COMPUTER APPLICATION IN DESIGN AND CONSTRUCTION OF SPACE FRAME

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BACKGROUND

In Japan, the construction of huge space structures, such as sports halls and exhibition halls, has recently become more widespread.
Space frames are an important method for constructing steel structures having extensive column-free space. In space frames technology, computers have been used for structural analysis, however, computer can also be used for design and construction, from the standpoint of information management.

FURTHER COMMENTS

I. Design of Space Frame Shape and Grid Pattern.

When the plane on the nondimensional coordinates is divided by a grid, such as "Example of grid patterns", the space frame on the three dimensional coordinates is also divided by a certain rule based on the isoparametric shape function of the finite element method. The member lengths, the joint coordinates and the joint angles are automatically determined.

II. Structural Calculations.

"Examples of stress distribution" shows the magnitudes of stress by the thickness of the line of the members, the qualitative tendency of stress distribution is visually portrayed. The line in black indicates compression stress, while the line in white indicates tension stress.

III. Design of Members and Joints.

"An example of member list" shows the sequential number marked on a member, the number of joints at both ends, and the length of a member. "An example of shop drawing" shows the drilling positions of a joint.

IV. Manufacture of Members and Joints.

Manufactures make the members and joints, accurately observing each specification , with no idea as to where they are used in the space frame.

V. Marking.

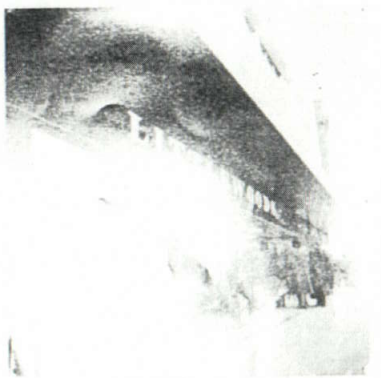
VI. On-Site Assemly and Erection.

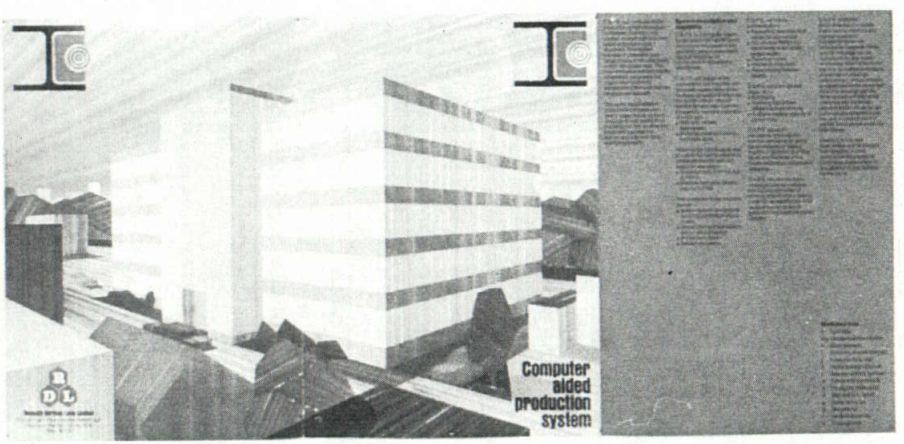
Computers can be also used for the safety analysis at the time of erection.
The figure shows the changing stress at each of erection and the calculation results.

FUTURE POSSIBILITIES

The concept of computer controlled information management is not limited to such examples and will become increasingly important to general building structures.

Littlewoods Store, Stoke on Trent, England – involved CAPS (Computer Aided Production System) detailing of 973 tonnes of structural steelwork.





CAPS - BASIC FEATURES

Some 18 man-years of research and development by RDL have gone into making the computer-aided detailing of beam and column structures a functioning reality. The benefits of this work are now available to the steelwork fabrication industry, consultants and other major users of structural steelwork.

CAPS is set up to handle beam and column structures of any geometry using a rationalised basis of design for all connections in accordance with British or National Standards.

All connections are designed automatically except where they exceed the design criteria and these are reported to the user.

The system works to a set of preferences, for instance bolt pitch and sizes, but it will adjust where necessary.

