Guidelines for use of Fly ash tiles in canal lining

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1. INTRODUCTION

1.1. Fly ash/bottom ash/pond ash, combustion product of Thermal Power Plant can be used in a variety of applications. Fly Ash collected by Electro Static Precipitator (ESP) is mostly consumed by the Cement Plant and can also be used to partly replace cement in concrete mix. Disposal of bottom ash/pond has always a matter of concern and therefore Government is always concerned to use this material effectively in lieu of soil as full or part replacement so that natural soil is saved. R&D works have been carried out by scientists and engineers, to seek and establish usage of ash in variety of areas. The efforts made by Several Institutions and thermal power plants in India have also resulted in development of various technologies and establishing use of ash in diversified areas.

1.2. **Ash from Thermal Power Plants have excellent Geotechnical Properties for use** in construction of roads and embankments, structural fills, reinforced fills etc. Its excellent **Pozzolanic Properties** enables its use in areas such as manufacture of Cement, Concrete & its products, building materials, etc. **Its Physico - Chemical Properties** being similar to soil this can be blended with soil for manufacturing of bricks.

1.3. Fly ash bricks and burnt clay fly ash building bricks are in extensive use in the field of building construction. The use of fly ash building bricks **in canal linings will create immense potential for consumption of ash** and will also provide cost effective solution for preventing seepage loss in canal which has been a matter of concern. Use of burnt clay fly ash building bricks as canal lining are allowed under IS 10430-2000 as per amendment no-1 August 2005.

1.4. Concrete lining can be used in canals, ditches replacing part of cement.

2. Definitions of fly ash brick

2.1. In this guideline Pulverised fuel ash lime brick also known as fly ash bricks and Burnt clay fly ash building bricks are considered for canal lining.

2.2. Pulverized fuel ash-lime bricks are obtained from materials consisting of pulverized fuel ash in major quantity, lime and an accelerator acting as a catalyst. Pulverized fuel ash-lime bricks are generally manufactured by intergrinding or blending various raw materials which are then moulded into bricks and subjected to curing cycles at different temperatures and pressures. On occasion as and when required, crushed bottom fuel ash or sand is also used in the composition of the raw material. Crushed bottom fuel ash or sand is used in the composition as a coarser material to control water absorption in the final product. Pulverized fuel ash reacts with lime in presence of moisture to forma calcium-silicate hydrate which is a binder material. Thus pulverized fuel ash-lime brick is a chemically bonded bricks.

2.3. Burnt clay fly ash building bricks are obtained from the admixture of suitable soils and fly ash in optimum proportions as per IS: 2117:1991.

3. APPLICABILITY OF CANAL LINING

3.1. Canal lining is made up of impervious material or chemical treatment, installed in an irrigation ditch, canal, or lateral and provided for Improvement of conveyance of irrigation water, Prevent water-logging of land, maintain water quality, prevent erosion and to reduce water loss.

3.2. Provision of canal linings is applicable to constructed ditches that are subject to erosion or excessive seepage and are integral parts of an irrigation water distribution or conveyance system. This is also applicable to ponds where rain water is stored for use in the non-monsoon period.

3.3. Lined ditches/canals/ponds does not apply to

3.3.1. Natural streams or canals having velocity of flow over 2 m/sec.

3.3.2. Susceptible to damage from side drainage flooding

3.4. Provision shall be made to protect the lining from external water pressures.

3.5. Thickness of canal linings must be established on the basis of engineering considerations for each site. Location, canal size, velocity, sub-grade conditions, method of construction, operation, lining material, and climate shall be evaluated in establishing thickness to be used.

3.6. Unlined canals require considerably increased operation and maintenance cost for periodical removal of silt, minor repairs, removal of weeds and water plants. The provisions of lining reduce these costs considerably.

4. MATERIALS:

4.1. Pulverised fuel ash lime bricks or burnt clay fly ash building bricks lining are resistant to sulphate, salts or other strong chemical concentrations.

