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Compressive Strength of Concrete Using Blended Local Supply Aggregates Over Different Curing Periods

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Abstract— *One of the most important variables in optimizing the compressive strength of concrete is identifying the quality of aggregate supply. However, due to scarcity and local restrictions prohibiting quarrying, maximizing the use of available supply is required. The compressive strengths of concrete made with aggregates from six different local suppliers blended together and cured for 60 days were compared in this study. Specific gravity and absorption, sieve analysis, abrasion test, workability test, and compressive strength test were all used to determine the suitability of these aggregates for concrete products. The study's specific findings revealed that as the number of curing days increased, the compressive strengths of the six different concrete mixtures increased as well. Using the local source of aggregates also showed a comparable increase in the compressive strength of concrete. The compressive strength of a concrete mixture at the 28-day curing period can be attained by the other mixture at a specified curing periods. Proper curing of concrete specimens by ponding at required temperature also showed a significant increase in the compressive strength of concrete. The study concludes that the compressive strengths of the six different concrete mixtures varied and can be properly attended by correct proportioning, handling, and proper mixing. The use of blended aggregates coming from the local supply, and the variation of water cement ratio per mixture yielded a good result. The study further revealed that all selected aggregates sources were applicable for concrete construction work in the area and can be blended to maximize volume used without much due effect on its quality.*

Keywords— *Concrete, Blended Aggregates, Curing Periods, Compressive Strength.*

I. INTRODUCTION

Water, fine aggregate, coarse aggregate, and cement constitute concrete, which is a compound building material. For concrete production, construction company mostly uses traditional construction resources such as ordinary aggregates, crushed aggregates and other sustainable replacement material, and cement. The quality of raw materials such as cement, aggregates, admixtures, and water is critical in the development of concrete's physical and mechanical qualities. [14][15][11][22].

When choosing aggregates for concrete, the compressive aggregate strength is taken into account.

Concrete's compressive strength is determined by the water-to-cement ratio, cement-to-aggregate ratio, degree of compaction, aggregate-to-mortar bond, aggregate strength, form, and size [1][2][3][4][23]. Concrete's compressive strength is largely determined by the type of aggregate used. One of the most essential components that affects the strength of concrete is fine aggregate that fills in the voids left by coarse aggregate during batching of concrete [5][6][4][24][25][27].

Aggregates have an impact on the mechanical attributes of high-performance concrete, such as strength and durability. The type of aggregate affects the stiffness and fracture energy of concrete for a certain water/cement ratio [7][8][9][26]. To obtain an acceptable mixture, other physical parameters of aggregate such as form, size, texture, moisture levels, specific gravity, unit weight, and soundness must be determined before using it for concrete production. The information acquired from these qualities, together with the water/cement ratio, allows for better precision in estimating the concrete's strength, workability, and durability. All of these characteristics have an impact on the quality of concrete [10][11].

The qualities of new concrete are more affected by the physical shape and texture of aggregate than those of hardened concrete. The smoothness and roundness of the aggregate in concrete determine its workability. Rough and irregular-shaped aggregate generates less workable concrete than the smooth and round aggregate. In concrete design mix, the fine aggregate fineness, physical shape, surface texture, and mechanical properties are determined because these properties may increase water consumption during mixing, which can greatly affect the quality[14][15][16]. Also, the degree of hydration and the water/cement (w/c) ratio determines the mechanical properties of concrete [12][13].Proper curing of concrete also greatly affects the compressive strength of concrete. Curing methods consider air curing, water-submerged curing, spray curing, polythene curing, moist sand curing and burlap curing until testing ages of 3, 7, 14, 21 and 28 days for nomal curing periods [17][18][19][20][21].

The researcher blended or mixed six different local supplies of aggregates in the Visayas Region, Philippines, and employed them as mixing aggregates for six different concrete design mixes in this paper. Due to the increasing building sector in the Philippines, concrete cylinder samples are cured for 60 days to measure the variance in compressive strengths if blended together to maximize the utilization of these aggregates.

II. MATERIALS AND METHODS

2.1 Materials

The following materials used in this research were as follows:

2.1.1 Cement: Ordinary Portland Cement was purchased from a local construction supply store in Visayas, Philippines.
2.1.2 Fine and Coarse Aggregates: Six different local suppliers of fine and coarse aggregates from Cebu and in the Visayas Region, Philippines, were blended or mixed and used as aggregates in the producton of concrete using six different concrete mixtures.
2.1.3 Water: Potable water from local water utility was used for concrete mixing.

