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Outline of Construction,
Total concrete Volume 550000m³
Maximum foundation 230000m³
Number of foundation 11
Maximum depth of sea 50m
Constructed by Honshu-Shi-koku Bridge Authority.

QUALITY CONTROL OF PREPACKED CONCRETE FOR LARGE FOUNDATIONS

Honshu-Shikoku Bridge Authority

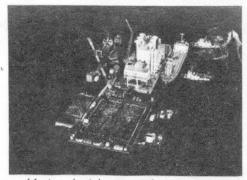
- (1) Prepacked aggregate: The aggregate were washed and classified in the storing base before shipment. Then they were carried to the foundation site and washed and classified again. At filling in, more than one time per day, sieving analysis test and within 0.03% by decantation test.
- (2) Grouting: In the mortar plant barge, mortar materials were lifted, weighed, mixed and poured into at the rate of 4000l/min under automatic control. Information of grouting was scattered over the wide range and whose contents is various kinds.



Coarse aggregate

During grouting, efforts to collect these data and to operate under the proper judgement should have been made. But as it was impossible to do all work by hand, the data were displayed on graphic panel, CRT display etc, in the operation room. Grouting mortar was checked per $1000 \, \mathrm{m}^3$ and it resulted favorable value over all items of quality as shown in table 1. Please pay attention to low bleeding rate. Bleeding rate could become so low, because fly ash cement of good quality and sand with controlled particle dia. (FM1.8 \pm 0.2) in the storing base were adopted.

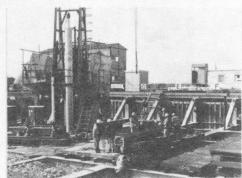
(3) Core sampling: After mortar was poured into completely, the cores with 45cm dia.from the base to the top of pier were taken, and these cores (without any material separation phenomeon) could be completely collected at each 5m pre-cut. Moreover the average compressive strength of age 91 day's was 200kgf/cm².



Mortar plant barge and workvessels



Operation room in the mortar plant barge



Core sampling



Quality Control of Prepacked Concrete for Large Foundations

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1. Introduction

Eleven main foundations in the strait for the Kojima-Sakaide route of the Honshu-Shikoku Bridges were constructed using the prepacked concrete method. This report describes the quality control of this prepacked concrete.

2. Summary of Prepacked Concrete

Table-1 shows the foundations which were constructed using the prepacked concrete method. The volume of concrete placed was $540,000~\text{m}^3$ in total, with the water depth of 10 - 50 m. These foundations were constructed between October 1980 and October 1984. The process of prepacked concrete consists of placing of the coarse aggregates and injection of the mortar. The construction was performed at the high rate of $50,000~\text{m}^3/\text{month}$ for aggregate placing and $240~\text{m}^3/\text{hr}$ for mortar grouting.

3. Placing of Coarse Aggregate

The type of coarse aggregate used was crushed stones of 80 - 150 mm from the viewpoint of the fluidity of the mortar in the caisson, availability, ease of handling, etc. The aggregate was stored at the rate of 200,000 m³ maximum. It was then hauled to the site according to the construction schedule of each foundation. The most important task in the placing of the coarse aggregates was, ① to remove aggregates of grain size smaller than 80 mm, ② to remove fragments, silt, etc. that had adhered to the surface of the coarse aggregate. Therefore, the aggregate was not only passed through a drum scrubber, vibrating screen, etc. at the storage yard, but also a water curtain, vibrating screen, etc. on the barge at the foundation site, making an exhaustive effort to clean and screen the aggregate. Also, the water level in the caisson was raised to the top of the caisson to prevent aggregate from crushing.

4. Grouting of Mortar

(1) Material control

Table-2 shows the specified mix proportions. As the sea sand used was large in grain size, i.e. fineness modulus 2.5 - 3.5, it was adjusted to fineness modulus of 1.8 + 0.2 in a rod mill. The sand was then stored in the storage yard, covered with a waterproof sheet and dried. The cement used was a fly ash cement made by pre-mixing ordinary Portland cement



with fly ash. Because the quality of fly ash differs depending on the power plant from which it is obtained, the quality of fly ash at each power plant was tested in advance for ignition loss, specific surface area, and carbon content, as well as confirming the shape by microscope, and then two power plants were selected for supply.

