concept and method should be used for the automated design system and, therefore, we believe that they should be combined.

Under the present conditions, where the method of optimum design is not employed extensively in practical fields, whether the results of study are adopted or not is decided by designers and, in many cases, the designers modify the results before they utilize them. The practical design work is undisciplined and, in most of cases, constraints and objective function are never represented by well arranged formulas and thus contain many factors which depend upon the man's intuition and, therefore, the CAD system is conveniently used for ensuring a smooth execution of design work. At the present time, the practical method by which we can most probably ensure constant and high quality design is the CAD system which is processed in such a way that the method of optimum design is used for deciding algorism of automated design, allowing the system to supply designers with the data necessary for them to make judgements and, according to such data, the system proceeds on the basis of the man-machine relationship.

Whether a designer can accomplish high quality design by using such a system or not depends on (1) whether the ability of the designer who utilizes this system is proper or not or (2) whether the system can conveniently and quickly supply the required data in an easily usable form and if the system can fully carry out "trial and error" in a short time.

Combination of the above methods is indispensable for the improvement of quality of design and the mathematical decision method is also an indispensable factors.

Even if data of the best quality, when viewed from the standpoint of optimum design, is not supplied from the system, it is expected that the designers may be able to accomplish a design of a considerably high quality, if he can use the system conveniently, which means utilizing both mathematical decision method and the judgement of the designers. Under these conditions, the writers of this report have developed the CAD system for bridge design and used it for practical applications. The following describes the design system of a girder bridge.

2. Design system of girder bridge

2.1 Outline

Most ordinary bridges are of the girder bridge type and, therefore, it is necessary to prepare a system which can be used conveniently and withstand the changes, additions and deletions of shape data, designing conditions, manufacturing conditions, etc.

The overall system consists of four subsystems as shown in Fig.1 which are consistently controlled through the data base. Emphasis has been placed on partial optimizing and data that can be used conveniently and utilized easily by designers.

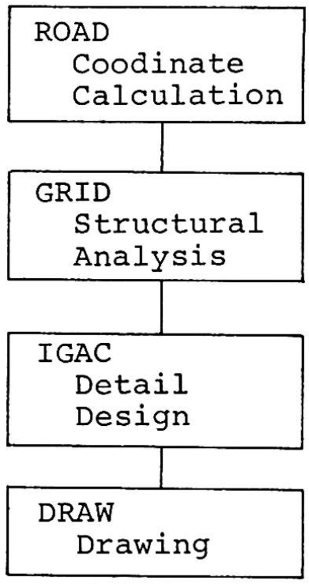

Fig. 1

2.2 ROAD Sub System

This is a universal type system of coordinate calculation. When the form of road, pier layout, main girder and cross beam arrangement are defined, this ROAD Sub System calculates the required values of coordinates. Consequently, the table of values, plan, longitudinal section and cross section are supplied as an output. For the following systems, various figures are filed in phase with each value being taken into consideration.

2.3 GRID Sub System

This system is a structural analysis system which employs a displacement method. When the input of the displacement method is fed independently, the coordinates, stiffness, loads, etc. are mostly fed as input data as far as the GRID is concerned, which is rather complicated for the designers. As for the matters concerning the coodinates, especially, since the results of the above ROAD Sub System are handed from the file, the input load is greatly alleviated.

When girder height is fed into this system as an input, a preliminary analysis is made for a simplified model structure by the stress-method as a preparatory calculation. An assumed stiffness and steel weight are set automatically and, thereafter, the number of input joints is about 200, thus requiring about 20 cards.

