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TENTATIVE GUIDELINES ON CEMENT-FLY ASH CONCRETE FOR RIGID PAVEMENT CONSTRUCTION

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1. INTRODUCTION

Cement-fly ash concrete, utilising good quality pozzolanic fly ash to replace parts of cement (15-20 per cent) and sand (about 10 per cent) in cement concrete, can be used in all pavement construction works where plain cement concrete is used. By adopting proper mix design methods, for the same design strength more economical mixes can be produced with cement-fly ash concrete as compared to plain cement concrete.

Use of cement-fly ash concrete in place of plain cement concrete will, not only enable substantial savings in the consumption of cement, but also provide an economic and useful avenue for disposal of fly ash, which is now a recognised national problem.

These guidelines were approved by the Cement Concrete Road Surfacing Committee (personnel given below) in their meeting held at Hyderabad on the 5th January, 1976.

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These were processed by the Specifications and Standards Committee in their meeting held on the 22nd August 1976 subject to certain modifications which on the authorisation of the

Committee, were carried out by Dr. R.K. Ghosh and Shri R. P. Sikka. These were later approved by the Executive Committee and the Council in their meetings held on the 18th November and 4th December 1976 respectively.

2. MATERIALS FOR CEMENT-FLY ASH CONCRETE

2.1. Fly Ash

Fly ash for use in cement-fly ash concrete shall conform to IS: 3812-1966 "Specification for Fly Ash (Part I) for Use as Pozzolana" and possess lime-reactivity of not less than 40 kg/cm^2, specific surface area (Blaine's) of not less than 3200 cm^2/gm and carbon content of not more than 12 per cent. Lignite fly ash may also be used provided it satisfies the above stipulations and its magnesium oxide (MgO) content and total sulphur content as sulphur trioxide (SO_3) do not exceed 5 and 3 per cent by weight respectively.

2.2. Cement

Cement shall be ordinary portland cement conforming to IS : 269-1 976 "Specification for Ordinary and Low Heat Portland Cement." or IS: 8112-1976 "Specification for High Strength Ordinary Portland Cement."

2.3. Aggregates

The aggregates shall conform to the requirements set out in para 2.2 of IRC : 15-1970 "Standard Specifications and Code of Practice for Construction of Concrete Roads."

2.4. Water

Water shall conform to the requirements set out in para 2.3 of IRC : 15-1970.

3. CEMENT-FLY ASH CONCRETE MIX DESIGN

3.1. While considerable work is in progress on the design of cement-fly ash concrete mixes, no direct mix design procedure is yet available for this purpose. The following procedure is suggested for indirect design of these mixes, wherein first a plain cement concrete mix is designed for the stipulated criteria using actual materials (except fly ash), and then an equivalent cement-fly ash concrete mix established therefrom.

3.2. The plain cement concrete mix may be designed as per IRC: 44-1976, "Tentative Guidelines for Cement Concrete Mix Design for Pavements".

3.3. The equivalent cement-fly ash concrete mix design should then be established as follows :

(1) Let W:C:S:A be the designed plain cement concrete mix, with, W, C, S, and A representing the quantities in kg of water, cement, sand and coarse aggregate respectively per cu.m. of the plain cement concrete mix.

(2) Let W' : C' : F : S' : A' be the equivalent cement-fly ash concrete mix, with W', C', F, S' and A' being the quantities in kg of water, cement, fly ash, sand and coarse aggregate respectively per cu.m. of the mix.

(3) Let, S_c, S_f, S_s and S_a be the specific gravities of cement, fly ash, sand and coarse aggregate respectively.

(4) Let $C' = p_c\, C$

$S' = p_s\, S$

The values of p_c and p_s depend on a large number of parameters like relative fineness, specific surface and specific gravity of cement, sand and fly ash. Select suitable values of p_c and p_s based on previous experience with the materials. Suitable values will generally be found within the following range :

$p_c = 0.90 - 0.80$

$p_s = 0.95 - 0.85$

In the absence of previous experience, the following values may be adopted for trial purposes :

$p_c = 0.85$

$p_s = 0.90$

(5) Calculate the total quantity of fly ash in the mix to compensate for reduction made in cement and sand with equal volumes of fly ash. Thus

F_c = wt. of fly ash of equal volume of cement replaced

$$= (C - C')\frac{S_f}{S_c},$$

F_s = wt. of fly ash of equal volume of sand replaced

$$= (S - S') \frac{S_f}{S_s},$$

and F = total quantity of fly ash per cu.m. of mix

$$= F_c + F_s$$

$$= (C - C') \frac{S_f}{S_c} + (S - S') \frac{S_f}{S_s}$$

(6) Calculate W' from the consideration of keeping the water/effective binder ratio same. This may be based on the following correlation:

$$\frac{W'}{C' + F_c} = \frac{W}{C}$$

or $$W' = W. \frac{C' + F_c}{C}$$

(7) Calculate A' from consideration of making up for reduction in volume of water, so that

$$A' = A + (W - W') S_a$$

(8) Make a trial mix with the calculated mix proportions ($W':C':F:S':A'$) and check for the workability. If the desired workability is not obtained, adjustment in the value of p_c may be necessary. If the workability of the trial mix is more or less than the stipulated value, reduce or increase respectively the value of p_c to increase or reduce the per cent replacement of cement by fly ash.

