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Autor: Ohashi, Masamitsu / Fujii, Ikuo / Okukawa, Atsushi
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Setting a Large Caisson on the Sea Bed

Mise en place de caissons sur un fond marin

Setzen eines Senkkastens auf den Meeresboden

Masamitsu OHASHI

Dr. Dir., Constr. Bureau
Honshu-Shikoku Bridge Auth.
Hiroshima, Japan



M. Ohashi, born 1928, got his Dr. civil engineering degree at the Kyoto University, Kyoto, Japan. From 1969 to 1974, he was engaged in the construction of Kanmon suspension bridge. Now, he has worked for the construction of Honshu-Shikoku Bridges as director.

Ikuo FUJII

Mgr, Eng. Dep.
Honshu-Shikoku Bridge Auth.
Tokyo, Japan



I. Fujii, born 1930, got his civil engineering degree at the Tokushima University, Tokushima, Japan. He worked as the structural engineer in Japan Highway Public Corporation until 1970. After that, he moved to Honshu-Shikoku Bridge Authority and has been engaged in the construction of Bridges as manager.

Atsushi OKUKAWA

Dr. Design Eng.
Honshu-Shikoku Bridge Auth.
Tokyo, Japan



A. Okukawa, born 1944, got his Dr. of civil engineering degree at the Tokyo University, Tokyo, Japan. For nine years, he is engaged in the design and the construction of long suspension bridges.

SUMMARY

This report describes the information processing system used for placing a large caisson on the sea bed. With this system, the floating steel caisson which is a kind of cofferdam and form for the required under water concreting of the main tower pier foundation of a long suspension bridge was set precisely on the sea bed at a water depth of 32 meters and with a 2.2 m/sec. tidal velocity.

RESUME

Le rapport présente le système d'information utilisé pour le contrôle de la mise en place d'un grand caisson sur fond marin. Par ce système, un caisson d'acier flottant est mis en place avec grande précision, à 32 m de profondeur, en présence d'un courant marin de 2.2 m/sec. Il remplit la fonction d'enceinte de protection et de coffrage pour la construction de fondations en béton du mât principal d'un pont suspendu.

ZUSAMMENFASSUNG

Dieser Bericht beschreibt ein EDV-System für die Ausführung von Senkkasten auf dem Meeresboden. Mit Hilfe dieses Systems konnte ein Stahlkasten, welcher als Fundament der Pylonen einer weitgespannten Hängebrücke dient, bei einer Strömungsgeschwindigkeit von 2.2 m/sec und einer Wassertiefe von genau 32 m an die geplante Stelle gebracht werden.



1. INTRODUCTION

Presently in Japan, several long suspension bridges are under construction across the straits of Seto Inland Sea. The details of these projects were already presented at past IABSE meetings [1] [2]. As the undersea foundations of the South and North Bisan Seto bridge which is one of these suspension bridges, the method of laying down a caisson has been adopted [2]. Since the substructure work began in October 1978, it is now in progress smoothly, and in October 1980, the first caisson at No. 5 pier site was set carefully on the sea bed in 32 meters water depth. One of the most important requirements in the laying down of a caisson is how to set the caisson precisely and safely at the required position against high tidal velocity. In order to answer the above mentioned requirement, each operator must have correct understanding and exact information about all motions of the caisson during the setting. Moreover, they must continuously conduct proper and effective operation according to the motions of the caisson, but these manual operations seem to be very difficult in the rough condition of the construction site. To solve these problems, we developed a measuring system which consists of computer processing and sensors.

This report describes the electronic measuring system used for setting a caisson on the sea bed.

2. SETTING OF A CAISSON

2. 1 Procedure of the method of laying down a caisson

The procedures of the method are as follows.

