Investigation on the Roller Compacted Concrete Mix Design with All in One Aggregate (ShahricorRCC Dam Case Study)

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Abstract

In concrete dam's projects, aggregate materials are produced, deposed and used in different fraction. This method of producing materials has advantages and disadvantages.The most important advantage of producing materials in different fraction is the exact proportions of the concrete mix design.On the other hand, this method has many disadvantages and limitations, which greatly reduces the rate of implementation of the concreting.Since one of the purpose of roller concrete dam is to achieve high rate and efficiency and reduce costs, therefore this problem can be eliminated by the production of All in One Aggregate (A.I.O).

One of the advantages of producing A.I.O aggregates can be increasing rate of material production, decreasing aggregate depot, increasing machinery increasing the production concrete in batching plant, moisture stability in materials, and the ability to maintain the condition of concrete production and reduce material pert. The production of A.I.O aggregates for achieving the high rate concreting can be very effective and by this method, only the form of material production is changed but the combination of the aggregate is preserved.In this paper, concrete mix design with all in one aggregate investigated and compared with valid standards.

Keywords: Roller compacted concrete, RCC dam, concrete mix design, All in One Aggregation

1. INTRODUCTION

Considering the problems of production, storage and transportation of four fraction materials especially in hot climatic region and high amount of concrete and the need for multiple machines, the feasibility of the material replacement by integrated material production method is investigated.

In this case, with preserving the combination of the materials, only the shape of the concrete aggregates is changed. Initial investigations on the grading curves of ShahriKorborrow showed that 0-50 aggregate can be well workability and close to the standard mix design. In addition, the results of the study on these materials and concrete design are discussed below.

2. All In One Aggregate materials

In most concrete dam projects, stone materials are produced and deposited in different fractions. This method of producing materials has advantages and disadvantages. The most important advantage of producing materials in this way is to observe the exact ratios of the approved concrete mix design.The higher the number of aggregates, the greater the accuracy. On the other hand, this method has its disadvantages and limitations, which together with the stone material eliminates these disadvantages. The benefits of producing all-in-one aggregates (0-50 natural) are as follows:

1- Increasing the efficiency of material production

2- Decreasing depo Area and increasing depo efficiency

3. Reduce number of machinary for trasportation

4- Increasing the production efficiency of concrete in batching plant as well as reducing the risk of damage to batching bins.

5- Stability of moisture inside the materials and the possibility of keeping the concrete production conditions constant

6. Reduce pert of materials

In This method only changes the form of material production and preserves the composition of the material.

Production of All-In-One Aggregates to Achieve High Rate Concreting Due to Multiple Production Benefits, Topographical Conditions, Lack of Deposition of Stone Materials, Highly Difficult production of Stone Material could be Very Effective.

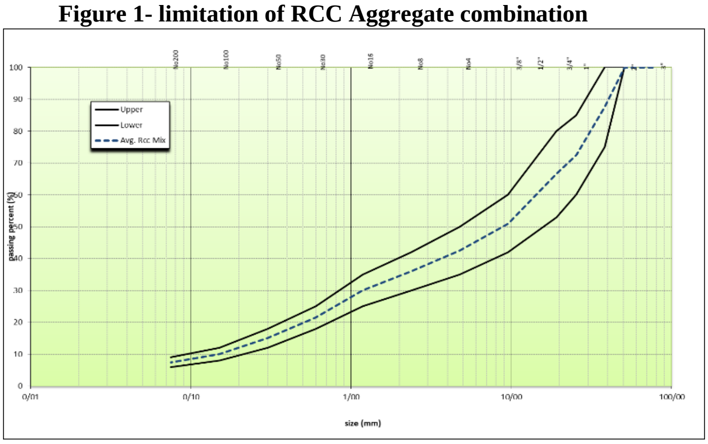
Sample of dams which are built with the All-In-One Aggregate material as follows:

1- Zaveh Dam in Iran (Sanandaj)
2- Burnett River Dam in Australia
3. Jack Turner Dam (Big Haynes) in the USA
4. Burton Gorge Dam in Australia

3. GRADING RANGE AND TECHNICAL SPECIFICATIONS

In the technical specifications of the project, the concrete mixing range of RCC is presented as an initial range in accordance with Figure 1. Also, the concrete mixing design of Shahrikor dam was optimized by the method of maximum density Aggregate. In this optimization, four fraction of stone aggregate including filler (0-5 natural), crushed sand (0-5), fine gravel (25-25) and coarse gravel (50-50) were used. The purpose of which is to investigate the possibility of using 0-50 natural aggregates (All in One) instead of four fraction aggregates.

