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Some Application of Computer aided Graphics

Exemples de répresentations graphiques à l'aide de l'ordinateur

Einige Anwendung von der automatischen Darstellung

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Summary

The author emphasizes the computer aided graphical presentation as useful means for structural analyses with several exemplary figures. Vibration data analyses of existing structures are being put to practical uses by systematic design of instrumentation and data processing. Structural design and analyses can be improved much by visual images. The author intends to standardize the specification of a computer for structural engineering, wherein programs for graphic purpose as well as those for stress analyses are included.

Résumé

L'auteur illustre la représentation graphique à l' aide de l' ordinateur comme moyen utile de calcul de structures au moyen de plusieurs exemples. L'analyse des données de vibration de structures existantes est en train de devenir opérationnelle grâce à l'étude méthodique des instruments et du traitement des informations. Le projet et le calcul de structures peuvent être améliorés grâce à images visuelles. L'auteur a l' intention de normaliser le cahier des charges d' un ordinateur pour le génie civil, qui comprendrait aussi bien des programmes de représentation graphique que d' analyse de contraintes.

Zusammenfassung

Es wird an Hand einiger beispielhaften Abbildungen gezeigt, dass für Tragwerksberechnungen mit dem Computer die automatische graphische Darstellung der Resultate wichtig ist. Der Autor regt an, das Pflichtenheft von Computern und Programmen für Tragwerksanalyse und graphische Darstellung in Konstruktiven Ingenieurbau zu vereinheitlichen.

1. INTRODUCTION

The author's research activities are basically laid on the safety of existing structures through their lives from the beginning of design works to the end of public uses. Besides theoretical analyses in the office, inspection of structural being gives much information at the sites during construction works or under public uses. It seems useful for structural safety to obtain information of static and dynamic characteristics of the existing structures by various non-destructive testing, because theoretical estimations will not always agree to the expected results tested in the field. Comparative studies must be, then, carried out by using various data so that some reasonable results may be obtained.

An electronic computer becomes, nowadays, a powerful tool for data processing as well as for numerical calculation. Moreover, electronic instruments are becoming much more convenient for measurement works. It is then considered as a system that is consisted of various equipments and devices used for structural surveys. An electronic computer will play a great deal in the system, however, the author would like to emphasize the presentation methods aided by the system.

Viewing from the topological aspect, most of the engineering activities have the aims to construct geometrical space objects. Moreover, before or even after their completion, many plain figures play a great deal of information exchanges. Engineering drawings, presentation figures, topographical maps and numerous documents with symbolic patterns i.e. letters are generally considered as plain figures which can be reproduced on sheets manually or automatically.

During the design activities of a structure, human brain imagines space figures, estimates dimensions iteratively and shows his decision graphically. The procedures include mathematical and logical methods. Therefore, the design works can be aided by computers. In order to save hand writing works total design procedures must be projected so that any of the results may be displayed graphically. Computer programs are then reviewed and must be reconstructed for the graphical purposes.

The author has been developing the computer aided design as a tool for research activities. The following articles are showing some examples of graphical application related to structural engineering.

2. VIBRATION TESTING AND ANALYSES

One of the inspection methods of existing structures is to obtain the dynamic behaviors. Generally, structures play more or less vibrational phenomena. Even on rigid foundation, ground shows small amplitudes if high sensitive sensors are used. Flexible structures, such as bridges, have natural frequencies that can be attested by theoretical estimation. The vibrational characteristics will be applied for the inspection of stability, for an instance, there is a fact that a very slow periodical phenomenon appears before buckling occurs in unstable members. As a medical doctor makes sonic inspection of human bodies, the vibrational characteristics may give much information on the states of structures if the data are statistically analysed. There arise two principal theses. One is practical procedure of measurement and the other is on the method how the results be prepared on the engineering decision making.

Since 1960, the author is gathering the vibrational data of bridges, dams, chimneys, earth structures as well as structural foundations. The measurements were carried out after a standadized procedure when any possible chances were allowed for tests. There arise some difficulties to test real strucures. Besides cost, which are anyhow basic ones, the tests are restricted not to disturb usual services which the structures are offering to. For instances, tests on highway bridges must be carried out not to disturb traffic flows. Building tests need special cautions for not to make their tenants feel uncomfortable vibration. Moreover, the tests must be so simple, low in costs and easy enough as to be operated anywhere the structures stand. Data of vibration must be gathered as much as possible from the view point of statistical analyses under consideration of standardized procedures. The measurements of vibration need some shaking force against the concerned structure. In cases of bridges, usual traffic gives sufficient excitation for the measurement. Large and flexible structures such as chimneys, suspension bridges, high story buildings etc. can be easily excited by wind without waiting for seismic shaking. A heavy duty truck often makes good excitation on earth structures.

