



Fig. 12: View of debris slide/flow along the nala between Ch. 102+060 to 102+070 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (102+650) to (102+680)

Length – 30 m

Height - 3.0 m

Proposed Solution:

1. A gabion breast wall of 3.0 m height and welded wire mesh with soil nailing up to 3.0 m.
2. Plantation is also important on the surrounding barren land to enhance slope stability



Fig. 13: View of debris slide on LHS between Ch. 102+650 to 102+680 km



Fig. 14: View of the landslide/sinking zone on LHS between Ch. 103+420 and 103+540 km



Fig. 15: View of the gravity retaining wall provided at the nearby sinking area on valley side of the affected area

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (115+285) to (115+405)

Length – 120 m

Height - 2.0 m

Proposed Solution:

1. MSE wall (2m ht) in 65 m (Km 115.285 to km 115.350)

L-65 m

H-2 m

W-3.6 m

Area- 130 m²

Fill vol- 468 m³

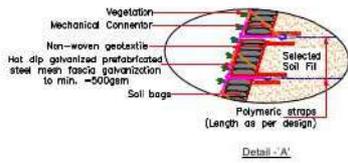
2. Gabion Retaining Wall (2 m ht) with perforated pipe in 55 m (km 115.350 to km 115.405)

3. Surface drain

4. Paved shoulders

5. Chute drain in the downslope side

6. Plantation



High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	g/sqm
		Mass per unit area total (geotextile+mini pipes)	612	g/sqm
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
		Under 20 kPa	5.0	mm
Tensile Strength	NF EN 150	Machine Direction	24	kN/m
		Cross Direction	24	kN/m

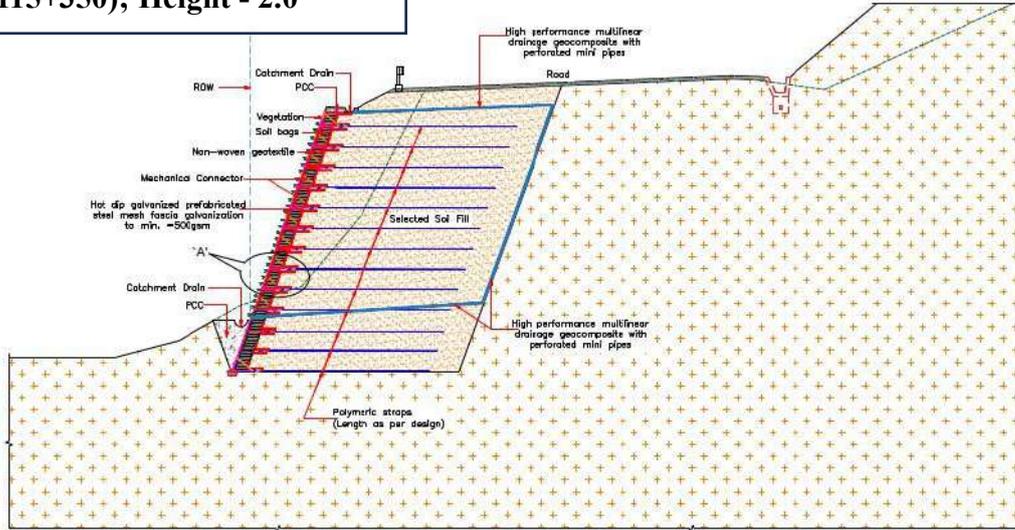
Polymeric Straps - Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE).

Polymeric Straps Specification				
Properties	Test Method	Unit	Minimum average rol value	
Ultimate Tensile Strength	Indian or International standard	kN	25	30
Width		mm	40	50
			60	70
			80	90
			100	

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B550c and hot dip galvanized to minimum 500gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.

Chainage from (115+285) to (115+350); Height - 2.0



Typical Cross Section with Mechanically Stabilization Earth Slope



Fig. 16: View of the junction of Tura-Dalu road with the village road and sinking zone-4 at Ch. 115+285 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (115+440) to (115+550)

Length – 110 m

Height - 3.0 m

Proposed Solution:

1. MSE wall (3m ht) in 50 m (Km 115.440 to km 115.490)

L-50 m

H-3 m

W-4 m

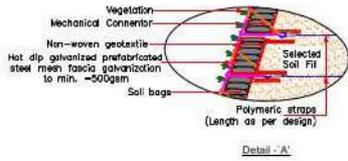
Area- 150 m²

Fill vol- 600 m³

2. Gabion Retaining Wall (3m ht) with perforated pipe in 60 m (km 115.490 to km 115.550)

3. Plantation

4. Paved shoulder up to the side drain



High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	g/sqm
		Mass per unit area total (geotextile+mini pipes)	612	
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
		Machine Direction	5.0	
Tensile Strength	NF EN 199	Machine Direction	24	kN/m
		Cross Direction	24	

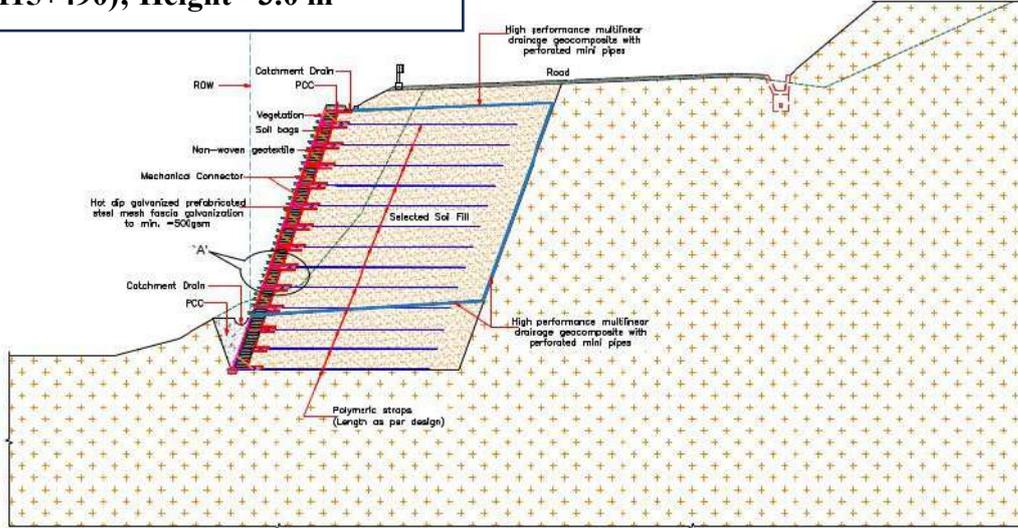
Polymeric Straps - Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE).

Polymeric Straps Specification					
Properties	Test Method	Unit	Minimum average rol value		
Ultimate Tensile Strength	Indian or International standard	kN	25	30	40
Width		mm	49.5	49.5	49.5

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B550c and hot dip galvanized to minimum 500gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.

Chainage from (115+440) to (115+490); Height - 3.0 m



Typical Cross Section with Mechanically Stabilization Earth Slope

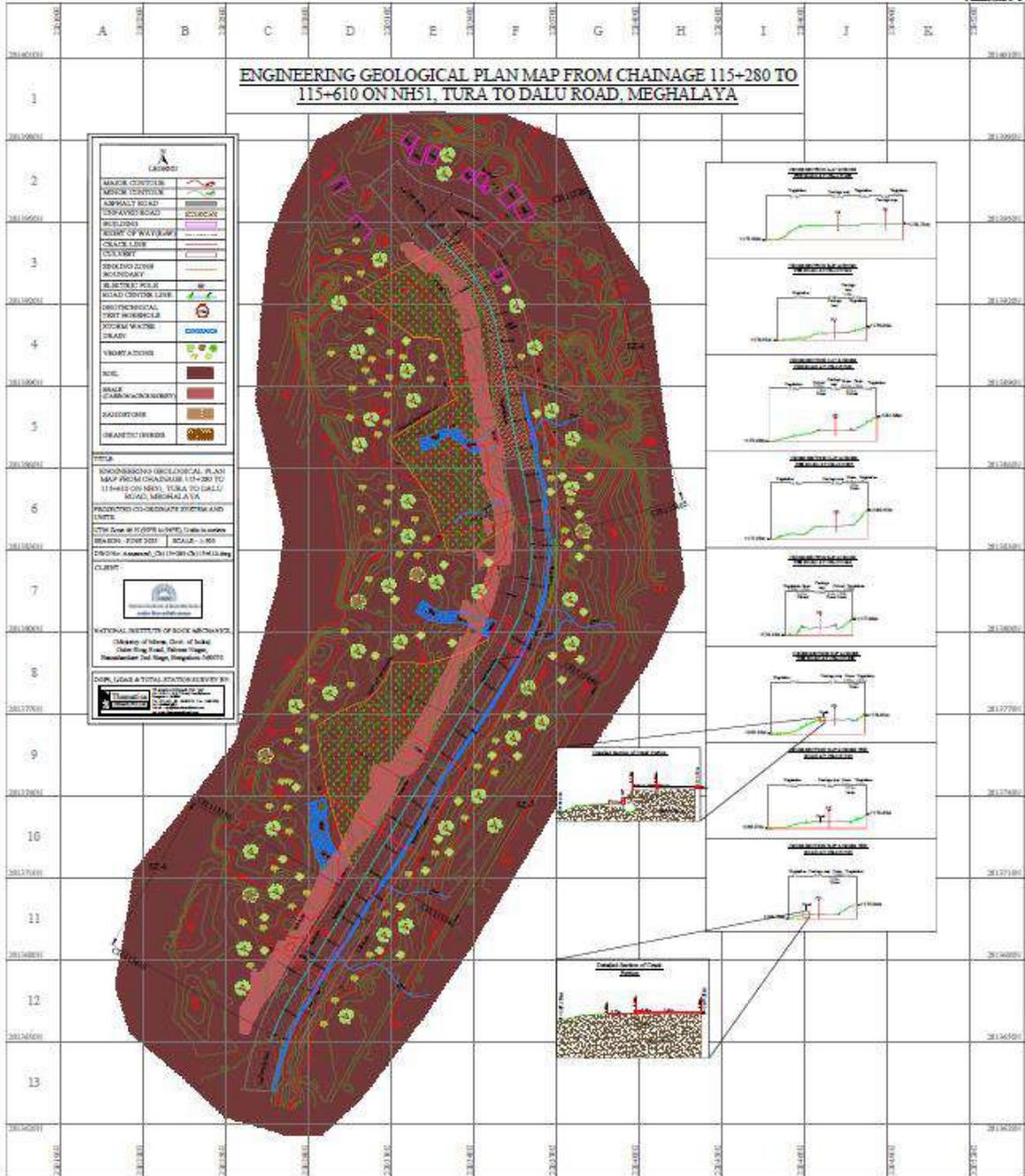




Fig. 17: View of sinking zone between Ch. 115+440 and 115+540 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (115+550) to (115+610)

Length – 60 m

Height - 3.0 m

Proposed Solution:

1. Mechanically stabilised Earth wall

L-60

H-3

W-4

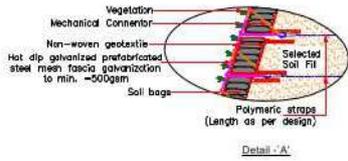
Area- 180

Fill vol- 728

2. Surface drain extended to existing culvert

3. Plantation

4. No paved shoulder



High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	
		Mass per unit area total (mass(geotextile+mini pipes))	612	g/sqm
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
		Machine Direction	5.0	
Tensile Strength	NF EN 150 10319	Cross Direction	24	kN/m

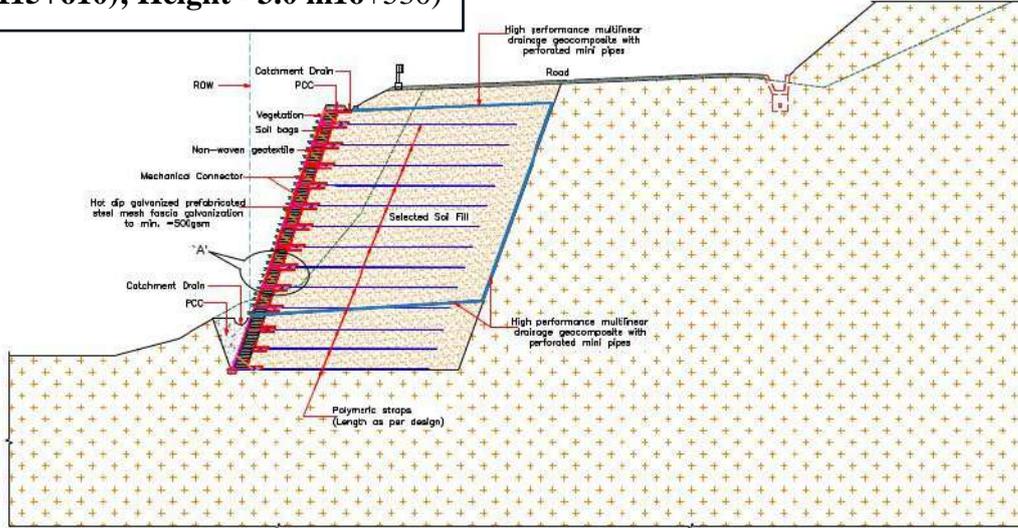
Polymeric Straps – Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE)

Polymeric Straps Specification					
Properties	Test Method	Unit	Minimum average roll value		
Ultimate Tensile Strength	Indian or International standard	kN	25	30	40
Width		mm	49.5	49.5	49.5

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B500c and hot dip galvanized to minimum 50gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.

Chainage from (115+550) to (115+610); Height - 3.0 m16+530)



Typical Cross Section with Mechanically Stabilization Earth Slope



Fig. 18: View of longitudinal crack on the RHS mapped between Ch. 115+550 and 115+610 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (115+635) to (115+690)

Length – 55 m

Height – 1.5 m

Proposed Solution:

1. Mechanically stabilised Earth wall

L-55

H-1.5

W-3.1

Area- 82.5

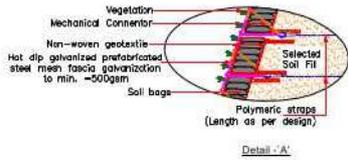
Fill vol- 256

2. Gabion Retaining Wall (2m height) with perforated pipe in 25 m from km 115.610 to km 115.635

3. Surface drain extended to the existing culvert

4. Plantation

5. No paved shoulder



High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	
		Mass per unit area total (mass (geotextile+mini pipes))	612	g/sqm
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
		Under 20 kPa	5.0	
Tensile Strength	NF EN 150 10319	Machine Direction	24	kN/m
		Cross Direction	24	

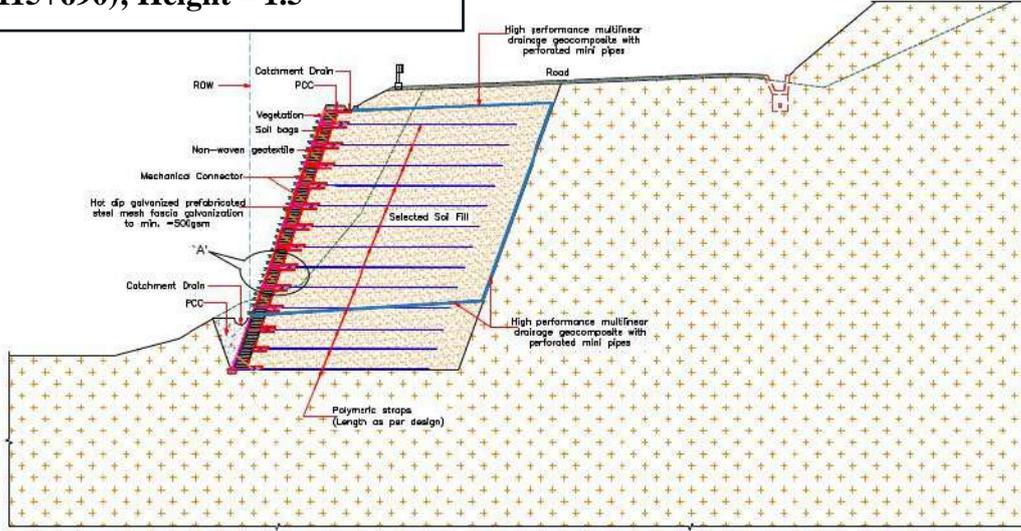
Polymeric Straps – Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE).

Polymeric Straps Specification				
Properties	Test Method	Unit	Minimum average roll value	
Ultimate Tensile Strength	Indian or International standard	kN	25	30
			40	50
			60	70
			80	90
			100	100
Width		mm	49.5	49.5
			49.5	49.5
			49.5	49.5

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MORTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B500c and hot dip galvanized to minimum 50gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min. 16 gauge wire.

Chainage from (115+635) to (115+690); Height – 1.5



Typical Cross Section with Mechanically Stabilization Earth Slope



Fig. 19: A longitudinal open crack approximately 15 m long and up to 10 cm wide with vertical displacement (up to 12 cm) along right edge of the pavement near Ch 115+675 km were mapped.

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (115+690) to (115+780)

Length – 90 m

Height – 3.0 m

Proposed Solution:

1. Gabion Retaining Wall (3m height) with perforated pipe to be started from km 115.690 (40 m additional).
2. Surface drain extended to existing culvert
3. Plantation

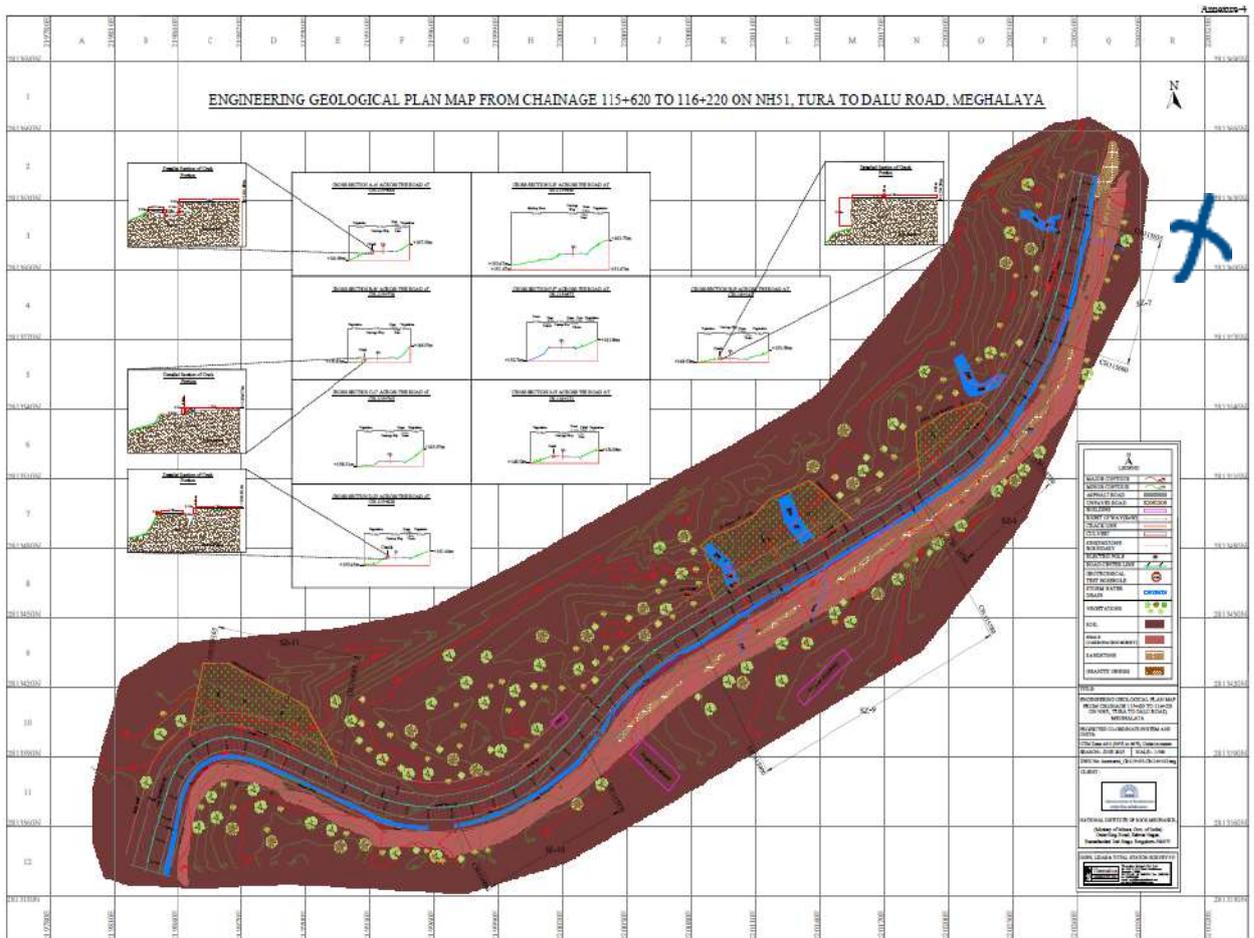




Fig. 20: View of damaged zone and longitudinal cracks at SZ-08 between Ch. 115+730 to 115+780 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (115+780) to (115+900)

Length – 120 m

Height – 3.0 m

Proposed Solution:

1. Gabion Retaining Wall (3m ht) with perforated pipe
2. Paved shoulder up to the side drain
3. Plantation

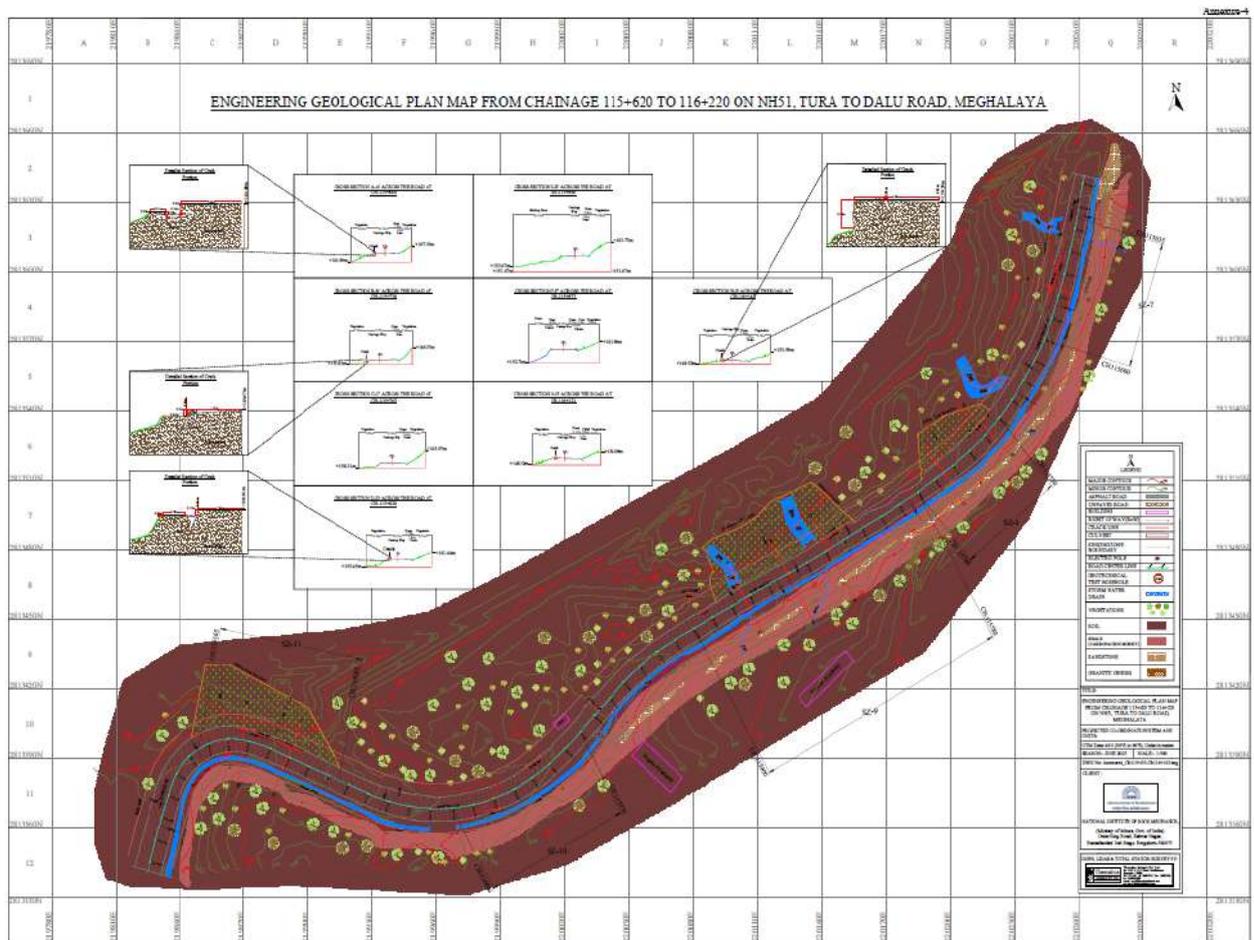




Fig. 21: Longitudinal open cracks (up to 25 cm wide) with vertical displacement (up to 30 cm) mapped along right edge of the pavement near Ch 115+867 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (115+970) to (116+095)

Length – 125 m

Height – 2.0 m

Proposed Solution:

1. Gabion Retaining Wall (2m ht) with perforated pipe to be continued upto km 116.095 (55 m additional).
2. Plantation

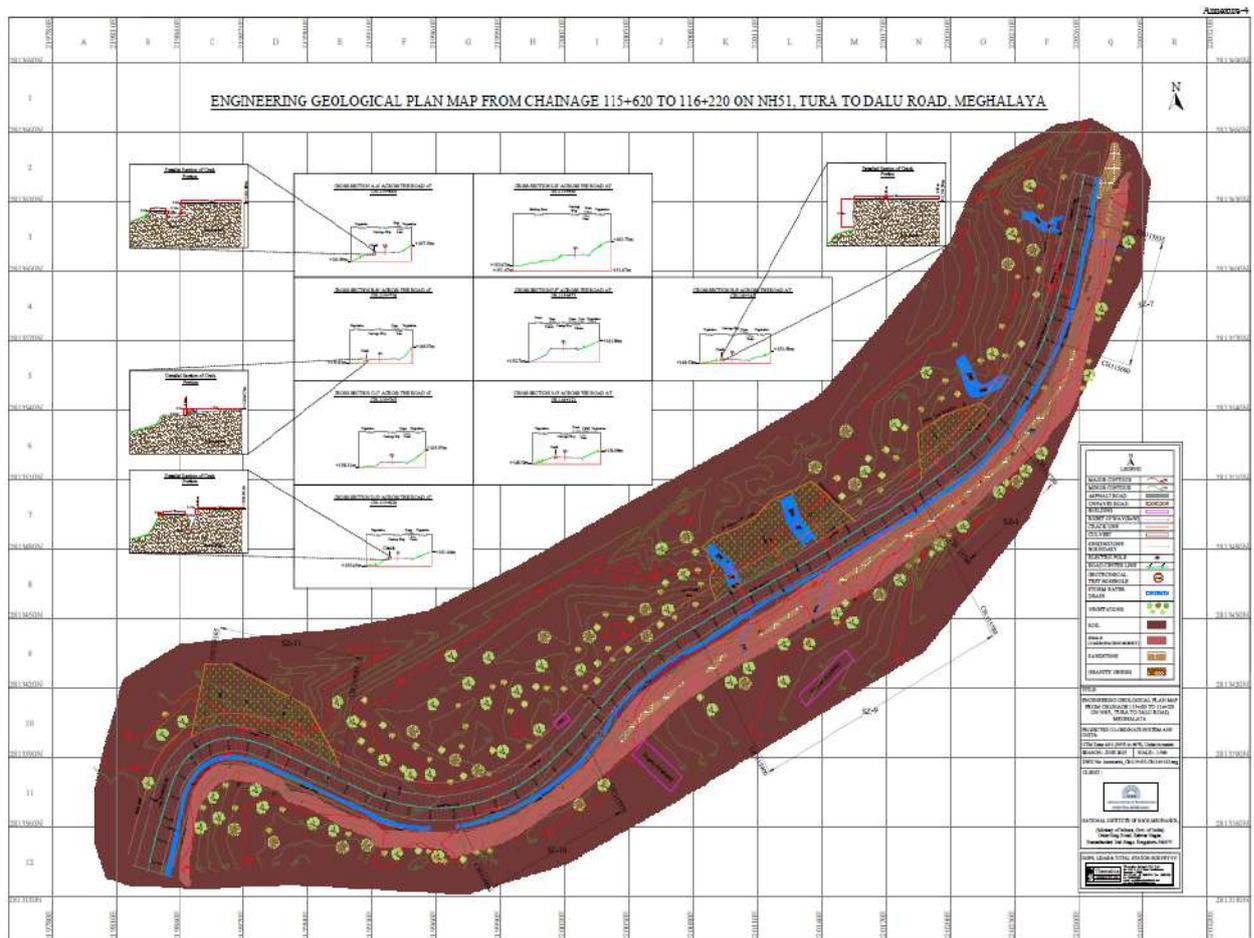




Fig. 22: View of longitudinal crack at the road level on LHS between Ch. 115+970 to 116+040 km



Fig. 23: View of longitudinal crack and sunk area of SZ-11 between Ch. 116+095 to 116+165 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (116+380) to (116+530)

Length – 150 m

Height - 3.0 m

Proposed Solution:

1. Mechanically stabilised Earth wall

L-150 m

H-3 m

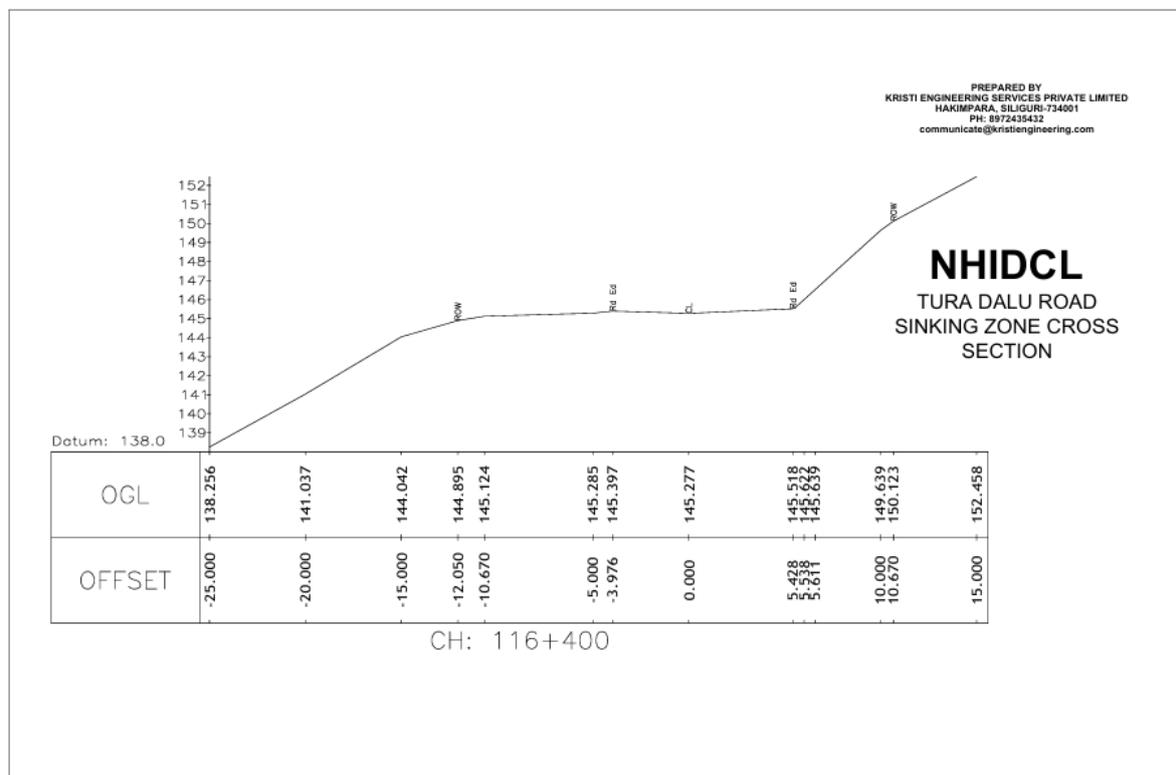
W-4 m

Area- 450 m²

Fill vol- 1800 m³

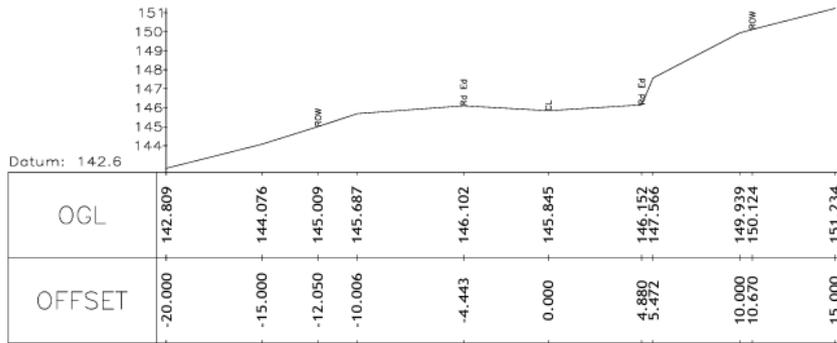
2. Plantation

3. Flexible retaining wall of 2.0 m height on the RHS and surface and subsurface drainage

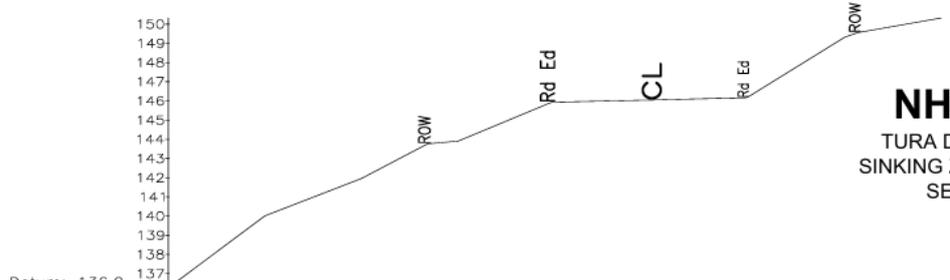


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 communicate@kristiengineering.com

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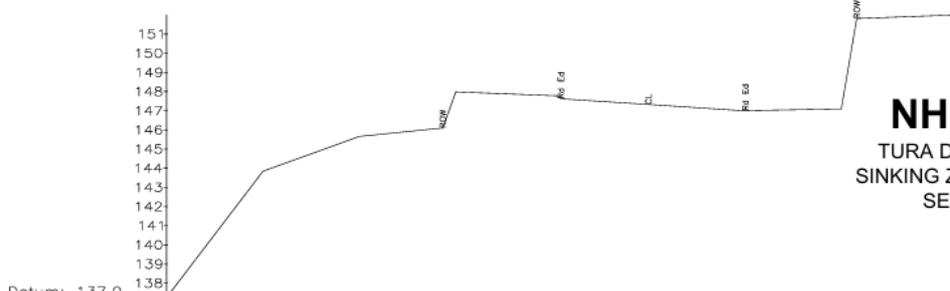
CH: 116+420



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OGL	136.262	140.014	141.962	143.767	143.907	145.882	145.934	146.048	146.167	146.257	149.315	149.554	150.320
OFFSET	-25.000	-20.000	-15.000	-11.580	-10.000	-5.282	-5.142	0.000	4.886	5.086	10.000	10.670	15.000

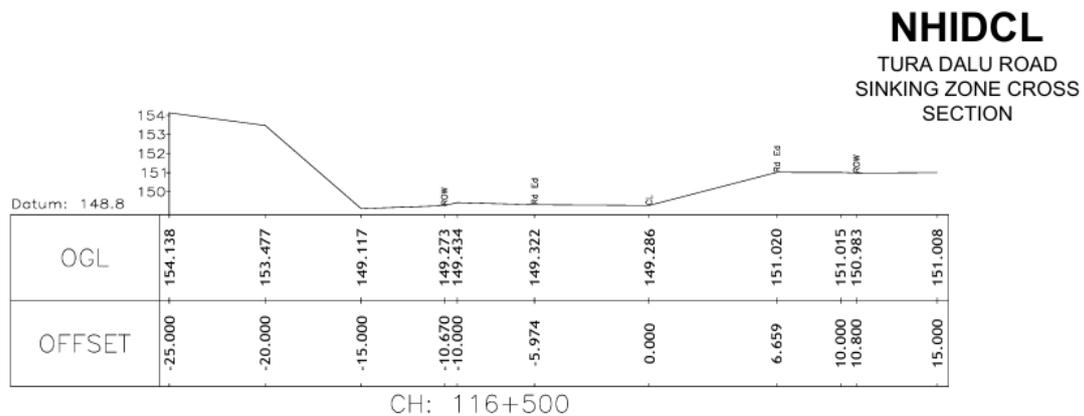
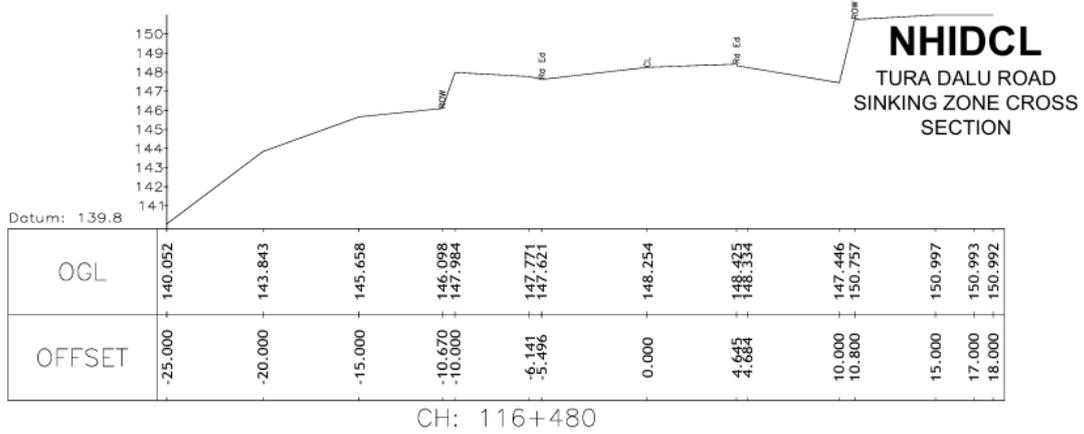
CH: 116+440

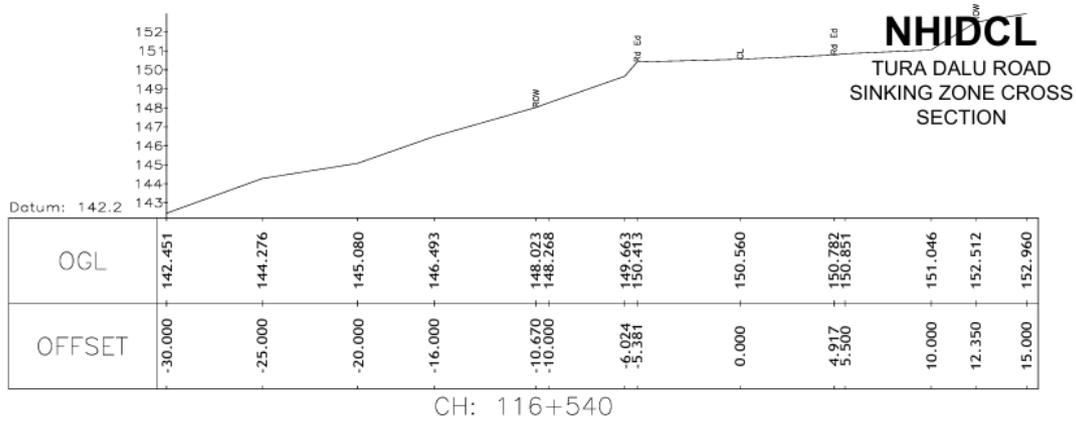
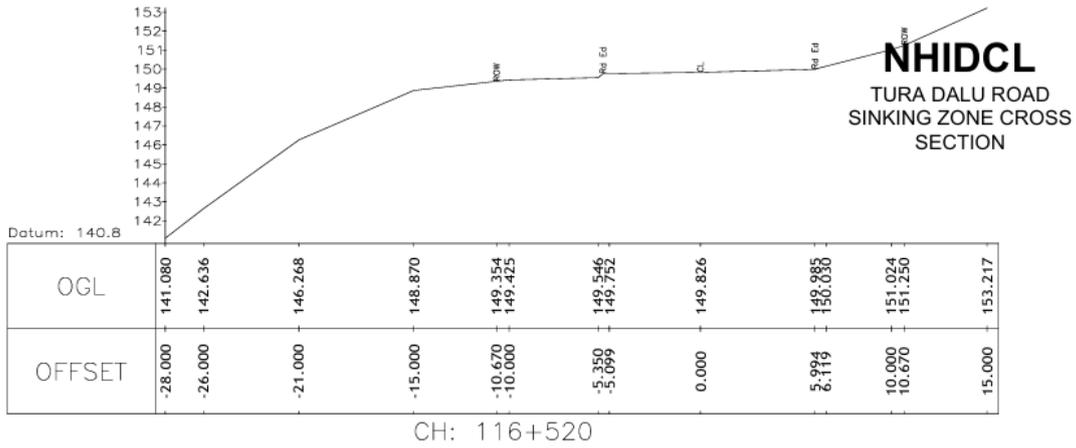


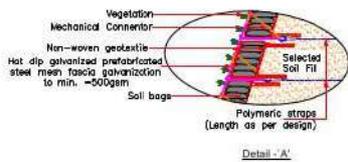
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OGL	137.254	143.843	145.658	146.098	147.984	147.771	147.621	147.327	146.990	147.009	147.096	151.808	151.964	151.997
OFFSET	-25.000	-20.000	-15.000	-10.670	-10.000	-4.611	-4.546	0.000	5.019	5.443	10.000	10.800	15.000	16.000

CH: 116+460







High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	
		Mass per unit area Total mass (geotextile+mini pipes)	612	g/sqm
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
		Under 20 kPa	5.0	
Tensile Strength	NF EN 150	Machine Direction	24	kN/m
		Cross Direction	24	

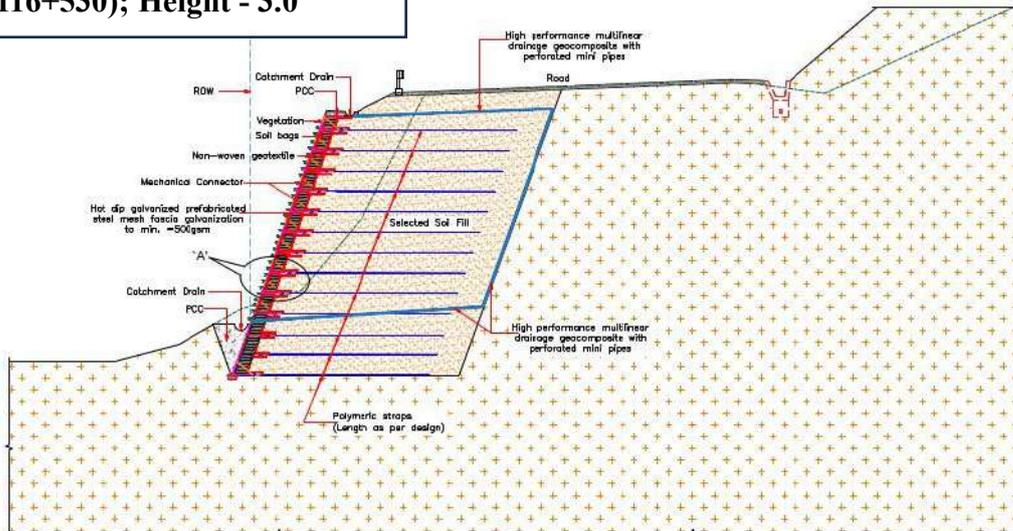
Polymeric Straps - Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE).

Polymeric Straps Specification				
Properties	Test Method	Unit	Minimum average roll value	
Ultimate Tensile Strength	Indian or International standard	kN	25	30
Width		mm	49.5	49.5

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B550c and hot dip galvanized to minimum 500gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.

Chainage from (116+380) to (116+530); Height - 3.0



Typical Cross Section with Mechanically Stabilization Earth Slope



Fig. 24: View of the sunk/sinking zone -12 between Ch. 116+380 to 116+530 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (117+060) to (117+180)

Length – 120 m

Height - 1.5 m

Proposed Solution:

1. Mechanically stabilised Earth wall (height of MSE wall to be 5m as per site verification).

L-120

H-1.5

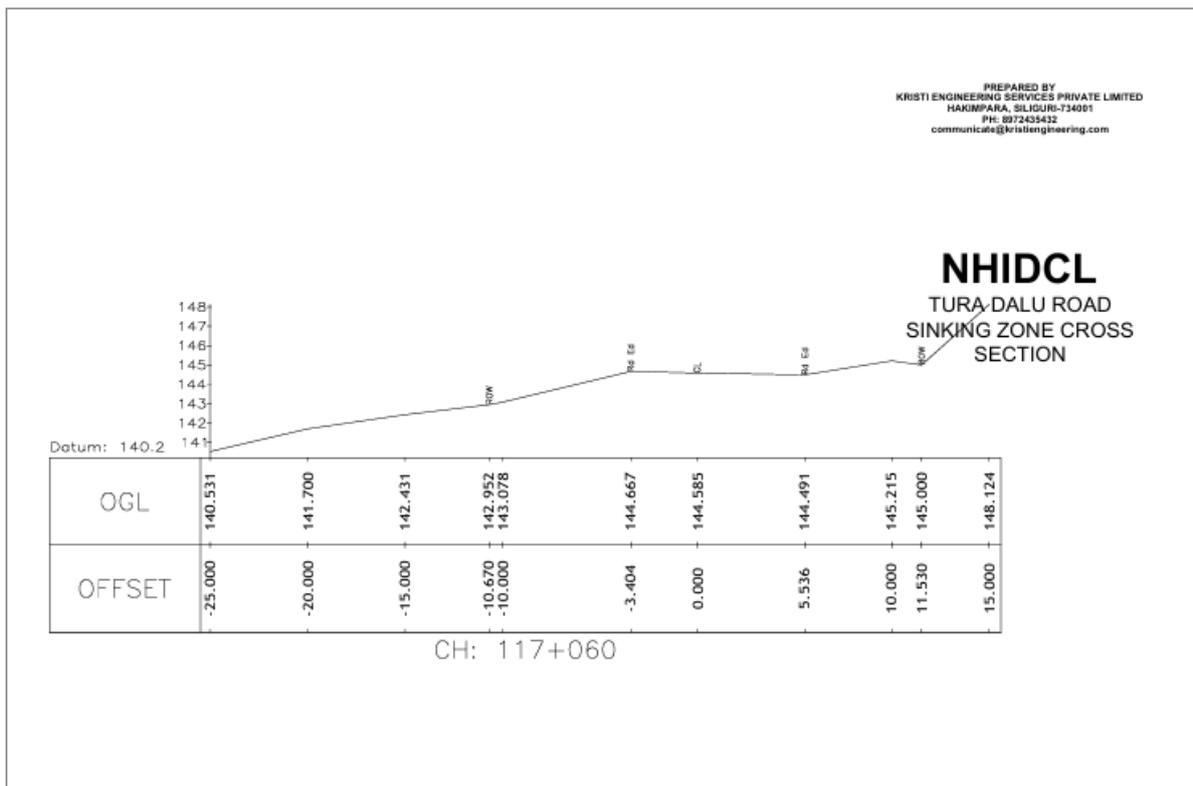
W-3.1

Area- 180

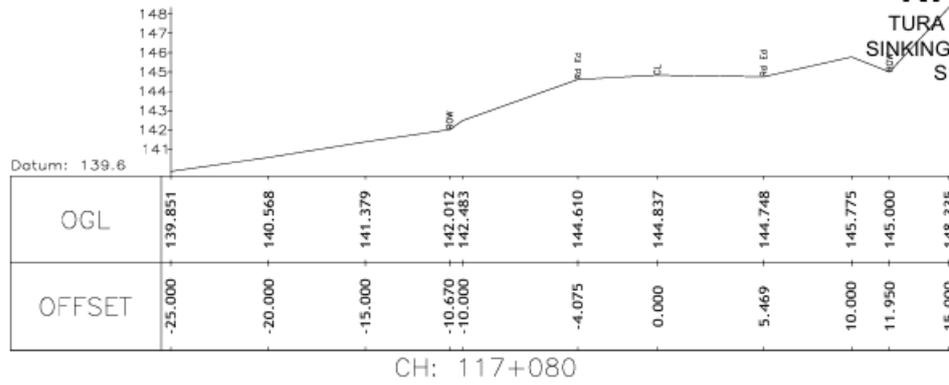
Fill vol- 558

2. 1.5-meter breast wall

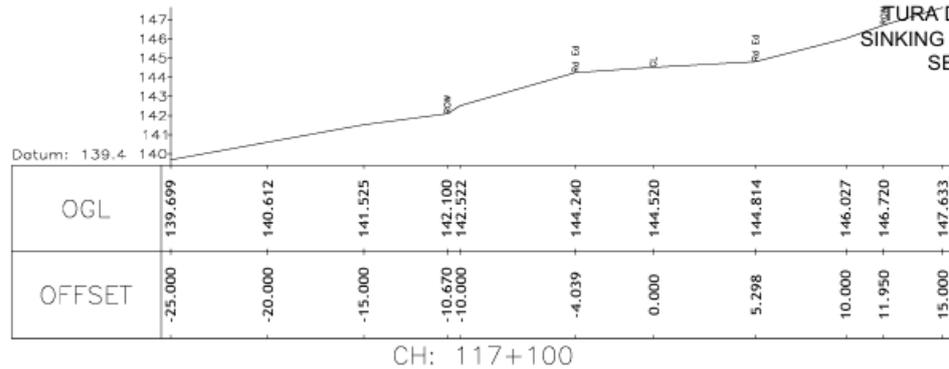
3. Plantation



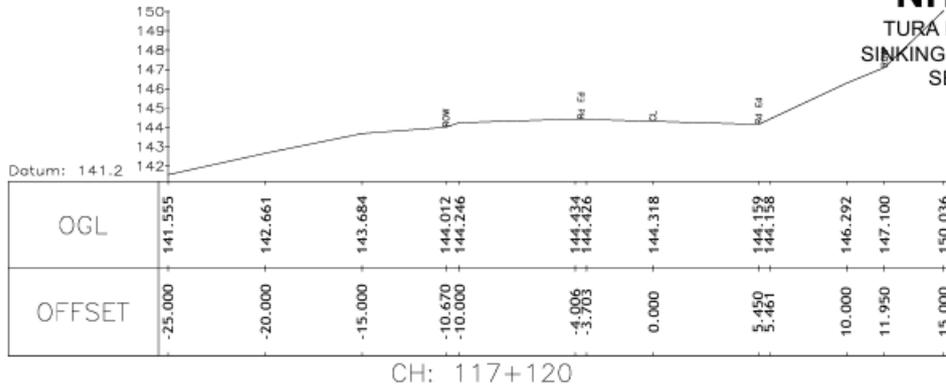
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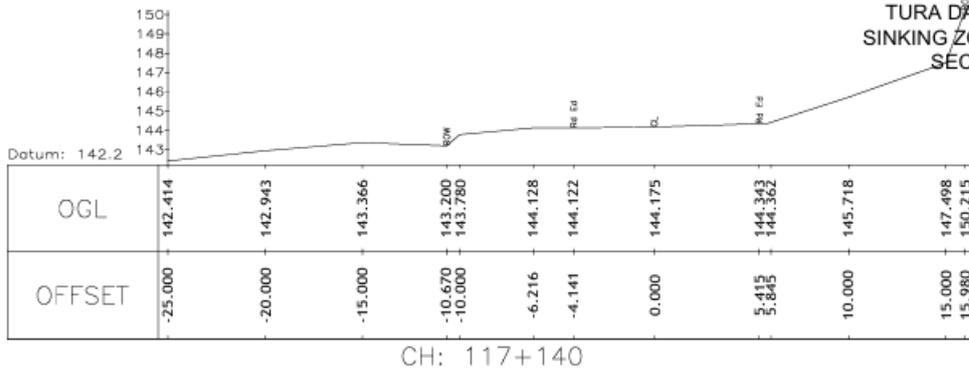
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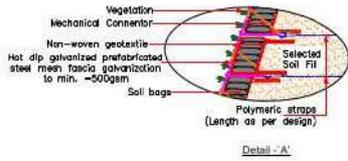


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High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	g/sqm
		Mass per unit area total (geotextile+mini pipes)	612	g/sqm
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
		Under 20 kPa	5.0	mm
Tensile Strength	NF EN 150	Machine Direction	24	kN/m
		Cross Direction	24	kN/m

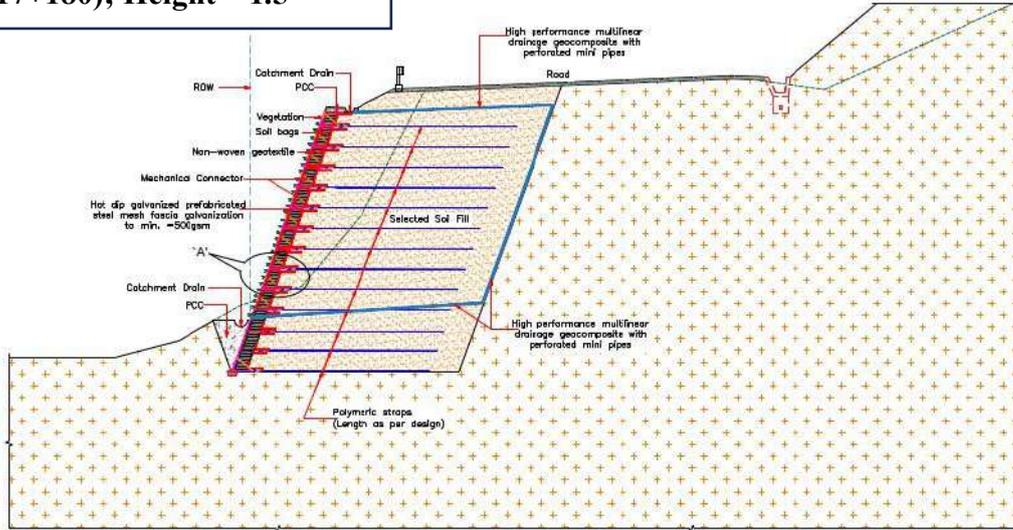
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Properties	Test Method	Unit	Minimum average rol value	
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Width		mm	49.5	49.5

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

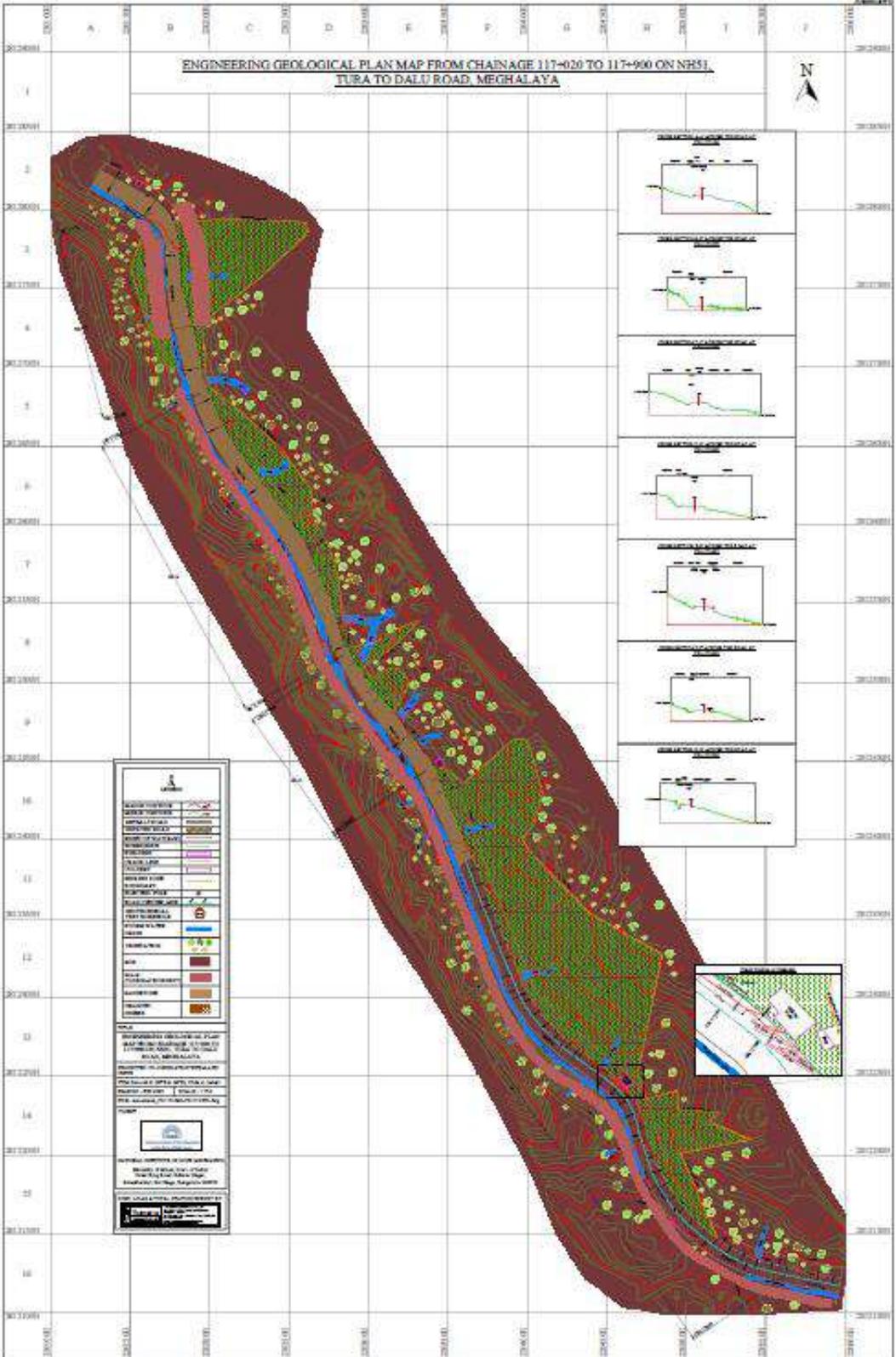
Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B550c and hot dip galvanized to minimum 500gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.

