International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume: 3 | Issue: 4 | May-Jun 2019 Available Online: www.ijtsrd.com e-ISSN: 2456 - 6470

Experimental Research on the Strength of Concrete for Local Cement with Various Replacement Materials

San San Myint

Department Of Civil Engineering, Technological University, Mandalay, Myanmar

How to cite this paper: San San Myint "Experimental Research on the Strength of Concrete for Local Cement with Various Replacement Materials" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-3 | Issue-4, June 2019, pp.1575-1580, URL: https://www.ijtsrd.com/papers/ijtsrd25198.pdf

IJTSRD25198

ABSTRACT

The main purpose of this paper is to study the effects of "Various replacement materials for cement" in concrete strength. Materials used in this research are abundant in Mandalay, Myanmar. In this paper, the chemical composition and physical properties of AAA cement is analysed. Cement replacement materials used in this research are blast-furnace slag powder which is obtained from iron and steel industry from Mandalay Industrial Zone, fly ash, and granite quarry dust which obtained from BaeLin, KyaukSe. The physical properties of cement, blast-furnace slag powder, fly ash and granite quarry dust, sand and aggregate are tested according to ASTM standard procedure. The specific gravity test, water absorption test and fineness modulus of fine and coarse aggregates are also carried out. The compressive strength of concrete is tested without and with replacement of cement materials. The dosages of fly ash are 10%, 20% and 30% respectively and Blast-furnace slag powder, 10%, 20%, 30% and 40% proportions are used for cement replacement. Different proportions of granite quarry dust 5%, 10%, 15%, 20% and 25% are also considered in this research. The compressive strengths of concrete are tested with cement and with cement replacement materials. The samples are tested for 7, 28, 60 and 91 days compressive strength.

Keywords: *compressive strength, blast-furnace slag powder, granite quarry dust, fly ash.*

I. INTRODUCTION

Concrete plays a significant role in the construction of structures around the world. Concrete is a composite material obtained by mixing cement, sand, gravel and water. A concrete mix can be considered to consist of two main parts, aggregates (sand and gravel) and cement paste (water and cement). The development and use of mineral admixtures for cement replacement is growing in construction industry mainly due to the consideration of cost saving, energy saving, environmental production and conservation of sources. Mineral admixtures are becoming more popular in recent decades. The use of recycled materials as concrete ingredients has been gaining popularity because of increasingly stringent environmental legislation, and the discovery that such materials often have complementary and valuable properties. The most conspicuous of these are fly ash, a by-product of coal-fired power plants, ground granulated blast furnace slag, and silica fume, a by-product of industrial electric arc furnaces. The objectives of the study are to know the physical properties of materials used in concrete and the strength of AAA cement concrete without and with cement replacement materials.

II. TESTING Of Materials Used In Concrete

In this study, the physical properties and chemical composition of AAA cement is tested. Then, the physical properties of fine and coarse aggregates are tested.

A. Chemical Composition of Cement

Table I shows the chemical composition of AAA cement.

Table I Chemical Composition Of AAA Cement

Chemical Constituents	Composition in percentage (%)
Calcium Oxide (CaO)	64.73
Silica(SiO_2)	21.18
Alumina (Al_2O_3)	4.97
Ferric Oxide (Fe_2O_3)	3.36
Manganese Oxide (MgO)	2.34
Sulphur Trioxide (SO_3)	1.53
Others	1.02
Loss	0.87
Total	100

B. Fineness of Cement

Fineness of cement is measured in terms of the percentage of the cement retained on ASTM No.200 sieve. This should not be more than 10 percent. Table II and Tables III to V show the results of fineness test for AAA cement only and with replacement of blast-furnace slag, fly ash and granite quarry dust respectively according to ASTM standard.

Table II Fineness Of AAA Cement

Test No.	Sieve No.	Shaking Time (min)	Percent Retained (%)
1	ASTM No.200	15	6.5
2	ASTM No.200	15	6.5
3	ASTM No.200	15	6.4
	Average (%)		6.5

Table III Fineness Of Cement with Different Percentages of Blast-Furnace Slag Powder

Percentage of Blast-Furnace Slag Replacement (%)	Fineness (%)
0	6.5
10	10.1
20	12.4
30	13.8
40	13.8

Table IV Fineness Of Cement with various mix proportions of fly ash

Replacement Percentage of Fly Ash (%)	Percent Retained (%)
0	6.5
10	8.9
20	9.2
30	13.7

Table V Fineness Of Cement with Different Percentages of Granite Quarry Dust

Percentage of Blast-Granite Quarry Dust Replacement	Fineness (%)
0	6.5
5	4.2
10	5.7
15	6.2
20	7.6
25	9.2

The fineness of AAA cement and partial replacement of granite quarry dust are less than 10% but others fineness with partial replacement of blast-furnace slag powder and 30% replacement of fly ash are greater than standard limit of 10%.

