Experimental Research on the Physical Properties of Byone Sand and Evaluation on Strength of Byone Sand Concrete

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***Abstract* — This study presents Experimental research on the physical properties of byone sand and evaluation on strength of byone sand concrete. Byone sand (Pali Lin, Taunggyi) is used as fine aggregate (F.A) and Portland cement (Double Rhinos Grade 42.5) are used in this study. Crushed stone aggregate is used as coarse aggregate (C.A). In this study, the physical properties of local materials such as cement, fine aggregate (byone sand) and coarse aggregate are determined according to the American Society of Testing and Materials (ASTM) procedure and ASTM designations. The suitable water content for Local Concrete is found to be 180 kg/m^3. Mix design and compression tests are made for various water/cement (w/c) ratios, using concrete samples of 15cm diameter and 30cm height cylinder. The strengths of concrete are determined at 7 days, 28 days and 91 days to investigate the strength development with age. The 28 day concrete compressive strengths are found greater than 3000psi for w/c up to 0.7. Water content of 180 kg/m^3 is used. The American Concrete Institute (ACI) Method is used in Concrete Mix Design. cylinder samples of 15cm diameter and 30cm height are used. In this research, the concrete mixes with sieved sand give the compressive strength of up to 5500 psi after testing. So this byone sand shows high potential to use as one of the ingredients of concrete mix to use in constructions.**

Keywords— *byone sand, byone sand concrete, compressive strength, fine aggregate, w/c ratio.*

I. INTRODUCTION

In the area such as Taunggyi, Shan State, Myanmar, there is no conventional (river) sand nearby because its location is far away from rivers. If the river sand is carried from other place, the price may be very high due to transportation cost. However, Byone is an abundantly found material in there. It is also found at other parts of Shan State, Kayah State and some area of Mandalay Division in Myanmar. Thus, it is necessary to know the physical properties of locally available byone sand and strength of concrete with local byone sand. However, there is little or no research about byone as Engineering Materials. So, in this paper, experimental research on the physical properties of byone sand and evaluation on strength of byone sand concrete is carried out. Fig.1 shows location of material studied [24].

Fig 1 Location of Taunggyi

II. BYONE SAND

Byone sand is pitted from loose part of local hills by manual or recently by backhoe easily and used naturally .Fig.2 shows photos of byone sand sample. It includes particles of size larger than 4.75mm (which is max limit of fine aggregate) as well as finer than 0.075 mm.

Fig. 2 Photos of local sand sample

The X-ray diffraction (XRD) result for the material investigated is shown in Fig. 3 ,which shows that it is dolomite [$CaMg(CO_3)_2$].

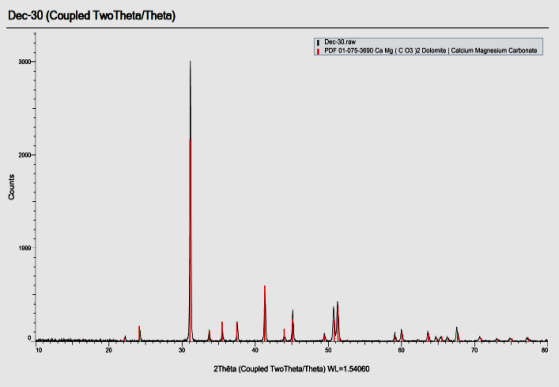

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Fig. 3 XRD Result for Local Sand Sample

III. Methodology

Firstly physical properties of ingredient materials of concrete are determined according to ASTM design-nations. And then trial mix designs for concrete with local materials are calculated with various water contents. After trying these trial mixes, suitable water content for concrete is determined. Hence, mix design calculations are made for required concrete mixes. Mixing concrete and moulding samples are followed. Then compressive strength tests are made. Evaluation on strengths is carried out.

IV. Physical Properties of Ingredient Materials

The ingredient materials of concrete: cement, sand and coarse aggregates are tested for their physical properties.

A. *Physical Properties of Cement*

Physical properties of cement: specific gravity, fineness, normal consistency, initial setting time, final setting time are tested according to ASTM standard procedures [14]-[18].The test results of Double Rhinos cement is described in Table I.

TABLE I
PHYSICAL PROPERTIES OF DOUBLE RHINO CEMENT

Properties	Result	Standard range
Specific Gravity	3.15	3.1-3.25
Fineness	4033 cm^2/g	>3500 cm^2/g
Normal consistency	28.5%	26%-33%
Initial setting time	100 min	> 60 min
Final setting time	207min	
Soundness(mm)	0.6 mm	< 1 mm

B. *Physical Properties of Fine Aggregate*

Physical properties of fine aggregate: sieve analysis, specific gravity and absorption are tested.

1) Sieve Analysis of Fine Aggregate: This test is used to determine the particles size distribution of fine aggregate. The grading of fine aggregate affects the workability of concrete. Fineness modulus is a term indicating the coarseness or fineness of the material. The standard specification of fineness modulus of fine aggregate is between 2.0 and 3.5 [3]. ASTM C136-01 is used for testing [19].