Chainage from (117+060) to (117+180); Height - 1.5



Typical Cross Section with Mechanically Stabilization Earth Slope

**ENGINEERING GEOLOGICAL PLAN MAP FROM CHAINAGE 117+020 TO 117+900 ON NH51,
TURA TO DALU ROAD, MEGHALAYA**



LEGEND	
	Road Right-of-Way
	Road Pavement
	Road Shoulder
	Road Embankment
	Road Cut
	Road Bridge
	Road Tunnel
	Road Culvert
	Road Drainage
	Road Utility
	Road Structure
	Road Foundation
	Road Slope
	Road Embankment
	Road Cut
	Road Bridge
	Road Culvert
	Road Drainage
	Road Utility
	Road Structure
	Road Foundation
	Road Slope
	Road Embankment
	Road Cut
	Road Bridge
	Road Culvert
	Road Drainage
	Road Utility
	Road Structure
	Road Foundation
	Road Slope
	Road Embankment
	Road Cut
	Road Bridge
	Road Culvert
	Road Drainage
	Road Utility
	Road Structure
	Road Foundation
	Road Slope
	Road Embankment
	Road Cut
	Road Bridge
	Road Culvert
	Road Drainage
	Road Utility
	Road Structure
	Road Foundation
	Road Slope
	Road Embankment
	Road Cut
	Road Bridge
	Road Culvert
	Road Drainage
	Road Utility
	Road Structure
	Road Foundation
	Road Slope
	Road Embankment
	Road Cut
	Road Bridge
	Road Culvert
	Road Drainage
	Road Utility
	Road Structure
	Road Foundation
	Road Slope
	Road Embankment
	Road Cut
	Road Bridge
	Road Culvert
	Road Drainage
	Road Utility
	Road Structure
	Road Foundation
	Road Slope
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	Road Cut
	Road Bridge
	Road Culvert
	Road Drainage
	Road Utility
	Road Structure
	Road Foundation
	Road Slope
	Road Embankment
	Road Cut
	Road Bridge
	Road Culvert
	Road Drainage
	Road Utility
	Road Structure
	Road Foundation
	Road Slope
	Road Embankment
	Road Cut
	Road Bridge
	Road Culvert
	Road Drainage
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	Road Structure
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	Road Foundation
	Road Slope
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	Road Cut
	Road Bridge
	Road Culvert
	Road Drainage
	Road Utility
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	Road Cut

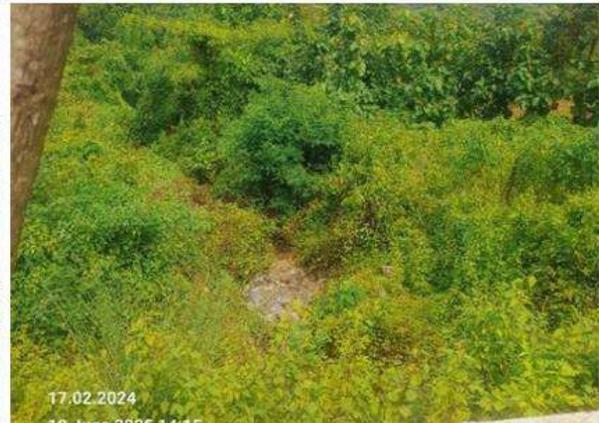


Fig. 25: Area along the road's left-hand side is affected by ground subsidence (sinking zone) between Ch 117+060 to 117+180 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (117+180) to (117+370)

Length – 190 m

Height – 3.0 m

Proposed Solution:

1. Mechanically stabilised Earth wall

L-190

H-3

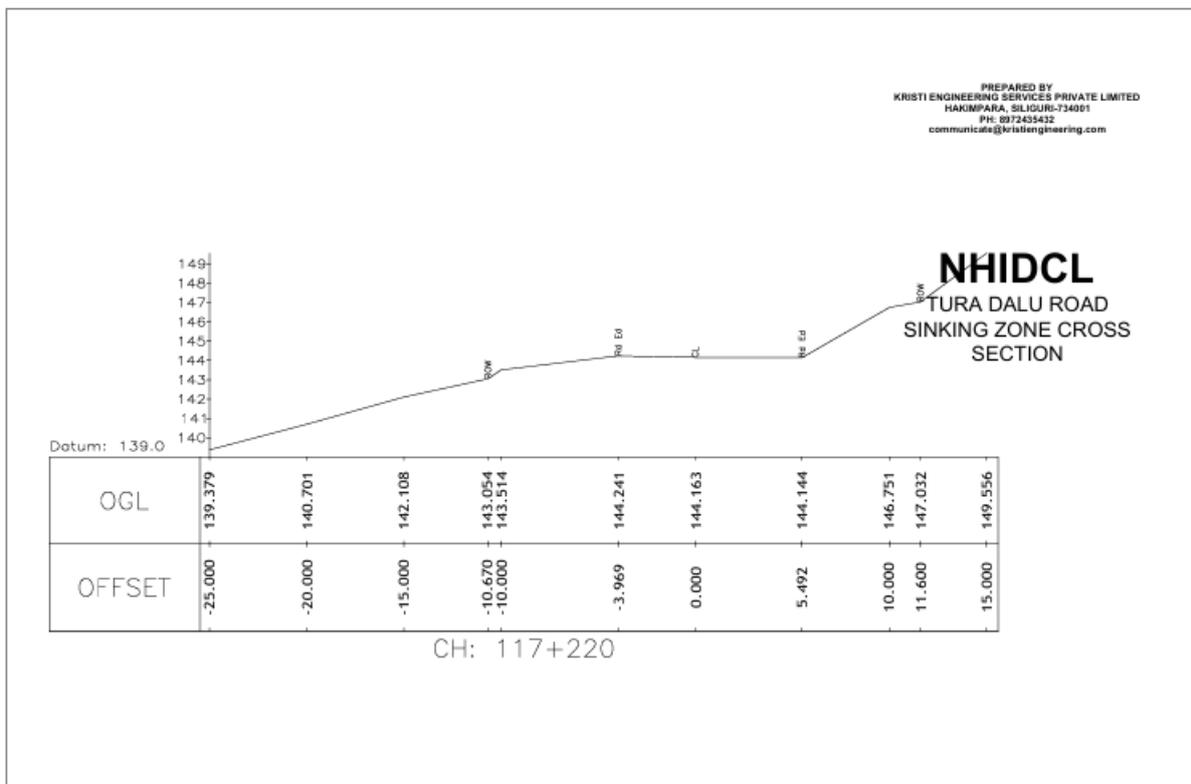
W-4

Area- 570

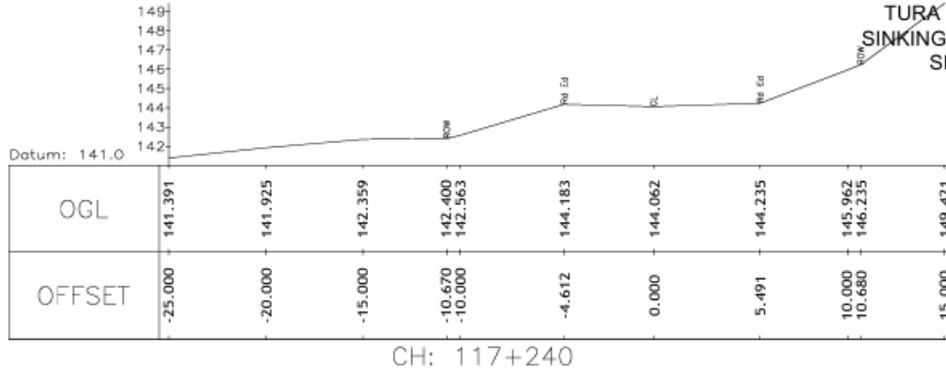
Fill vol- 2280

2. Paved Shoulders

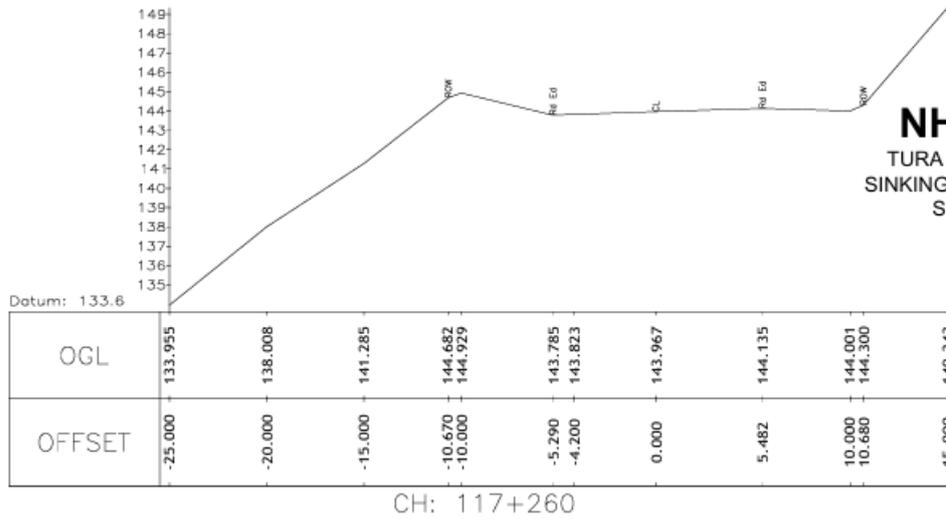
3. Plantation



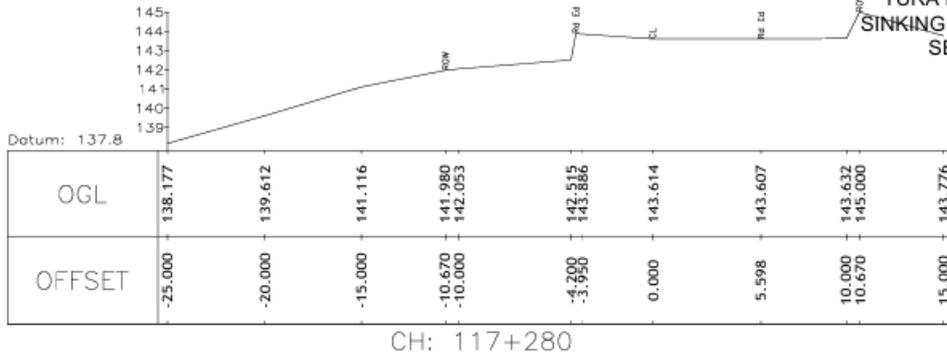
NHIDCL
TURA DALU ROAD
SINKING ZONE CROSS
SECTION



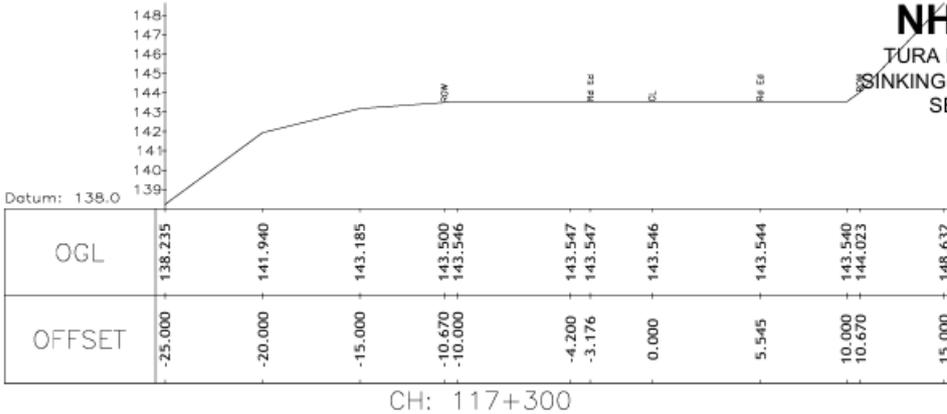
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TURA DALU ROAD
SINKING ZONE CROSS
SECTION

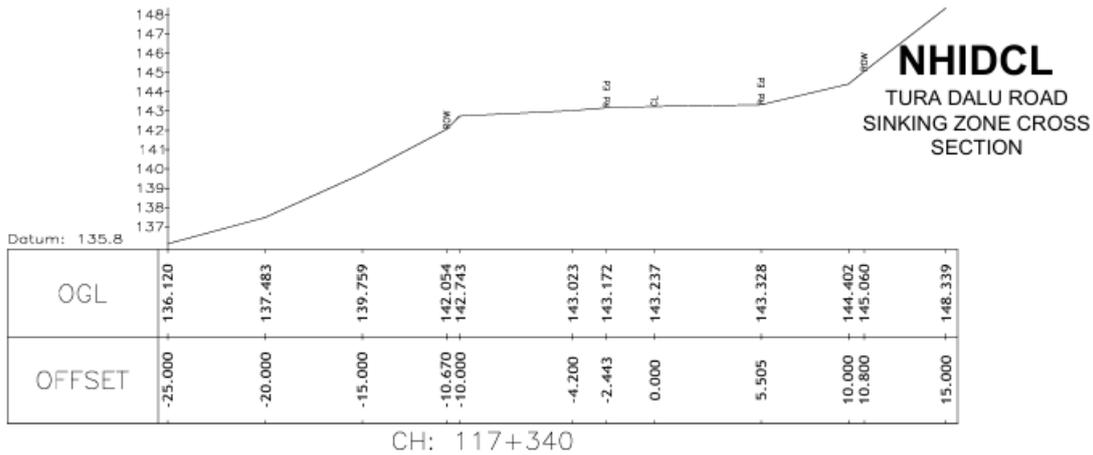
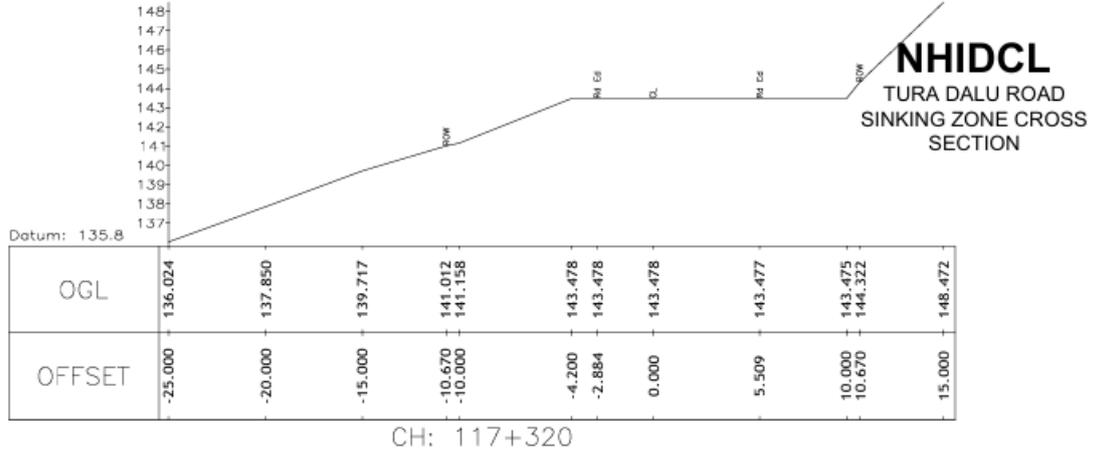


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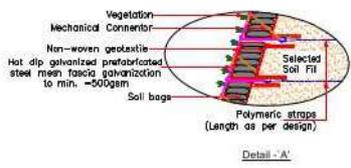
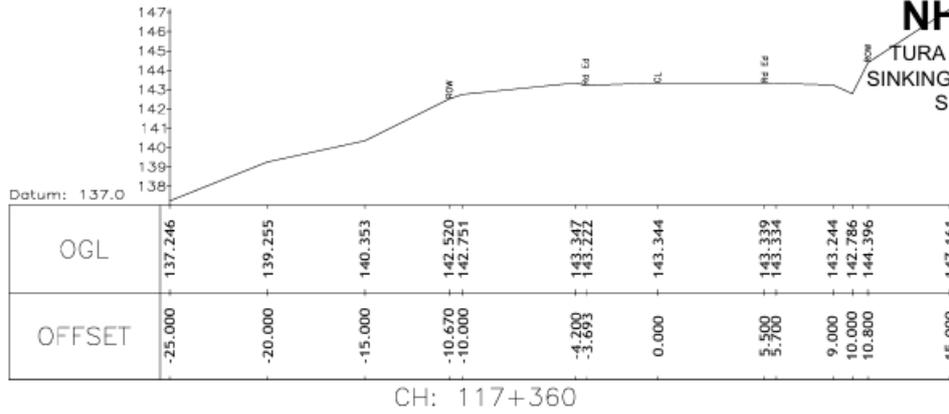


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 SECTION





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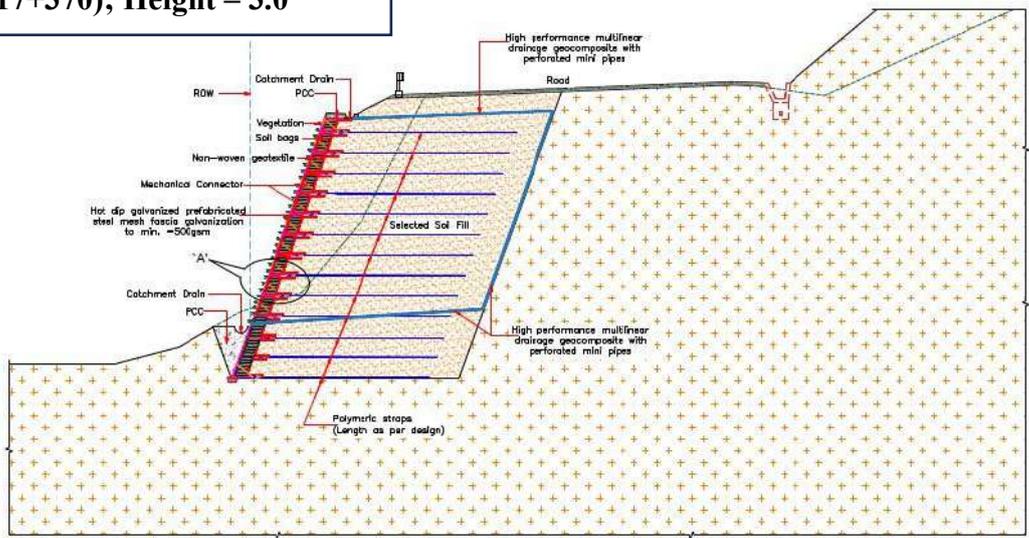


High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	g/sqm
		Mass per unit area total (mass(geotextile+mini pipe)	612	
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
	NF EN 150	Machine Direction	24	
Tensile Strength	10319	Cross Direction	24	kN/m

Polymeric Straps :- Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE)

Polymeric Straps Specification											
Properties	Test Method	Unit	Minimum average rol value								
Ultimate Tensile Strength	Indian or International standard	HN	25	30	40	50	60	70	80	90	100
Width		mm	49.5	49.5	49.5	49.5	49.5	49.5	49.5	49.5	49.5

Chainage from (117+180) to (117+370); Height – 3.0



Typical Cross Section with Mechanically Stabilization Earth Slope

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B500c and hot dip galvanized to minimum 200gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.

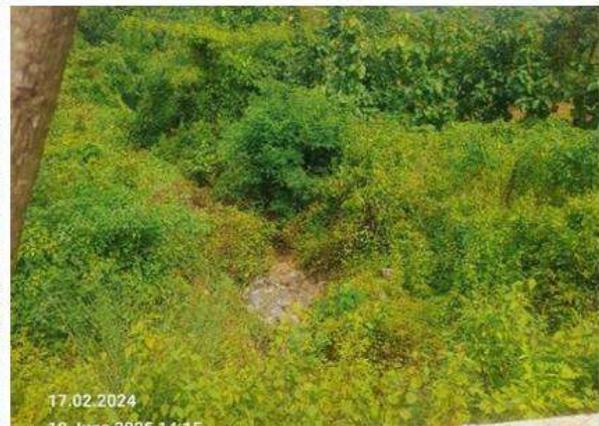


Fig. 25: Area along the road's left-hand side is affected by ground subsidence (sinking zone) between Ch 117+060 to 117+180 km



Fig. 26: View of sinking zone -14 on LHS

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (117+370) to (117+440)

Length – 70 m

Height – 5.0 m

Proposed Solution:

1. Mechanically stabilised Earth wall with wire mesh facia and selected backfill materials (height of MSE wall to be 5m as per site verification).

L-70

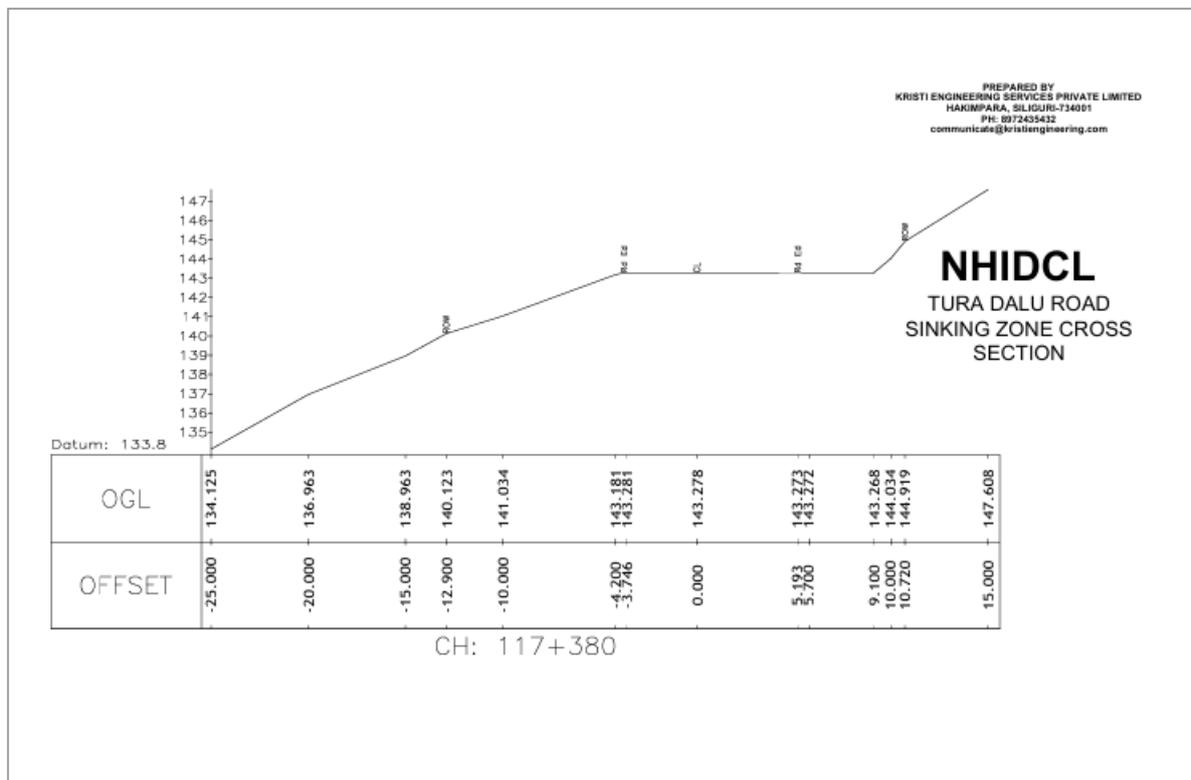
H-5

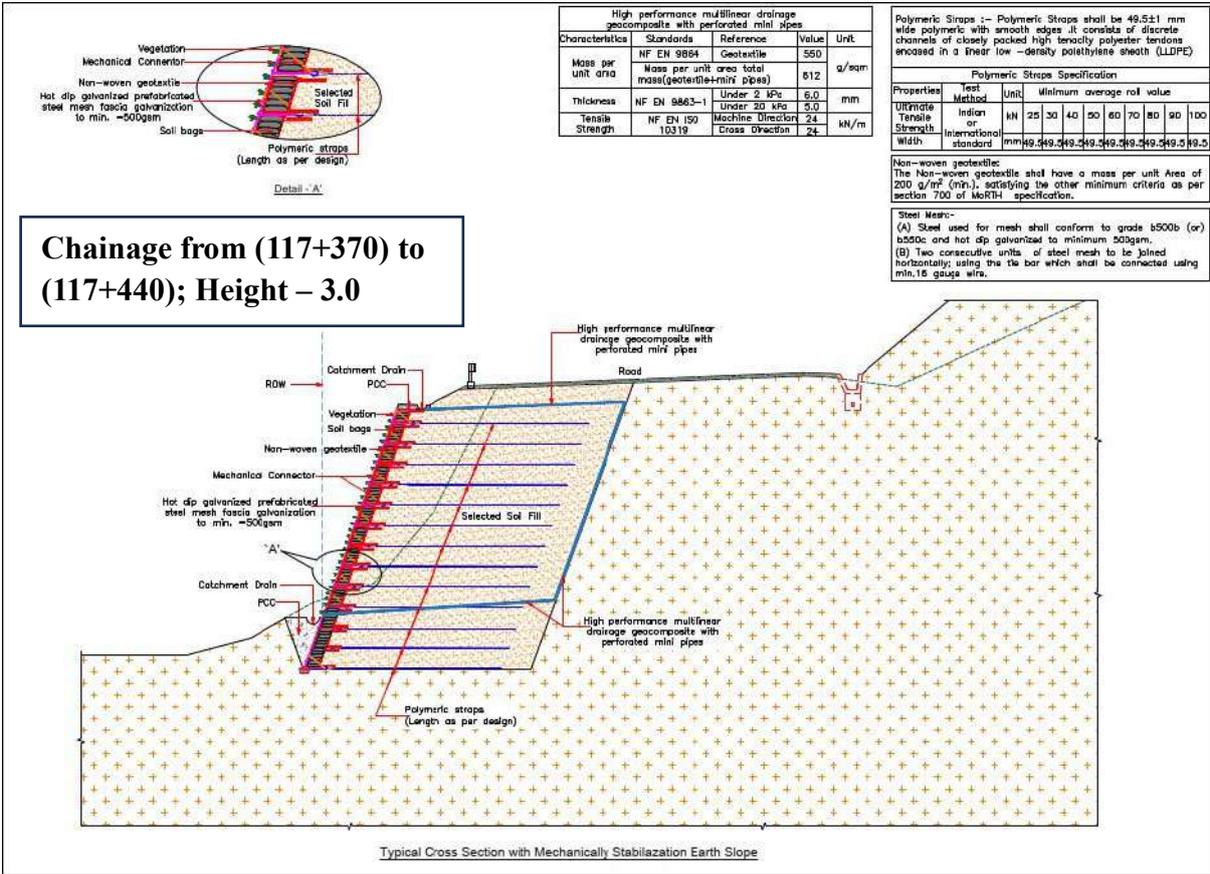
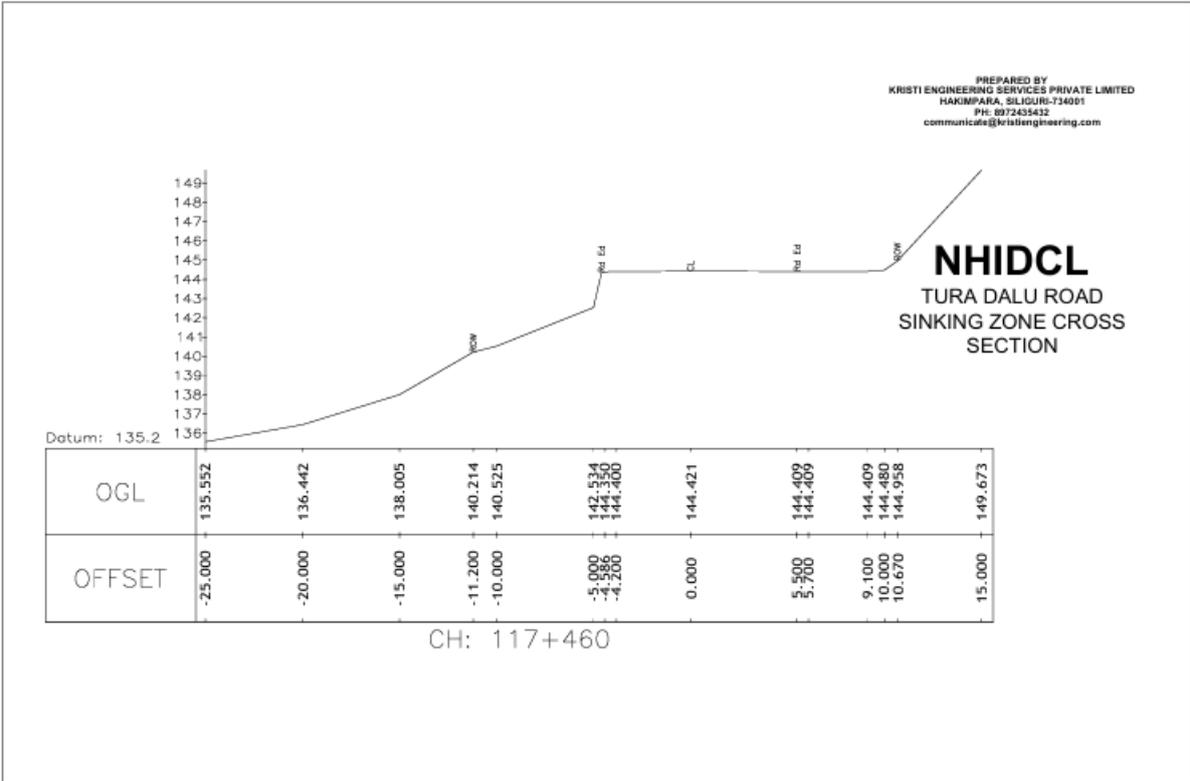
W-4.6

Area- 350

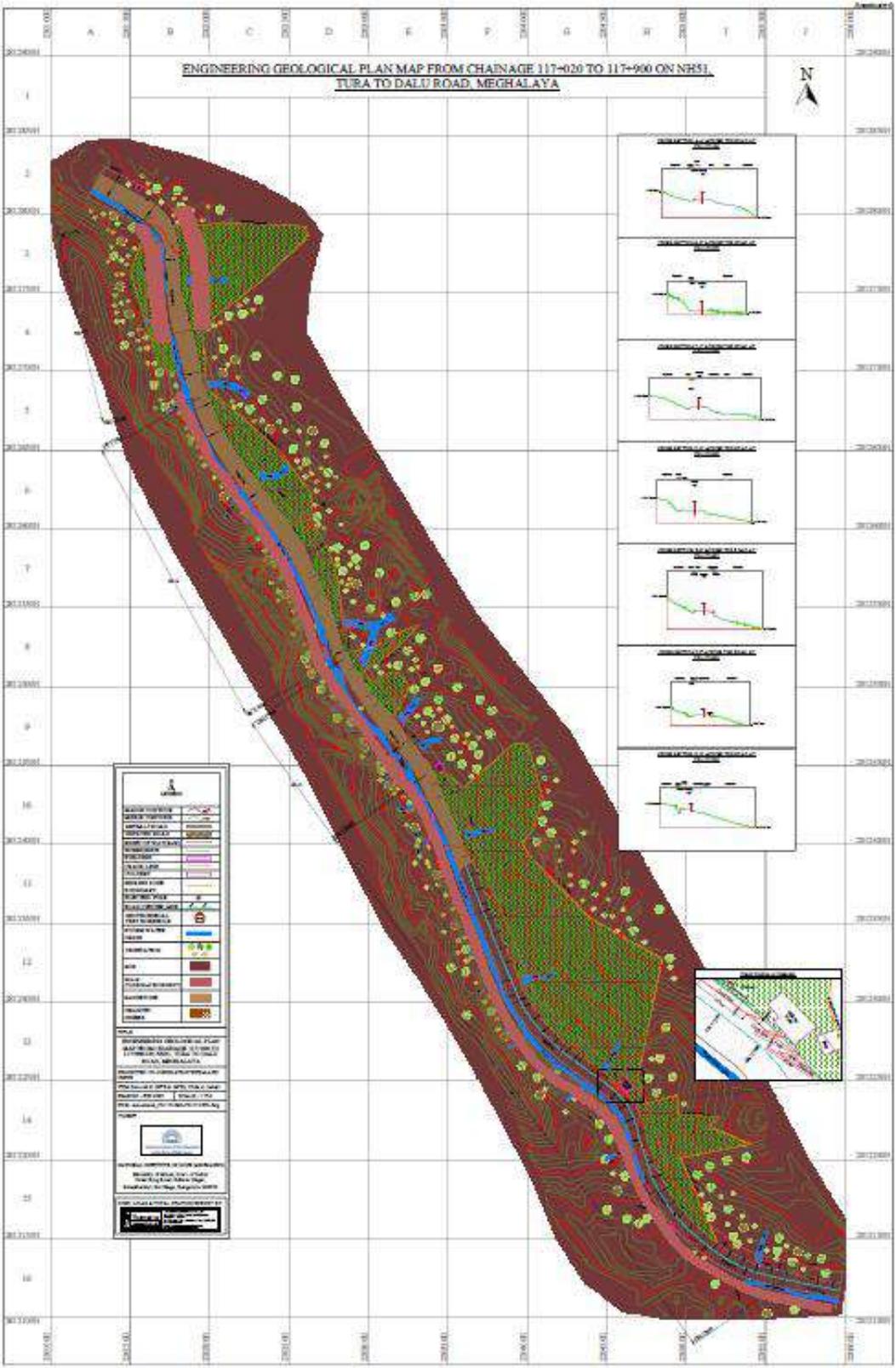
Fill vol- 1610

2. Plantation





**ENGINEERING GEOLOGICAL PLAN MAP FROM CHAINAGE 117+020 TO 117+900 ON NH51,
TURA TO DALU ROAD, MEGHALAYA**



LEGEND	
	Survey Station
	Road
	Contour Line
	Soil Type
	Rock Formation
	Fault
	Water Body
	Boundary
	Spot Height
	Proposed Road
	Existing Road
	Drainage Channel
	Erosion Gully
	Rock Outcrop
	Soil Profile
	Geological Boundary
	Fault Line
	Water Course
	Boundary Line
	Spot Height
	Proposed Road
	Existing Road
	Drainage Channel
	Erosion Gully
	Rock Outcrop
	Soil Profile
	Geological Boundary
	Fault Line
	Water Course
	Boundary Line
	Spot Height
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	Drainage Channel
	Erosion Gully
	Rock Outcrop
	Soil Profile
	Geological Boundary
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	Spot Height
	Proposed Road
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	Drainage Channel
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	Erosion Gully
	Rock Outcrop
	Soil Profile
	Geological Boundary
	Fault Line
	Water Course
	Boundary Line
	Spot Height
	Proposed Road
	Existing Road
	Drainage Channel
	Erosion Gully
	Rock Outcrop
	Soil Profile



Fig. 27: Ground subsidence (sinking zone) near Ch 117+390 km, which may impact road stability. Culvert is separated and moved away near Ch 117+345 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (117+460) to (117+870)

Length – 410 m

Height – 4.0 m

Proposed Solution:

1. MSE Wall (4m ht) in 40 m (km 117.460 to km 117.500).

L-40

H-4

W-4.2

Area- 160

Fill vol- 672

2. MSE Wall (4m ht) in 120 m (km 117.660 to km 117.780).

L-120

H-4

W-4.2

Area- 480

Fill vol- 2016

3. MSE Wall (4m ht) in 30 m (km 117.840 to km 117.870).

L-30

H-4

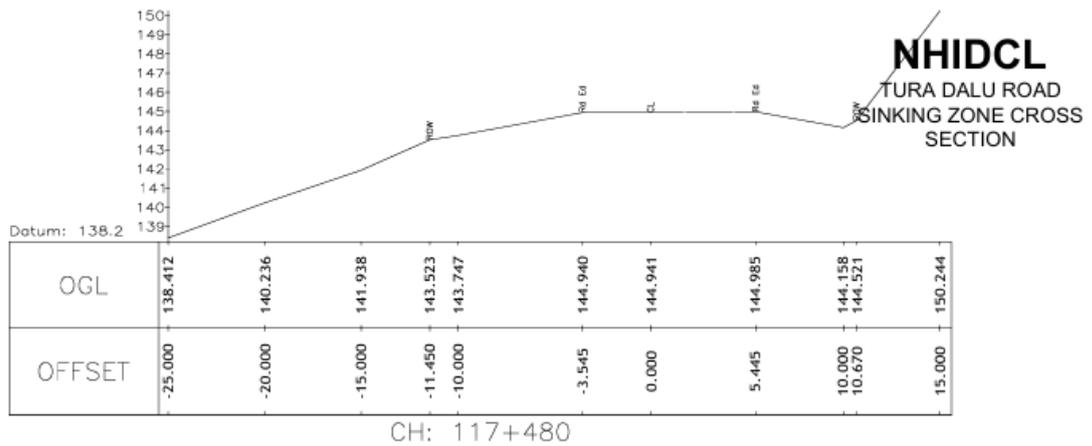
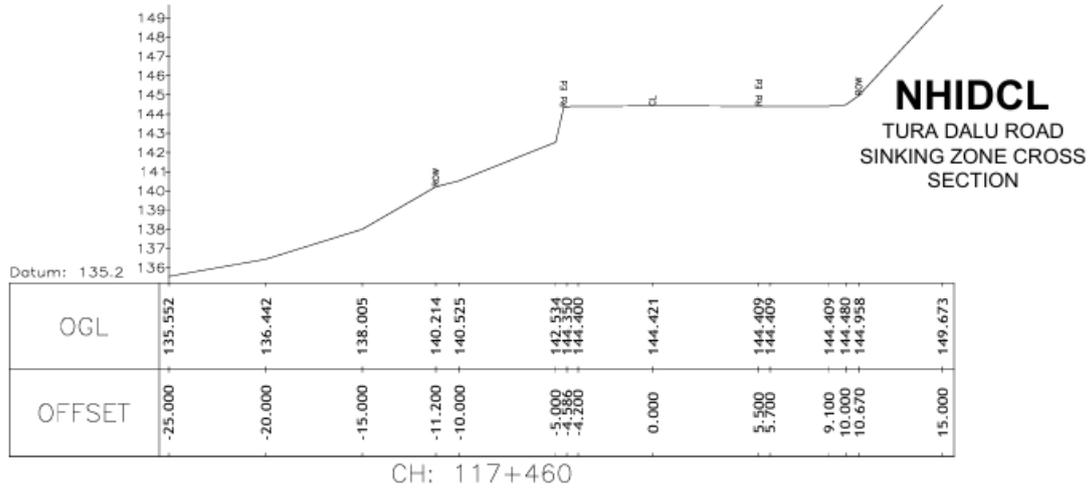
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Area- 120

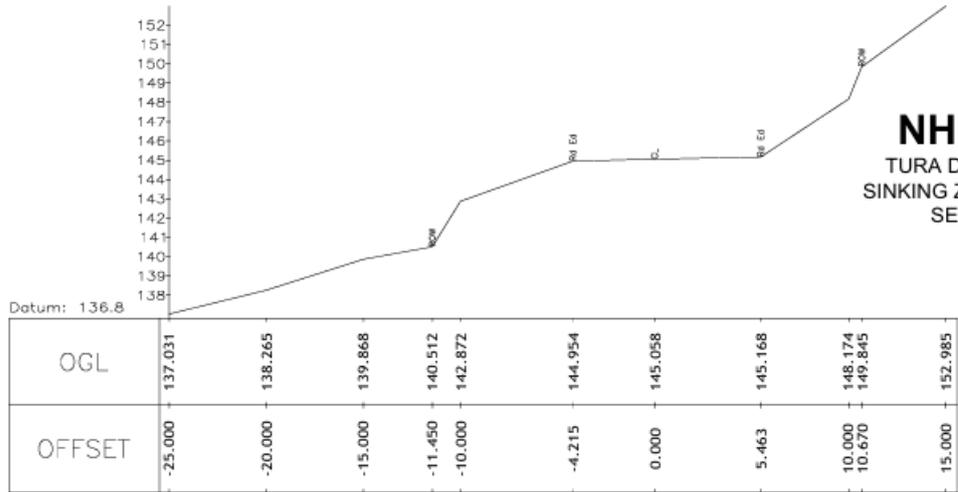
Fill vol- 504

4. Gabion Retaining Wall (4m ht) with perforated pipe in 160 m (km 117.500 to km 117.660)

5. Plantation



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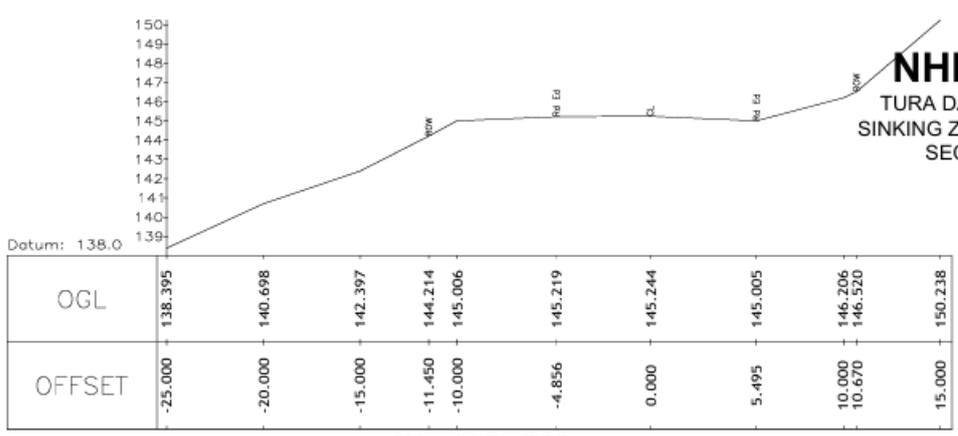


CH: 117+500

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SINKING ZONE CROSS
SECTION

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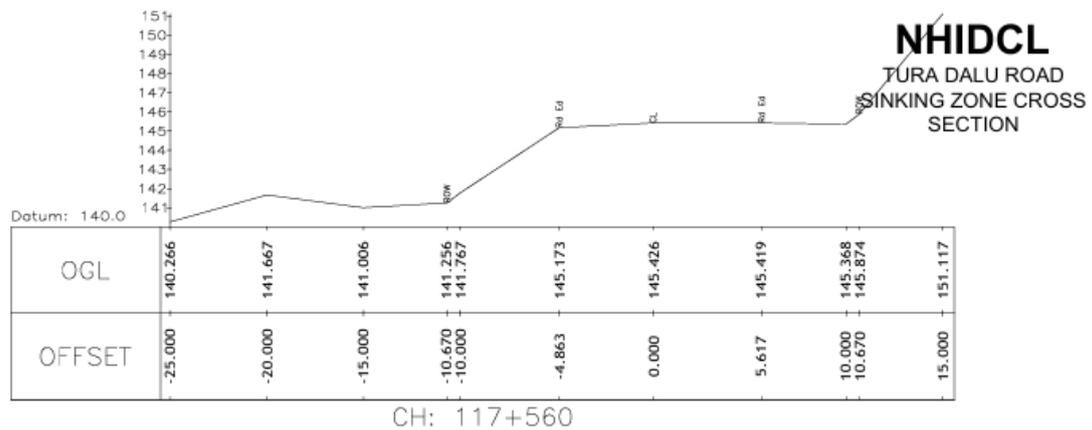
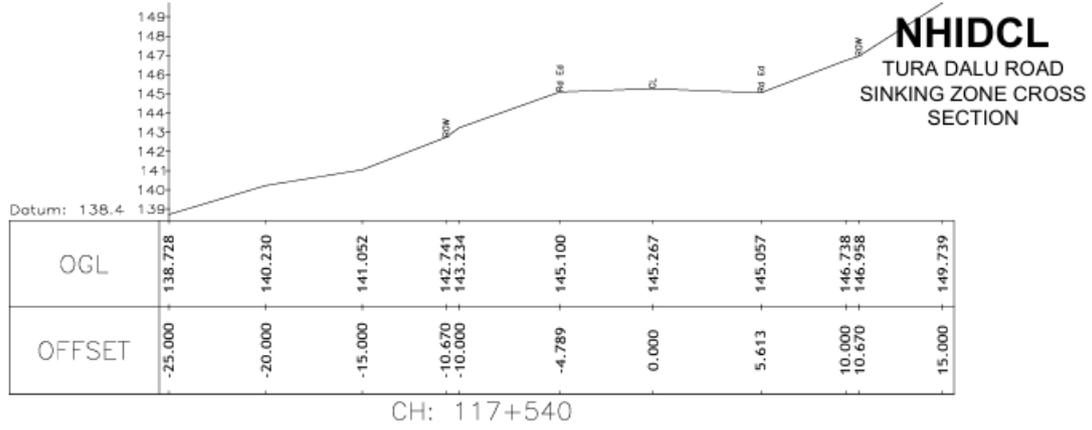
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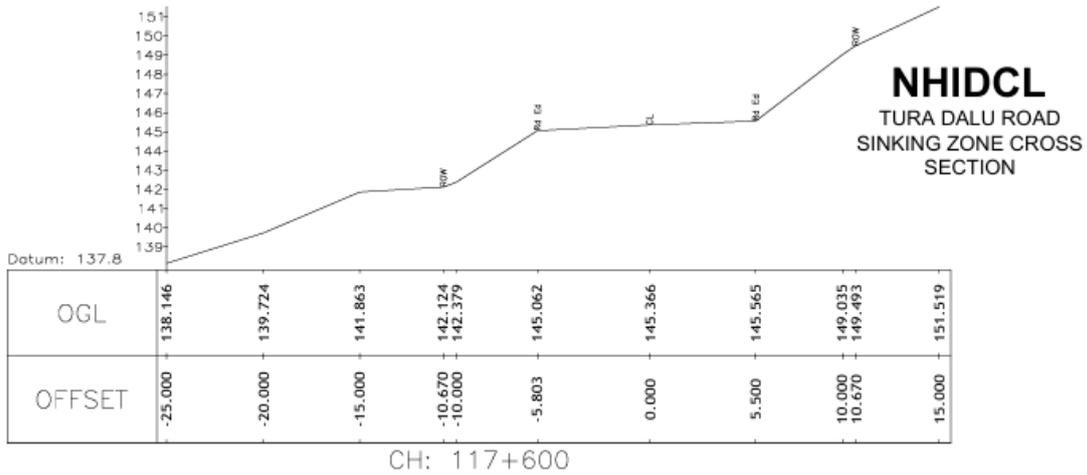
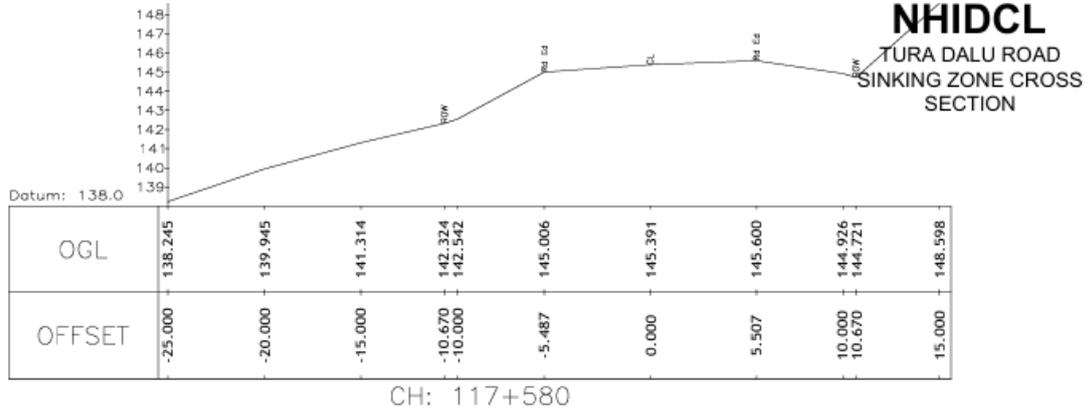


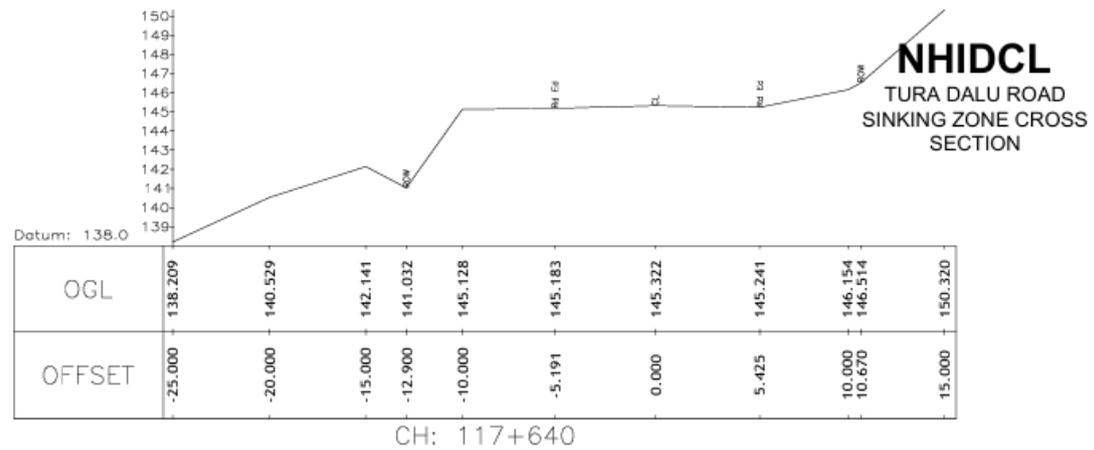
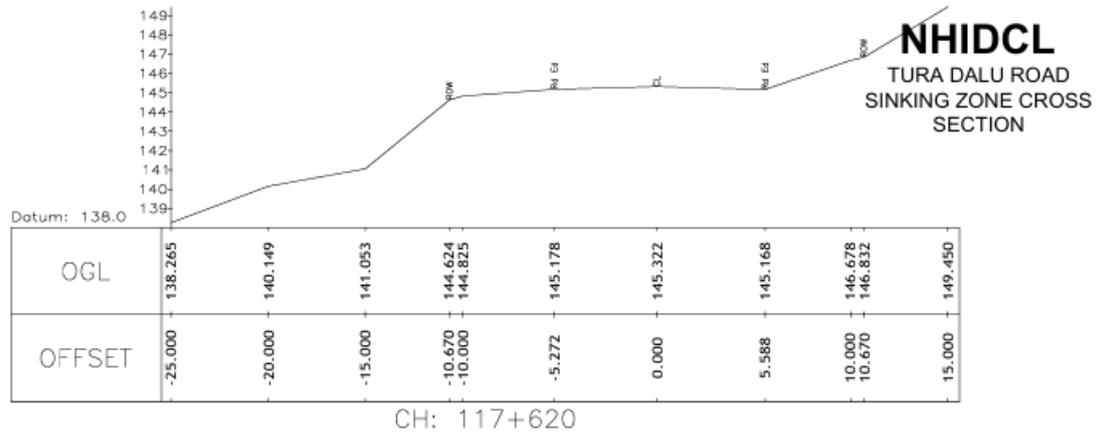
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TURA DALU ROAD
SINKING ZONE CROSS
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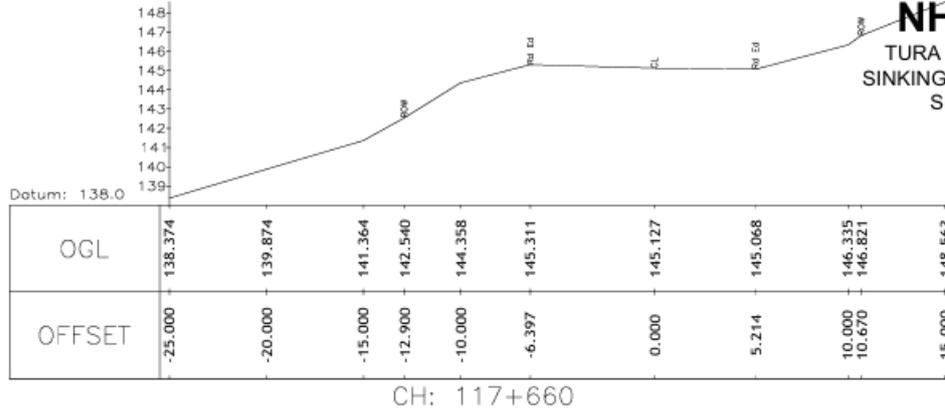
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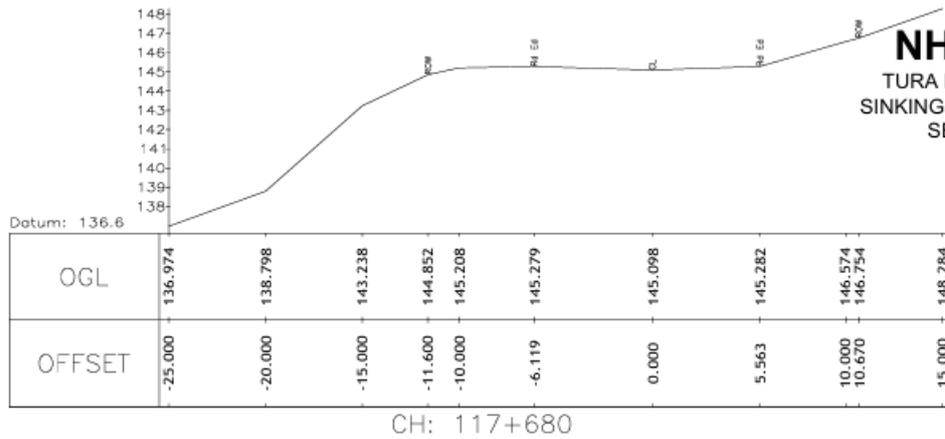


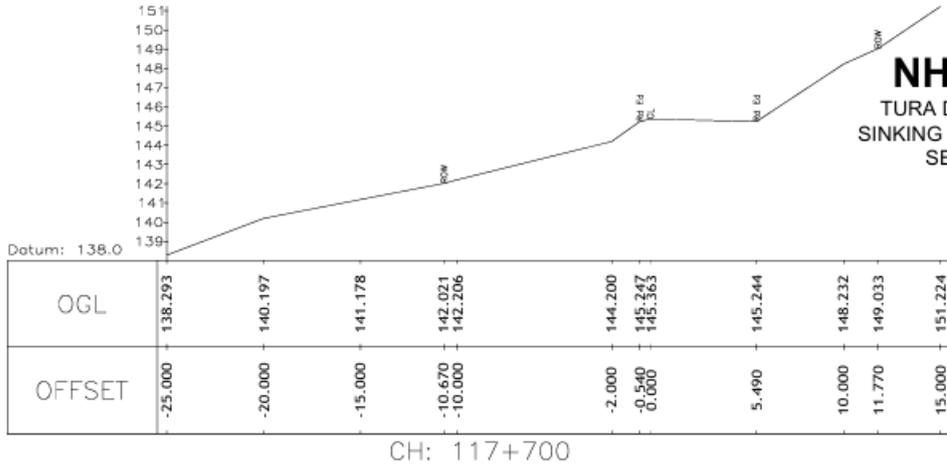


NHIDCL
 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION

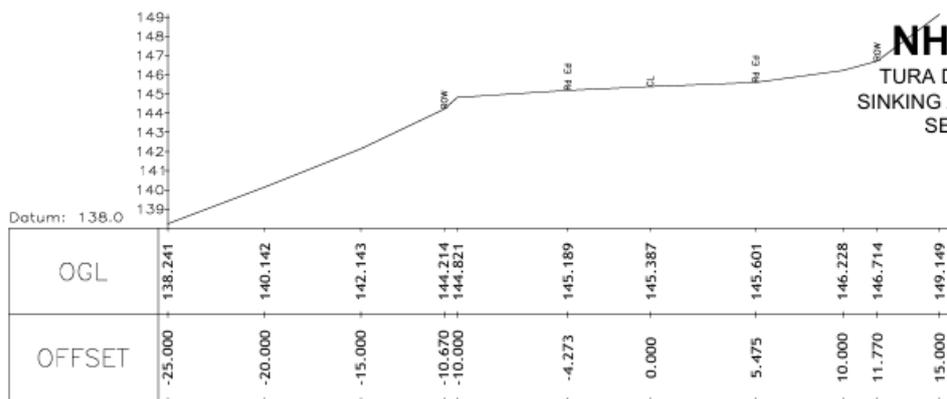


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 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION



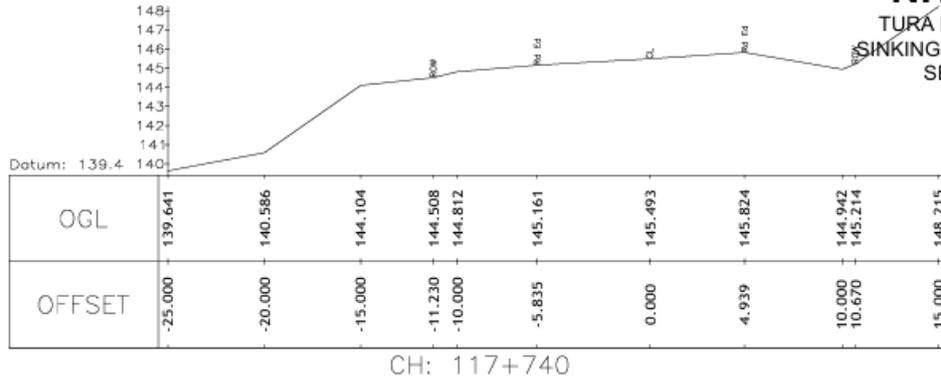


CH: 117+700

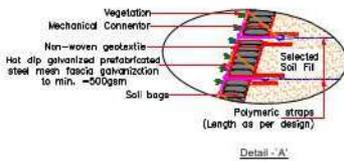


CH: 117+720

NHIDCL TURA DALU ROAD SINKING ZONE CROSS SECTION



Chainage from (117+460) to (117+870); Height - 3.0 m



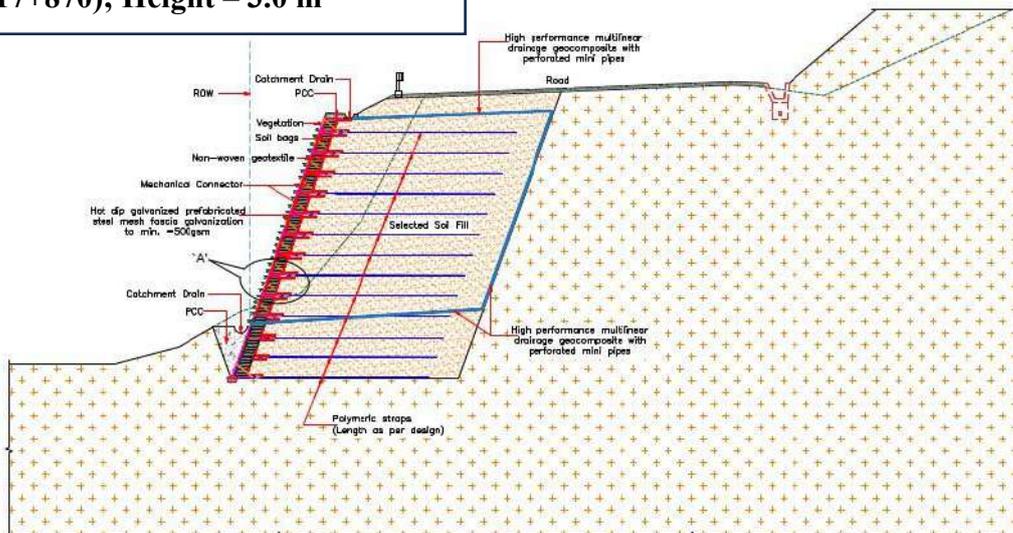
High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	g/sqm
		Mass per unit area total mass (geotextile+mini pipe)	612	
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
Tensile Strength	NF EN ISO 10319	Machine Direction	24	kN/m
		Cross Direction	24	

Polymeric Straps :- Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE)

Polymeric Straps Specification											
Properties	Test Method	Unit	Minimum average rol value								
Ultimate Tensile Strength	Indian or International standard	kN	25	30	40	50	60	70	80	90	100
Width		mm	49.5	49.5	49.5	49.5	49.5	49.5	49.5	49.5	49.5

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B500c and hot dip galvanized to minimum 50gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.