2.2 Methods

The following methods were adopted in this research were as follows:
2.2.1 Mixture proportion: Six different concrete mixtures were used in determing the quantities of ingredients of the concrete mix.
2.2.2 Laboratory tests
Specific gravity and the amount of water absorption: One of the most essential features of fine and coarse aggregates in the computation of mix design is specific gravity. The standard test method ASTM C128 was used in the determination of the specific gravity.
Sieve Analysis: Standard test method ASTM C136 was used for sieve analysis of blended fine and coarse aggregates.
Abrasion Test: The hardness of the blended coarse aggregates was determined by the Los Angeles abrasion test. Standard test method ASTM C131 was used in the test.
Curing: Standard test method ASTM C31 was used for curing of test specimens and curing by ponding at standard temperature was used.
Slump Test: Separate test of a slump for the concrete mixtures using the blended aggregates. Standard test method ASTM C143 was used for the test.
Compressive Strength Test: Compressive strength of concrete was determined under a normal curing period of 7 days, 14 days, 28 days, 35 days, 40 days, 50 days and 60 days. Standard test method ASTM C39 was used for the test.

III. Results and Discussion

TABLE 1: Proportions of Concrete Mixture

Concrete Mixture	Mixture Proportion
A	1 : 1 : 1.5
B	1 : 1.5 :2.5
C	1 : 2 : 3
D	1 : 2 : 5
E	1 : 2.5 : 6
F	1 : 3 : 7

The material ratios required for a cubic unit of the concrete mixture are shown in Table 1. For a given concrete batch, 1 denotes the amount of cement, 1.5 the quantity of fine aggregates (a blend of six local supplies), and 2.5 the quantity of coarse aggregates (a blend of six different local supplies). It should be noted that all of the concrete materials per mix will be measured in the same way.

Table 2 shows the findings of the slump test. The average slump for mixture A was 105.50 mm, and it is increasing up to mixture F. The increase is noticeable because the water-cement ratio increases, and the aggregates in the concrete mixture are sourced from six different suppliers that were blended together.

TABLE 2: Slump Test Results Per Concrete Mixture

Concrete Mixture	Average Slump, mm
A	105.50
B	124.25
C	155.74
D	170.85
E	190.15
F	230.36

TABLE 3: Water-Cement Ratio and Compressive Strength

Concrete Mixtures	Water-Cement Ratio by Weight	Ave. Compressive Strength, fc' (28-day)
A	0.65	24.19 MPa
B	0.75	20.98 MPa
C	0.90	17.59 MPa
D	1.01	15.81 MPa
E	1.13	13.85 MPa
F	1.42	11.50 MPa

The water-cement (W/C) ratio of the six distinct concrete mixtures and the compressive strength necessary for a 28-day curing period are shown in Table 3. The corresponding water-cement ratios are calculated using the absolute volume formula in concrete material proportioning calculations. Table 3 further demonstrated that as the water-cement ratio increases, the specimens' compressive strength for a 28-day curing period decreases.

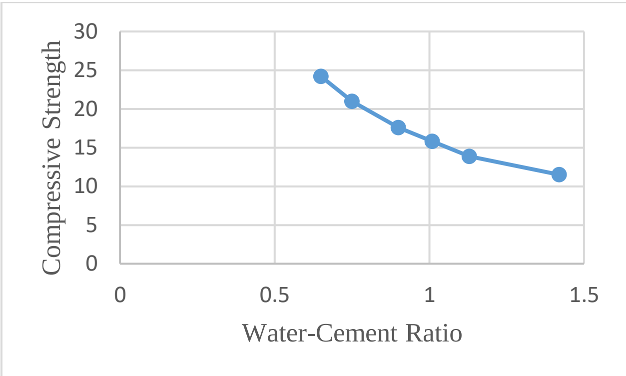

Fig. 1: W/C Ratio and Compressive Strength

The graph in Figure 1 shows an increasing compressive strength with a decreasing water-cement ratio (W/C). The lower the water-cement ratio (W/C), the greater the compressive strength of the concrete.

Table 4 illustrates the compressive strengths of concrete specimens measured on a concrete testing equipment from 3-day to 60-day curing periods in MPa (N/mm^2). The results indicate an increasing compressive strength of the six different concrete mixtures from the 3-day to the 60-day curing (ponding) period. A considerable amount of increase is very evident from the start of curing to 60 days. Mixture A, for example, has an increase of 5.44 MPa (N/mm^2) from the 3-day to 7-day curing period. Mixture B has an increase of 3.31 MPa (N/mm^2) from the 7-day to 14-day curing period. Mixture C has an increase of 2.32 MPa (N/mm^2) from the 14-day to 28-day curing period. Mixture D, on the other hand, has an increase of

0.53 MPa (N/mm^2) on the 28-day to the 35-day curing period. Mixture E also shows an increase of 0.41 MPa (N/mm^2) on the 35-day to the 40-day curing period. Lastly, mixture F attains an increase of 0.45 MPa (N/mm^2) from 50-day to 60-day curing interval. The amount of increase in the compressive strengths of each mixture per curing interval also decreases as the curing interval increases.

