UTILISATION OF CONSTRUCTION DEMOLITION AND MUNICIPAL SOLID WASTES FOR ROAD EMBANKMENT CONSTRUCTION

Presentation by

Dr. Vasant G Havanagi

Chief Scientist

CSIR-CENTRAL ROAD RESEARCH INSTITUTE,

NEW DELHI-110 025

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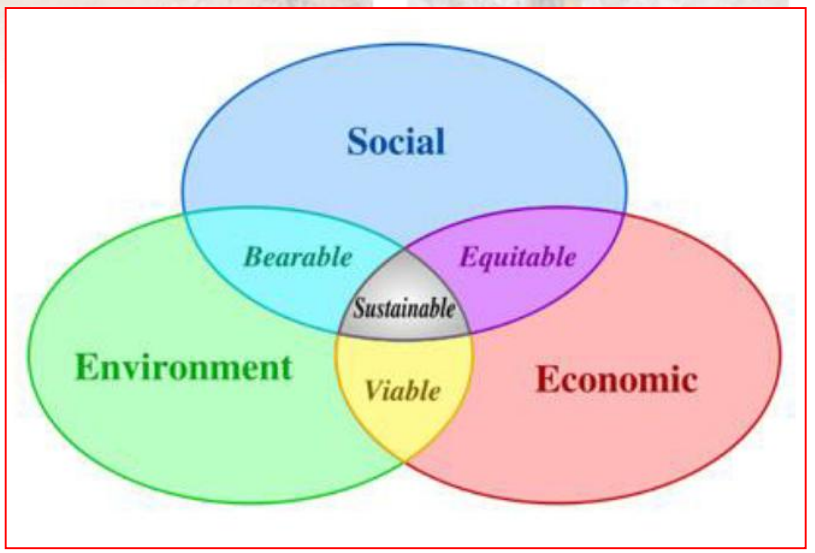
COST AND ENVIRONMENTAL IMPACT OF ROAD PROJECTS

- 62 Lakh Road Network in the country.
- 70% of GHG emissions from Civil infrastructure projects as per UN Report (25% from Road sector)- Need for sustainability in Road construction
- Non availability within economical lead (States of Tripura, Mizoram, Bihar, WB, Rajastan, M.P)-Delays and tremendous increase in total cost of Project
- Mining of natural resources-Reduction of green belt, fertile soil and depletion of water table-Dust and Noise pollution Environmental degradation.
- Utilization of industrial waste /locally available waste materials (C&D wastes/ MSW wastes) provides environmentally preferable alternative and to achieve sustainability



R&D STATUS/CHALLENGES IN INDIA

- **Lack of awareness/data base**
- **Number of Laboratory level studies available on marginal/waste materials- Very few data on actual field applications/long term performance behavior.**
- **Paucity of time/lack of initiative from the implementing authorities to experiment with the unconventional materials.**
- **Apprehensions/doubts regarding the quality of roads constructed with unconventional materials.**
- **Uncertainty and lack of confidence due to non availability of codes/specifications.**

INDUSTRIAL WASTE UTILIZATION FOR ROAD CONSTRUCTION

(Swachh Bharat Mission - Govt. of India)

ANNUAL PRODUCTION IN MILLION TONNES

- Fly ash (200)
- Copper slag(2)
- Iron and Steel slag (30)
- Zinc wastes (Zinc Slag; Jarofix) (4)
- Phosphogypsum (12)
- Chrome Slag (5)
- Tailings (Zinc &Kim-berlite)(20).
- Marble dust
- Foundry sand (3)
- Redmud (4)
- Construction and Demolition wastes (C&D) (30)
- Municipal Solid Waste (70)
- Waste plastics.
- Recycled Asphalt Pavements

INDIAN ROADS CONGRESS (IRC)-GUIDELINES

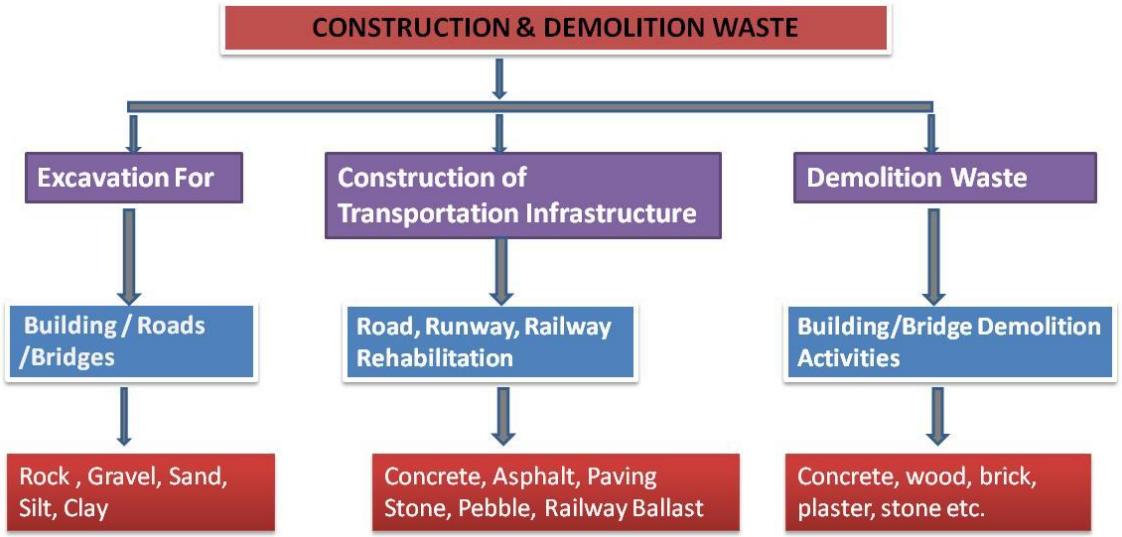
- ✓ IRC:SP-58-2001 – Guidelines for use of Fly ash in Road Embankments.
- ✓ IRC:SP:98-2013-Guidelines for the use of waste plastic in hot Bituminous mixes.
- ✓ IRC-120-2015-Recommended practice for Recycling of Asphalt pavements
- ✓ IRC:121-2017. Guidelines for Use of Construction and Demolition Waste (C&D) in Road Sector.
- ✓ IRC-SP 121-2018 – Guidelines for use of iron, steel and copper slag in the construction of Rural road.
- ✓ IRC-SP-132-2022-Guidelines on use of Industrial wastes for Road embankment and subgarde construction

FIELD APPLIC-ATIONS

- ✓ Fly ash is being used extensively in Road construction
- ✓ Six laning of Chittorgarh-Udaipur-NH 76 (About 2 lakh ton of Jarofix and Zinc slag).
- ✓ Four laning of Madhurai-Tuticorin (NH-45 B) & National Highways near Dahej (About 1 lakh ton of copper slag).
- ✓ Four lanning of Ranchi-Rargaon-Jamshedpur section of NH-33 (About 2 lakh tonnes of steel slag).
- ✓ Delhi –Meerut expressway (NH-9) (Usage of C&D waste).
- ✓ Internal Roads within Paradeep Phosphate Limited (PPL) plant premises (20,000 ton of Phosphogypsum).

CONSTRUCTION & DEMOLITION WASTES

- 25-30 million tons of C&D waste is generated annually in the country, Delhi alone generates about 5 million tonnes.
- Dumped haphazardly causing environmental Pollution (Clogs rivers, blocks traffic, occupies costly dumping space.)
- India is the second largest Road network in the world- **C&D waste have a great potential to replace the already depleting natural resources for Road Construction**.



