Concrete Mix Design with Fly Ash and Superplasticizer

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Fly ash or pulverished fuel ash (pfa) is a finely divided powder thrown out as a waste material at the thermal power plants using pulverized coal for raising steam in the boilers. In the building industry, the use of fly ash a part replacement of cement in mortar and concrete at the construction site has been made all over the world including India and is well known. The important building materials which can be produced from fly ash are:

- Portland flyash cement
- Ready-mixed fly ash concrete
- Precast fly ash concrete building units
- Sintered fly ash lightweight aggregate for concrete
- Lime fly ash cellular concrete
- Fly ash building bricks
- Fly ash stabilized high-magnesia cement
- Oil-well cementing composition
- Hydraulic binders and
- Bitumious products

The advantages of fly ash concrete over the corresponding plain cement concrete are:

- Improved workability.
- Lower heat of hydration.
- The increase in creep with fly ash content upto 15% is negligible.
- Increases the modulus of elasticity of concrete when concretes of the same strength with and without fly ash are compared.
- Superior resistance to freezing and thawing.
- Improved sulphate resistance.
- Lower water and air permeability.
- Lower leaching of lime liberated during hydrated of cement.
- Reduced alkali-aggregate reactions.
- Greater resistance to attack of aggressive waters.

Since a huge quantity of cement is used in concrete in mass concrete construction and the cost of fly ash is negligible as compared to that of the cement, the use of fly ash concrete brings about a substantial saving in cement consumption and overall construction cost.

Fly ash concrete may be used in general RCC structures including high strength concrete without any risk of steel corrosion. Researchers have proved that concrete with approved quality fly ash does not induces corrosion of reinforcing steel even in marine and industrial aggressive environments. With proper mix design the 7 and 28-days strength of fly ash concrete may be equal or even more than plain concrete. The 90 days strength of fly ash concrete may be more than 140% of plain concrete. The cost of fly ash is negligible. Therefore the use of fly ash in structural concrete may bring a substantial saving in cement consumption and over all cost of concrete production. The fly ash is an industrial waste and great hazard for our environment. The designers of concrete structures therefore must incorporate the use of fly ash in their structural concrete.

Example of Mix Design

A mix is to be designed for characteristic strength of 50 N/mm^2 at 28 days having target strength of 62 N/mm^2 at 28 days. 30% of fly ash is to be included by weight of cementitious material. Maximum w/c ratio or w/c + f.a. ratio = 0.4, minimum cement concrete or cement + f.a. content = 400 kg/m^3. Slump 50 ± 10 mm.

Date of Material

Cement : OPC, 53 grade, specific gravity = 3.15

Fine aggregate : From river of Zone II Sp.gr. = 2.6

Coarse aggregate : Crushed 20 mm graded, Sp. Gr. = 2.6

Fly ash : As per I.S.: 3812, Sp. Gr = 2.25

Superplasticizer : Liquid Sp.gr. 1.15, dosage 1% b.w.c. for required

Workability

Water content reduction for fly ash concrete : 5%

Increase in cementitious material : 12%

Designed plain concrete of above strength and workability:

Water (free) = 170 kg/m^3

OP Cement = 430 kg/m^3

Fine aggregate = 707 kg/m^3

Coarse aggregate = 1060 kg/m^3

Superplasticizer = 4.300 kg/m^3= 3739 ml/m^3

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Total = Sum of all of the above = 2371 kg/m^3 (air = 1%)

Fly ash concrete of above strength and workability :

Total cementitious	wt. (kg/m^3)	vol (m^3)
Material = 1.12 x 430 = 482		
OP Cement = 482 x 0.70 = 337	337 / 3150	= 0.1070
Fly ash= 482 x 0.30 = 145	145 / 2250	= 0.0644
Water (free) = 170 x 0.95 = 162	162 / 1000	= 0.1620
Superplasticizer= 482 x 0.01 = 4.82*	4.82 / 1150	= 0.0042
Air = 1%		= 0.0100
Total	= 0.3476	
Aggregates=	1-0.3476	= 0.6524
Coarse aggregate(SSD) unaltered=1060	1060 / 2600	= 0.4077
Fine aggregate = 0.2447×2600= 636	0.6524-0.4077	= 0.2447
Total	= 2345	= 1

• Total dosages of superplasticizer may be reduced on actual trials.

Standard deviation for fly ash concrete is assumed unaffected with the ash.

Comparison (kg/m^3)

Materials	Plain Concrete	Fly ash Concrete
Water (free)	170	162
OP Cement	430	337
Fly ash	—	145

Fine aggregate	707	636
Coarse aggregate	1060	1060
Superplasticizer	4.300	4.820
	2371	2345

Saving in cement 430-337 = 93 kg/m^3

It may be noticed that, for the fly ash concrete the total cementitious material is greater but the OP cement content is smaller, the fine aggregate content is reduced but the coarse aggregate content is deliberately the same, the water is reduced and the density is reduced because of the lower density of fly ash compared with cement.

Note that it should not be assumed that ggbfs concrete or other fly ash concretes would require the same adjustment. The factors can differ appreciably between materials, source and quantities and will be influenced by the proportion of ggbfs or fly ash, the cement content and other factors. The method, however will be applicable and can be used for any situation, provided the factors are known.

Method of Fly Ash Concrete Mixing

For obtaining the best result the fly ash concrete should be prepared by the following mixing method:

About 3/4^{th} quantity of the mixing water be taken in the concrete mixer. Weighted amount of the required quantity of fly ash then added to it and mixed for 30 sec. To the slurry of fly ash so obtained, weighted quantities of coarse aggregate, fine aggregate, cement and remaining quantity of the mixing water be added and mixed for 90 sec.

However, if this is not convenient normal mixing method may be adopted i.e.

Weighted quantities of coarse aggregate, fine aggregate cement and fly ash should be put together in the concrete mixer and mixed dry for 30 sec. The required quantity of the mixing water then added and the mixing continued for 90 sec. The superplasticizer by added just before discharge of the mix from mixer.

References

1. I.S. 3812 (Part-I) – Specification for fly ash
2. Kishore Kaushal –Concrete Mix Design With Flyash & Superplasticizer ICI Bulletin April – June, 1997, pp. 29-30.

*We at engineeringcivil.com are thankful to **Er. Kaushal Kishore** for submitting the paper on **Concrete Mix Design with Fly Ash and Superplasticizer**. This will not only be a great help to fellow civil engineers but also in saving environment by using the waste fly ash.*