TABLE 4: Curing Period and Compressive Strength

Curing Period (Days)	Mix. A	Mix. B	Mix C	Mix D	Mix E	Mix F
3	11.82	10.15	8.44	7.65	6.75	5.40
7	17.26	14.78	12.55	11.33	9.95	7.97
14	21.30	18.09	15.22	13.61	12.23	9.72
28	24.19	20.98	17.54	15.81	13.85	11.50
35	25.34	21.72	18.10	16.34	14.48	11.58
40	26.06	22.34	18.67	16.75	14.89	11.92
50	27.03	23.22	19.36	17.42	15.44	12.35
60	28.00	24.00	20.00	18.00	16.00	12.80

In Table 5, the increase in the compressive strength of the concrete mixtures increases as the curing period increases. Mixture A has a relative increase in compressive strength of 23.41% from the 7-day to the 14-day curing period. It still increases on the next curing interval but is lesser than the preceding increase. Mixture B to Mixture F also showed an increase in compressive strengths in every curing interval but also decreased as the curing period increased. The percentage increase in compressive strengths of the six different concrete mixtures per curing interval shows a constant or uniform increase. The average increase in compressive strengths of the six different concrete mixtures per curing interval decreases, despite the fact that there is a tiny discrepancy in the 35-day to 40-day interval. But on the 40-day and 50-day to 50-day to the 60-day interval, the results showed that the percentage again decreased. The greater the concrete proportions, the lesser the strength, as shown in the results of the compressive strengths of the six different concrete mixtures. Larger proportions have greater volume but are lesser in strength. On the other hand, lesser proportions have greater strengths.

TABLE 5: Percent Increase of Compressive Strength Per Curing Period

Curing Period (Days)	Mix. A	Mix. B	Mix C	Mix D	Mix E	Mix F
3-7	46.02	45.62	48.7	48.1	47.4	47.59
7-14	23.41	22.4	21.3	20.12	22.91	21.96
14-28	13.56	15.97	15.24	16.16	13.24	18.31
28-35	4.75	3.53	3.2	3.35	4.55	3.04
35-40	2.84	2.85	3.14	2.5	2.83	2.93
40-50	3.72	3.93	3.69	4	3.69	3.60
50-60	3.58	3.35	3.3	3.32	3.62	3.64

Table 6 below, illustrates the increase in compressive strengths of the concrete proportion per curing interval. Considering mixtures D and E, mixture E produces lesser compressive strength than mixture D, as shown in the preceding tables of the compressive strengths of concrete. The percent increase in compressive strength during the 3-day curing period is 13.33%, 13.87% on the 7-day period, 11.27% on the 14-day period, 14.15% on the 28-day period, 16.34% on the 35-day period, 16.75% on the 40-day period, 17.82% on the 50-day period and 18% on the 60-day curing period. A considerable constant increase in compressive strength of the two mixtures per curing interval is seen. The average increase is 15.19%. Mixtures C and D also indicate a uniform percent increase in compressive strength per curing interval. The average value is 14. 99%. Mixtures E and F; mixtures C and B; mixtures B and A also showed the same trend in percent increase in compressive strengths. These results mean that the lesser the concrete proportion, the greater the strength.

TABLE 6: Percent Increase of Compressive Strengths of Concrete Proportions

Curing Period (Days)	Mix A-B	Mix B-C	Mix C-D	Mix D-E	Mix E-F
3	16.45	20.26	10.33	13.33	25
7	16.78	17.76	10.76	13.87	24.84
14	17.74	18.86	11.83	11.28	25.82
28	15.30	19.61	10.94	14.15	25.04
35	16.66	20.00	18.10	16.34	14.48
40	16.65	19.65	18.67	16.75	24.91
50	16.40	19.93	19.36	17.42	25.02
60	16.66	2.00	20.00	18.00	25.00

IV. Conclusions, Recommendations

4.1 Conclusion

4.1.1. The compressive strengths of the six different concrete mixtures increase as the number of curing day periods increases using blended aggregates.
4.1.2. The compressive strengths of the concrete mixtures increase as the quantities for proportioning concrete materials decrease. A concrete mixture ratio of 1:1:1.5 has greater compressive strength compared to a concrete mixture ratio of 1:1.5:2.5.
4.1.3. The compressive strength of a concrete mixture at the 28-day curing period can be attained by the other concrete mixture at a longer or shorter curing period. The compressive strength of mixture C during the 28-day curing period can be attained by mixture D during the 50-day curing period.
4.1.4. All six local supplies of aggregates can be blended together and can be used as aggregates in concrete to produce a good quality concrete product.

4.2 Recommendation

For the future development and betterment of this study, the researcher recommends the following:
4.2.1 To test aggregates properties coming from other sources outside the Visayas Region for more blending processes.
4.2.2 Based on the conclusions, the six local supplies of aggregates is of good quality and to maximize its use, it is recommended that blended aggregates is suitable for concrete work production.

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