The vibration data are recorded in a magnetic tape of a data recorder about three to five minutes as unit logical length of a datum. The quality of data is not always expected in refined manner, but the data usually show random waves which are seemed to be less useful. Recent development of statistical analyses has changed the situation and now such random data are most valuable, because the randomness occurs as the results of fruitful properties mixed in a single datum. If those properties could be separated individually or transformed into some visual paterrns, we could ignore some information on the states of structures. Graphical presentation is then applied in order to judge the results of measurements, because some definite values will scarcely appear among the data.

Decision on the states of structures is made by human brain, by comparing those graphical patterns as a medical doctor watches X-ray films. Fig. 1 shows an example of our catalog file of vibration data. Each line has length of one minute phenomena. Numerals on the left column indicates the counters of data location on a digitalized magnetic tape. Fig. 2 shows the results of spectrum analyses of the above records. Each line shows a spectrum of some definite number of samples. Samples are dislocated by a definite number of counters and every tenth line is written by a thick pen for visual aid. The author names those figures as catalog records and running spectra for data storage purpose. Fig. 3 shows more detail presentation chosen from the catalog records by the aid of the counters.

The vibration data do not directly give definite conclusion on the safety of structures, but they shall be considered as some references to be compared with various other structural properties. Comparative studies are making good conclusions among similar structures. Aging of a structure will be obtained from two data taken on its completion and after some length of years. For this reason, it is proposed by the author to the Japanese Expressway Corporation that the vibration data should be taken on the bridges on their comple-

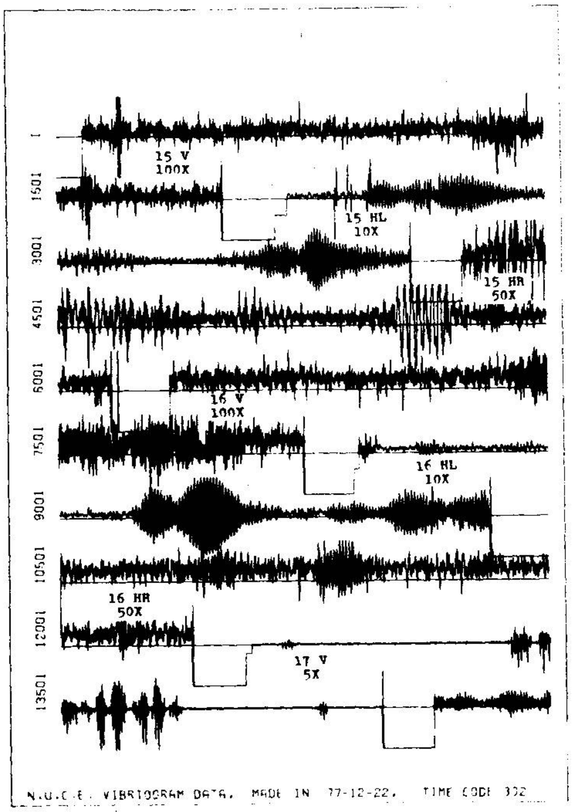

Fig.1 Vibration Data reproduced graphically from MT storage file.