TABLE II
SIEVE ANALYSIS OF FINE AGGREGATE (PASSING 4.75MM SIEVE)

Sieve No	Sieve Opening	Accumulated % Retained		
		Test1	Test 2	Test 3
4	4.75	-	-	-
8	2.36	29.12	26.94	28.76
16	1.18	51.48	50.06	52.95
30	0.6	65.39	64.41	66.83
50	0.3	74.22	73.71	75.93
100	0.15	79.98	79.37	81.53
∑		300.19	294.49	306.01
Fineness modulus		3.00	2.94	3.06
Avg .Fineness modulus		3.00		

[*]Fineness Modulus =Σ Accumulated percent retained/100

Sieve analysis of fine aggregate passing 4.75mm sieve is calculated and results are shown in Table II. Fineness modulus is 3.0.

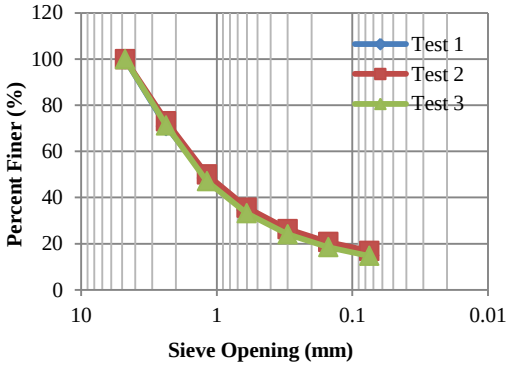

Fig.4 Particle Size Distribution of Local Sand

Fig. 4 shows the particle size distribution curve and the aggregate is found well- graded.

Grading of fine aggregate is also checked by specification of ASTM C33-92a and the resulting grading curve is shown in Fig. 5. It can be seen that it is just near the lower limit of ASTM C33-92a [2]

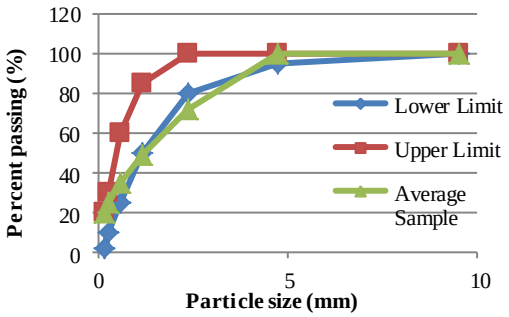

Fig. 5 Grading of Fine Aggregate (ASTM C33-92a)

2) Specific Gravity and Absorption of Fine Aggregate: Specific gravity and absorption is tested by ASTM C128 standard procedures [21].

TABLE III
SPECIFIC GRAVITY AND ABSORPTION OF FINE AGGREGATE

Test No	(1)	(2)	(3)	Ave -rage
Wt. of SSD Sample (S)	499.1	500.1	500	
Wt. of Bottle + water (full) (B)	675.2	675.1	675.0	
Wt. of Bottle +F.A + water (C)	997.0	998.6	997.9	
Wt. of Oven Dry Sample (A)	487.8			
Specific Gravity (SSD)	2.81	2.83	2.82	2.82
Absorption (%)	2.5 %			

Specific gravity of fine aggregate is 2.82 which is greater than normal weight aggregate limit of 2.5-2.7 [3] and absorption is 2.5% due to the presence of very fine fraction.

C. Physical Properties of Coarse Aggregate

Rodded unit weight is tested according to ASTM C29/29M-97(2003) [12]. Specific gravity and absorption is tested by ASTM C127 standard procedures [20]. The recorded values are shown in Table 6.

TABLE IV
PHYSICAL PROPERTIES OF COARSE AGGREGATE

Properties	Result
Rodded Unit Weight	1650 kg / m^3
Specific Gravity	2.76
Absorption	0.5 %

V. PREPARATION FOR MIX DESIGN

A Concrete should have good workability at fresh state and good strength and durability at hardened state. Concrete mix design can give not only safe but also economical concrete.

For concrete mix design, the physical properties of constituent materials of concrete are necessary to know. Properties of materials used for concrete mix design are as follow:

Cement – Specific Gravity = 3.15
F.A - Specific Gravity = 2.82
- Absorption = 2.5 %
- Fineness Modulus = 3.0
C.A – Rodded Unit Weight =1650 kg/ m^3
- Specific Gravity = 2.76
- Absorption = 0.5 %

In concrete mix design, water content is very important. Only suitable water content can lead to the right cement content, which can give required strength and economical concrete mix. Thus, before the concrete mix design, suitable water content must be determined by the trial mixes. Trial mixes are tried with water contents of 205, 200, 190, 185, 180 kg/m^3 of concrete, respectively and result are shown in Table V. In testing, C.A & F.A in saturated surface dry (SSD) condition are used with Double Rhinos Cement (Grade 42.5).Water content is targeted to about slump 3 in (75mm) (concrete used for structural design of building; beam, column, slab, footing, etc.).