C&D Segregation plants in Delhi

C&D SEGREGATION PLANTS-
VIEW OF SEGREGATED SOIL/AGGREGATES

C&D PROCESSING PLANT- BURARI

<75micron

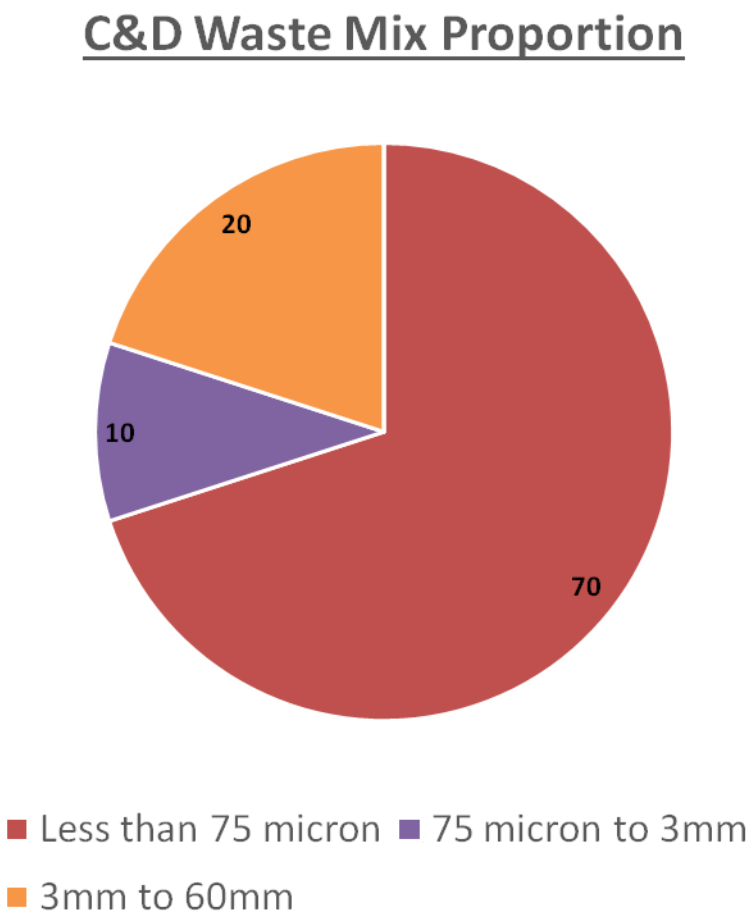
10mm – 20mm

C&D PROCESSING PLANT- SHASTRY PARK

75micron-3mm

20mm-60mm

C&D WASTE FOR ROAD CONSTRUCTION



✓< 75micron IS sieve (70%)- Embankment construction.

✓75 micron-60mm (30%)- Pavement layers

R&D Study on < 75 micron IS Sieve

- **65 to 70% of C&D waste - less than 75 micron IS sieve.**
- Feasibility of this major constituent is being checked for bulk utilization in road embankment construction. Following geotechnical characteristics are being studied.

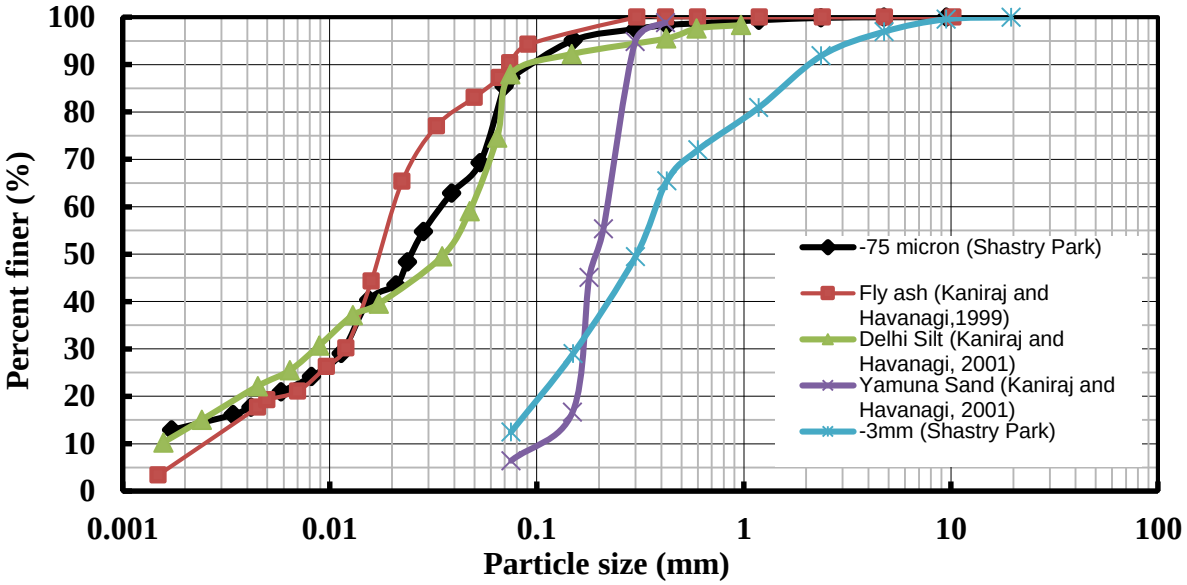
❖ **Physical Characteristics**

- Grain Size Analysis
- Organic Content
- Specific Gravity

❖ **Geotechnical Characteristics**

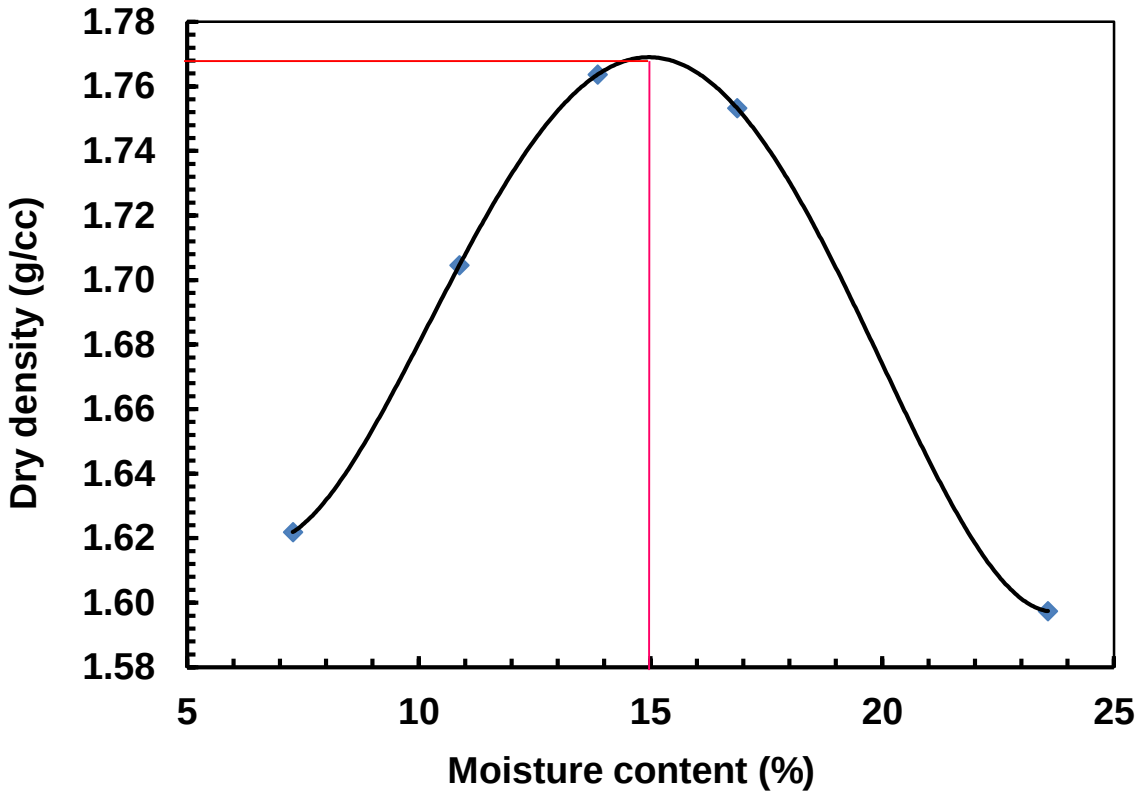
- Free Swell Index
- Atterberg Limits
- Compaction Characteristics
- Shear Strength Characteristics
- Consolidation Characteristics
- Permeability Characteristics

