A Method of proportioning Flyash Concrete

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ABSTRACT

Replacement of portland cement in concrete with flyash by weight reduces the workability and necessitates vibration compaction or the use of chemical workability aids. In this paper a method of proportioning of flyash concrete is suggested in which parts of cement and sand are replaced with flyash by equal volumes. The requirement of water of flyash concrete thus proportioned does not exceed that of plain concrete of similar workability. Thus flyash concrete can be either hand compacted or vibrated with the same effort as for plain concrete. 7 days and 28 days compressive strength of the flyash concretes of workabilities similar to that of plain concretes are not affected. The method of proportioning of flyash concrete is recommended to the site engineer. Economy in cement in conventional mixes is of the order of 10-16 per cent.

INTRODUCTION

Substituting flyash for cement in concrete mix by weight or by volume will nearly always have lower strength than their control mix at ages upto 28 days but frequently the strength attained would be equal or higher at 90 days and beyond (1). Lovewell and Washa (2) developed method for proportioning flyash concrete mixes for 28 days strength equal to that of control mix. In their method the amount of flyash added always exceeded the amount of cement replaced. Based on this study Rehsi and Garg (3) suggested a method for proportioning flyash concrete aiming equal 28 days strength, using Indian flyashes of different fineness and carbon content. However, these flyash concrete mixes required mechanical vibration for compaction on account of the stiff composition of the mixes produced being unsuitable for hand compaction. Use of chemical water-reducing admixtures could increase the workability of flyash concrete to enable hand compaction (4) but chemical admixtures are considered to be expensive additives. Recently a new method of proportioning flyash concrete has been devised attaining the same workability as of plain concrete. Flyash concretes thus produced can be hand compacted or vibrated without any extra effort as their corresponding plain concretes of workable or stiff consistencies and without the use of chemical admixtures. Almost equal strengths are achieved at 28 days of curing. The paper describes the proportioning method and the results of investigation.

EXPERIMENTAL

Materials

(a) *Flyash* : Delhi flyash was taken. Its chemical composition is reported in Table 1.

TABLE 1

Chemical Composition of Delhi Flyash

Constituents	Per cent
Silica (SiO_2)	59.17
Alomina (Al_2O_3)	25.59
Ferric Oxide(Fe_2O_3)	7.13
Calcium Oxide(CaO)	2.74
Magnesium Oxide(MgO)	1.38
Loss on ignition(%)	3.09
Total	99.10

Its physical characteristics as per IS 1727-67 are reported.

TABLE 2

Physical properties of Delhi Flyash

Property	Results	Limits
Fineness(Blains) cm^2/g	4000	not less than 3200
Lime Reactivity Kg/cm^2	59	50

(b) *Fine aggregate* : Badarpur sand having the following sieve analysis was taken.

TABLE 3

Sieve Analysis of Badarpur sand

I.S. Sieve Designation	Percentage passing
4.75mm	100
2.36mm	99.9
1.18mm	95.1
600 micron	74.7
300 micron	12.3
150 micron	2.3
Fineness modulus	2.16

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(c) *Coarse aggregate* : Natural gravel passing 19 mm sieve was taken.

(d) *Cement* : Two normal portland cements A&B were taken. Their physical properties are reported.

TABLE 4

Physical properties of cements

Property	Results A	Results B	Limits of IS 269—1967
Surface area(Blains) cm²/g	4100	3430	2250
Setting Time(minutes)			
Initial	75	320	not less than 30
Final	160	495	not more than 600
Compressive strength Kg/cm²			
3 days	221	160	not less than 160
7 days	282	253	not less than 220
28 days	420	400	

The two cements comply with IS 269—1967

Cement B is, however, comparatively inferio in strength and has much longer setting time.

PROPORTIONING METHOD

Nominal 1:2:4 concrete mix by volume wa taken as the control mix. Since flyash is a muc lighter material than cement or sand and it specific gravity is lower, volume replacement o cement or sand with flyash was adopted. In th mix 1:2:4, part of cement A and Badarpur sand were replaced with flyash by equal volume and the water requirement of each mix and of con trol was determined for compaction factors o 0.86, 0.89 and 0.92 taking care to see that th water requirement of the flyash concrete thu proportioned did not exceed that of control con crete for the same volume. It was observed that replacing 16 parts of cement and 10 part of sand with equal volumes of flyash yielded the optimum results in each case. Quantities of materials and water requirement of each mix per cubic metre of concrete are reported in Table 5.

