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Educational System for Structural Engineering Using Personal Computers

Système d'enseignement dans le génie des structures à l'aide de micro-ordinateurs

Ausbildungssystem mit Minicomputern für das Bauingenieurwesen

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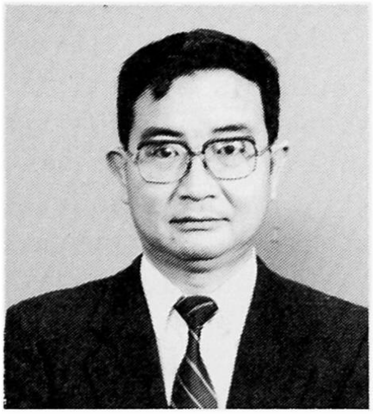

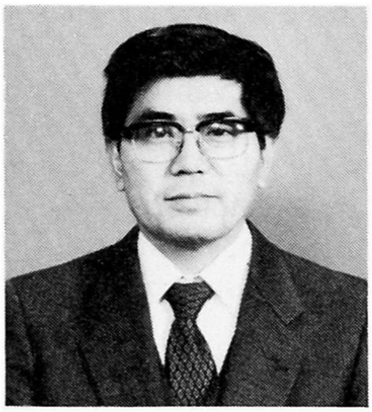

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SUMMARY
There are many subjects that students must learn in the short time available for structural mechanics and engineering. By using animation techniques, color display functions, etc. on mini-computer systems, it will be easier for students to understand the relationships among many concepts, theories and equations in the structural engineering field.

RÉSUMÉ
Il y a un bon nombre de sujets que les étudiants doivent apprendre en peu de temps. Par l'utilisation des techniques d'animation, les possibilités de l'écran en couleur, etc. du système de micro-ordinateur, les étudiants pourront comprende aisément les relations parmi un bon nombre de concepts, de théories et d'équations dans le domaine du génie des structures.

ZUSAMMENFASSUNG
Bautechnikstudenten müssen sich in kurzer Zeit Wissen in vielen verschiedenen Fachbereichen aneignen. Bisher mußte der Student sein Wissen mit Lehrbüchern, Tafelbildern und Uebungsvorlagen erarbeiten. Unter Verwendung eines Minicomputersystems, mit Animationstechnik, Farbdisplayfunktion u. dergl. kann der Student auf einfache Weise die Zusammenhänge zwischen verschiedenen Konzepten, Theorien und Gleichungen im Rahmen des Faches Bautechnik begreifen.

1. INTRODUCTION

Students must learn and study many subjects and terms in the structural engineering field. There are fundamental subjects such as mechanical properties from pure physics, and strength of materials. Combining these subjects, students must also understand the more complex subjects of structural engineering. They must learn about the materials of which buildings are made. There are the more linear elastic materials such as steels and also the nonlinear materials such as soils and concrete. The teachers will also explain the difference between static and dynamic problems. At the same time, engineers in this field need to understand the relationship between these subjects and real structural designs. As a result, both teachers and students waste much energy in coming to understand these complex subjects.

In conventional structural engineering education, many subjects and terms are studied step by step from the fundamental theories and axioms, using only blackboard, paper, and simple exercises to reinforce them using abacuses and calculators. This process requires much time to build up understanding of complex structural designs through many simplified exercises and experiments. This would be logical, if the student learns to understand and manage complex designs in the end, but most do not.

On the other hand, the development of computer systems, both hardware and software, has been remarkable since 1950. Many application programs for structural analysis and design have been developed. It has been quite convenient for users of this software to get their results simply by preparing the input data and putting it into the computer systems. However, these application programs are not the ones used as educational systems for structural engineering. It is quite easy to use application software for structural analysis and design. It does not mean that users end up with an understanding of the essence of structural engineering, though it is quite difficult to produce the structural analysis and design software without understanding the essence of structural engineering.