Users can easily specify their own preferences by simple commands and can select, for example:
- Bolts from 4.6, 8.8 or HSFG grades.
- Rolled sections, made-up section plate girders and also AUTOFAB.

Bolted and welded connection types available include:
- Bolted moment connections using top and bottom angles or tees.
- Welded moment connections with or without haunch.
- Double web cleats.
- Welded end plates.
- Splices, base plates.

CAPS will handle automatically:
- Eccentricity and skew, both horizontal and vertical.
- Extra fittings, etc., extra holes, shear studs, ledger angles, unusual stanchion bases, stiffeners.

CAPS will automatically check for:
- Bolt fouling.
- Notching.
- Adequate connection strength.

Users may nominate the erection sequence by giving the boundaries of 'blocks' in terms of grid lines and floor levels and the order of the blocks determining the erection sequence.

The output produced by CAPS is extremely comprehensive and includes the following schedules automatically:
- Cost estimates - materials and workmanship.
- Scheme drawings - marked and cross-referenced.
- Detail drawings - with piece marks, standard symbols and an index.
- Material lists.
- Cutting and drilling lists.
- Shop bolt lists.
- Site bolt lists.
- Erection sequence lists.
- Numerically controlled tool tapes.

All CAPS operations are carried out in a fraction of the time they would take by traditional methods.

For further information please contact:
BUROTEC, 53 Goldington Road, Bedford, England.

NIKKEN SEKKEI
JAPAN

Harmonious Development of Computer Analysis and Structural Design

Dynamic Analysis of a Tall building under Strong Earthquakes

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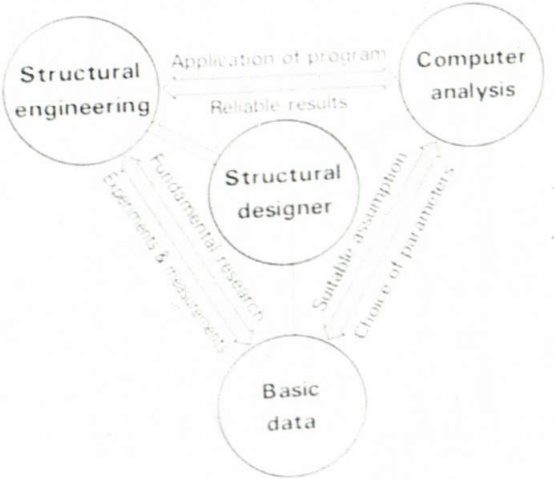
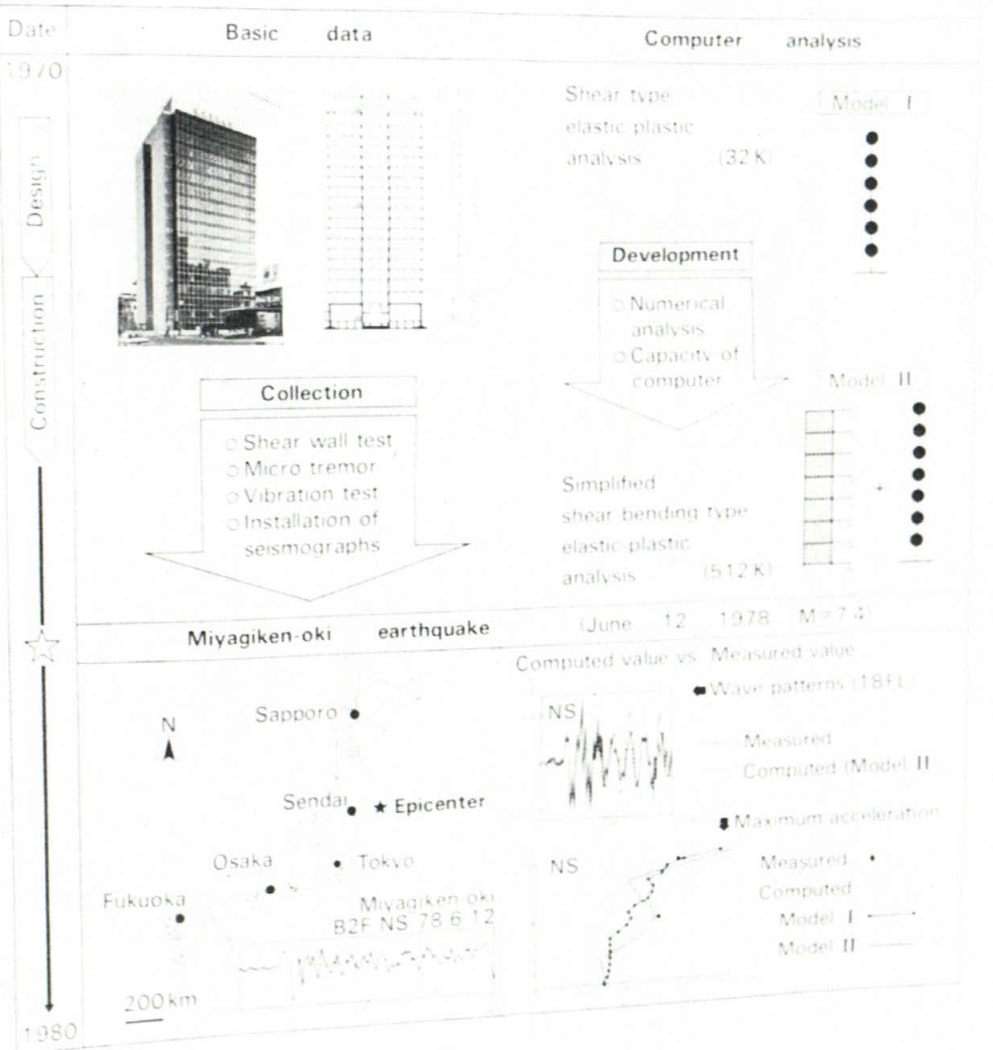
A computer plays the following two major roles in the field of structural design. One is the fast and accurate processing of data, a task which involves enormous volume of work but requires only simple thinking. The other is the computer's aid in theoretical analysis of structure, which has tremendously expanded the domain of numerical analysis. The future development of structural engineering depends, to a great extent, on the pursuit of theoretical analysis through understanding of the computer's roles and at the same time on the storage of basic data, both requirements having to be advanced in a well balanced state. From this viewpoint, the authors introduce here their ten year experience obtained from the design thro simulation analysis for a tall building (in Sendai city) which encountered strong earthquakes.