- (1) Underwater blasting of weathered seabed rock to the setting level of foundation.
- (2) Excavation of blasted rocks by large-scale grab dredgers.
- (3) Leveling of bedrock surface by using a large diameter rotary drilling machine.
- (4) Towing, mooring and setting of the caisson which is prefabricated at a dry dock in ship build up yard.
- (5) Casting of the pre-packed concrete in the caisson. Among each above mentioned procedures of construction, the details of setting of the caisson in item (4) is as follows.

2. 2 Caisson

The Steel caisson is required to be a kind of cofferdam and form for the underwater concreting. As the weight of this caisson is about 10,000 tons, it is not possible to lift up and carry a caisson by a floating crane. Thus, the caisson is divided into two sections (the inner and outer) as viewed on a horizontal plane section. The outer section of the caisson is used as ballast tank in order for it to float stably by itself. The outer section is also divided into ten partitions restricting free water flow at the laying down stages. The caisson is equipped for towing, mooring and setting at a shipyard.

2. 3 Setting of caisson

The positioning and setting of the caisson is conducted during a period of about 3 hours

when the tide turns. The laying down of the caisson is conducted by pouring water into ten partitions of the caisson hull with twenty individually controlled water pumps, and the positioning of the caisson is controlled by eight wire cables with 80 mm diameters and eight mooring winches, as shown in Fig.1. The allowance of setting the caisson is expected to be within ± 50 cm in position by using the following information processing system which is provided in the control room installed on the deck of caisson.

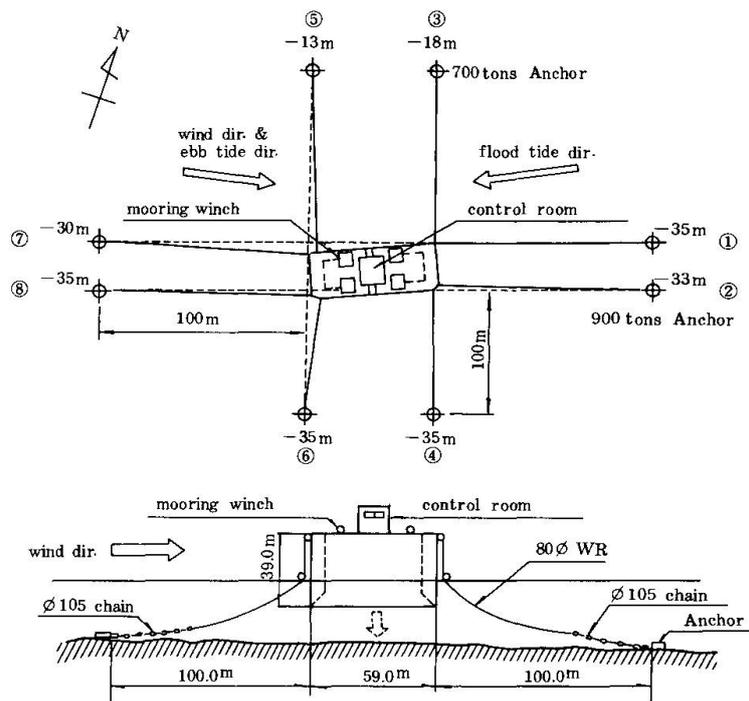


Fig. 1 Mooring of caisson

3. INFORMATION PROCESSING SYSTEM FOR CAISSON-POSITIONING

3. 1 Principal concepts

In order to precisely locate the floating caisson to the required position, the operators would need to know in detail much information, that is, i) the difference between the present position and the required one (in vector), ii) the actual movement status of caisson (in vector), iii) the following position expected by the present position, iv) the following operation on the basis of iii), v) any abnormality of machines when it can be detected and/or how to react to a crisis.

Under the consideration of the above mentioned requirements, the principal concepts for designing the information processing system for caisson positioning are as follows.

