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TENTATIVE GUIDELINES
FOR
THE USE OF LIME-FLY ASH CONCRETE AS PAVEMENT BASE OR SUB-BASE

THE INDIAN ROADS CONGRESS

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1. INTRODUCTION

1.1. These guidelines were approved by the Cement Concrete Road Surfacing Committee (personnel given below) in their meeting held at Chandigarh on the 1st March, 1975.

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These were processed by the Specifications and Standards Committee in their meeting held on the 13th December 1975 and later approved by the Executive Committee and the Council in their meetings held on the 22nd December 1975 and 3rd January 1976 respectively.

1.2. General

Lime-fly ash concrete is a semi-rigid material having distinctly superior load dispersion characteristics as compared to conventional granular bases and sub-bases like water-bound macadam. As such a smaller thickness of this material can be used to replace the conventional base and subbase courses in flexible and rigid pavement construction. IRC: 15-1970 "Standard Specifications and Code of Practice for Construction of Concrete Roads (First Revision)" permits the use of 10 cm thick lime-pozzolana concrete in place of 15 cm thick water-bound macadam as subbase under concrete pavement.

Besides superior load spreading properties, lime-fly ash concrete is resistant to softening under water action and can serve as a good working platform on softer foundations. These properties make this material particularly suitable for use in heavy rainfall areas, black cotton soil areas (when laid over lime-stabilised black cotton soil) and in areas where good quality stone for base courses has to be obtained from long distances. Lime-fly ash concrete will enable 20-30 per cent reduction in thickness *vis-a-vis* granular base courses.

As disposal of fly ash from thermal power stations is a recognised national problem, use of lime-fly ash concrete as a structurally superior paving layer will also contribute towards relieving this problem.

2. THICKNESS DESIGN OF LIME-FLY ASH CONCRETE BASE/SUBBASE LAYER

2.1. As Base Course in Flexible Pavement

The thickness of lime-fly ash concrete layer for use as base course in flexible pavement should be designed in accordance with the CBR method of design, vide IRC: 37-1970 "Guidelines for the Design of Flexible Pavements," using an equivalency factor of 1.25-1.5 depending on the discretion of the designer. Thickness of lime-fly ash concrete layer should, however, in no case be less than 10 cm.

2.2. As Subbase Course under Rigid Pavement

The thickness of lime-fly ash concrete layer for use as a subbase course under cement concrete pavement should be as per IRC: 15-1970 "Standard Specifications and Code of Practice for Construction of Concrete Roads (First Revision)". IRC : 15-1970 recommends the provision of 10 cm thickness of lime-pozzolana concrete subbase in lieu of 15 cm thickness of water bound macadam.

3. MATERIALS FOR LIME-FLY ASH CONCRETE

3.1. Lime

Lime used for lime-fly ash concrete should, as far as possible, conform to Class C variety as per IS: 712-1972: "Standard Specifications for Building Limes." The purity shall, however, not be less than 60 per cent. Lime shall be used in hydrated form.

3.2. Fly Ash

Fly ash should conform to IS: 3812 (Part II)-1966: Standard Specifications for Fly Ash: Part II.

3.3. Aggregates

Coarse aggregate for use in lime-fly ash concrete should be either natural stone aggregate conforming to IS: 383-1970: Standard Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete (Revised), or broken brick conforming to IS: 3068-1965: Specification for Broken Brick Coarse Aggregate for Use in Lime Concrete, or Cinder aggregate conforming to IS: 2686-1964: Specifications for cinder aggregates for use in lime concrete, depending upon the situation of use. Similarly, fine aggregate for use in lime-fly ash concrete should conform to IS: 383-1970: Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete or IS: 3182-1967: Specification for Broken Brick Fine Aggregate for use in Lime Mortar. Aggregates conforming to IS: 2686-1964 and having the required grading for fine aggregate as stipulated in IS: 383-1970 may also be considered. In selecting the aggregates, the strength requirement stipulated in para 4.1. should be kept in view.