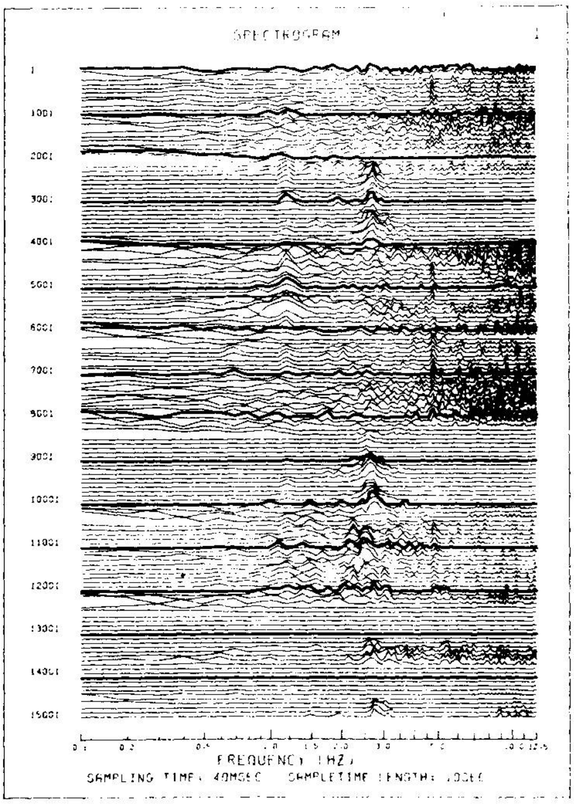

Fig.2 Running Spectrum Presentation of Vibration Data.

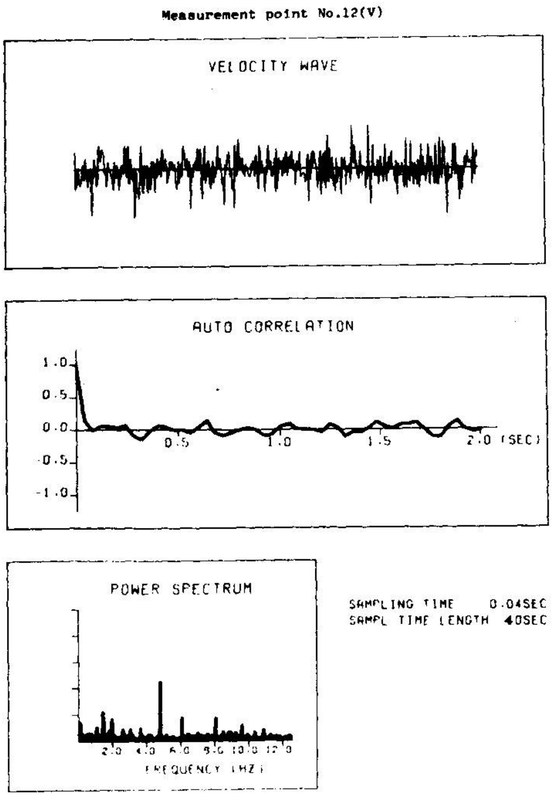

Fig.3 A Graphical Document of some finite length of Data Record.

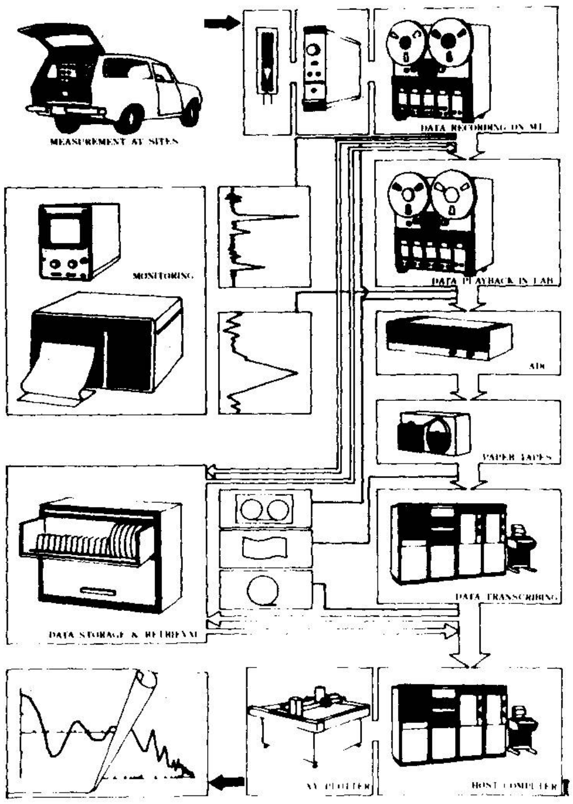

Fig.4 Systems flow on Data Processing of Vibration Data.

tion as one of their maintenance documents. After some years of public uses, current vibration data will inform some useful knowledge on the safety of bridges. The systems design is considered on both hardwares and softwares.