TABLE 5

Mix No.	Concrete Mix Proportions C	F	S	A	Compaction Factor	Materials required per cubic metre of concrete (Litre) C	F	S	A	W
1.	1	0	2	4	0.92	274	0	538	1255	223
2.	0.84	0.36	1.8	4	0.92	233	58	490	1283	216
3.	1	0	2	4	0.89	277	0	545	1270	206
4.	0.84	0.36	1.8	4	0.89	238	59	501	1312	200
5.	1	0	2	4	0.86	276	0	542	1262	192
6.	0.84	0.36	1.8	4	0.86	242	60	508	1331	186

*C,F,S,A, and W stand for cement, flyash, sand aggregate and water.

Using cement A, 10 cm. cubes of the control and flyash concrete were cast by hand moulding, demoulded after 24 hours, cured under water and tested for compressive strength. The results are reported in Table 6.

TABLE 6

Mix No.	W/C	W/C+F	Compressive strength (Kg/cm2) 3d	7d	28d
1.	0.81	—	80	103	133
2.	0.93	0.74	70	85	137
3.	0.74	—	83	113	165
4.	0.84	0.68	76	107	173
5.	0.70	—	91	125	177
6.	0.77	0.61	88	116	185

Similar study was carried out for mix proportions 1:1:2, 1:1.5:3, 1:2:4 and 1:3:6 by volume each at compaction factor of 0.92 (slump 10 cm) using cement B. Quantities of Materials and water requirements for each mix are indicated in Table 7.

TABLE 7

Mix No.	Concrete Mix Proportions C	F	S	A	Materials required per cubic metre of concrete C	F	Kg/S	A	Litres W
1.	1	0	1	2	500	0	493	1164	233
2.	1	0.2	0.8	2	503	59	396	1169	233
3.	1	1	1.5	3	357	0	528	1246	214
4.	0.9	0.25	1.35	3	327	53	483	1266	214
5.	1	0	2	4	276	0	544	1284	223
6.	0.84	0.36	1.8	4	238	59	502	1317	219
7.	1	0	3	6	189	0	559	1319	214
8.	0.84	0.76	2.4	6	163	86	460	1357	202

Compressive strength of 10cm cubes of plain and fly ash concrete of the above mixes, using cement B, are reported in Table 8.

TABLE 8

Mix No.	W/C	W/C+P	Compressive strength (Kg/cm²) 3d	7d	28d	90d
1.	0.47	—	147	215	346	467
2.	0.46	0.41	158	225	335	485
3.	0.60	—	95	148	233	292
4.	0.65	0.56	92	151	240	327
5.	0.81	—	74	91	130	184
6.	0.92	0.74	68	84	134	221
7.	1.13	—	40	53	73	114
8.	1.24	0.81	41	53	102	151

DISCUSSION

Results of Table 5 and 7 show that the admixture of flyash in concrete as per the proportioning method suggested reduces or is equal to the water requirement of concrete for similar workability in terms of compaction factor. This is contrary to the earlier finding (5) that the admixture of flyash in concrete increase water requirement for the same workability.

Development of strength of flyash concrete at 28 days is of the same order as of plain concrete of similar workability even when using cement B of inferior quality. This is important from the point of view of design of flyash concrete for structural purposes. Seven days strength of flyash concrete approaches or is equal to that of plain concrete. This is significant in that the use of flyash in concrete as cement or sand replacement will not delay the striking of form work.

Saving in cement in 1:3:6, 1:2:4 and 1:1.5:3 is of the order of 10—16 per cent. No saving could be achieved in very rich mix 1:1:2 used primarily for durability under aggressive conditions.

CONCLUSION

A method of proportioning flyash concrete is suggested. The design strength of flyash concrete at 28 days is found to be at par with that of plain concrete. The method has the advantage that the admixture of flyash in concrete does not affect its workability adversely for vibration compaction or hand compaction as desired.

Economy in cement in conventional concrete mixes is of the order of 10—16 percent.

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REFERENCES

1. Cumlon, R. W. 'Proportioning flyash concrete mix for strength and economy, ACI Jour. Vol. 65, No. 11, Nov. 1968, pp. 969-979.

2. Lovewell, C. E. and Washa, G. W. 'Proportioning concrete mixtures using 'fly ash', ACI Jour. Vol. 54, No. 12, June 1958, pp. 1093-1102.

3. Rehsi, S. S. and Garg S. K. 'Proportioning concrete mix containing flyash', Journal of the Institution of Engineers (India), Vol. XIV, No. 1, Pt. Cl. Sept. 1964.

4. Chopra, S. K. Rehsi, S. S. and Garg, S. K. 'Use of water and set-reducing admixture in flyash' concrete RILEM International Symposium on Admixtures for Mortar and concrete, Brussels, August 30th-Sept. 1st 1967.

5. Rehsi, S. S. and Garg, S. K. 'Evaluation of Indian flyash' Indian concrete journal, June, 1963, p. 215.