3.4. Water

Water used in-mixing or curing of concrete should be clean and free from injurious amounts of deleterious matter. Potable water is generally considered satisfactory for this purpose.

4. PROPORTIONING OF LIME FLY ASH CONCRETE

4.1. Mix Design Criteria

To act as a semi-rigid pavement layer, lime-fly ash concrete should be designed to give a minimum compressive strength of 40-60 kg/cm^2 at 28 days in the field, as specified in IRC: 15-1970. As compaction in the field is done by rolling, workability should be kept low, with zero slump.

4.2. Mix Design

4.2.1. Like lean cement concrete, the mix proportions for lime-fly ash concrete are designed by trial and error method. To facilitate selection of suitable proportions of the trial mix, particulars for a few lime-fly ash concrete mixes, designed with fly ash having lime-reactivity of 40-50 kg/cm^2, lime of 60 per cent purity, medium coarse sand, and good quality crushed coarse aggregate of 20 mm max. size are given in Table 1.

TABLE 1

PARTICULARS OF TYPICAL LIME-FLY ASH CONCRETE MIXES

S. No.	Mix Proportions (by weight)	Water Content (% by dry weight of mix materials)	28-days strength	
	Lime:Fly Ash:Sand:Coarse Aggregate		Compressive	Flexural
1.	1 : 2.0 : 4.0 : 9.0	10.7	36	5.7
2.	1 : 2.0 : 4.0 : 9.0	9.7	49	8.0
3.	1 : 2.0 : 2.5 : 5.25	10.0	69	14.8
4.	1 : 2.0 : 2.25 : 6.75	10.8	72	11.6
5.	1 : 2.0 : 2.7 : 6.3	11.0	75	14.8
6.	1 : 1.5 : 3.3 : 7.5	9.7	60	8.0
7.	1 : 1.5 : 2.7 : 8.3	7.0	69	11.6
8.	1 : 1.5 : 2.25: 5.25	9.7	75	14.8

The maximum size of the coarse aggregate in the mix is limited by the thickness of the lime-fly ash concrete layer to be laid, and should generally not exceed 40 mm for 10 cm thickness. For thicknesses exceeding 10 cm, multilayer construction should be adopted when compaction is effected through rolling. While selecting trial mix proportions from Table 1, allowance should be made for change in the maximum size and shape of aggregate, as increase in maximum size of aggregate requires reduction in water content, change in shape from angular (crushed aggregate) to rounded (uncrushed gravel) requires reduction in both water and sand contents, and increase or decrease in fineness modulus of sand, a like change in sand content. Significantly lower strength may be expected when broken brick or cinder is used as coarse and/or fine aggregate instead of crushed stone. As a rough guide, for the stipulated 28 days compressive strength of 40-60 kg/cm^2, the approximate total aggregate/binder (lime+fly ash) ratio may be between 2.5 and 3.5 (by wt.) with water content about 10-11 per cent by wt. of total dry materials, when crushed stone is used as coarse aggregate.

4.2.2. To ensure min. 28 day field compressive strength of 40-60 kg/cm^2, allowing for process variances in the field, the laborarory mix should be designed for 1.25 times the required field strength.

4.2.3. Wherever practicable, both cube and beam test samples should be made for the trial mixes to determine compressive as well as flexural strength of the mixes. Where casting and testing

beam samples is not feasible, only cube samples for determination of compressive strength may be made. In the latter case, flexural strength of lime-fly ash concrete (in the range of 40-60 kg/cm^2 compressive strength) should be assumed to be 1/6th of the compressive strength. The strength tests should be conducted as per relevant Indian Standard specifications for cement concrete.