Experimental researches on structural behavior need many instruments operated in field as well as in laboratory. The circumstance for tests at the sites of structures is not usually expected better than in laboratory tests. The sytems through measurements and analyses must be then carefully designed in order to save the costs and manpower. The instruments for tests usually transmit voltage signal, i.e. analog data. Every instrument is more or less is an analog computer that makes calculation among voltage signals. Data processing after the tests is operated by both analog and digital instruments. As most of theoretical analyses are calculated by digital computers, it is preferable to convert the measured data into digital format. Therefore, the instrumentation consists of several data conversion systems. Fig. 4 shows a schematic presentation of our data processing layout.

3. GRAPHICAL PRESENTATION OF STRUCTURAL ANALYSES

Numerical calculation by the use of a computer is becoming an essential task in structural engineering. Above all, structural analyses require a great deal of special calculation that is scarecely used in common. For an instance, those calculation which are aimed at each different purpose such as for stress estimation in design works, real stress distribution under construction, structural behavior under public uses and so on. In order to prevent overrunning of calculation by false instruction, the calculation must be delayed at several check points where an engineer makes his decision whether the task should be continued or corrected. Instead of mass of numerals, graphical presentation is preferable to inform him useful messages that can be checked at a glance. Visual patterns are not always necessary to be theoretically correct but enough to emphasize the properties now in process.

Figs. 5/8 are some of the graphical trials to emphasize the structural characteristics in stresses and deformations. Fig. 5 shows a perspective presentation of a steel arch bridge as a wire structure. Hidden line elimination is applied to clarify spatial member location. Fig. 6 is showing deformation under loading of a heavy duty truck at a quarter of bridge span. The scale of deformation is magnified by a hundred times so that relative displacement of members may be emphasized. Figs. 7/8 are both showing member stresses in two different manners. The former displays whether the stress is tensile or compressive. The latter shows absolute magnitude of stresses without regarding these signs. A motion picture can be applied for dynamic characteristics of such structure under moving vehicles. Vibrational response is an interesting research object for flexible structures, however the programs must be supplied for such purposes.

Generally speaking on structural analyses, a great deal of data are necessary, such as, for structural dimensions, loads, etc. The data are classified into two sorts, that is of original condition and of secondary produced ones. Stresses and deformations under vehicle loads are the secondary data that are partly given as one of the

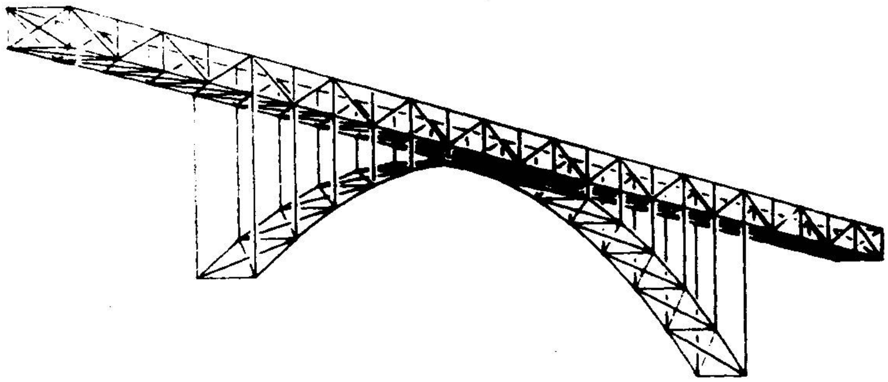

Fig.5 Perspective View of a Wire Structure.

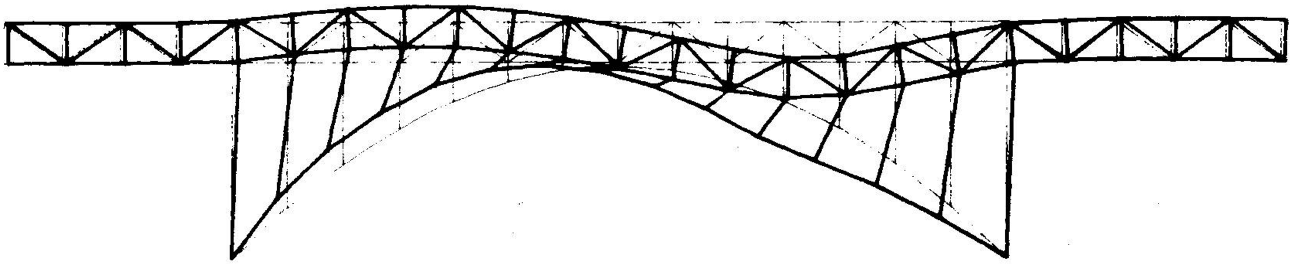

Fig.6 Emphasized Deformation of a Bridge.