4.2. Linings

4.3.1. Pulverised fuel ash lime bricks lining

6.3.1.1. The Pulverised fuel ash lime bricks must be manufactured as per IS 12894.

4.3.2. Burnt clay fly ash building bricks lining

6.3.2.1. The burnt clay fly ash building bricks must be manufactured as per IS 13757.

4.3.3. The quality of water after immersing the above fly ash bricks after 24 hours shall have following limiting properties

Parameters	Pollution Control Board norms (for discharge in inland surface water)
pH	5.5-9.0
TSS (mg/L)	100.00
TDS	2100
Ca	75.00
Mg	30.00
N-NO3	50.00
F	2.00
I	-
Fe	1.00
Pb	0.10
Cd	2.00
Ni	3.00
Total Cr as (Cr)	2.00
Co	-
As	0.20
Hg	0.01

Radioactivity (Bq/kg)	
a- emitters	<0.1
P- emitters	<0.8

Characteristic of Indian Fly Ash Vs Natural Soil

Sl. No.	Compounds	Fly ash (%)	Natural Soil (%)
1	Sio_2	35-70	40-65
2	Al_2O_3	10-35	10-30
3	TiO_2	0.2-2.0	0.2-2.0
4	Fe_2O_3	2.0-7.0	1-14
5	Mno	0.1-0.5	0-0.1
6	Mgo	0.01-4.5	0.2-3.0
7	Cao	0.2-20	0-7.0
8	K_{20}	0.05-0.9	0.2-0.4
9	Na_{2o}	0.05-2.0	0.2-2.5
10	LOI	0.1-8.0	5-15

5. **LINING REQUIREMENT**:

5.1. Structural Stability :

5.1.1. The sides of the canal to be lined should preferably be kept at the stable slope of the soil so that there is no earth pressure or any other external pressure against the lining. Pressure due to saturated backfill and the differential water head across lining should be avoided. Arrangements like weep holes, graded filter behind weep holes shall be made so that no water gets behind the lining from an external sources.

5.1.2. Where the side slopes are made steeper than the stable slopes of the soil, or where external pressures cannot be avoided, the lining will have to be designed accordingly in such special case.

5.1.3. To provide relief from differential pressure, adequate sub-soil drainage arrangements and pressure release arrangements (*see* IS 4558) shall be provided wherever necessary.

5.2. Strength and Durability

5.2.1. The canal lining shall be able to withstand the effect of velocity of water, rain, sunshine, temperature and moisture changes, chemical action of salts, etc. With suitable treatment, lining should be able to withstand the effect of gypsum, black cotton soil/bentonite. It should also be able to withstand the damaging effect caused by abrasions, cattle traffic, rodents and weed growth.

5.2.2. For the purpose of economic analysis, the life expectancy of concrete and brick/tile lining may be assumed to be of the order of 60 years.

5.3. Reparability/Easy Maintenance

5.3.1. Since with lapse of time the lining may get damaged, it should be such that it can be repaired easily and economically.

5.3.2. Brick/tile, stone-pitched and precast slab linings are more easily repairable or replaceable than *in-situ* concrete lining.

5.4 Advantages

- Economy

-Structural stability and durability

-Resistance to erosion

-Ability to prevent weed growth

-Impermeability

6. Parameter for design of lined canals

6.1. **Side slopes**

6.1.1. The side slopes should be such that they are stable depending upon the type of the soil.

6.1.2. A comparatively steeper slope can be provided in cutting rather than in filling.

6.1.3. Side slopes are designed in such a way that lining will rest on natural stable slopes so that no earth pressure or any other external pressure is exerted over the back of lining.

6.1.4. In those cases where there is chances of sudden drawdown, canal slopes should be checked for stability using slip circle analysis as per IS: 7894.

6.1.5. For different types of soil side slopes are recommended below in the table 1.

Table-1 (Recommended side slopes)

Sl no.	Types of soil	Side slopes (Horizontal: Vertical)
1	Very light loose sand to average sandy soil	2:1 to 3:1
2	Sandy loam	1.5:1 to 2:1 (in cutting) 2:1 (in embankment)
3	Sandy gravel / murum	1.5:1 (in cutting)

		1.5:1 to 2:1(in embankment)
4	Black cotton	1.5:1 to 2.5:1 (in cutting) 2:1 to 3.5:1 (in embankment)
5	Clayey soils	1.5:1 to 2:1 (in cutting) 1.5:1 to 2.5:1(in embankment)
6	Rock	0.25:1 to 0.5:1

6.2. Drainage holes

6.2.1. Pressure, Relief Valve - A valve provided in a canal lining which opens in to the canal to relieve excess hydrostatic pressure behind the lining.