- (1) The conventional surveying techniques which are commonly used in the state of repose can not be applied as is, because the caisson floats and its position is every-changing.
- (2) The informations required for the setting work are i) the positions in plane, ii) the positions in height, iii) draft, iv) gradient, v) ballast tank waterlevel and vi) winch and pump operation status.
- (3) The accuracy and the resolution of measuring the position of caisson is within 10 centi-meters and 1 centi-meter respectively. So, triangulation is adopted using two optical distance meters and one digital theodolite. Surveying apparatuses are installed on the land station. The data of surveying are transmitted to the control room on the deck of caisson by radio as shown Fig. 2.



- (4) The draft and the water depth against the specified seabed are measured at four corners of caisson in order to obtain the caisson-position in height. The measuring accuracy of water depth is required to be ± 1 cm.
- (5) The gradient accuracy is required to be ± 0.01 degree.
- (6) The accuracy of the ballast tank water level is required to be $\pm 0.5\%$ F.S..
- (7) The renewable interval of measuring data is required to be 5 seconds considering the measuring period of the distance meter and editing time of the such picture in CRT display.
- (8) Software is composed of functions as data collection, data processing, hazard monitor, alarm, CRT display, record, storage of review data and review.
- (9) CRT display has six kinds of pictures in seven colors. Each one of these pictures (e.g. the picture of plane position management, height position management and so on) is selected as)
- (10) This information processing system is limited to processing and display of various informations. The operations of mooring winches and water pumps are conducted by each operator who works a operation panel under the order of the director. However, the operation status of each machine is pictured together with the other data on CRT display.

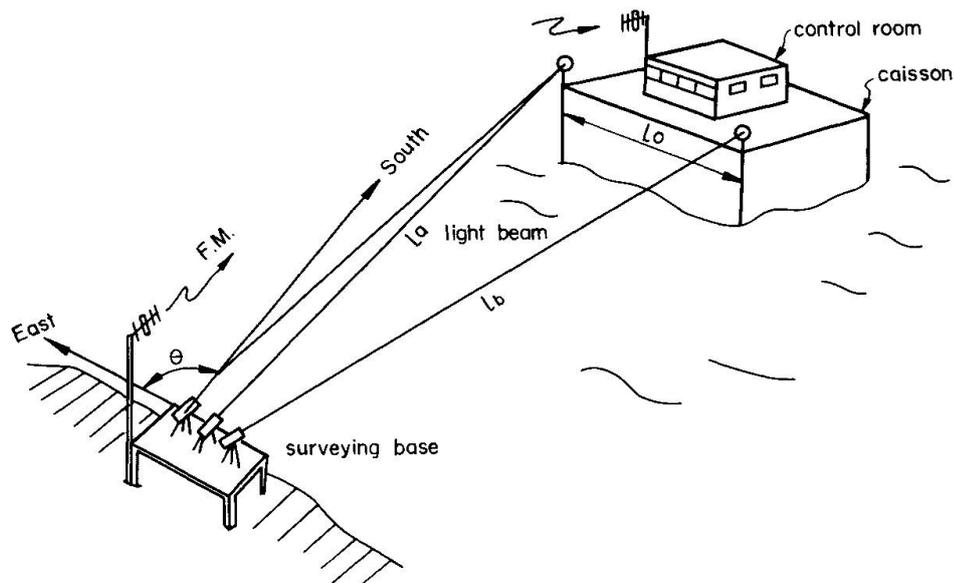


Fig. 2 Surveying system

**Table 1 List of equipments**

Equipments	No. of set	Main specification
Central Processor	1	Memory Capacity; 128 kw, 16 bits/one word, micro-programing controll system
Input-Output Device	1	Input-oneput interface; which connects between data of sensors and CPU
Paper Tape Reader	1	Speed; 30000 words/min.
Typewriter	1	Speed; 120 words/sec.
External Memory	1	Memory Capacity; 300 k bite, 2 units
CRT	1	20 inches size, 7 colors
FM transminitor	1	Radio frequency; 400 MHz band, Speed; 1200 bits/sec.
Optical Distance Meter	2	Accuracy; 1 cm
Digital Transit	1	Accuracy; 3 sec. in horizontal, 6 sec. in vertical
Depth Sounder	4	Resolution; 1 cm
Diferencial Pressure		
Pick up	14	Accuracy; $\pm 0.5\%$ F.S.
Diferencial Tranceducer		
Gradient Pick up	2	Accuracy; $\pm 1/300$ F.S.