5. EQUIPMENTS

5.1. Batching and mixing Equipment for Lime-Fly Ash Concrete

Batching of materials for lime-fly ash concrete should be done by weight, and volume batching may be permitted only when unavoidable. Mixing should be done in power driven concrete mixers of adequate capacity. The stipulations of IRC: 43-1972 "Recommended Practice for Tools, Equipment and Appliances for Concrete Pavement Construction" in respect of weigh-batchers and mixers for concrete pavements should be followed in this case also.

5.2. Compacting Equipment

Compaction of lime-fly ash concrete layer in the field should be done by means of an 8 to 10 tonne smooth wheel roller for harder aggregates and 6 to 8 tonne roller for softer aggregates. Alternatively, vibratory roller of equivalent capacity may also be used.

6. PREPARATION OF THE SUBGRADE/SUBBASE

The subgrade or subbase over which lime-fly ash concrete, layer is to be laid, should be checked for line, grade and cross-section, as per provisions of Chapter 7 of IRC SP-1973: Handbook of Quality Control for Construction of Roads and Runways. All irregularities beyond the permitted tolerance should be rectified. It should be ensured that there are no soft spots therein. Soft and yielding spots and ruts should be corrected and rolled until firm. The checking and rectification of the underlying layer should be done at least 2 days in advance of laying lime-fly ash concrete thereon.

To prevent absorption of water from lime-fly ash concrete, the underlying layer should either be covered with water proof paper or brought to moist condition without free water at the surface before laying lime-fly ash concrete. For this purpose, it may be saturated with water not less than 6 hours nor more than 20 hours in advance of laying lime-fly ash concrete, if necessary, followed

by light sprinkling prior to concreting, if any areas have become dry.

7. CONSTRUCTION

7.1 Storage and Handling of Lime

Lime should be stacked under cover in a dry place. When slaking of quick lime is carried out at site, the lime should be left overnight for slaking to complete and for cooling down. The lime so slaked should be used within about a week's time to avoid carbonation by aeration. If slaked lime is supplied in airtight bags in dry hydrated form, the period of storage can be longer (upto 3 months).

7.2. Storage and Handling of Fly Ash

Fly ash, being a very fine material, gets easily air-borne. For protection against this, fly ash may be either bagged or soaked with water at the top during transport, as well as storage. When not bagged, it may be stored in regular trapezoidal pits dug for the purpose. The top surface may be either kept wet or covered with tarpaulins.

7.3. Storage and Handling of Aggregates

The provisions of IRC: 15-1970: Standard Specifications and Code of Practice for Construction of Concrete Roads, Clause 8.2 should be followed in respect of storage and handling of aggregates.

7.4 Batching and Mixing of Materials

The materials for making lime-fly ash concrete mix should be batched by weight, using approved weigh-batching equipment, and volume batching may be permitted only when unavoidable. Water may be measured by volume using calibrated containers. Proportioning of the constituent materials should be as specified on the basis of designed mix proportions, making due allowance for free moisture absorption in aggregates and moisture present in lime and fly ash. It has been found that moist fly ash facilitates easy mixing to obtain the desired compactibility.

Mixing should be done in power driven mixers of approved type, and uniform homogeneous mixing of all the ingredients should be ensured. The mixer should not be overloaded, and adequate mixing time (1-2 min.) should be given to ensure uniform mixing.

7.5. Transportation and Placement of Lime-Fly Ash Concrete

The lime-fly ash concrete should be transported and placed on the prepared subgrade/subbase so that the compacted layer has the required depth, slope and camber. The amount of surcharge required is about 20-25 per cent of the thickness of layer to be laid. The actual amount of surcharge may be determined through field trial. Transportation and placement should be so done as to avoid segregation. Any portion of the batch which becomes segregated during placing should be thoroughly mixed with the main body of the batch during the process of spreading.

7.6. Compaction

When sufficient length of lime-fly ash concrete has been laid to permit rolling, compaction should be done by rolling (see para 5.2). Rolling should start from the outer edges of the pavement and proceed towards the middle except at superelevated portions where it should commence at the lower edge and progress towards the higher. Adequate number of passes should be given to ensure full compaction.