It has recently become possible to run this software on personal computers. Such a machine, equipped with a large amount of memory (1 Megabyte or more) and a hard disk with a capacity of 40MB or more is no longer difficult to find, or afford.`Hardware makers supply the colour display with high resolution and performance. The users can see the behavior of the structures under different loading cases like the real ones, utilizing animation techniques of the systems. Using these excellent computer systems, it is possible to understand the true essence of huge structural engineering projects, not only as the theories, but also through the behaviors that computer systems show. It is easy to demonstrate some of the more complex behaviors, that cannot be seen even in the actual experiments, by using this display equipment.

In this paper, several of the functions in the system that is now being developed are reported.

2. CONVENTIONAL EDUCATION

Generally speaking, the curriculums for conventional education in the structural engineering field are planned for 4 years of universities study and 3 years in the technical high schools. All the content of the education is divided into many lectures. Some teachers take charge of each part in their lectures from preliminary stages. Students start to learn the primitive axioms, and theories from the first step. After they perfectly understand each theory and term, the teachers progress to the next step. With this method, students learn the strength of materials from linear to nonlinear problems, structural mechanics from static to dynamic problems, etc. For this reason, they can understand the theories and terms loosely in each course of lectures. It is difficult for students to understand theories and terms while recognizing the logical connections among them in the whole structural engineering.

When students go out into the world of practice, corporations and laboratories must reeducate them. Because the structural engineering field is quite large, teachers and students must recognize the fundamentals of it in their lectures. Recently, students are able to use many computer systems. According to these environments, the lectures on the use of computer systems have been started in the universities and many technical high schools. It is easy for students to perform some numerical analysis, statistics and graphic presentstion of experimental data.

3. COMPUTER–AIDED EDUCATION

It is true that the computer faculties are more powerful in the structural engineering field. Especially, it is quite efficient for us to get good results for numerical analysis, simulations, etc. The developments of numerical techniques have been done for many differential equations in the structural engineering field. Many computer programs for numerical analysis have been produced with this development. These programs could not be made without understanding the essence of structural engineering. In the process of production of these programs, it is necessary to know the fundamentals in order to check the results.

It is not useful for students to use only computers and see results output. Once many programs in development are finished , it will be difficult to understand all of the programs due to their complexity. As the excellent environments of the computer systems were described before in this paper, the educational systems will be changed by using modern computer facilities. Using these computers, it will be easier to study structural engineering. Students will be able to see the behaviors of structures under dynamic loadings that could not be inspected even in experiments. It is necessary to combine basic theories and axioms with the high numerical methods and technologies for making the convenient systems. The total concept has been working by considering the database of the system for functions and terms. It will result in a bigger system. However, the functions of the systems should be divided into compact sizes. Some prototype functions have been built. They are shown in this paper.

4. HARDWARE CONFIGURATION

We show the hardware system in Fig. 1 that has one central processing unit, 1 mega byte main memory, 2 floppy disks which users will select the size 5 inch or 8 inch, as the external memory, one lineprinter, one keyboard typewriter, one mouse and one colour display.

Students always use the keyboard by seeing the colour display to understand the lectures. It will be necessary to set the lineprinter for a hardcopy of the lecture. It will be better to select the command and the data for students to use the mouse. We estimate the cost for this system less than 5 hundred thousand yen. It will also be necessary to have the animation function with th display cathode ray tube in this hardware configuration.