2.4 IGAC Sub System

Detailed design is conducted for the main girder section, splices, stiffeners, shear connectors, sway bracings and lateral bracings. As for the coordinates and sectional force, the results of the previous system can be used and, therefore, the designers feed the assembling method of sway bracing and lateral bracing as an input. It is also possible to make various kinds of special designations. Usually, when 10-20 cards are fed as an input, the optimizing process is carried out in the system, one set is decided upon and the design calculation sheet and sectional variation diagrams are produced as an output and filed. However, the designer's personal taste, interchangeability of parts, etc. should also be taken into consideration when the decision is made and, therefore, there arises a demand that some modification should be made after studying the outputs. Meanwhile, questions and modifications can be made by using CRT(IBM 2250).

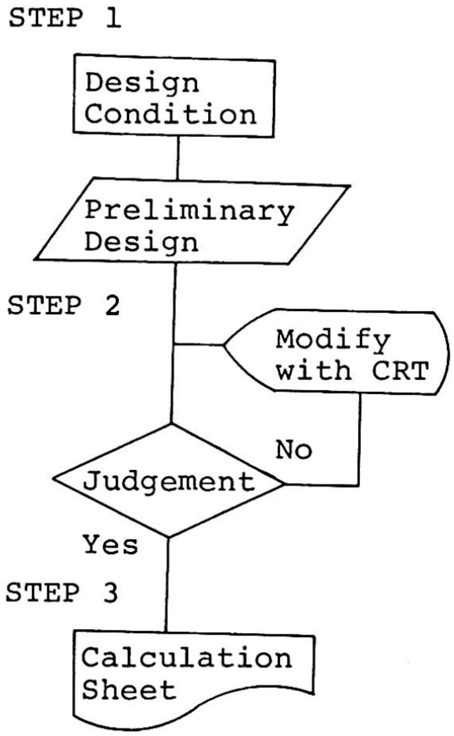

Fig. 2

This system consists of the following three steps;

Step 1; Temporary decision concerning the main girder, cross beam and lateral bracing, preparation of data to be studied(substitute plan included) and filing into Step 2.

Step 2; Question and modification by using CRT device. Filing into Step 3.

Step 3; Preparing a design calculation sheet. Filing into DRAW Sub-System.

Step 2 is provided with the CRT pictures of sections, splices, stiffeners, shear connecters, cross beams and lateral bracings. In one particular section, for example;

a. What kind of section can be made if the material at a certain location is changed?
b. What will be the best section if this location is moved 30cm?
c. What will be the thickness of plate when the upper flange width is changed to 50cm?

Various questions such as are listed above are given and if the answers from the system are accepted, the files are renewed accordingly and, thus, the design is modified continuously. Then, the final results are filed for the DRAW Sub System of design drawing.

The final stiffness is filed and the GRID can be reopened by using the file.