Typical Cross Section with Mechanically Stabilization Earth Slope



Fig. 28: Separation of the road with adjacent ground due to erosion along the roadside may lead to pavement failure due to insufficient lateral confinement at Ch 117+595 km

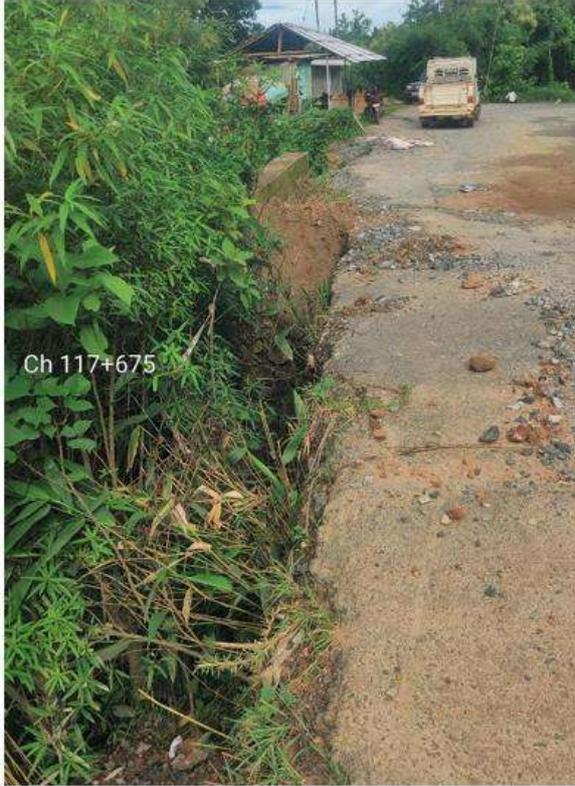


Fig. 29: Erosion along the roadside has caused separation between the road and adjacent ground, reducing lateral confinement. This lack of support can result in cracking or collapse of the pavement structure near the areas of Ch 117+650 and 117+675 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (117+870) to (117+945)

Length – 75 m

Height – 3.0 m

Proposed Solution:

1. Mechanically stabilised Earth wall (height of MSE wall to be 5m as per site verification)

L-75

H-3

W-4

Area- 225

Fill vol- 900

2. Paved Shoulders

3. Plantation

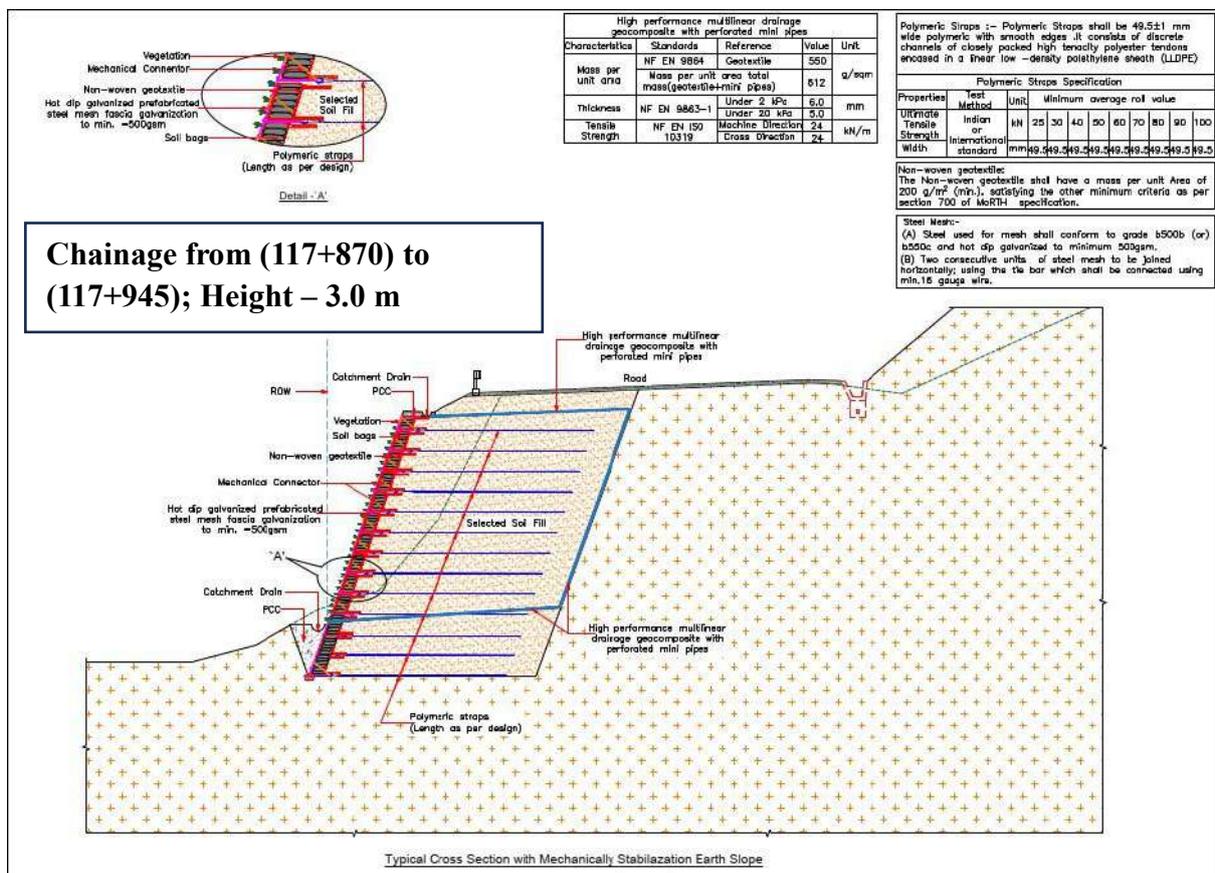




Fig. 30: Longitudinal crack appeared at the joint between the pavement and the shoulder close to Ch 117+920 km.



Fig. 31: Right-side portion of the road pavement failed and collapsed near Ch 117+843 km.

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

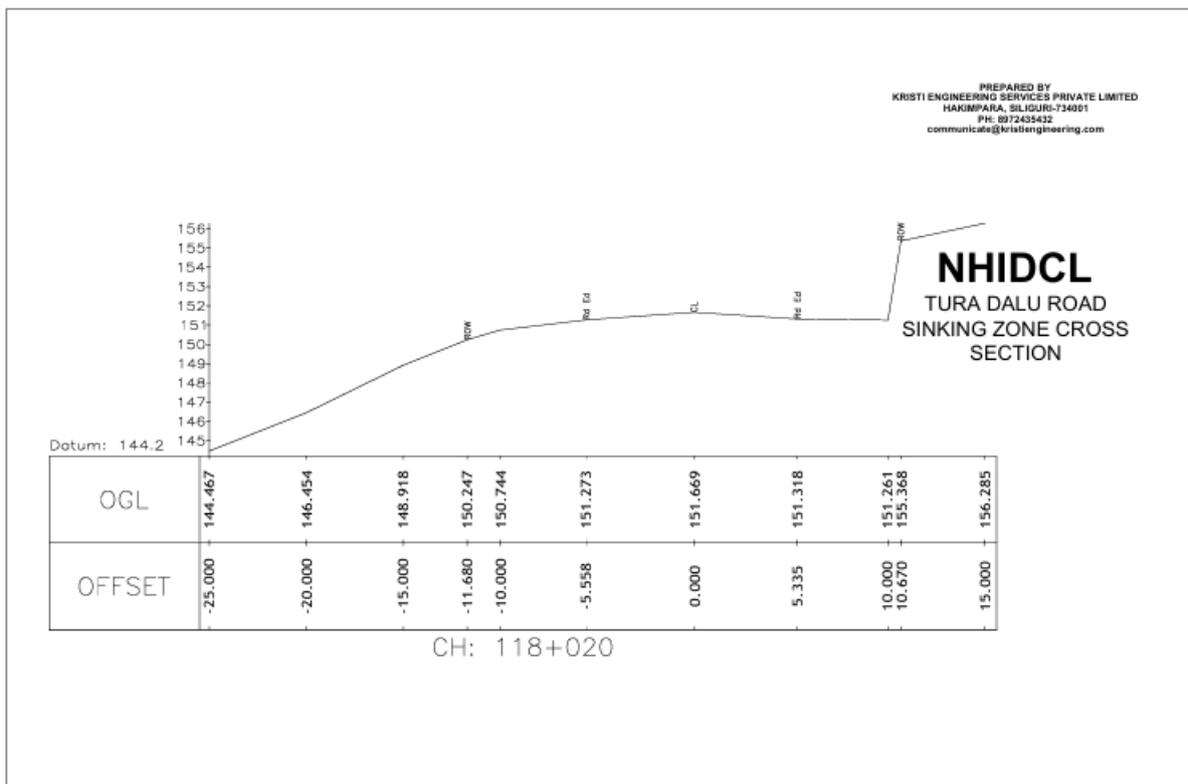
Chainage from (118+000) to (118+290)

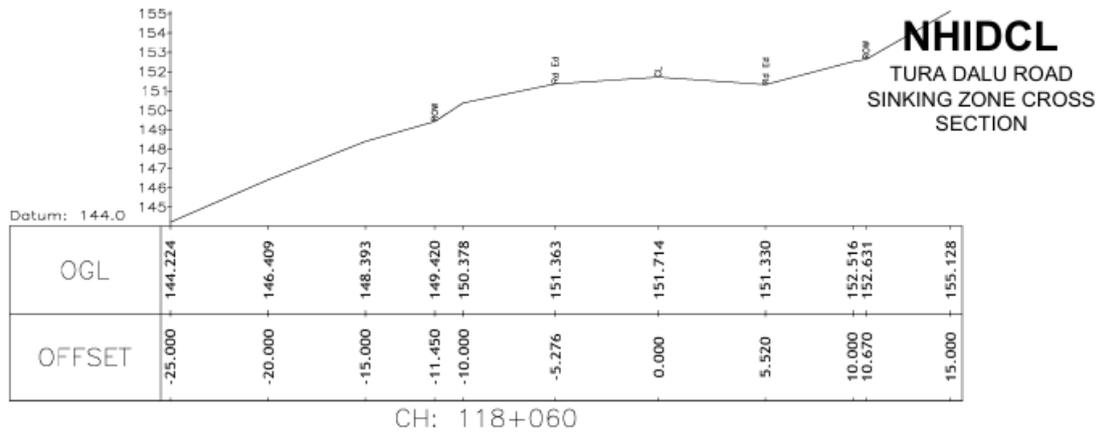
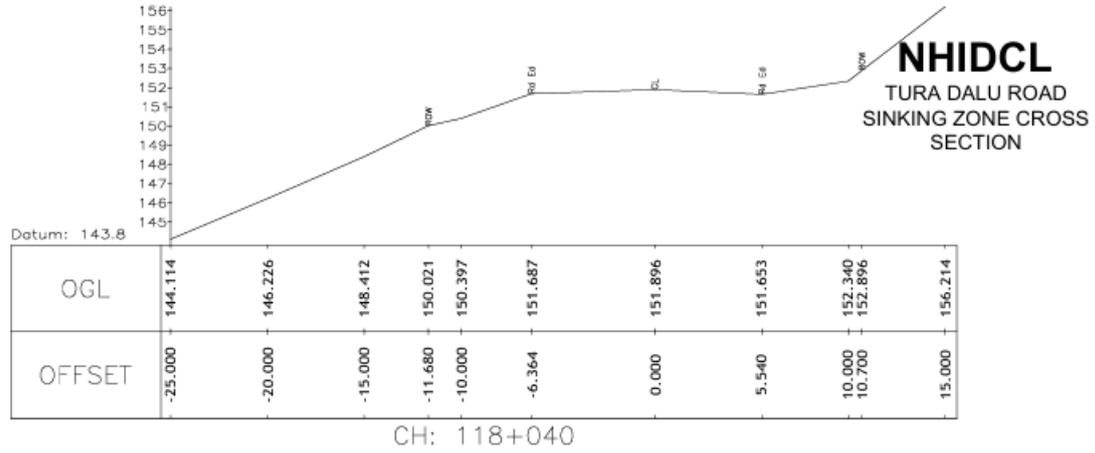
Length – 290 m

Height – 8.0 m

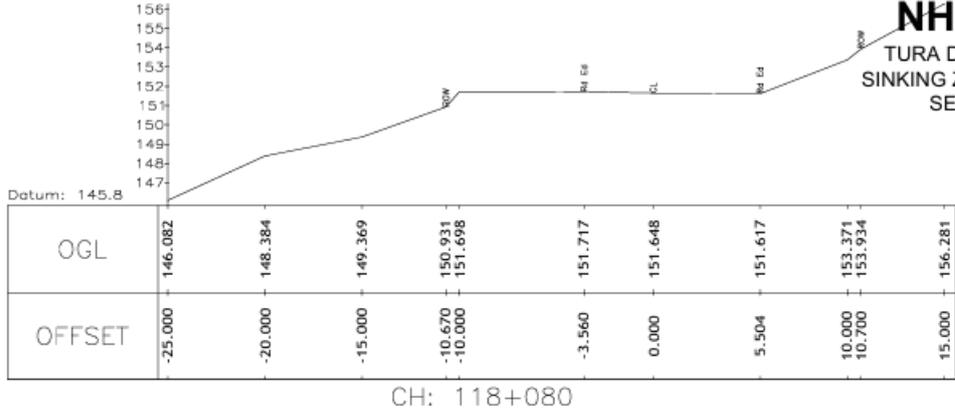
Proposed Solution:

1. Gabion Retaining Wall (2m ht) with perforated pipe in 230 m (km 118.000 to km 118.230)
2. MSE Wall (3m ht) in 60 m (km 118.230 to km 118.290).
3. Paved Shoulders
4. Plantation

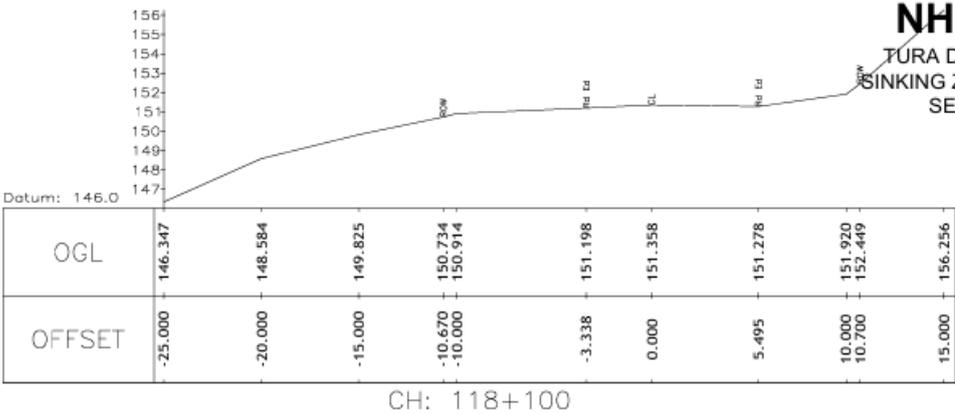




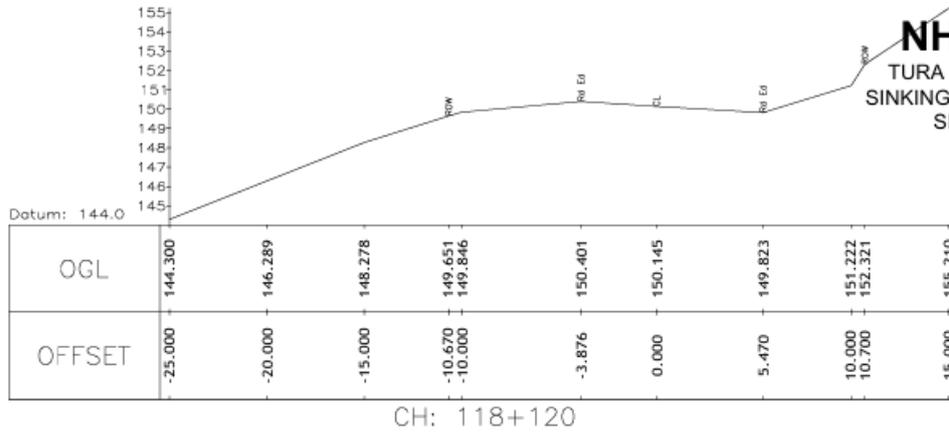
NHIDCL
 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION



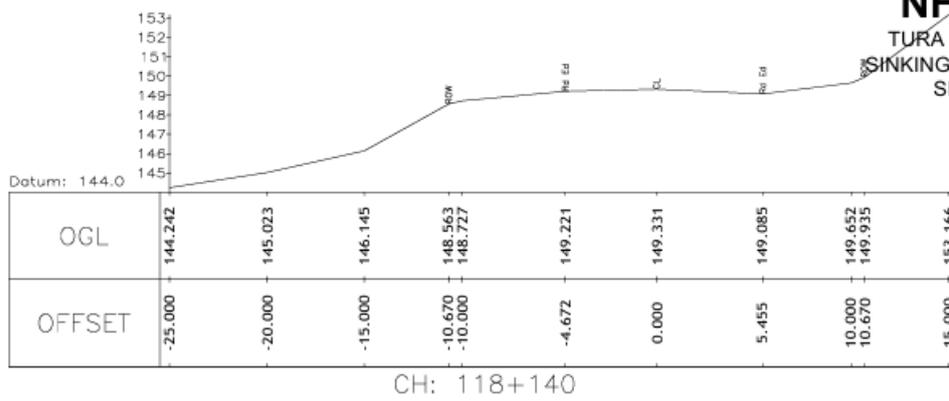
NHIDCL
 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION



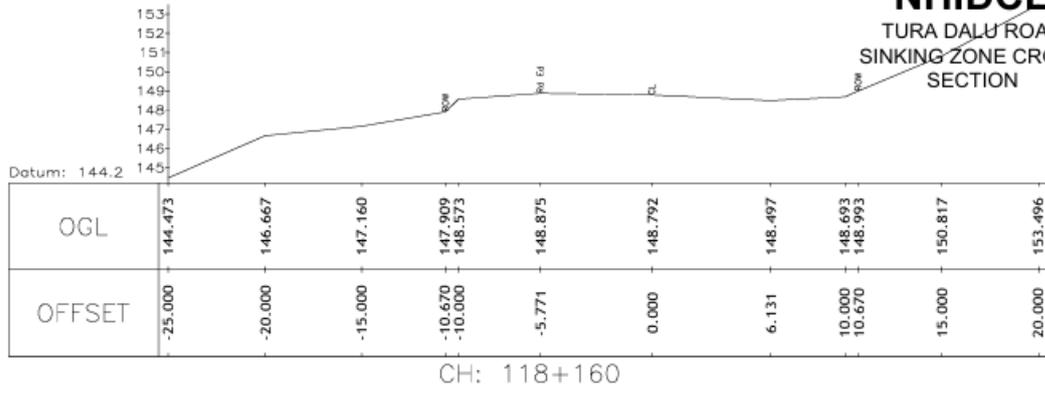
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TURA DALU ROAD
SINKING ZONE CROSS
SECTION



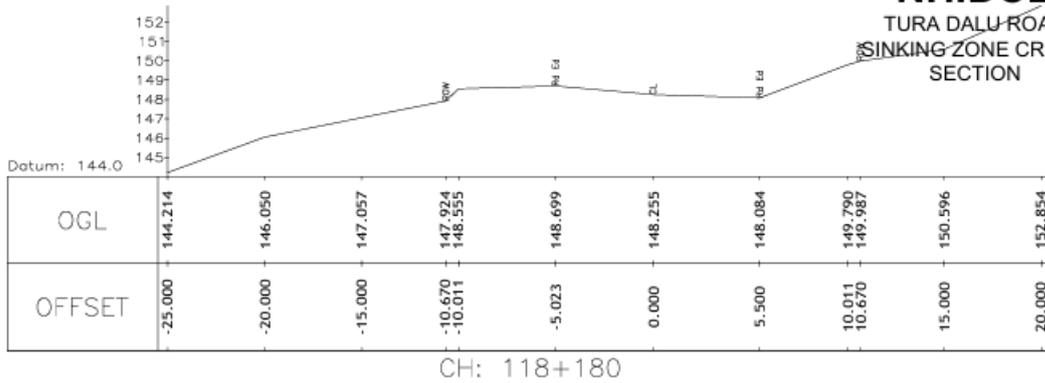
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TURA DALU ROAD
SINKING ZONE CROSS
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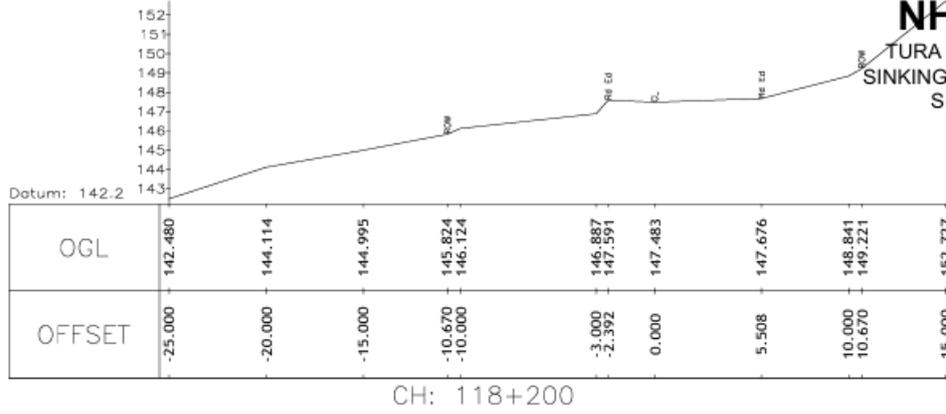
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 TURA DALU ROAD
 SINKING ZONE CROSS
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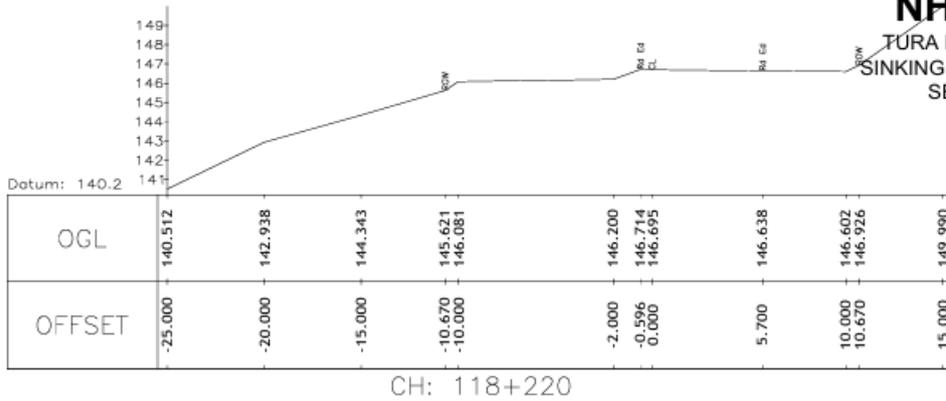
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 TURA DALU ROAD
 SINKING ZONE CROSS
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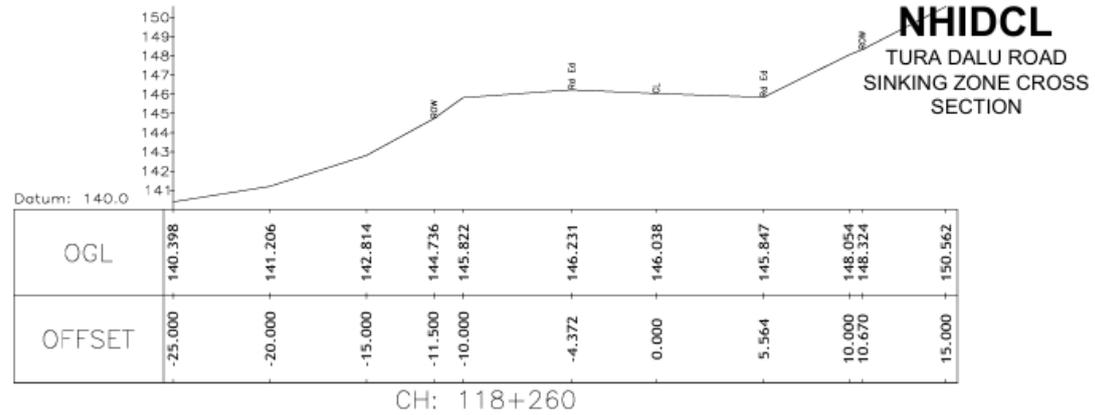
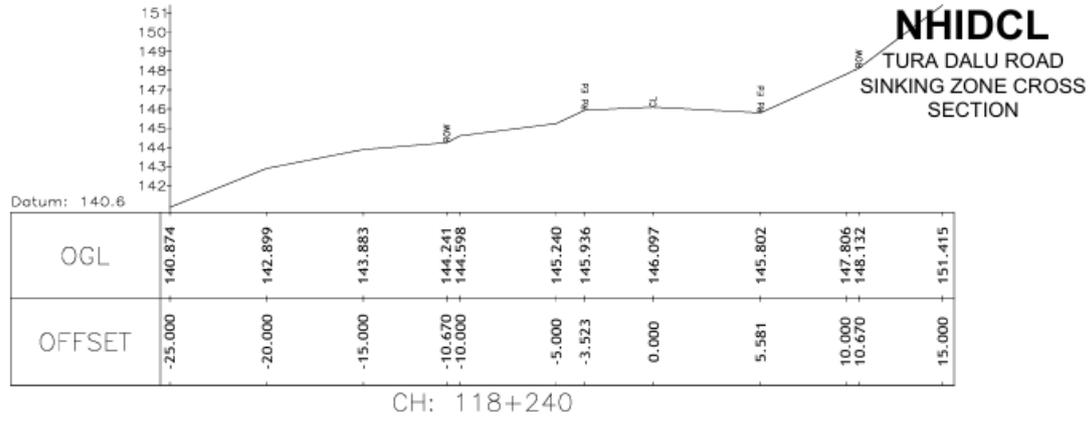


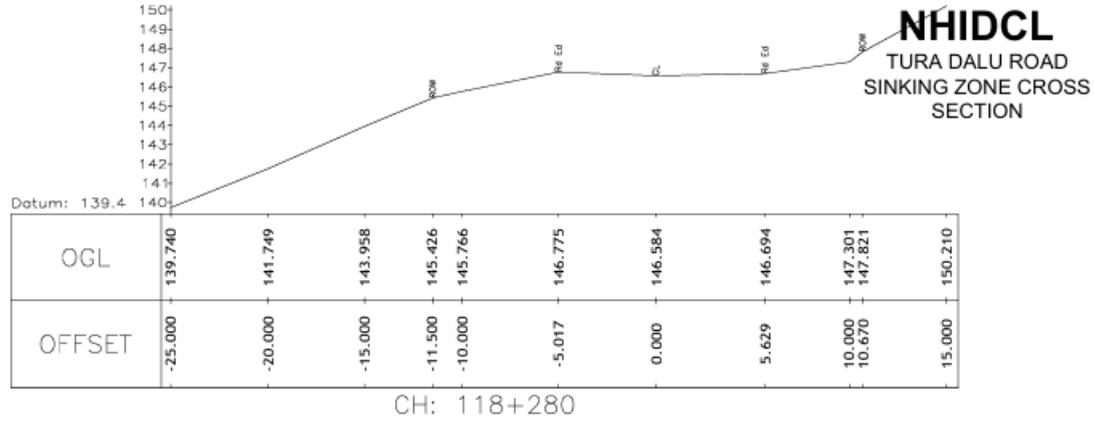
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 SINKING ZONE CROSS
 SECTION







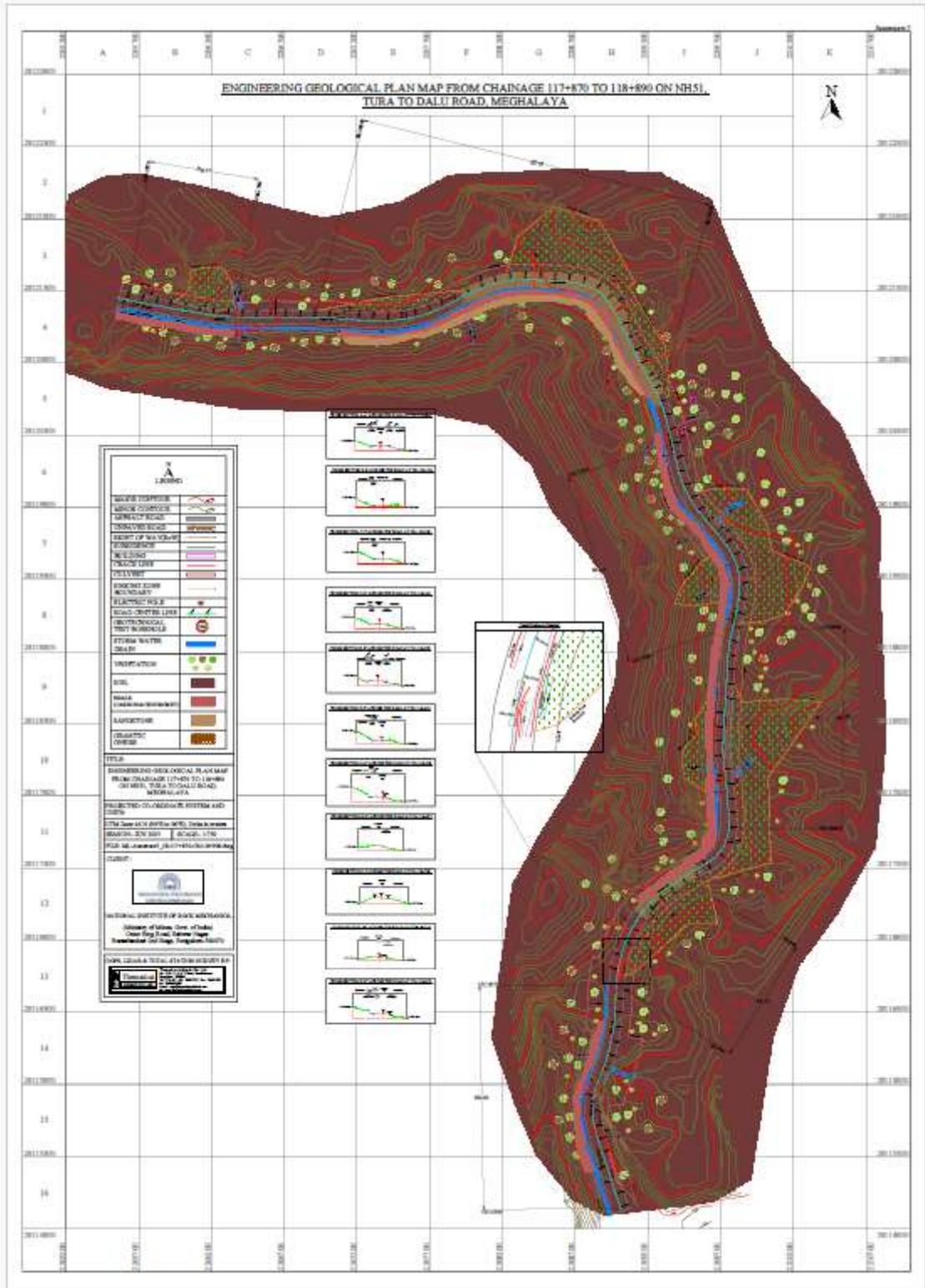




Fig. 32: View of uphill side between chainage 118+000 to 118+290 km



Fig. 33: Cracks observed in village road to Rumamgiri

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

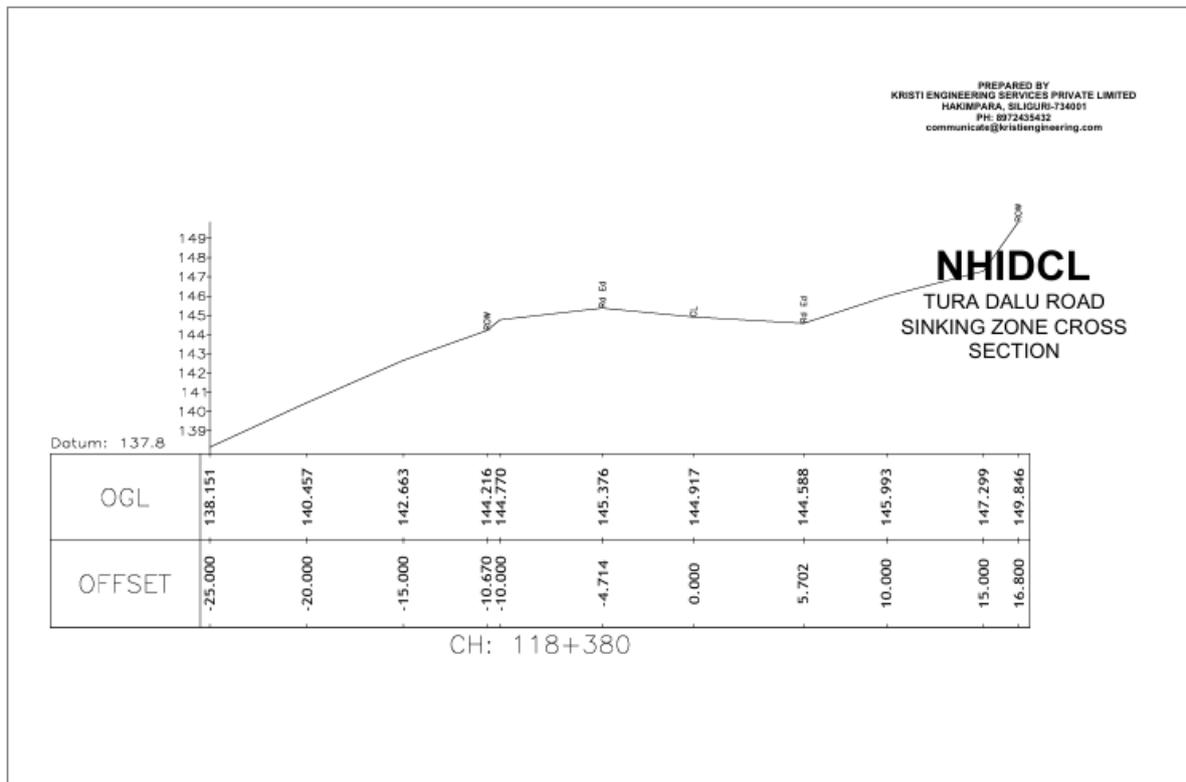
Chainage from (118+320) to (118+460)

Length – 140 m

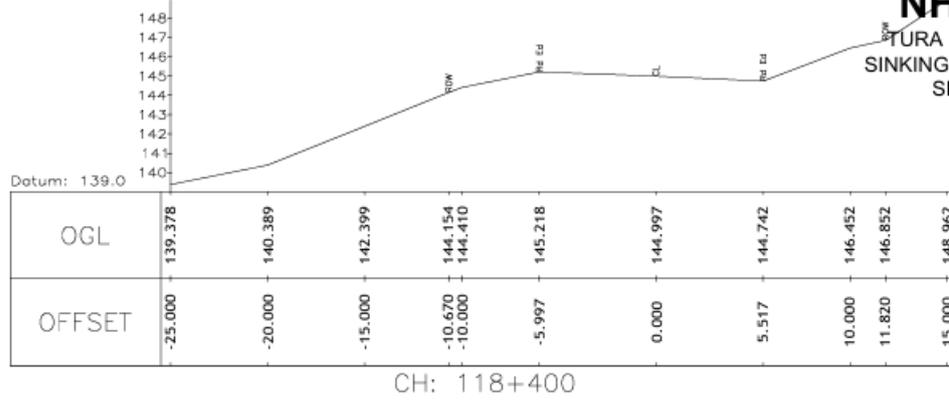
Height – 2.0 m

Proposed Solution:

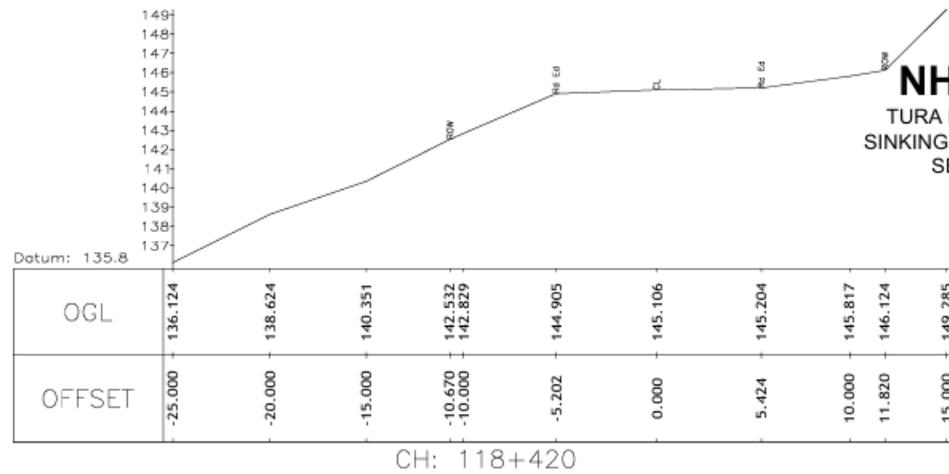
1. Gabion Retaining Wall (2m ht) with perforated pipe.
2. Paved Shoulders
3. Plantation
4. Grouting towards valley



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 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION



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 SINKING ZONE CROSS
 SECTION



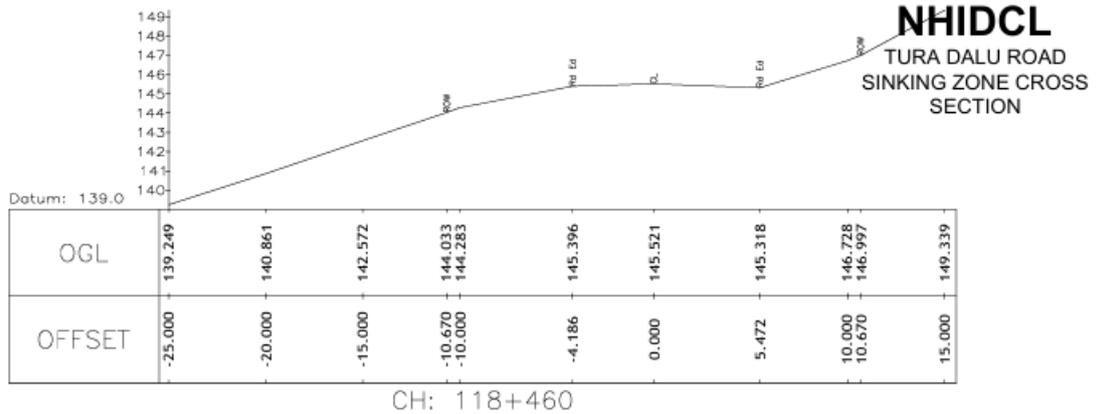
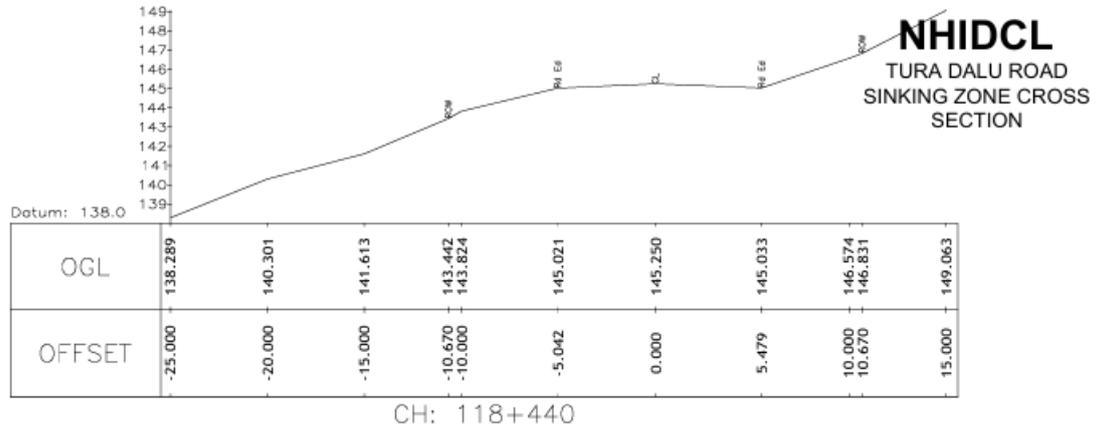




Fig. 34: View of sinking zone between Ch. 118+320 to 118+460 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (118+460) to (118+600)

Length – 140 m

Height – 5.0 m

Proposed Solution:

1. Mechanically stabilised Earth wall

L-140

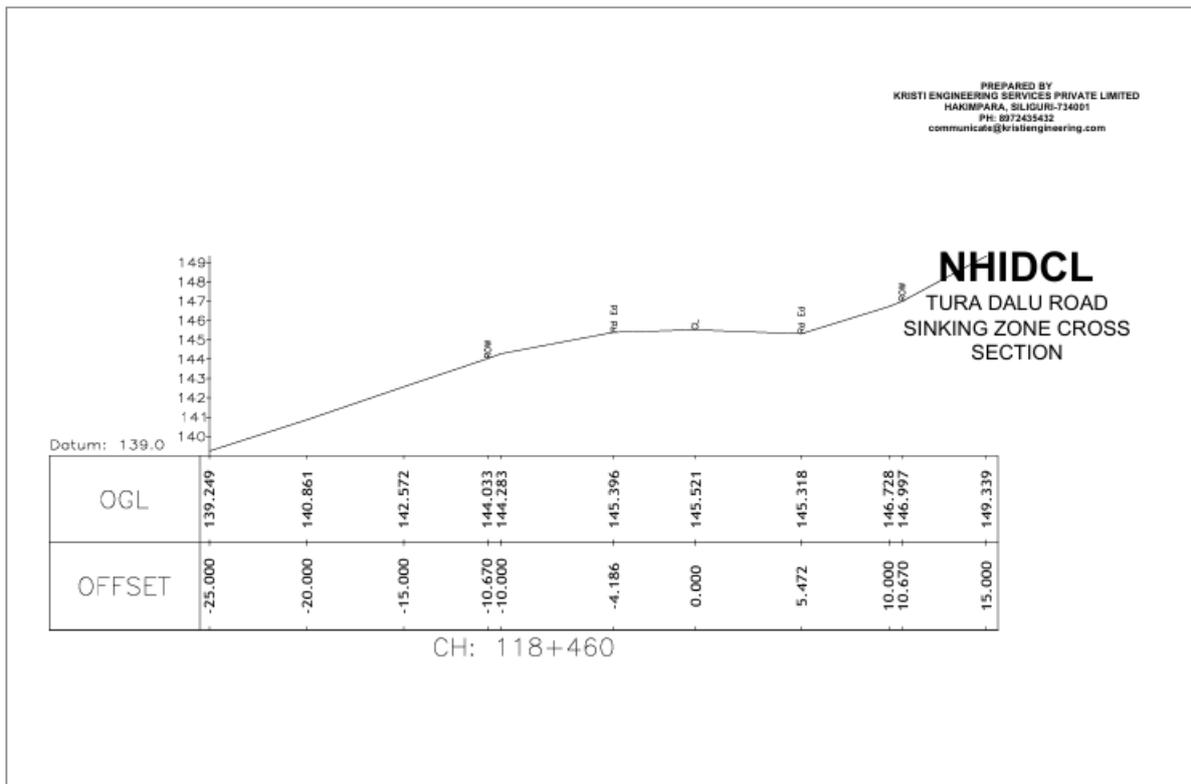
H-5

W-4.3

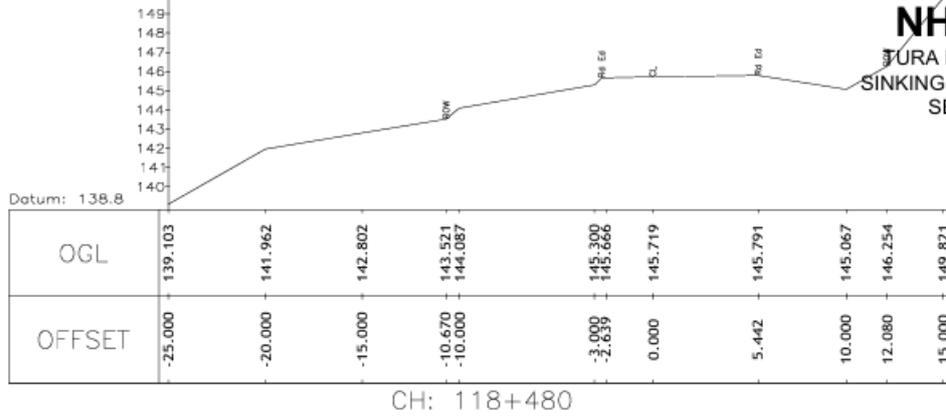
Area- 700

Fill vol- 3010

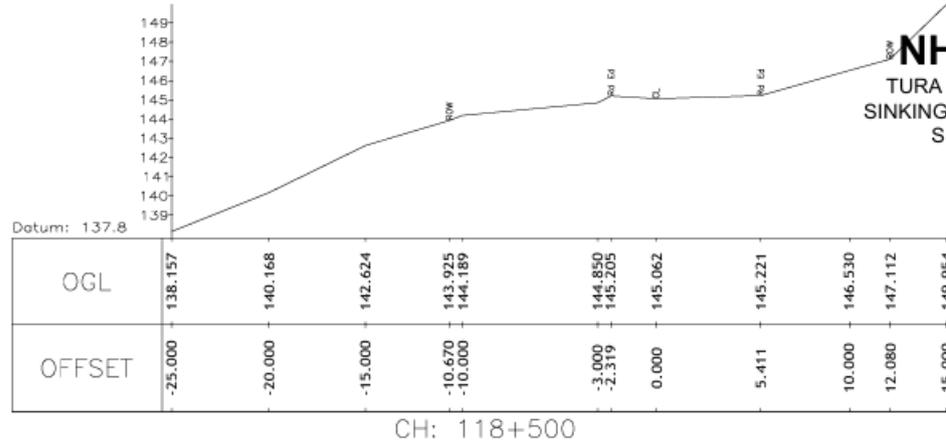
2. Paved Shoulders

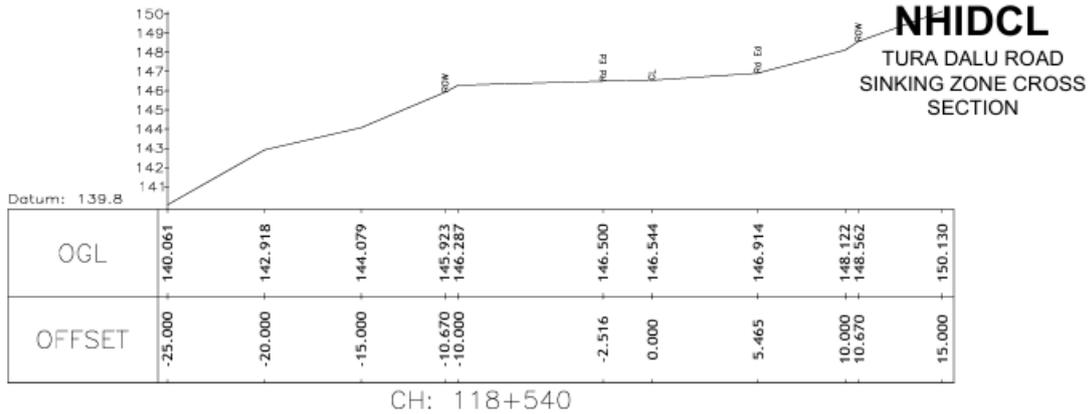
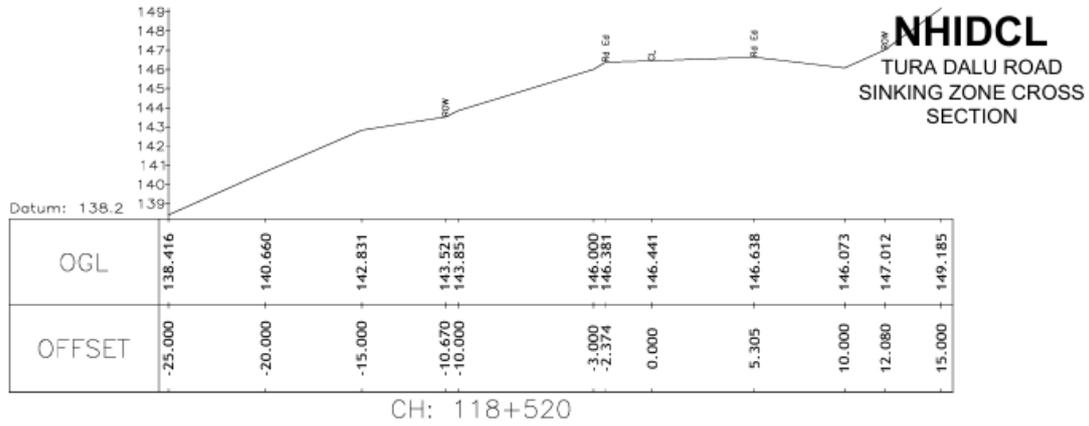


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 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION

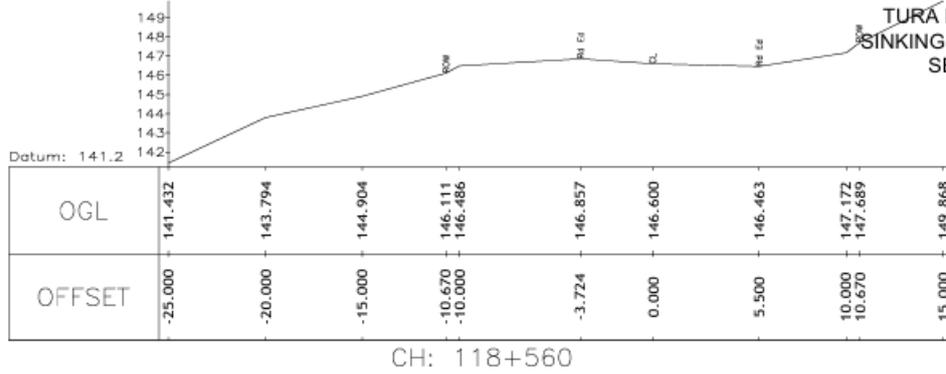


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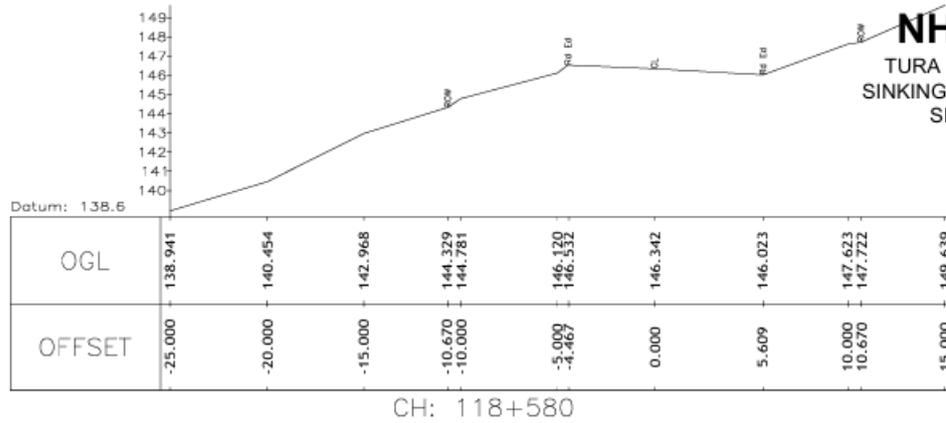


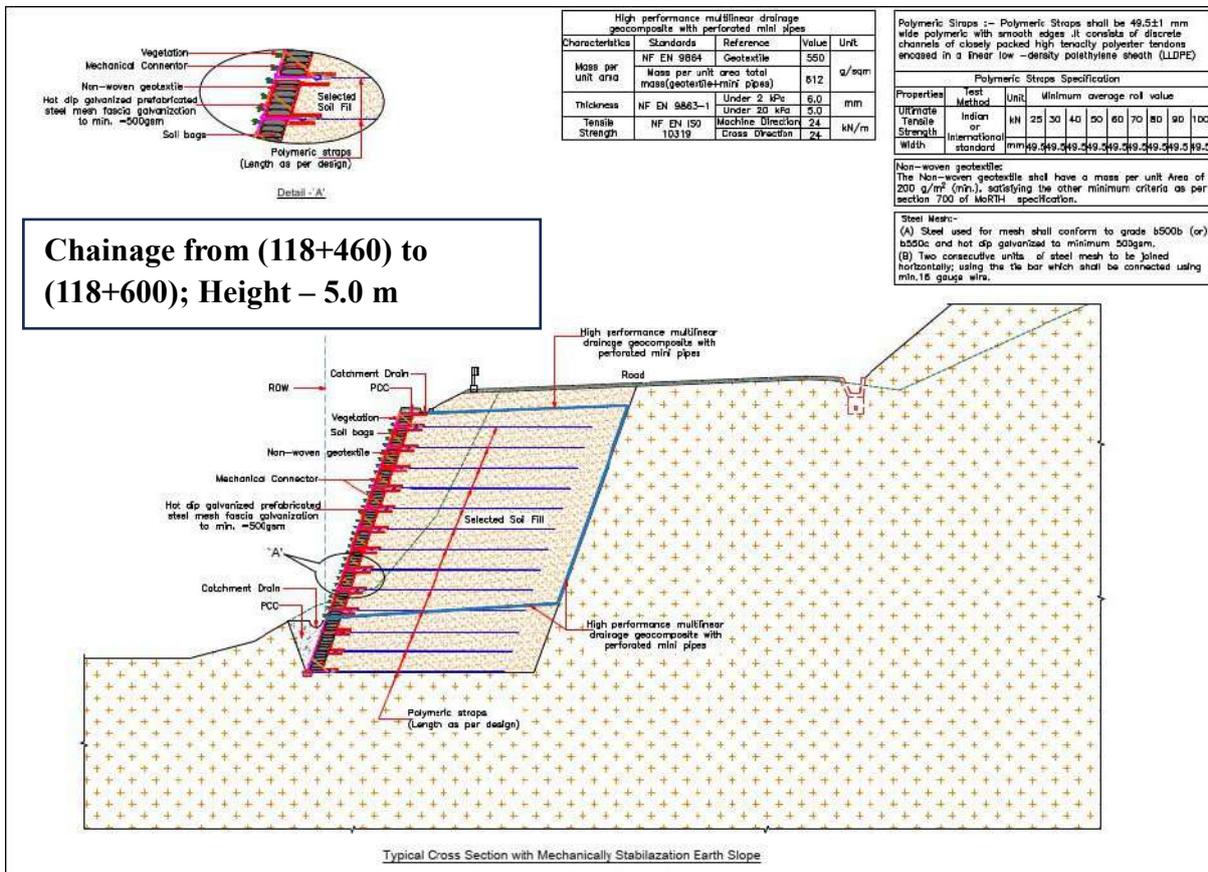
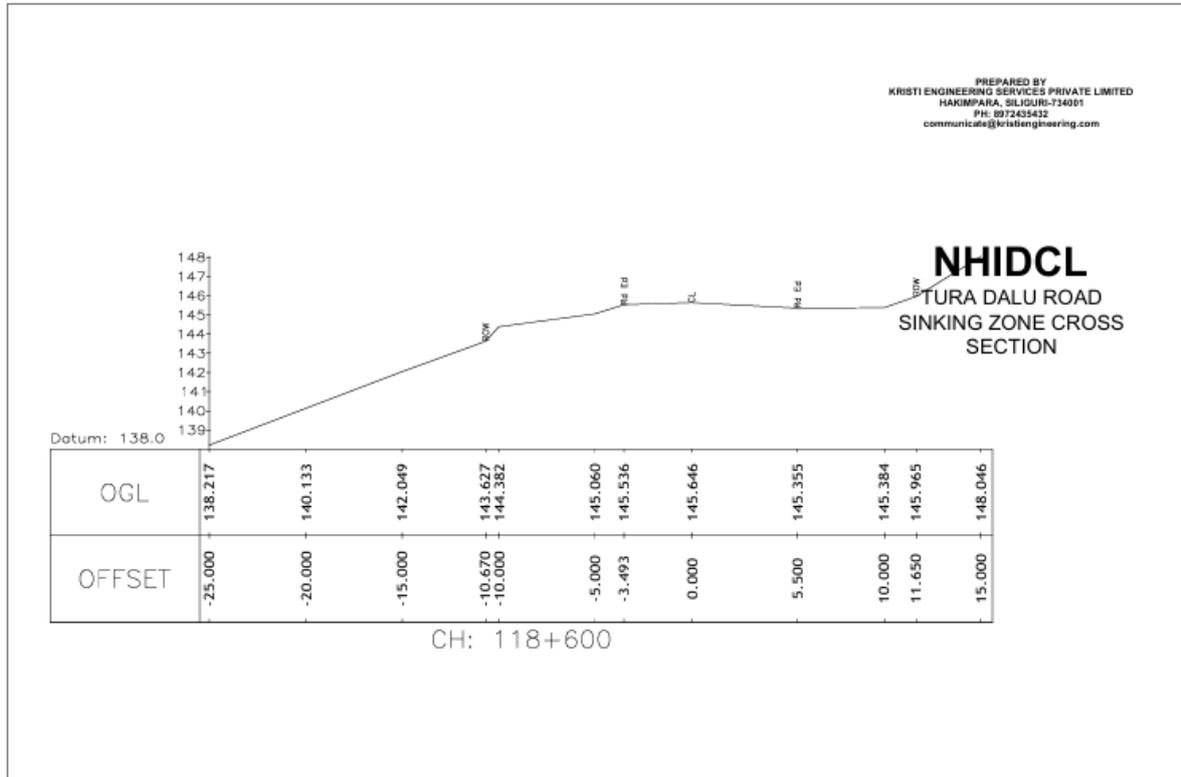


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 SINKING ZONE CROSS
 SECTION



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 SECTION





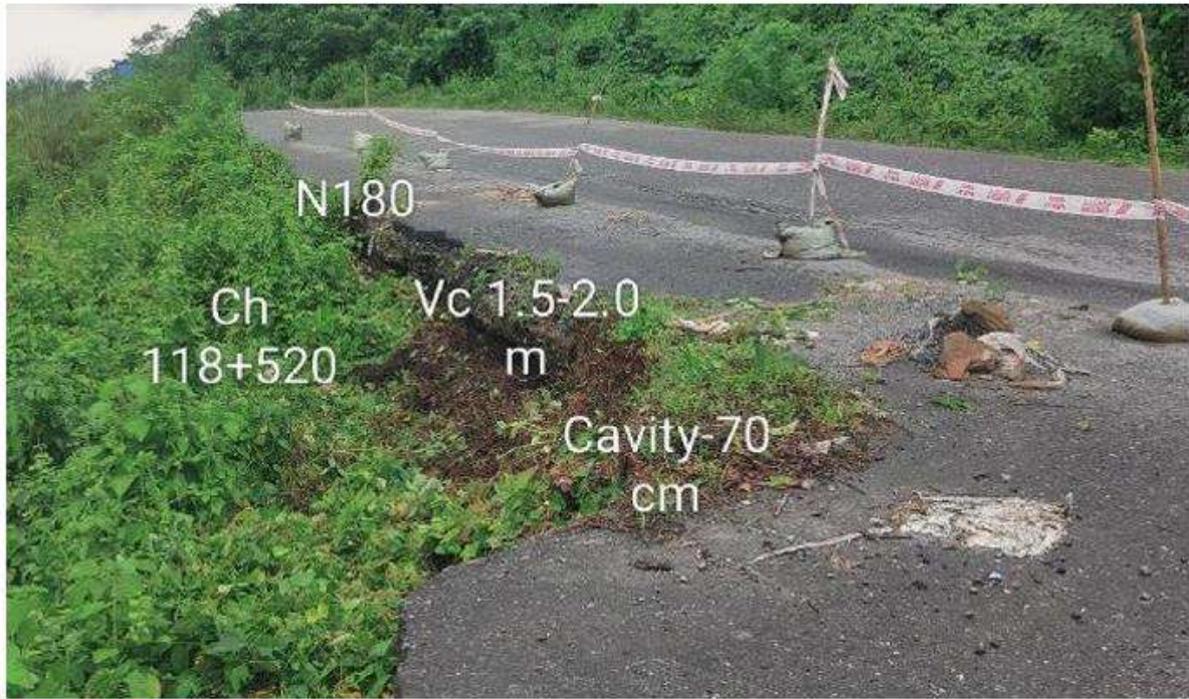


Fig. 35: View of sinking area at Ch. 118+520 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