TABLE V
FINDING WATER CONTENT

Water Content (kg/m^3 of Concrete)	Slump in(mm)	Remark
205	-	Flowing (Too much to add all water into mix)
200	-	Flowing
190	-	Segregation
185	6 (150)	Shear Slump
180	3 (75)	

Therefore Water Content required for Mix Design is 180 kg / m^3.

VI. MIX DESIGN

ACI 211 procedure is used for mix design [8]. Absolute volume method is used. For lab mix, byone sand passing 4.75 mm sieve is used. Mix designs for fineness modulus 3.0 and 3/4" maximum aggregate size are shown in Table VI. Both fine and coarse aggregates are saturated surface dry (SSD) condition.

TABLE VI
MIX DESIGN RESULTS

w/c	Cement (kg/m^3)	F.A (kg/m^3)	C.A (kg/m^3)	Water (kg/m^3)
0.4	450	813.4	990	180
0.5	360	894.0	990	180
0.6	300	947.7	990	180
0.7	257	986.1	990	180
0.8	225	1014.8	990	180

VII. Compression Test Results

Strength tests are made to check on the quality of concrete. Compressive Strength tests for concrete mixes with various water cement ratios (0.4, 0.5, 0.6, 0.7, 0.8) are carried out at the age of 7 days, 28 days and 91 days. Three test specimens for each age of each mix are cast and cured until testing. Table VII indicates the results of compressive strength of concretes.

TABLE VII
Compressive Strength Results

w/c	Compressive strength (psi)		
	7-day	28-day	91-day
0.4	4693.6	5511	6207.8
0.5	4091.5	4849.4	5599.2
0.6	3489.4	4187.8	4990.6
0.7	2887.3	3526.2	4382
0.8	2285.2	2864.6	3773.4

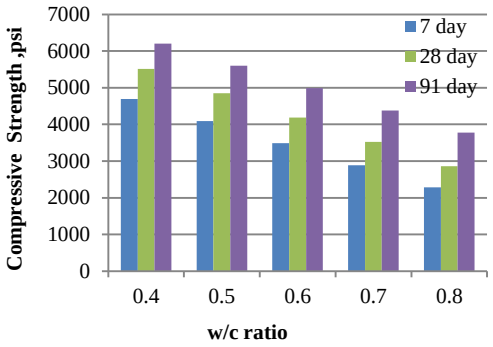

Fig 6 Compressive cylinder strength for Byone Sand Concrete

Fig. 6 shows that the compressive strength decreases significantly with increasing w/c ratio and increases with the age of concrete. It can be seen that compressive strength of about 5500 psi for w/c 0.4 and about 2900 psi for w/c 0.8 after curing age of 28 days. Fig. 6 indicates that the 28-day cylinder strengths are greater than 3000 psi (which is design strength required for building in high seismic zone according to MNBC Code) up to w/c 0.7. At the age of 91 days, the strength reaches to 6200 psi for w/c 0.4 .Obviously, even for w/c 0.8, strength greater than 3000 psi is obtained. So At the age of 91 days, all mixes give strength greater than 3000 psi.

Fig. 7 shows the relation curve between optimized strength and w/c ratio resulting from the linear regression analysis [7]. As an example, optimum w/c ratio for compressive strength 4000 psi can be calculated from the following optimized equation for 28-day strength.

$$Y = 8157.4 - 6166\,X \quad \ldots\ldots\ldots\ldots (1)$$
$$4000 = 8157.4 - 6166\,X$$
$$X = 0.628$$

Optimum water cement ratio is 0.628.

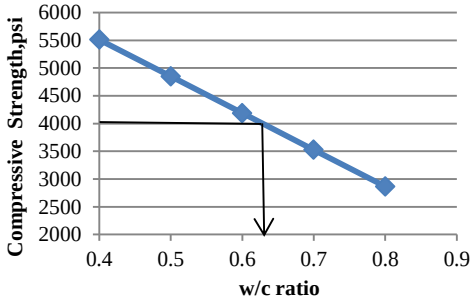

Fig. 7 Optimum water cement ratio

VIII. Conclusions

Byone sand from Taunggyi, Shan State is used. In this research, the concrete mixes with sieved sand give the compressive strength of up to 5511 psi after testing. The 28 day concrete compressive strengths are found greater than 3000psi for w/c ratio up to 0.7. So this local byone sand shows high potential to use as one of the ingredients of concrete mix to use in constructions.

Acknowledgment

The author expresses her deepest gratitude to Dr. Ni Lar Aye, Professor and Head, Department of Civil Engineering, Mandalay Technological University for her guidance. The author would like to express deepest thanks to the teachers from Mandalay Technological University for their effective suggestions and help. The author wishes to acknowledge to experts and staff in Irrigation Training Centre (ITC), Patheingyi township, for their valuable advice and allowing to use Lab.

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