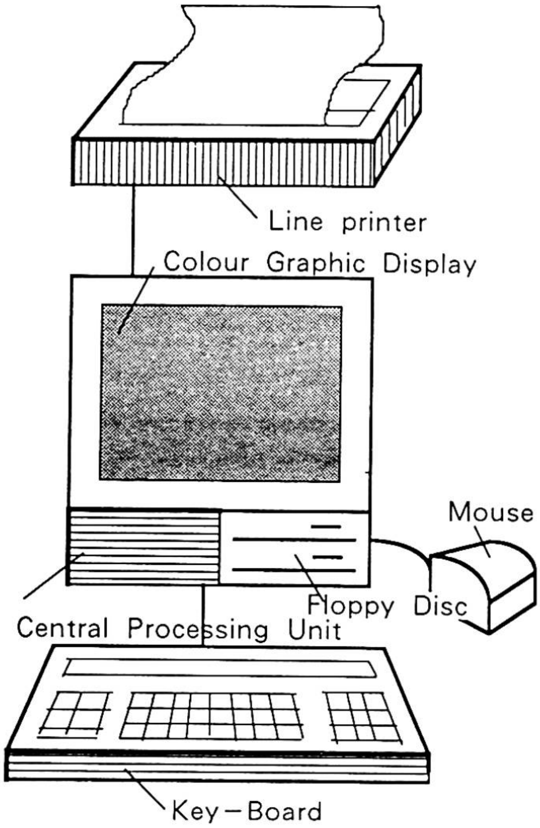


Fig.1 Hardware Configration

5. SOFTWARE FUNCTIONS

We list up the software functions as followings.

(1) Students can see the relations between all subjects by using the indices on the terminals. This system has the database system which connects with all subjects.

(2) By using the database system, students can select all suppositions, all theorems, and all knowledges. It will be quite easy to study them in accordance with their selected levels.

(3) There is the HELP function to give instructions to the userswhat they need to perform.

(4) Users can see the explanations with beautiful and understandable display, for example, aminations.

(5) Teachers can know the students' capabilities, and also can advise the students.

(6) Teachers can select the exercise problem on the terminal arbitrarily.

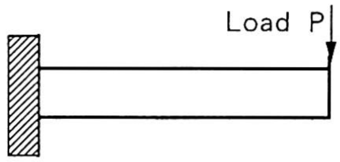
(7) There is the calculator function in this system. With this facility, students

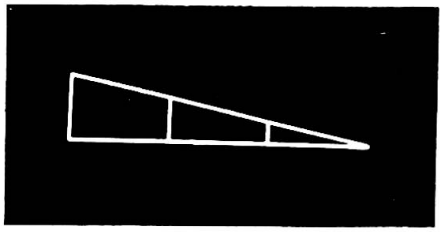
can perform calculations for the exercise problems. With a mouse, students can calculate.
(8) Students can handle the fomulas. And also check them.
(9) Students can use the display as the memorandum paper.

First of all, you will be able to see the displacement diagrams of the canti–lever beam for the concentrated load in Fig 2. Students would be able to understand if the bending moment is considered. Probably, students will better understand if they have the basic concept for the bending moment from the teachers exactly. Students can see the dynamic behaviors with the animation function,e.g. for experiments. It is easy to change the sectional sizes of beams, and on the colour display all of the forces can be seen as if forces were propagating.

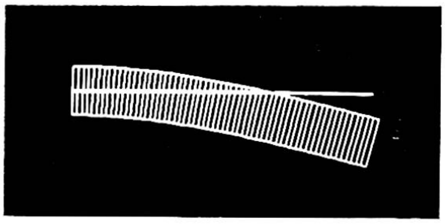
In Fig 3, students will be able to see the shear deformation that the bending moment will be ignored by considering only shear deformation. After that, students will learn Navier assumption for the stress and strain distribution in the beam by showing them on the colour display. At last, students will be able to understand the assumptions. In other words, it will be clear for students to understand the difference between two assumptions. We show the diagrams in the final stages. Actually, students will be able to see the displacement diagrams by using the animation technique. Students know the essence of the deformations for bending moment case and shear deformation case, because we will show the deformations gradually corresponding to the static load scales.

Next, we will show another deformation diagram for the frames in Fig 4. At the same time, students will understand the bending moment diagram in Fig 5. In Fig 6, we will show the space structure. Seismic ground motion from many directions will