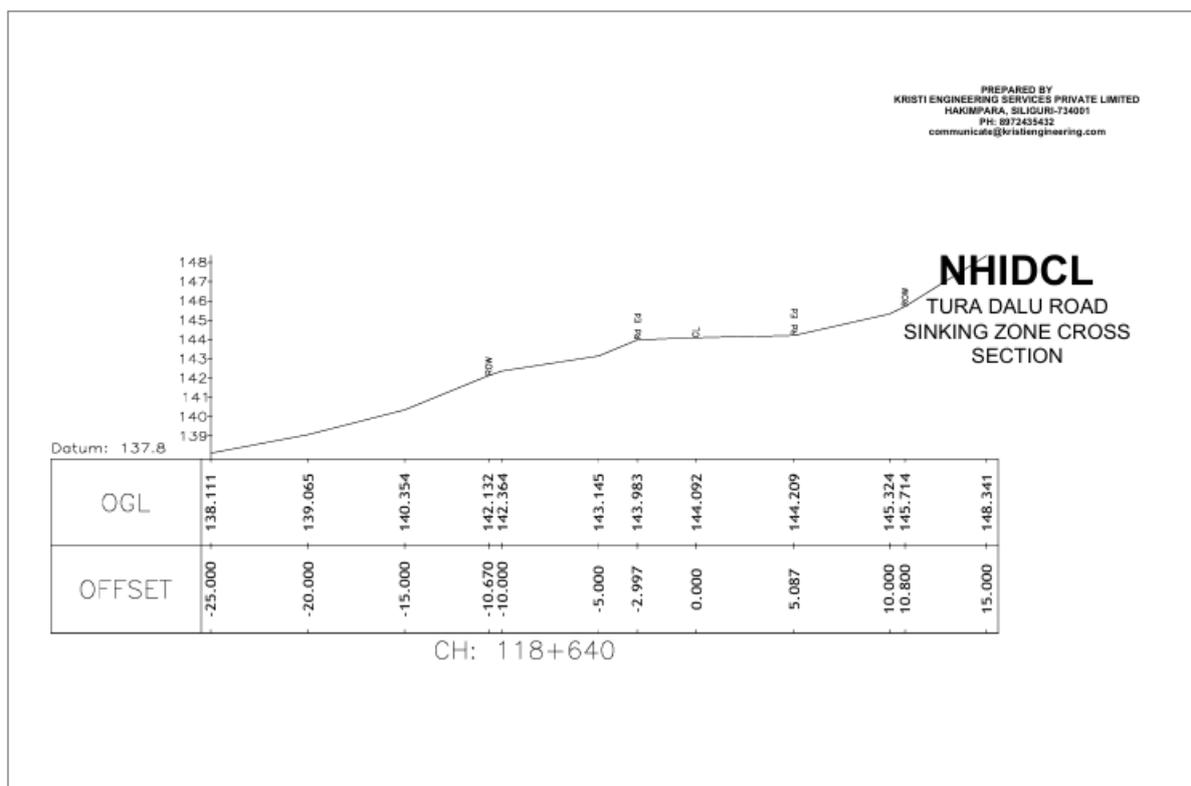
Chainage from (118+650) to (118+740)

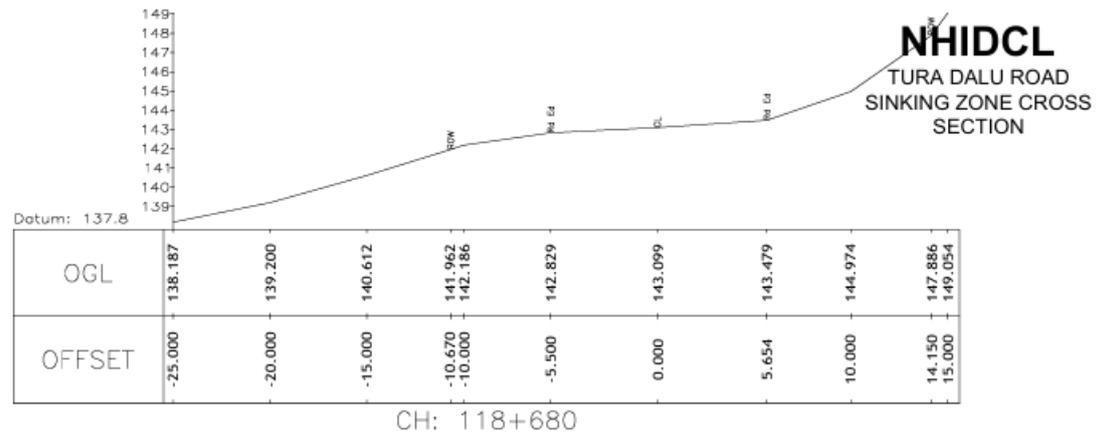
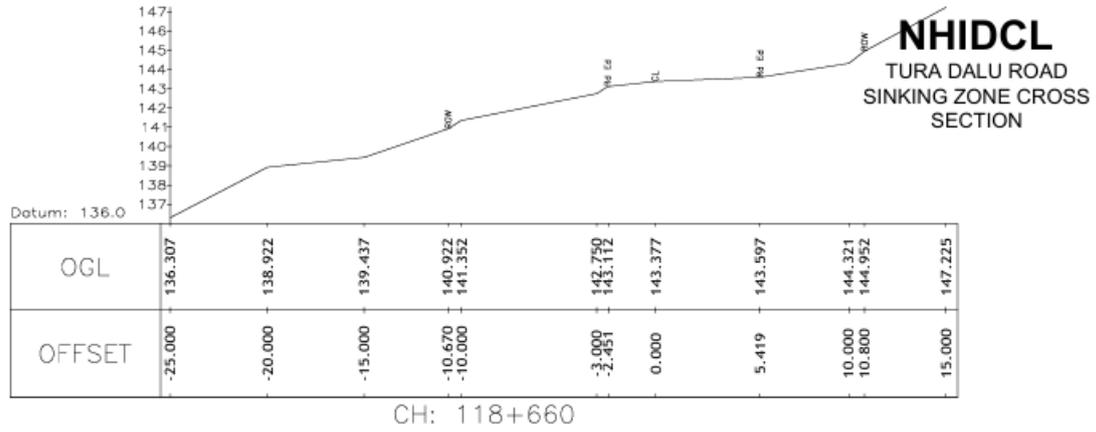
Length – 90 m

Height – 5.0 m

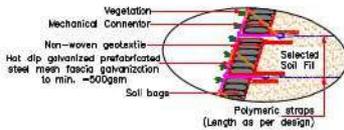
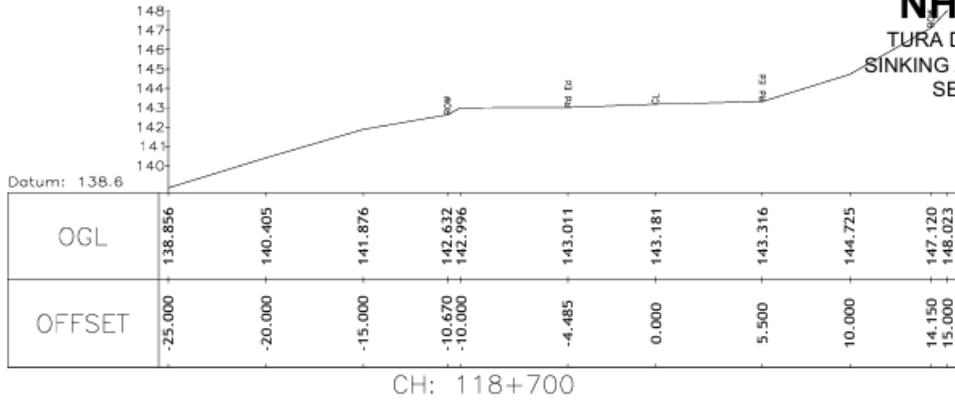
Proposed Solution:

1. Mechanically stabilised Earth wall (height of MSE wall to be 5m as per site verification)
2. Paved Shoulders



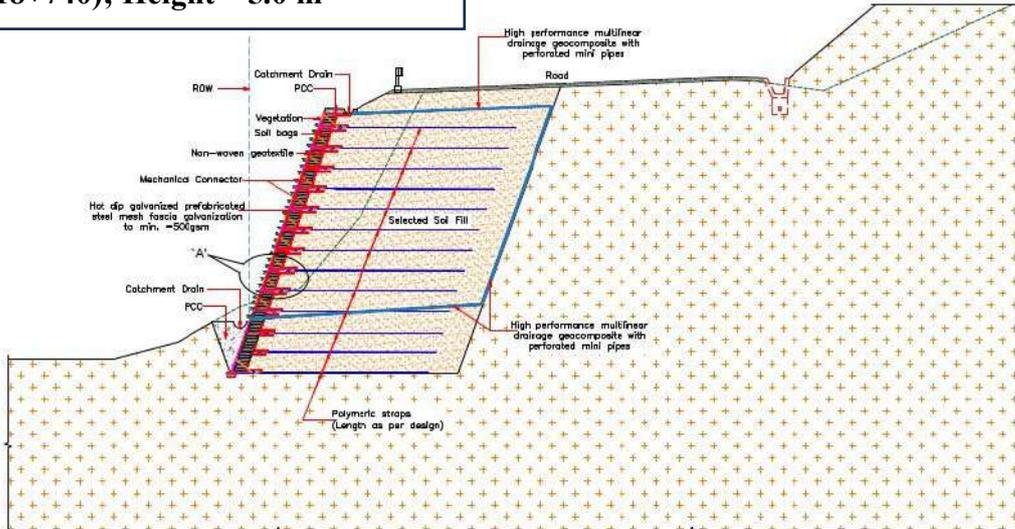


NHIDCL TURA DALU ROAD SINKING ZONE CROSS SECTION



Detail - A'

Chainage from (118+650) to (118+740); Height – 5.0 m



Typical Cross Section with Mechanically Stabilization Earth Slope

High performance multilinear drainage geocomposite with perforated mini pipes			
Characteristics	Standards	Reference	Value
Mass per unit area	NF EN 9884	Geotextile	550
	Mass per unit area total mass (geotextile+mini pipes)		612
Thickness	NF EN 9883-1	Under 2 kPa	6.0
		Under 20 kPa	5.0
Tensile Strength	NF EN ISO 10319	Machine Direction	24
		Cross Direction	24

Polymeric Straps :- Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons encased in a linear low-density polyethylene sheath (LLDPE).

Polymeric Straps Specification			
Properties	Test Method	Unit	Minimum average roll value
Ultimate Tensile Strength	Indian or International standard	kN	25 30 40 50 60 70 80 90 100
		mm	49.5 49.5 49.5 49.5 49.5 49.5 49.5 49.5

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MORTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade b500b (or) b500c and hot dip galvanized to minimum 500gsm.
(B) Two consecutive units of steel mesh to be joined horizontally, using the tie bar which shall be connected using min. 16 gauge wire.



Fig. 36: Area along the road's left-hand side is affected by ground subsidence (sinking zone) near Ch 118+650 km, which may impact road stability



Fig. 37: Erosion along the roadside has led to a gap between the road and the adjacent ground, decreasing lateral confinement. This reduced support may contribute to pavement cracking or structural failure near Ch 118+705 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (118+740) to (118+900)

Length – 160 m

Height – 3.0 m Retaining Wall, and 4.0 m MSE Wall

Proposed Solution:

1. Gabion Retaining Wall (3m ht) with perforated pipe in 50 m (km 118.740 to km 118.790)
2. MSE Wall (4m ht) in 110 m (km 118.790 to km 118.900)

L-110

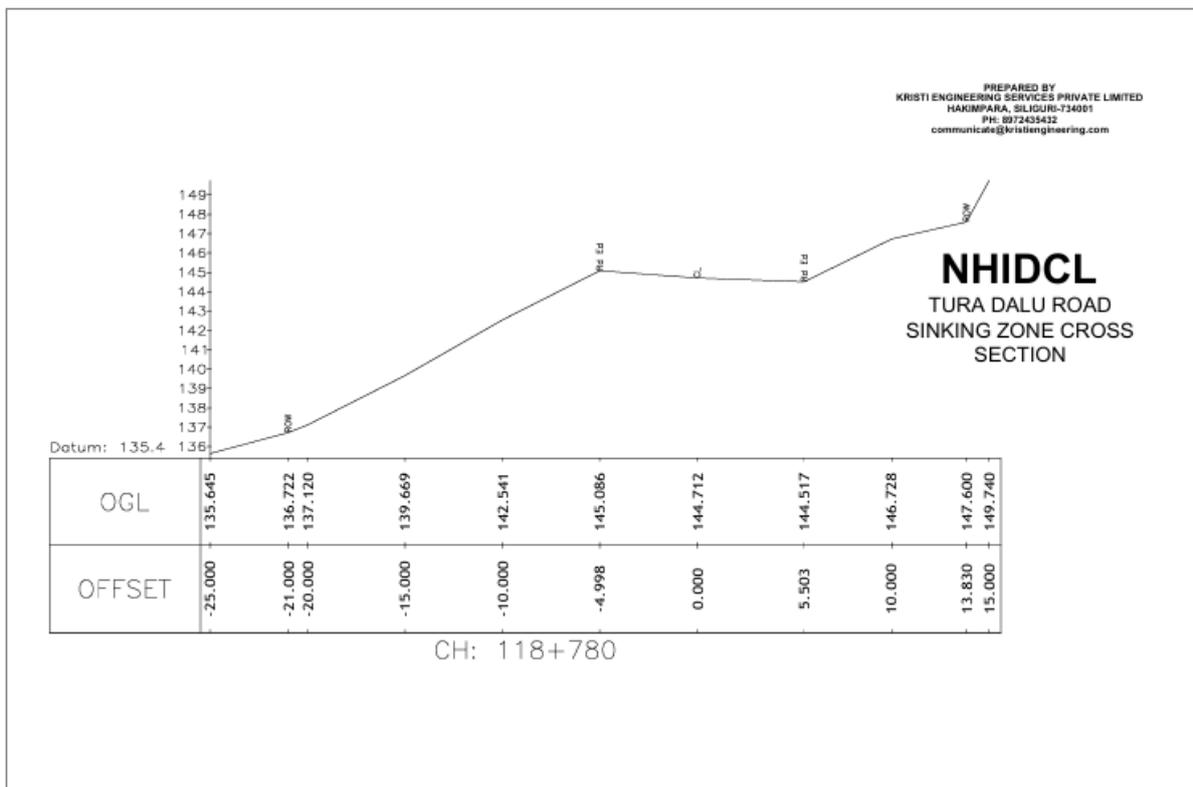
H-4

W-4.2

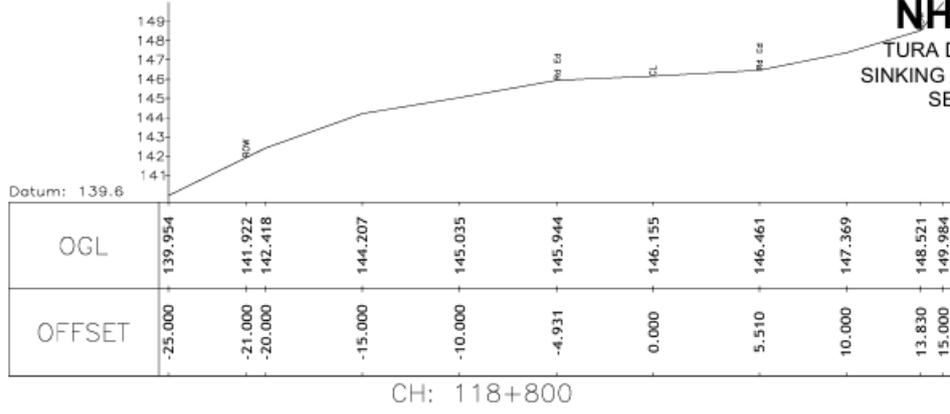
Area- 440

Fill vol- 1848

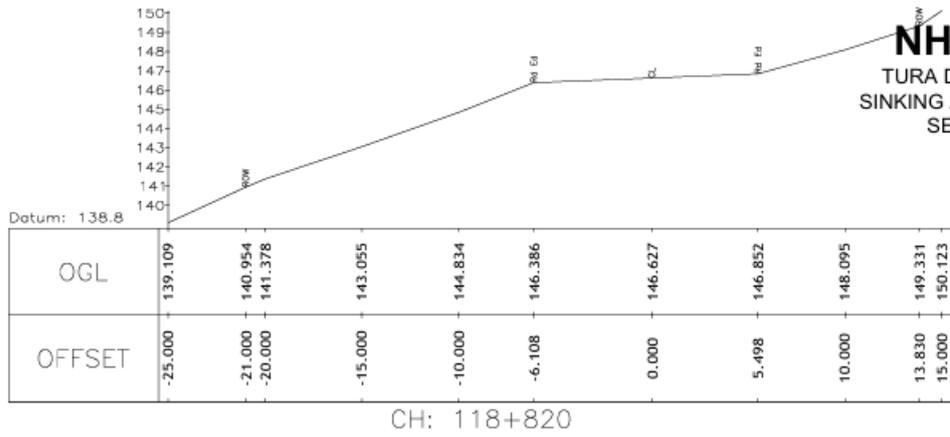
3. Paved Shoulders



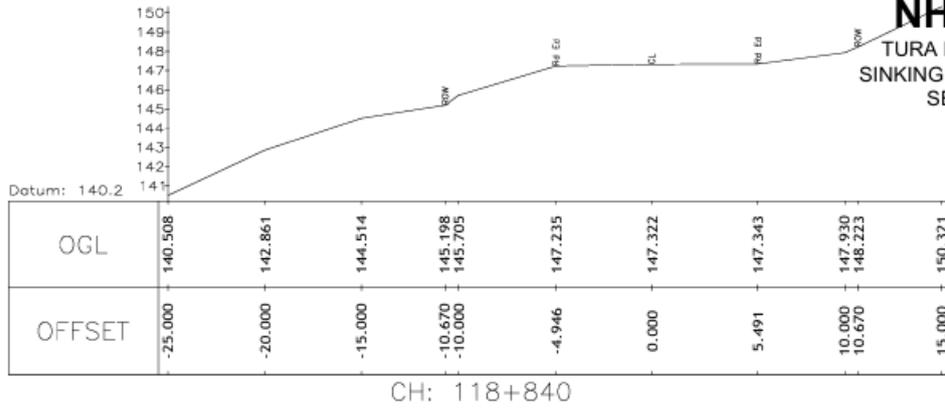
NHIDCL
 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION



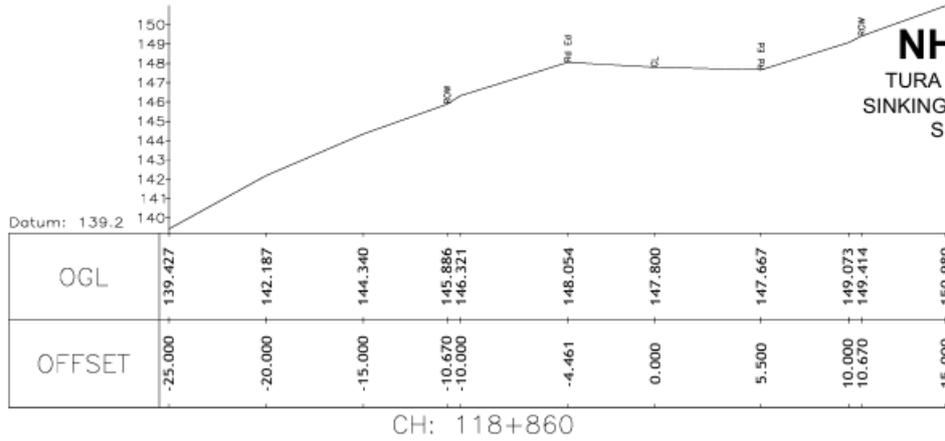
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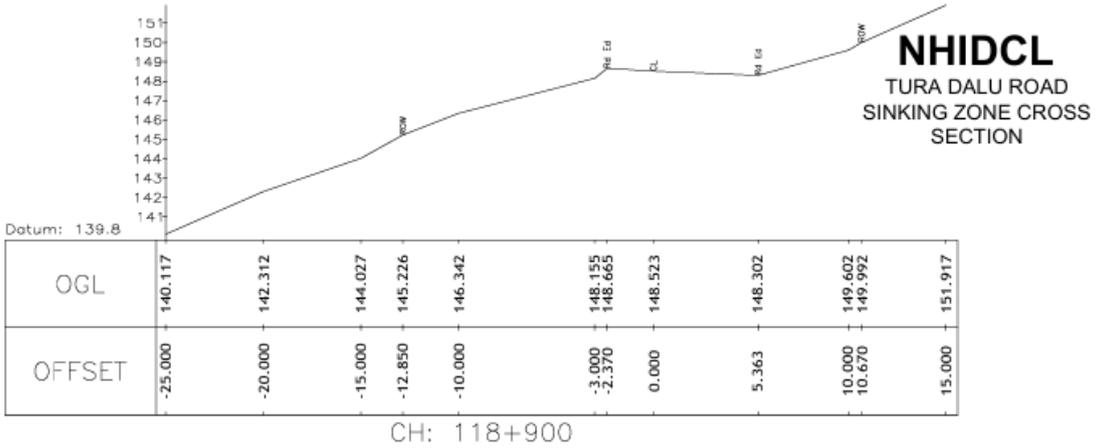
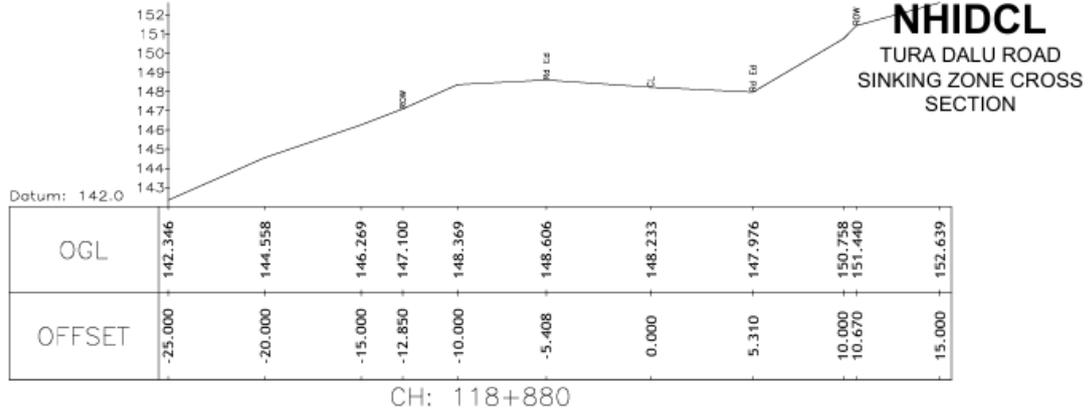


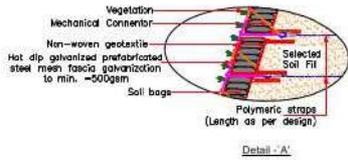
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 SECTION



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 SINKING ZONE CROSS
 SECTION







High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	g/sqm
		Mass per unit area total (geotextile+mini pipes)	612	
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
		Under 20 kPa	5.0	
Tensile Strength	NF EN 150	Machine Direction	24	kN/m
		Cross Direction	24	

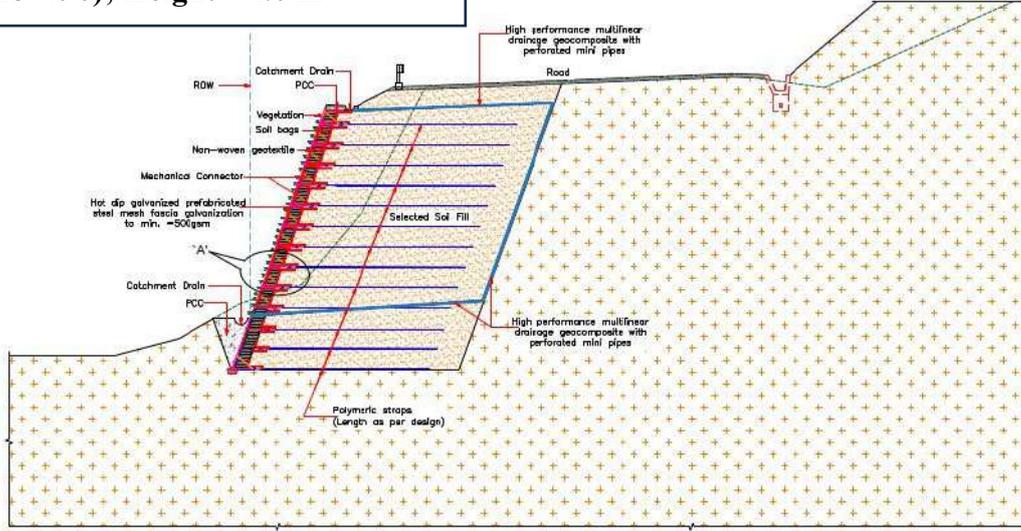
Polymeric Straps - Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE).

Polymeric Straps Specification				
Properties	Test Method	Unit	Minimum average rol value	
Ultimate Tensile Strength	Indian or International standard	kN	25	30
Width		mm	49.5	49.5
			49.5	49.5

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B550c and hot dip galvanized to minimum 500gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.

Chainage from (118+740) to (118+790); Height - 4.0 m



Typical Cross Section with Mechanically Stabilization Earth Slope

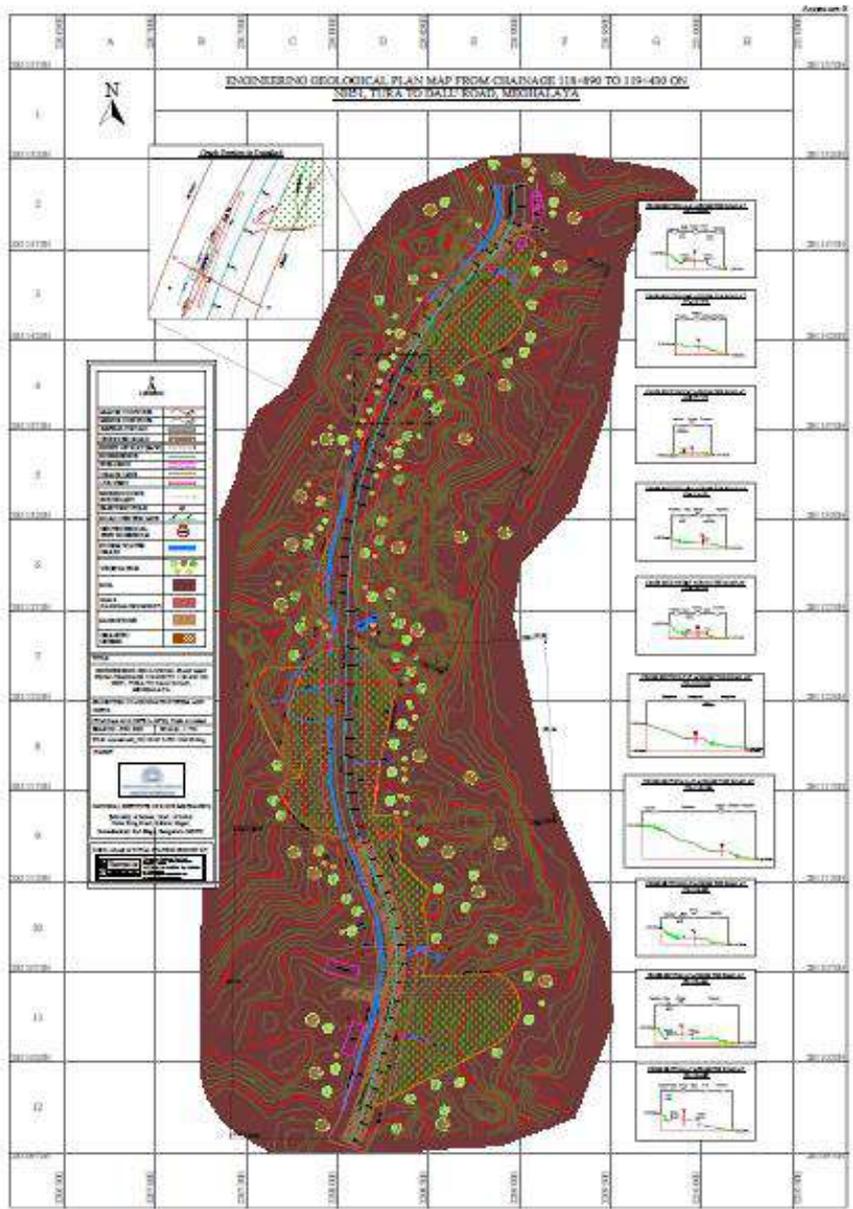




Fig. 38: Left-side portion of the road pavement failed and collapsed near Ch 118+825 km. Failed blocks were moved horizontally up to 25 cm and vertically up to 120 cm.



Fig. 39: Erosion along the roadside has caused separation between the road and adjacent ground, reducing lateral confinement. This lack of support can result in cracking or collapse of the pavement structure near the area of Ch 118+850 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (118+915) to (119+160)

Length – 324 m

Height – 8.0 m

Proposed Solution:

1. MSE Wall (5m ht) in 100 m (km 118.915 to km 119.015).

L-50

H-5

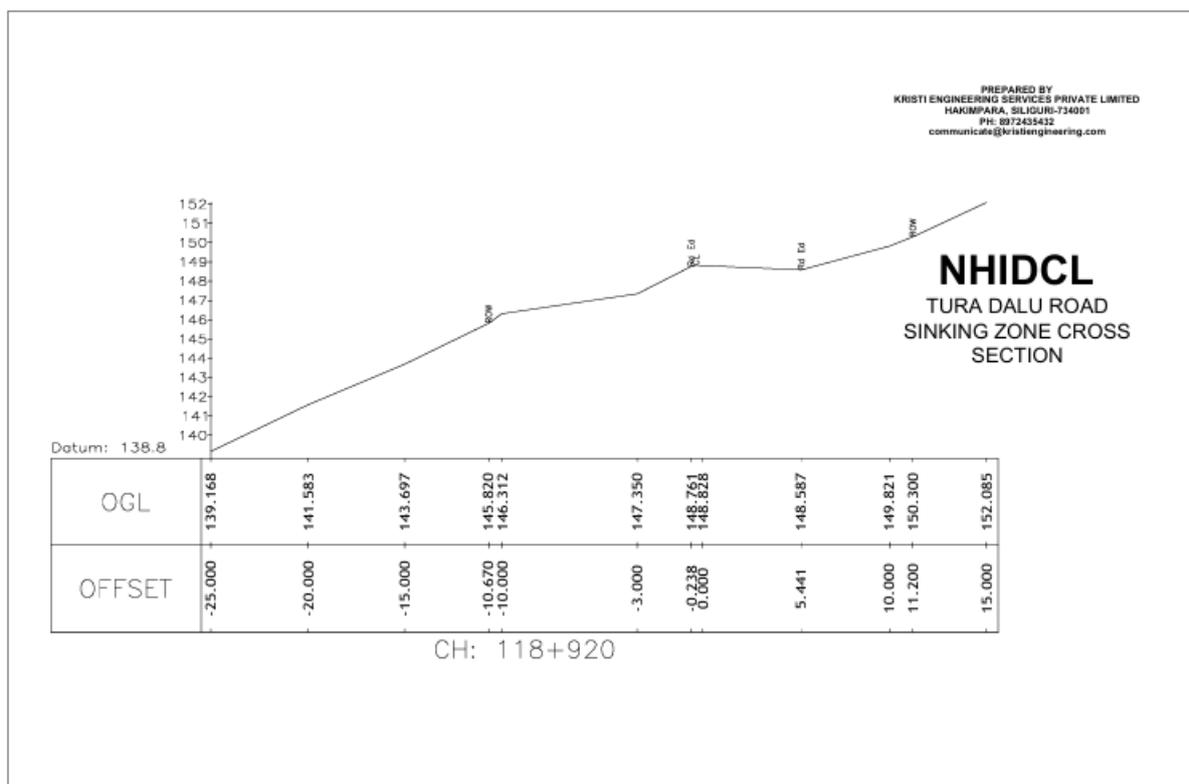
W-4.6

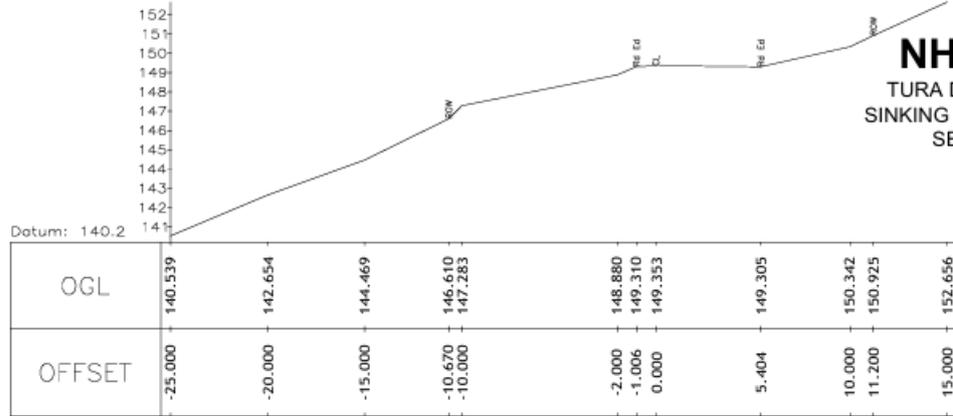
Area- 250

Fill vol- 1150

2. Gabion Retaining Wall (5m ht) with perforated pipe in 145 m (km 119.015 to km 119.160)

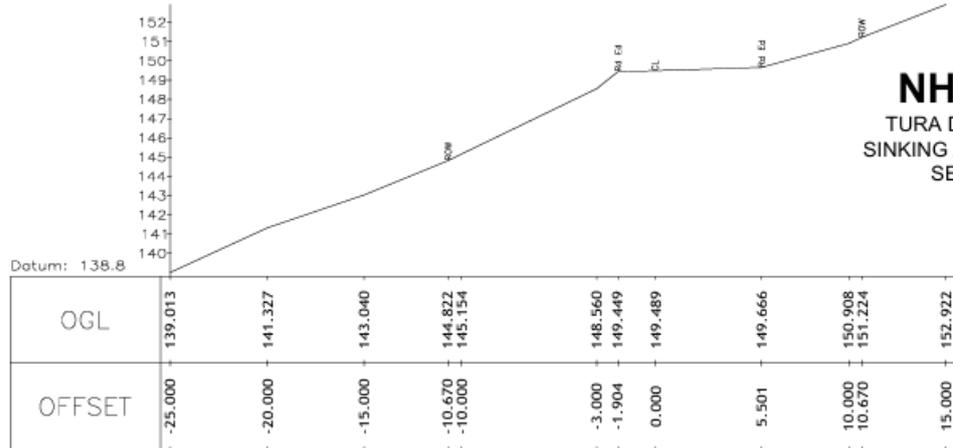
3. Paved Shoulders





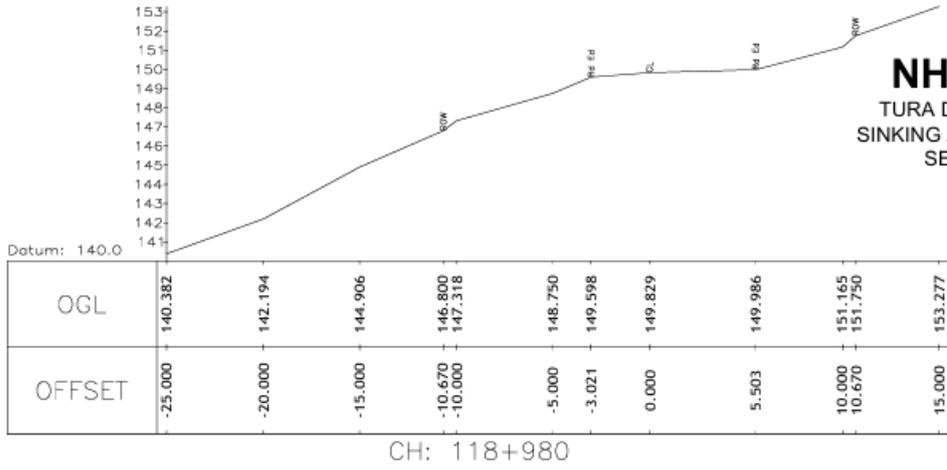
CH: 118+940

NHIDCL
TURA DALU ROAD
SINKING ZONE CROSS
SECTION

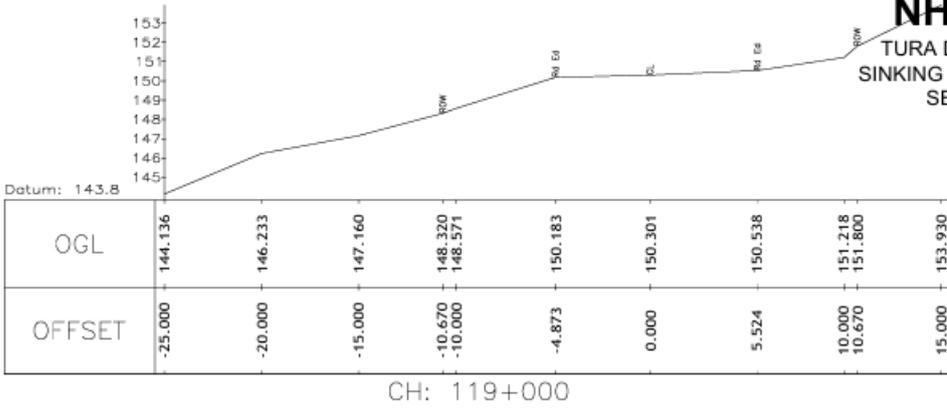


CH: 118+960

NHIDCL
TURA DALU ROAD
SINKING ZONE CROSS
SECTION

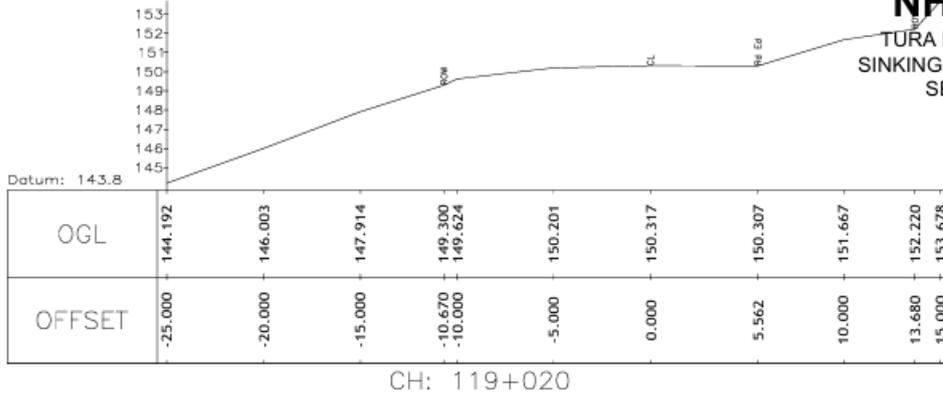


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 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION

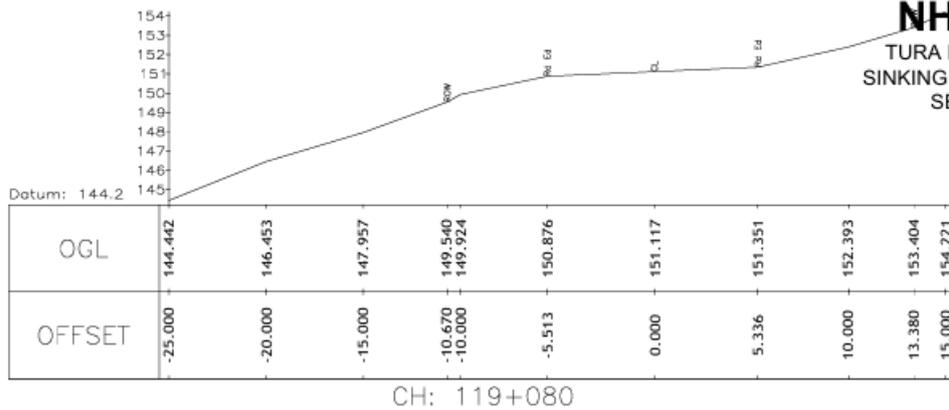


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 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION

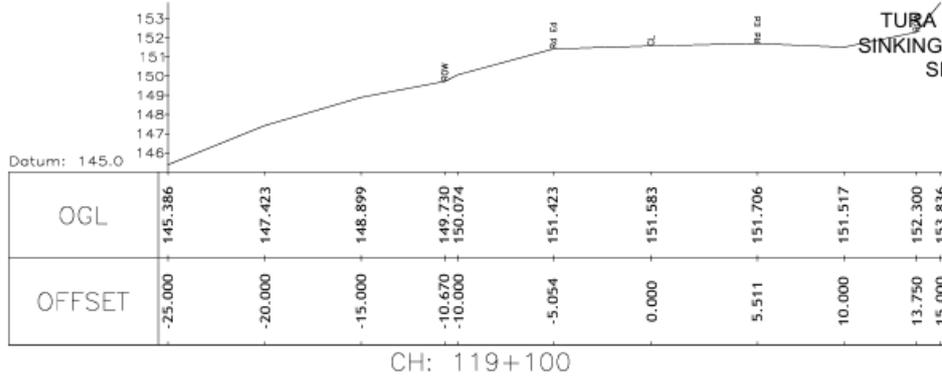
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 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION



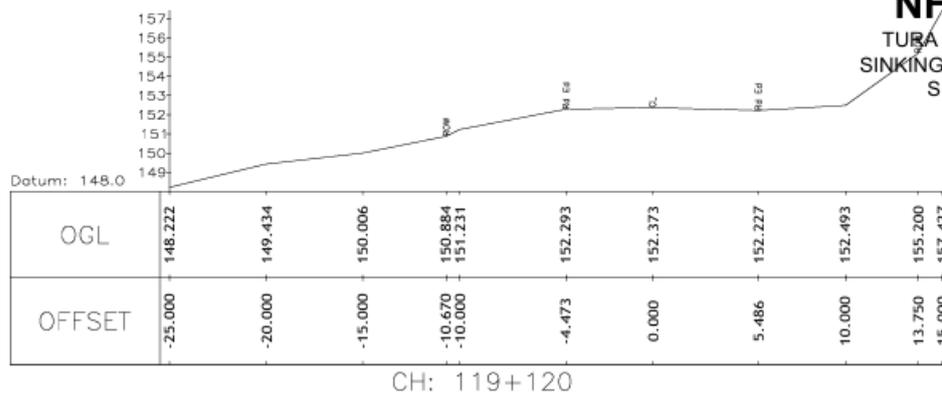
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 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION



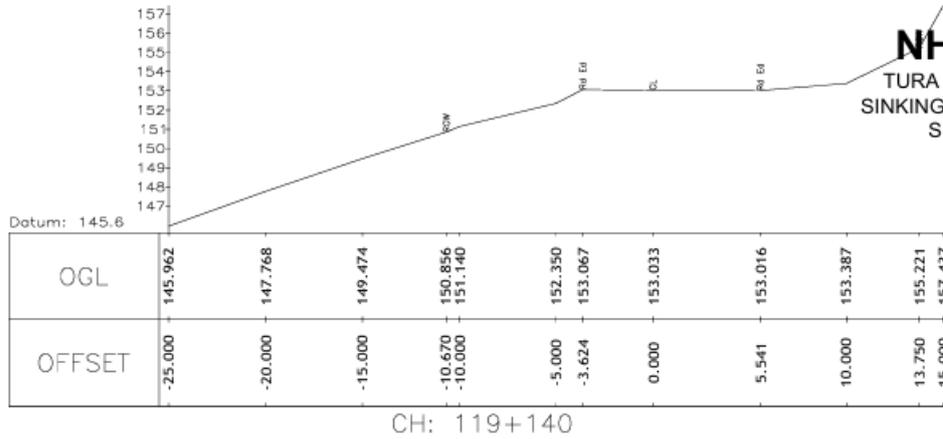
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 TUBA DALU ROAD
 SINKING ZONE CROSS
 SECTION



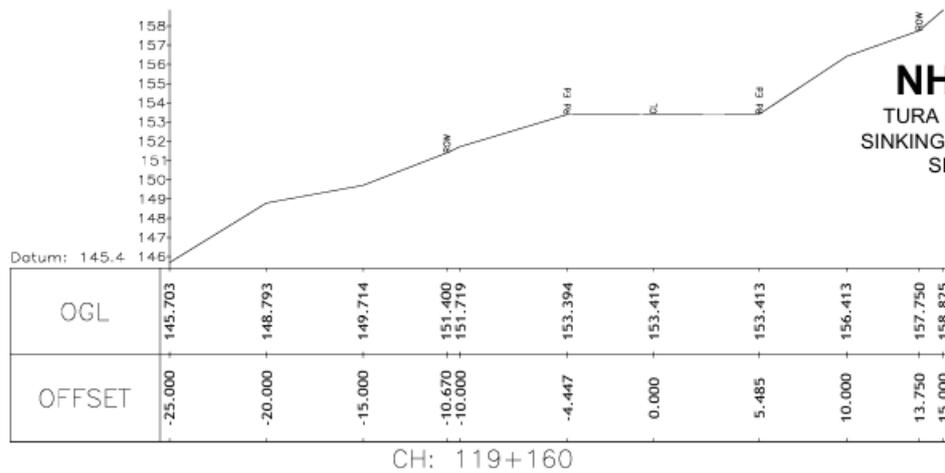
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 SINKING ZONE CROSS
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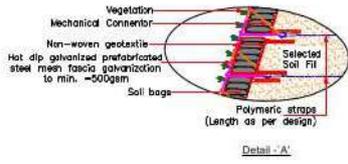


NHIDCL
TURA DALU ROAD
SINKING ZONE CROSS
SECTION



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SINKING ZONE CROSS
SECTION





High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	g/sqm
		Mass per unit area total (geotextile+mini pipes)	612	
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
		Under 20 kPa	5.0	
Tensile Strength	NF EN 150	Machine Direction	24	kN/m
		Cross Direction	24	

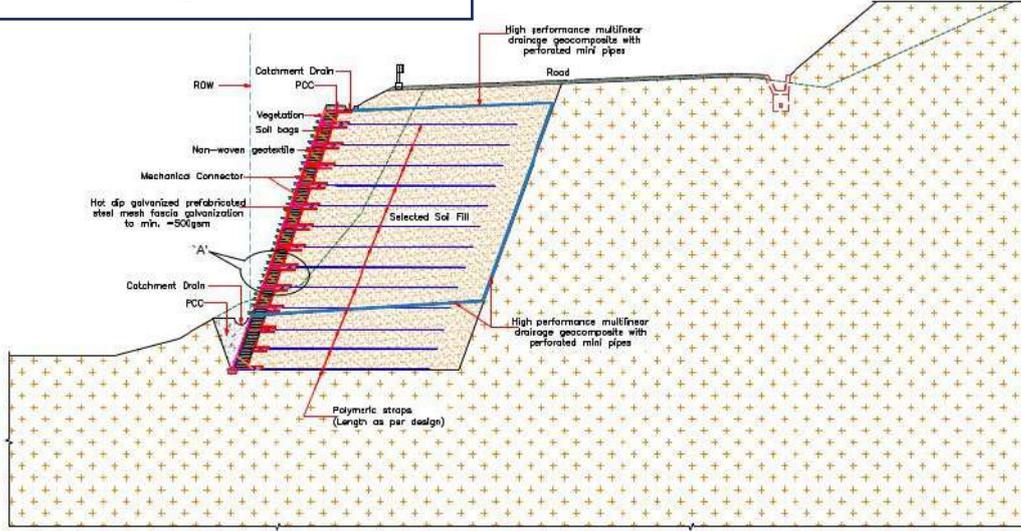
Polymeric Straps - Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE).

Polymeric Straps Specification				
Properties	Test Method	Unit	Minimum average rol value	
Ultimate Tensile Strength	Indian or International standard	kN	25	30
			40	50
			60	70
			80	90
			100	
Width		mm	49.5	49.5
			49.5	49.5
			49.5	49.5

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B550c and hot dip galvanized to minimum 500gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.

Chainage from (118+915) to (119+015); Height – 5.0 m



Typical Cross Section with Mechanically Stabilization Earth Slope

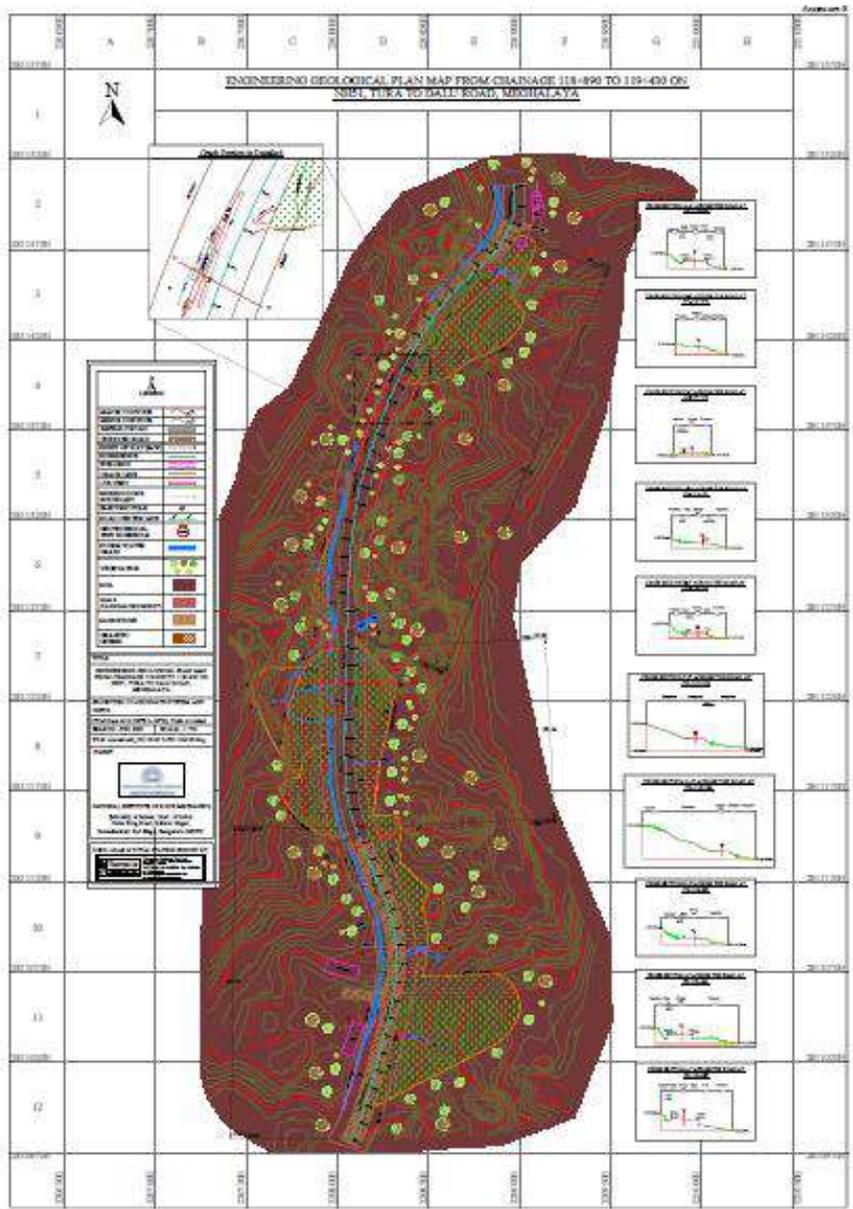




Fig. 40: Sinking and subsidence were observed in the left-side section of the road pavement due to soil erosion between Ch 118+915 and 119+160 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (119+160) to (119+270)

Length – 110m

Height – 5.0 m

Proposed Solution:

1. Mechanically stabilised Earth wall (height of MSE wall to be 5m as per site verification)

L-110

H-5

W-4.6

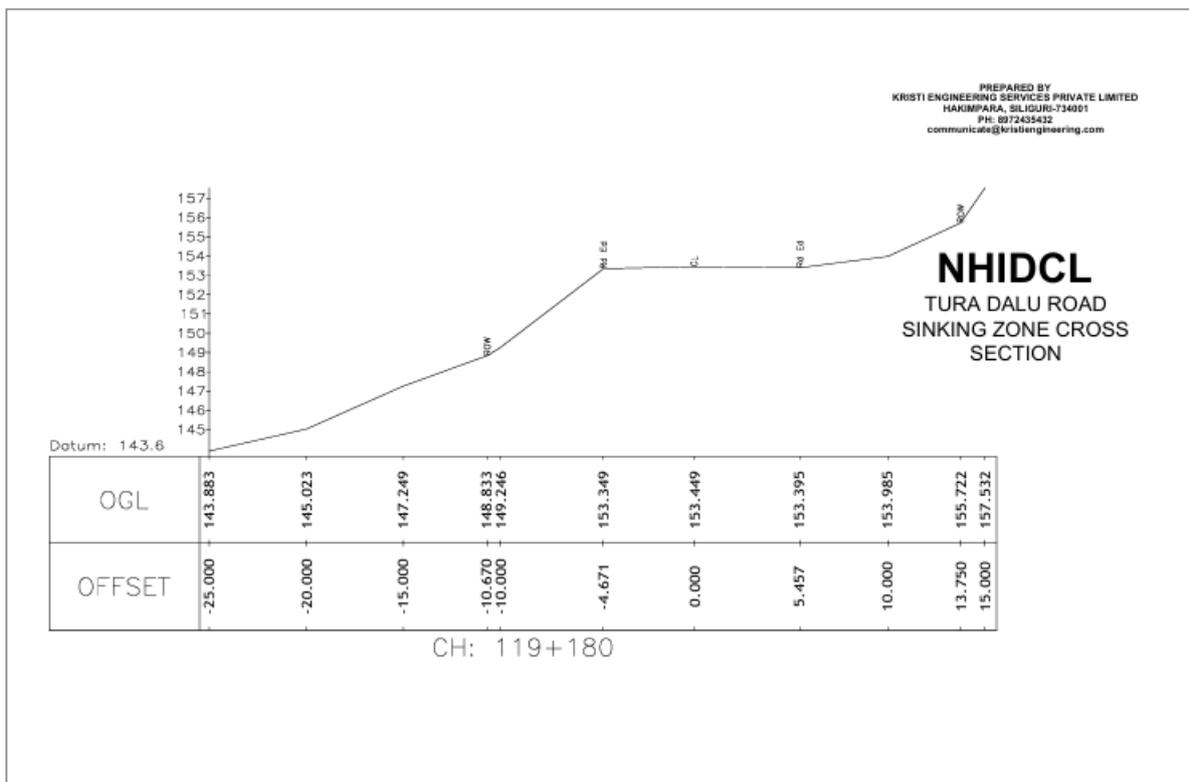
Area- 550

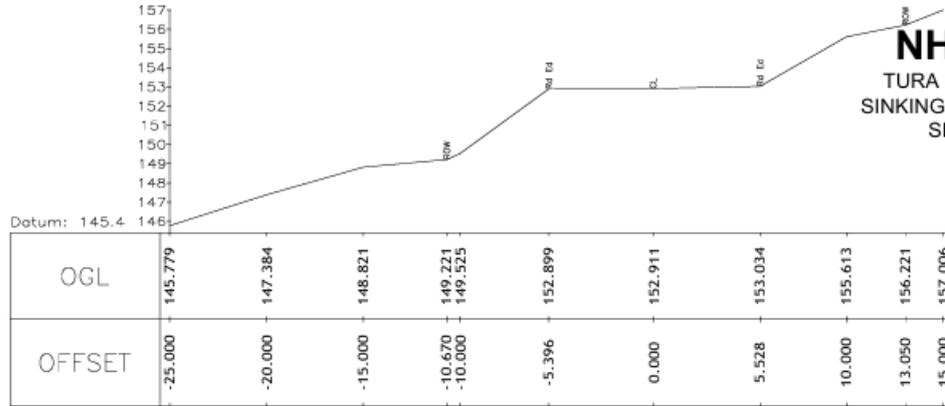
Fill vol-2530

2. Paved Shoulders

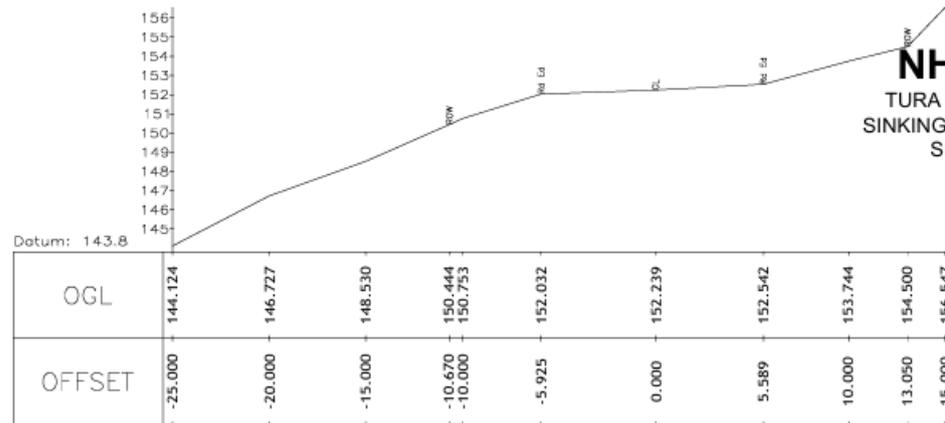
3. Plantation

4. Grouting

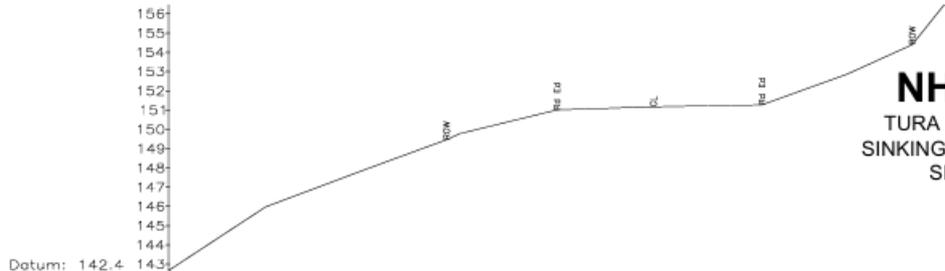




CH: 119+200



CH: 119+220

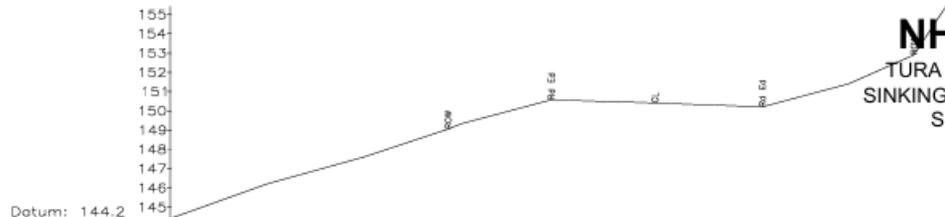


NHIDCL
 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION

Dotum: 142.4

OGI	142.677	145.976	147.865	149.462	151.011	151.172	151.271	152.870	154.400	156.469	
OFFSET	-25.000	-20.000	-15.000	-10.670	-10.000	-4.975	0.000	5.594	10.000	13.350	15.000

CH: 119+240

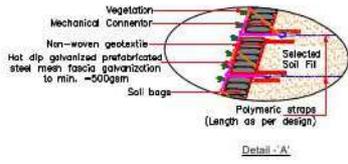


NHIDCL
 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION

Dotum: 144.2

OGI	144.411	146.210	147.609	149.055	150.569	150.406	150.205	151.404	152.900	155.403	
OFFSET	-25.000	-20.000	-15.000	-10.670	-10.000	-5.352	0.000	5.535	10.000	13.350	15.000

CH: 119+260



High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	
		Mass per unit area total (geotextile+mini pipes)	612	g/sqm
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
		Machine Direction	5.0	
Tensile Strength	NF EN 150	Machine Direction	24	kN/m
		Cross Direction	24	

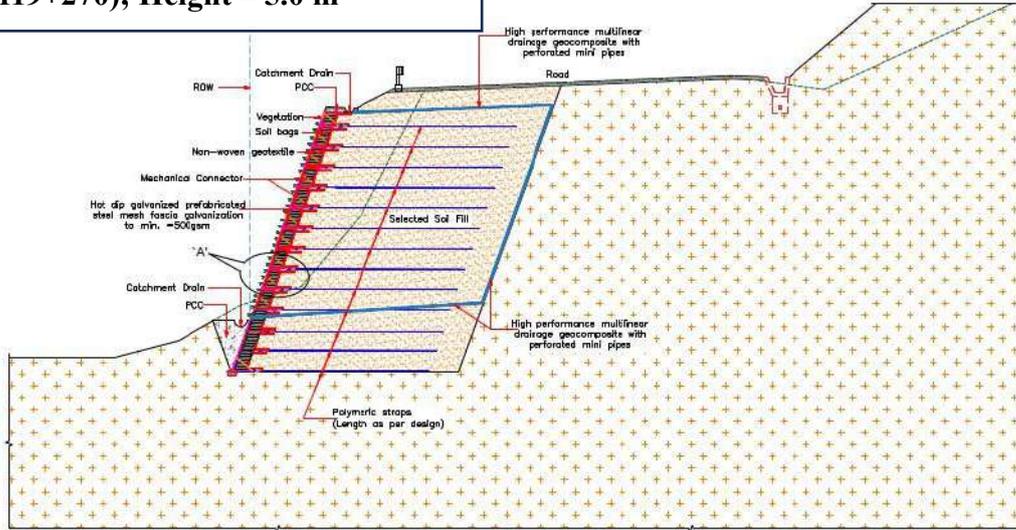
Polymeric Straps – Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE)

Polymeric Straps Specification				
Properties	Test Method	Unit	Minimum average roll value	
Ultimate Tensile Strength	Indian or International standard	kN	25	30
Width		mm	49.5	49.5

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MORTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B500c and hot dip galvanized to minimum 500gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.