6.2.2. The pressure relief valves shall be such that it will operate by a differential pressure less than that which will be damaging to the lining with safety factor of 2.

6.2.3. This should be operative generally with a differential head of 100 mm and above. Pressure relief valves are generally of such material, which will be abrasive resistant and will not be effected due to its presence in the water.

6.2.4. Pipes/drain - Pipes are provided with filter all round so that sub soil water can flow in the pipe; without changing the soil strata beneath the lining. Pipes are kept open so as to facilitate the entry of water.

6.3. Under drainage measures

6.3.1. In case of Canals in embankments in permeable soil there is no requirement of drainage measures

6.3.2. But in some cases under drainage becomes essential from safety considerations.

a) Where the lined canal passes through an area with seasonal ground water level higher likely to be higher than the water level inside the canal,

b) Where sub grade is sufficiently impermeable to prevent the free drainage of seepage or leakage from the canal, and

c) Where there is built up pressure due to time lag between drainage of the sub-grade following drawdown of canal

6.3.3. **Methods Of Under Drainage**.

6.3.3.1. The under drainage of canal lining for the following types of sub-grades may be accomplished by the methods below.

a) Free draining sandy soil-

Soil comprising of gravel and clear sand or clear sand. This may have permeability greater than 10^{-4} cm/sec but less than 10^{-3} cm/sec.

b) Poor draining-

Soil comprising of very fine sand admixture of sand, silt and clay or clay. Soil with permeability less than 10^{-4} cm/sec and greater then 10^{-6} cm/sec; and

c) Practically impervious –

Soil comprising of homogeneous clays below zone of weathering. Soil with permeability less than 10^{-6} cm/sec.

6.3.4. **Selection of Drainage Arrangement**

6.3.4.1. The drainage arrangements provided to reduce or eliminate hydrostatic pressure behind lining usually comprise of longitudinal drains, cross-drains, pressure release valves and continuous filters.

6.3.4.2. These are provided singly or in combination depending upon classification of sub-grade and position of GWT.

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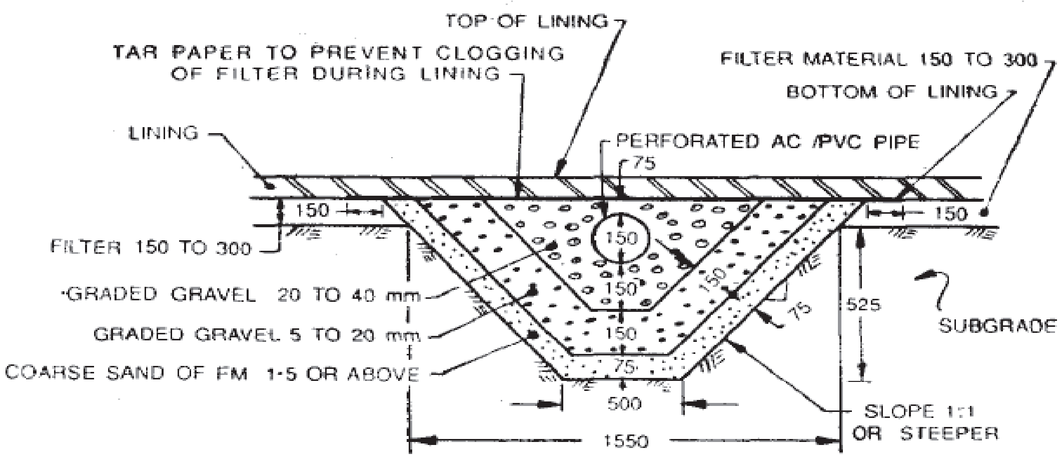


Typical section of longitudinal/ Transverse drain

Pressure relief valve not shown

6.4. Freeboard

6.4.1. The required freeboard varies according to the ditch, velocity of water, horizontal and vertical alignment, the amount of storm or wastewater that may be intercepted, and the change in water surface elevation that may occur when any control structure is operating. The minimum freeboard for any lined ditch or canal shall be as follows.

Canal discharge in cumecs	Free Board in metre
>10	0.75
3-10	0.60
1-3	0.5
< 1	0.3
<0.1	0.15

6.4.2. Additional freeboard shall be provided if required by velocity, depth of flow, alignment, obstruction, curves, and other site conditions.