3. 2 Hardware

The list of the equipments composing this system is shown in Tab. 1. The processing unit consists of a central processor, input-output device, PTR (Paper Tape Reader), and CMT (Cassette Magnetic Tape), which are set in the machine room on the deck of caisson.

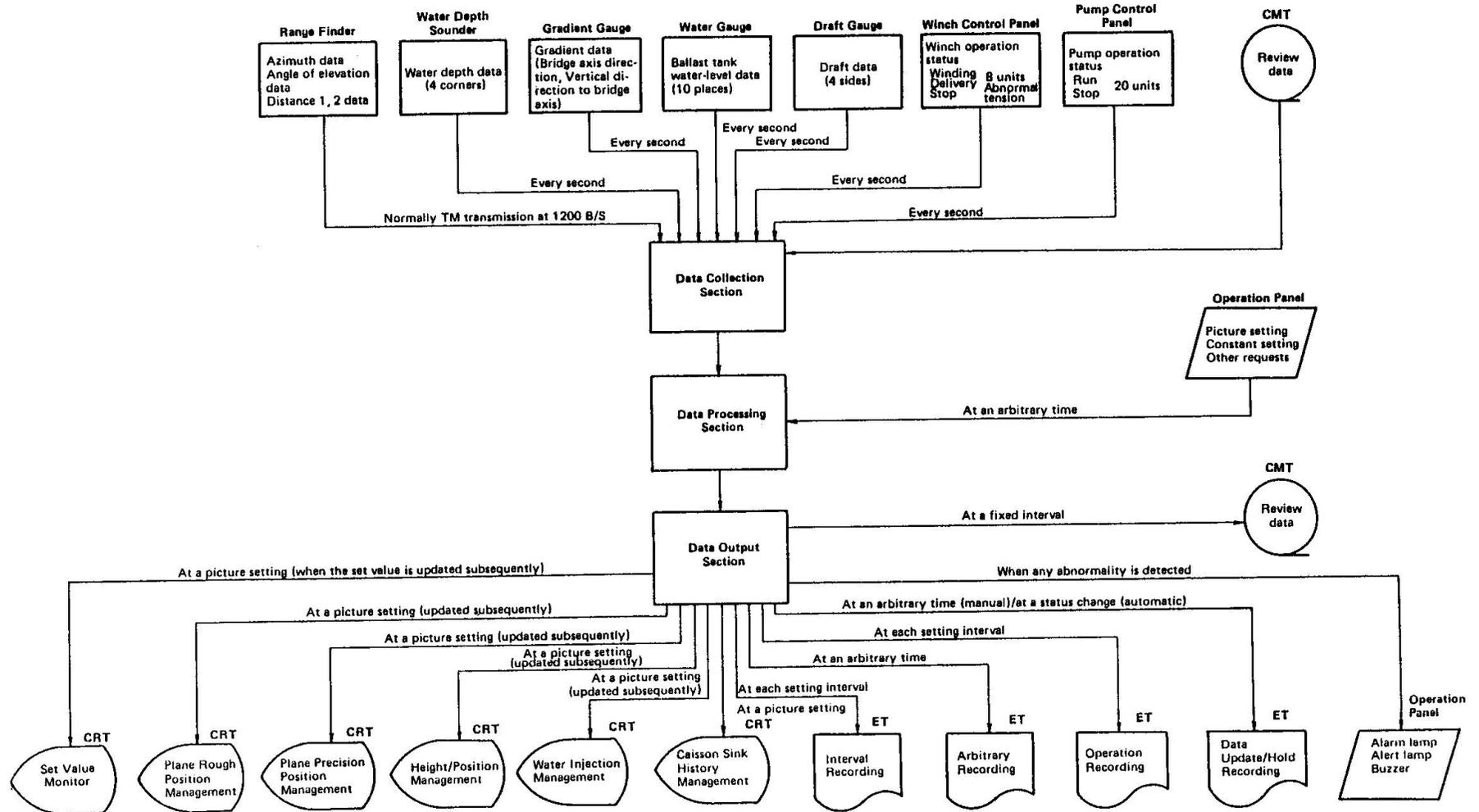
These range finders are set in the datum points at the surveying station, which is about 200 m away from the position of setting caisson. Each surveyor, respectively, aims at and persues the targets which are set on the caisson. The data sent from these sensors are collected every one second under the control of the central processor.