Figure 1- limitation of RCC Aggregate combination



4. AGGREGATION OBTAINED FROM NATURAL RIVER MINE

As respectmixing design ratios are difficult to observe due to the uniformity of the depot aggregates in the All In One, therefore, quality control of the aggregate content is more important in terms of the grading curve, so appropriate mixing of the depot area and batching depot is achieved. Due to the decrease in the number of aggregate fractions, the possibility of separation in aggregates and consequently lack of overall aggregate aggregation is increased, so in order to check the uniformity of the aggregates, the aggregate curves of the aggregates should be controlled daily.

However, different aggregate limitation may be obtained in the different mine, and the results show that in all sampling of aggregate limitation, the aggregate fluctuates only in the sand portion, with the most critical being added by adding 10 to 30 percent sand is the grading curve, off-course the optimum is to add 23% crushed sand to a natural 0-50 aggregate.

Figures 2 and 3 show the aggregate A.I.O curves of natural 0-50 from different locations of the Mines. In the first mine, the aggregate curvature is standard, but in the second mine due to the lack of a fine-grained part (below 5 mm), the sand has to be sanded to fit the standard aggregate curve as shown in Figure 4.

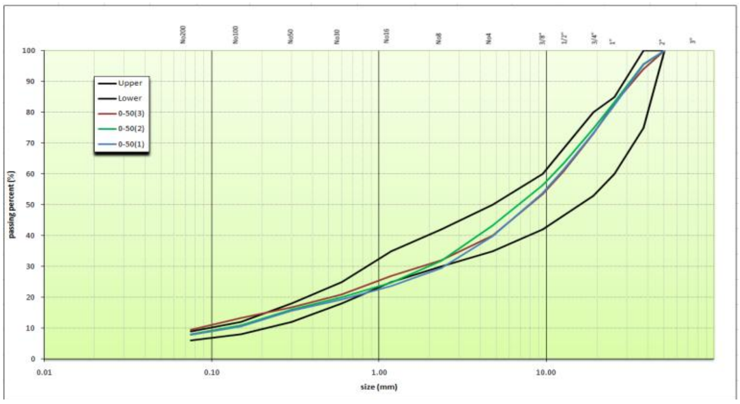


Figure 2- Natural Aggregate CURVE WITH ALL NATURE MATERIEL (First MINE)

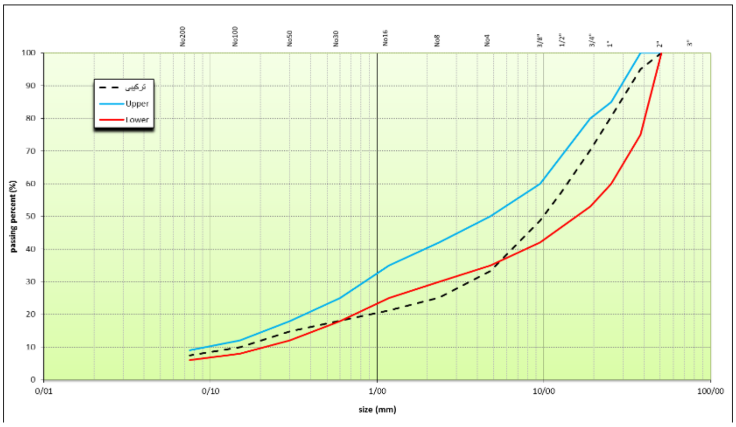


Figure 3- Natural Aggregate CURVE WITH ALL NATURE MATERIEL (First MINE)

