Utilisation of Fly Ash in Roads and Embankment Works

Around 110 million tonnes of fly ash get accumulated every year at the thermal power stations in India. Internationally fly ash is considered as a by product which can be used for many applications. Fly Ash Mission was initiated in 1994 to promote gainful and environment friendly utilisation of the material. One of the areas identified for its bulk utilisation was in construction of roads and embankments. Central Road Research Institute (CRRI), New Delhi, chosen as the 'Nodal Agency' for this activity, has undertaken many demonstration projects. Some of these are jointly with Fly Ash Mission (Presently Fly Ash Utilisation Programme). As a result of experience gained through these projects, specifications for construction of road embankments and guidelines for use of fly ash for rural roads were compiled and have since been published by the Indian Roads Congress. Fly ash utilisation in the country rose from 3 per cent (of 40 million tonnes) of fly ash produced annually in 1990s to about 32 per cent (of 110 million tonnes) of fly ash generated annually now. Out of this total utilisation, about 22 per cent, amounting to 7.75 million tonnes, was used in the area of roads and embankments last year.

a) **Advantages of using fly ash for road construction**

- Fly ash is a lightweight material, as compared to commonly used fill material (local soils), therefore, causes lesser settlements. It is especially attractive for embankment construction over weak subgrade such as alluvial clay or silt where excessive weight could cause failure.
- Fly ash embankments can be compacted over a wide range of moisture content, and therefore, results in less variation in density with changes in moisture content. Easy to handle and compact because the material is light and there are no large lumps to be

broken down. Can be compacted using either vibratory or static rollers.

- High permeability ensures free and efficient drainage. After rainfall, water gets drained out freely ensuring better workability than soil. Work on fly ash fills/ embankments can be restarted within a few hours after rainfall, while in case of soil it requires much longer period.
- Considerable low compressibility results in negligible subsequent settlement within the fill.
- Conserves good earth, which is precious topsoil, thereby protecting the environment.
- Higher value of California Bearing Ratio as compared to soil provides for a more efficient design of road pavement.
- Pozzolanic hardening property imparts additional strength to the road pavements/ embankments and decreases the post construction horizontal pressure on retaining walls.
- Amenable to stabilisation with lime and cement.
- Can replace a part of cement and sand in concrete pavements thus making them more economical than roads constructed using conventional materials.
- Fly ash admixed concrete can be prepared with zero slump making it amenable for use as roller compacted concrete.
- Considering all these advantages, it is extremely essential to promote use of fly ash for construction of roads and embankments.

b) **Economy in use of fly ash**

Use of fly ash in road works results in reduction in construction cost by about 10 to 20 per cent. Typically cost of borrow soil varies from about Rs.100 to 200 per cubic metre. Fly ash is available free of cost at the power plant and hence only transportation cost, laying and rolling cost are there in

case of fly ash. Hence, when fly ash is used as a fill material, the economy achieved is directly related to transportation cost of fly ash. If the lead distance is less, considerable savings in construction cost can be achieved. Similarly, the use of fly ash in pavement construction results in significant savings due to savings in cost of road aggregates. If environmental degradation costs due to use of precious top soil and aggregates from borrow areas quarry sources and loss of fertile agricultural land due to ash deposition etc. the actual savings achieved will be much higher and fly ash use will be justified even for lead distances up to say 100 km.

c) **Environmental Impact of Fly ash Use**

Utilisation of fly ash will not only minimize the disposal problem but will also help in utilizing precious land in a better way. Construction of road embankments using fly ash, involves encapsulation of fly ash in earthen core or with RCC facing panels. Since there is no seepage of rain water into the fly ash core, leaching of heavy metals is also prevented. When fly ash is used in concrete, it chemically reacts with cement and reduces any leaching effect. Even when it is used in stabilisation work, a similar chemical reaction takes place which binds fly ash particles. Hence chances of pollution due to use of fly ash in road works are negligible.

d) **Demonstration road projects using fly ash**

In the last decade, CRRI had undertaken many R&D and field studies to promote utilisation of fly ash in road embankment and pavement construction. Of the different types of ash available in a power plant, pond ash is available in abundance, it needs no processing and its moisture content happens to be nearer to OMC after having been taken out from pond and stored for one or two days. The major activities in such field projects included:

- Investigation/collection of data on existing ground/sub-soil conditions
- Characterisation of engineering and physical properties of identified source of fly ash
- Design of embankment structure incorporating ash as a construction material
- Preparation of specifications for construction using fly ash
- Field visits during construction and advising the implementing agency regarding quality control measures to be adopted during construction
- Instrumentation and monitoring
- Preparation of project reports and dissemination of information among the user agencies after completion of the project

e) **Characterisation of fly ash**

Engineering and chemical properties of Indian ashes of various power plants tested at CRRI have been found to be favourable to construction of roads and embankments. Properties of fly ash from different power plants vary and therefore it is recommended that characterisation of ash proposed to be used should be conducted to establish the design parameters. The properties of ash depend primarily on type of coal and its pulverisation, burning rate and temperature, method of collection, etc. The significant properties of fly ash that must be considered when it is used for construction of road embankments are gradation, compaction characteristics, shear strength, compressibility and permeability properties. Individual fly ash particles are spherical in shape, generally solid, though some times hollow. Fly ash possesses a silty texture and its specific gravity would be in the range of 2.2 to 2.4, which is less than natural soils. Fly ash is a non-plastic material. Typical properties of Indian fly ash compared to different types of soil are given in the following table:

Parameter	Gravel	Sand	Silt	Clay	Fly Ash
Specific gravity	2.65 – 2.67	2.65 – 2.67	2.67 – 2.70	2.70 – 2.80	1.90 – 2.55
Plasticity Index	NP	NP	1% – 1 7%	>17%	NP
Maximum Dry Density (g/cc)	1.76 – 2.27	1.76 – 1.84	1.52 – 2.08	1.44 – 1.84	0.9 – 1.60
Optimum Moisture Content (%)	7 – 18	9 – 15	10 – 20	15 – 30	18 – 38
Cohesion (kN/m2)	0	0	6	>6	Negligible
Angle of Internal Friction (f)	$35^0 – 50^0$	$27.5^0 – 45^0$	$27^0 – 35^0$	$0 – 6^0$	$30^0 – 40^0$
Coefficient of Consolidation Cv (cm^2/sec)	-	-	5×10^{-3}	$0.001 - 2x10^{-4}$	$1.75x10^{-5}$-$2.01x10^{-3}$
Compression Index	-	0.01 – 0.05	0.05 – 0.15	0.21 – 2.6	0.05 – 0.4
Permeability (cm/sec)	1	$10^{-1} – 10^{-3}$	$10^{-5} – 10^{-7}$	10^{-7}&less	$8x10^{-6}–7x10^{-4}$
Coefficient of Uniformity	>4	>6	-	-	3.1 – 10.7

f) **Expertise / work done by CRRI**

In the recent past CRRI offered advise/ consultancy services in the following road/embankment projects in which fly ash was utilised:

- Fly ash embankment construction for Okhla flyover at Delhi adopting 'Reinforced Embankment Technique' (Collaboration with Delhi PWD – executed as Fly Ash Mission demonstration project)
- Fly ash embankment construction for Hanuman Setu flyover at Delhi adopting 'Reinforced Embankment Technique' (Collaboration with Delhi PWD and Badarpur Thermal Power Station, Delhi)
- Construction of plant roads at Budge-Budge thermal power station using fly ash based pavement specifications (Collaboration with CESC Ltd, Kolkata)
- Construction of one km long rural road near Raichur in Karnataka with fly ash based flexible/semi-rigid pavement composition (Collaboration with Karnataka PWD and Raichur thermal power station - executed as Fly Ash Mission demonstration project)
- Construction of 1.9 km long, 6 to 9 m high road embankment forming eastern approach of the second Nizamuddin Bridge in Delhi using fly ash (Collaboration with Delhi PWD and Indraprastha thermal power station, Delhi)
- Construction of plant road and two rural roads using fly ash

(collaboration with National Capital Power Station, NTPC, Dadri, U.P)

- Construction of reinforced approach embankment using fly ash at Sarita Vihar flyover in Delhi (Collaboration with Delhi Development Authority and Badarpur Thermal Power Station, Delhi)
- Construction of embankment for Noida-Greater Noida Expressway project (Collaboration with IRCON International and Badarpur Thermal Power Station, Delhi)
- Construction of approach embankment using fly ash at Mukerba Chowk in Delhi (Collaboration with Delhi PWD)
- Construction of plant roads using fly ash admixed concrete at Chandrapur, Maharashtra (Collaboration with Maharashtra State Electricity Board)
- Use of fly ash for NH-6 four laning work near Kolkata (Collaboration with M/s RBM-PATI, sponsored by Fly Ash Mission)
- Characterisation of UPRVUNL thermal power station coal ash samples
- Guidance for construction of embankment of road near Shastri Park and Kalindi Kunj in Delhi (Sponsored by Delhi PWD)
- Construction of rural roads using fly ash at Dandeli in Karnataka (Sponsored by Rajiv Gandhi Rural Housing Corporation Ltd, Bangalore)
- Use of fly ash for construction of colony roads at Dwarka (Sponsored by Delhi Development Authority, New Delhi)
- Use of fly ash for construction roads in Bawana Industrial area (Sponsored by Delhi State Industrial and Infrastructure Development Corporation, Delhi)

g) Societal Impact

Since, we are able to use fly ash, as a road construction material, the utilisation of fly ash in road works is environmental friendly and economical, thus helping the society at large.

Construction of embankment with fly ash at Second Nizamuddin Bridge

Construction of embankment with fly ash at Kalindi Bypass in Delhi

For more information please contact:

Shri Sudhir Mathur
Head
Geotechnical Engineering Division
Central Road Research Institute
P.O CRRI, Delhi Mathura Road
NEW DELHI – 110 020
E mail: sudhirmathur.crri@nic.in

or

Shri U.K.Guru Vittal
Scientist
Geotechnical Engineering Division
Central Road Research Institute
P.O CRRI, Delhi Mathura Road
NEW DELHI – 110 020
E mail: vittal.crri@nic.in