C. Normal Consistency of Cement

Neat cement paste of a normal consistency is used to determine the initial setting time, the final setting time, and Le Chatelier soundness tests. Therefore, it is necessary to determine the water content which will produce a paste of normal consistency for any given cement. This is considered to be normal consistency, when the plunger penetrates the paste to a point 10 ± 1 mm from the top of the mould. The water content of the paste is expressed as a percentage by weight of the dry cement, the usual range of values being between 26 to 33 percent. The test results of normal consistency for the AAA cement and cement with various replacement materials are shown in Tables VI to IX respectively.

Table VI Normal Consistency Of AAA Cement

Test No.	Wt. of Cement (g)	Volume of Water (ml)	Normal Consistency (%)
1	300	79.5	26.5
2	300	78	26
3	300	78	26
	Average (%)		26

Table VII Normal Consistency Of Cement with Different Percentages of Blast-Furnace Slag Powder

Percentage of Blast-Furnace Slag Replacement	Normal Consistency (%)
0	26
10	24.5
20	24.5
30	24.5
40	24

Table VIII Normal Consistency Of cement with various mix proportions of fly ash

Replacement Ratio of Fly Ash (%)	Normal Consistency (%)
0	26
10	27.3
20	26.2
30	25.3

Table IX Normal Consistency Of cement with various mix proportions of Granite Quarry Dust

Replacement ratio of Granite Quarry Dust (%)	Normal Consistency (%)
0	26
5	29.75
10	29.5
15	29.5
20	29
25	28.5

From the test results, normal consistency of cement and cement with partial replacement materials are within the standard range.

D. Specific Gravity of Cement

Specific gravity is not an indication of the quality of cement but it is used in the calculation of mix proportion. The specific gravity of good Portland cement should be between 3.15 and 3.2. This test is carried out according to ASTM-C 188-95. The specific gravity test results of cement and various replacement materials are described in Table X and XIII.

Table X Specific Gravity Of AAA Cement

Test No.	I	II	III
Wt. of cement (W) (g)	64	64	64
Volume of Kerosene + Cement (V_1) (ml)	20.5	20.4	20.6
Volume of kerosene(V_2) (ml)	0.1	0.1	0.1
Density of cement (g/ml)	3.14	3.15	3.12
Density of water (g/ml)	0.99626	0.99626	0.99626
Specific gravity of Cement	3.15	3.16	3.13
Average Specific gravity of Cement	3.15		

Table XI Specific Gravity Blast-furnace Slag Powder

Test No.	I	II	III
Wt. of cement (W) (g)	90	90	90
Volume of Kerosene + Blast-furnace Slag powder (V_1) (ml)	32.9	33	32.7
Volume of kerosene(V_2) (ml)	1	1	1
Density of Blast-furnace slag powder (g/ml)	2.82	2.81	2.84
Density of water (g/ml)	0.99626	0.99626	0.99626
Specific gravity of Blast-furnace slag	2.83	2.82	2.85
Average Specific gravity of Blast-furnace slag powder	2.83		

Table XII Specific Gravity Of Fly ash

Test No.	I	II	III
Wt. of fly ash(W) (g)	70.3	70.3	70.3
Volume of fly ash+ kerosene(V_1) (ml)	0.6	0.7	0.4
Volume of kerosene (V_2) (g)	32.8	32.8	32.6
Specific gravity of fly ash	2.18	2.19	2.18
Average specific gravity		2.18	

Table XIII Specific Gravity Granite Quarry Dust

Test No.	I	II	III
Wt. of granite quarry dust (W) (g)	90	90	90
Volume of Kerosene + granite quarry dust (V_1) (ml)	32.9	33	32.7
Volume of kerosene(V_2) (ml)	0	0.6	1
Density of granite quarry dust (g/ml)	2.73	2.74	2.75
Density of water (g/ml) (T°C = 28°C)	0.99624	0.99624	0.99624
Specific gravity of granite quarry dust	2.75	2.75	2.76
Average Specific gravity of granite quarry dust	2.75		

The average specific gravity of various replacement materials is range from 2.75 to 2.83 which is less than the specific gravity of good Portland cement.

E. Setting Time of Cement

This is the term used to describe the stiffening of the cement paste. Setting refers to a change from a fluid to a rigid state. The initial setting time should not occur in less than 45 min and final setting time should not be greater than 10 hrs according to ASTM standard. Table XIV and Table XVII show the setting time of AAA cement and with various replacement materials respectively.