Structural design in Computer Era



" HARMONIOUS DEVELOPMENT OF COMPUTER ANALYSIS AND STRUCTURAL DESIGN "

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Basically, the authors' poster is separable into two segments: a theoretical vision reflecting a structural engineer's roles in the computer era; and a typical example of such correlative event and study as envisaged in that vision. Thus, the following two became the main subjects of discussion with the audience.

☐ Discussion about "Structural Design in Computer Era"

Most of audience favorably agreed to this vision, with the related discussion covering the following.

1) Development of Program: At the authors' firm, the typical way of developing computer programs is that related engineers, say, those at the computer department and the structural department associate themselves with each other by establishing an adhoc task force on a specific project. When this was explained to the audience, most of them admitted that this approach was the most preferable way because the structural engineers' participation in programming would certainly make the program easier to operate and more effective, but some audience commented that this approach was difficult to follow in their country because of professional separation of analysis from design in practice.

2) Operation of Program: The authors explained that they used their own computers installed for in-house use, viz. two machines of IBM 370-M138 and associated terminals. Besides these machines, small computers of about 100 K are provided at the structural departments for simple calculation and analysis. Though all these programs being developed for in-house use, two major programs for integrated structural analyses as authorized by the Minister of Construction are made available to outside structural engineers under licensing agreements. Such positive attitude of the authors toward computer use was favorably accepted by the audience.

☐ Discussion about "Typical Example (Dynamic Analysis of a Tall Building under Strong Earthquakes)"

The practitioners for whom seismic force is an indispensable consideration made wide-ranging inquiries, from aseismic design methods in Japan to assumption of coefficients for the analyses, eventually being followed by rewarding discussion. They regarded this example as very rare and invaluable study which certainly helped to provide a basis for the harmonious development of computer analysis and structural design.

Thus, the authors acknowledge that the poster session afforded the authors with an otherwise unobtainable chance for better communication among participants to have them thoroughly understand the authors' philosophy. With their attitude so successfully supported, the authors wish to develop further study.