Trial of Grout Enriched Roller Compacted Concrete or commonly known as GE-RCC

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1. Introduction

A recent innovation in Roller Compacted Concrete (RCC) Dam construction is the use of Grout enriched RCC (GE-RCC) in place of conventional vibrated concrete. The big advantage of GE-RCC is that RCC placement work is easier, quicker and better economic of scale. Although, the GE-RCC technique may seem simple, if due consideration is not given to the viscosity of the grout mixture, penetration of the GE milk can be a problem, propagating in non-uniform and poor ‘off-form’ finishes. This article explains the approaches and procedure adopted for determining a suitable GE mix proportion compatible to the RCC design mix used for construction of the dam.

2. Mix Proportion of RCC

Cementitious material used for the RCC and GE-RCC are OPC-Class 42.5 and Flyash from a nearby coal-powered Power Plant. Aggregate for RCC is extracted from an on-site Granite quarry and run through an on-site crusher facility which is designed to produce the various aggregate sizes ranging from Gmax 63mm down to the rock powder. The RCC aggregate combined grading curve is as shown in **Fig-1** and Mix proportion of RCC is as shown in **Table-1**.

3. Design Mix of GE-RCC

Although low water to cement ratio (W/C) of GE milk is effective in raising the strength of GE-RCC, however, the high viscosity of the GE milk tends to pose difficulty in penetrating the fresh RCC layer. It is on this basis that the GE milk will have to be designed to have the appropriate W/C - flow rate relationship well balanced so that the penetrability in the RCC is not impaired. Some experiences[1], where GE-RCC technique has been successfully used show that W/C of GE milk is in the region from 0.8 to 1.0. In this investigation, GE milk was designed by first trying to establish the relationship between W/C and flow rate. The flow test was conducted using Marsh Cone as shown in **Fig-2**. The GE milk is filled to a designated level in the Marsh Cone and released to gravity flow into the mug with a stopwatch starting synchronically. The time taken for the milk to empty completely into the mug is referred to as the Marsh Cone Value (MCV). At the laboratory tests, OPC, Flyash, water

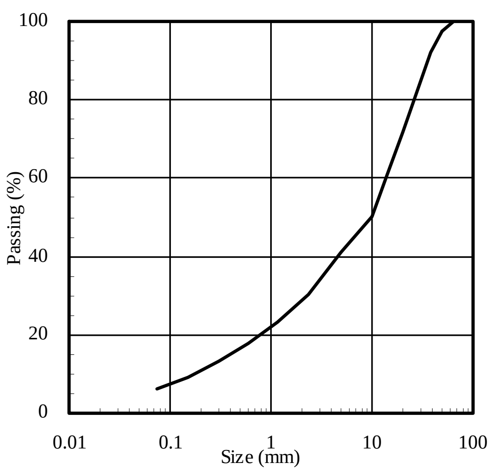

Fig-1 Combined Grading Curve of RCC

Fig-2 Marsh Cone

Table-1 Mix Proportion of RCC

	Gmax	VeBe Time	Water cement ratio W/C	Percent fine s/a	Water Reducer & Retardar A1	Unit weight (kg／m³)								Theoretical Density
						Water	Cement (OPC)	Fly ash	Fine aggergate Quarry	Coarse aggregate 63～40mm	40～20mm	20～5mm	Water Reducer & Retardar	
	（mm）	（sec）	(%)	(%)	(%)	W	C	F	Qs	G1	G2	G3	A1	(kg／m³)
RCC	63	10-25	72	41	0.2	130	90	90	858	229	457	548	0.360	2402

*Specific Gravity (OPC:3.15, Flyash:2.09, Quarry aggregate:2.62)

Key-Words Grout Enriched RCC, GERCC, RCC, March Cone Value, Penetration

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reducer (Type B&D) and NSF superplasticizer (Type F&G) were used. **Fig-3** shows the relation between MCV and W/C. From the flow tests conducted it was found that:

- The W/C is lower than 0.8, the MCV with a OPC is higher.
- The 30 % Flyash replacement has shown to be not so efficient.
- The MCV with a W/C 0.6 + superplasticizer was not so much different from the OPC grout milk with W/C of 0.8 and 1.0.

With only plain water flowing through the Marsh cone funnel produces a MCV of 30-35 seconds and this was adopted as benchmark. From the above flow tests, approximately 40-45 sec of MCV was targeted for use in the field test, which were executed using W/C = 0.8 and W/C = 0.6 + superplasticizer @ dosage (C+F) x 0.6%.

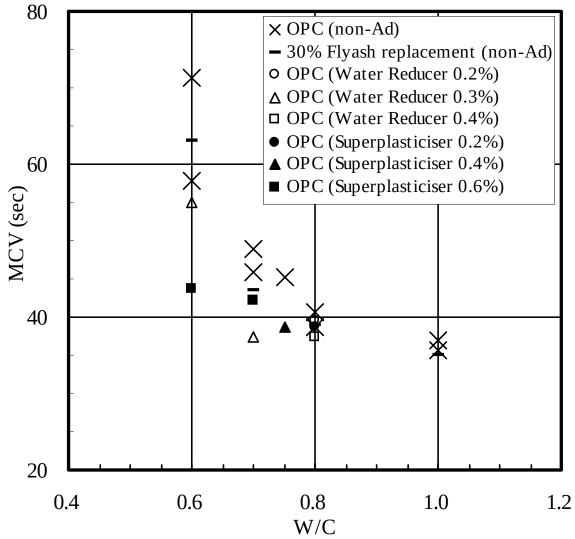

Fig-3 Relation between MCV and Water to Cement ratio

4. Field Test

GE milk is batched by the site concrete plant using a twin-shaft wet type mixer and transported to placement site by agitator trucks. As settlement of cement particles is expected to occur fairly immediately the moment the milk is left undisturbed, the GE milk was discharged into a portable agitator on site and agitated continually for use. The GE milk was then tapped into small plastic container measuring approximately 8 litres each. The GE milk in the 'small' container provided a means for measurement of how much GE milk is poured over a predetermined RCC area. In the application of GE milk a GE-RCC zone, it is crucial that the freshly spread RCC is kept loose to secure good GE penetration. After spreading of RCC by bulldozer, it is important that neither man nor machine trample around the GE-RCC area to assist penetration of GE milk into the RCC. Two parallel lines of holes at intervals of 150mm were made in the 400mm width of RCC to be grout enriched. GE milk was then poured onto the RCC and after a lapse of 1-2 minutes to allow for the GE milk to percolate, vibration pokers were initiated to compact the GE-RCC as shown in **Fig-4**. Samples of GE-RCC for slump test and making of cylinders for compressive strength test of GE-RCC were taken from the site just after the end of compaction. The slump of the GE-RCC was 15mm to 20 mm, and the compressive strength of GE-RCC of W/C=0.6 is almost equivalent to RCC strength at 90 days age.

Fig-4 Pouring and vibrating GE-RCC

5. Conclusion

The GE-RCC method eliminates the need for a separate concrete mix to be used for Dam construction, resulting in no holding up of RCC placement process, enabling RCC placement to be carried out efficiently, reducing the costs of construction without any compromise to quality. However, the penetration of GE milk is the most crucial aspect for the successful application of GE-RCC technique. The mix proportion of GE milk has to be designed using locally available materials and resources to match the RCC mix. As raw material resources differ from region to region, a detailed laboratory testing and field testing is required to be carried out for a successful GE-RCC construction.

【 Reference 】

1) *Brian A Forbes, Some recent innovative methods and techniques in the design and construction of Proc. of the International Symposium on Roller Compacted Concrete Dams, Nov, 2003*