GEOTECHNICAL CHARACTERIZATION OF C&D WASTES- GRAIN SIZE ANALYSIS



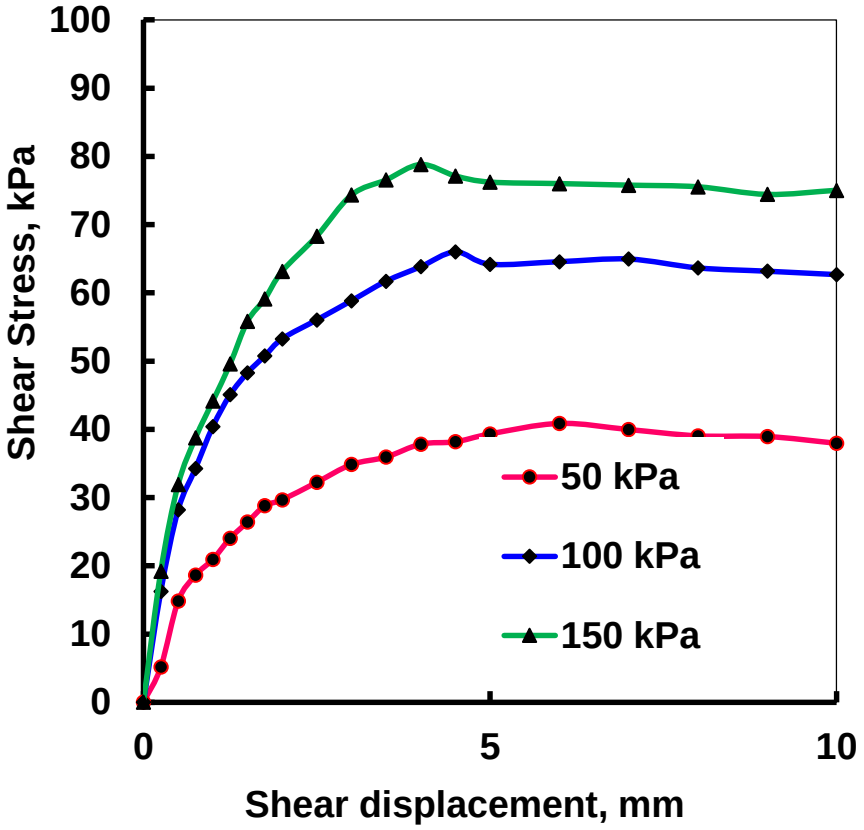
Item	Unit	<-75 micron (Shastry Park)	-3mm (Shastry Park)	Fly Ash (1)	Delhi Silt (2)	Yamuna Sand (2)
Gravel	%	0	3.04	0	0	0
Sand	%	12.76	84.52	12.76	12.02	93.6
Silt	%	74.35	12.44	83.85	77.72	6.4
Clay	%	12.89		3.39	10.26	
Cu	-	23.33	5.71	9.52	45.45	2.00
Cc	-	2.74	0.80	2.38	1.47	0.85

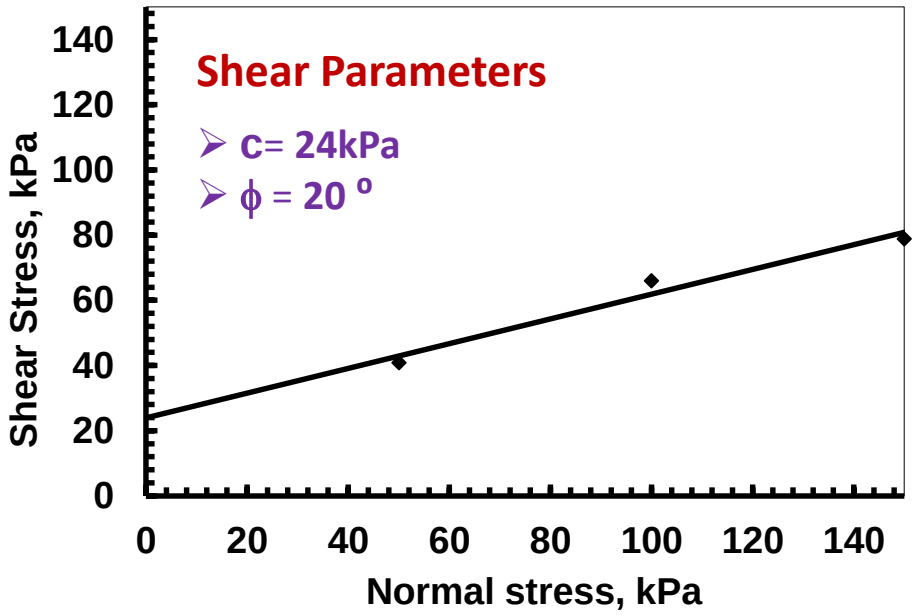
GEOTECHNICAL CHARACTERIZATION OF C&D WASTES- MODIFIED PROCTOR TEST RESULTS



- MDD = 1.77 gm/cc
- OMC= 15%

GEOTECHNICAL CHARACTERIZATION OF C&D WASTES- SHEAR STRENGTH PROPERTIES





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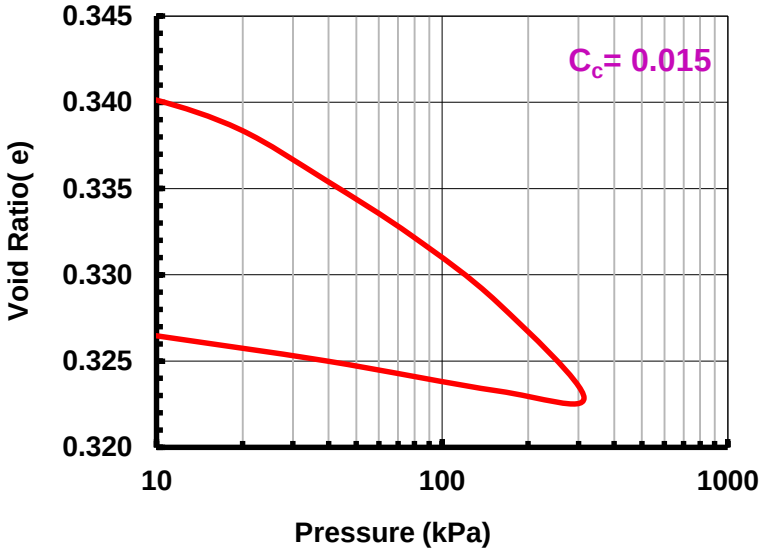
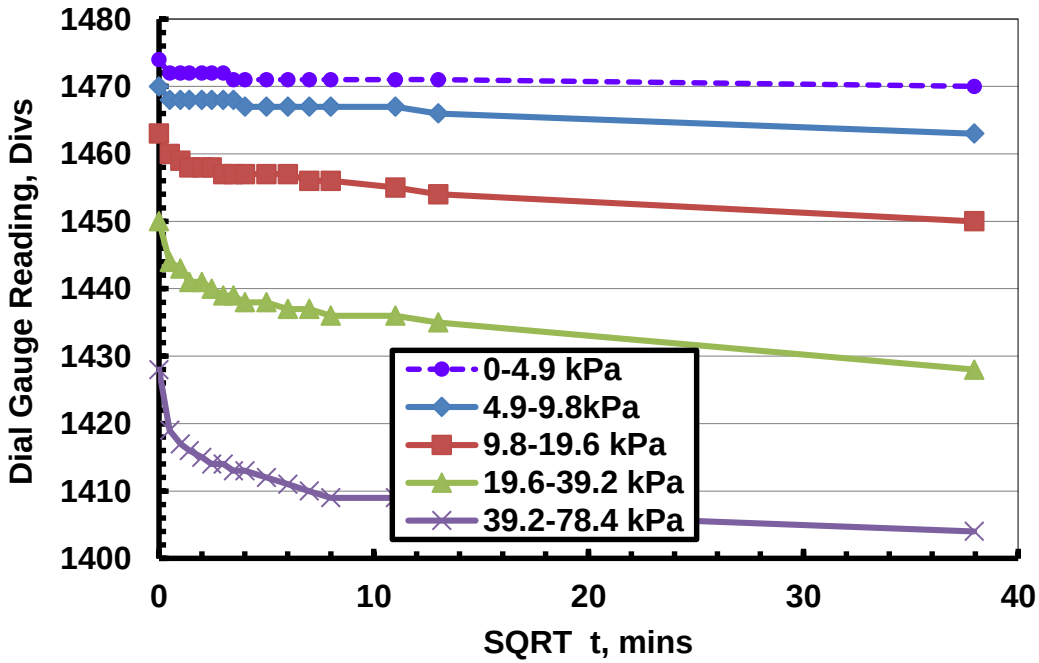