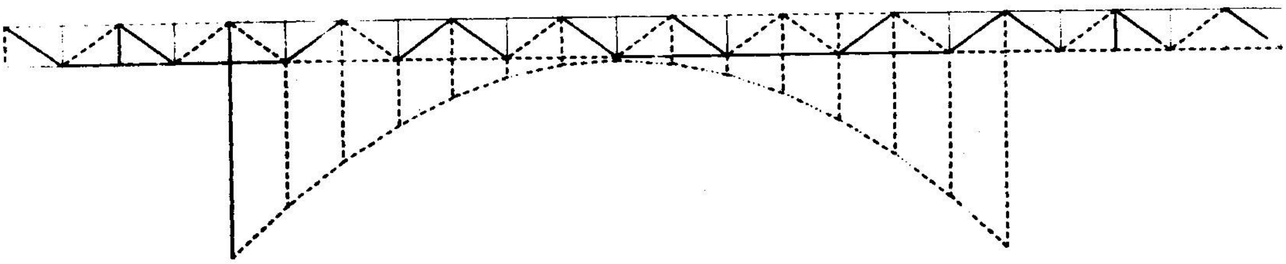

Fig.7 Member Stresses whether tensile or compressive.

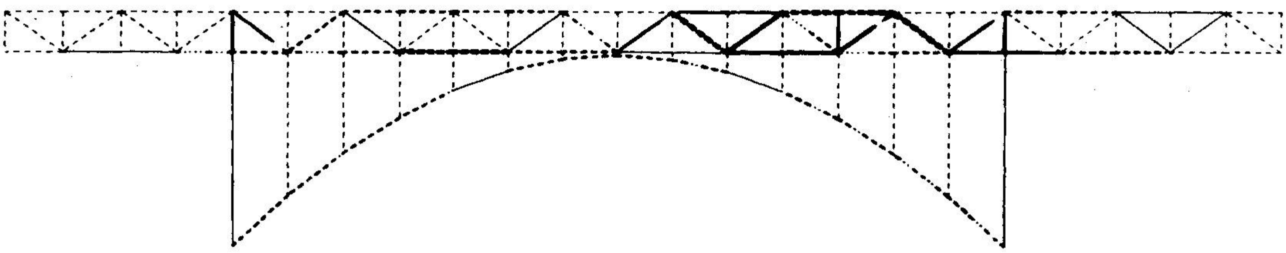

Fig.8 Member Stresses regarding on their absolute magnitude.

conditions and estimated from the other data. In course of practical works, many data are calculated, checked, revised and stored for engineering documents. It is only possible in computing processes where the data are commonly stored in a huge storage device and also many requirements for calculation are separated into each small unit program that work absolutely. The programs for graphical purposes are composed to be one of those unit processes. A large program unit such as STRESS or NASTRAN is not always preferable for our researches because the data can not be dymnamically referred on user's request. The most important design of computing system is, therfore, that of data storage and retrieval for structural analyses. A researcher can compose any special processes only regarding the standardized data format.

4. GEOMETRICAL SYNTHESIS OF SPACE STRUCTURES

An intersting application is found on the simulative generation of space structures by means of a graphic terminal and a keyboard connected to a computer. Operating procedures are in the following manners. A man looking at a CRT send his instruction to generate several units of three dimensional bodies in an imaginary space. Each body can be spatially moved or rotated by his instruction from the keyboard. The bodies are then synthesized to create more complicated space figures by so-called addition, subtraction, cutting and welding among bodies. The procedures are like machinery works. The processed bodies can be visible perspectively wherein hidden figures are eliminated or may be shown by broken lines. Shade and contrast are possible for more realistic images. Coloring depends on a display device that can generate color images. Orthogonal projection is also possible that may be applied for engineering drawings.

The several created bodies are then relatively connected so that they are assembled into a structure or a structural member. Modulus of spatial figures such as volume, surface area, center of gravity, moment of inertia and principal axes can be obtained. Therefore, the program will be directly applied for estimation of materials in, such as, concrete structures. The same processes are also developed for generating and synthesizing of two dimensional figures. This is applied for structures built up from steel plates as shown in Fig. 9.