Chainage from (119+170) to (119+270); Height – 5.0 m



Typical Cross Section with Mechanically Stabilization Earth Slope

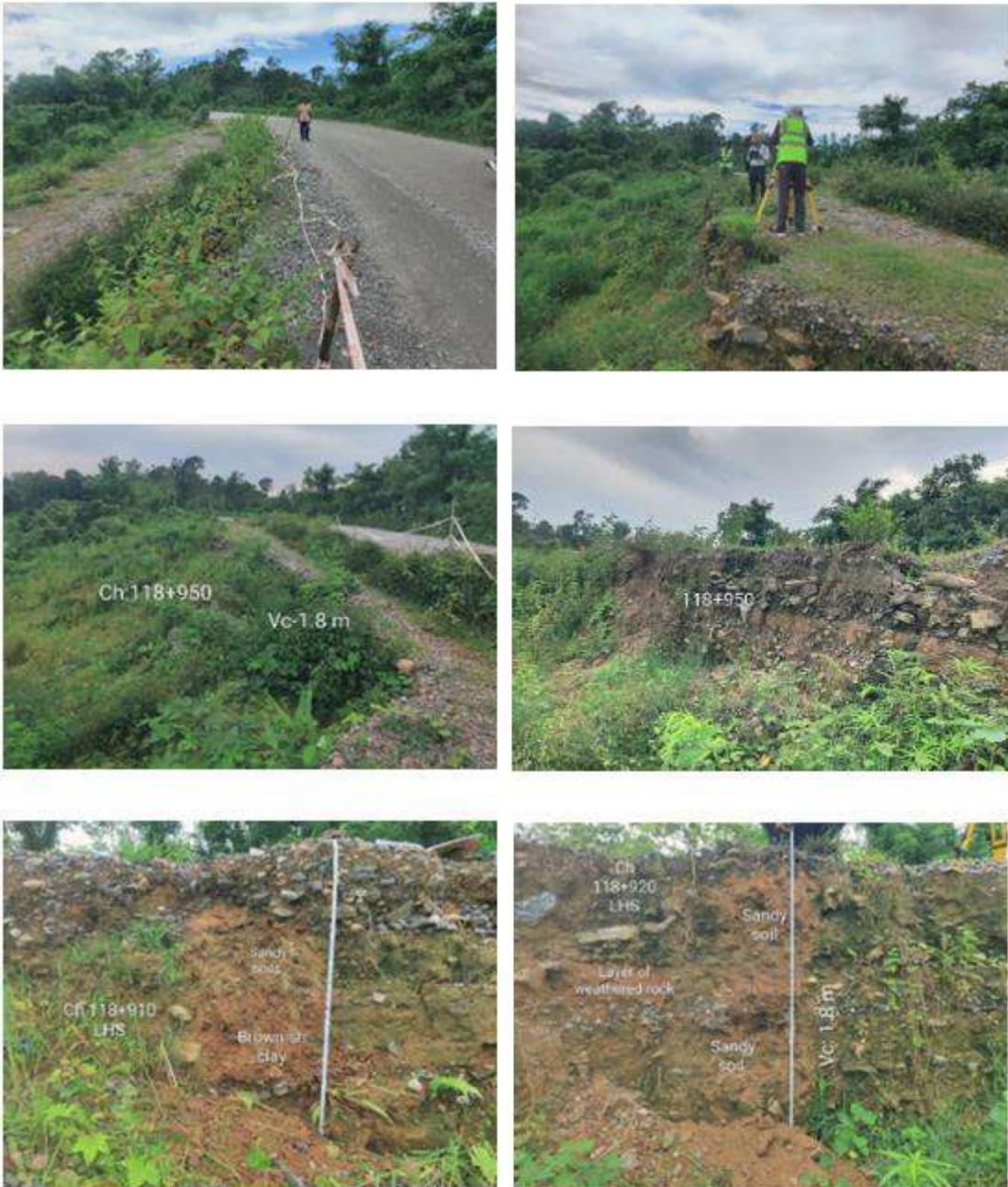


Fig. 40: Sinking and subsidence were observed in the left-side section of the road pavement due to soil erosion between Ch 118+915 and 119+160 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (119+270) to (119+450)

Length – 180 m

Height – 6.0 m

Proposed Solution:

1. Mechanically stabilised Earth wall (height of MSE wall to be 6m as per site verification)

L-180

H-6

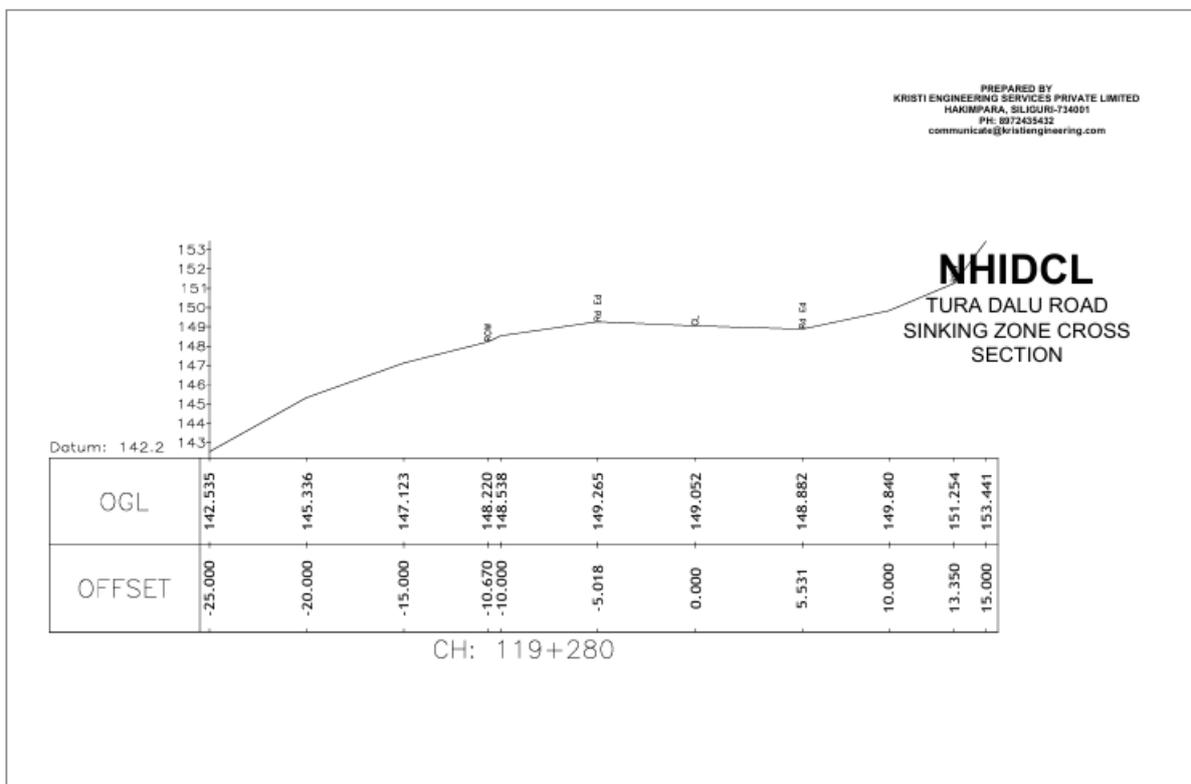
W-5

Area- 1080

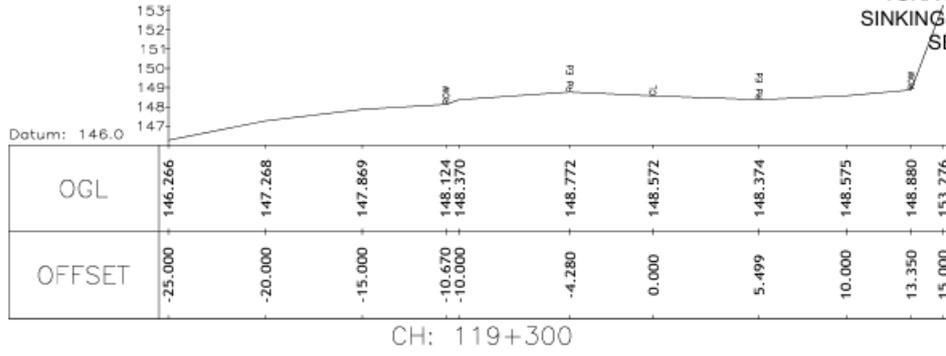
Fill vol- 5400

2. Paved Shoulders

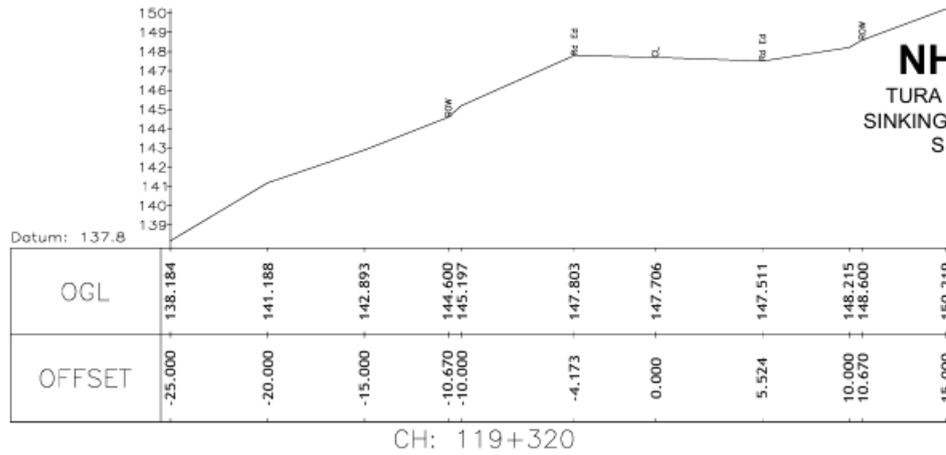
3. Plantation



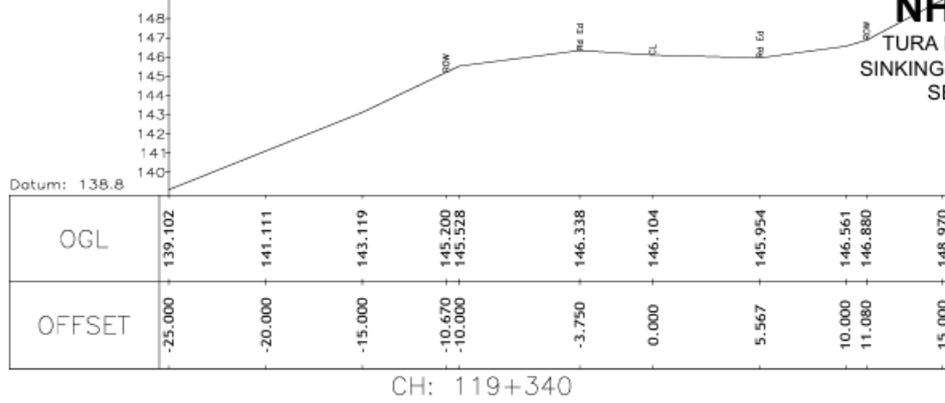
NHIDCL
 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION



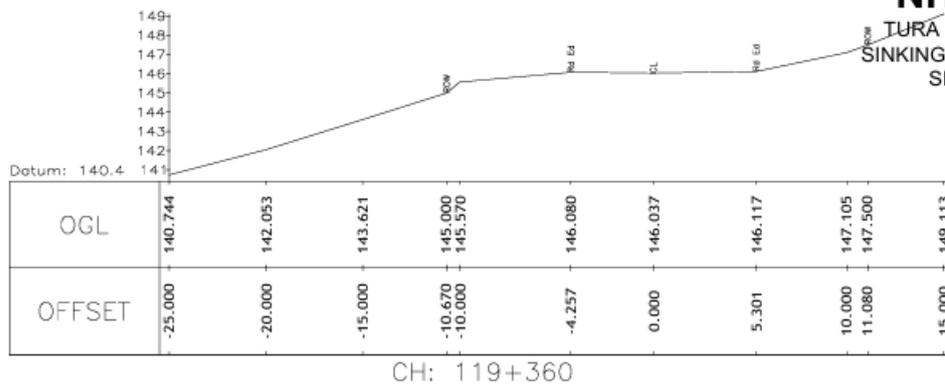
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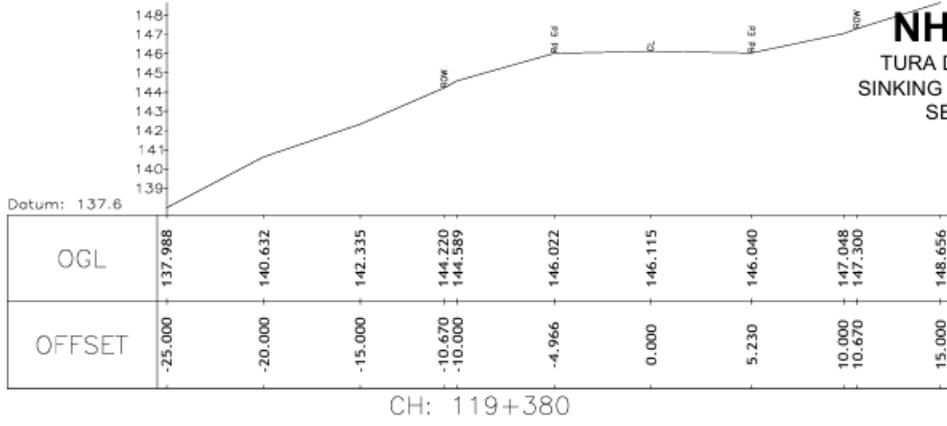


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 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION

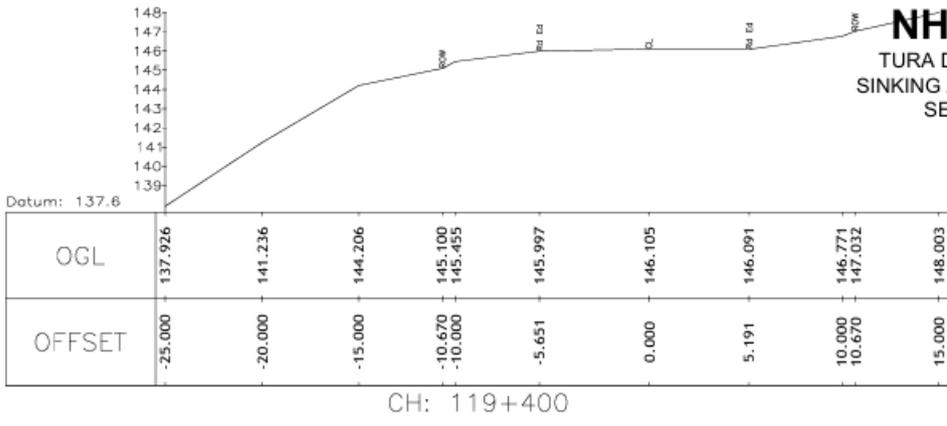


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 SINKING ZONE CROSS
 SECTION



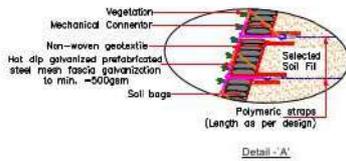
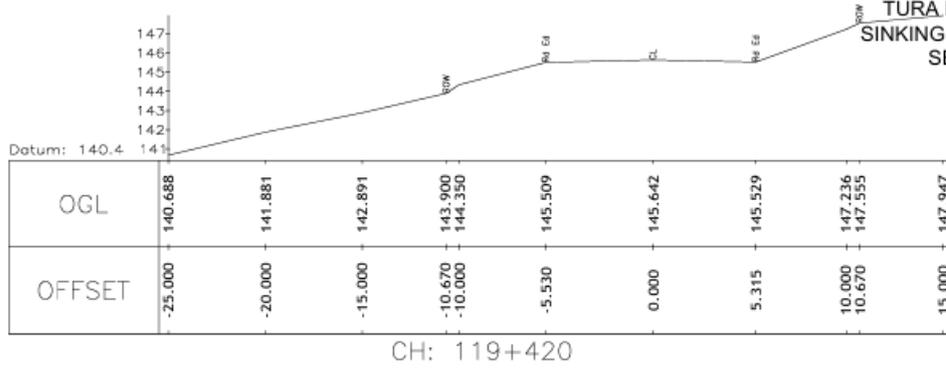


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 SINKING ZONE CROSS
 SECTION



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 SINKING ZONE CROSS
 SECTION

NHIDCL TURA DALU ROAD SINKING ZONE CROSS SECTION



High performance multilinear drainage geocomposite with perforated mini pipes			
Characteristics	Standards	Reference	Value
Mass per unit area	NF EN 9884	Geotextile	550
		Mass per unit area total (mass/geotextile+mini pipes)	612
Thickness	NF EN 9883-1	Under 2 kPa	6.0
Tensile Strength	NF EN 150 10319	Machine Direction	24
		Cross Direction	24

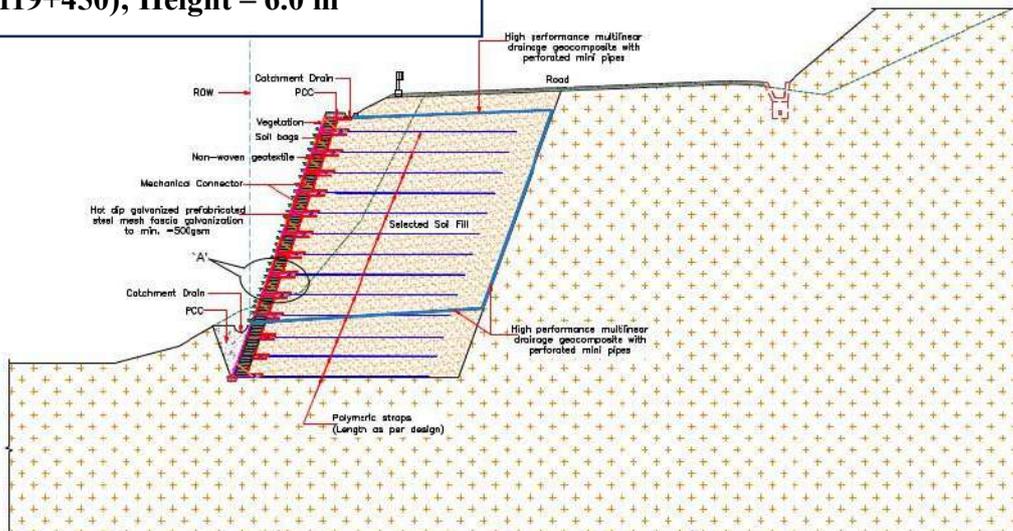
Polymeric Straps :- Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE)

Polymeric Straps Specification			
Properties	Test Method	Unit	Minimum average rol value
Ultimate Tensile Strength	Indian or International standard	kN	25 30 40 50 60 70 80 90 100
Width		mm	49.5±0.5 49.5±0.5 49.5±0.5 49.5±0.5 49.5±0.5 49.5±0.5

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B500c and hot dip galvanized to minimum 50gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.

Chainage from (119+270) to (119+450); Height – 6.0 m



Typical Cross Section with Mechanically Stabilization Earth Slope

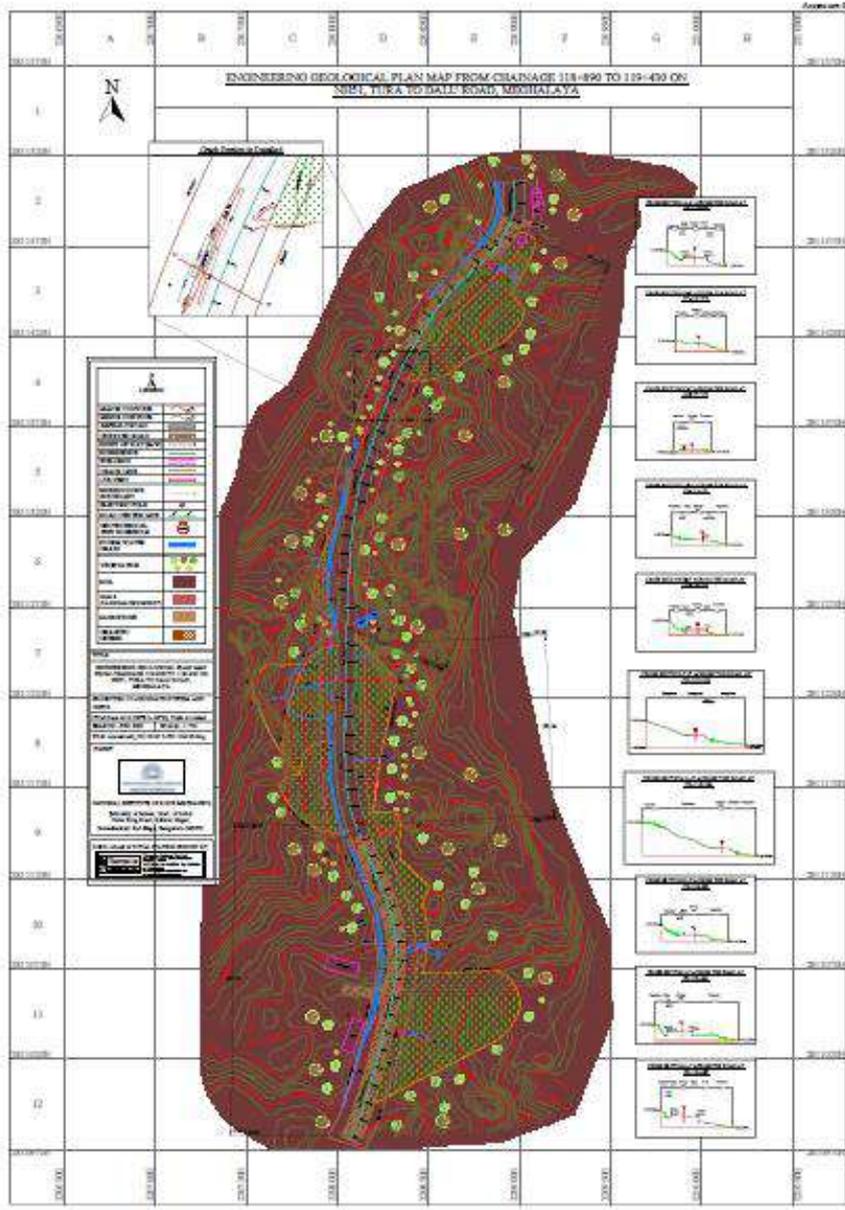




Fig. 43: View of sinking zone -25 on LHS

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (120+900) to (121+280)

Length – 380m

Height – 5.0 m

Proposed Solution:

1. Mechanically stabilised Earth wall

L-380

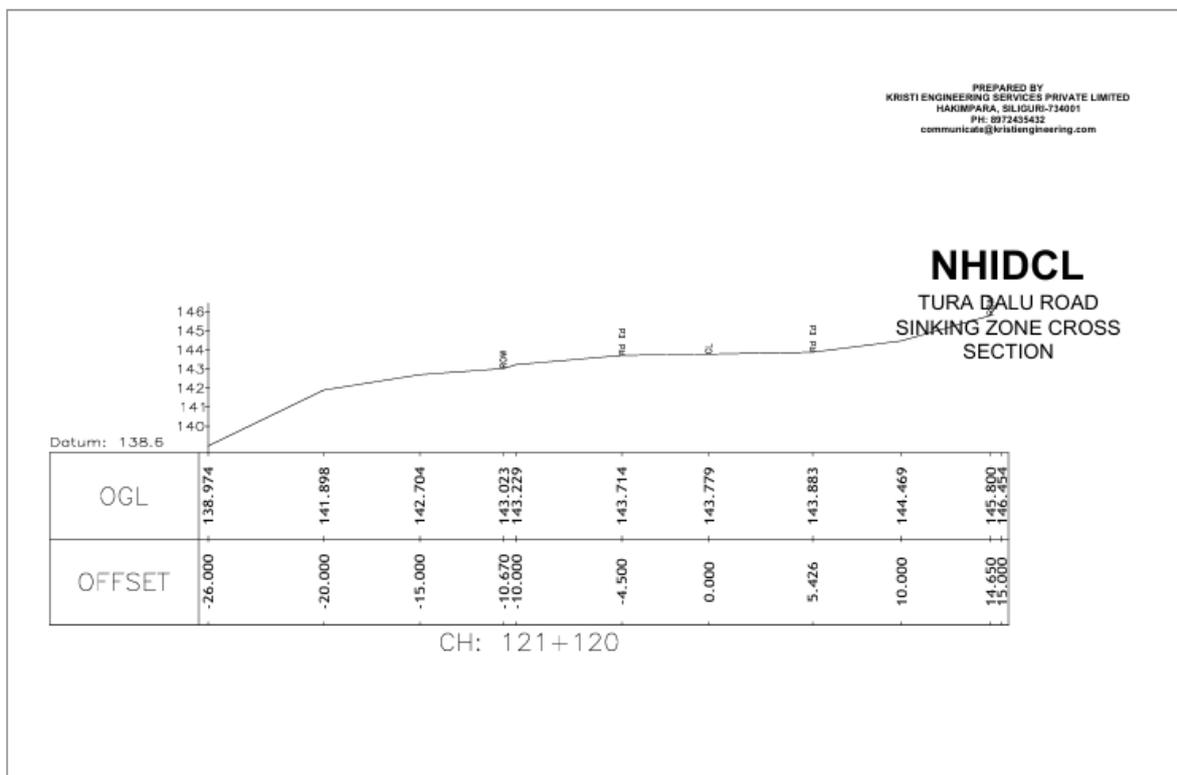
H-5

W-4.6

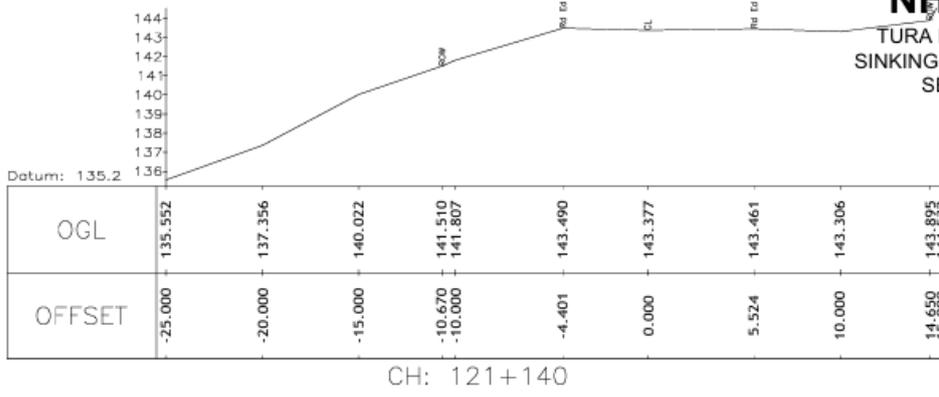
Area- 1750

Fill vol- 8050

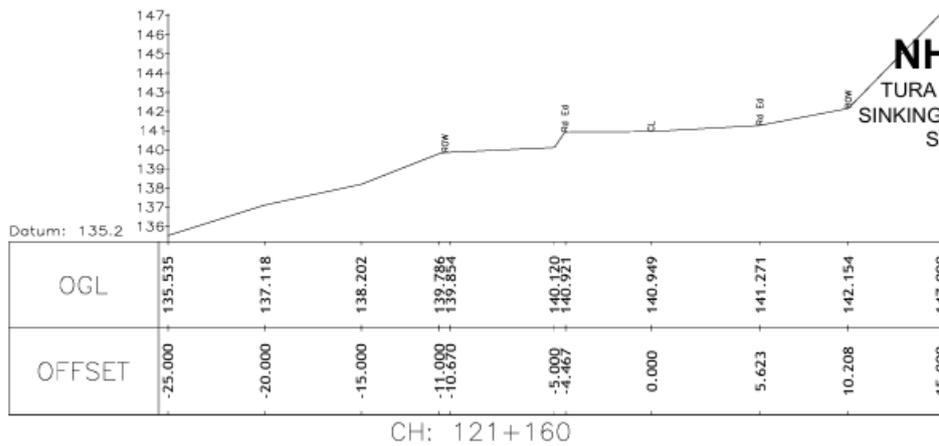
2. Paved Shoulders
3. Culverts



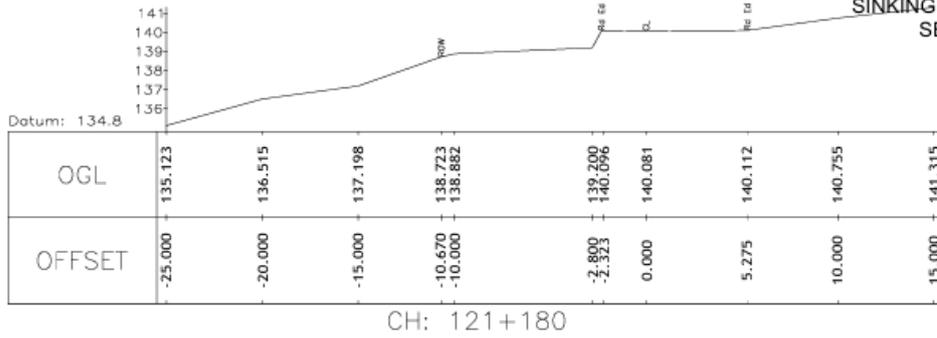
NHIDCL
 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION



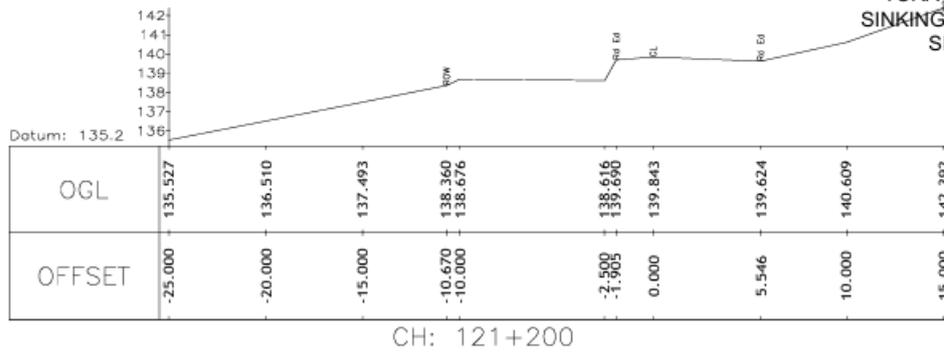
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 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION



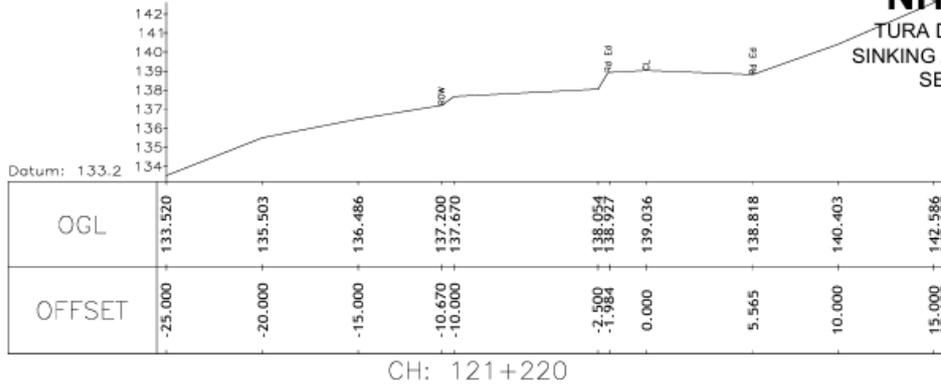
NHIDCL
TURA DALU ROAD
SINKING ZONE CROSS
SECTION



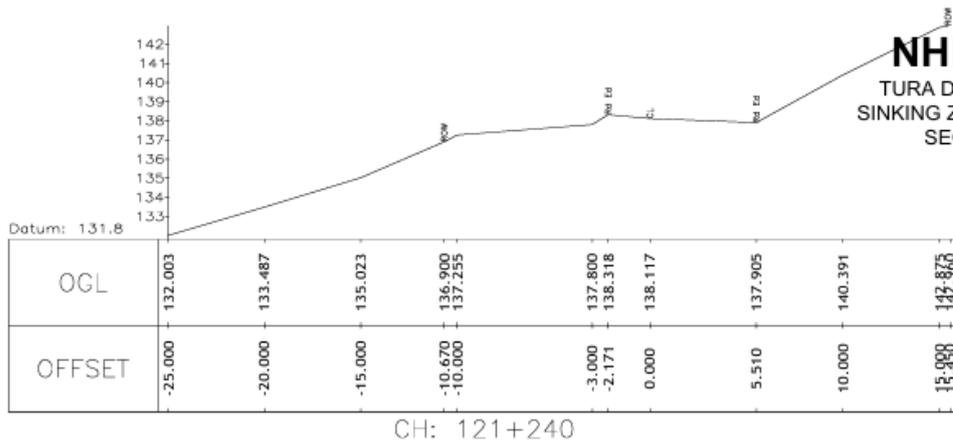
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SINKING ZONE CROSS
SECTION

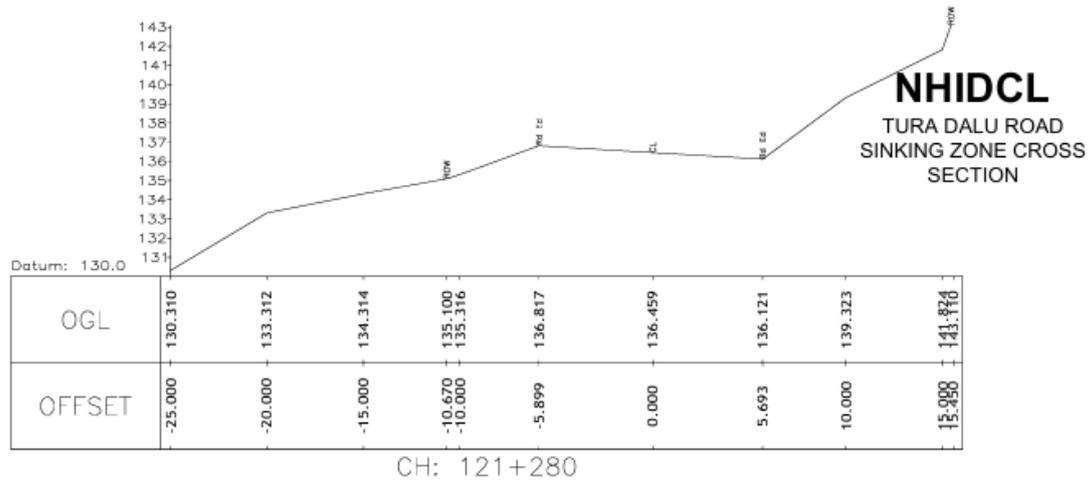
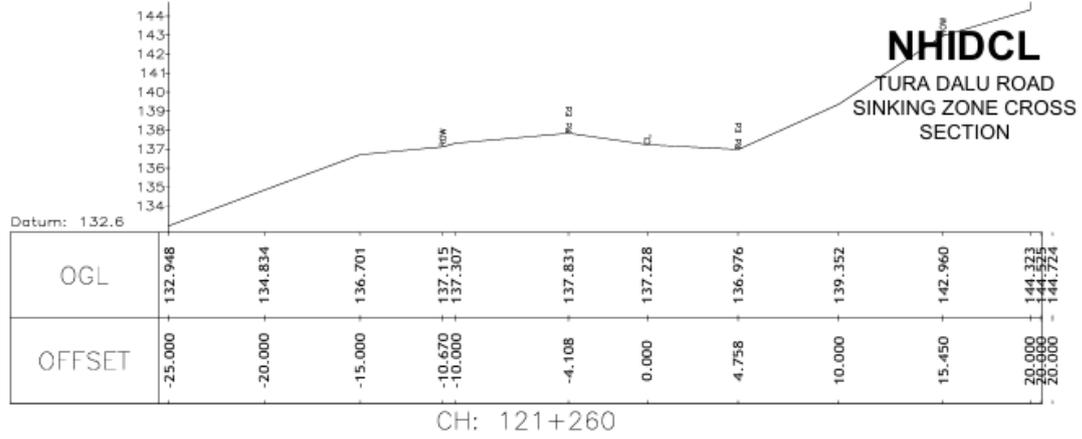


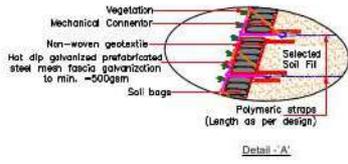
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TURA DALU ROAD
SINKING ZONE CROSS
SECTION



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SINKING ZONE CROSS
SECTION







High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	g/sqm
		Mass per unit area total (geotextile+mini pipes)	612	g/sqm
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
		Under 20 kPa	5.0	mm
Tensile Strength	NF EN 150	Machine Direction	24	kN/m
		Cross Direction	24	kN/m

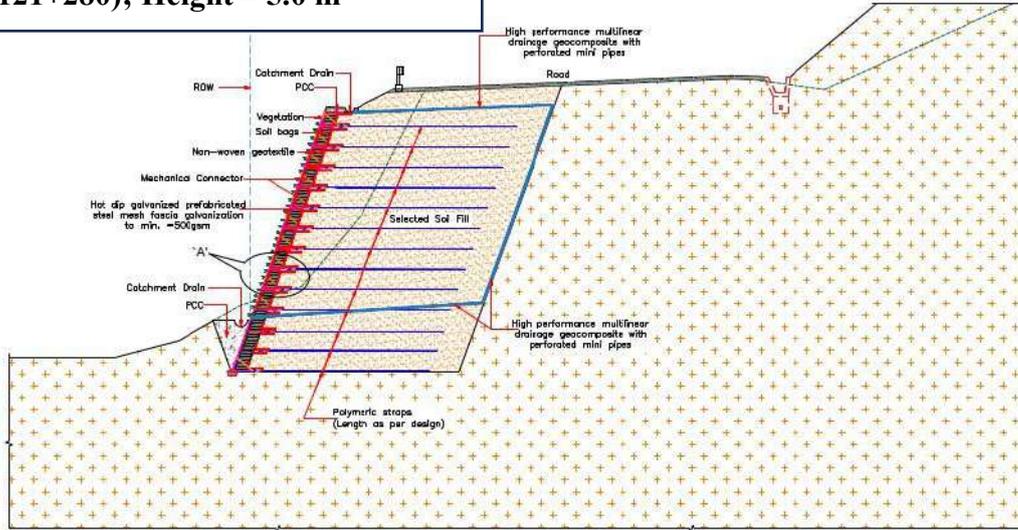
Polymeric Straps - Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE).

Polymeric Straps Specification				
Properties	Test Method	Unit	Minimum average rol value	
Ultimate Tensile Strength	Indian or International standard	kN	25	30
Width		mm	49.5	49.5

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B550c and hot dip galvanized to minimum 500gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.

Chainage from (120+900) to (121+280); Height - 5.0 m



Typical Cross Section with Mechanically Stabilization Earth Slope



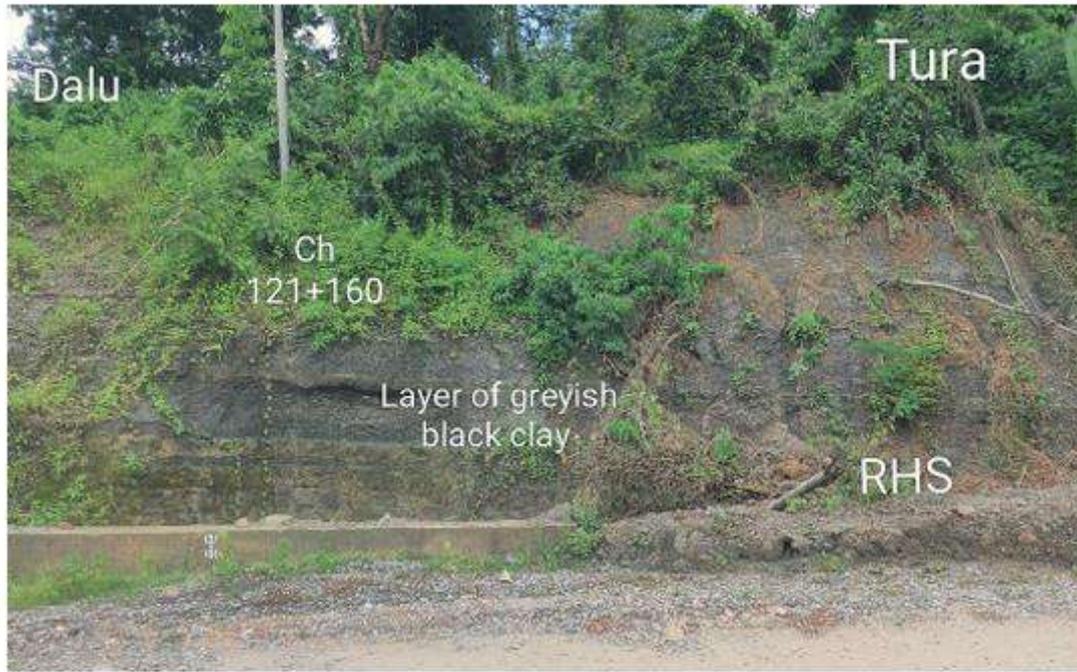


Fig. 44: Erosion occurring around the culverts and along the roadway has led to a separation between the pavement and the adjoining ground, decreasing lateral support. This reduced confinement may contribute to cracking or potential failure of the culverts and pavement structure in the vicinity of area between Ch 121+061 and 121+160 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (121+320) to (121+405)

Length – 85 m

Height – 5.0 m

Proposed Solution:

1. Mechanically stabilised Earth wall

L-85

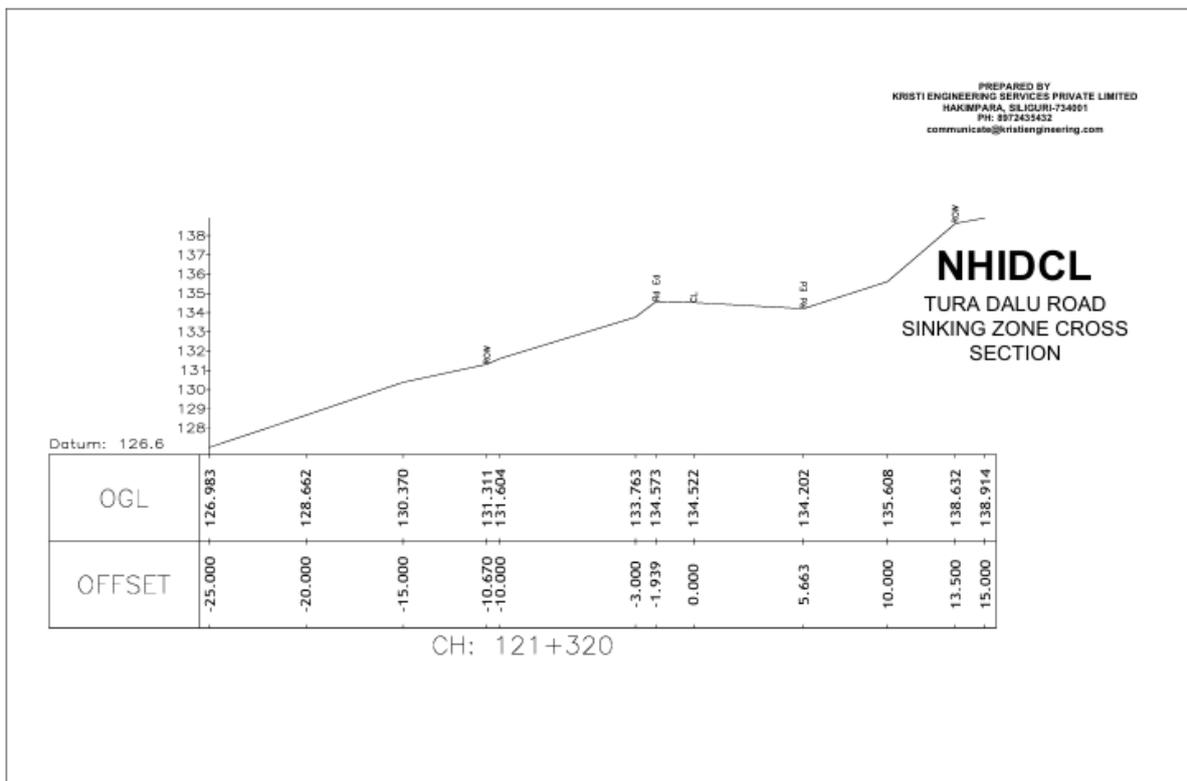
H-5

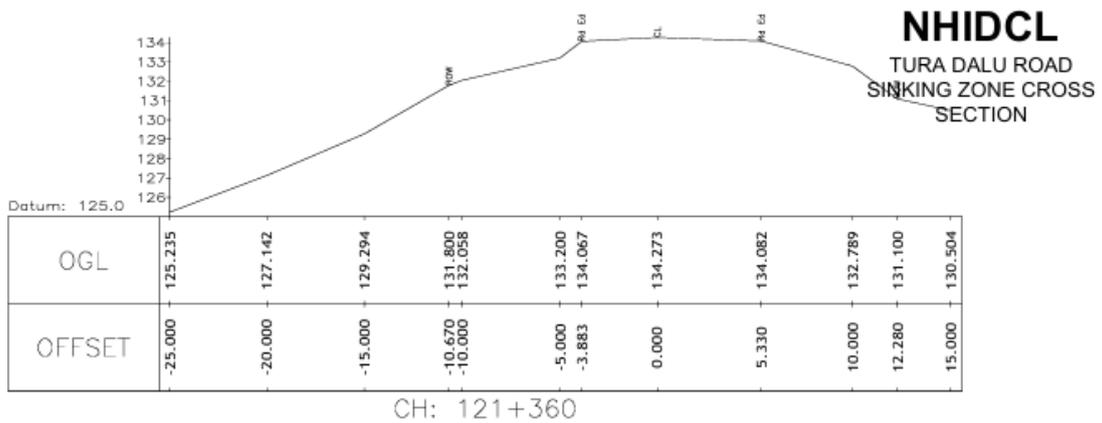
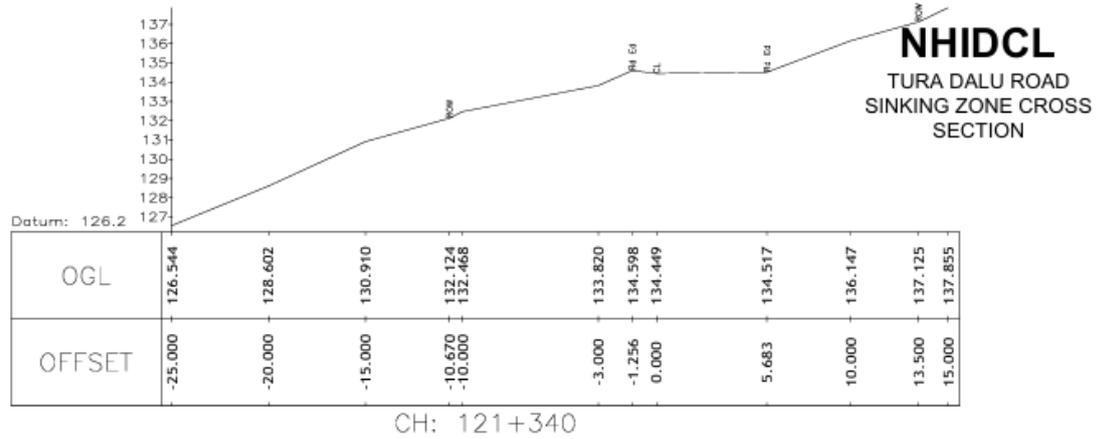
W-4.6

Area- 425

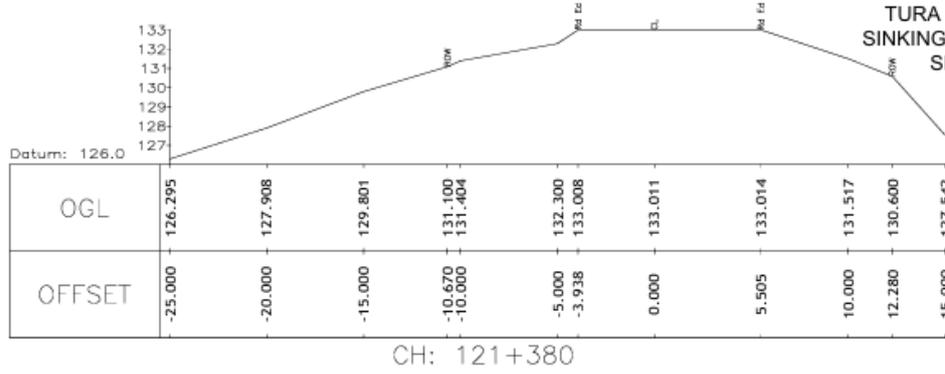
Fill vol- 1955

2. Paved Shoulders

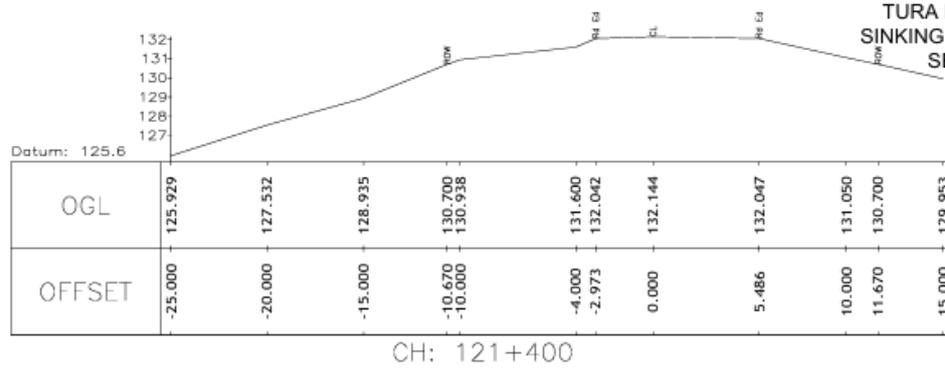


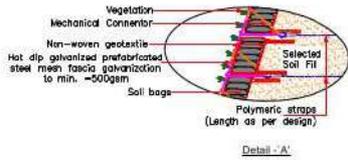


NHIDCL
 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION



NHIDCL
 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION





High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	g/sqm
		Mass per unit area total (geotextile+mini pipes)	612	
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
		Under 20 kPa	5.0	
Tensile Strength	NF EN 150	Machine Direction	24	kN/m
		Cross Direction	24	

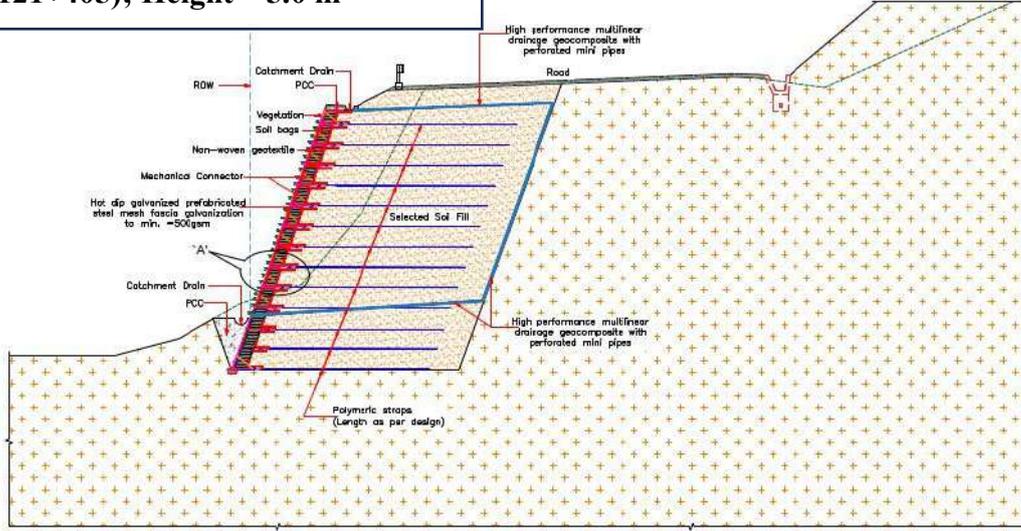
Polymeric Straps - Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE).

Polymeric Straps Specification				
Properties	Test Method	Unit	Minimum average rol value	
Ultimate Tensile Strength	Indian or International standard	kN	25	30
Width		mm	49.5	49.5

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B500c and hot dip galvanized to minimum 500gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.

Chainage from (121+320) to (121+405); Height - 5.0 m



Typical Cross Section with Mechanically Stabilization Earth Slope



Fig. 45: View of sinking zone -27 from Ch. 121+330 to 121+405 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (121+450) to (121+705)

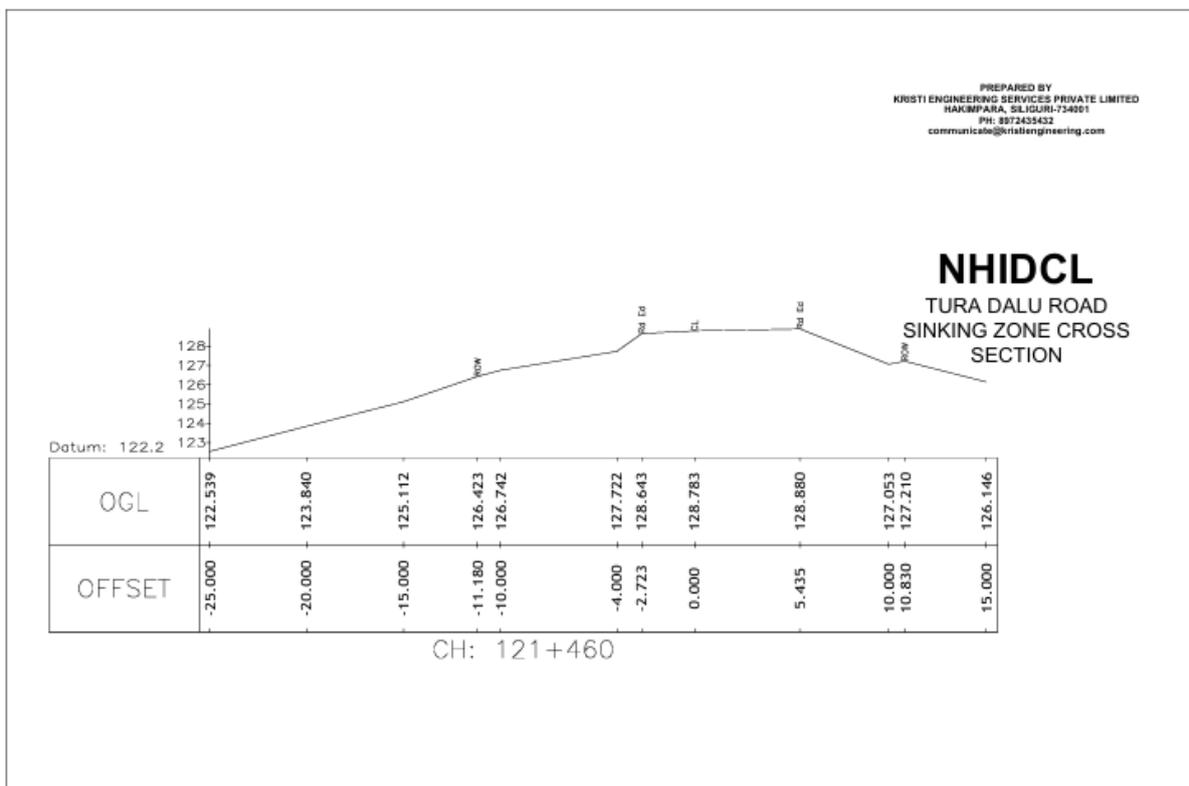
Length – 255 m

Height – 5.0 m

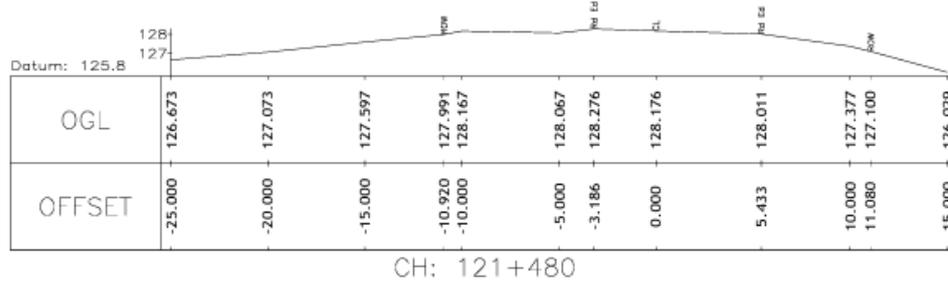
Proposed Solution:

1. Gabion Retaining Wall (5m ht) with perforated pipe to be extended up to km 121.705 (3 m height in extended 195 m length).