Table XIV Setting Time Of AAA Cement

Test No.	I	II	III
Wt. of Cement (g)	300	300	300
Wt. of Water (g)	76.5	75	75
Starting Time of Supply of Water (hr:min)	11:25	10:25	9:45
Time Observed Initial Setting Time (hr:min)	2:10	1:15	12:40
Initial Setting Time (min)	135	140	145
Average Initial Setting Time (min)		140	
Time Observed Final Setting Time (hr:min)	3:20	2:30	2:10
Final Setting Time (min)	205	215	235
Average Final Setting Time (min)		218	

Table XV Initial and Final Setting Time Of Cement with Different Percentages of Blast-Furnace Slag Powder

Percentage of Blast-Furnace Slag Replacement	Initial Setting Time (min)	Final Setting Time (min)
0	140	218
10	138	220
20	136	222
30	145	254
40	158	273

Table XVI Initial and Final Setting Time Of Cement with Different Percentages of Fly Ash

Replacement Percentage of Fly Ash	Initial setting time (min)	Final setting time (min)
0	140	218
10	117	230
20	138	240
30	67	180

Table XVII Initial and Final Setting Time Of Cement with Different Percentages of Granite Quarry Dust

Replacement Percentage of Granite Quarry Dust	Initial setting time (min)	Final setting time (min)
0	140	218
5	120	240
10	125	240
15	130	245
20	145	250
25	150	250

The initial and final setting times of AAA cement only and also with partial replacement of materials are within standard limit.

F. Soundness

Soundness test is carried out to detect the presence of un-combined lime in cement. This test is performed with the help of Le-Chatelier apparatus. The expansion exhibited by the Le-Chatelier mould should not exceed 1mm for any type of Portland cement. Table XVIII and Table XXI show the test results of soundness for AAA cement and with various replacement materials respectively.

Table XVIII Soundness Of AAA Cement

Number of test	I	II	III
Before boiling (cm)	3.1	2.77	2.705
After boiling (cm)	3.2	2.82	2.76
Difference (mm)	0.1	0.05	0.055
Average (mm)		0.7	

Table XIX Soundness Of Cement with Different Percentages of Blast-Furnace Slag Powder

Percentage of Blast-Furnace Slag Replacement	Soundness (mm)
0	0.7
10	0.5
20	0.4
30	0.4
40	0.4

Table XX Soundness Of cement with various mix proportions of fly ash

Replacement Percentage of Fly Ash	Soundness (mm)
0	0.7
10	0.57
20	0.53
30	0.4

Table XXI Soundness Of Cement with Different Percentages of Granite Quarry Dust

Percentage of Granite Quarry Dust Replacement	Soundness (mm)
0	0.7
5	0.37
10	0.37
15	0.4
20	0.4
25	0.47

The soundness exhibited by the Le-Chatelier mould is not exceeding 1mm for cement alone and with various replacement materials.

G. Sieve Analysis Test for 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. The standard specification of fineness modulus in fine aggregate is between 1.6 and 3. Table XXII shows the test result of sieve analysis of fine aggregate.

Table XXII Sieve Analysis of Fine Aggregate

Sieve No.	Sieve Opening (mm)	Wt. Retained (g)	Percent Retained (%)	Accumulated Percentage Retained (%)	Finer (%)
4	4.75	3.2	0.64	0.64	99.36
8	2.36	5	1	1.64	98.36
16	1.18	16.6	3.32	4.96	95.04
30	0.595	99.1	19.82	24.78	75.22
50	0.297	313.3	62.66	87.44	12.56
100	0.149	56.9	11.38	98.82	1.18
Pan		5.9	1.18	100	0
Total		500	100		

In this study, the fineness modulus of fine aggregate is 2.18 and it is within typical range from 1.6 to 3.

H. Water Absorption of Fine Aggregate

The test results for water absorption of fine and coarse aggregate are shown in Table XXIII and XXIV respectively.

Table XXIII Water Absorption Of Fine Aggregate

Test No.	I	II	III
Wt. of container + Wt. of wet fine aggregate (g)	1435.5	1434.1	1446.9
Wt. of container + Wt. of dry fine aggregate (g)	1425	1423.3	1435.5
Wt. of container (g)	388	358.4	320.6
Wt. of water (W_w) (g)	10.5	10.8	11.4
Wt. of dry fine (W_d) (g)	1037	1064.9	1114.9
Absorption (%)	1.01	1.01	1.02
Average (%)	1.01< 2%		

Table XXIV Water Absorption of Coarse Aggregate

Test No.	I	II	III
Wt. of saturated surface dry sample, B (g)	3020	2990	2983
Wt. of oven dry sample, A (g)	2950	2918	2910
Absorption (%)= B-A/A x 100	2.4%	2.5%	2.5%
Average absorption (%)	2.5 %		

I. Specific Gravity of Fine and Coarse Aggregates

Table XXV and Table XXVI show the test results of specific gravity of fine and coarse aggregates.