The fundamental idea of processing was written by Prof. Hosaka [1] and a program package GEOMAP(Geometrical Modelling and Processing) is written in FORTRAN by the effort of Mr. Kimura. The author has been developing the package to more extended fields covering structural analyses. Some exemplary figures are shown in Figs. 10/13. In the first place, an over crossing bridge is planned at some location with several concrete piers and spans. Piers and girders are generated respectively and composed so as to build a long pass in a space. Secondly, a photograph is taken at a position viewing perspectively on a proposed location where the structue may be constructed. Geographical data are necessary in taking pictures. They are, such as, the position of a camera, viewing direction, coordinates of several objects that must be taken in the photograph etc. A perspective view of generated structure is then displayed graphically on a plotter sheet after triming its scale to fit the photograph. A montage picture is synthesized for the proposed structure. It is not our purpose to generate a complete picture by completely

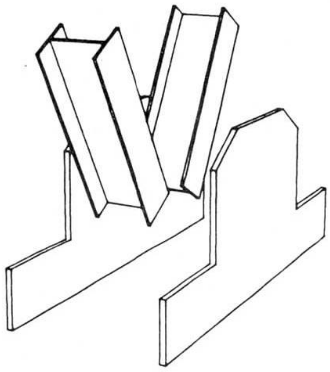

Fig.9 Synthesized built-up Members and assemblies.

Fig.10 Montage Picture by a Photograph and a synthesized Bridge.

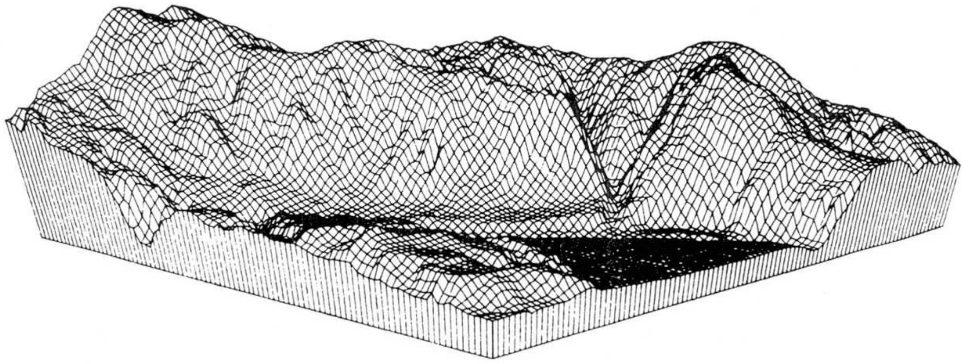

Fig.11 Landscape View of Digitalized Terrain Model.

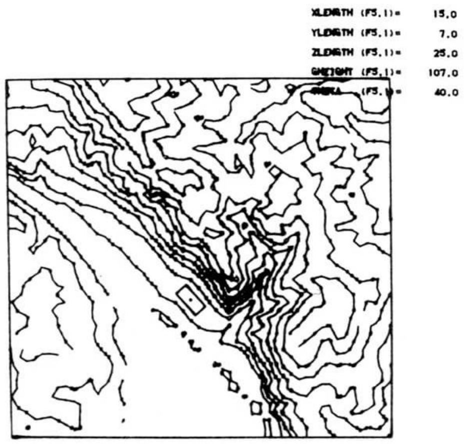

Fig.12 A Contour Map for Location Planning.

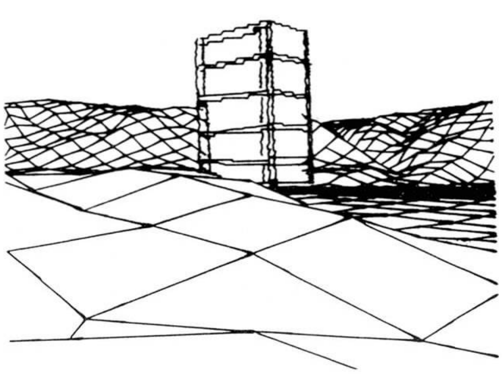

Fig.13 Composite View of a Building Model and Landscape.

automated procedures, but an artist may correct the picture by the aid of geometrical prototypes, which we call a persguide as a means after a perspective drawing guidlines.