2. Paved Shoulders



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 SINKING ZONE CROSS
 SECTION



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 SINKING ZONE CROSS
 SECTION

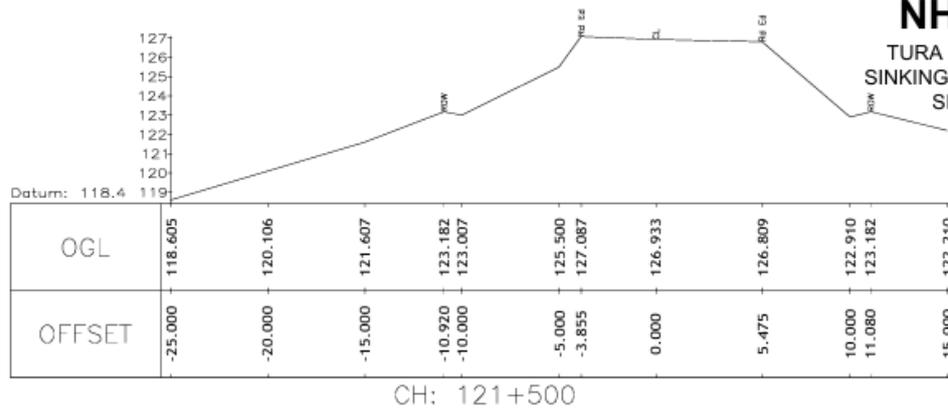




Fig. 46: View of sink zone-28

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (121+705) to (121+760)

Length – 55 m

Height – 4.0 m

Proposed Solution:

1. Mechanically stabilised Earth wall

L-55

H-4

W-4.2

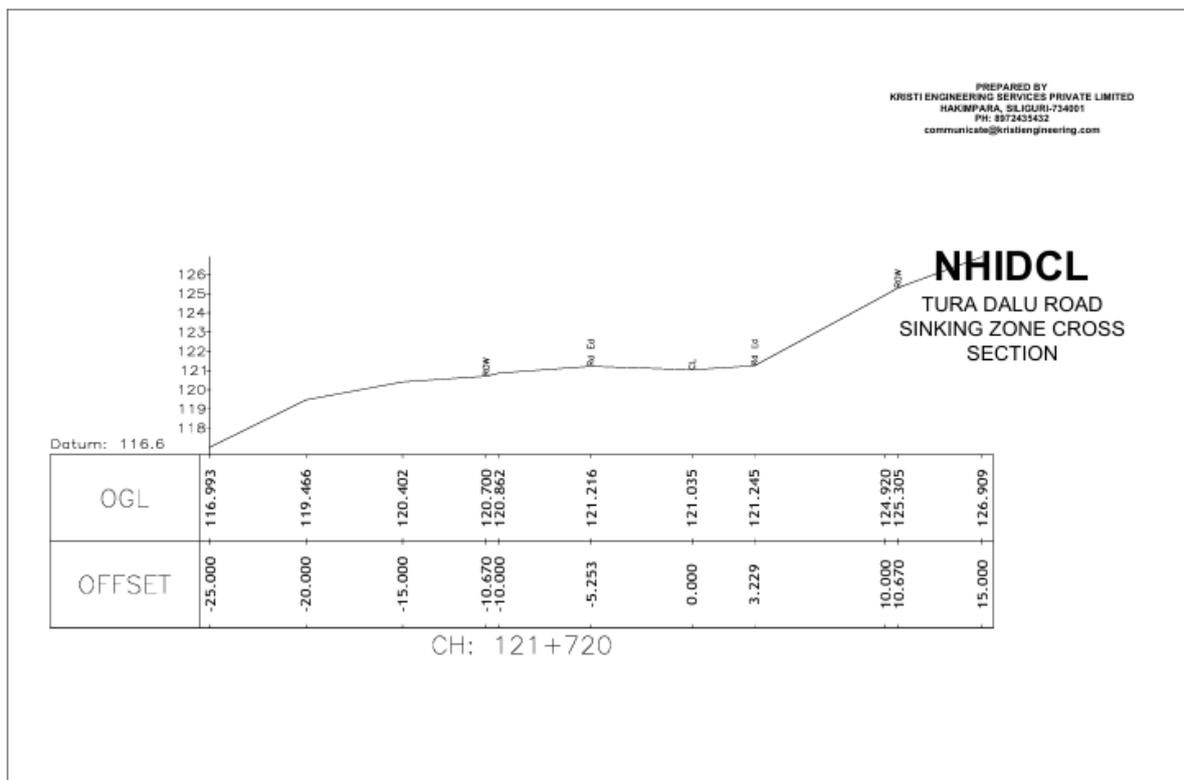
Area- 220

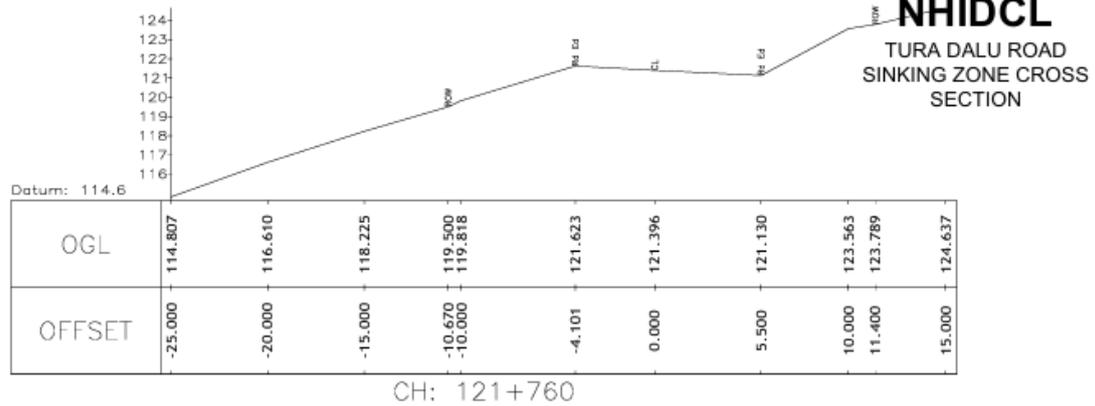
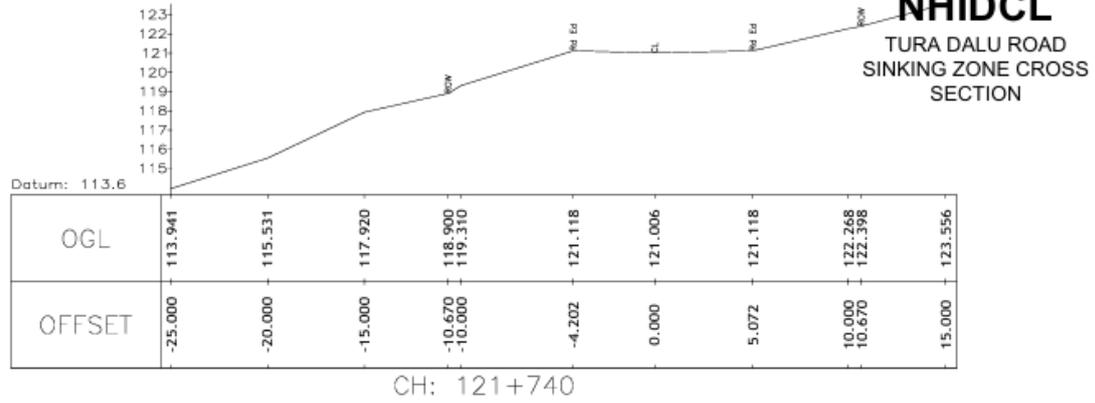
Fill vol- 924

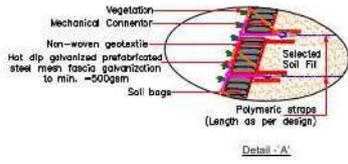
2. Paved Shoulders

3. Plantation

4. Grouting







High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	g/sqm
		Mass per unit area total (geotextile+mini pipes)	612	
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
		Under 20 kPa	5.0	
Tensile Strength	NF EN 150	Machine Direction	24	kN/m
		Cross Direction	24	

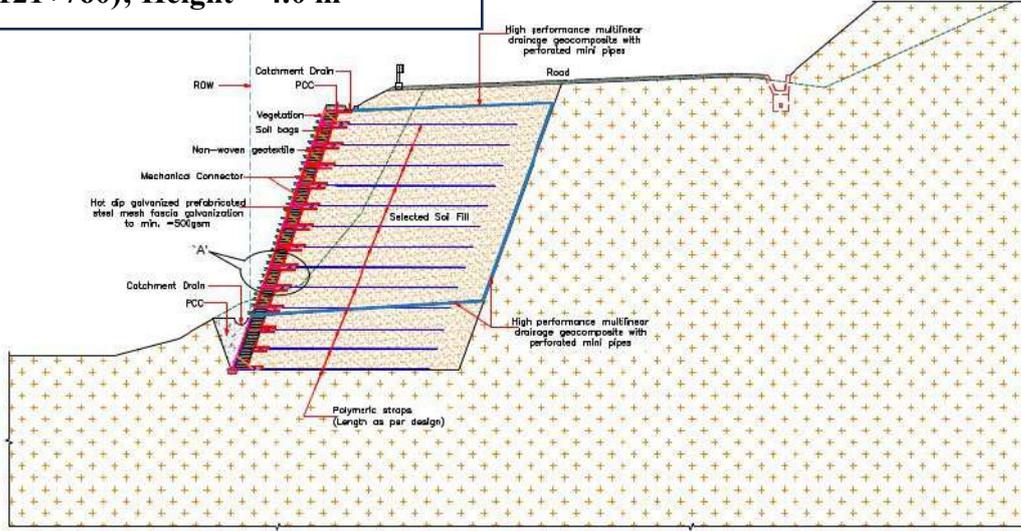
Polymeric Straps - Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE).

Polymeric Straps Specification				
Properties	Test Method	Unit	Minimum average rol value	
Ultimate Tensile Strength	Indian or International standard	kN	25	30
			40	50
			60	70
			80	90
			100	
Width		mm	49.5	49.5
			49.5	49.5
			49.5	49.5

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B500c and hot dip galvanized to minimum 500gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.

Chainage from (121+705) to (121+760); Height - 4.0 m



Typical Cross Section with Mechanically Stabilization Earth Slope



Fig. 47: View of sinking zone-29 between Ch. 121+705 to 121+760 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (121+800) to (121+880)

Length – 80 m

Height – 3.0 m

Proposed Solution:

1. Gabion Retaining Wall (3m ht) with perforated pipe.
2. Paved Shoulders
3. One row of grouting on both sides at 3 m spacing and 5 m depth
4. Plantation



Fig. 48: View of sinking zone -30 between Ch. 121+800 and 121+830 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (121+880) to (122+050)

Length – 170 m

Height – 4.0 m

Proposed Solution:

1. Gabion Retaining Wall (4m ht) in 90 m with perforated pipe (km 121.880 to km 121.970)
2. MSE Wall (4m ht) in 80 m (km 121.970 to km 122.050).

L-80

H-4

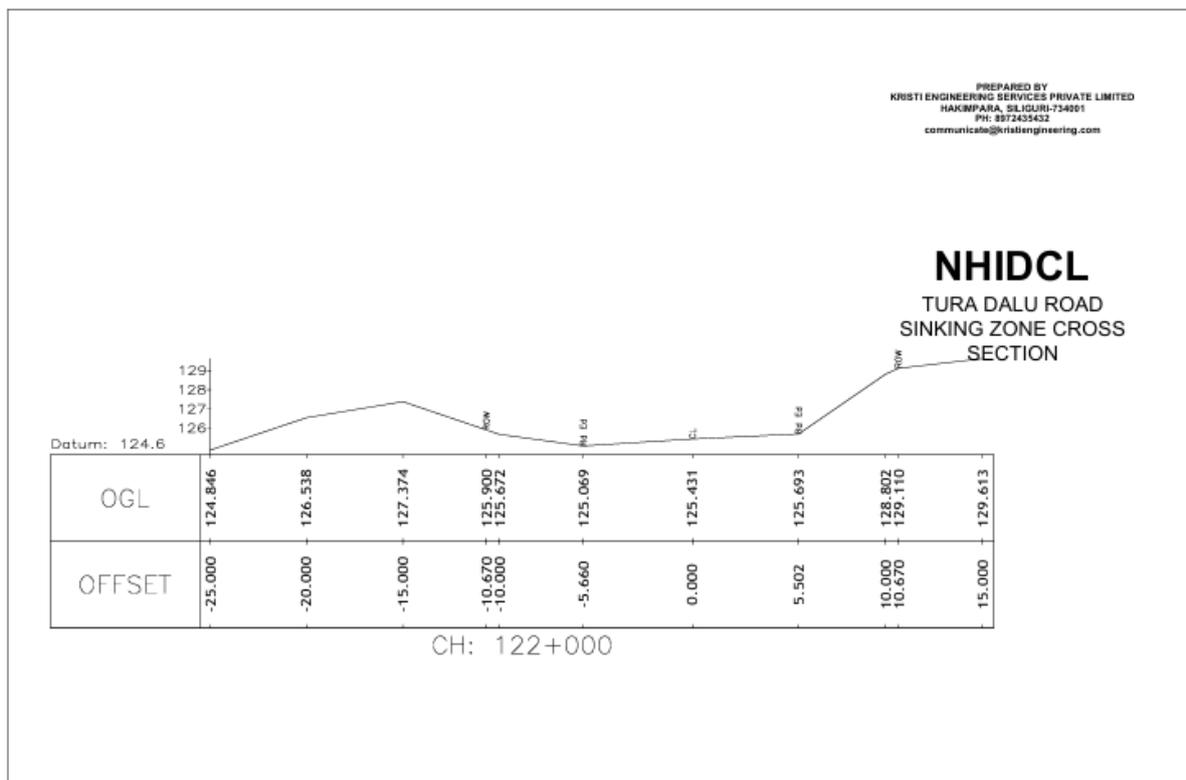
W-4.2

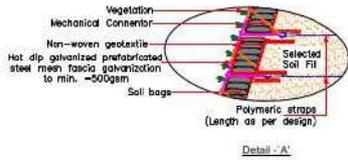
Area- 320

Fill vol- 1344

3. Paved Shoulders

4. Plantation





High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	g/sqm
		Mass per unit area total (geotextile+mini pipes)	612	
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
		Machine Direction	5.0	
Tensile Strength	NF EN 150	Machine Direction	24	kN/m
		Cross Direction	24	

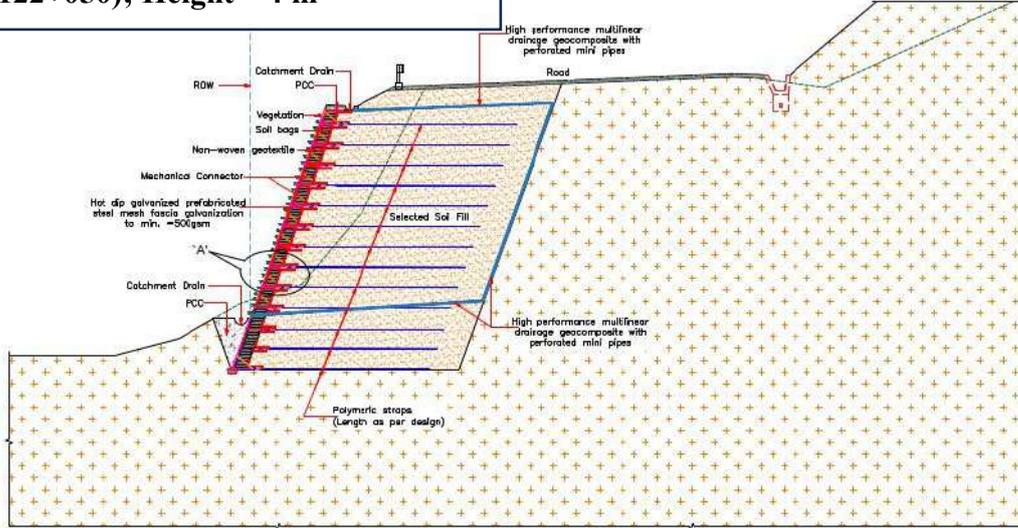
Polymeric Straps - Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE).

Polymeric Straps Specification				
Properties	Test Method	Unit	Minimum average rol value	
Ultimate Tensile Strength	Indian or International standard	kN	25	30
			40	50
			60	70
			80	90
			100	
Width		mm	49.5	49.5
			49.5	49.5
			49.5	49.5

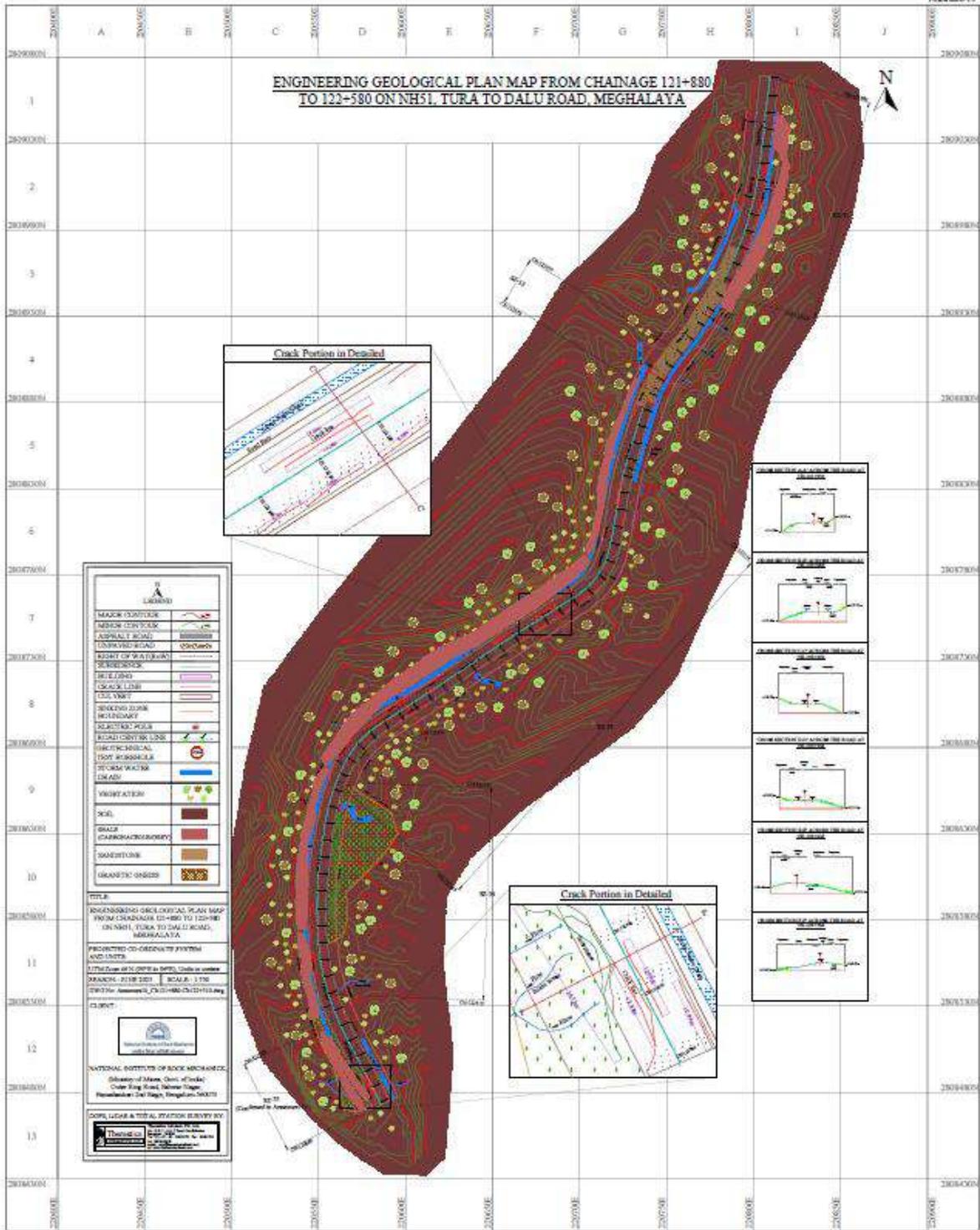
Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B550c and hot dip galvanized to minimum 500gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.

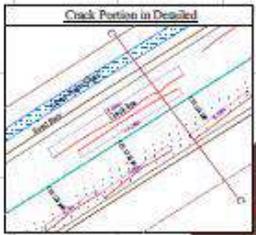
Chainage from (121+790) to (122+050); Height - 4 m



Typical Cross Section with Mechanically Stabilization Earth Slope



ENGINEERING GEOLOGICAL PLAN MAP FROM CHAINAGE 121+880 TO 122+580 ON NH51, TURA TO DALU ROAD, MEGHALAYA



LEGEND	
MAJOR HIGHWAY	
MINOR HIGHWAY	
ASPHALT ROAD	
UNPAVED ROAD	
RIGHT OF WAY BOUNDARY	
BOUNDARY	
WELL LINE	
CRACK LINE	
CRACK	
SEWERING DRAIN	
BOUNDARY	
SECTION POLE	
BOUNDARY LINE	
HYDROLOGICAL	
TOOT BOUNDARY	
FORM WATER	
ROAD	
WATER ATEN	
SOIL	
SHALE (CARBONACEOUS)	
SANDSTONE	
GRANITE GNEISS	

TITLE
 ENGINEERING GEOLOGICAL PLAN MAP FROM CHAINAGE 121+880 TO 122+580 ON NH51, TURA TO DALU ROAD, MEGHALAYA

PROJECTED CO-ORDINATE SYSTEM AND UNITS
 UTM Zone 48Q UTM & SPTS Units in meter
 DATUM: 2011
 SCALE: 1:75
 DRAWN BY:
 23/07/2023

NATIONAL INSTITUTE OF ROCK MECHANICS
 (Division of Mining, Geol. & Envtl.)
 Outer Ring Road, Shillong (Jage)
 Meghalaya - 791 004, India

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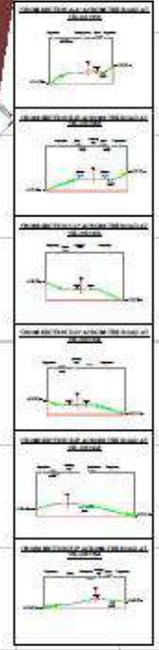
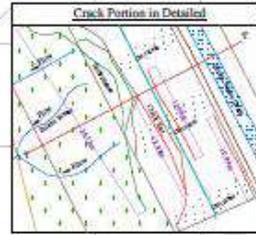




Fig. 49: View of longitudinal crack on the LHS between Ch. 121+880 and 122+010 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (122+050) to (122+078)

Length – 28 m

Height – 4.0 m

Proposed Solution:

1. Gabion Retaining Wall (4m ht) with perforated pipe
2. Paved Shoulders
3. Plantation

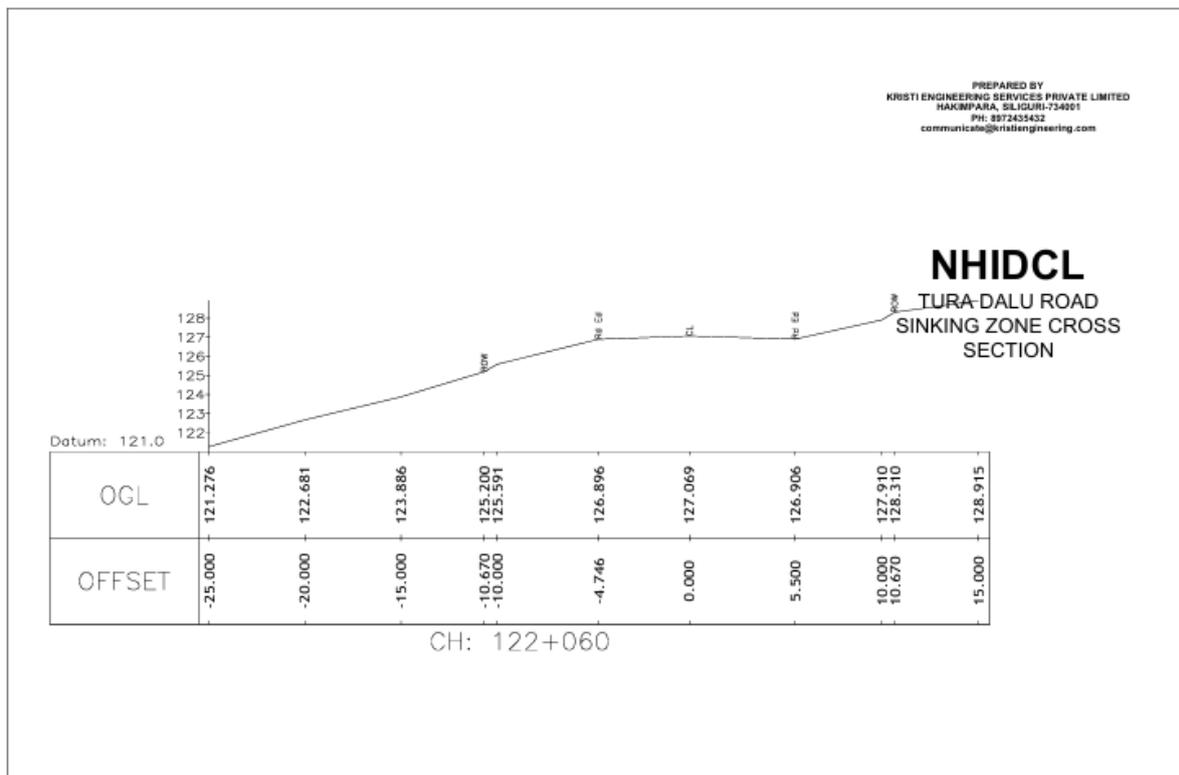




Fig. 50: View of longitudinal cracks and sinking area on the LHS

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (122+118) to (122+385)

Length – 267 m

Height – 4.0 m

Proposed Solution:

1. Gabion retaining walls Valley side
2. Paved Shoulders
3. Plantation



Fig. 51: View of longitudinal cracks on LHS in SZ-33

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

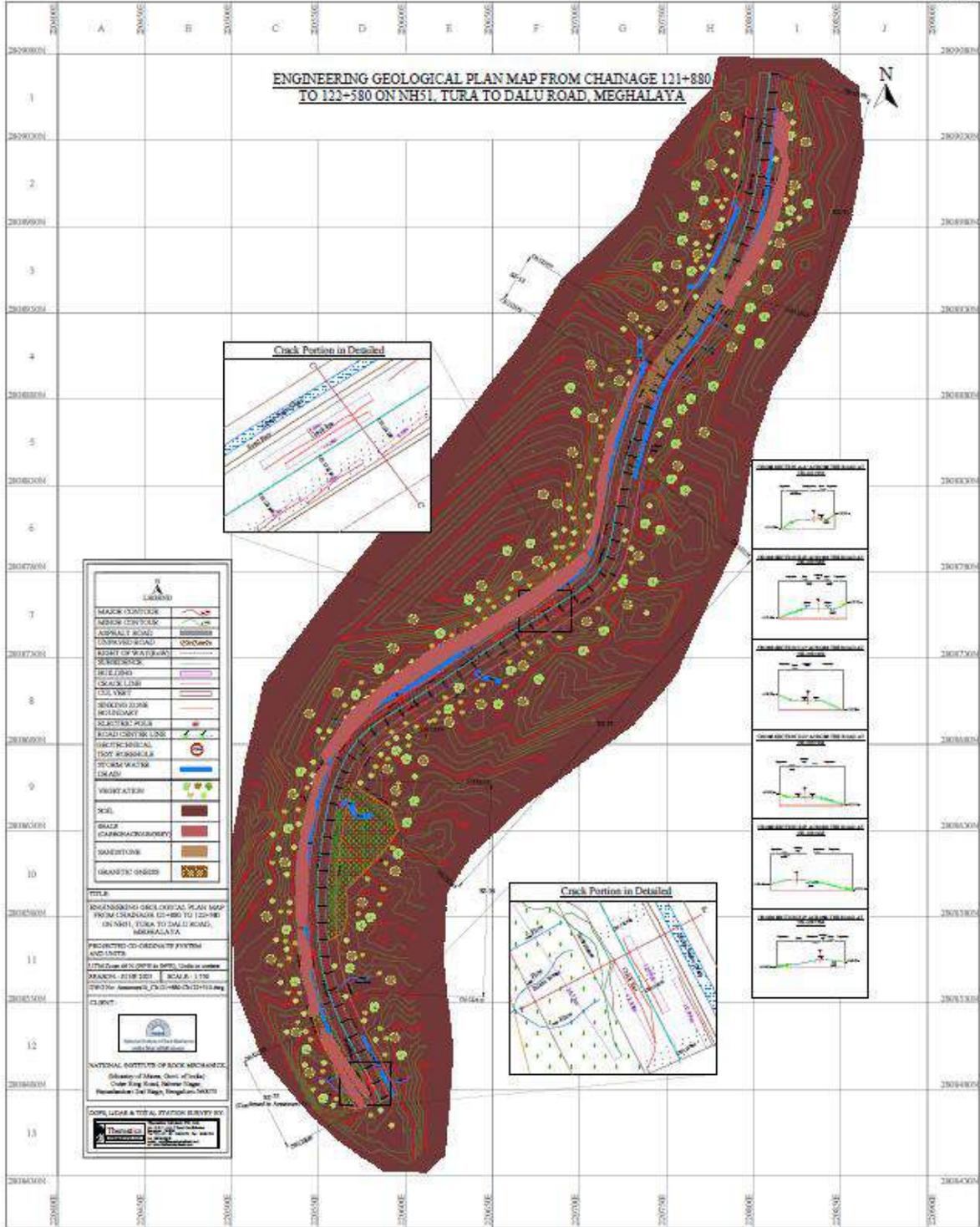
Chainage from (122+385) to (122+510)

Length – 125 m

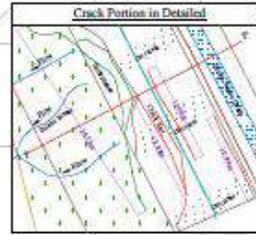
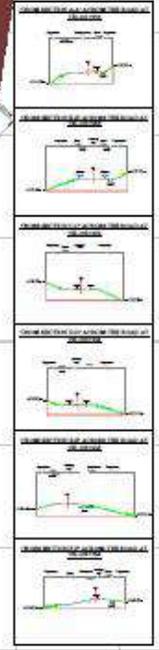
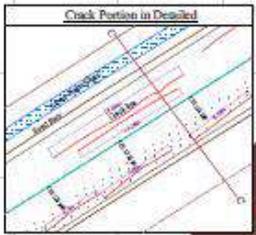
Height – 5.0 m

Proposed Solution:

1. Gabion Retaining Wall (5m ht) with perforated pipe
2. Paved Shoulders
3. Breast wall 2 meters
4. Plantation



ENGINEERING GEOLOGICAL PLAN MAP FROM CHAINAGE 121+880 TO 122+580 ON NH51, TURA TO DALU ROAD, MEGHALAYA



LEGEND	
MAJOR DRAINAGE	
MINOR DRAINAGE	
ASPHALT ROAD	
UNPAVED ROAD	
RIGHT OF WAY BOUNDARY	
SEWERAGE	
WELL/SHED	
CRACK LINE	
TOE WALL	
SEWERING DRAIN	
BOUNDARY	
SECTION POLE	
ROAD CENTER LINE	
HYDROLOGICAL	
TOOT BOUNDARY	
FORM WATER	
GRADE	
WATER TABLE	
SOIL	
SHALE (CARBONACEOUS)	
SANDSTONE	
GRANITE/GNEISS	

TITLE
 ENGINEERING GEOLOGICAL PLAN MAP FROM CHAINAGE 121+880 TO 122+580 ON NH51, TURA TO DALU ROAD, MEGHALAYA

PROJECTED CO-ORDINATE SYSTEM AND UNITS
 UTM Zone 48Q UTM & SPTS Units in meter
 DATUM: 2011
 SCALE: 1:750
 DRAWN BY:
 CHECKED BY:
 DATE: 2023

NATIONAL INSTITUTE OF ROCK MECHANICS
 (Division of Mining, Geol. & Envtl.)
 Outer Ring Road, Shillong (Jage)
 Meghalaya - 791 004, India

COPY LOGS & TOTAL STATION SURVEY BY



Fig. 42: Erosion occurring along the left-side of the roadway has led to a separation between the pavement and the adjoining ground, decreasing lateral support. This reduced confinement may contribute to cracking or potential failure of pavement structure in the vicinity of the area near Ch 122+405 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (122+525) to (122+780)

Length – 255 m

Height – 3.0 m

Proposed Solution:

1. MSE Wall (3m ht) in 80 m (km 122.535 to km 122.615).
2. Gabion Retaining Wall (3m ht) with perforated pipe in 165 m (km 122.615 to km 122.780)
3. Paved Shoulders
4. Plantation

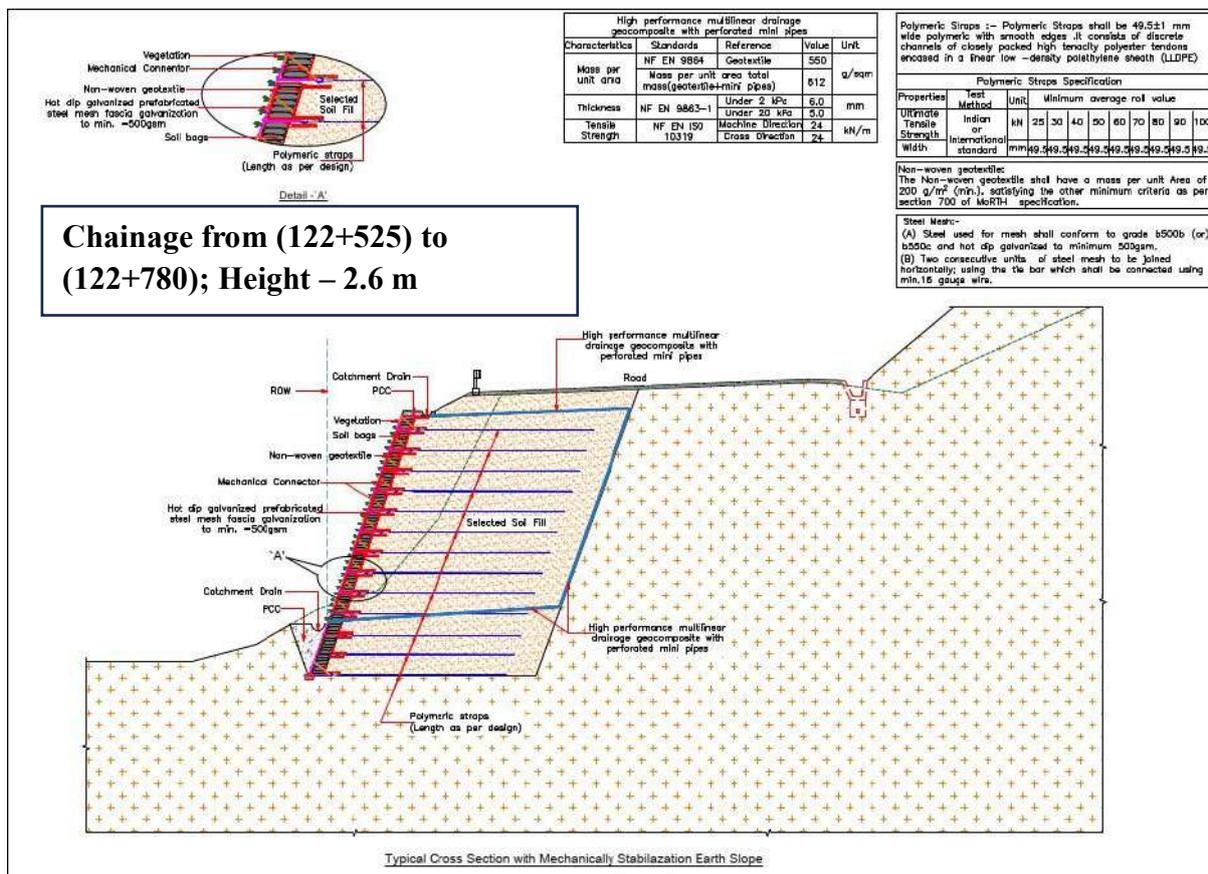




Fig. 53: Right-side portion of the road pavement failed and collapsed near Ch 122+565 km. Failed blocks were moved horizontally up to 30 cm and vertically up to 160 cm. Development of longitudinal cracks are continued in previous and further chainages to this zone. The main causes of these failure and settlement are, lack of drainage, inadequate lateral support, a weak pavement and foundation, erosion, and the movement of large vehicles near the edge.

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (122+780) to (122+870)

Length – 90 m

Height – 4.0 m

Proposed Solution:

1. Gabion Retaining Wall (4m ht) with perforated pipe to be continued upto km 122.870 (additional 15 m).
2. Paved Shoulders
3. Plantation



Fig. 54: View of longitudinal crack on LHS from Ch. 122+780 to 122+820 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

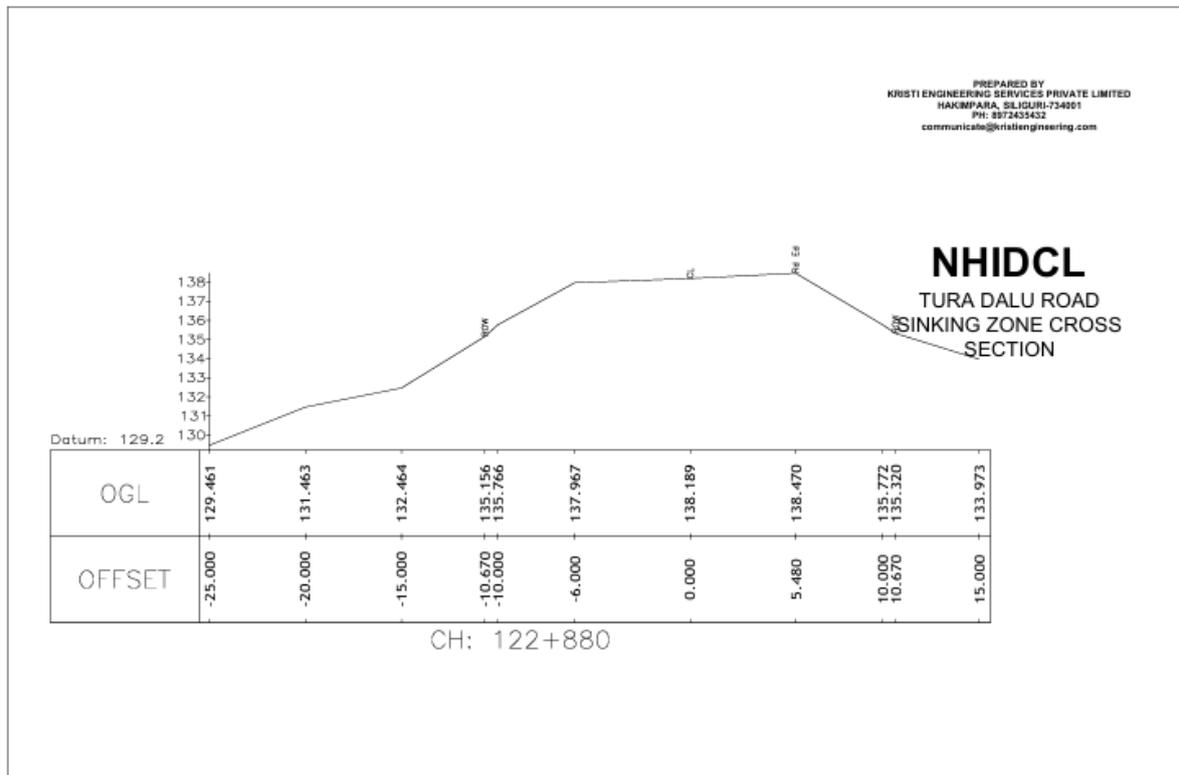
Chainage from (122+870) to (122+985)

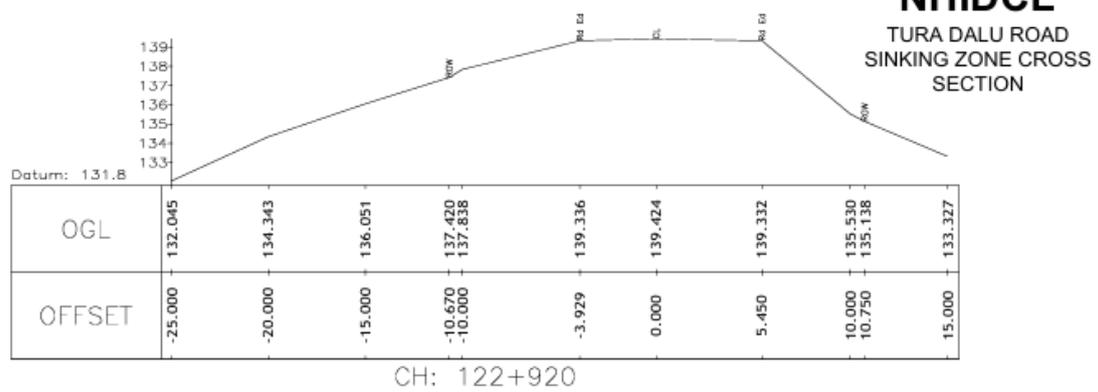
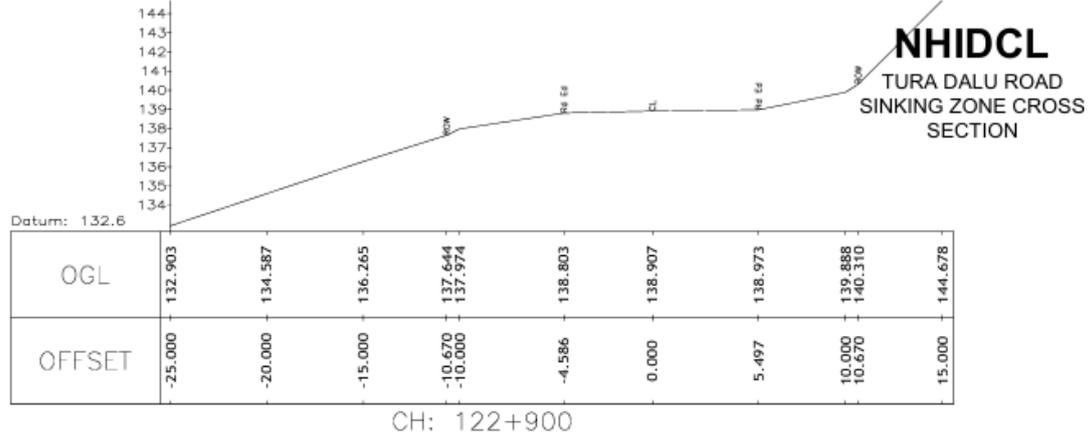
Length – 115 m

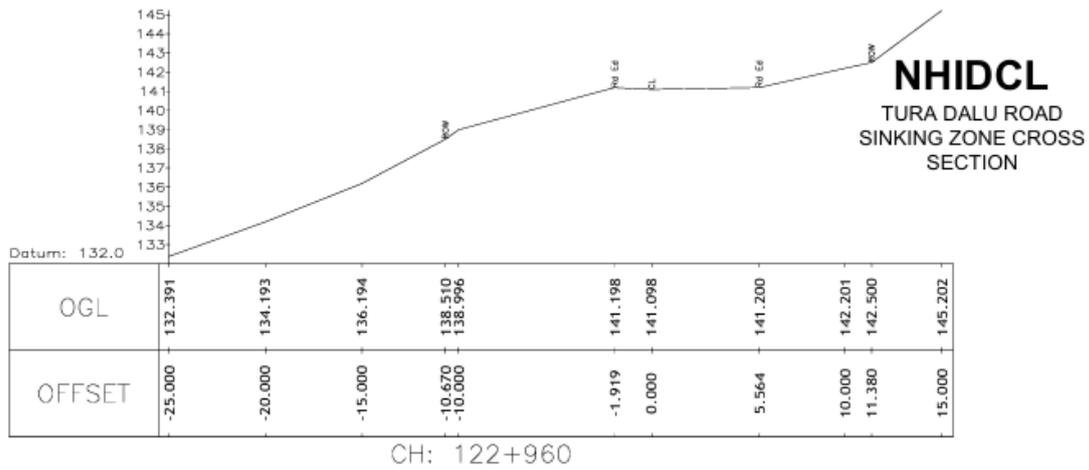
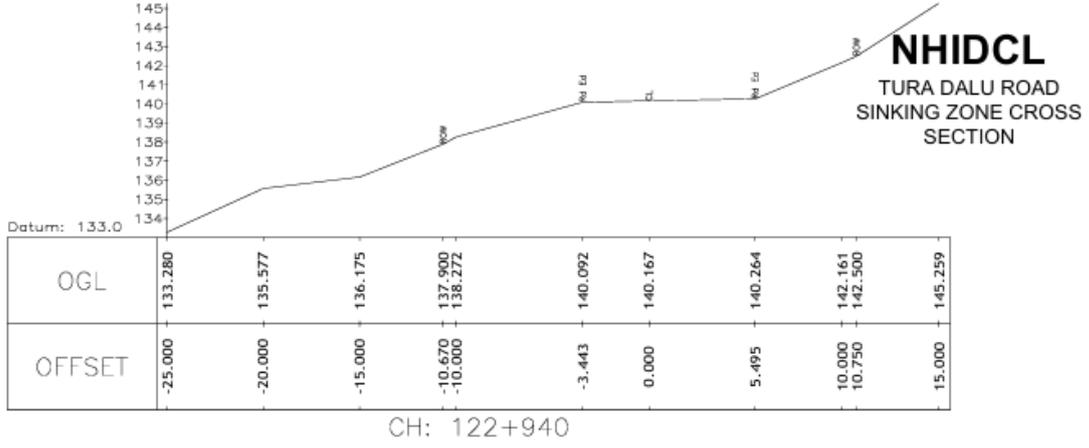
Height – 3.0 m

Proposed Solution:

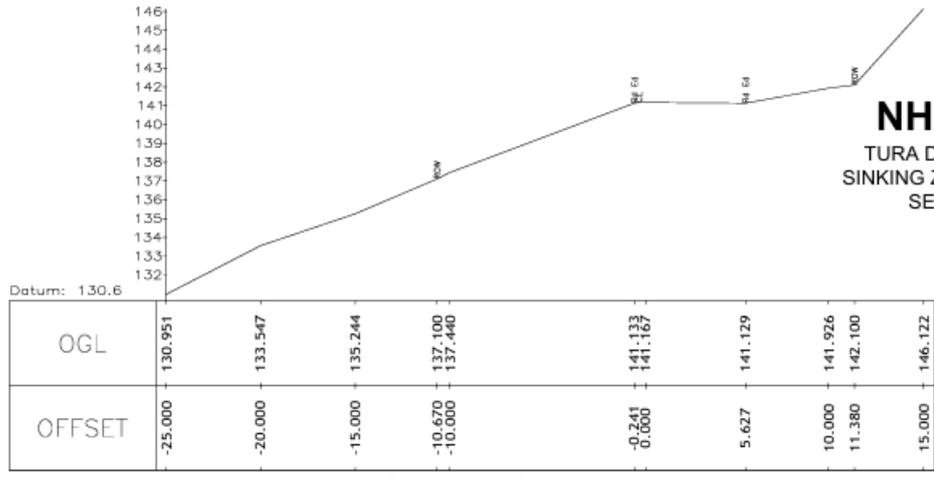
1. Gabion Retaining Wall (3m ht) with perforated pipe
2. Paved Shoulders
3. Plantation







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 KRISTI ENGINEERING SERVICES PRIVATE LIMITED
 HAKIMPURJA, SILIGURI-734001
 PH: 9872455432
 communicate@kristiengineering.com



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 SINKING ZONE CROSS
 SECTION

CH: 122+980



Fig. 55: View of sinking zone on LHS from Ch. 122+870 to 122+985 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (122+985) to (123+160)

Length – 175 m

Height – 3.0 m

Proposed Solution:

1. Gabion Retaining Wall (3m ht) with perforated pipe in 105 m (km 122.985 to km 123.090).
2. MSE Wall (3m ht) in 70 m (km 123.090 to km 123.160).

L-70

H-3

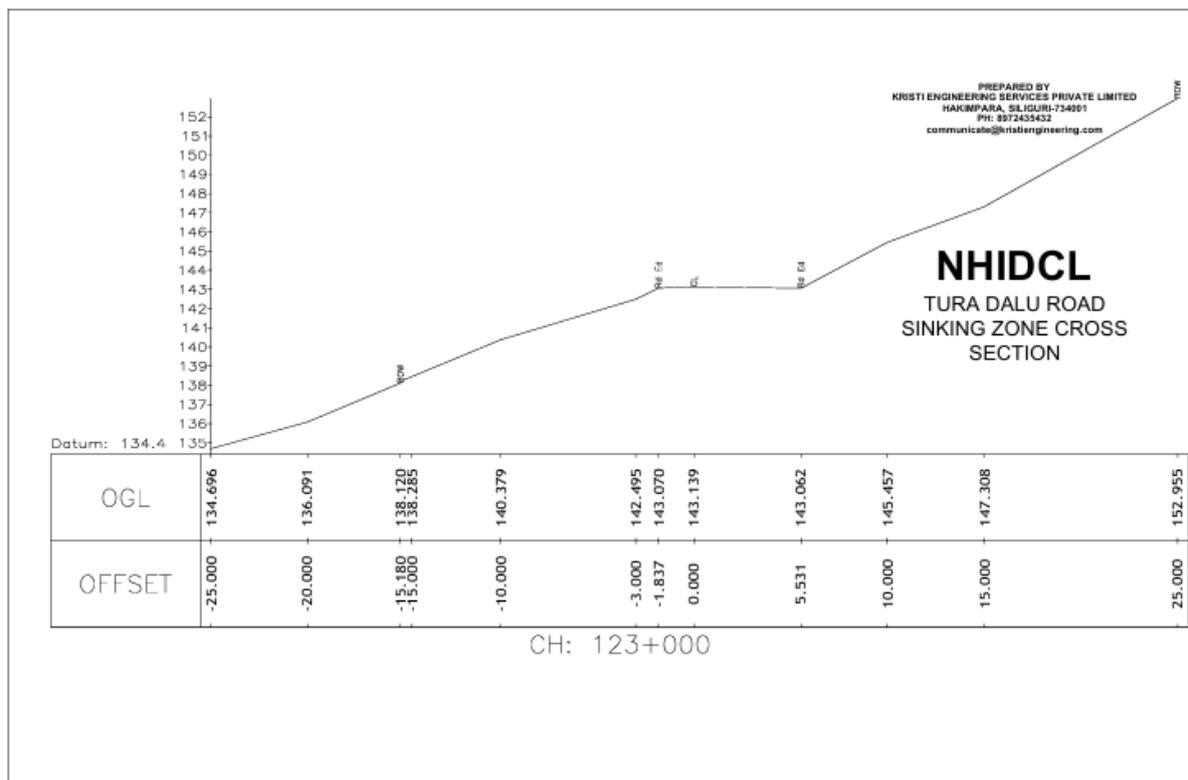
W-4

Area- 210

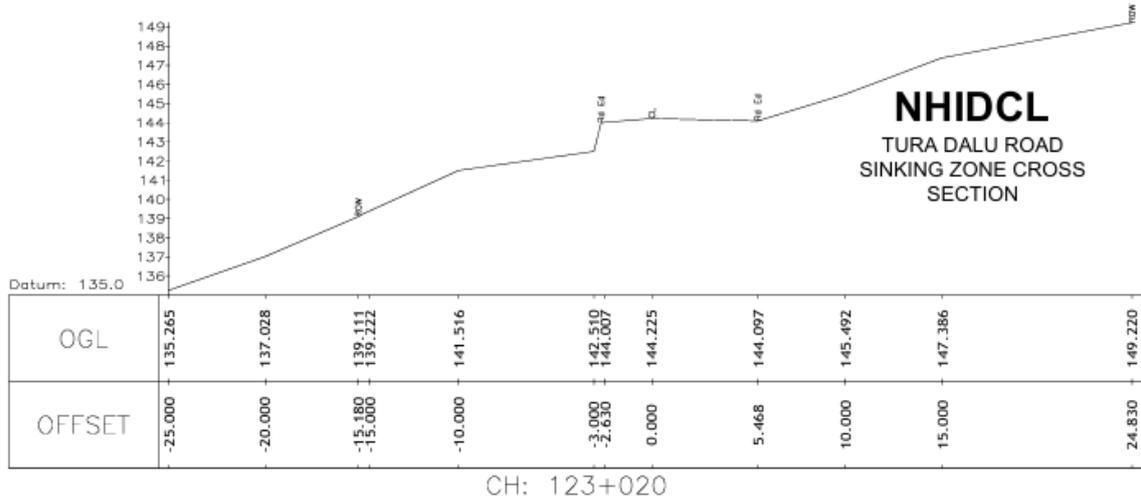
Fill vol- 840

3. Paved Shoulders

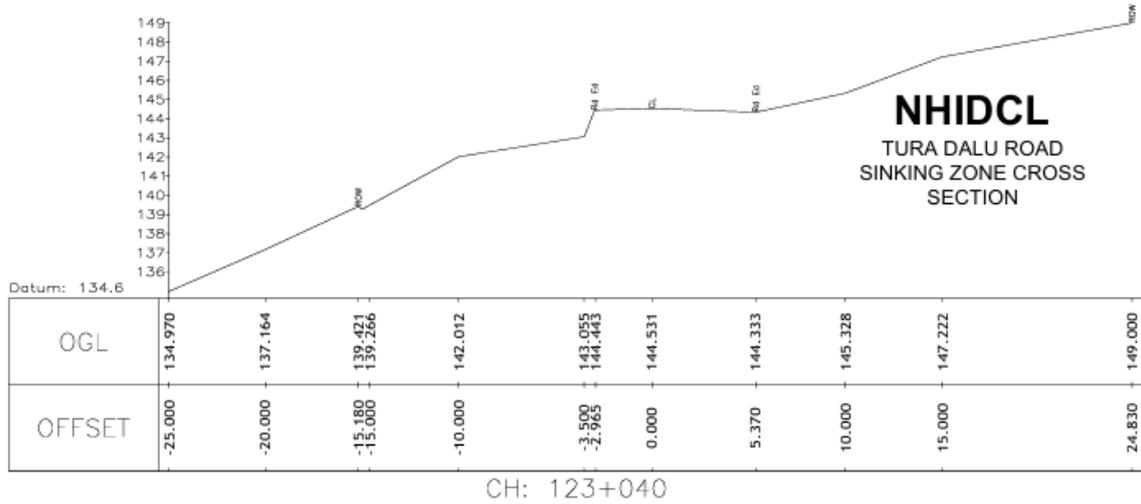
4. Plantation



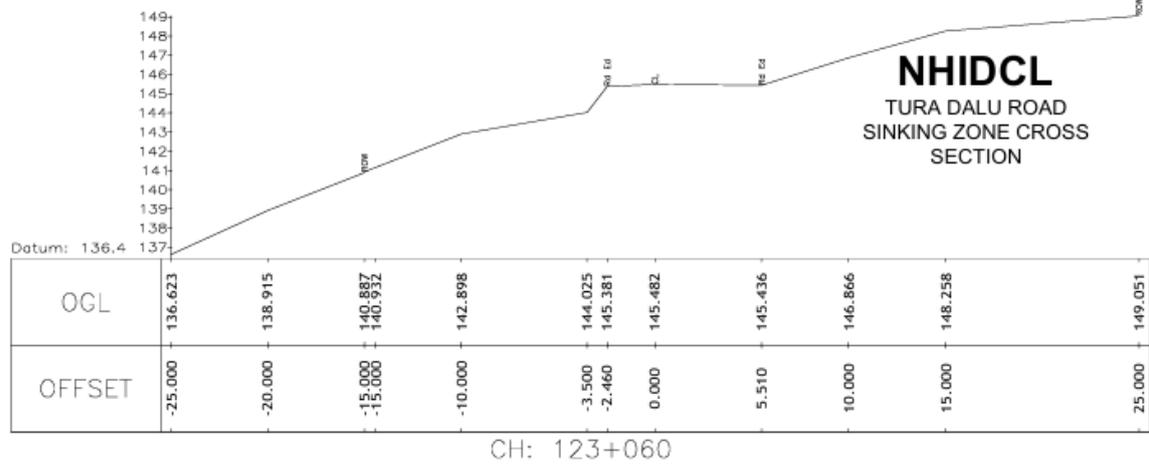
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HAKIMPURA, SILIGURI-734001
PH: 9873435432
communicate@kristiengineering.com



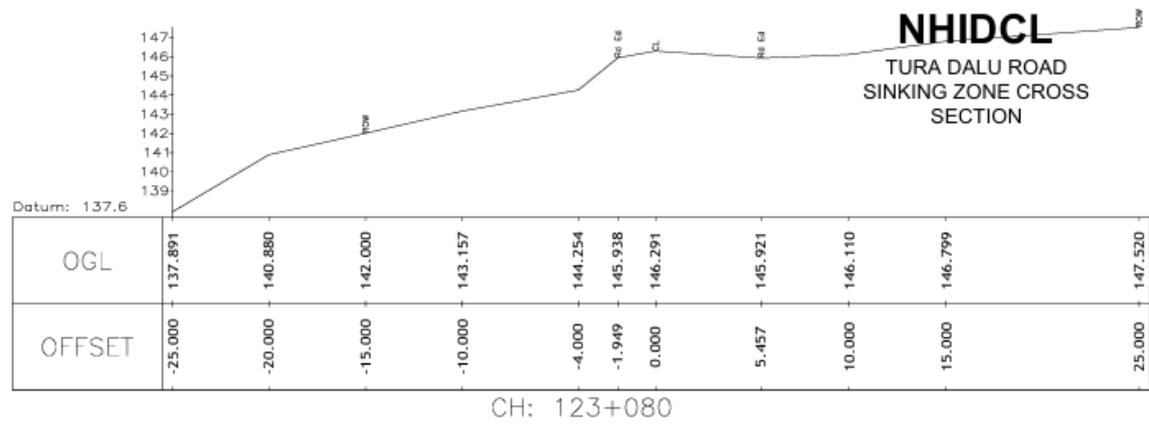
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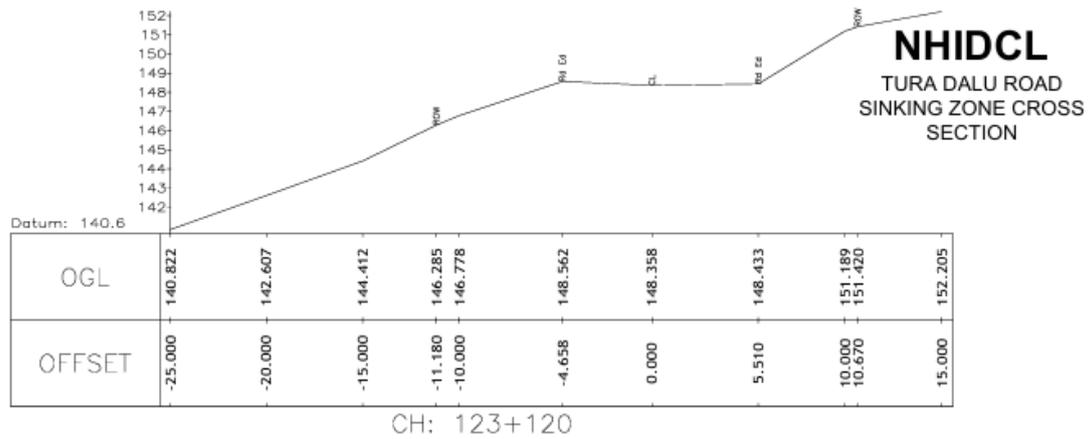
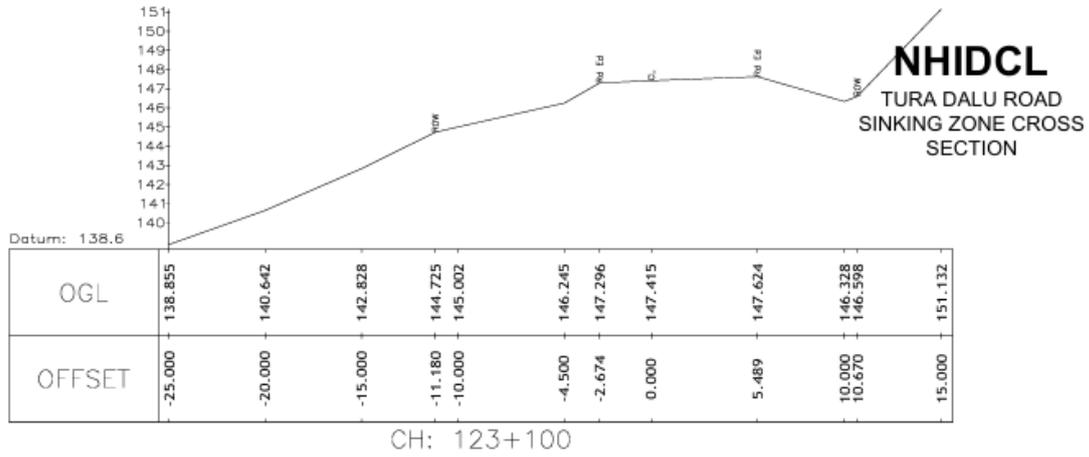