(2) Production of mortar

A mortar plant barge equipped with three mortar production plants, each of which has a production capacity of 2,000 /min., was used for mortar injection. Two plants were operated constantly, producing 4,000 /min. of mortar, the third one being used as a reserve. When producing mortar, the value of the mortar flow in the mixer was measured automatically for every batch, and the mortar within the range of 16.5+2 seconds was discharged to the agitator, with the rest being disposed of. The disposal ratio was about 0.3%. Also, the coefficient of the surface moisture of the sand was corrected by the average value of mortar flow. In addition, a sample was taken from the agitator for every 1,000 m³ of production, and was tested in the laboratory on the plant barge.

(3) Mortar injection

The injection of mortar was performed continuously using 20 grouting pipes from the base to the top of the caisson. The mortar injection pipe was of a duplex type as shown in Fig-1, and the rise of mortar was automatically measured, according to which the pipe was raised. The rate of injection was 4,000 /min by using 20 pipes. The proportion for each pipe was determined according to the ratio of each injection area and the mortar flow was constantly measured and adjusted during the injection adhering to the dividing ratio. As a result, the level of the mortar was raised constantly and evenly.

5. Strength of Concrete

The concrete at the top of the foundation was removed to a depth of about 50 cm one month after the mortar injection. And the strength of concrete was measured throughout the entire area of the foundation using a schmidt hammer. Also, from two points, the points nearest to and farthest from the injection pipe, a large diameter core of 45 cm was taken throughout the total height of the foundation and compression tests were performed. The average compressive strength (age 91 day strength) of these was approximately 200 f/cm² for all foundations.

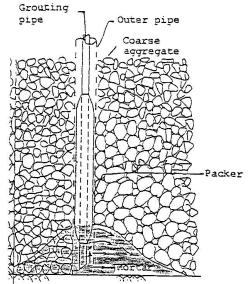


Fig-1 Grouting pipe

Table-1 Submarine Foundatin Major Factors

	Hitsug	Hitsugilshijima	Iwagur	Iwagurojima Bridge (IB)	lge (IB)		Nanbok	u-Bisan-S	Nanboku-Bisan-Seto Bridge (BB)	le (BB)		Total
	Bride	Bridge (HB)	×							PATRICIANUM TOCKERO LAMPRICO		
	2P	32	2P	3.5	4₽	2P	2P 3P	4.8	4A SP	6P	7A	
Plane dimension (m)	25 x 46	25 x 46 29 x 46 18 x 46 22 x 46 36 x 32 23 x 57 23 x 57 57 x 62 27 x 59 38 x 59 75 x 59	18 x 46	22 x 46	36 x 32	23 x 57	23 x 57	57 x 62	27 x 59	38 x 59	75 x 59	
Reight of foundation base (TPm)	-28	-25	-15	-24	-14	-10	-10	-10	-32	-50	-50	
Top level of marine concrete	0+1	-12	+1	0+1	- 2	0+1	0+1	0+1	0 +1	+2.3	+2.3	
Solume of marine concrete	35,000	000'6	9,000 12,000	24,000	13,000	12,000	12,000	34,000	47,000	114,000	24,000 13,000 12,000 12,000 34,000 47,000 114,000 228,000 540,000	540,000

Table-2 Specified Mix Proportions

Ç	Coarse aggregate								Unit	Unit volume	
			Range of settling (sec)	Range of settling Water-binder ratio Admixture ratio, Sand-binder ratio (sec) $W/(C+F)$ $E/(C+F)$ $S/(C+F)$	Admixture ratio F/(C + F)	Sand-binder ratio S/(C + F)	32	Gu	σ σ	W C F S Admixture Aluminum	Aluminum
Max	imum size	Minimum Size Maximum size Percentage of voids		(3)	(8)		(kg)	g) (kg	(kg)	(kg) (kg) (kg) (g)	(6)
	150	50	17±2	48	20	1	391 65	2 163	815	391 652 163 815 8,150 81.5	81.5