Fig.3 An example of the CRT pictures

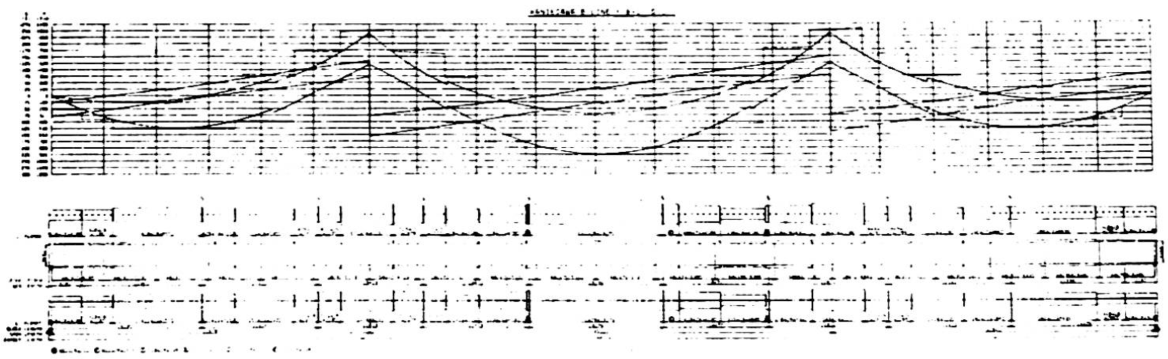

Fig.4 Sectional variation diagram

2.5 DRAW Sub System

This is a system which is used for deciding the details of structures and for making drawings. The results of design calculation are insufficient when they are used as the data for making drawings and, therefore, the mode of structure should be decided in detail. In many cases, however, the details of structure are different depending on each customer. Because of these reasons, the details of structure most often used to meet the standards and design requirements of customers are stored in the system, thus expanding the range of applications. The input designates the items which change the standard of the systm . As for the coordinates, the file is used as a reference and, therefore, the designated item is usually represented by about 10 cards. The outputs are; main girder, cross beam, lateral bracing, detailed design drawing, diagram and the list of steel materials, welding lengths, painting area, etc.

For making the drawings, COM(Computer Output Microfilming) of CALCOMP CO. is used. Unlike the plotter or the drafter in which a pen moves mechanically, this COM is so designed that the locus of an electronic beam is traced on film. One drawing is completed in about five seconds and the operating cost is also very low.

3. Postscript

With this system, the fundamental design(deciding girder arrangement, girder height, etc.) is made after full "traial and error" by means of the ROAD and GRID and, then, the detailed design made by IGAC system is corrected by means of CRT and drawings are made by DRAW. The fundamental design and detailed design are separated, but when the optimum property of design is taken into consideration, we do not believe that there will be much trouble in the actual application if the fundamental values are properly selected.

When this system is used, one designer can complete within one week about 50 drawings, material lists and design calculation sheets for a bridge constructed with five main girders and three span-continuous I girders. Only girder bridges, are described in this report.