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 communicate@kristiengineering.com

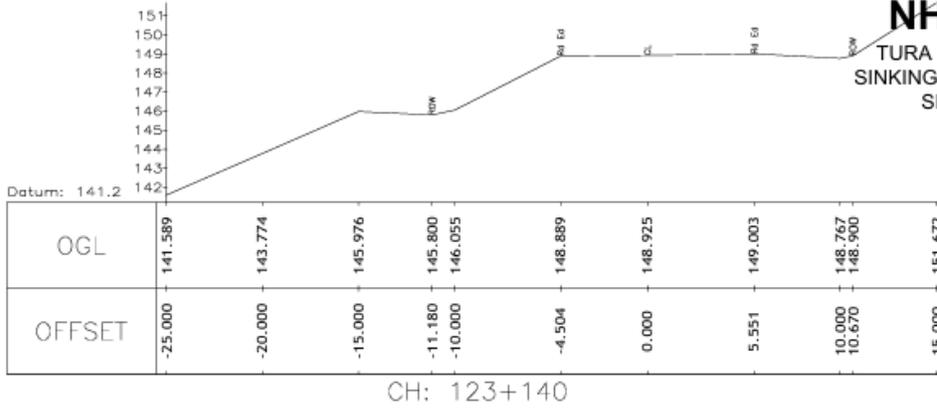


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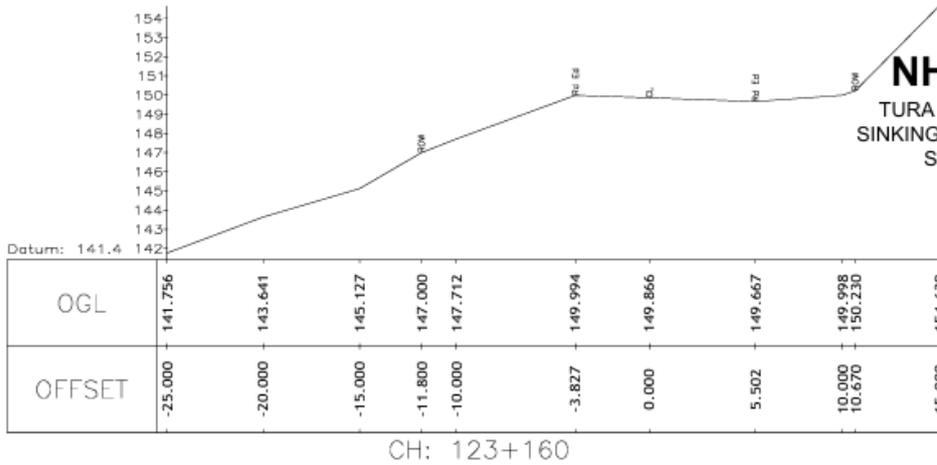


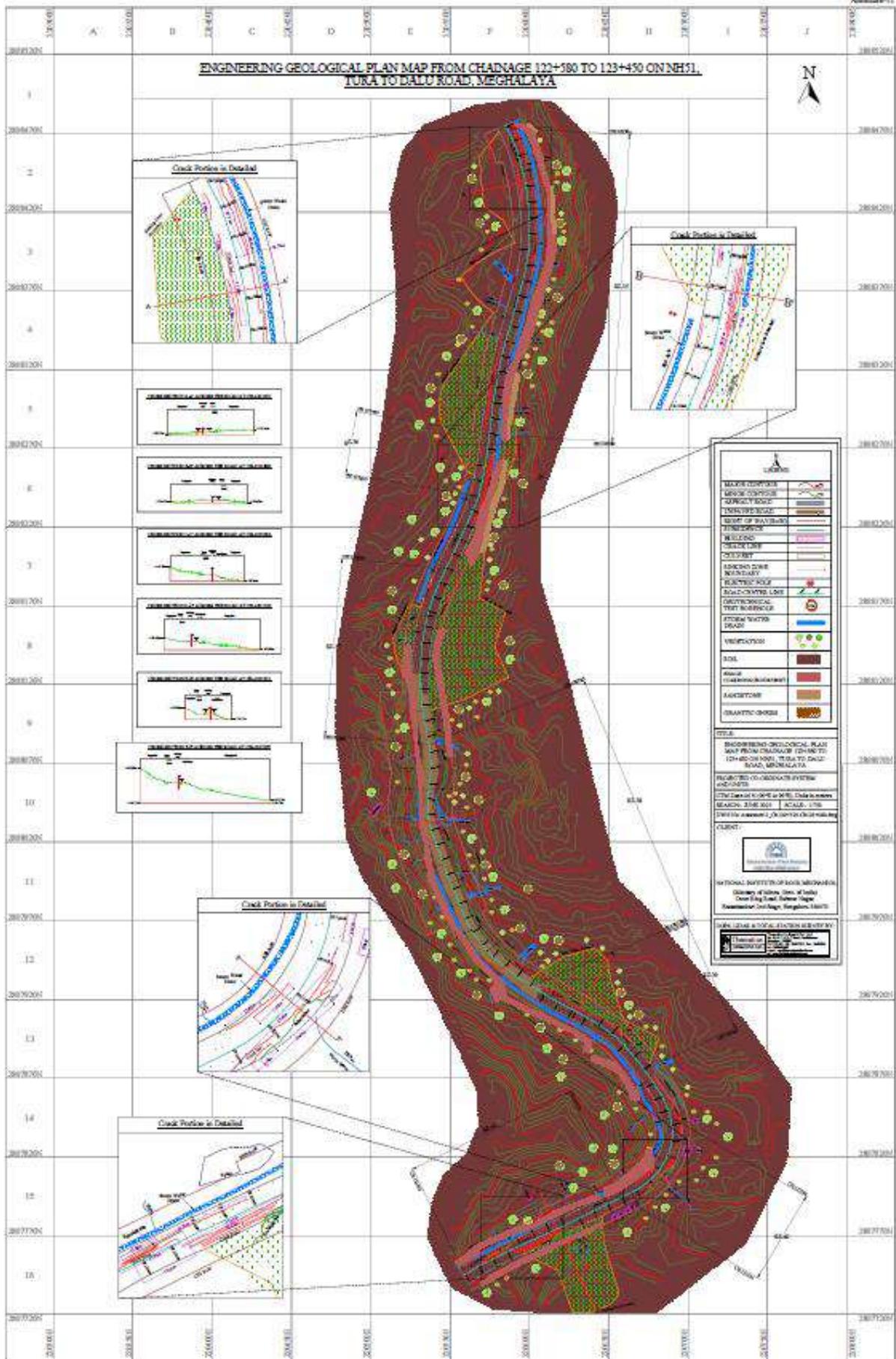


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 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION



NHIDCL
 TURA DALU ROAD
 SINKING ZONE CROSS
 SECTION





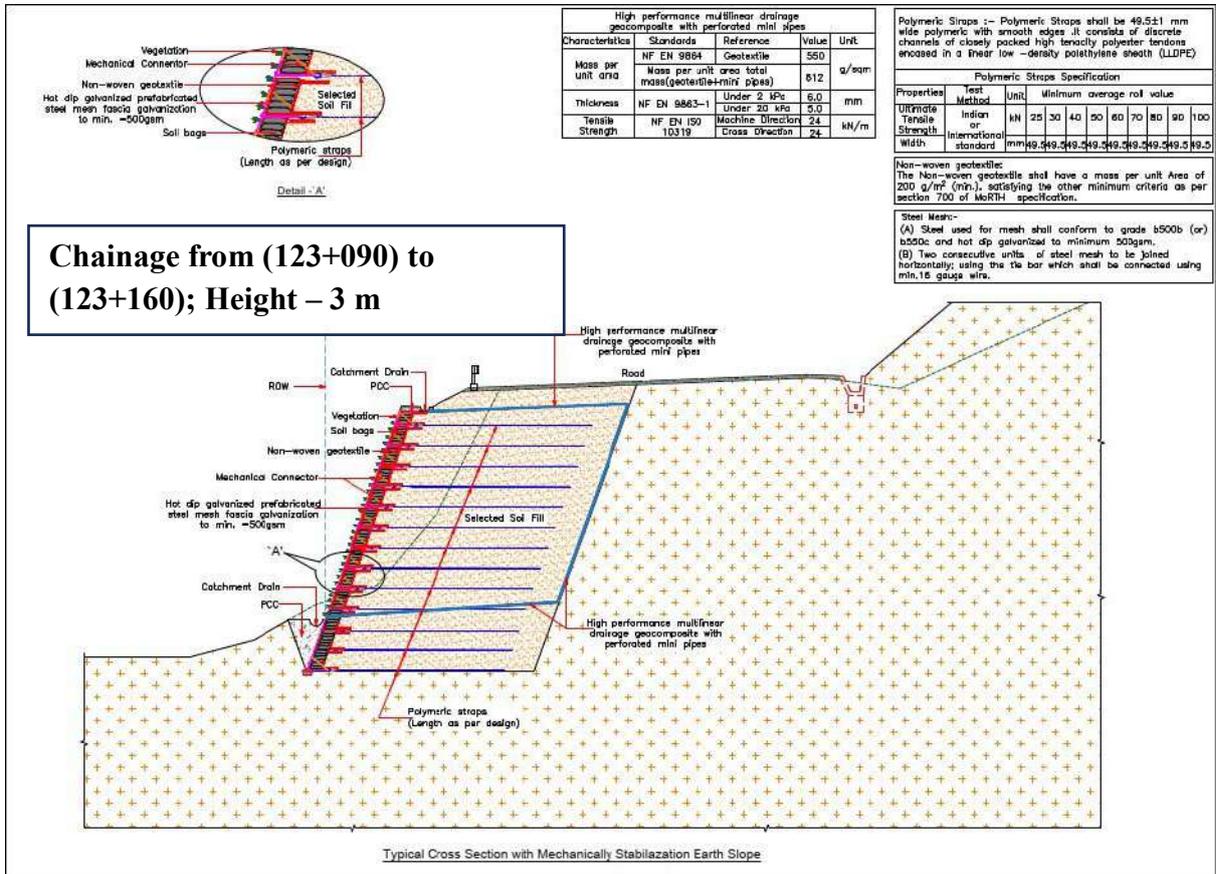


Fig. 56: View of sinking zone -38 on RHS

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (123+160) to (123+250)

Length – 90 m

Height – 3.0 m MSE, and 2.0 m Gabion breast wall

Proposed Solution:

Mechanically stabilized earth wall with gabion facia/steel wire mesh facia, selected backfill materials and drain holes is recommended. Maximum height of the wall will be 3.0 m. Gabion breast wall of 2.0 m high is also recommended. Paved shoulder up to side drain is recommended.

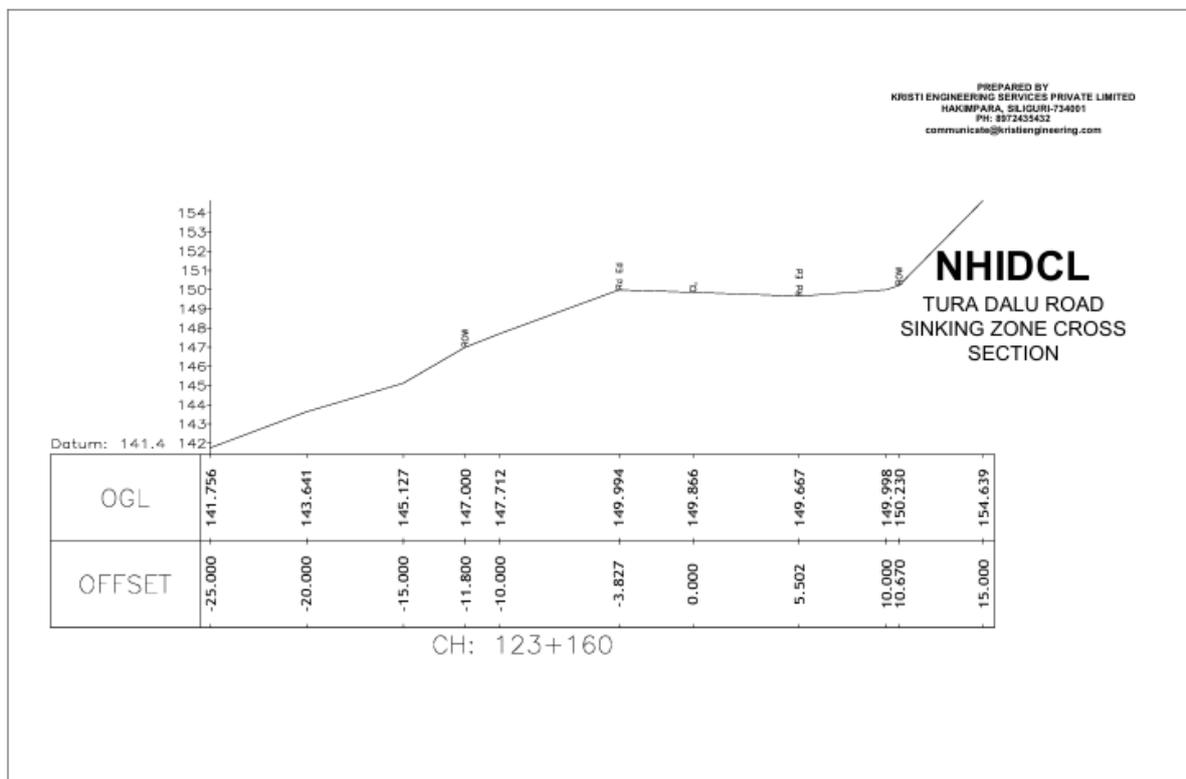
L-90

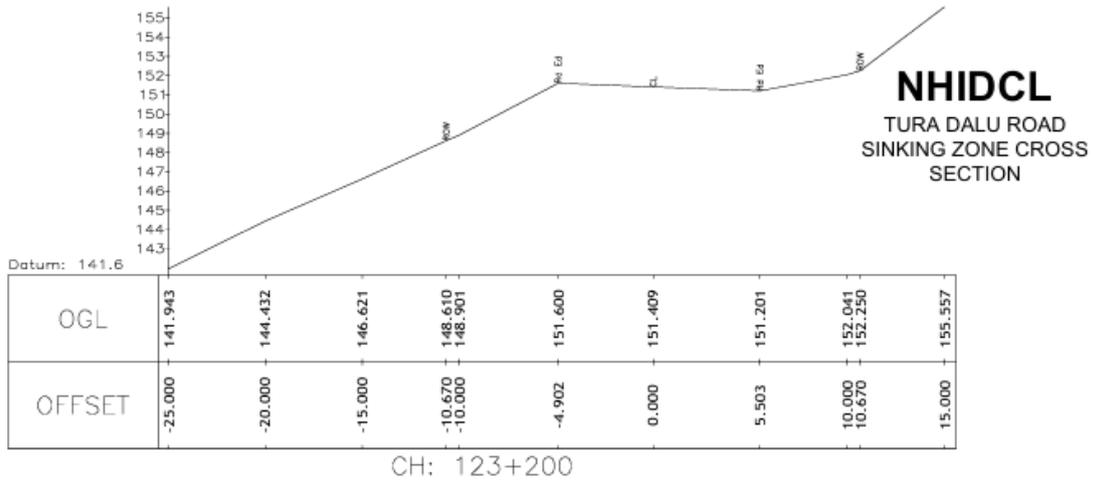
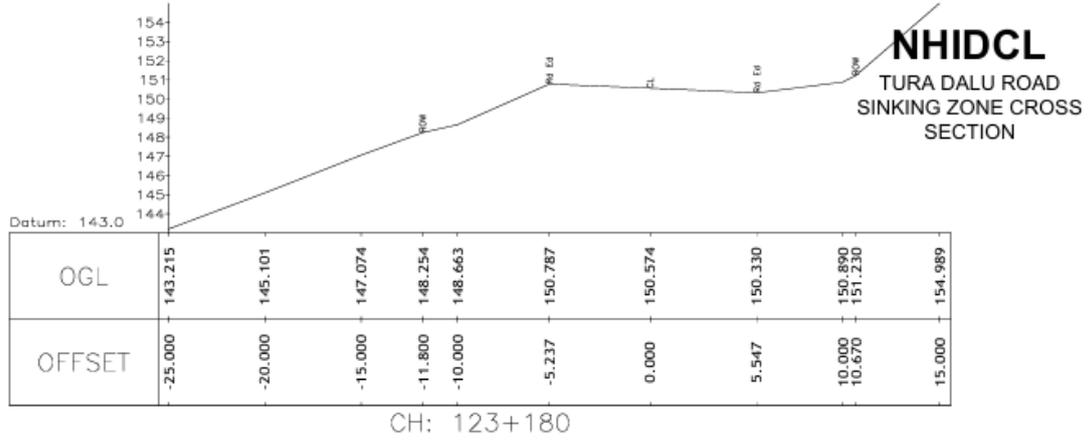
H-3

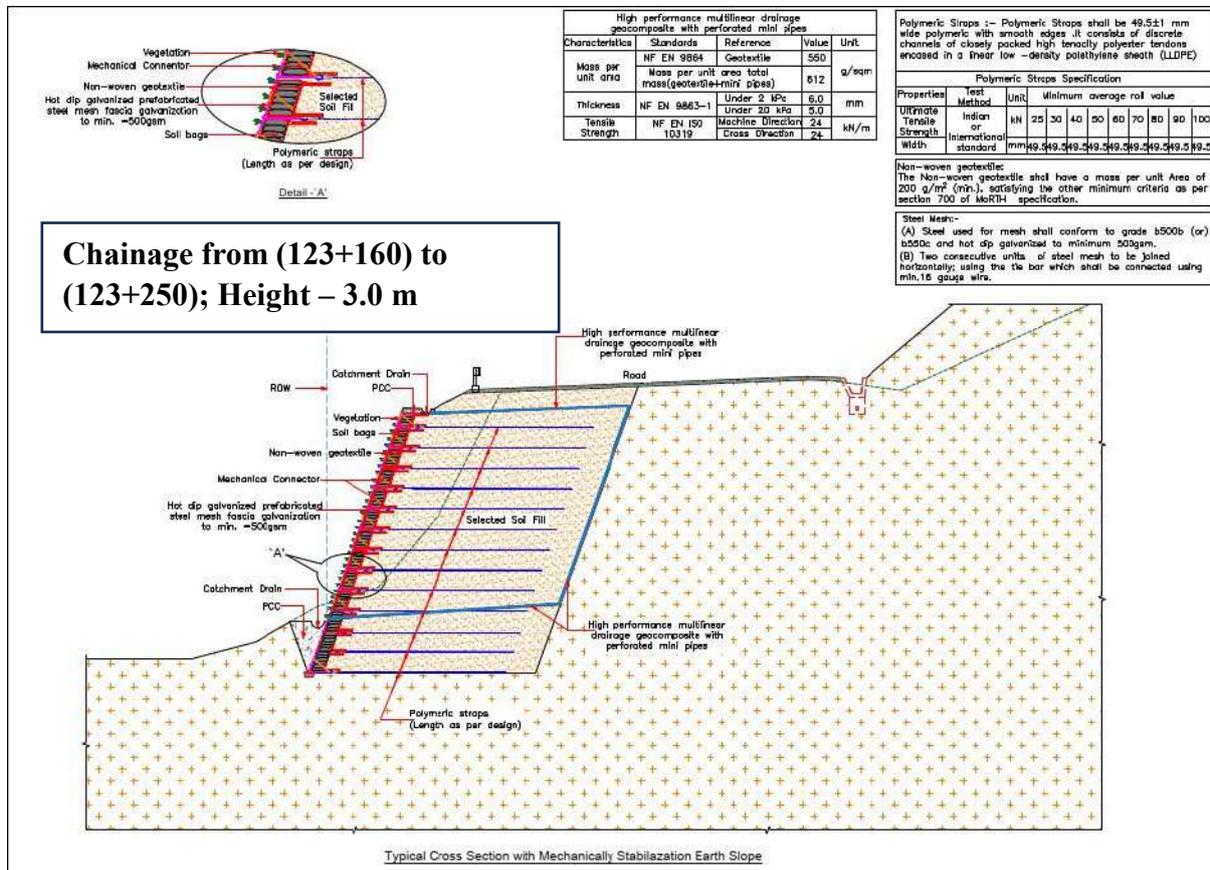
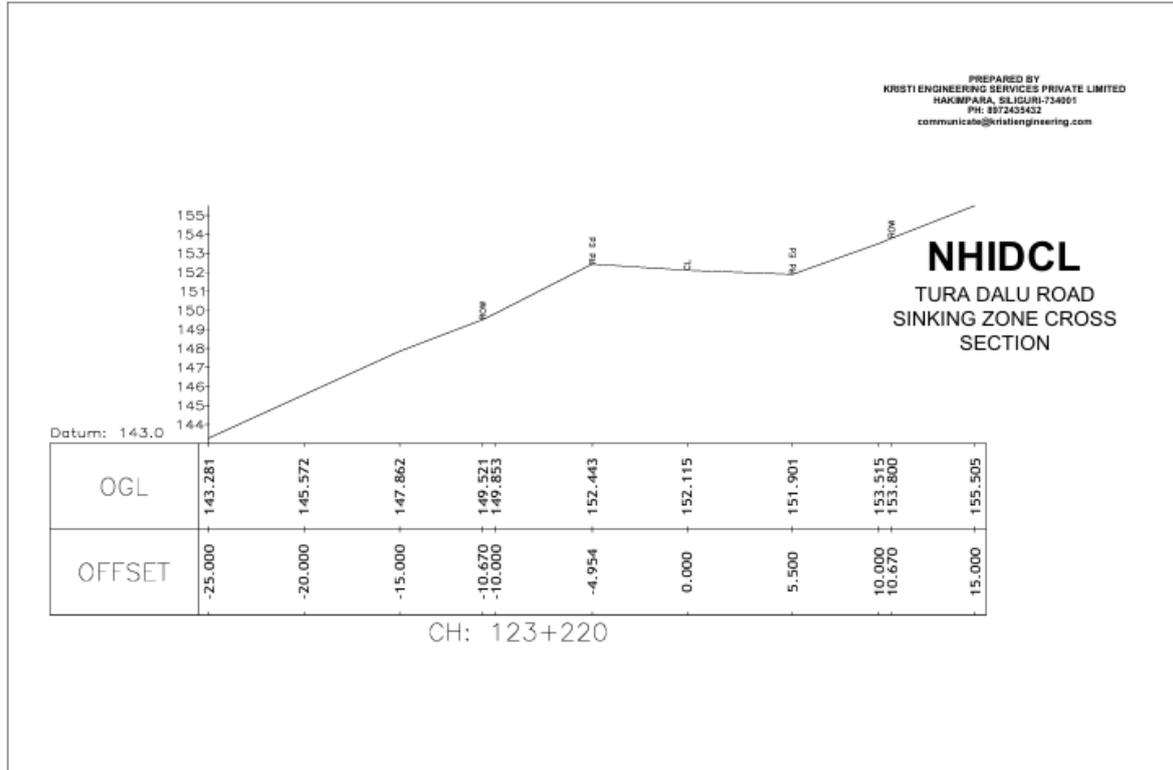
W-4

Area- 270

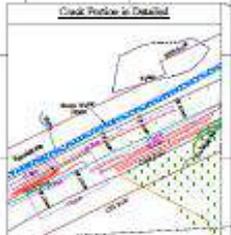
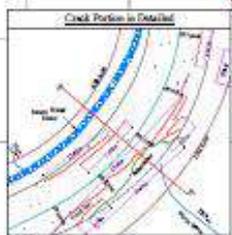
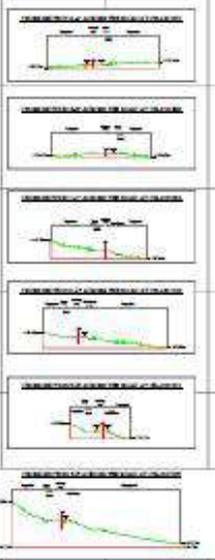
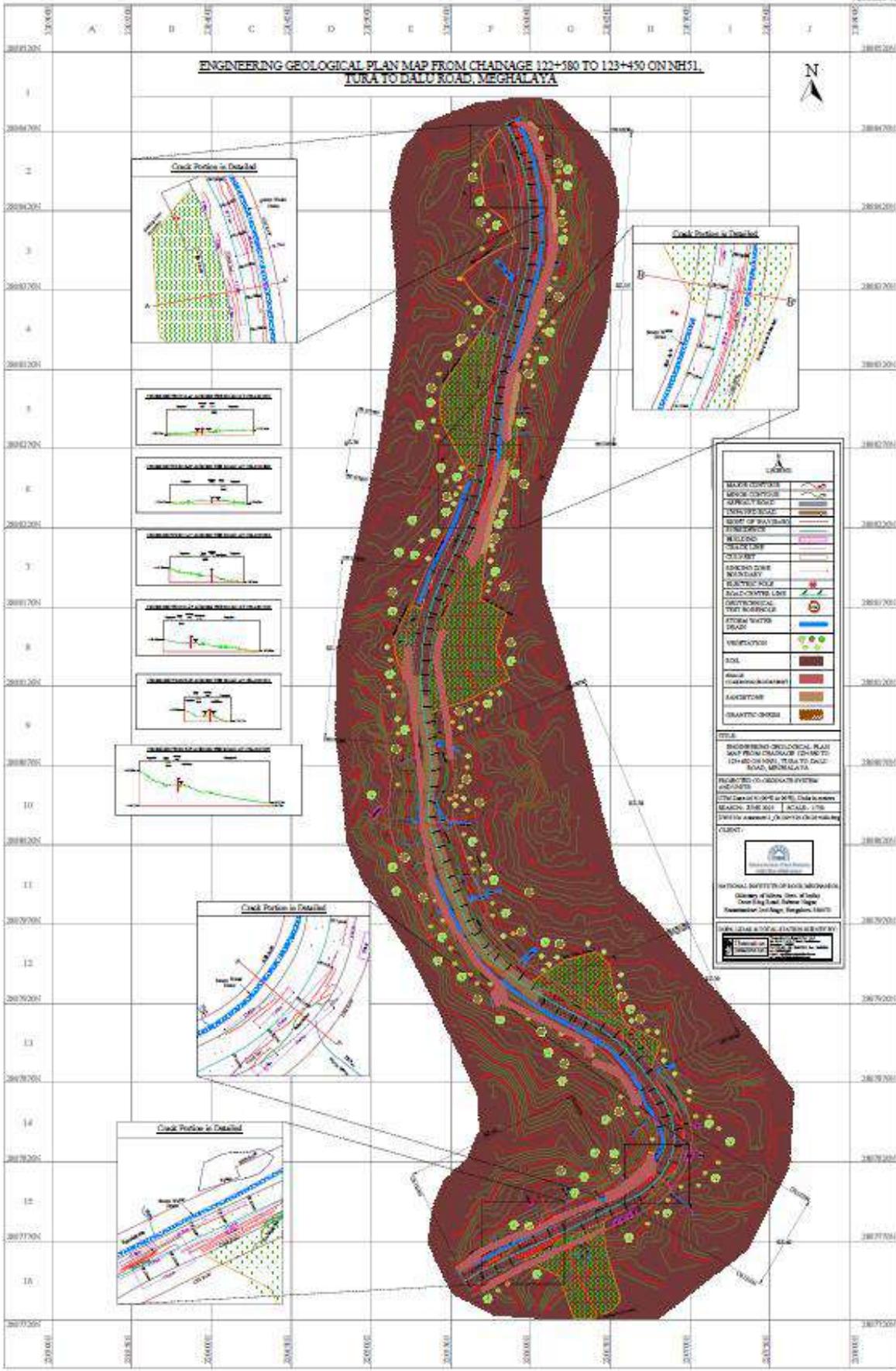
Fill vol- 1080







ENGINEERING GEOLOGICAL PLAN MAP FROM CHAINAGE 122+580 TO 123+450 ON NH51, TURA TO DALU ROAD, MEGHALAYA



LEGEND	
MAPS SYMBOLS	
ROAD CENTERLINE	
ROAD BOUNDARY	
PROPERTY BOUNDARY	
TOPOGRAPHIC	
SOFT OF SUBSTRATA	
FOUNDATION	
WELLING	
CRACK LINE	
CRACK DEPT	
FOUND. DEPT. BOUNDARY	
ELECTRIC POLE	
ROAD-CHYME LINE	
GEOTECHNICAL TEST BORING	
STONE WATER BRIDGE	
VEGETATION	
SOIL	
ALLUVIAL (sand/silt/clay)	
SANDSTONE	
DIAMANTIC GNEISS	

TITLE
 ENGINEERING GEOLOGICAL PLAN MAP FROM CHAINAGE 122+580 TO 123+450 ON NH51, TURA TO DALU ROAD, MEGHALAYA

PROJECT TO ORGANIZATION
 MORTH

DATE OF WORK
 MARCH 2018

SCALE
 1:100

CLIENT
 MORTH

APPROVED BY

PROJECT ENGINEER
 NATIONAL INSTITUTE OF ROAD METEOROLOGICAL & CIVIL ENGINEERING
 University of Jorhat, Assam, India
 Guwahati, Assam, India
 Guwahati, Assam, India

DATE OF ISSUE
 MARCH 2018



Fig. 47: Left-side portion of the road pavement failed and collapsed near Ch 123+195 km. Failed blocks were moved horizontally up to 50 cm and vertically up to 200 cm. Lack of lateral support, side erosion, weak foundation and pavement and passing of heavy vehicles close to the edge are the major cause of these cracks and shoulder settlement

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

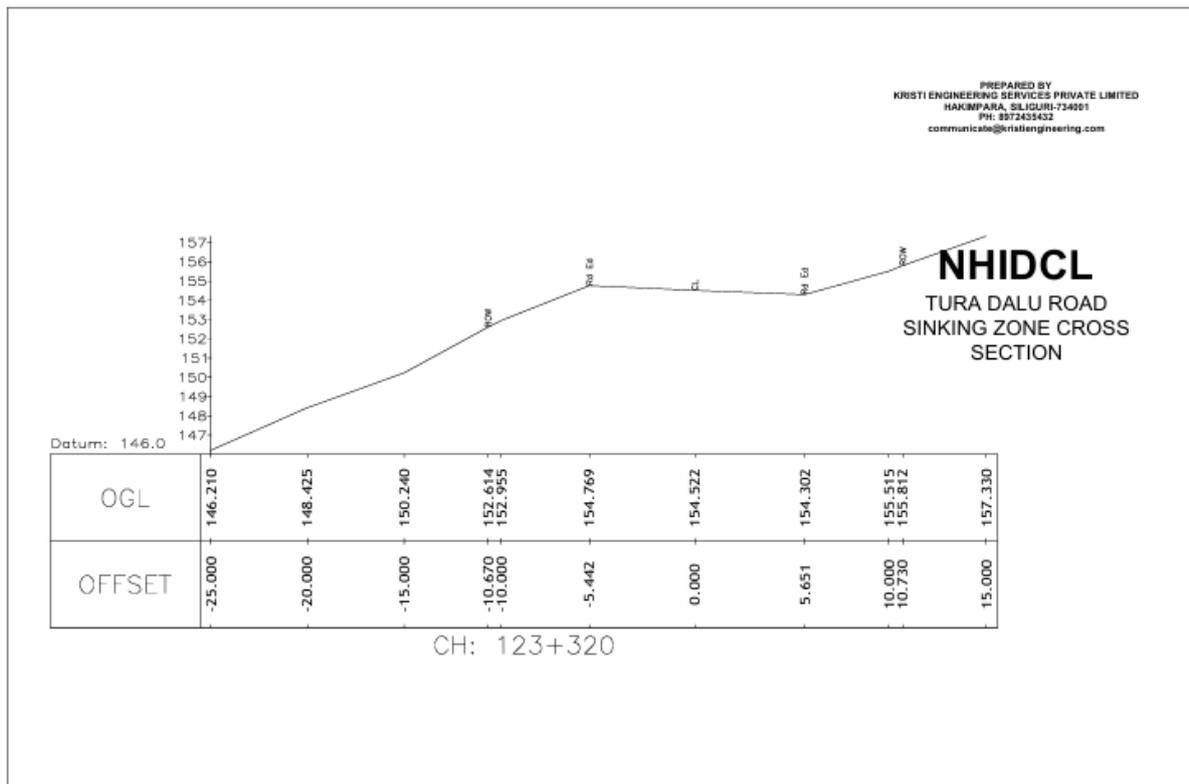
Chainage from (123+284) to (123+350)

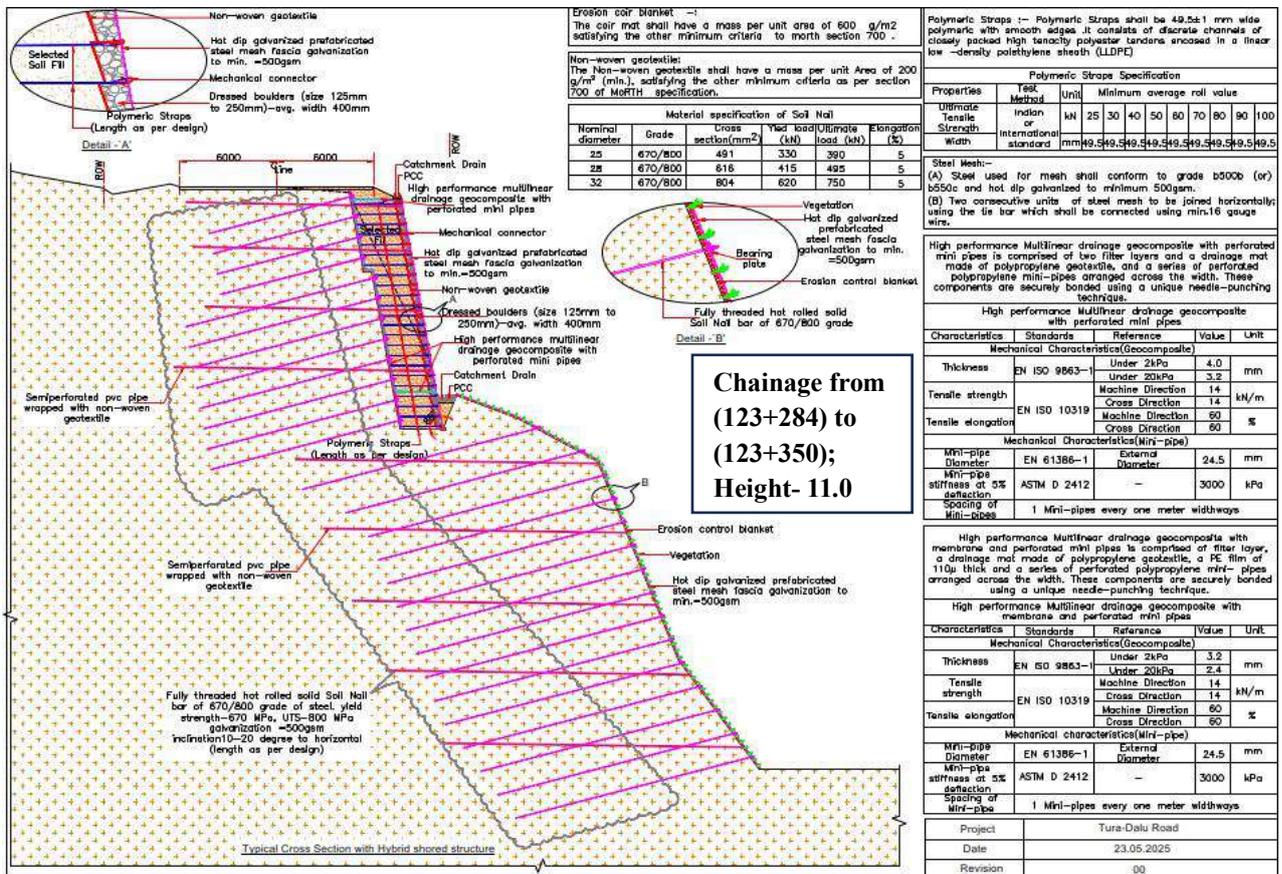
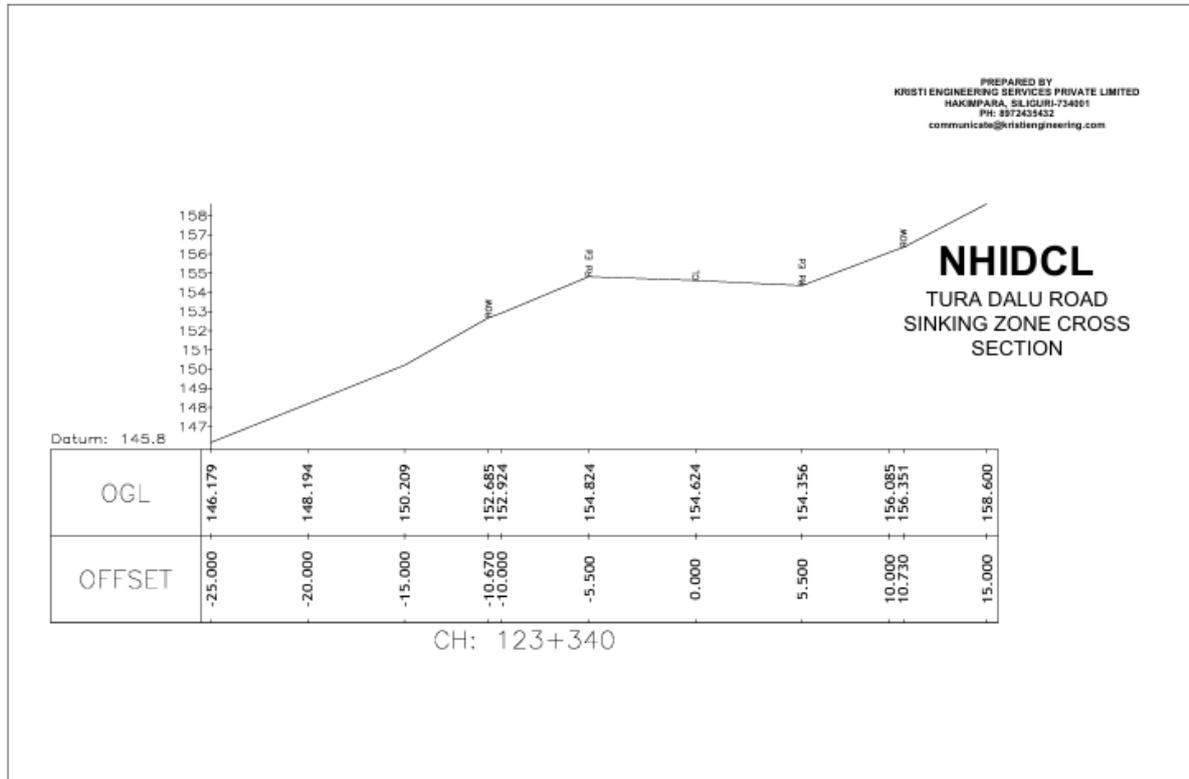
Length – 66 m

Height – 11.0 m

Proposed Solution:

1. Shored hybrid Reinforced soil structure (10-11 m ht) in 40 m length





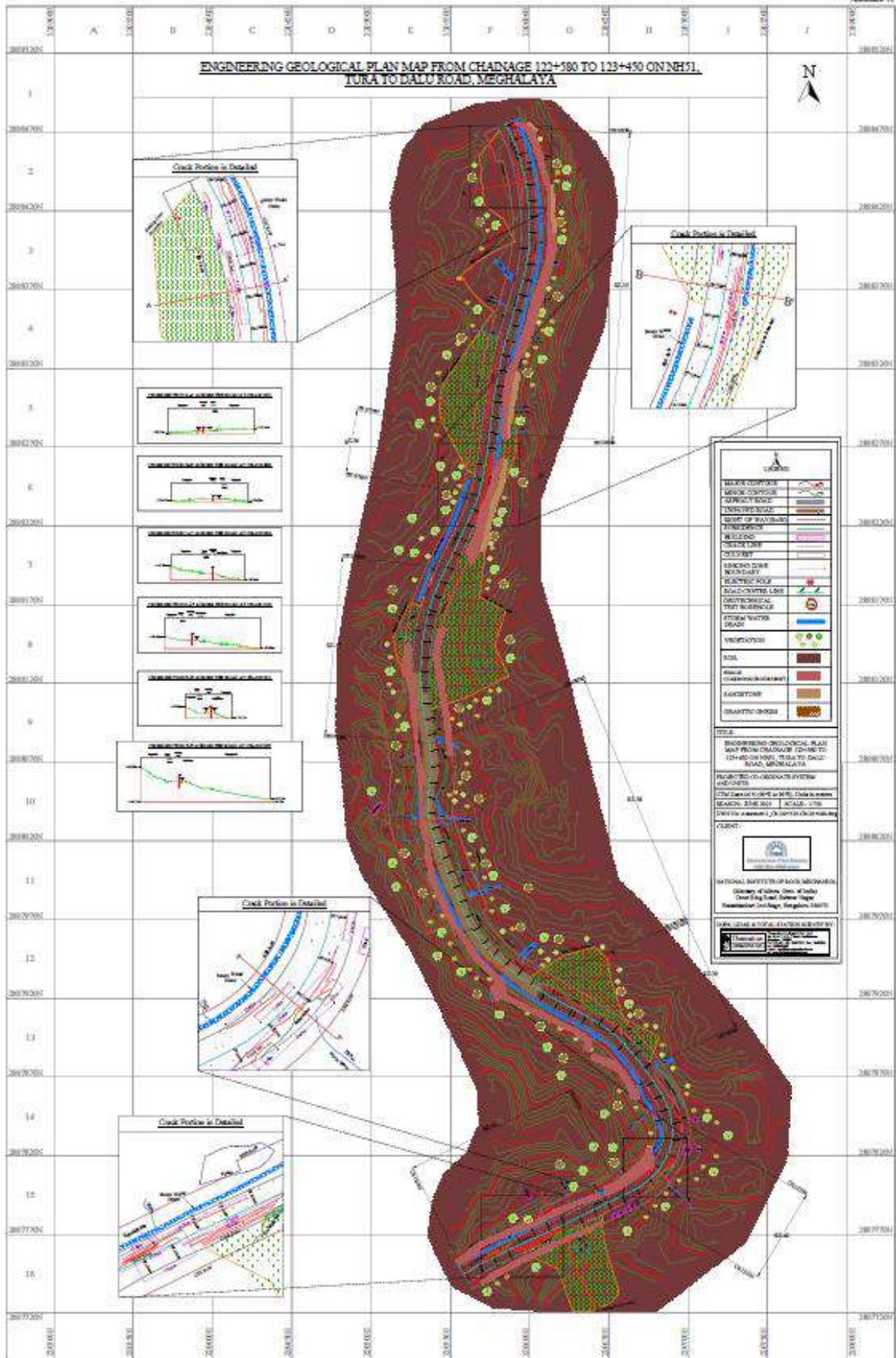




Fig. 58: The left-side portion of the road pavement near Ch 123+330 km failed and collapsed. The affected pavement sections shifted both horizontally and vertically. The underlying layers supporting the pavement consists of rock pieces and silty, sandy clay.



Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (123+350) to (123+460)

Length – 110 m

Height – 4.0 m

Proposed Solution:

1. (i) MSE Wall (4m ht) in 40 m (km 123.360 to km 123.400).

L-40

H-4

W-4.2

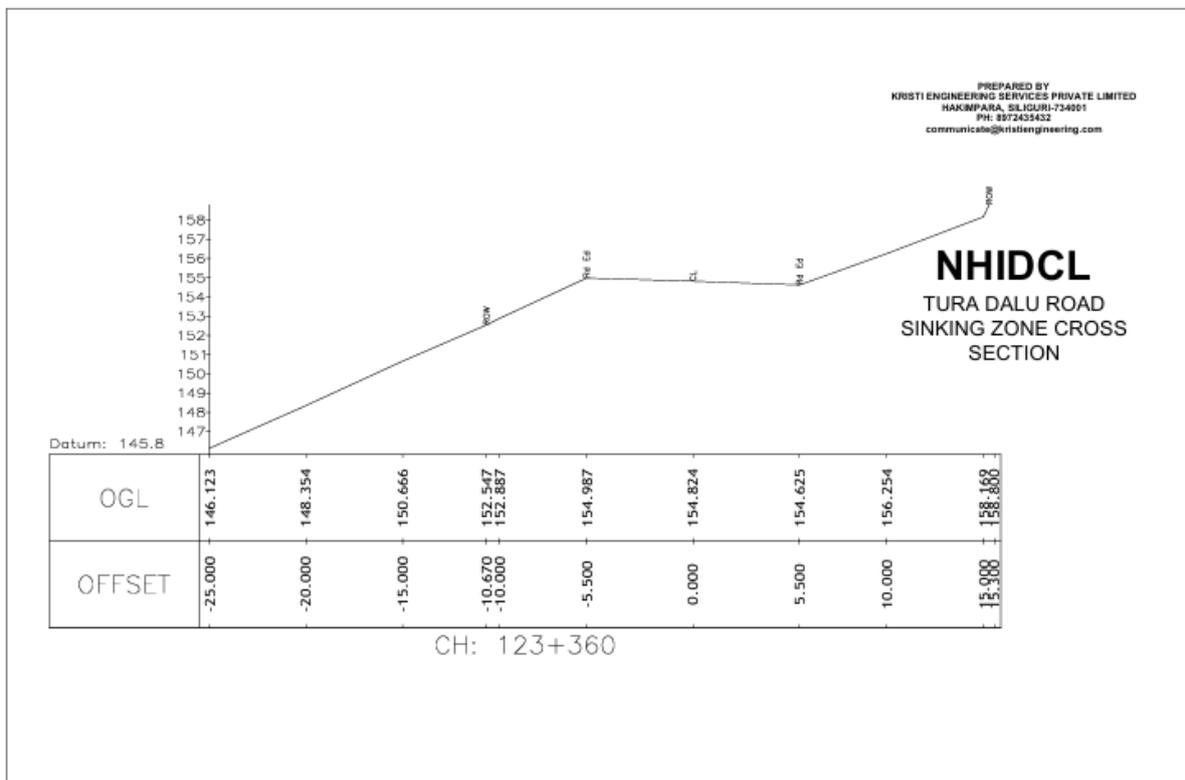
Area- 160

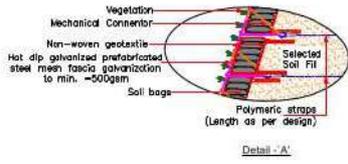
Fill vol- 960

2. Gabion Retaining Wall (4m ht) with perforated pipe in 60 m (km 123.400 to km 123.460)

3. 2-meter breast wall

4. Plantation





High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	g/sqm
		Mass per unit area total (geotextile+mini pipes)	612	g/sqm
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
		Under 20 kPa	5.0	mm
Tensile Strength	NF EN 150	Machine Direction	24	kN/m
		Cross Direction	24	kN/m

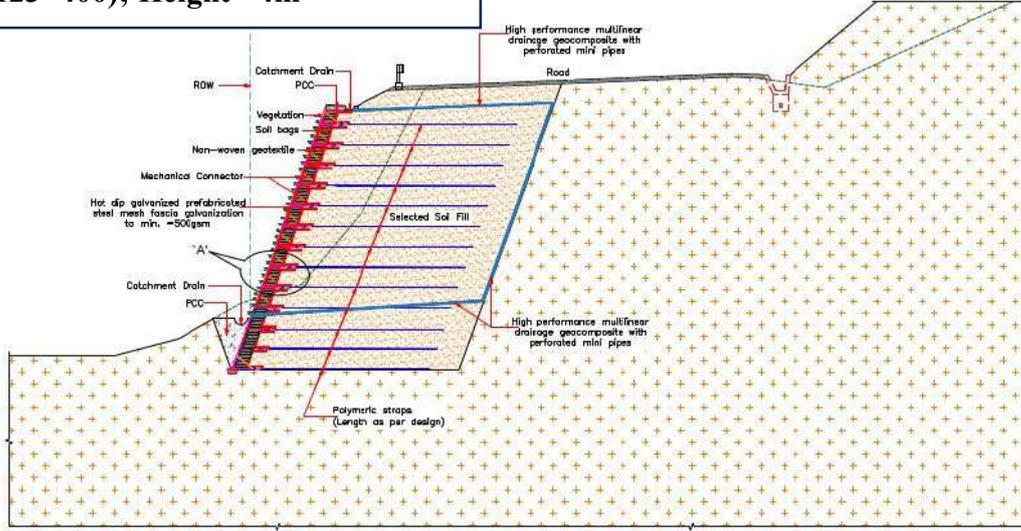
Polymeric Straps - Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE).

Polymeric Straps Specification				
Properties	Test Method	Unit	Minimum average rol value	
Ultimate Tensile Strength	Indian or International standard	kN	25	30
Width		mm	40	50
			60	70
			80	90
			100	

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B550c and hot dip galvanized to minimum 500gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.

Chainage from (123+360) to (123+400); Height - 4m



Typical Cross Section with Mechanically Stabilization Earth Slope



Fig. 59: The left-side portion of the road pavement near Ch 123+395 km failed and collapsed. The affected pavement sections shifted both horizontally and vertically. The underlying layers supporting the pavement consists of rock pieces and silty, sandy clay.

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (123+500) to (123+680)

Length – 180 m

Height – 2.0 m

Proposed Solution:

1. Gabion retaining wall of 2.0 m height towards valley side
2. Perforated pipes to be provided for sub-surface drainage
3. Two of grouting towards LHS are recommended



Fig. 60: View of longitudinal crack from Ch. 123+500 to 123+680 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (123+930) to (123+990)

Length – 60 m

Height - 4.0 m

Proposed Solution:

1. Mechanically stabilised Earth wall (height of MSE wall to be 4m as per site verification)

L-60

H-4

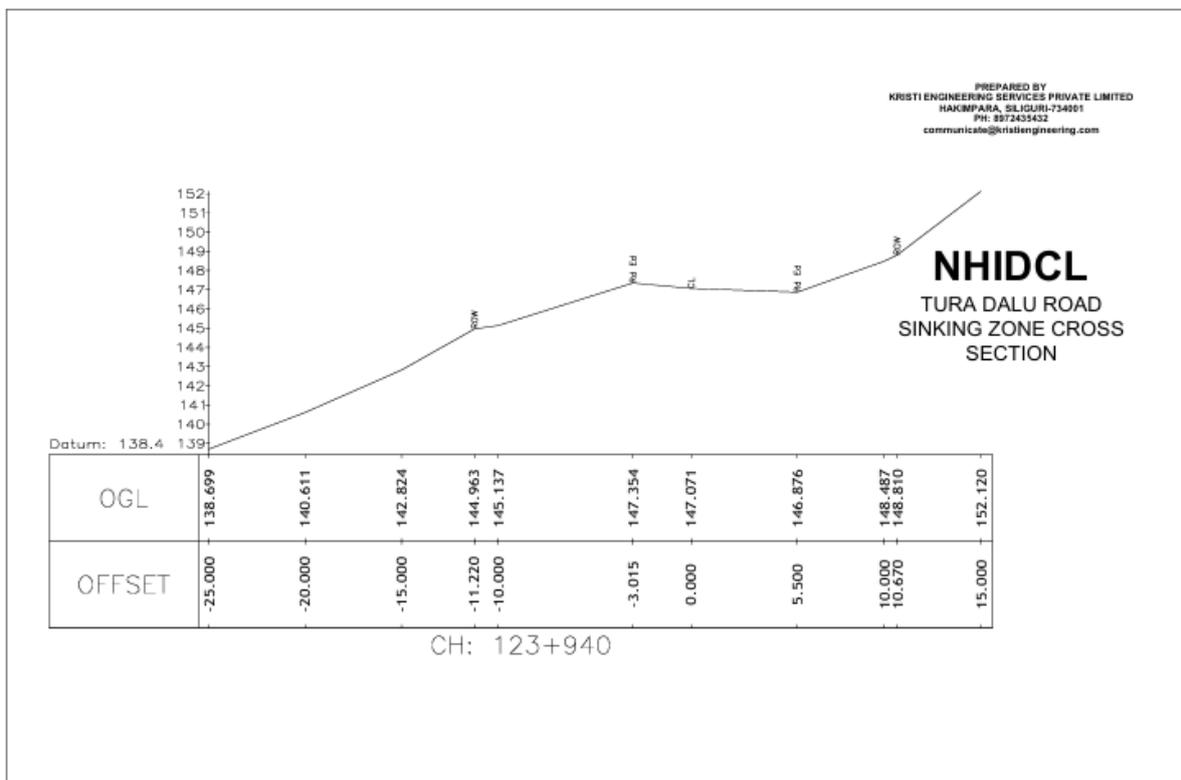
W-4.2

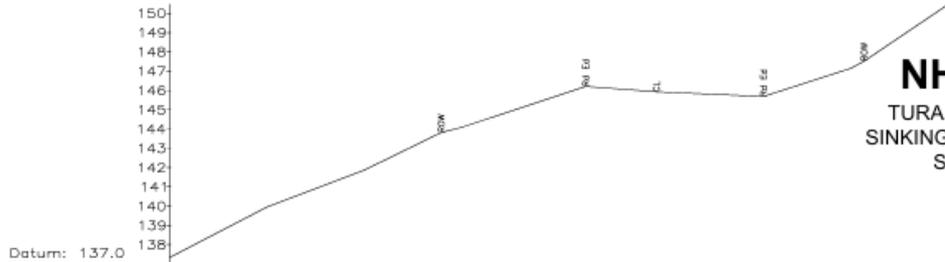
Area- 240

Fill vol- 1008

2. Paved Shoulders

3. 2-meter breast wall



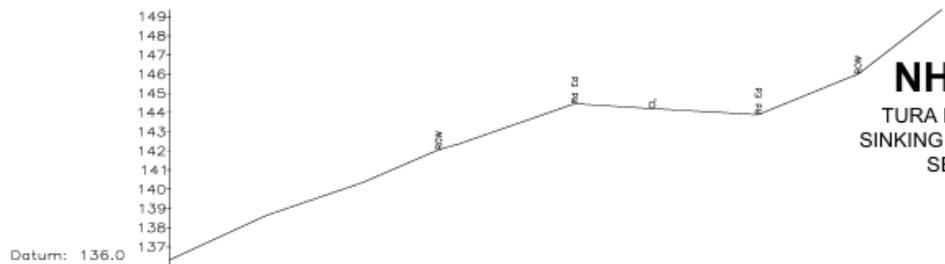


NHIDCL
TURA DALU ROAD
SINKING ZONE CROSS
SECTION

Datum: 137.0

OGI	137.343	139.959	141.874	143.821	144.090	146.210	145.933	145.689	147.153	147.321	150.469
OFFSET	-25.000	-20.000	-15.000	-11.050	-10.000	-3.635	0.000	5.500	10.000	10.670	15.000

CH: 123+960

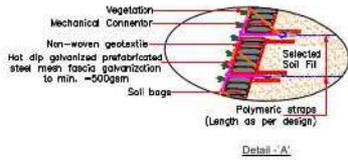


NHIDCL
TURA DALU ROAD
SINKING ZONE CROSS
SECTION

Datum: 136.0

OGI	136.319	138.636	140.353	142.067	142.370	144.460	144.204	143.893	145.738	146.000	149.355
OFFSET	-25.000	-20.000	-15.000	-11.050	-10.000	-4.021	0.000	5.500	10.000	10.670	15.000

CH: 123+980



High performance multilinear drainage geocomposite with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9884	Geotextile	550	g/sqm
		Mass per unit area total (geotextile+mini pipes)	612	
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
		Machine Direction	5.0	
Tensile Strength	NF EN 193	Machine Direction	24	kN/m
		Cross Direction	24	

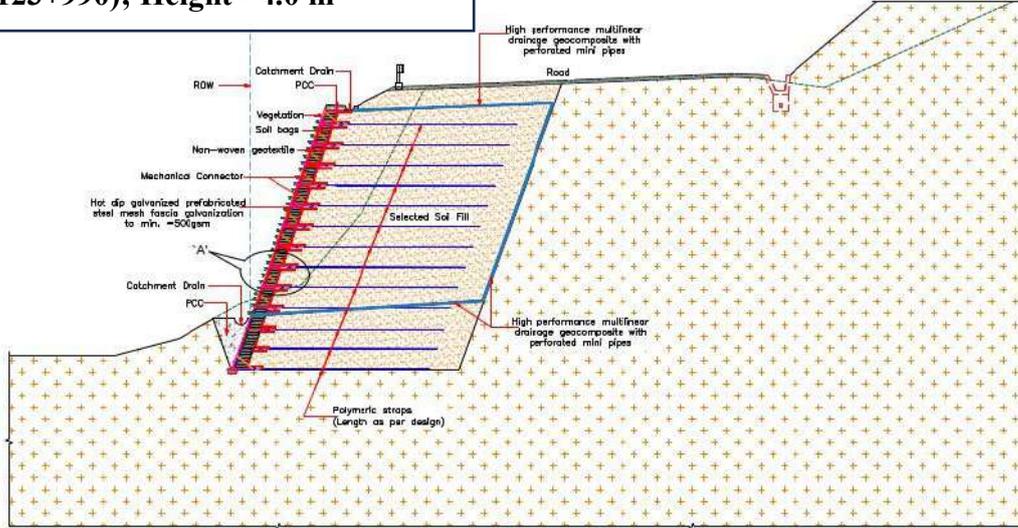
Polymeric Straps - Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons enclosed in a linear low-density polyethylene sheath (LLDPE).

Polymeric Straps Specification				
Properties	Test Method	Unit	Minimum average rol value	
Ultimate Tensile Strength	Indian or International standard	kN	25	30
			40	50
			60	70
			80	90
			100	
Width		mm	49.5	49.5
			49.5	49.5
			49.5	49.5

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B550c and hot dip galvanized to minimum 500gsm.
(B) Two consecutive units of steel mesh to be joined horizontally; using the tie bar which shall be connected using min.16 gauge wire.