C_c= 0.015
C_v= 8.8x10^{-8} – 4.28x10^{-9} m^2/sec

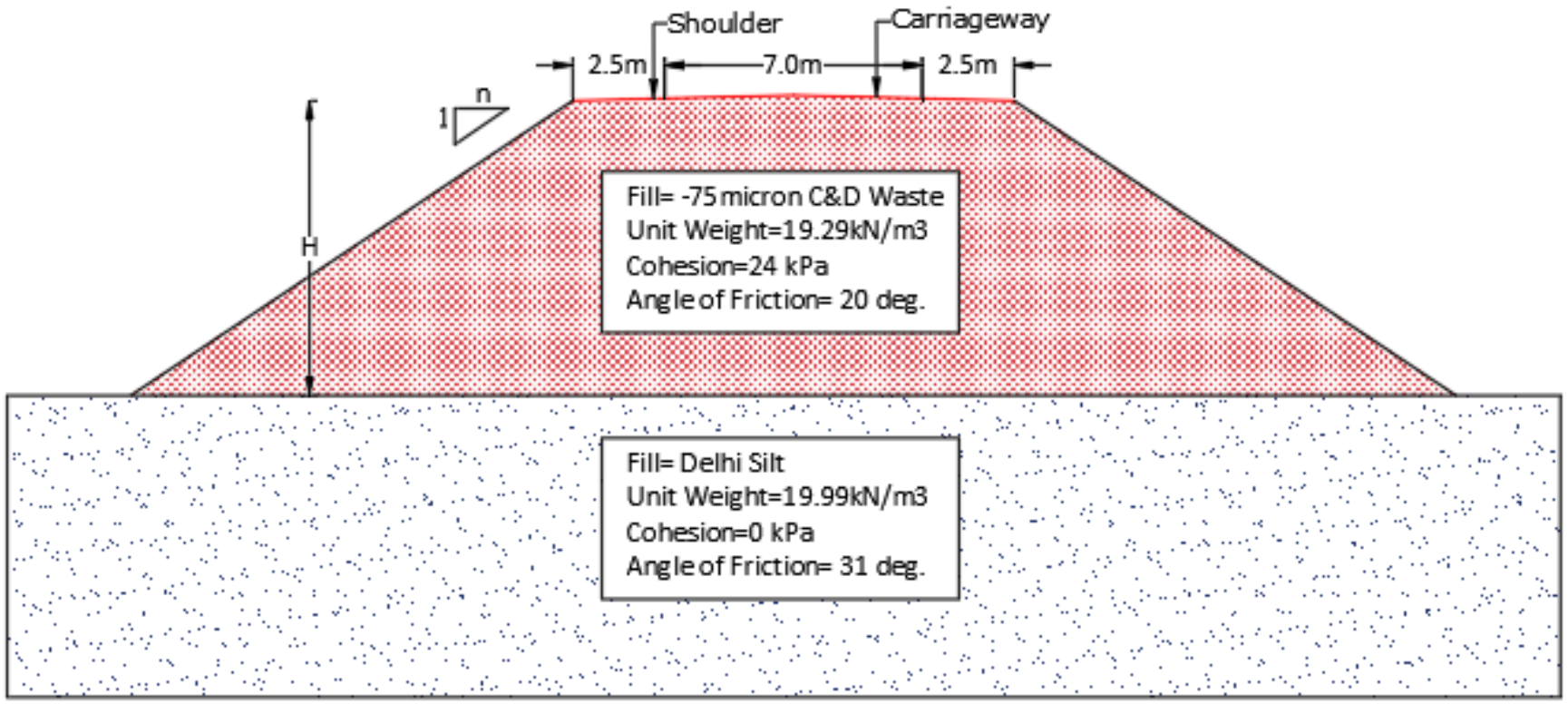
Stress Range (kPa)	Coefficient of Consolidation (m^2/sec)
4.9-9.8	8.82E-08
9.8-19.6	2.43E-08
19.6-39.2	3.89E-08
39.2-78.4	5.59E-09
78.4-156.9	4.28E-09



SUMMARY OF GEOTECHNICAL CHARACTERISTICS (C&D WASTES) - COMPARISON WITH CONVENTIONAL SOIL

ITEM	-75μ C&D WASTE	DELHI SILT
Gravel (%)	0	0
Sand (%)	13	12
Silt (%)	74	78
Clay (%)	13	10
Organic Content (%)	2.67	NA
FSI (%)	Non-Swelling	Non-Swelling
Liquid Limit (%)	30.8	-
Plasticity Index (%)	NP	NP
IS Classification	ML	ML
MDD (kN/m^3)	17.3	19
OMC (%)	15	14
Cohesion (kPa)	24	0
Angle of friction (°)	20	31

TYPICAL CROSS SECTION OF C&D WASTE EMBANKMENT



EMBANKMENT CROSS SECTION FOR HEIGHT <=6m

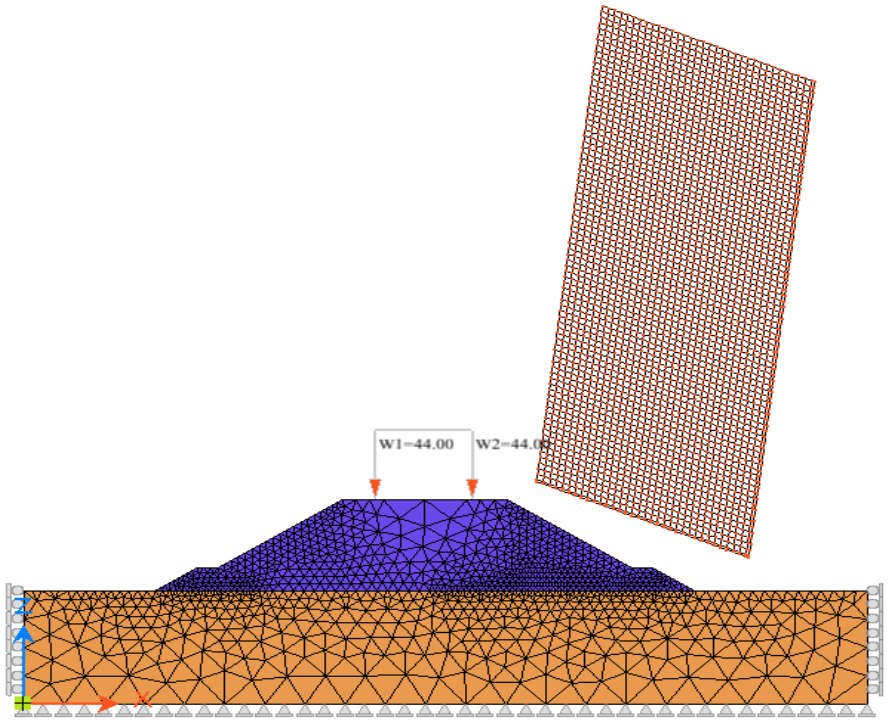
Slope Stability Analysis

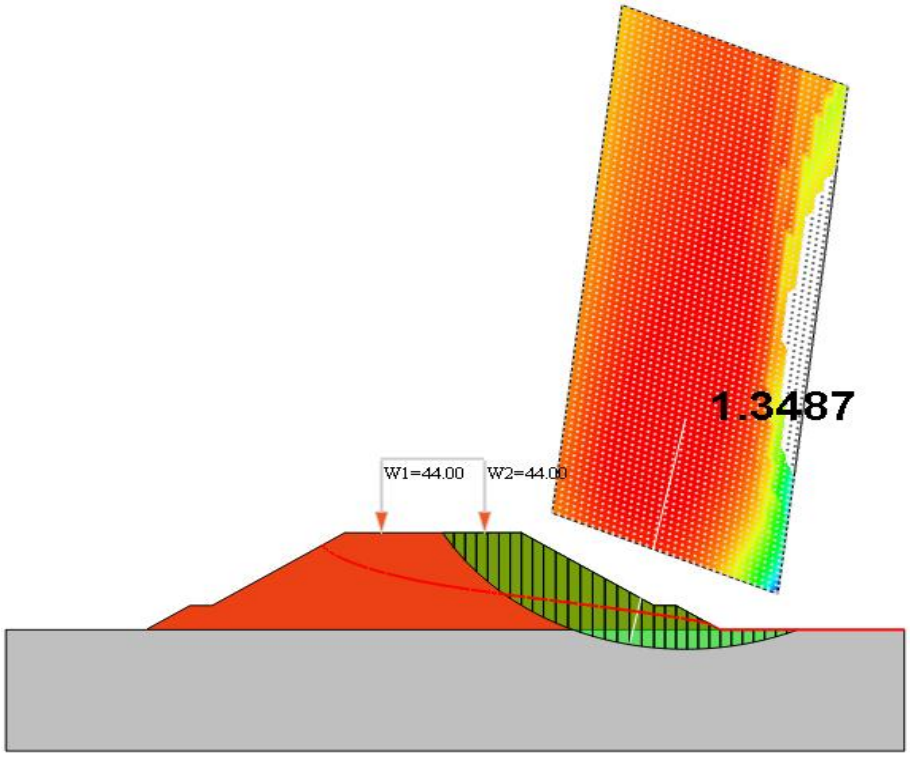
- **1V:2H** — 4m, 6m, 8m, 10m
- **1V:1.5H** — 4m, 6m, 8m, 10m

- **Traffic Loading = 24kPa**
- **Dead Load of Pavement = 20kPa**
- **Seismic Zone = IV**

Total 48 analysis are performed.

