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Artikel: Quality control of prepacked concrete for large foundations

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Outline of Construction,
Total concrete Volume 550000m^3
Maximum foundation 230000m^3
Number of foundation 11
Maximum depth of sea 50m
Constructed by Honshu-Shikoku Bridge Authority.

QUALITY CONTROL OF PREPACKED CONCRETE FOR LARGE FOUNDATIONS

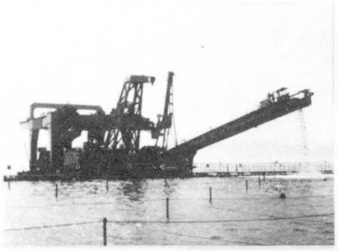
Honshu-Shikoku Bridge Authority

(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 decantation test were taken controlling within 2% pass rate by 80mm sieving analysis test and within 0.03% by decantation test.

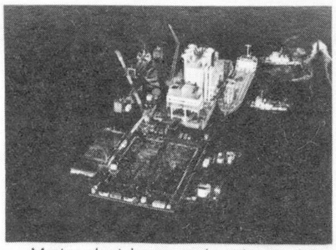
Table-1. Quality of poured mortar

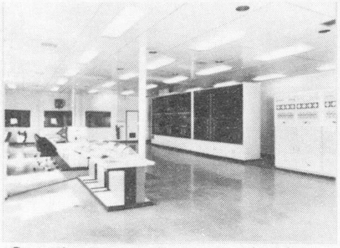
Frow value	bleeding rate	Expantion rate	Compresive strength
17.9 SEC	2.0% (3HR)	5.7% (3HR)	319kgf/cm^2 (28day)

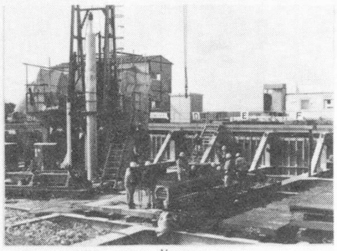
(2) Grouting : In the mortar plant barge, mortar materials were lifted, weighed, mixed and poured into at the rate of 4000l/min under automatic control. Information of grouting was scatterred over the wide range and whose contents is various kinds. During grouting, efforts to collect these data and to operate under the proper judgement should have been made. But, as it was imppossible 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 1000m^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.


Coarse aggregate

(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/cm^2.


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 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 m^3/month for aggregate placing and 240 m^3/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 m^3 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 $\pm$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 ℓ/min., was used for mortar injection. Two plants were operated constantly, producing 4,000 ℓ/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 m^3 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 ℓ/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/cm^2 for all foundations.

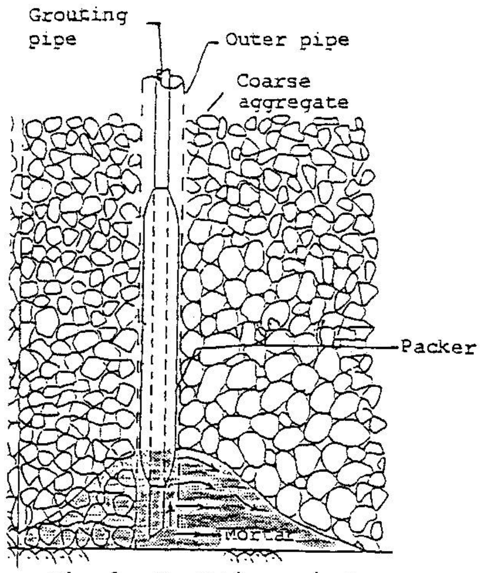

Fig-1 Grouting pipe

Table-1 Submarine Foundatin Major Factors

	Hitsugiishijima Bridge (HB)		Iwagurojima Bridge (IB)			Nanboku-Bisan-Seto Bridge (BB)						Total
	2P	3P	2P	3P	4P	2P	3P	4A	5P	6P	7A	
Plane dimension (m)	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	
Height of foundation base (TPm)	-28	-25	-15	-24	-14	-10	-10	-10	-32	-50	-50	
Top level of marine concrete	± 0	-12	± 0	± 0	- 2	± 0	± 0	± 0	± 0	+2.3	+2.3	
Solume of marine concrete	35,000	9,000	12,000	24,000	13,000	12,000	12,000	34,000	47,000	114,000	228,000	540,000

Table-2 Specified Mix Proportions

Coarse aggregate			Range of settling (sec)	Water-binder ratio W/(C + F)	Admixture ratio F/(C + F)	Sand-binder ratio S/(C + F)	Unit volume					
Minimum Size	Maximum size	Percentage of voids		(%)	(%)		W (kg)	C (kg)	F (kg)	S (kg)	Admixture (g)	Aluminum (g)
80	150	50	17±2	48	20	1	391	652	163	815	8,150	81.5