In planning of landscape, a large area of geodetical figure makes a body with limited boundaries and a curved plain. Practical evaluation of this body is carried out by the aid of aerial photograph into a set of elevation at each intersection of meshes covering the area. A perspective view of this area can be drawn graphically from any desired direction. Excavation and banking are the same procedures as subtraction and addition of other bodies to this body. Fig. 11 shows a simulative addition of a cubic structure in this area after indicating its position and height by the instruction from the keyboard.

5. AUTOMATED DOCUMENT LISTING IN JAPANESE LETTERS

Most of the japanese users of computers have ever been wishing to obtain the list of processes by japanese letters, so-called KANJI or chinese symbolic lettters, because japanese words have much homonyms if they are spelled alphabetically after their pronounciation. Symbolic letters, KANJI are the only methods to inform exact messages of japanese documents. However, input/output devices for japanese documents are not so familiar machines as alphanumerical typewriter which has only about 50 species of symbolic types. Typists for KANJI-typewriters are the specialists for typing japanese documents searching and selecting desired letters from a board which contains more than three thousand of KANJI types.

KANJI letters are, as well known, nothing but graphical patterns. If graphical informations of each characters are stored in random access files and referred by such codes that are defined previously in connection with KANJI typewriter codes, japanese documents could be obtained graphically after they are processed by editing for the layout and presentaions. Principle of program technique is not so difficult, however, practical maintenances will cause excess works unless systematic concepts are undertaken. The author developed japanese letter presentation as one of the graphical tools that can be applied for engineering documents and engineering drawing aided by computers. The works are also applied in the university library for information services of japanese documents. Fig. 14 is showing a part of listing obtained graphically.

25 ドクメンテーション研究〔日本ドクメンテーション協会〕〔月〕 〔２〕中央館

26 Ｉｓｏｔｏｐ Ｎｅｗｓ〔日本放射性同位元素協会〕〔月〕 診技師学校

27 科学〔岩波書店〕〔月〕 工一化 理一数 理一水 工一物 理一物 工一数 理一化

文 工一航 診 空 養 中 工一核 工一制 一介 工一分 フ 工一電 育 経

28 ドクメンテーション研究〔日本ドクメンテーション協会〕〔月〕 〔２〕中央館

29 Ｉｓｏｔｏｐ Ｎｅｗｓ〔日本放射性同位元素協会〕〔月〕 診技師学校

Fig. 14 Japanese documents listing by a plotter

6. DESIGN OF COMPUTER PROGRAMS

There is a lot of resources on computer programs used in our researches. Most of them are carefully written so as to satisfy the least requirement for FORTRAN-7000 which is normalized by the Japanese Standards Organization. The programs are stored as subroutines to be connected on the request of main works. Length of each subroutine is written within one or two pages as far as possible, so that some of the subroutines indirectly call several other routines to save the pages. There are, therefore, many programs that seem less valuable because of their simple function, however, they become much valuable if a lot of those routines can be immediately referred for saving the length of user's program. For an instance, VMOVEP works for destinating of storage location from A to B with or without changing sign.

The resource programs have been developed by the following procedures. When a problem to be analysed occurs, a researcher at first composes his thought regardless of the resources. In most of the cases, the length of program becomes rather long for complete works. The program is then carefully reviewed so that some of the sentences may be replaced by one of the resources or may be composed as one of the resources. Such requirements often occur that the specification of some resource programs must be revised for more useful purposes. The author thinks that in a future trend these routines will become a set of structural analyses. Moreover, each routine will be fabricated in a micro-computer which is built in or connected logically to a host computer. As a table computer is getting smaller and cheaper nowadays, it is possible to think a computer, for structural purposes, composed of many pre-programed micro-computers. Use of high ability computers along with micro-computers is also necessary by means of communication lines and remote stations.

7. CONCLUSION

In order to make good interface between a computer and a man, graphical presentation aided by a computer will become necessary means in structural engineering. The application will be found throughout all engineering activities from design to maintenance works. Appropriate systems design must be carried out on both hardwares and softwares. It is expected that a built-up computer is to be fabricated for structural engineering with many pre-programed micro-computers in it. Standardization of programs is, then, necessary for the purpose.

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