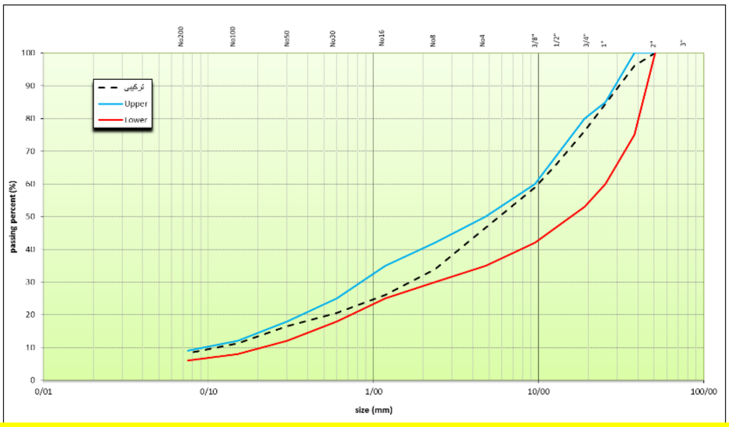


Figure 4- Natural Aggregate CURVE WITH ALL NATURE MATERIEL (First MINE)

5- COMPARISON OF THE PROPOSED CURVE WITH ACI 207.5R

In order to compare and better understand the mixture obtained from the All In One aggregates 0-50 mm with 23% crushed sand, the aggregate obtained from the borrow compared to a number of aggregate projects implemented. ACI 207.5R in accordance with Table 1, and Figure 5 are provided. As can be seen, the aggregate range obtained for the ShahriKor Dam is in good adjustment with other projects implemented in the world. Also, compared to the proposed curve of ShahriKor Dam with other implemented dams, it is clear that in value retained from sieve No 200 is in better condition and this has a positive effect on increasing the Vp / Vm ratio.

Table 1: Aggregation of some roller concrete projects from ACI 207.5R

Table 2.2—Combined aggregate gradings for RCC from various projects in U.S.

Sieve size	Willow Creek	Upper Stillwater	Christian Siegrist	Zintel Canyon	Stagecoach	Elk Creek
4 in. (100 mm)	—	—	—	—	—	—
3 in. (75 mm)	100	—	—	—	—	100
2.5 in. (62 mm)	—	—	—	100	—	96
2 in. (50 mm)	90	100	—	98	100	86
1.5 in. (37.5 mm)	80	95	100	91	95	76
1 in. (25 mm)	62	—	99	77	82	64
0.75 in. (19 mm)	54	66	91	70	69	58
3/8 in. (9.5 mm)	42	45	60	50	52	51
No. 4 (4.75 mm)	30	35	49	39	40	41
No. 8 (2.36 mm)	23	26	38	25	32	34
No. 16 (1.18 mm)	17	21	23	18	25	31
No. 30 (0.60 mm)	13	17	14	15	15	21
No. 50 (0.30 mm)	9	10	10	12	10	15
No. 100 (0.15 mm)	7	2	6	11	8	10
No. 200 (0.075 mm)	5	0	5	9	5	7
$C + P$ lb/cy	80 + 32	134 + 291	100 + 70	125 + 0	120 + 130	118 + 56
Total fines*	20%	21%	19%	21%	—	21%
Workability	Poor	Excellent	Excellent	Excellent	Good	Excellent

*Total fines = all materials in full mixture with particle size smaller than No. 200 sieve.