6.5. **Lining**

6.5.1. As per IS:10430-2000 various rigid linings used in canals are as follows:

1) Stone-pitched lining;
2) Burnt clay tile or brick lining;
3) Burnt bricks or pulverized fuel ash-lime bricks or burnt clay fly ash building bricks lining;
4) Precast cement concrete/stone slab lining;
5) Cement concrete tile lining;
6) In situ cement/lime concrete lining,
7) Stone masonry lining;
8) Soil cement/soil cement and flyash lining;
9) Shotcrete lining;
10) Ferrocement lining, and
11) Asphaltic cement concrete lining.

6.5.2. Burnt clay fly ash building bricks lining

6.5.2.1. For lining purpose the bricks to be used should confirm to IS: 13757-1993. Burnt clay fly ash building bricks are classified on the basis of average compressive strength.

Class Designation	**Average Compressive strength not less than**	
	N/mm^2	**Kgf/cm^2**
30	30	300
25	25	250
20	20	200
17.5	17.5	175
15	15	150
12.5	12.5	125
10	10	100

7.5	7.5	75
5	5	50
3.5	3.5	35

6.5.3. Pulverised fuel ash lime bricks

6.5.3.1. For lining purpose the bricks to be used should confirm to IS: 12894: 2002. Fly ash building bricks are classified on the basis of average compressive strength.

Class Designation	**Average Compressive strength not less than**	
	N/mm^2	**Kgf/cm^2**
30	30	300
25	25	250
20	20	200
17.5	17.5	175
15	15	150
12.5	12.5	125
10	10	100
7.5	7.5	75
5	5	50
3.5	3.5	35

6.5.4. The size of bricks generally used is 20X10X10cm.

6.5.5. Before use the bricks should be tested in accordance with the procedure laid down in IS: 3495 (part–1)-1992 for compressive strength.

6.6. **Berm**

6.6.1. In deep cut reaches of canals with discharge capacity exceeding 10 cumecs, it is desirable to provide berms of 3 m to 5 m width on each side for stability, facility of maintenance, silt clearance, 6.7. **Service roads:**

6.7.1. Service roads are provided on canals for inspection purposes, and may simultaneously serve as the means of communication in remote areas.

6.7.2. In case of distributaries, service road should be provided on one bank for inspection and maintenance purpose.

6.7.3. However, in case of main and branch canals service road should be provided on both the banks.

6.7.4. They are provided 0.4m to 1.0m above FSL depending upon the size of the channel.

6.8. **Bank top width**

6.8.1. According to the type and capacity of the canal, bank width varies. The table below shows minimum bank top width for different discharge condition.

Discharge (m^3/s)	**Minimum Bank Top Width**	
	Inspection bank / wider bank in m	**Non inspection bank / Other bank in m**
0.15 to 1.5	4.0	1.5
1.5 to 3.0	4.0	2.0
3.0 to 10.0	4.0 + dowel	2.5
10.0 to 30.0	5.0 + dowel	4.0
30.0 and above	6.0 + dowel	5.0

NOTES

1. Bank widths given above may be altered when justified by specific conditions.

2. For distributary canals carrying less than 3.0 cumecs and minor canals, it is generally not economical to construct a service road on top of bank as this usually requires more materials than the excavation provides. In such cases, service road suitably lowered below top of lining may be provided on natural ground surface and adjacent to the bank; however the importance of providing adequate service roads where they are needed should always be kept in view. The service road should be above normally encountered high flood level (HFL) with some free board.

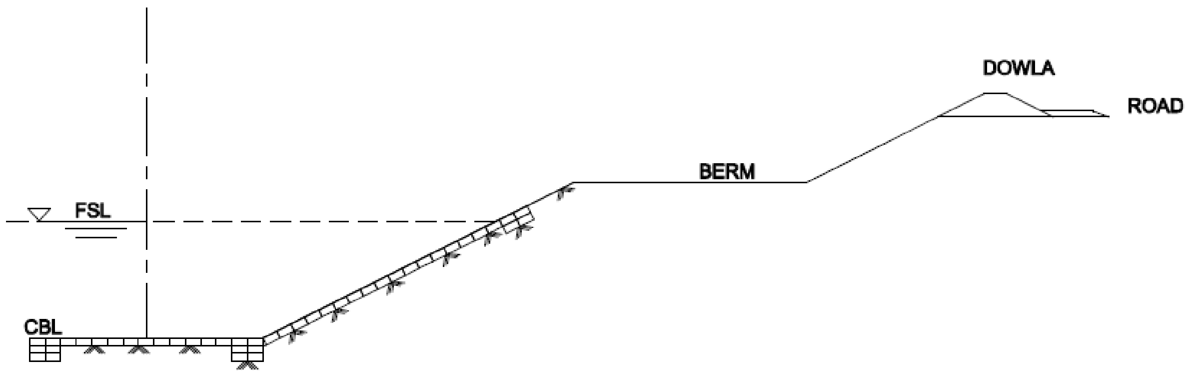
3. Where the stability of the embankment is required. Wider bank widths can be provided. Turfing should be provided on the outer slopes.