Bending Moment



Deformation

Fig. 2 Cantilever beam

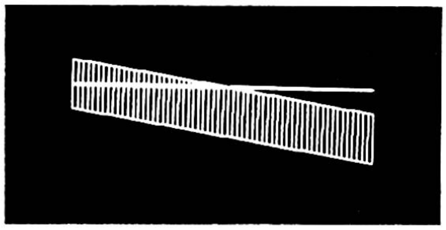


Fig. 3 Shear Deformation

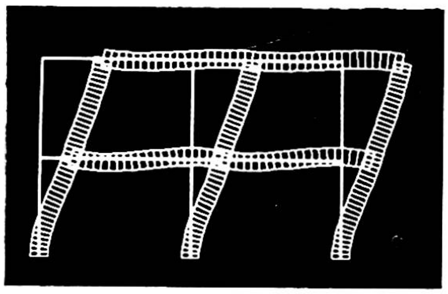


Fig. 4 Deformation

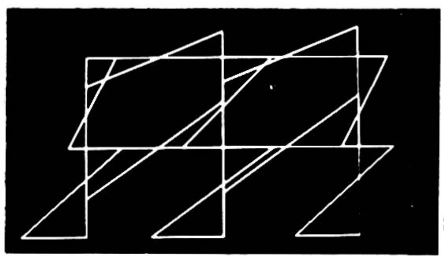


Fig. 5 Bending Moment

come to the structures with reinforced concrete columns' properties as shown in Fig 7. In Fig 8, and in Fig 9, we can see loci of column shear forces in X and Y directions. Of course it will be possible to understand the dynamic behavior of the structure. It will be very easy to understand the dynamic response for the seismic ground motion. It should be very good to understand the behavior of the structures as students can actually see the behaviors of structures for the earthquakes on the colour display. At the next stage, students will perform the exercise problem on the display terminal. If students make errors, this system will suggest and advise with some comment.

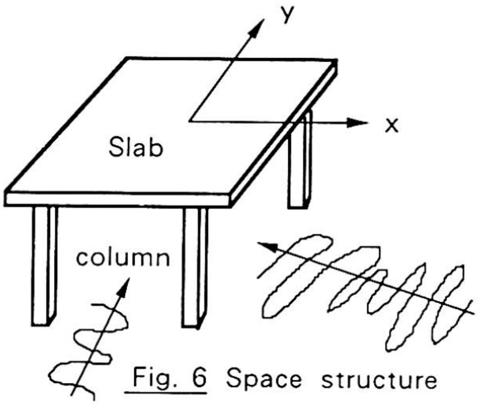


Fig. 6 Space structure

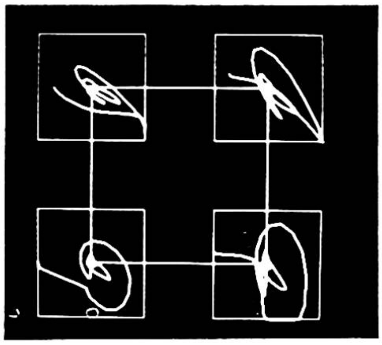


Fig. 8 Loci of column shear force X and Y

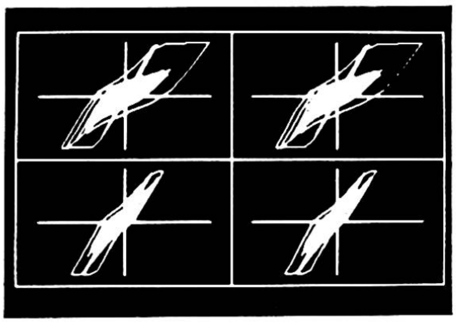


Fig. 7 Hysteresis loop of column shear force and story deflection

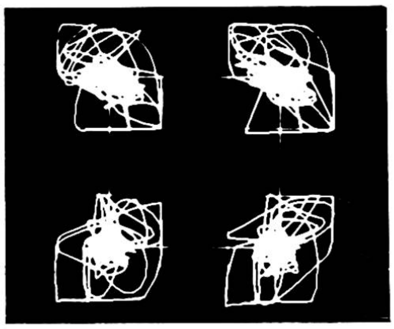


Fig. 9 Loci of column shear force X and Y after Some time in Fig. 8

6. CONCLUSION

Now we are on the way to develop good education systems using personal computers. Gradually, we will study the essence of the education system by investigating real education. From now on, it will be necessary to get many opinions from the people who will use the education systems. In the near future, we will consider combining the artificial intelligence systems with education systems. However, it is necessary to make the small systems with micro−computers. From these each small systems, we will develop systems adequate for students and teachers alike. We intend to connect this system with large network systems.