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DEVELOPMENT OF ADVANCED SYSTEM FOR CONSTRUCTION TECHNOLOGIES WITH PROPER USE OF ELECTRONICS

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ABSTRACT

Since 1983, Ministry of Construction has been engaged in the research project "Development of Advanced Systems for Construction Technologies with Proper Use of Electronics". This project has the purpose of making contribution to improve construction technologies related to planning, design, execution, maintenance and conservation by application of the electronics-related technologies. Building Research Institute researched in architecture field and Public Works Reseach Institute researched in the other construction field.

The results of this project done by Public Works Research Institute are as follows:

1) Advanced systems for construction of tunnel, dam, bridge, pavement, etc. are designed conceptually.
2) Specifications of highly advanced construction equipments are proposed.
3) Some technologies for automatization of bulldozer and compacting equipment are developed.
4) Digital photogrammetric system is developed and applied to construction management of large-scale earthworks.
5) Construction information database system is developed.

1. OUTLINE OF THIS PROJECT

The Ministry of Construction of Japan annually sets up one or two general technological development projects, which have much publicness, technical feasibility and innovativeness and social adaptability.

Research and development for robotization in the constrution field started on 1983 as one of these proiects. The name of this project is "Development of Advanced System for Construction Technologies with Proper Use of Electronics" and after 5 years research this project is accomplished on 1988. The main objective is to make the way clear how to advance construction technologies in the sight of totality by properly and effectively utilizing high technologies.

This project consists of three principal items. The first two are individual elementary technical ones in software- and hardware-oriented approarch respectively and the third is a totalization of the system in integrational approach. In this project, soft technologies relate to computerized information processing and hard ones relate to new construction methods with robots and other automated mechanisms. The third main item evaluates each applicational development and totalizes into wholly integrated operational system.

For this Project, Building Research Institute researched in architecture field and Public Works Research Institute researched in the other construction field.

2. PURPOSES OF THE RESEARCH AND DEVELOPMENT

As things now stand the construction industry has many problems to

cope with. Large number of fatal workmen's accidents, decline in the construction work efficiency, decline in the number of workers laboring under severe conditions, aging of the working population of this sector, decline in the labor productivity of the construction industry and etc. Improving and upgrading measures are required to cope with these problems. Furthermore, concurrently with the increase in the social capital stocks, such as public facilities and the like, improvement is longed in connection with the efficiency of their maintenance and conservation.

On the other hand, electronics-related technologies such as computers, sensors, robots, etc., progressed rapidly of late, making it possible to automate works of various kinds and to execute them swiftly and accurately. The diffusion of industrial robots is a typical example.

Under the circumstances like this, there is an increasing demand for development of construction technologies aimed at improving the safety and efficiency, saving manpower and upgrading the quality and accuracy of the construction industry by making use of the said advances.

Bearing in mind the said background, this project has the purpose of making constributions to improve construction technologies related to the planning, design, execution, maintenance and conservation in the construction industry, by investigating the status quo and the conditions of application of the electronics-related technologies in the construction industry, and by developing the required systems and electronics-related technologies.

3. RESEARCH AND DEVELOPMENT PROGRAM

This project carries out the research and development of advanced systems utilizing electronics for the construction industries throughout a period of 5 years starting in 1983, in conformity with the research and development program described in the followings.

3.1 Research on the application of electronics to construction technology

(1) Investigation of the peculiarities of the construction industry

Aspects related to the construction industry, such as the form of production and distribution of construction materials, composition of the construction industry work force by type of occupation, age group and technical skill, the actual circumstances of the work at various labor environments such as high places, deep places, urban areas, as well as other relevant matters, are elucidated through the existing literature and statistical data, and fields of the construction industry susceptible of technical improvements, fields susceptible of application of electronics-related technologies, etc., are examined with the purpose of identifying factors related to the promotion of the advancement in some aspects of the constrution industry, such as upgrading of the safety, improvement of the productivity, upgrading of the quality and accuracy, as well as setting up the foundations to examine the fields susceptible of application of electronics-related technologies.

(2) Study related to the conditions of utilization of electronics in the construction industry

The conditions related to the application of electronics in construction technology are elucidated by examining the status quo of the electronics-related technologies as well as examples of their utilization in the costruction industry, through the investigation of the existing literature and data as well as a fact-finding study, and through the identification of the operational characteristics and other relevant

aspects of the electronics-related technologies (computer technology, sensor technology, laser technology, etc.).

Furthermore, the various fields of the construction industry susceptible of technical improvement as well as the various fields susceptible of applicatin of electronics-related technologies are pieced together to examine the framework of the advanced system utilizing electronics in the various field.