The grade and camber of the surface should be checked during compaction, and all irregularities should be corrected by removing or adding fresh material.

Compaction should be completed within specified period which shall not exceed 4 hours since the time of mixing as stipulated in IS: 5817-1970: Code of Practice for Preparation and Use of Lime Pozzolana Concrete in Buildings and Roads. When lime-fly ash concrete is to be laid in two layers, the second layer should be laid within 2-3 hours of compaction of the lower layer.

7.7 Joints

No joints may be provided except construction joints at the end of the day's work, and each successive length taken up for rolling. These should be formed by chamfering the edge of the already laid concrete at an angle of about 30°, and subsequently laying the fresh concrete thereon.

7.8. Curing

After laying and compaction of the total thickness of lime-fly ash concrete base or sub-base has been completed, it should be cured for the first 48 hours by covering it with wet gunny bags or hessian and subsequently by spreading wet sand or watering frequently in moderate quantities, but not by ponding as that would lead to

leaching. Curing should be carried out for not less than 7 days, and preferably 14 days depending on seasonal and other considerations. No traffic should be allowed on the lime-fly ash concrete layer before top courses thereon are placed.

7.9. Rectification of Surface Irregularities

The finished surface should be checked for line, level, grade and surface finish. Provisions of Chapter 7 of IRC SP-11-1973: Handbook of Quality Control for Construction of Roads and Runways should be followed for this purpose. The checking and rectification should be carried out while the mix is still plastic. Any surface irregularities left in the hardened layer should be corrected by cutting out sufficiently large patches and relaying to specification.

8. SURFACE COURSE

Lime-fly ash concrete, being a semi-rigid material, may develop transverse cracks on account of thermal/drying shrinkage effects. These cracks are likely to get reflected on the surface if the pavement thickness over lime-fly ash concrete is insufficient. To prevent such reflection cracking, when lime-fly ash concrete is used as a base course in flexible pavement construction, it is recommended that an intermediate layer of bitumen bound material should be provided thereon before providing the wearing course, so as to absorb the movement of cracks in the lime-fly ash concrete base, and to prevent their reflection on the surface. Water bound macadam may also be considered tentatively in lieu of bitumen bound materials. The minimum thickness of this intermediate layer plus wearing course should not be less than 10 cm.

In case of rigid pavement, where lime-fly ash concrete is used as a subbase, the cement concrete wearing course can be laid directly thereon without provision of any intermediate layer, as due to greater rigidity of the cement concrete layer, such cracks from the semi-rigid subbase do not get reflected thereon.

9. QUALITY CONTROL

Quality control of lime-fly ash concrete construction should be done as per the provisions of IRC SP-11-1973: "Handbook of Quality Control for Construction of Roads and Runways", in respect of

TABLE 2 : QUALITY CONTROL TESTS FOR LIME-FLY ASH CONCRETE

S. No.	Test	Test Method	Minimum desirable frequency
1.	Quality of lime	IS: 712/1514	Once initially for approval of the source of supply and later for each consignment of the material
2.	Quality of Fly ash	IS: 3812 (Part II)	-do-
3.	Los Angeles Abrasion Value/Aggregate Impact Value	IS: 2386 (Part IV)	One test per 200 m^3
4.	Aggregate gradation	IS: 2386 (Part I)	One test per 100 m^3
5.	Aggregate moisture content	IS: 2386 (Part III)	As required
6.	Control of grade, camber, thickness and surface finish	Vide Chapter 7 of IRC SP: 11-1973	Regularly
7.	Strength of cubes (2 specimens for each age of 7 and 28 days)	IS: 2541	One test for 50 m^3

Lime-Pozzolana Concrete. Relevant quality control tests and their minimum desirable frequency as specified therein, are partly reproduced in Table 2 for ready reference.