Uniformity Performance of RCC Production System

HAZAMA Sg.Kinta Dam Project Office T. Temmyo, F. Konno, B. A. Chew
HAZAMA Head Office T. Fujita, Y. Murakami

1. Introduction

RCC (Roller Compacted Concrete) construction is an extremely rapid method of construction. Continuous mixers specifically intended for RCC, properly operated and maintained generally achieve the high production rates and uniformity required. The location and system for supplying aggregates to feed the continuous mixing plant must be co-ordinated with the RCC plant to minimize segregation and variability. This article reports on the uniformity tests conducted for the RCC production system adopted for construction of the Kinta dam in Malaysia, and authors view on the permissible variation for the various concrete properties tested for uniformity performance.

2. Mix Proportion for RCC

The materials used for RCC is Cement (OPC), Flyash, Crushing aggregate, Mining sand and Admixture. Typical mix proportion is as shown in **Table 1.** For the Kinta dam, GE-RCC (Grout Enriched RCC) method[1)] is adopted for the formed concrete at the upstream and downstream face enabling the whole dam to be constructed entirely with RCC.

Table 1 Typical mix proportion

Gmax	VeBe Time	Water cement ratio	Percent fine	F/(C+F)	Unit weight (kg／m^3)								
					Water	Cement (OPC)	Fly ash	Fine aggergate mining	Fine aggergate crushing	Coarse aggregate 63～40mm	Coarse aggregate 40～20mm	Coarse aggregate 20～5mm	Water reducer and retarder
(mm)	(sec)	(%)	s/a (%)	(%)	W	C	F	Ms	Qs	G1	G2	G3	(liter)
63	12-17	75.0	41	50.0	150	100	100	329	493	221	441	529	0.8

3. Performance of Continuous Mixing Plant

The continuous mixing plant at Kinta dam project is as shown in **Figure 1**. Three sizes of aggregates and two types of sand are stored under covers and withdrawn by conveyors to feed storage hoppers within the mixing plant. The aggregates, sand, cement and flyash are delivered to the mixer by volumetric control. Water and additive is measured and added by metered pumps.

Uniformity of continuous mixer is generally better if production is higher. This mixer is set to produce RCC at a rate of 300m^3/hr, although the rated plant capacity is 400m^3/hr. However the actual average placing rate is approximately 250m^3/hr as haul vehicles are used for delivery of the RCC to the dam.

Figure 1 Continuous mixing plant at Kinta dam project in Malaysia

Key-Words RCC, Continuous mixer, Uniformity
Karung Berkunci No.1, 31409 Taman Ipoh Perak Malaysia TEL: +603-2282 2210 FAX: + 603-2282 2209 (KL Office)

4. Uniformity Test

4.1 Testing Item and Method for Fresh RCC

Uniformity test for fresh RCC produced is conducted using ASTM C94 and JSCE-I 502-1999 as a guide. Sampling is carried out every 2 hours and 3 samples of approximately 35kg are taken from the spread RCC. To determine the unit weight of air free mortar, the RCC is sieved and from materials passing a 5mm mesh, a sample of mortar of approximately 500g is obtained. The sample is placed into a 1 liter measuring cylinder and filled with water to the 1 liter mark and expel air from within the mortar. The Unit weight of air free mortar is then calculated using the formula below.

$$\text{Unit weight of air free mortar} = \frac{M_{c+m} - M_c}{1000 - (M_{c+m+w} - M_{c+m})} \qquad (1)$$

where, M_{c+m} : Mass of cylinder+mortar, M_c: Mass of cylinder, M_{c+m+w} : Mass of cylinder+mortar+water

The remaining quantity of the RCC sample of approximately 25 kg is used for determination of the grading and moisture content of the RCC mix.

4.2 Results

The difference in the result is calculated by the formula shown below for each batch sampled.

$$\text{Difference in result} = \frac{(\text{Max} - \text{Min})}{\text{Average}} \qquad (2)$$

The results for 10 batches tested since Sep 2004 are as shown in **Figure 2**. It is considered that the deviation is contributed from the non-uniformity of the aggregates being fed to the mixer, segregation during the transfer and transportation to Site, spreading by bulldozers, as well as the method of sampling and testing not only from the continuous mixer.

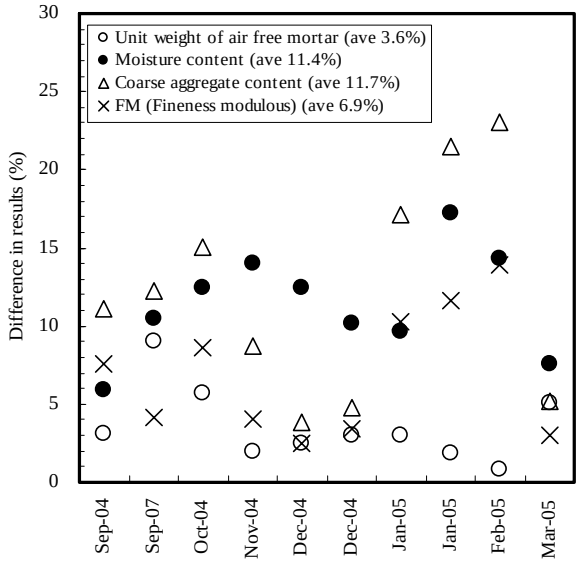

Figure 2 Uniformity test result

4.3 Compressive strength test result

Compressive strength test results of RCC produced since March 2004 is as shown in **Table 2**. The variation factor is approximately 22%. According to the ACI standard[2)], "Typical coefficients of variation for RCC compression tests with reasonable weight or volume controls in mass mixtures tend to be approximately 20 to 25%." The test results for this continuous RCC production system indicates that the performance is satisfactory.

Table 2 RCC Compressive strength result

		28 days	90 days
Numbers of cylinder set		123	115
Average	(Mpa)	9.2	14.5
Variation coefficient	(%)	22.9	21.7

5. Suggestion

It is suggested that the average variation of 4% for Unit weight of air mortar, 12% for Moisture content, 12% for Coarse aggregate content and 7% for FM is reasonable for Uniformity tests conducted under similar as those used for this project.

【References】

1) Brian A Forbs: Some recent innovative methods and techniques in the design and construction of RCC dams, Prc. of the Fourth International Symposium on Roller Compacted Concrete Dams, Spain, pp49-60, 2003

2) ACI Committee 207 Report 1999: Roller compacted concrete, ACI207.5R-99, 1999