3.2 Development of elementary technologies utilizing electronics

(1) Development of systems

The work stages of various kinds involved in the constructin industry, such as planning, design, execution, supervision, etc., as well as the individual works related to the maintenance and conservation (steps of procedure, contents of the work, etc.), and the mutual relationship between the individual works are investigated and analyzed, and the peculiarities of the work are elucidated. Then, systems are developed for each construction work stage suited for utilization of electronics-related technologies.

(2) Development of technologies

Individual technologies (planning/design technology, execution technology, inspection technology, maintenance technology, etc.), that become partical elements of the systems of the various construction work stages, are developed, the performance, construction and other particularities of the equipment (construction equipment, inspection equipment, maintenance equipment, etc.) object of application of electronics-related technologies are elucidated, and the relevant specificaitons are defined.

3.3 Development of advanced systems for construction technologies

(1) Research on evaluation of advanced systems

Techniques are developed with the purpose of evaluating the individual system to be developed from the standpoints of safety, applicability, economical efficiency, etc.

(2) Development of advanced systems

The individual systems of the various construction work stages are pieced together, the advanced systems able to function systematically throughout the planning, design, construction, supervision and maintnance stages are developed, and the basic course for their application is set up.

4. CONCEPTUALLY DESIGNED ADVANCED CONSTRUCTION SYSTEMS

Advanced construction systems are designed for bridge, pavement, tunnel, under water construction and dam. Fig. 1 shows one system of dam construction.

5. SPECIFICATIONS OF HIGHLY ADVANCED CONSTRUCTION SYSTEMS

Advanced degrees of construction equipment and method at present and in future are shown on Table 1.

6. TECHNOLOGIES FOR AUTOMATION OF BULLDOZER AND COMPACTING EQUIPMENT

6.1 Leveling work assist system for bulldozer

This system is develped by joint research with Komatsu co. Photo 1 shows this device.

6.2 Automatic measuring system for soil compacted density

This system is developed by joint research with Tokyu construction co., Fudo construction co. and Mitsui construction co. There are 3 types for measure soil density and 2 types for survey position. Photo 2 shows one of this system.

7. DIGITAL PHOTOGRAMMETRIC SYSTEM

This system is develped by joint research with Japan photograph survey society. This system is shown on fig. 2.

8. CONSTRUCTION INFORMATION CONTROL SYSTEM

Structure of this sytem is shown on fig. 3. And real data on soil improvement work is compiled.

9. CONCLUSION

Utilization of electronics in construction technologie and promotion of automatization and robotization in construction field are indispensable to advance the construction industry. By this project it was indicated for advance construction technologies in the sight of totality to utilize high technologies properly and effectively.

TABLE 1 USING LEVEL OF ELECTRONICS FOR CONSTRUCTION WORK

ARTICLE		LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
INVESTIGATION		NO NEED	NEED EXIST NON REALIZED	INDEPENDANTRY AUTOMATED WORK	FLOW WORK AUTOMATED	SYSTEMATIC AUTOMATED	CONNECTED OTHER STAGE WITH DATABASE
DESIGN & PLANNING		NO NEED	NEED EXIST NON REALIZED	AUTOMATED CALUCULATION BY COMPUTOR	AUTOMATED PLANNING & DESIGN	LEVEL 3 BY DIALOGUE TYPE COMPUTOR	CONNECTED OTHER STAGE WITH DATABASE
CONST-RUCTION	METHOD	NO NEED	NEED EXIST NON REALIZED	INDEPENDANTRY AUTOMATED WORK	CONNECTTED FEW AUTOMATED WORKS	TOTALIZED CONSTRUCTION WORK	ADVANCED AUTO-MATED CONSTRU-CTION WORK
	MESURE-MENT	NO NEED	NEED EXIST NON REALIZED	INDEPENDANTRY AUTOMATED MESUREMENT	TOTALIZED AUTOMATE ME-SUREMENT	SYSTEMATIC CONTROLED MESUREMENT	ADD LEVEL 4 CONNECTED OTHER STAGE WITH DATABASE
MAINTENANCE		NO NEED	NEED EXIST NON REALIZED	INFRASTRUCTURE MANAGEMENT DATABASE or AUTOMATED INSPECTION	ADD LEVEL 2 ROBOTIZED MAINTENANCE WORK	SYSTEMATIC MAINTENANCE WORK	ADD LEVEL 4 CONNECTED OTHER STAGE
INFORMATION CONTROL		NO NEED	NEED EXIST NON REALIZED	INDEPENDANT ORIENTED USE DATABASE	ADVANCED INDEPENDANT ORIENTED USE DATABASE	TOTALIZED DATABASE	DISPERSION CONTROL DATABASE