SLOPE STABILITY ANALYSIS-C&D WASTE EMBANKMENT

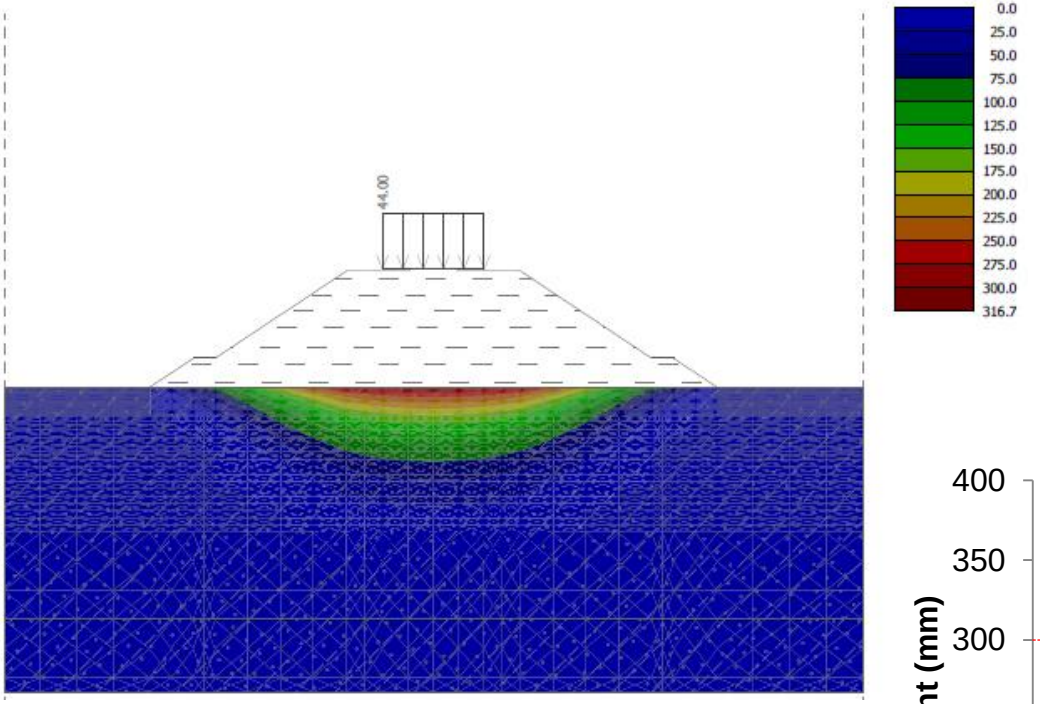




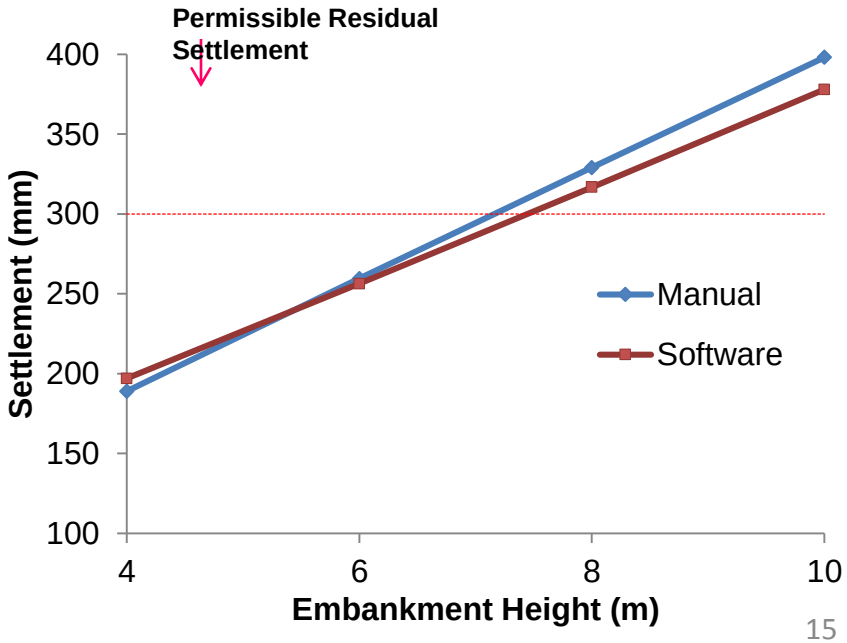
Embankment Height = 4-8m

Loading Condition	Static FOS		Seismic FOS	
Slope →	1V:1.5H	1V:2H	1V:1.5H	1V:2H
Static Loading	1.6-1.8	1.8-2.0	1.3-1.5	1.6-1.4
Steady Seepage	1.5-1.7	1.7-1.8	1.3-1.2	1.4-1.3
Sudden draw down	1.3-1.6	1.5-1.7	1.2-1.0	1.2-1.04

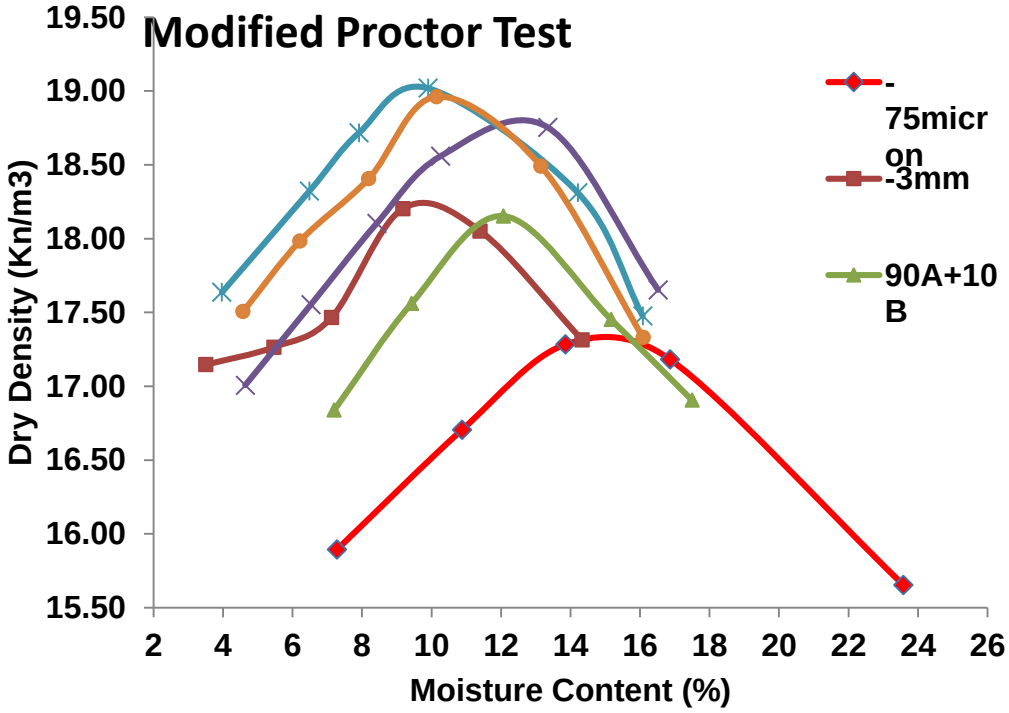
SETTLEMENT ANALYSIS-C&D WASTE EMBANKMENT