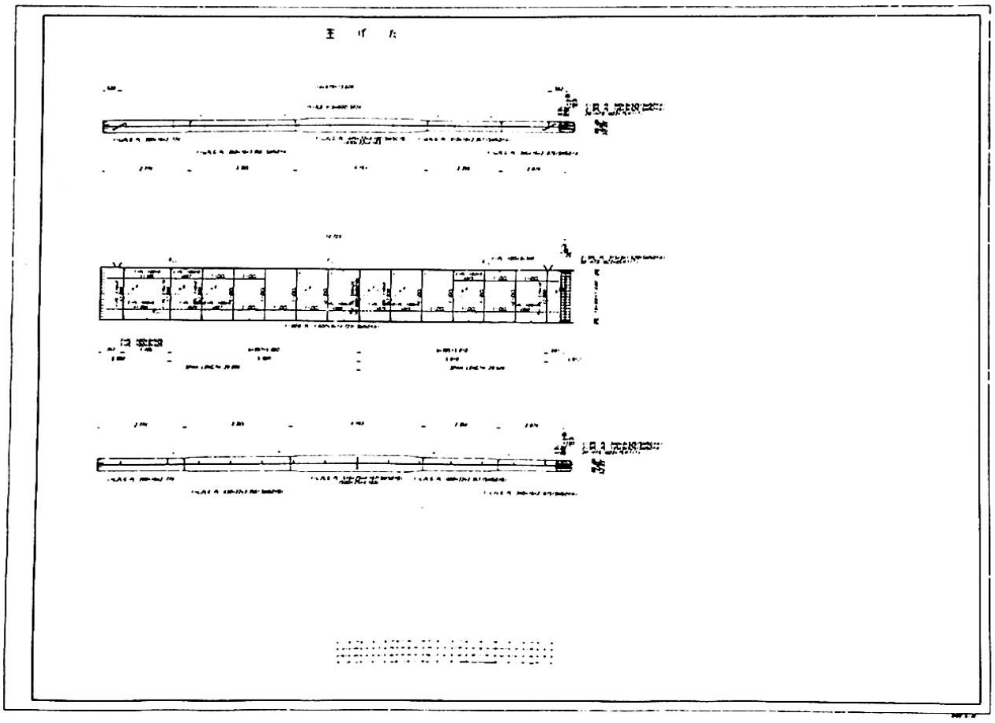

Fig.5 A drawing of main girder by COM

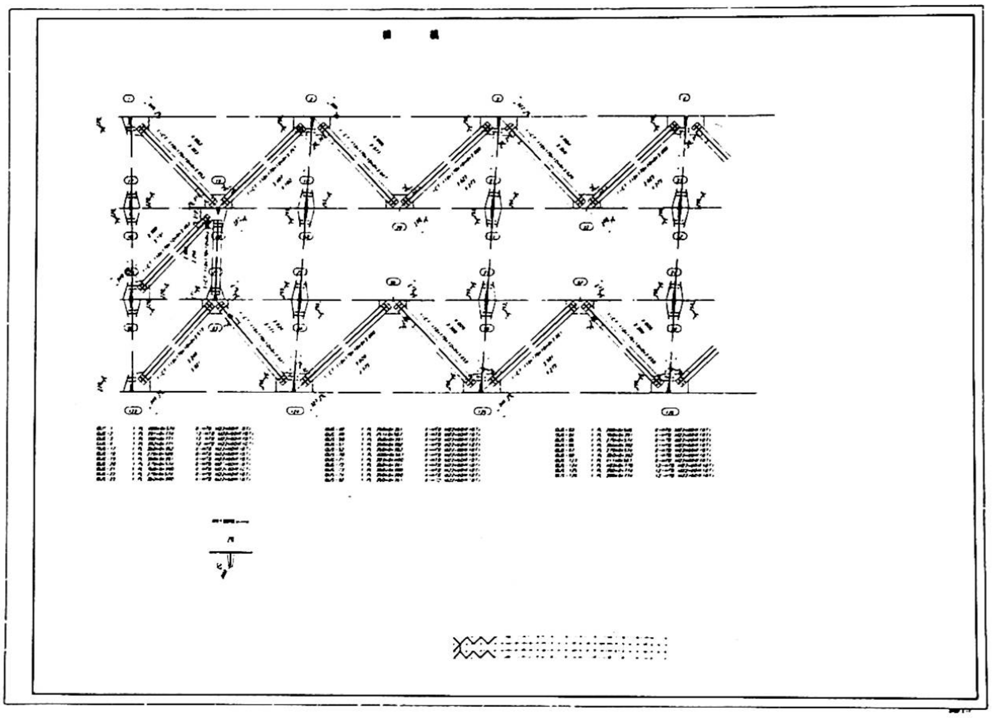

Fig.6 A drawing of lateral bracings by COM

4. REFERENCE

1. Ueno, Mikami, Tanaka, Kamemura and Maruyasu: "Total Computer System for Bridge Design and Loft" Civil Engineering Society Bulletin, No.65, Feb. 1974

2. Sasaki, Sugawara, Tanaka, Shoji, Kamemura, Oishi, Maruyasu and Mayuzumi: "Total Computer System for Bridges", Nippon Kokan Technical Report Overseas, No.21, Dec. 1975

SUMMARY

A "Total Computer System for Bridges" has been developed, which is aimed at combining the optimum design and the judgement of designers. This system has already been used for actual applications and has produced good results. This report introduces design of a girder bridge in the overall system.

RESUME

Un système global pour le projet de ponts au moyen de l'ordinateur a été développé. Ce système combine le calcul optimal et le jugement de l'ingénieur. Il est déjà utilisé en pratique et donne des résultats excellents. Cet article présente la partie du projet de pont en poutres dans le système global.

ZUSAMMENFASSUNG

Ein totales Computersystem für einen optimierten Brückenentwurf wird entwickelt. Das System verbindet die Absichten des Entwurfes mit einer optimalen Problemlösung; in praktischer Anwendung hat das System bereits gute Resultate geliefert. Am Entwurf von Brückenträgern stellt der vorliegende Beitrag einen Teil des gesamten Computersystems vor.