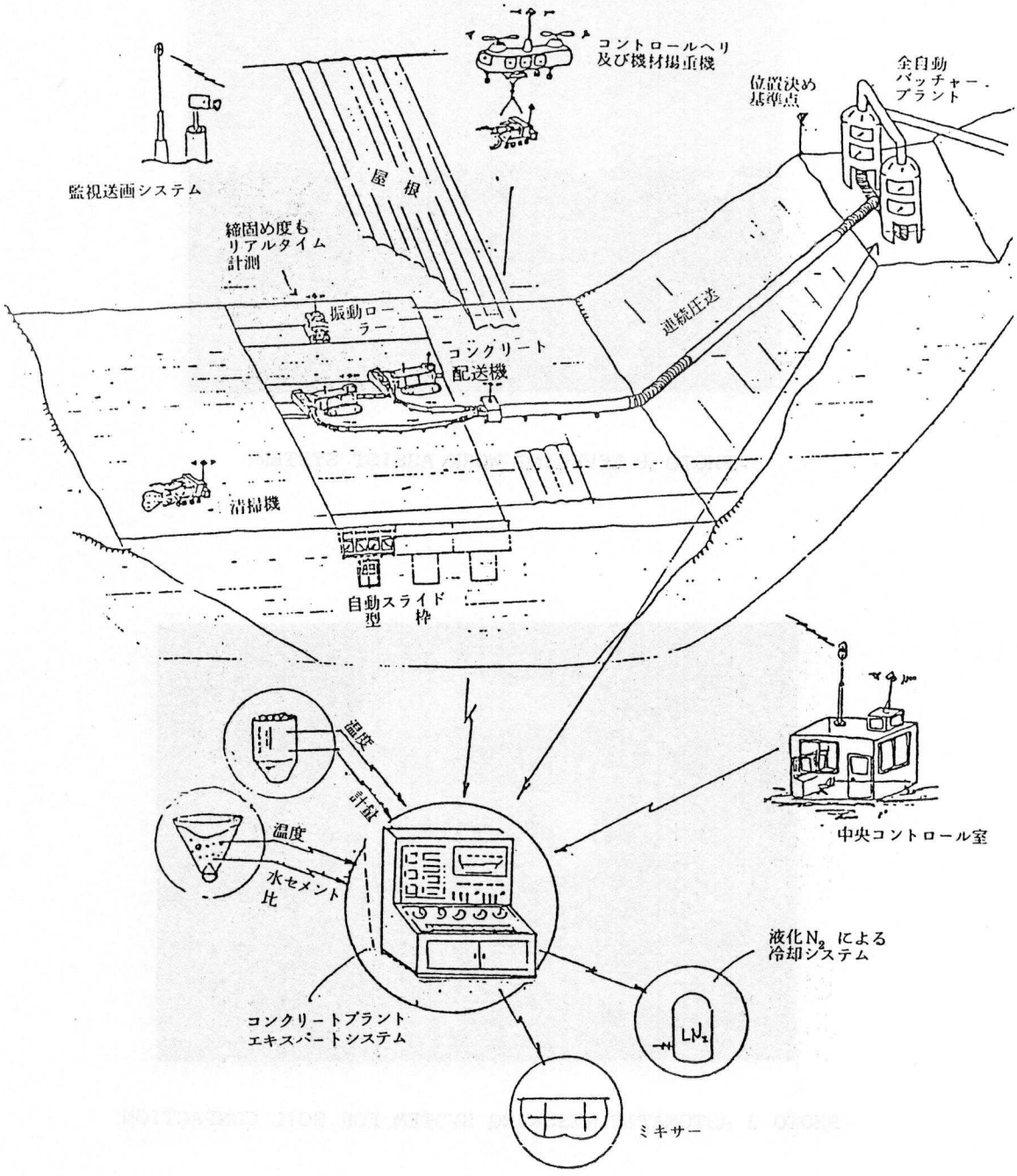

FIG. 1 ADVANCED SYSTEM FOR DAM CONSTRUCTION

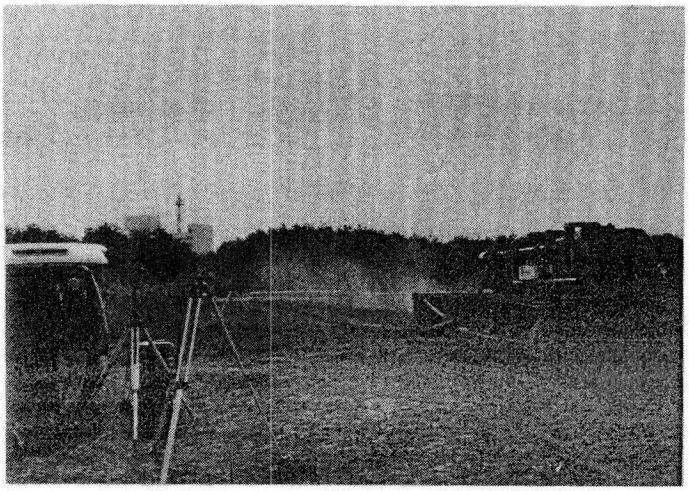

PHOTO 1 LEVELING WORK ASSIST SYSTEM