(9) After adjustment of workability has been made by one or more trials as required, the adjusted mix should be used as the basis of trial mixes for checking the strength.

3.4. An illustrative example of calculation of equivalent cement-fly ash concrete mix corresponding to a given plain cement concrete mix is given in *Annexure*.

4. EQUIPMENTS

The stipulations contained in para 4 of IRC: 15-1970 and in IRC: 43-1972 "Recommended Practice for Tools, Equipment and Appliances for Concrete Pavement Construction" should be complied with.

5. CONSTRUCTION

5.1. Cement-fly ash conerete pavement construction is identical to that of plain cement concrete pavements, but for the difference that parts of cement and sand are replaced by suitable fly ash at the batching stage. Provisions of IRC: 15-1970 may, therefore, be followed in this respect.

5.2. Storage and Handling of Fly Ash

Beeng a very fine material, fly ash gets easily airborne. For protection against this, fly ash may be either bagged or soaked with water at the top during transport. When not bagged, it may be stored in rectangular trapezoidal pits dug for the purpose. The top should be kept covered with tarpaulins or other suitable cover.

5.3. Batching of Fly Ash

Like other constituents in the mix, fly ash should also be batched by weight. Water may, however, be batched by volume using calibrated containers, and cement by the bag ensuring that each bag contains the specified standard quantity of cement. For small-sized constructions, as the amount of fly ash per batch of one bag of cement is small, it is normally more convenient to weigh fly ash separately on a pan balance and feed it directly to the mixer instead of weighing in the weigh batcher. In case fly ash is wet, its moisture content should be determined and allowance made therefor.

5.4. Mixing

Provisions contained in para 8.4 of IRC: 15-1970 should apply except that water should first be fed into the mixer followed by fly ash to form a slurry and thereafter cement and aggregates added. It is important to ensure that the fly ash is well dispensed in the mix.

6. QUALITY CONTROL

6.1. In general, quality control of cement-fly ash concrete constructions should be on lines indicated in Chapter 6 of IRC SP: 11-1973 "Handbook of Quality Control for Construction of Roads and Runways". In addition, quality of fly ash should be checked as

per IS: 3812 (Part I)—1966 once initially for approval of the source of supply and subsequently for each fresh consignment. Moisture content of fly ash should also be determined once or twice daily as required.

6.2. Thorough mixing should be ensured as per para 5.4.

Annexure

EXAMPLE OF DESIGN OF EQUIVALENT CEMENT—FLY ASH CONCRETE MIX FOR A GIVEN PLAIN CEMENT CONCRETE MIX

1. The given plain cement concrete mix, designed for 28 day compressive strength of 300 kg/cm² in the laboratory, has the following quantities of materials per cu.m. of concrete:

Water	W	= 150 kg
Cement	C	= 333 kg
Sand	S	= 828 kg
Coarse Aggregate	A	=1235 kg
Air Voids		= 1%

Weights of sand and coarse aggregate are on saturated surface dry basis. The specific gravities of the materials are:

Cement	S_c	= 3.150
Sand	S_s	= 2.687
Coarse Aggregate	S_a	= 2.900

Design equivalent cement-fly ash concrete mix for the following conditions:

Cement replacement by fly ash	=15% by wt.
Sand replacement by fly ash	=10% by wt.
Specific gravity of fly ash, S_f	=2.250

2. In the example:

W=150 kg
C=333 kg
S=828 kg
A=1235 kg
S_c=3.150
S_s=2.687
S_a=2.900
S_f=2.250
p_c=0.85
p_s=0.90

$$\frac{S_f}{S_c}=\frac{2.25}{3.15}=0.715;\quad \frac{S_f}{S_s}=\frac{2.25}{2.687}=0.836$$

3. $C' = p_c \quad C = 0.85 \times 333 = 283$ kg

   $S' = p_s \quad S = 0.90 \times 828 = 745.2$ kg

4. $F_c = \dfrac{(C - C')\,St}{S_c} = 50 \times 0.715 = 35.75$ kg

   $F_s = \dfrac{(S - S')St}{S_s} = 82.8 \times 0.836 = 69.25$ kg

   $\therefore F = F_c + F_s = 35.75 + 69.25 = 105.0$ kg

5. $W' = \dfrac{W}{C}(C' + F_c)$

   $\dfrac{150}{333}(283 + 35.75) = 150 \times \dfrac{318.75}{333} = 143.6$ kg or l

6. $A' = A + (W - W')\,S_a$
   $= 1235.0 + (150 - 143.6) \times 2.9$
   $= 1235.0 + 6.4 \times 2.9 = 1253.5$ kg

7. Hence, equivalent cement-fly ash concrete mix, which may be used as a basis for trials, is:

   $W' = 143.6$ kg or l
   $C' = 283.0$ kg
   $S' = 745.2$ kg
   $F = 105.0$ kg
   $A' = 1253.5$ kg