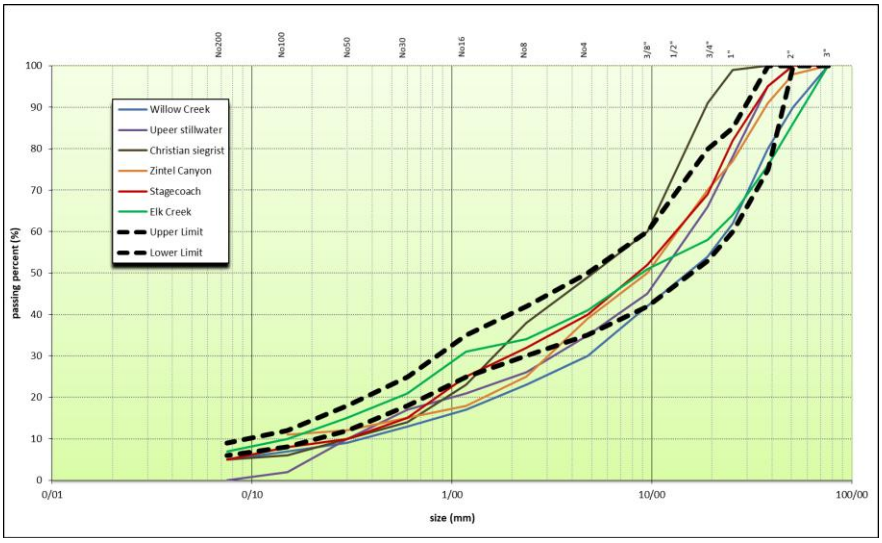


Figure 5. Aggregate curve of RCC Dam projects implemented around the world

5. CEMENT IN RCC

According to the technical specifications of shahricor project, the cement used in RCC Dam can be of Portland type II (with moderate hydration heat), ordinary Pozzolanic or special Pozzolani cement. This type of cement is preferable to type I cement in terms of producing less heat in mass concrete. . In Shahrakor Dam project, due to the potential of silica-alkali reaction in Aggregates, KhashPozzolanic cement with 30% Pozzolani type (N-type Pozzolan type) is used in concrete. This cement is controlled in laboratory by physical and chemical testing. The results of chemical and physical tests of these cements are shown in Tables 2 and 3.

Table 2: Results of Chemical Testing of KHASH Cement (ASTM C 595-16)

SiO2	31.27	
Al2O3	8.81	
Fe2O3	3.73	
CaO	49.04	
MgO	2.52	Max6%
Na2O	0.94	
K2O	0.95	
SO3	1.93	Max 4%
Loss-on-Ignition	1.66	Max 5%
Na2O	0.95	
CL	0.25	

Table 3 - Physical Test Results of KHASH Pozzolani Cement

Autoclave (Percent)	0.08
Fc 3 day(kg/cm2)	180
Fc 7 day(kg/cm2)	235
Fc 28 day(kg/cm2)	380
Initial setting time(min)	140
Final setting time(min)	170
Blain(cm2/g)	3300

6. WATER USED IN RCC

Water used in RCC is the water collected in Cofferdam reservoir, which is the result of chemical analysis of water as below table according to ASTM C 114 as Table 4.

Table 4 - Results of water chemical tests

Tests	Result
PH Value 25°c	7.9
Specific conductance micro mhos /cm	470
Filterable residue (T.D.S) dried at 110˚c (ppm)	749
Chlorides (CL) - (ppm)	135
Sulphates (SO4)-2 (ppm)	282
Sodium Na2o+(ppm)	493
Potassium K+ (ppm)	10

7 .COMPRESSIVE STRENGTH OF RCC

The characteristic compressive strength for the RCC is 120 kg / cm 2. According to the technical specifications, the target compressive strength at 90 days will be at least 170 kg / cm 2 (cylindrical).

8. VEBE TIME

The intended Vebe time in the specifications of Shahricor project is between 15 and 22 seconds, but in some project, it is lower than due to hot environmental conditions. In order to maintain the efficiency of RCC retarding additive has been used. Meanwhile, the suggested range of the Us Army for the Vebe time is 12 to 25 seconds.

9. RATIO OF PASTE VOLUME TO MORTAR VOLUME(VP/VM)

The ratio of paste volume to mortar has a direct impact on the efficiency and density of the RCC mix design. This ratio is related to the passing of sieve No 200. In the US Army Roller Compacted Concrete Instruction (EM1110-2-2006) it is recommended that at least 0.42 and values less than this ratio may be Have a negative impact on the strength of the RCC mix and lead to an increase in confined air, increased permeability and reduced Workability.