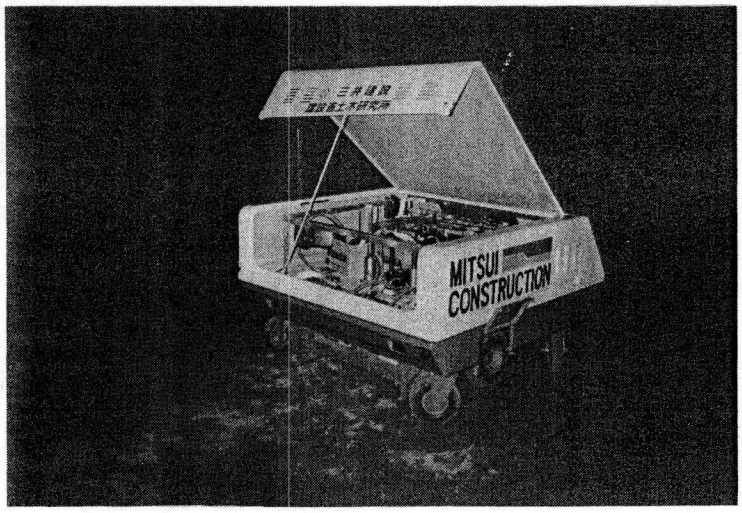

PHOTO 2 AUTOMATIC MESURING SYSTEM FOR SOIL COMPACTION

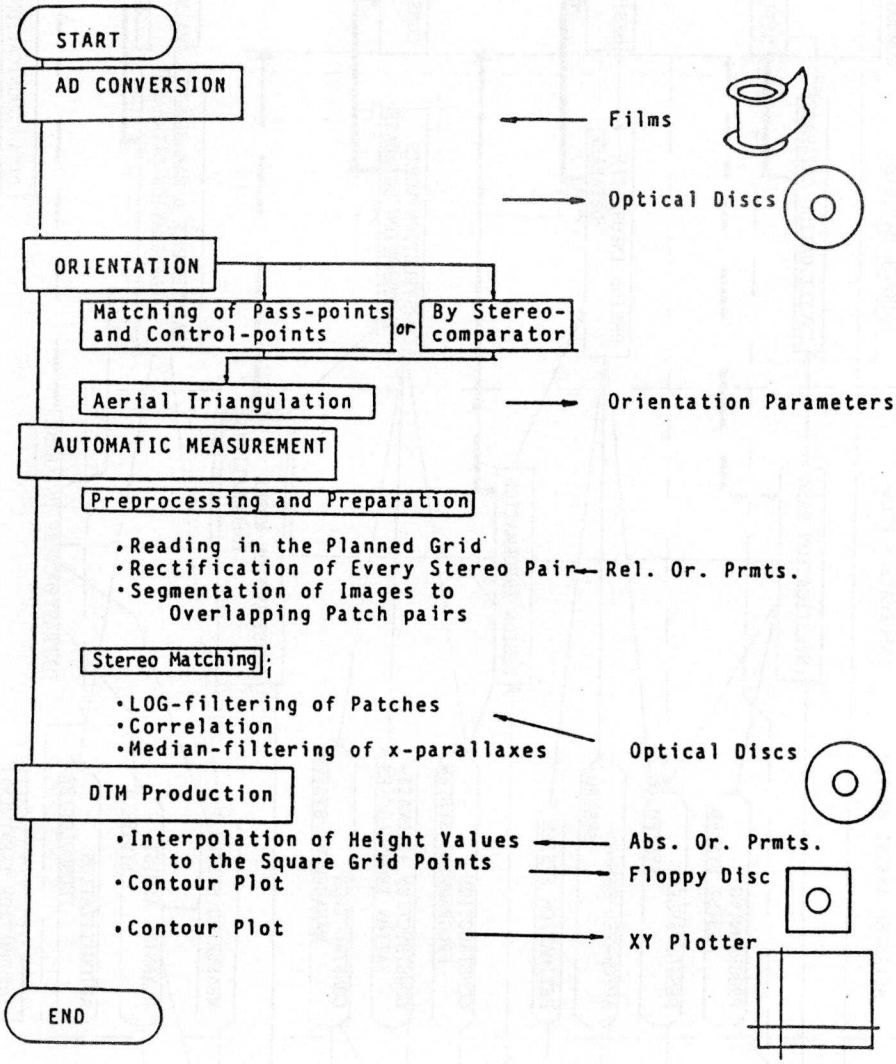