3. 3 Software

Software for this system consists of main system program, caisson position watching program and review program.

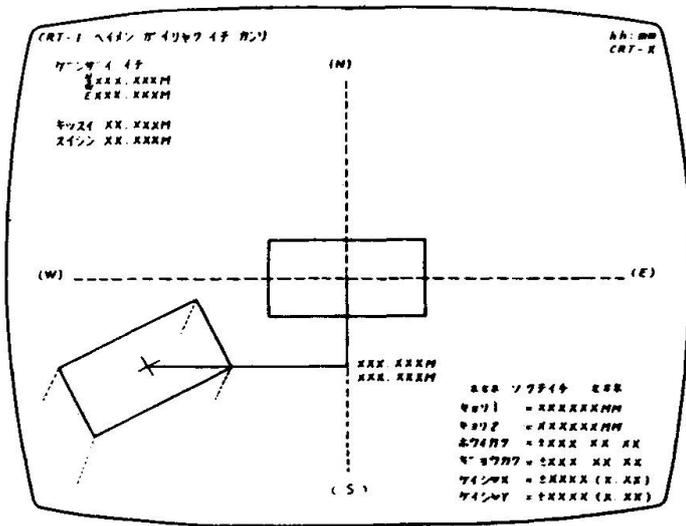
- (1) Functions of main system program are made up of data collection, data processing, hazard monitor, alarm, CRT display, record, storage of review data and review, as shown in Fig.3. The details of each function are as follows.
 - i) Data collection section collects both the measured data and the observed data. The measured data are taken from range finders, water depth sounders, gradients guages, ballast tank waterlevel guages and draft guages. The observed data are the winch operation status and the pump operation status.