SETTLEMENT RESULTS	
Slope Height (m)	**Subsoil Settlement (mm)**
4	**197**
6	**256**
8	**317**
10	**378**



SUITABILITY OF C&D WASTES FOR SUBGRADE CONSTRUCTION



Test	Modified Proctor Test	
IS Code	IS 2720(Part 8)-1983	
Notation	MDD	OMC
Unit	kN/m³	%
-75 µ (A)	17.33	15
-3mm (B)	18.19	11
90%A+10%B	18.15	12
70%A+30%B	18.62	12
50%A+50%B	19.21	11
30%A+70%B	18.89	10.8

CONCLUSIONS

EMBANKMENT

- **1V:2H Slope: Slope is Safe up to 10m height.**
- **1V:1.5H Slope: Slope is Safe up to 6m height.**

SUBGRADE

- **-75µ C&D fraction needs to be stabilized with 15-20% of -3mm fraction for using in the subgrade construction**

MUNICIPAL SOLID WASTES FOR ROAD EMBANKMENT CONSTRUCTION

- **R&D studies were carried out to investigate the feasibility of Municipal Solid Waste (MSW) from Ghazipur (Delhi), Ramana landfill (Varanasi, U.P), for Road embankment construction.**

- **Ghazipur 3000t/day (Varanasi 650t/day) – 40-50 m dump height (Varanasi 3-5m height), 70 hectares (Varanasi = 10 hectares). Accumulated 13 million tons (Varanasi = 0.5 milllon tons).**

- **EDMC/CSIR-CRRI/NHAI : Pilot study Planned for its utilisation in service road of NH-9.**

GHAZIPUR LANDFILL, DELHI, UP GATE, NH-24

RAMANA LANDFILL, VARANASI

METHODOLOGY ADOPTED FOR THE R&D STUDY

- Collected 200 tons of Raw garbage (MSW) (Ghazipur, Delhi), three locations based on age (5, 10, 15 years)/150 tons from Ramana dump site, Varanasi (Fresh, 1 year, 2 year)
- After drying, MSW was segregated in existing compost plant (80mm,35mm,16mm, 4mm), Varanasi =200mm, 80mm, 35+16mm, 4mm
- Carried out Proportioning(% fractions) /Composition of MSW/Geotechnical characterization
- Selection of MSW fraction for embankment construction.
- Proposed a new methodology for segregation of MSW –
- Proposed design cross sections for field construction

DRYING AND SEGRGATION AT COMPOST PLANT

View of Raw MSW-Drying at compost plant

Process of Segrgation of MSW in compost plant

VIEW OF SEGREGATED FRACTIONS FROM MSW

Fraction passing 80 mm sieve.(65-79%)

Fraction passing 35 mm sieve.(55-65%)

Fraction passing 16 mm sieve.(44-48%)

Fraction passing 4 mm sieve.(27-34%)

VIEW OF SEGREGATED VARANASI,U.P MSW SAMPLES

View of -16mm MSW samples

View of -4mm MSW samples

PROPOSED FINAL MATERIAL FOR EMBANKMENT CONSTRUCTION (65-79%)

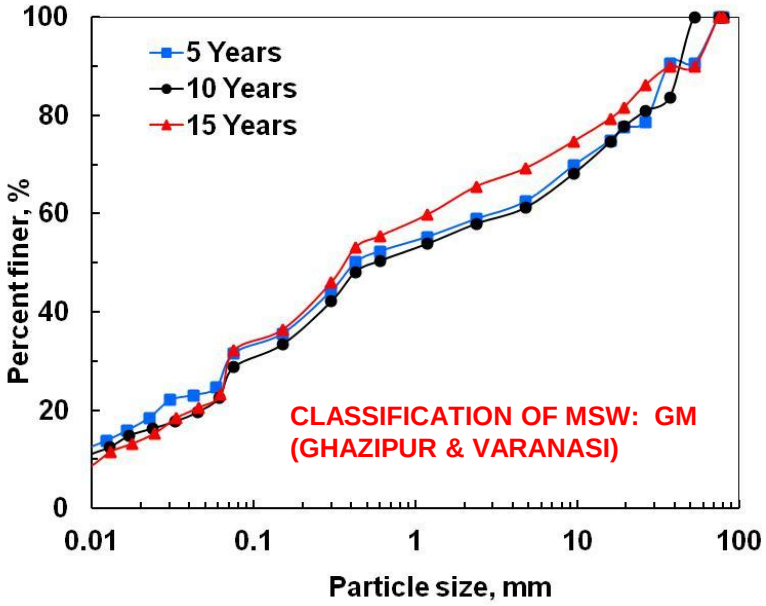
PASSING 16MM FRACTION (44-48%)
+
RETAINED ON 35MM +16MM FRACTION (21-31%)