4. In hilly terrain where it is not possible to provide above bank widths, the bank widths may be suitably reduced.

5. When the bank widths are reduced on exceptional ground. refuges after every 100 m should be provided for passing and sheltering of opposing traffic.

6.9. Dowla

6.9.1. Considering safety in driving, dowlas 0.3m high and 0.3 to 0.6m wide at top, with side slopes of $1\frac{1}{2}$:1 to 2:1 are provided along the banks.



(Fig-1)

6.10. **Typical Cross Sections**

6.10.1. Typical Cross-Sections of the lined canals in cutting using burnt clay fly ash bricks (20X10X10 cm) are given in fig 2.

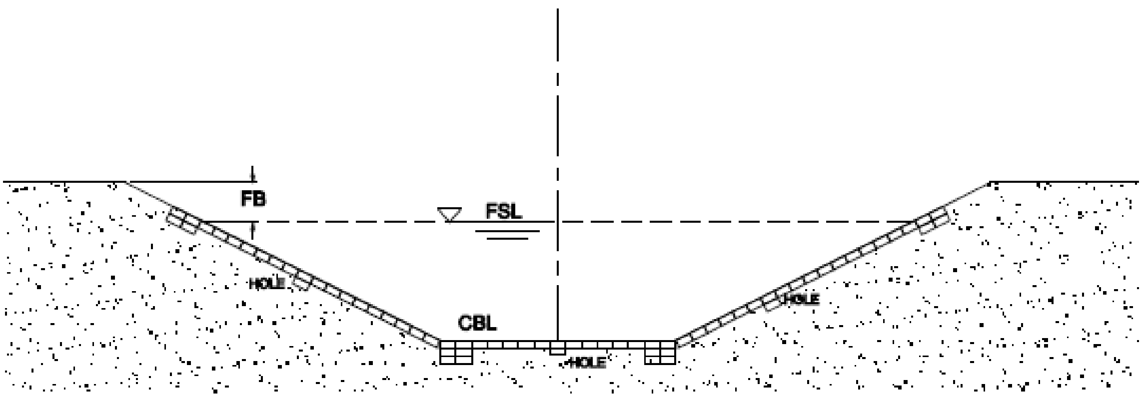


Fig-2

6.11. **Limiting Velocities in Different Types of Lining**

6.11.1. The maximum permissible velocities for guidance for some types of lining are given below:

a) Stone-pitched lining- 1.5 m/s

b) Burnt clay tile or brick lining - 1.8 m/s

c) Cement concrete lining - 2.7 m/s

Summary

Radioactive elements in coal and fly ash should not be sources of alarm. The vast majority of coal and the majority of fly ash are not significantly enriched in radioactive elements, or in associated radioactivity, compared to common soils or rocks. This observation provides a useful geologic perspective for addressing societal concerns regarding possible radiation and radon hazard.

The location and form of radioactive elements in fly ash determine the availability of elements for leaching during ash utilization or disposal. Existing measurements of uranium distribution in fly ash particles indicate a uniform distribution of uranium throughout the glassy particles. The apparent absence of abundant, surface-bound, relatively available uranium suggests that the rate of release of uranium is dominantly controlled by the relatively slow dissolution of host ash particles.

Previous studies of dissolved radioelements in the environment, and existing knowledge of the chemical properties of uranium and radium can be used to predict the most important chemical controls, such as pH, on solubility of uranium and radium when fly ash interacts with water. Limited measurements of dissolved uranium and radium in water leachates of fly ash and in natural water from some ash disposal sites indicate that dissolved concentrations of these radioactive elements are below levels of human health concern.