Fig. 3 Schematic diagram of software

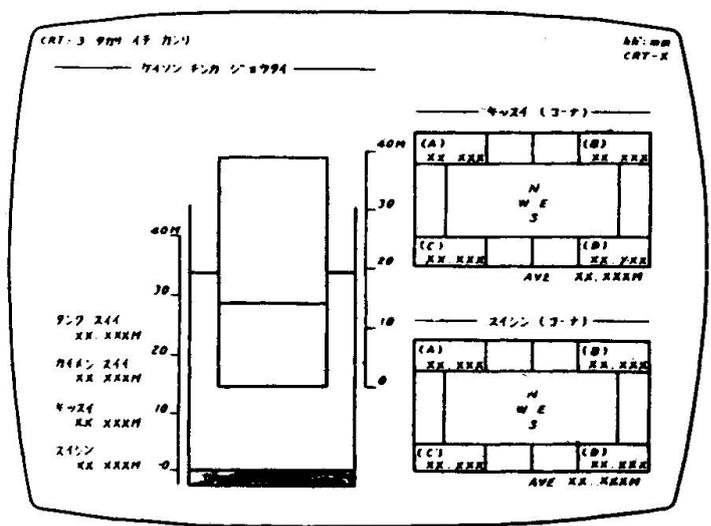




- ii) Data processing section has functions of correcting the water-depth by both water temperature and inclination of caisson, and correcting the distance data by the weather conditions. Then it calculates the momentary caisson position.
 - iii) Hazard monitor has function of finding the abnormal data of updated caisson position, gradient and sinking speed in comparison with the preset limit. And then if abnormality is detected, the monitor puts a light to the alarm lamp or the alert lamp, and rings the buzzer. Then the messages of the abnormality are printed out.
 - iv) CRT display function edits six kinds of pictures which are the set value monitor, the plane rough position management (Fig. 4(a)), the plane precision position management, the height position management (Fig. 4(b)), water injection management and caisson sink history management.
 - v) Record function edits the results of calculation and prints out the fixed interval recording, the arbitrary recording and operation recording.
 - vi) Storage function of review data stores the measured data, the observed data and caisson position data in the CMT at the initial preset interval.
- (2) The program is prepared in order to check the run of this system and also to confirm the position of caisson before or after the setting of caisson. This program calculates the position of caisson on the basis of the data which is mainly obtained by the conventional surveying. The data for this program is input by means of a key board. This program can run parallel to the main processor system program.
- (3) Review program is prepared to review the history of the status of setting of caisson by calling the data from CMT, after the main system is carried out.



(a) Plane rough position



(b) Height position

Fig. 4 CRT display format



4. RESULT OF SETTING OF CAISSON

At 10:28, in October 3 1980, the setting of the steel caisson at No. 5 pier site was completed to scheduled time. The position of caisson after the completion of setting was measured precisely by means of the conventional surveying method. Fig. 5 shows the results which were obtained by conventional surveying one week after the setting. The difference between the CRT display values and the results of conventional surveying is about 3 centi-meters. The positioning errors of caisson are zero in rotation against a vertical axis and several centi-meters at the center of the bottom of caisson from the required position. It is considered that this information processing system for caisson-position is available, because the work of setting of caisson was conducted smoothly to scheduled time.

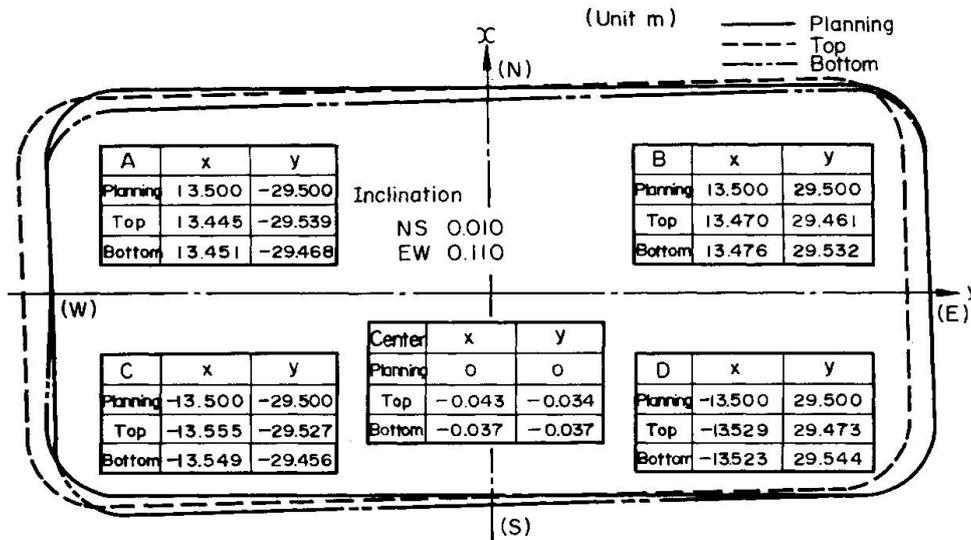


Fig. 5 Error of setting-caisson

5. POSTSCRIPT

The information processing system for caisson-position in this report was developed for the purpose of the specified work, that is, positioning and setting of a large steel caisson with about 10,000 tons. However, it is expected that this technology can be sufficiently applied to the dynamic measuring system for various offshore construction works.

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- [1] Yoshimaro MATSUZAKI "Honshu-Shikoku Bridge Planning in Japan", IABSE Symposium in Zurich 1979
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