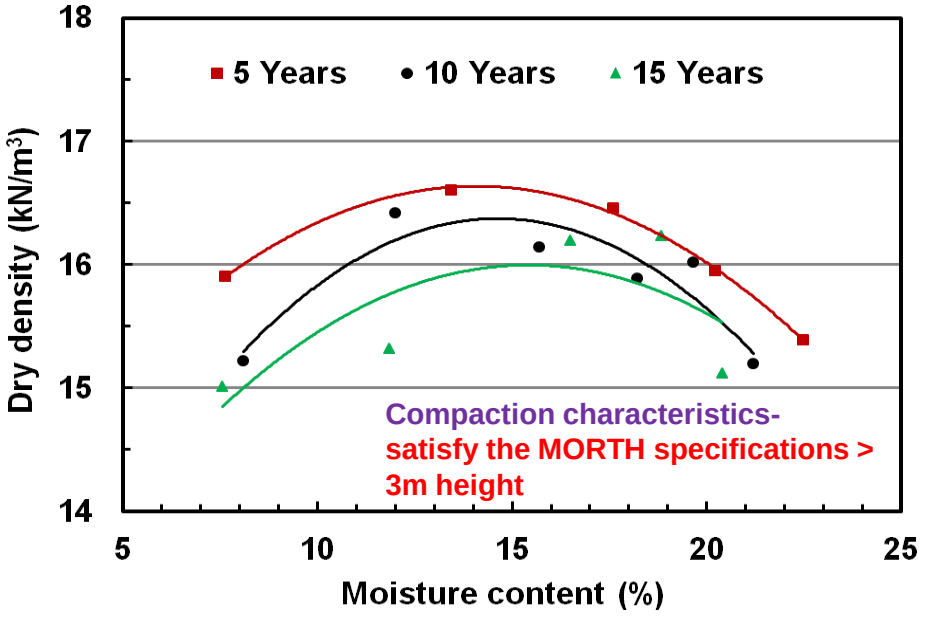
GHAZIPUR, DELHI

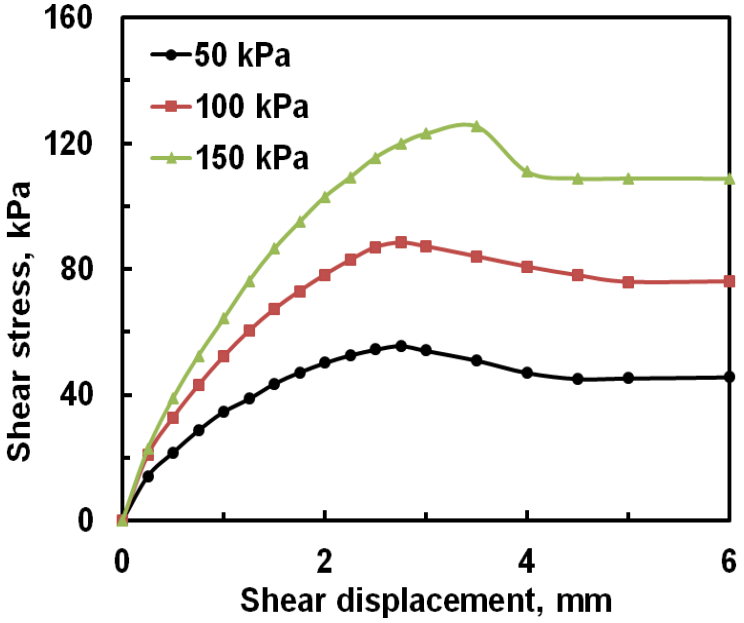
VARANASI ,U.P

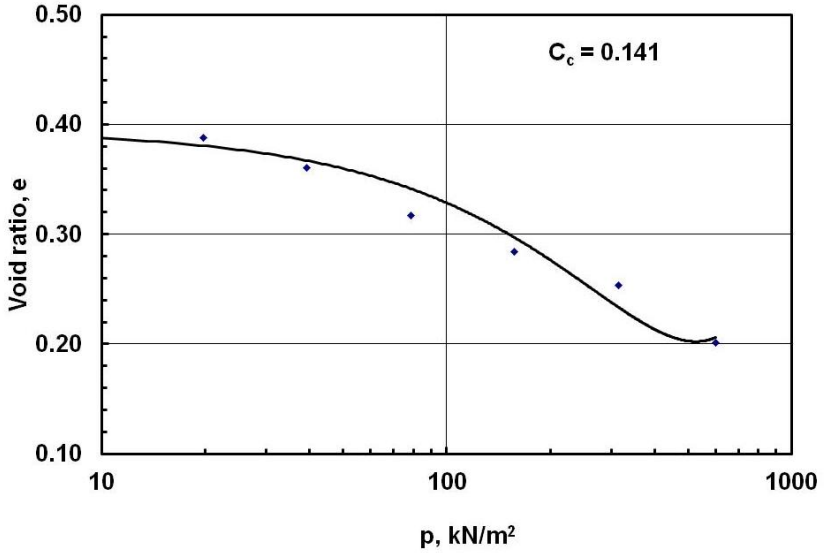
VIEW OF FINAL EMBANKMENT MATERIAL
(65-79% potential for embankment construction)