FIG. 2 FLOW OF DIGITAL PHOTOGRAMMETRIC SYSTEM

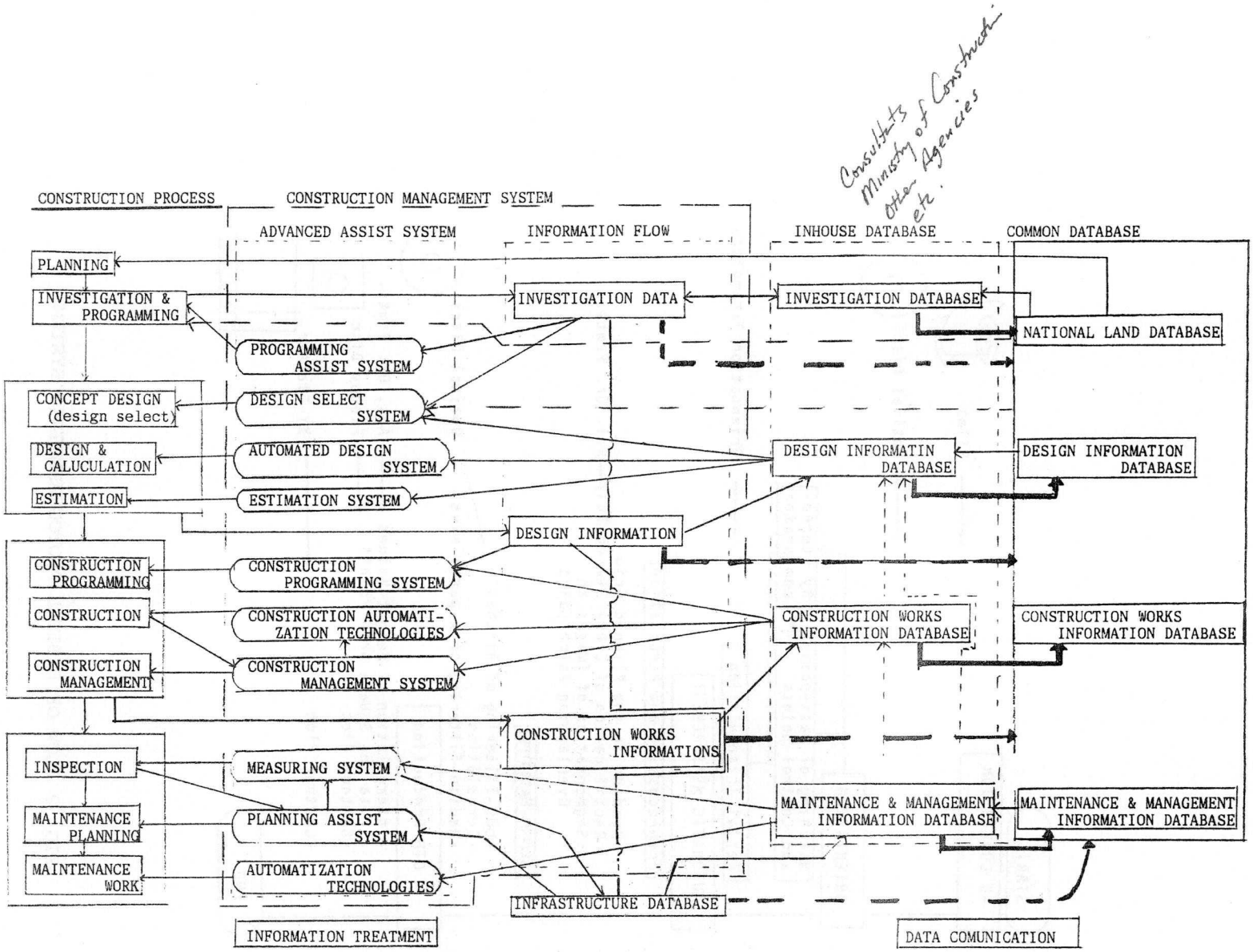

FIG. 3 STRUCTURE OF CONSTRUCTION INFORMATION CONTROL SYSTEM