10. CONCRETE MIX DESIGNS WITH ALL IN ONE AGGREGATE

The specifications and results of all-in-one RCC mix design with required tests are presented in Table 5

Table 5 - Results of All-In-One Concrete Mix Design

sample name	C+P(ppv)	w/c	Retarder	aggregate compound		fresh concrete				compressive strength			K	tensile strength
			dose			Vp/Vm	vebe 5 min	vebe 30 min	unit weigth	7 day	28 day	90 day	K	
	kg/m3			%			sec	sec	kg/m3	kg/cm2	kg/cm2	kg/cm2	Cm/sec	kg/cm2
RCC-01 (ALL IN ONE)	180	0.6	1/0%	0-50N (100)		0.54	17	19	2381	77	125	145	1.78E-11	23.5
RCC-02 (ALL IN ONE)	170	0.6	1/0%	0-50N (100)		0.53	18	21	2373	75	106	137	2.16E-11	20.6
RCC-03 (ALL IN ONE)	160	0.65	1/0%	0-50N (100)		0.52	18	21	2371	72	101	134	9.03E-10	17.2
RCC-04 (ALL IN ONE)	160	0.7	----	0-5C (23)	0-50N (77)	0.43	14	27	2369	60	84	127	6.02E-10	15
RCC-05 (ALL IN ONE)	180	0.72	----	0-5C (23)	0-50N (77)	0.44	14	25	2373	66	90	147	1.02E-10	19.6
RCC-06 (ALL IN ONE)	200	0.7	1/0%	0-5C (23)	0-50N (77)	0.48	8	11	2377	93	125	185	9.1E-12	30.1
RCC-07 (ALL IN ONE)	190	0.7	1/0%	0-5C (23)	0-50N (77)	0.47	9	12	2381	86	117	174	1.28E-11	26.4
RCC-08 (ALL IN ONE)	180	0.7	1/0%	0-5C (23)	0-50N (77)	0.46	10	12	2374	81	111	151	1.35E-11	21
RCC-09 (ALL IN ONE)	160	0.6	1/0%	0-5C (23)	0-50N (77)	0.41	13	17	2370	82	102	135	7.69E-10	17.5

11. TESTS ON CONCRETE

In these concrete mix designs, compressive strength tests According to ASTM C-39, Brazilian tensile strength tests According to ASTM C-496 and depth-penetration permeability tests According to EN 12390 were performed on the samples, the results of which are presented in the table 5. Permeability tests based on the depth of water penetration in concrete and the determination of compressive strength and tensile strength show in figure No 6 , 7

Figure 6- Performing Water Influence Depth Test of Rcc Mixing Plans with All In One Materials

Figure 7-Tests to determine compressive strength and tensile strength of Rcc mixing designs with All In One.

12. – Conclusion

1. Due to the low Concrete Materials in borrow sources and in order to optimum use of aggregate, concrete mixdesign were performed using All In One natural aggregates in 0-50 mm range.
2. Different part of the Shahrikor borrow have been sampled at different times, and the aggregate results indicate fluctuations in the fine-grained. Preferably using crushed sand to improve the quality of materials used in RCC and less cement amount.
3. Considering the primary and important parameter in concrete mix design that provide characteristic compressive strength as well as the target strength with natural All in one Aggregate added natural sand.Concrete mix designthe No. RCC-06 and RCC-07 with 200 and 190 kg cementitious materials (cement + pozzolan) per cubic meter with 77% aggregate natural 0-50 (23%) and 23% crushed sand are

recommended which can provide the required compressive strength, permeability and tensile strength and other necessary requirements.

4. The use of retarding materials in the concrete mix designs to preserving the workability and reduces the water / cement ratio and improves the concrete properties including compressive strength, tensile strength and permeability.
5. Production of RCC with All in One Aggregate materials and quality control can increase the efficiency of concreting in dam body and reduce the cost of implementation in project.

6. REFERENCES

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