GEOTECHNICAL CHARACTERISTICS

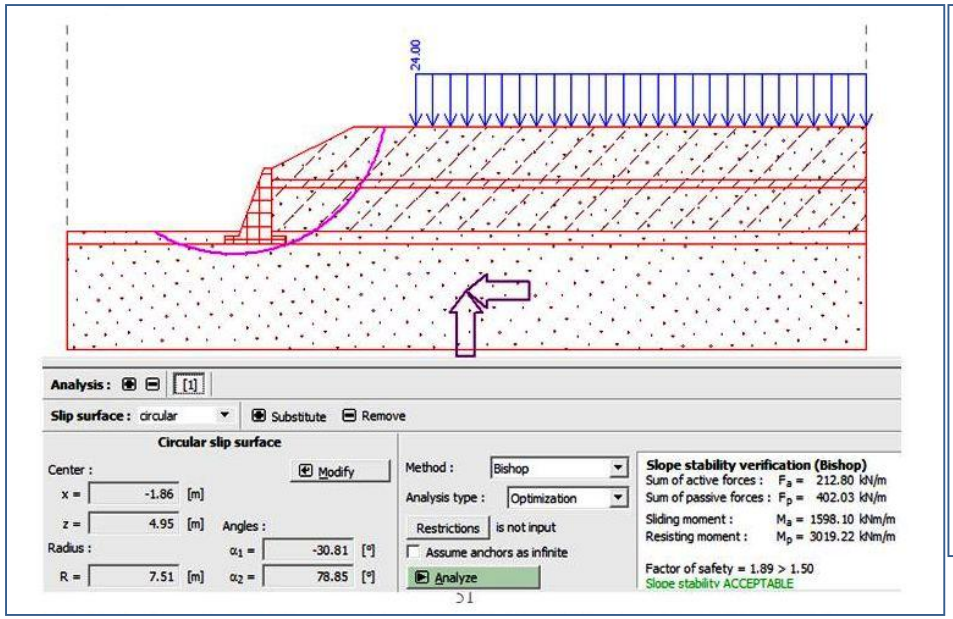


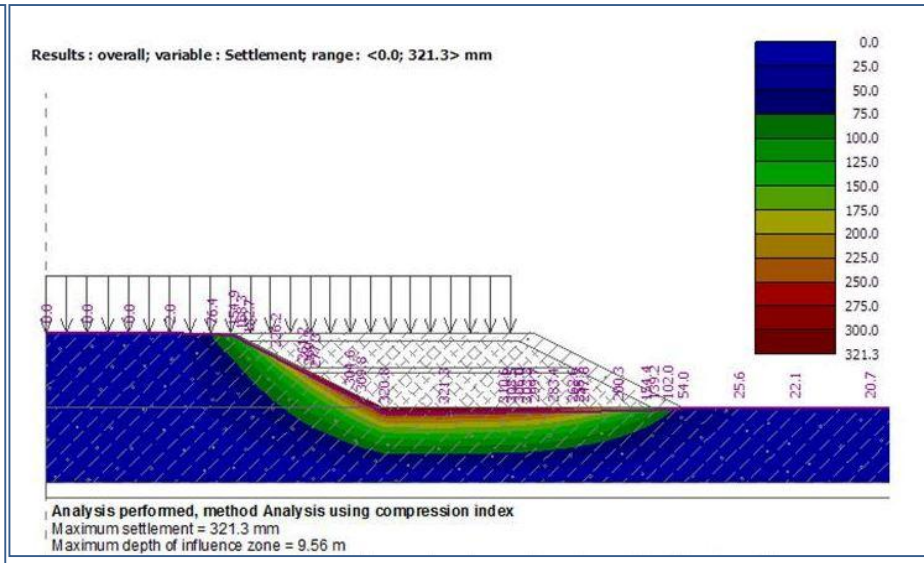






TYPICAL STABILITY AND SETTLEMENT ANALYSIS



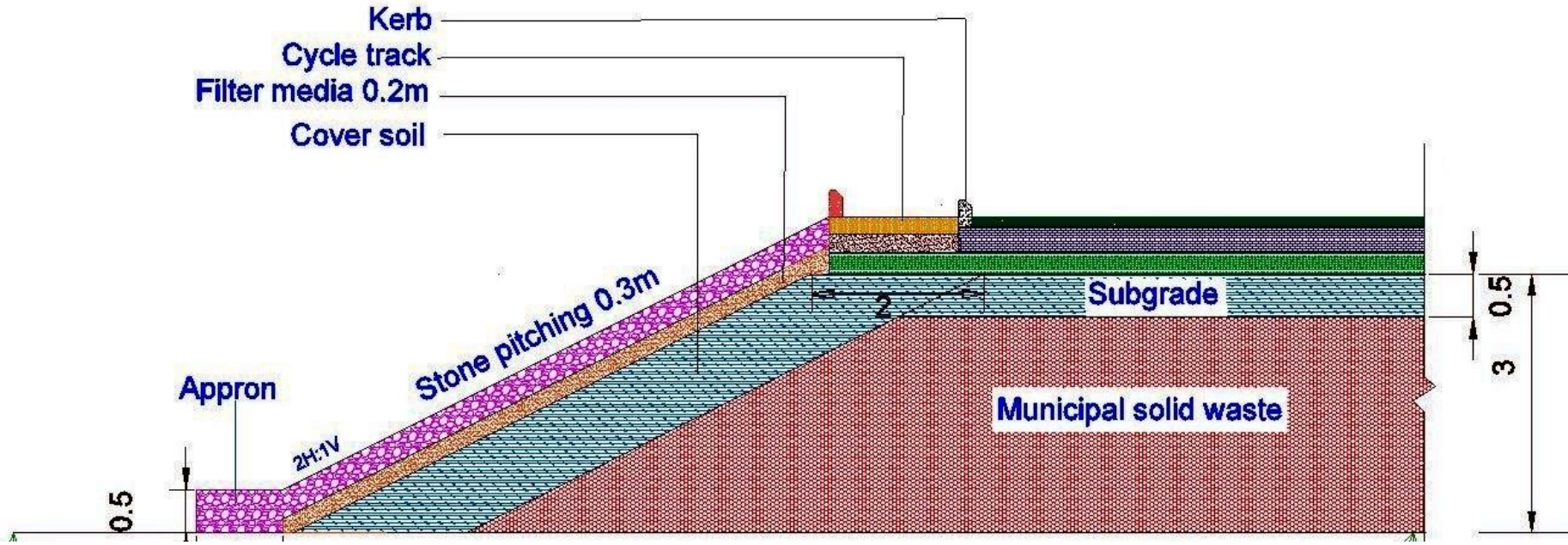


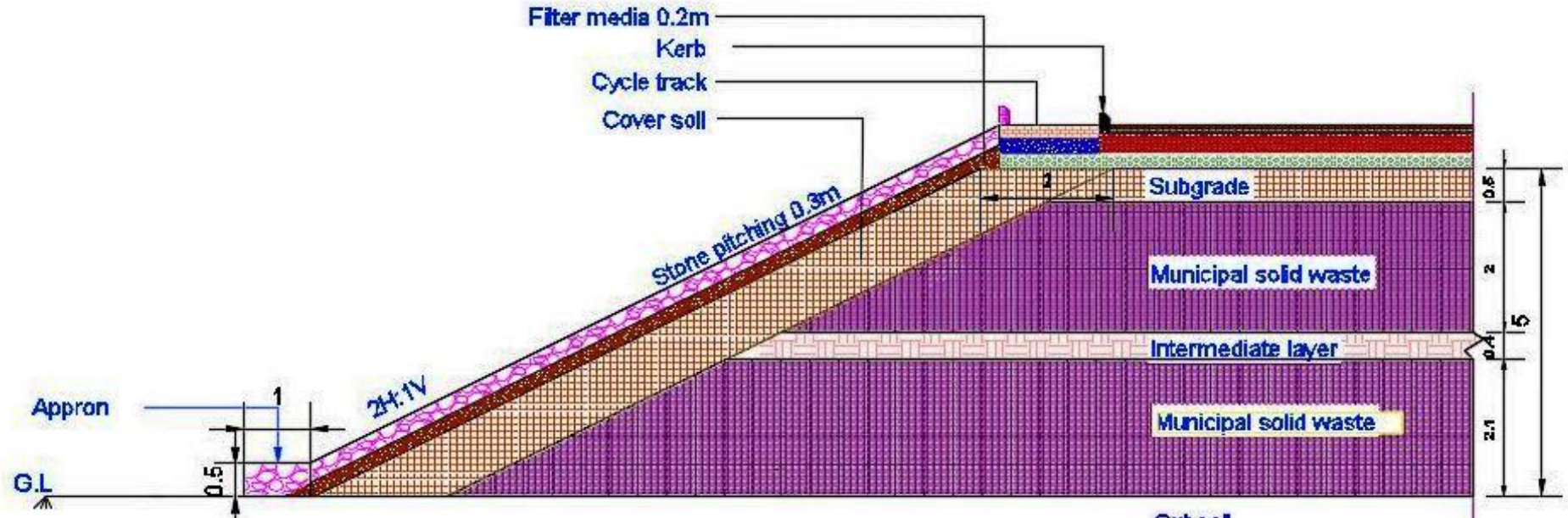
CONCLUSIONS FROM R&D STUDY

- **About 60-70% of segregated Municipal Solid wastes can be used for Road embankment construction.**

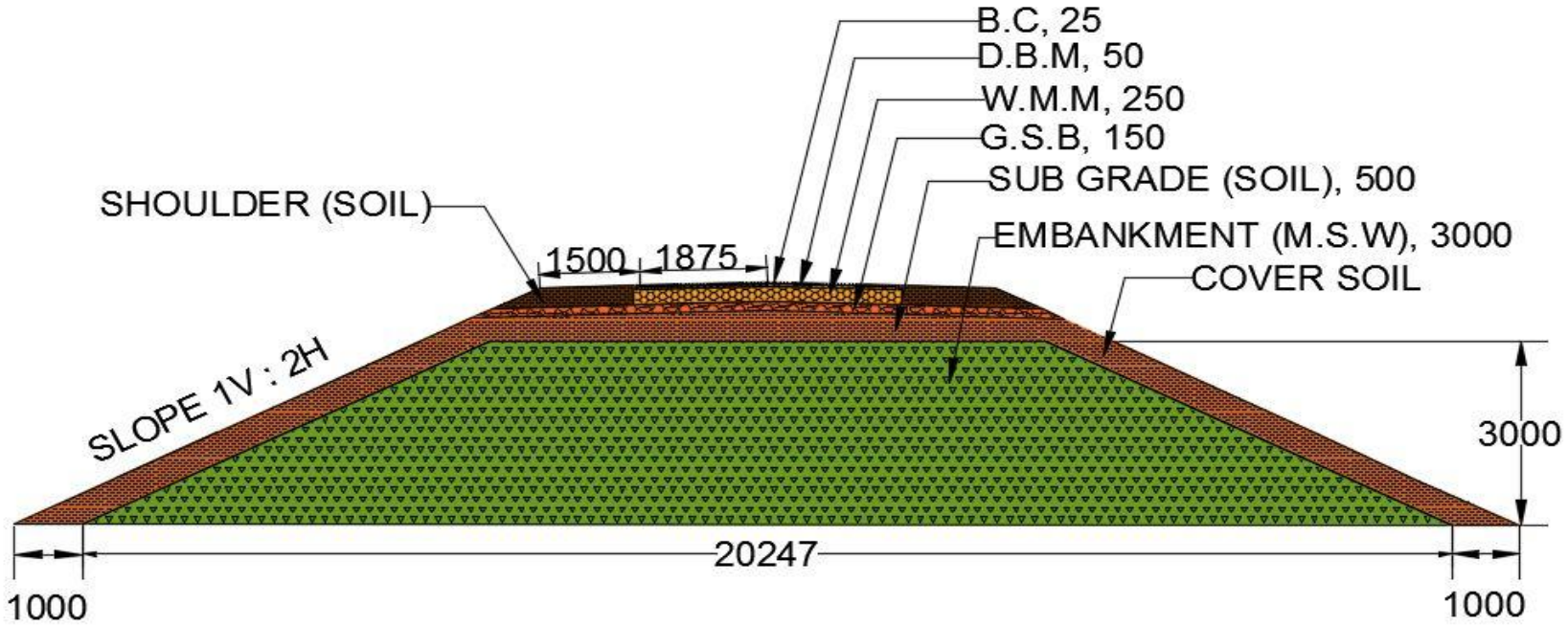
- **Based on the study of leachate characteristics, it was concluded that MSW is non hazardous material as per HWM rules.**

TYPICAL CROSS SECTIONS OF MSW EMBANKMENT





TYPICAL CROSS –SECTION FOR CONSTRUCTION OF 3M HEIGHT MSW EMBANKMENT (RAMANA, VARANASI,U.P)



All dimensions are in mm

SEGREGATION OF MSW FRACTIONS, GHAZIPUR DELHI

Trommels installed for segregation, Ghazipur

-6mm fraction

-30mm fraction

UTILIZATION OF MUNICIPAL SOLID WASTES IN APPROACH EMBANKMENT (APPROACH LINK TO DELHI-MUMBAI EXPRESSWAY)

SEGREGATED MSW DUMP ALONG ALIGNMRNT

COMPACTION OF MSW LAYER

INCINERATED RESIDUES (WASTE TO ENERGY PLANTS) IN ROAD CONSTRUCTION

Timarpur-Okhla Waste to Energy Plant

Bottom ash

Fly ash

View of Incinerator Residues

➢The recyclable materials like wood, paper and plastics from landfills are used in waste to energy plants as RDF (Refuse derived fuel, 10-30%). By incineration, the volume of MSW is reduced to 90-95 %, and incinerated residues are produced.

➢Incinerator residues viz. **Bottom ash and fly ash** are non-plastic and non-swelling materials.

➢The value of MDD (16.5-17.1 kN/m^3) indicated good compaction characteristics

➢Can be tried for construction of >3m height embankment in both National Highways and Rural Roads.

➢The bituminous mix with 30% bottom ash replacement of conventional natural aggregates resulted in an economical mix.

CONCLUDING REMARKS

- Term 'Waste Material' replaced with 'Valuable alternative Resource'.
- Waste reduction/curtailment at the source.
- Utilization of waste/marginal materials as an alternative to natural resources should become a policy of the government for infrastructure development.
- Each State/City/District/Corporation shall develop their own Solid Waste management programs.

WASTE MATERIALS

PROTECTS OUR ENVIRONMENT

SOLVES DISPOSAL PROBLEM

REDUCES COST OF CONSTRUCTION

RESULTS IN

SUSTAINABLE ROAD CONSTRUCTION

CREATE

WEALTH OUT OF WASTE

THANK YOU