Table XXV Specific Gravity Of Fine Aggregate

Test No.	I	II	III
Wt. of fine aggregate (g)	500	500	500
Wt. of bottle, W_1 (g)	164.2	164.2	164.2
Weight of bottle + water, W_2 (g)	661.5	660.8	661
Weight of bottle + water + sand, W_3 (g)	974.5	973	973.1
Specific Gravity	2.67	2.66	2.66
Average	2.66 > 2.5		

Table XXVI Specific Gravity of Coarse Aggregate

Test No.	1	2	3
Wt. of SSD aggregate, B (g)	3020	2990	2983
Wt. of saturated sample in water, C (g)	1781	1763	1767
Specific gravity= B/ (B-C)	2.44	2.44	2.45
Average specific gravity	2.44		

III. Testing On Concrete

Strength tests are made to check the quality of concrete.

A. Compressive Strength Test

Compressive strength is a measure of the maximum resistance of a concrete specimen that can maintain against axial loading. It is one of the primary parameters for concrete quality control testing. The average compressive strength of mix design is tested at 7, 28, 60 and 91 days. The specimens are tested under a compressive axial load. At each period interval, three cubes with and without replacement materials are tested and average compressive strength of the three cubes are taken as the compressive strength. The results of compressive strength are shown in Tables XXVII to XXIX.

Table XXVII Compressive Strength of Concrete with replacement percentages of Blast-furnace Slag Powder

Percentage of Blast-Furnace Slag Replacement	Compressive Strength, psi			
	7 days	28 days	60 days	91 days
0	3700.3	4267.3	4579.0	5075.3
10	3402.7	4139.7	4309.7	4664.0
20	2623	2977	3573	4253
30	1971	2623	2751.3	3189.7
40	1460.3	2353.3	2438.7	2821.3

Table XXVIII Compressive Strength of Concrete with replacement percentages of Fly Ash

Percentage of Fly Ash Replacement	Compressive Strength, psi			
	7 days	28 days	60 days	91 days
0	3700.3	4267.3	4579.0	5075.3
10	2693.27	3458.67	4252.53	4578.56
20	2154.61	3175.33	3685.52	3912.33
30	2026.97	2466.49	2891.72	3217.75

Table XXIX Compressive Strength of Concrete with replacement percentages of Granite Quarry Dust

Percentage of Granite Quarry Dust Replacement	Compressive Strength, psi			
	7 days	28 days	60 days	91 days
0	3700.3	4267.3	4579.0	5075.3
5	3895.1	4345.1	4703.7	5224.9
10	4150.98	4454.9	4829.2	5319.4
15	3852.45	4308.5	4678.6	5130.4
20	3497.05	4125.4	4415.2	4900.8
25	2885.8	3551.7	3938.6	4401.3

IV. DISCUSSION AND CONCLUSION

In this study, physical properties of cement such as fineness test, setting time test, specific gravity test, consistency test and soundness test are carried out. Similarly, specific gravity test, water absorption test and sieve analysis test of fine and coarse aggregates are also carried out. According to the test results, the fineness of cement and granite quarry dust as cement replacement are less than 10%. The normal consistency, initial and final setting time of cement alone and with various replacement materials are within the standard range. All soundness values of cement only and blast-furnace slag powder, fly ash and granite quarry dust as cement replacements are within the ASTM standard since soundness values are less than 1mm. To study how the various cement replacement materials are influence on the compressive strength of concrete with local cement, the compressive strength of concrete without and with various percentage of replacement materials as cement are tested. All samples are cured for 7 days, 28 days, 60 days and 91 days. It can be found that, the compressive strength of concrete decreases with increase percent of both blast-furnace slag powder and fly ash are used as cement replacement at all ages. However, it is clear that 5% and 10% of granite quarry dust is used as cement replacement; the compressive strength of concrete is increased and 15% replacement is also greater than the compressive strength of cement alone. This is because the fineness of granite quarry dust is within the ASTM standard value of cement. It can be concluded that 10% of blast-furnace slag powder and 20% of granite quarry dust as cement replacement mix proportions are appropriate for the use of concrete material 28 days strength of 4000 psi in reinforced concrete structural members design.

REFERENCES

[1] Nevile. A. M and Brooks. J. J., 1990. Concrete Technology.

[2] ASTM, 1975. Annual Book of ASTM Standards.

[3] Irving Kett, Engineered Concrete, Mix Design and Test Methods.

[4] Ken W. Days, James Aldred, Berry Hudson, Concrete Mix Design, Quality Control and Specification (4Th edition)

[5] U Nyi Hla Nge. Essentials of Concrete Inspection, Mix Designs and Quality Control.