Chainage from (123+930) to (123+990); Height - 4.0 m



Typical Cross Section with Mechanically Stabilization Earth Slope



Fig. 61: View of sinking area from Ch. 123+930 to 123+990 km on LHS

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (124+070) to (124+175)

Length – 105 m

Height - 6.0 m

Proposed Solution:

1. MSE Wall (6m ht) in 65 m (km 124.070 to km 124.135).

L-65

H-6

W-5

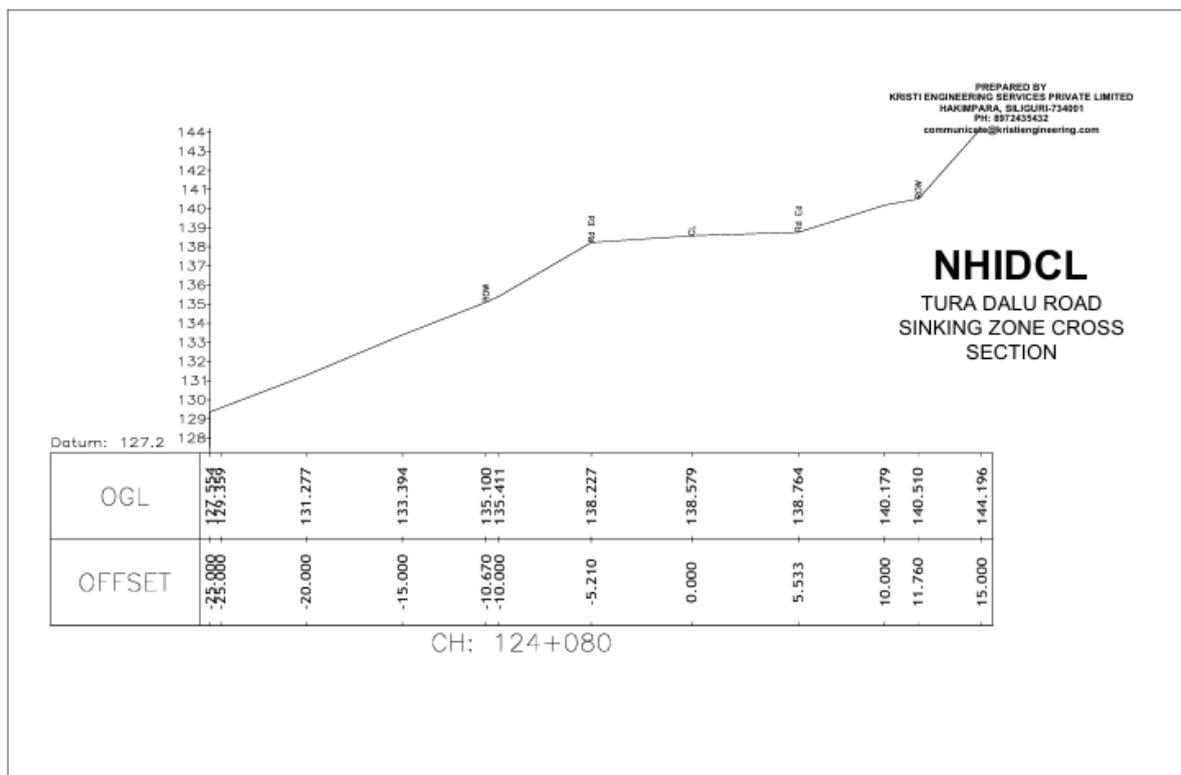
Area- 390

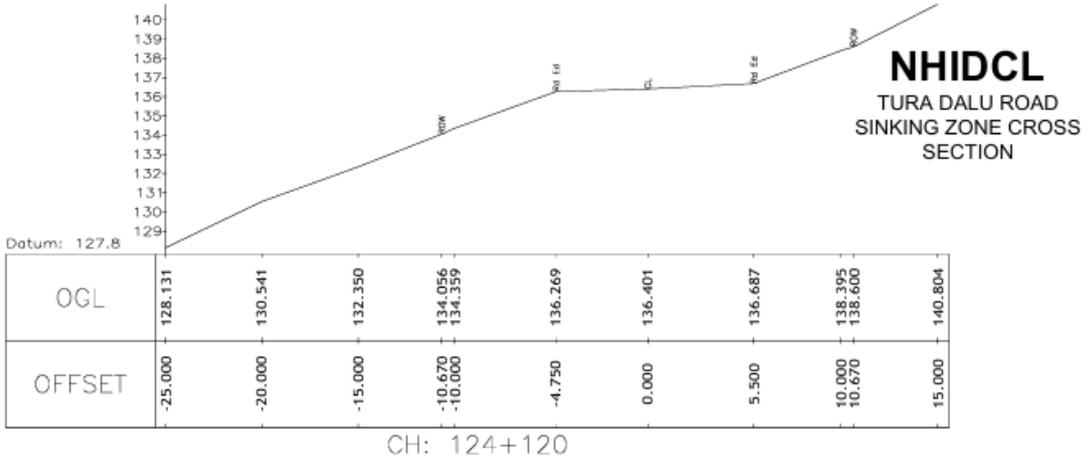
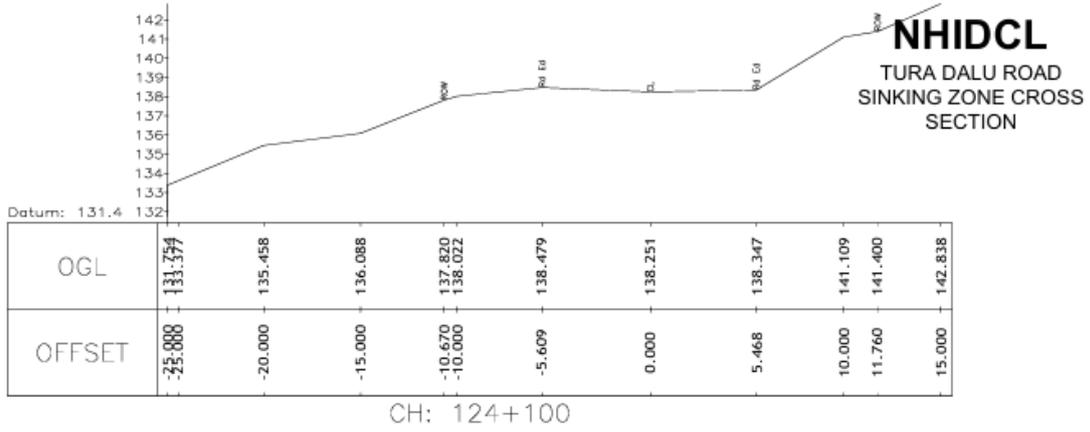
Fill vol- 1950

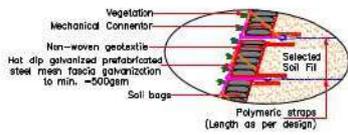
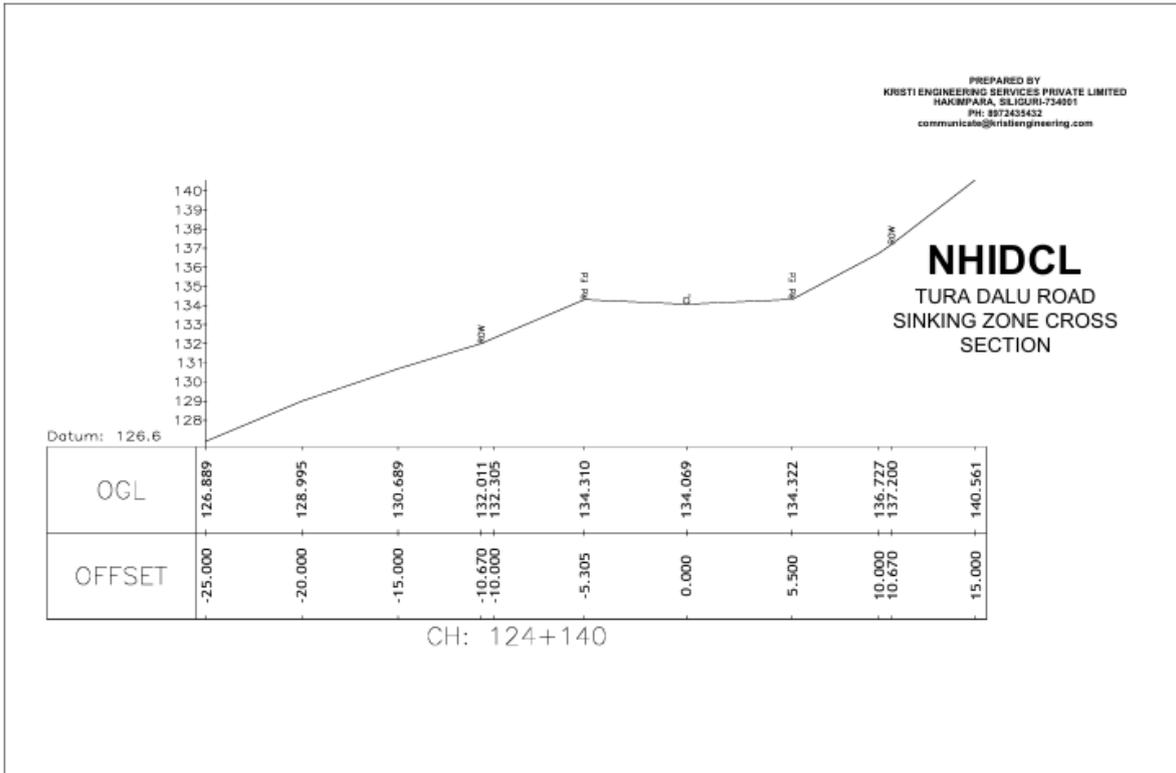
2. Gabion Retaining Wall (3m ht) with perforated pipe in 40 m (km 124.135 to km 124.175)

2. Paved Shoulders

3. One row of grouting towards LHS are recommended.







High performance multilinear drainage geocomposite with perforated mini pipes			
Characteristics	Standards	Reference Value Unit	
Mass per unit area	NF EN 9884	Geotextile	550
	Mass per unit area total mass (geotextile+mini pipes)		612 g/sqm
Thickness	NF EN 9883-1	Under 2 kPa	6.0 mm
		Under 20 kPa	5.0
Tensile Strength	NF EN ISO 10319	Machine Direction	24 kN/m
		Cross Direction	24

Polymeric Straps :- Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons encased in a linear low-density polyethylene sheath (LLDPE)

Polymeric Straps Specification				
Properties	Test Method	Unit	Minimum average roll value	
Tensile Strength	Indian or International standard	kN	25	30
			40	50
Width	mm	49.5	49.5	49.5
		49.5	49.5	49.5

Non-woven geotextile: The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
 (A) Steel used for mesh shall conform to grade b500b (or) b550c and hot dip galvanized to minimum 503gsm.
 (B) Two consecutive units of steel mesh to be joined horizontally, using the tie bar which shall be connected using min. 16 gauge wire.

Chainage from (124+070) to (124+135); Height - 6.0 m

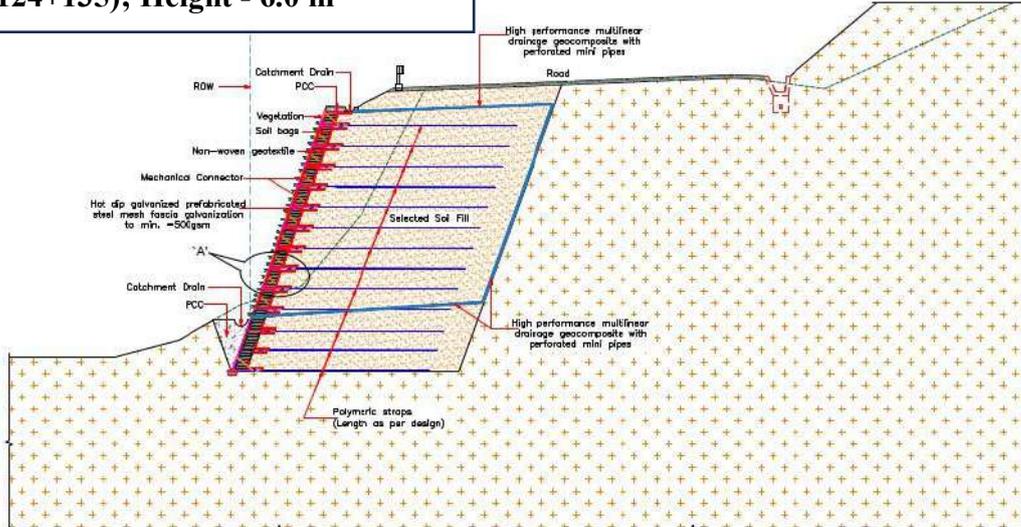




Fig. 62: View of sinking zone from Ch. 124+0790 to 124+175 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (124+175) to (124+255)

Length – 80 m

Height – 2.0 m

Proposed Solution:

1. Gabion Retaining Wall (2m ht) with perforated pipe and other items
2. Paved Shoulders
3. Grouting



Fig. 63: View of debris flow near Ch. 124+210 and 124+255 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

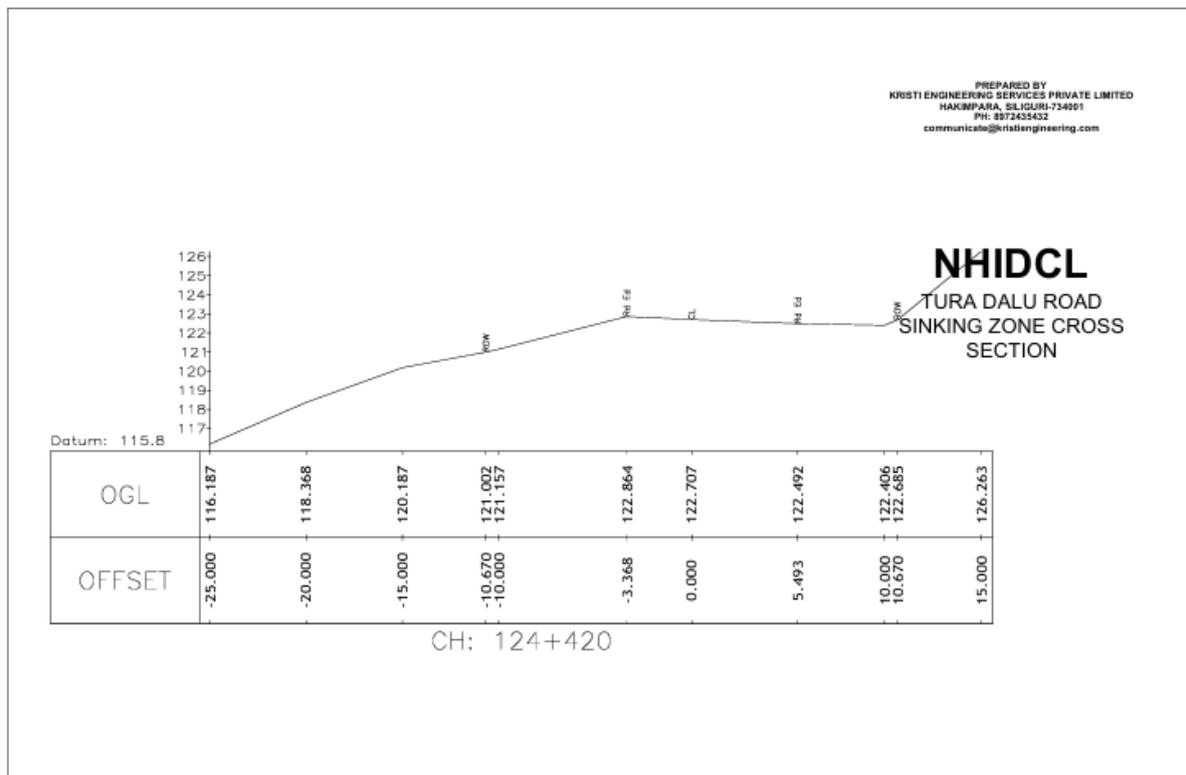
Chainage from (124+415) to (124+535)

Length – 120 m

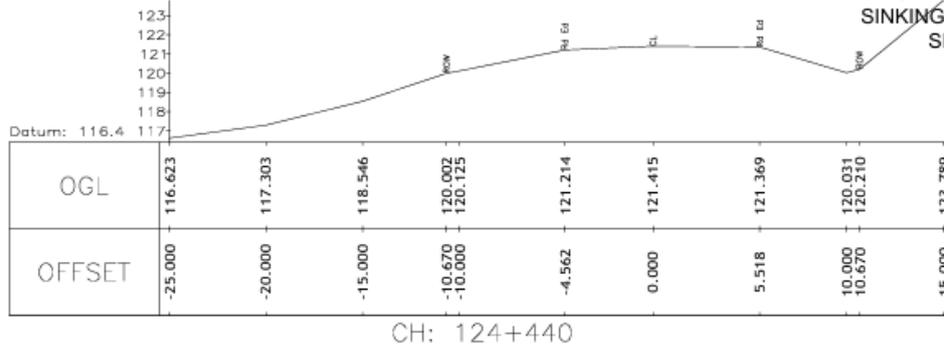
Height – 3.0 m

Proposed Solution:

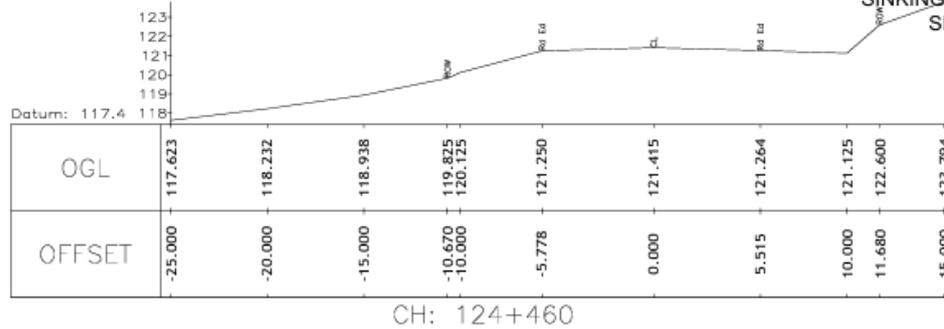
1. Mechanically stabilised Earth wall (height of MSE wall to be 3m as per site verification)
2. Paved Shoulders
3. One row of grouting towards LHS



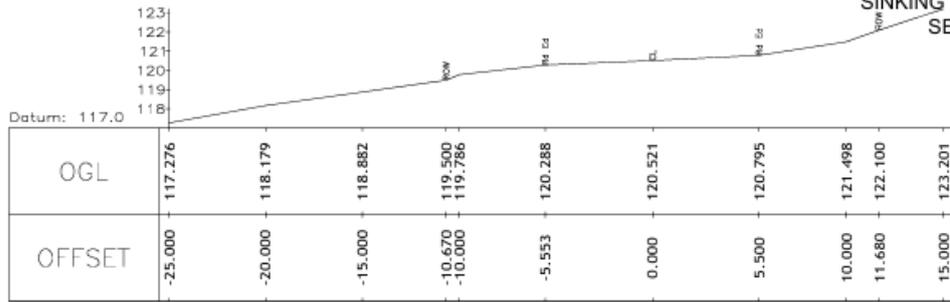
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SECTION



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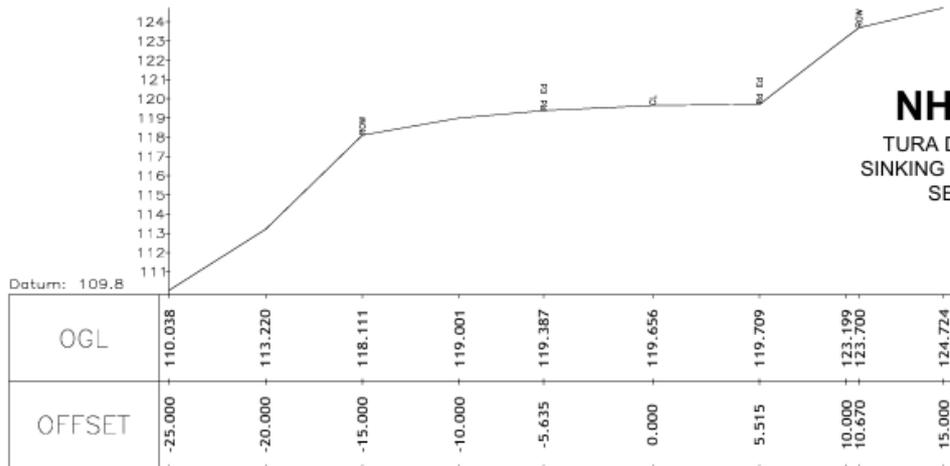


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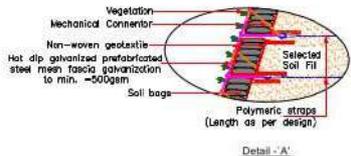
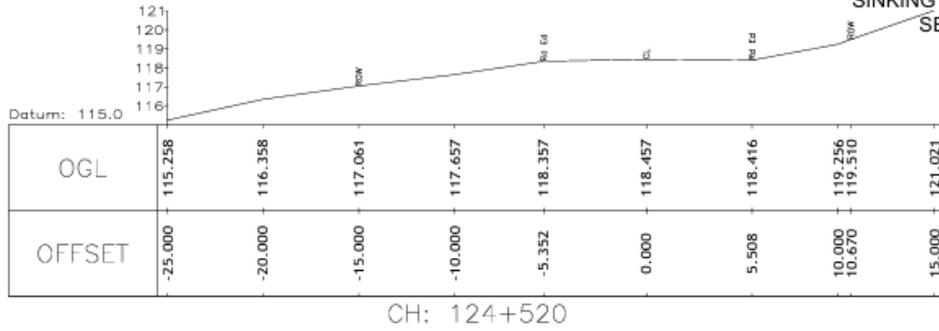
CH: 124+480

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CH: 124+500

NHIDCL TURA DALU ROAD SINKING ZONE CROSS SECTION



High performance multilinear drainage geocomposites with perforated mini pipes				
Characteristics	Standards	Reference	Value	Unit
Mass per unit area	NF EN 9864	Geotextile	550	
Mass per unit area total mass (geotextile+mini pipes)			612	g/sqm
Thickness	NF EN 9863-1	Under 2 kPa	6.0	mm
	NF EN ISO 10319	Machine Direction	24	mm
Tensile Strength		Cross Direction	24	kn/m

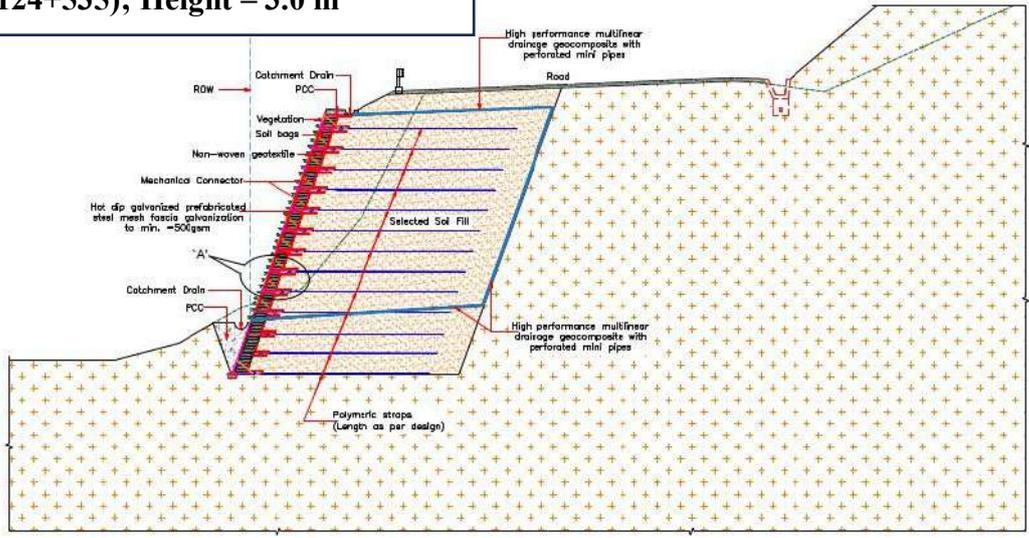
Polymeric Straps :- Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester tendons encased in a linear low-density polyethylene sheath (LLDPE)

Polymeric Straps Specification											
Properties	Test Method	Unit	Minimum average rat value								
Ultimate Tensile Strength	Indian or International standard	KN	25	30	40	50	60	70	80	90	100
Width		mm	49.5	49.5	49.5	49.5	49.5	49.5	49.5	49.5	49.5

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoRTH specification.

Steel Mesh:-
(A) Steel used for mesh shall conform to grade b500b (or) b500c and hot dip galvanized to minimum 500gsm.
(B) Two consecutive units of steel mesh to be joined horizontally, using the tie bar which shall be connected using min.16 gauge wire.

Chainage from (124+415) to (124+535); Height – 3.0 m



Typical Cross Section with Mechanically Stabilization Earth Slope



Fig. 64: View of sinking zone on the downhill and uphill sides at near Ch. 124+460 km



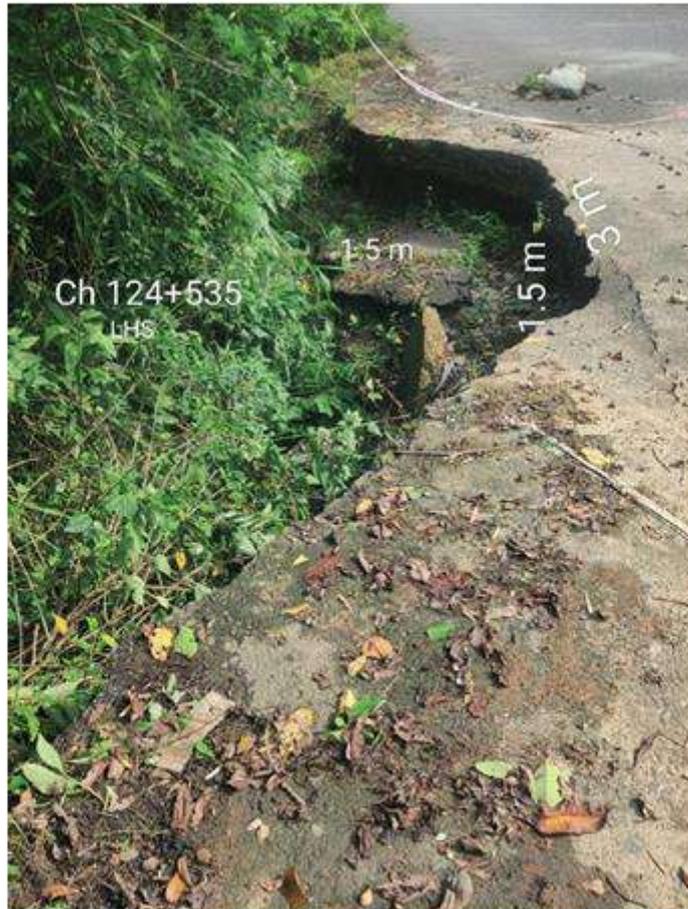


Fig. 65: The left-side portion of the road pavement near Ch 124+485 km failed and collapsed. The affected pavement sections shifted both horizontally and vertically. The underlying layers supporting the pavement consists of rock pieces and silty, sandy clay. The lack of lateral support and side erosion led to the horizontal shift of the pavement, while a weak foundation and heavy vehicles contributed to vertical settlement and cracking

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

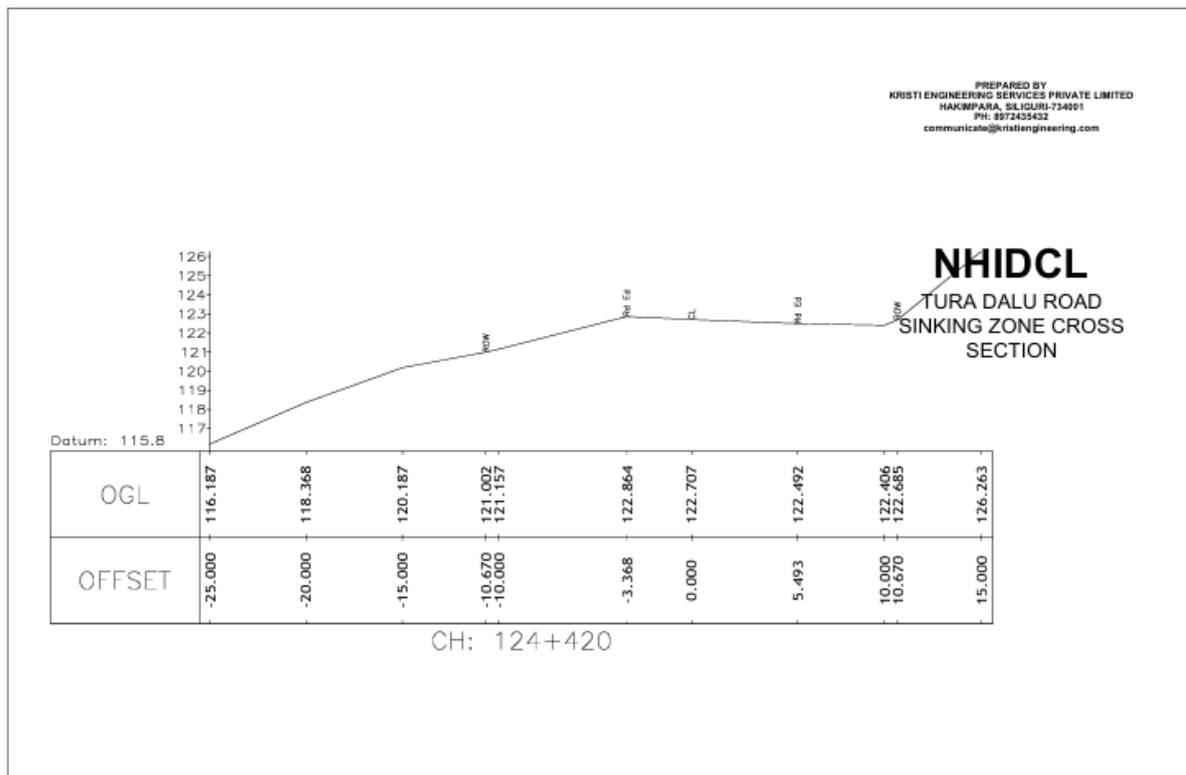
Chainage from (124+555) to (124+613)

Length – 58 m

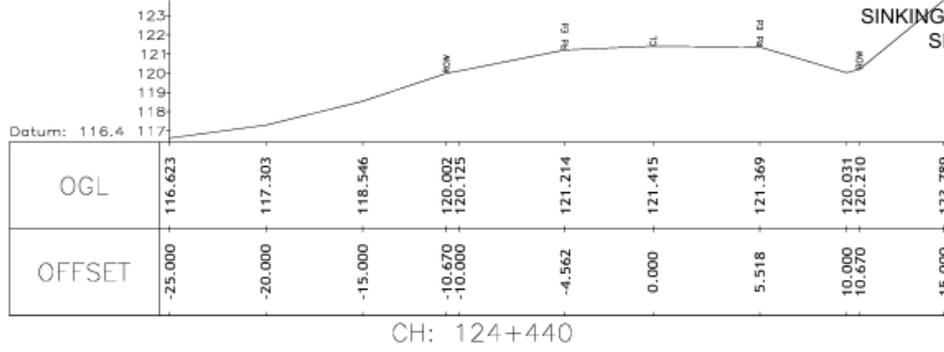
Height – 5.0 m

Proposed Solution:

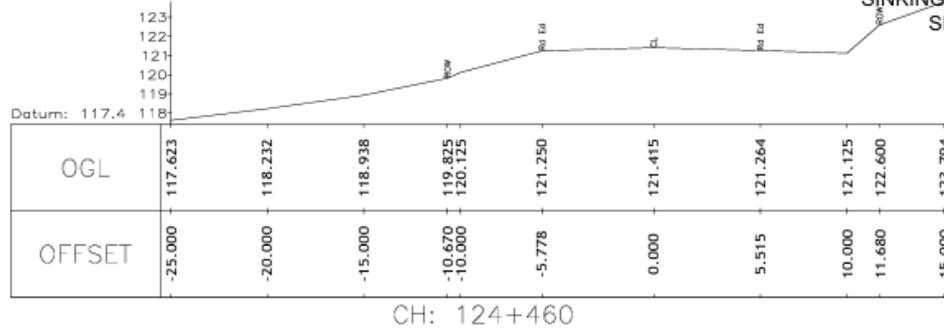
1. Gabion Retaining Wall (5m ht) with perforated pipe.
2. Paved Shoulders
3. One row of grouting towards LHS



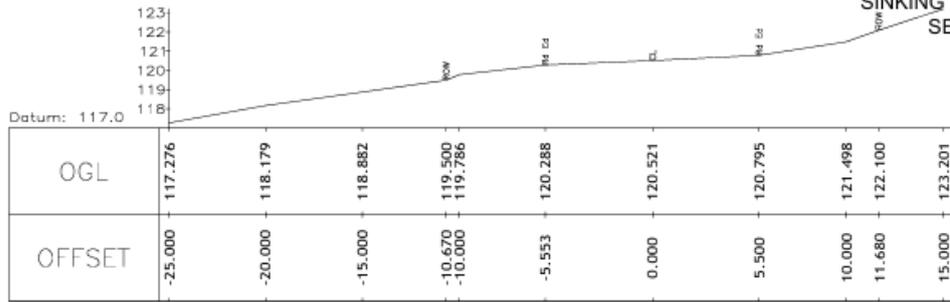
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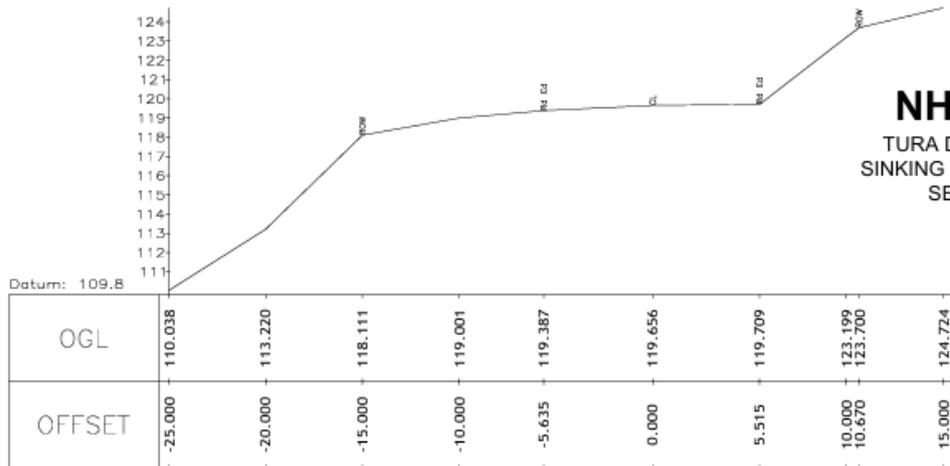


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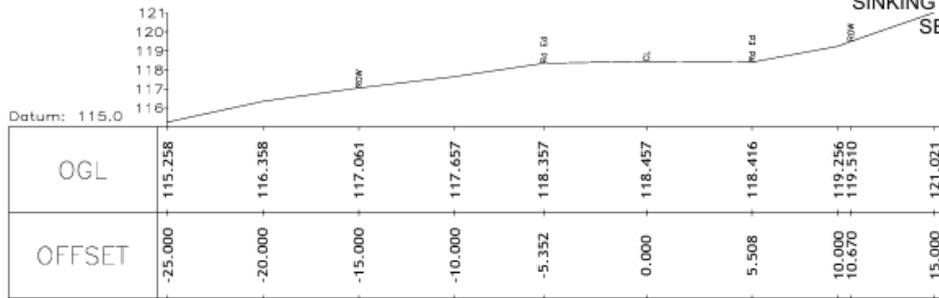
CH: 124+480

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CH: 124+500

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SECTION



CH: 124+520

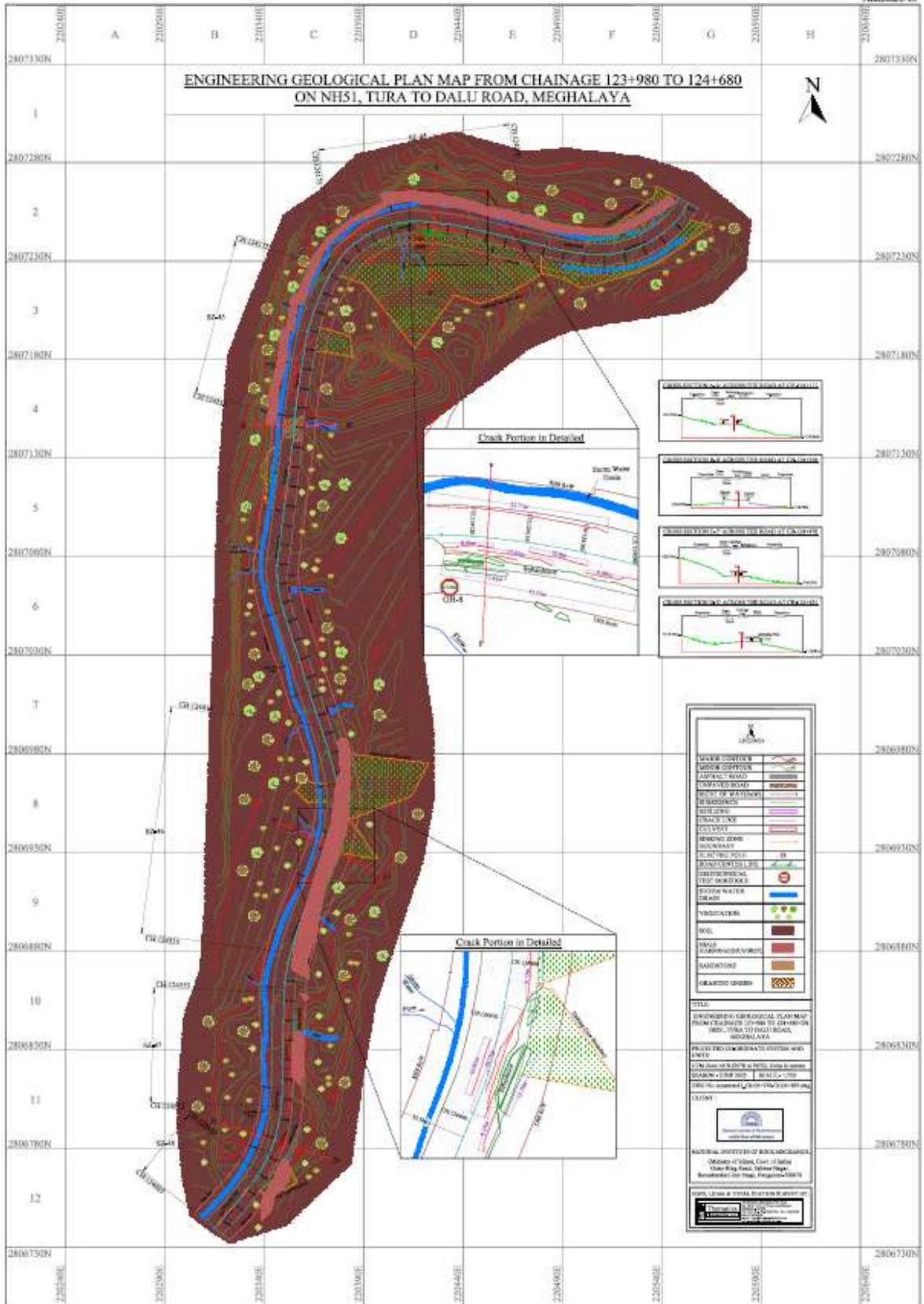




Fig. 66: View of sinking zone-47 between Ch. 124+555 and 124+613 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (124+649) to (124+685)

Length – 36 m

Height – 5.0 m

Proposed Solution:

1. Gabion Retaining Wall (5m ht) with perforated pipe.
2. Paved shoulders up to the drain and road edge.
3. One row of grouting towards LHS.
4. Gabion breast wall of 3.0 m height.

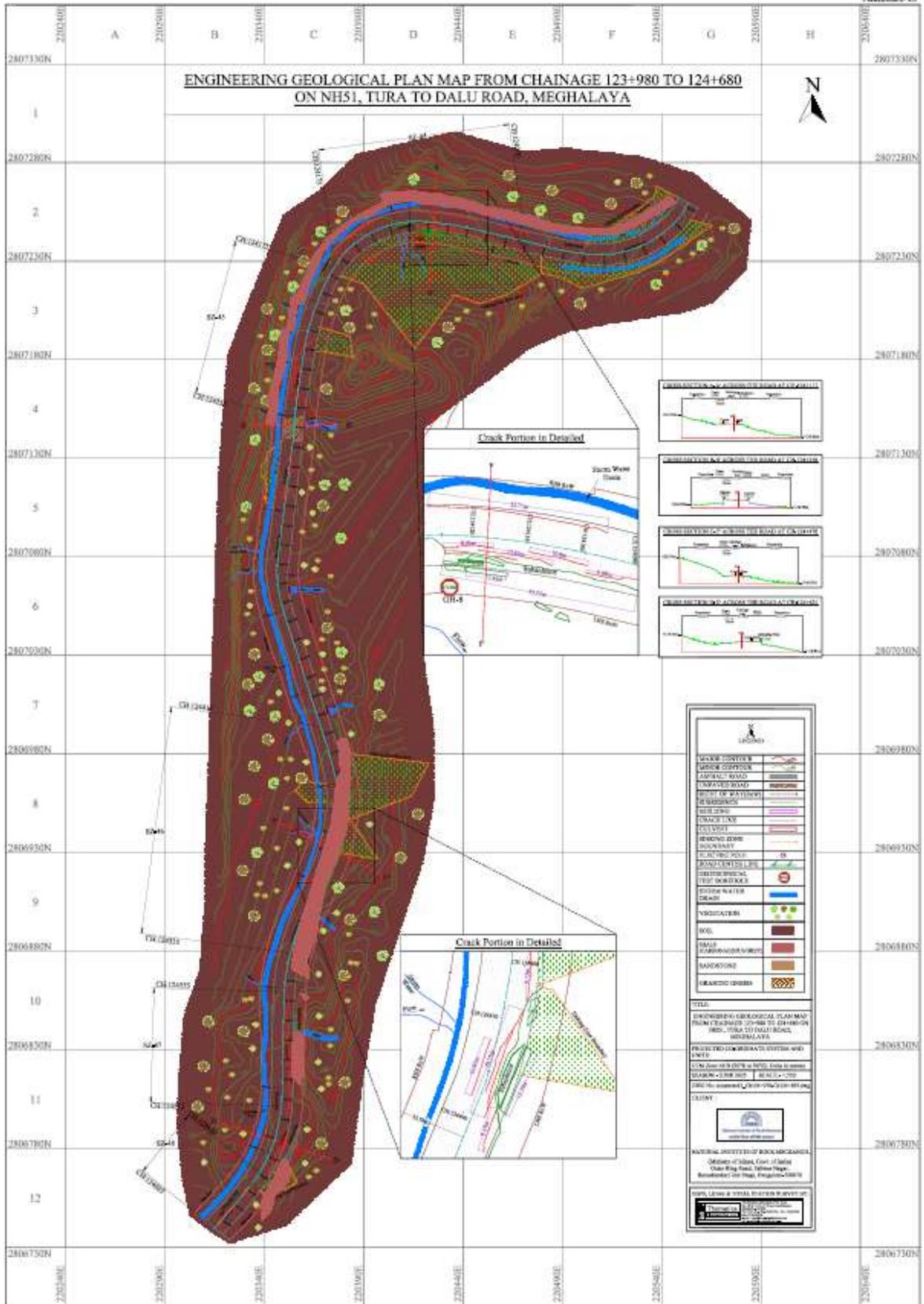




Fig. 67: View of slope instability area between Ch. 124+649 and 124+685 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

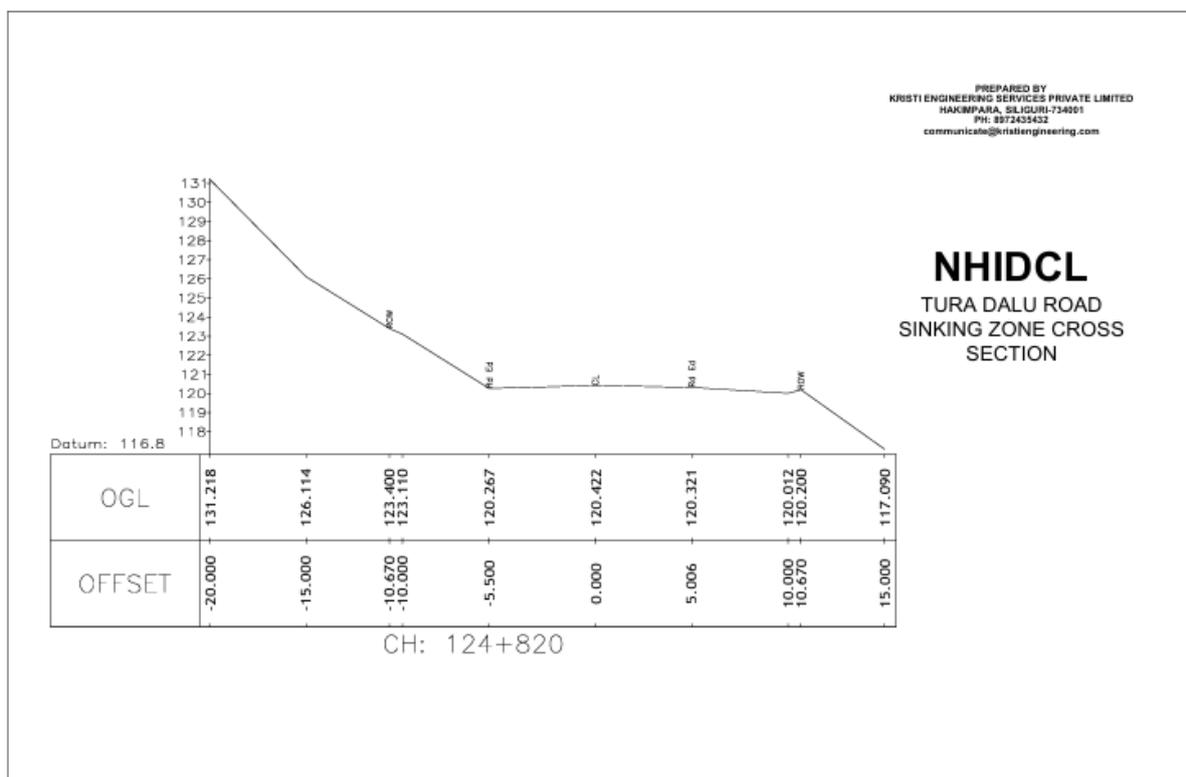
Chainage from (124+800) to (124+870)

Length – 70 m

Height – 5.0 m

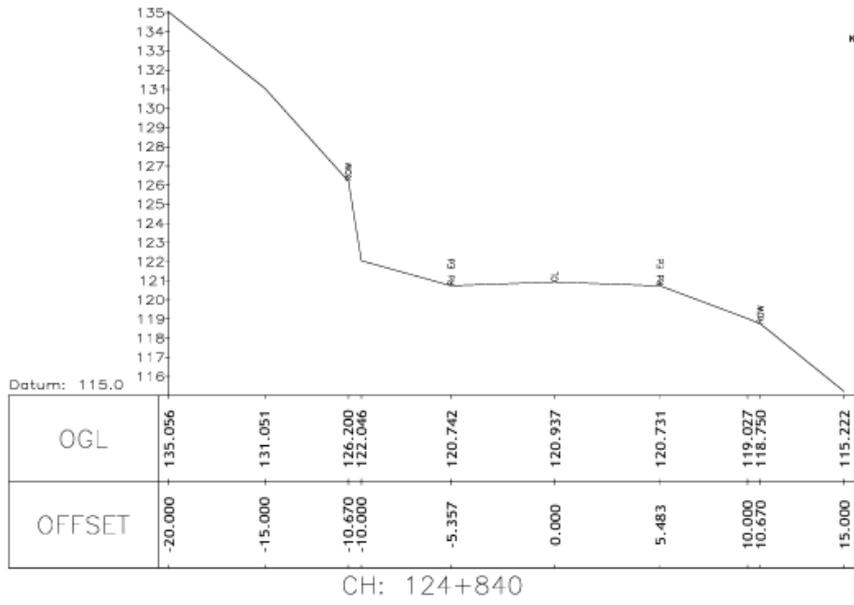
Proposed Solution:

1. Gabion Retaining Wall (5m ht) with perforated pipe.
2. Paved Shoulders



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HAKIMPURA, SILIGURI-734001
PH: 937435432
communicate@kristiengineering.com

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SINKING ZONE CROSS
SECTION

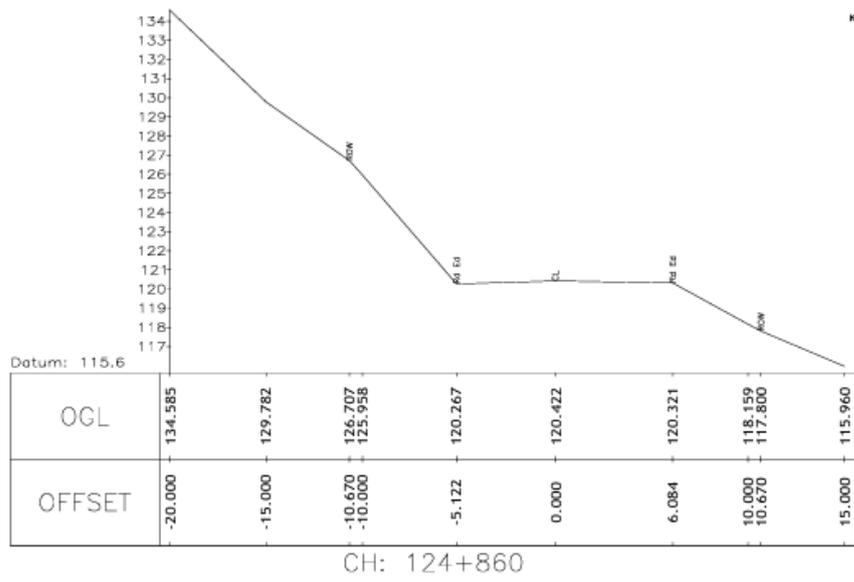




Fig. 68: View of the sinking area on RHS of National Highway between Ch. 124+800 km to 124+870 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (125+055) to (125+100)

Length – 45 m

Height – 3.0 m

Proposed Solution:

1. Gabion retaining wall. A flexible retaining structure is recommended. The maximum height of the wall will be 3.0 m.
2. Gabion Retaining Wall (3m ht) with perforated pipe
3. Paved shoulder up to the drain is also recommended



Fig. 69: View of newly formed sinking area between Ch. 125+055 and 125+100 km on RHS of NH

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of Chainage from (125+170) to (125+200)

Length – 30 m

Height – 5.0 m

Proposed Solution:

1. Gabion Retaining Wall (5m ht) with perforated pipe
2. Existing retaining wall is recommended to extend at RHS towards the Tura side. Height of the wall will be 5.0 m.

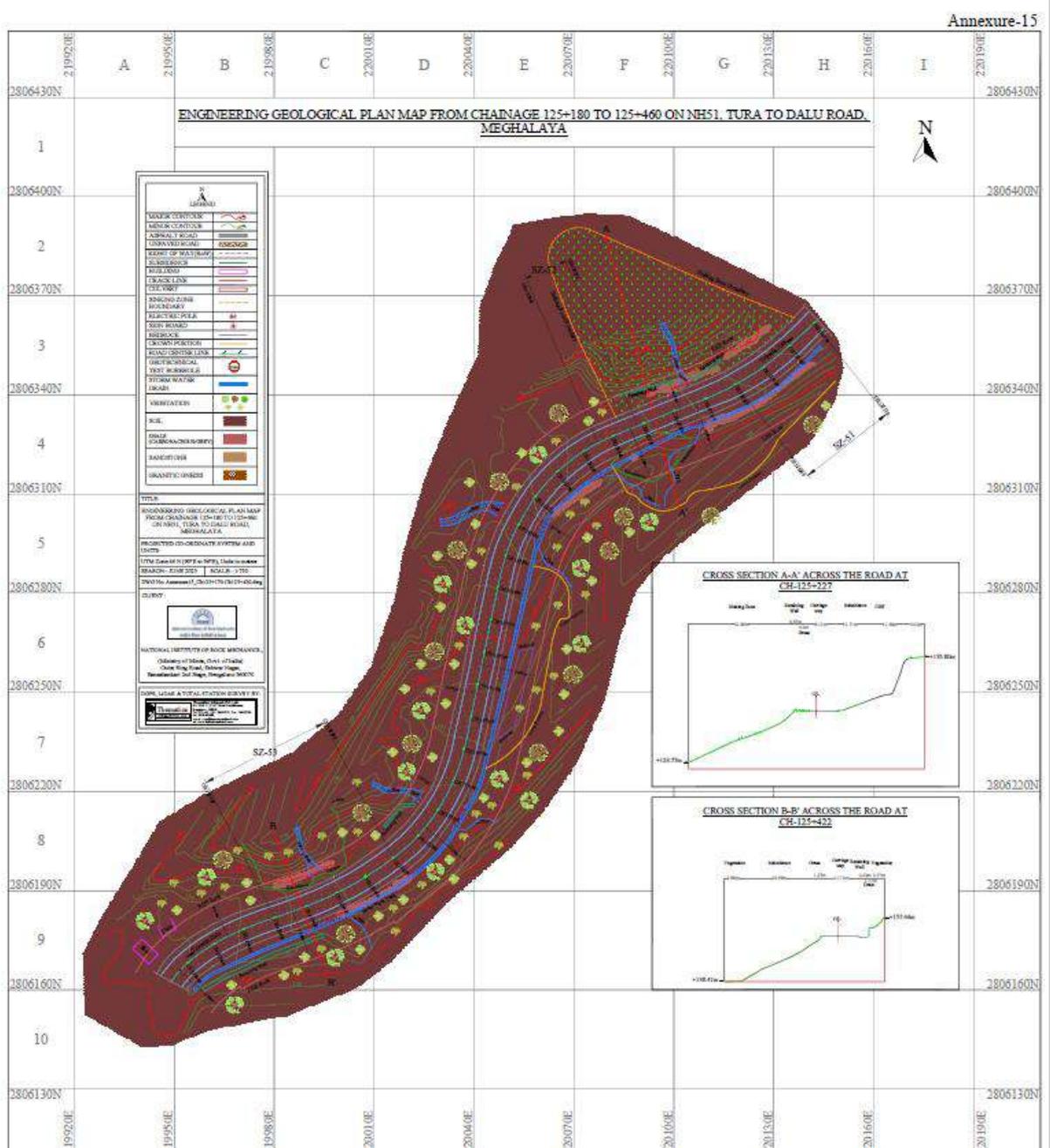




Fig. 70: View of the landslide between Ch. 125+185 and 125+200 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (125+232) to (125+245)

Length – 13 m

Height – 5.2 m

Proposed Solution:

1. Gabion Retaining Wall (5m ht) with perforated pipe
2. Height of breast wall will be 6.0 m.
3. From the crown area, surface water should be diverted on either side of the slide
4. Road side drain.



Fig. 71: View of debris slide at Ch. 125+240 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (125+390) to (125+430)

Length – 40 m

Height – 6.0 m

Proposed Solution:

1. Gabion Retaining Wall (6m ht) with perforated pipe
2. Extension of retaining wall on both sides up to 15.0 & 20.0 m towards Tura and Dalu side respectively.
3. Height of the wall will be varying from 4.0 to 9.0 m.
4. Plantation.



Fig. 72: View of sinking/sliding and right flank of the sinking zone-53

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (126+450) to (126+475)

Length – 25 m

Height – 5.2 m

Proposed Solution:

1. Mechanically stabilised Earth wall (height of MSE wall to be 7m as per site verification)
2. Plantation

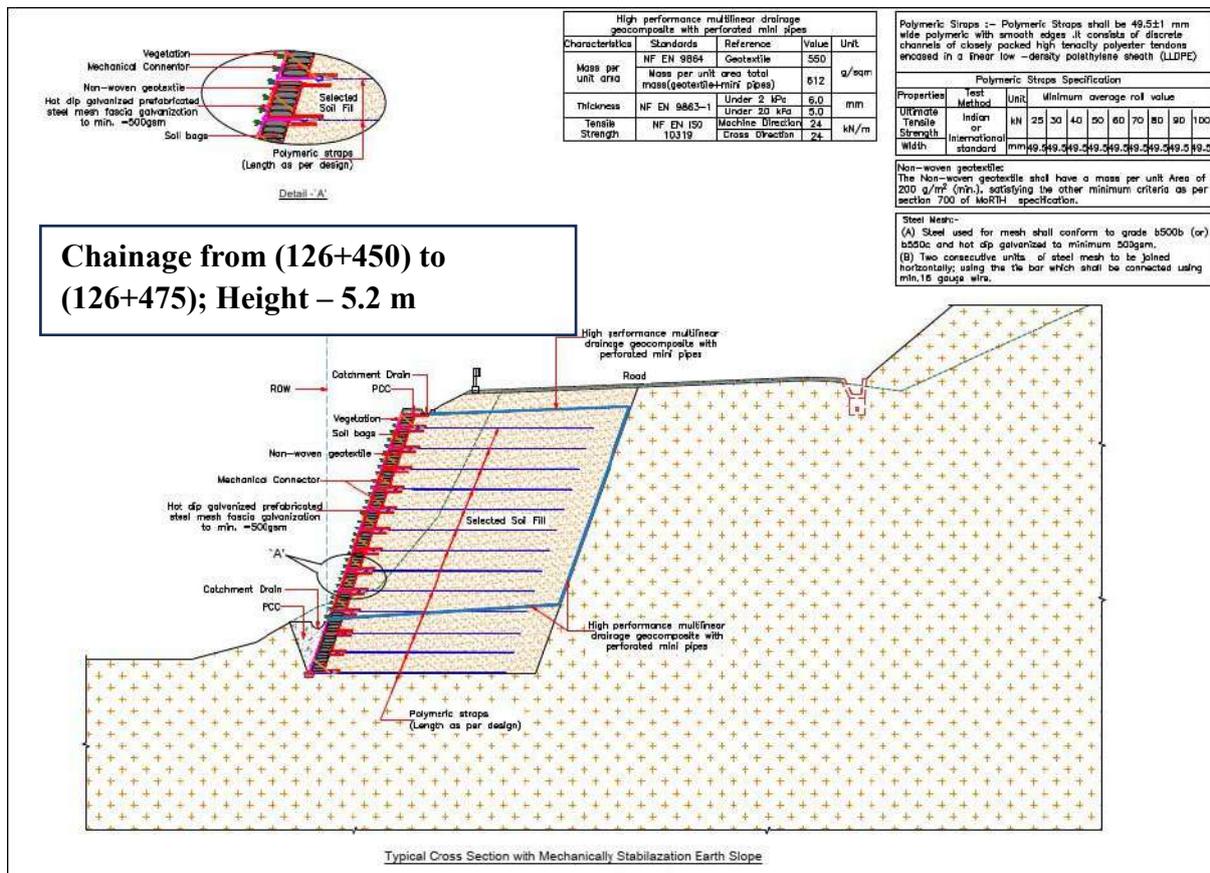




Fig. 73: View of sinking area between Ch. 126+450 and 126+475 km on RHS of NH

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of Chainage from (127+400) to (127+770)

Length – 370 m

Height – 3.0 m

Proposed Solution:

1. Gabion breast wall of 3.0 m height with a proper surface drainage system towards the hillside area.
2. Plantation

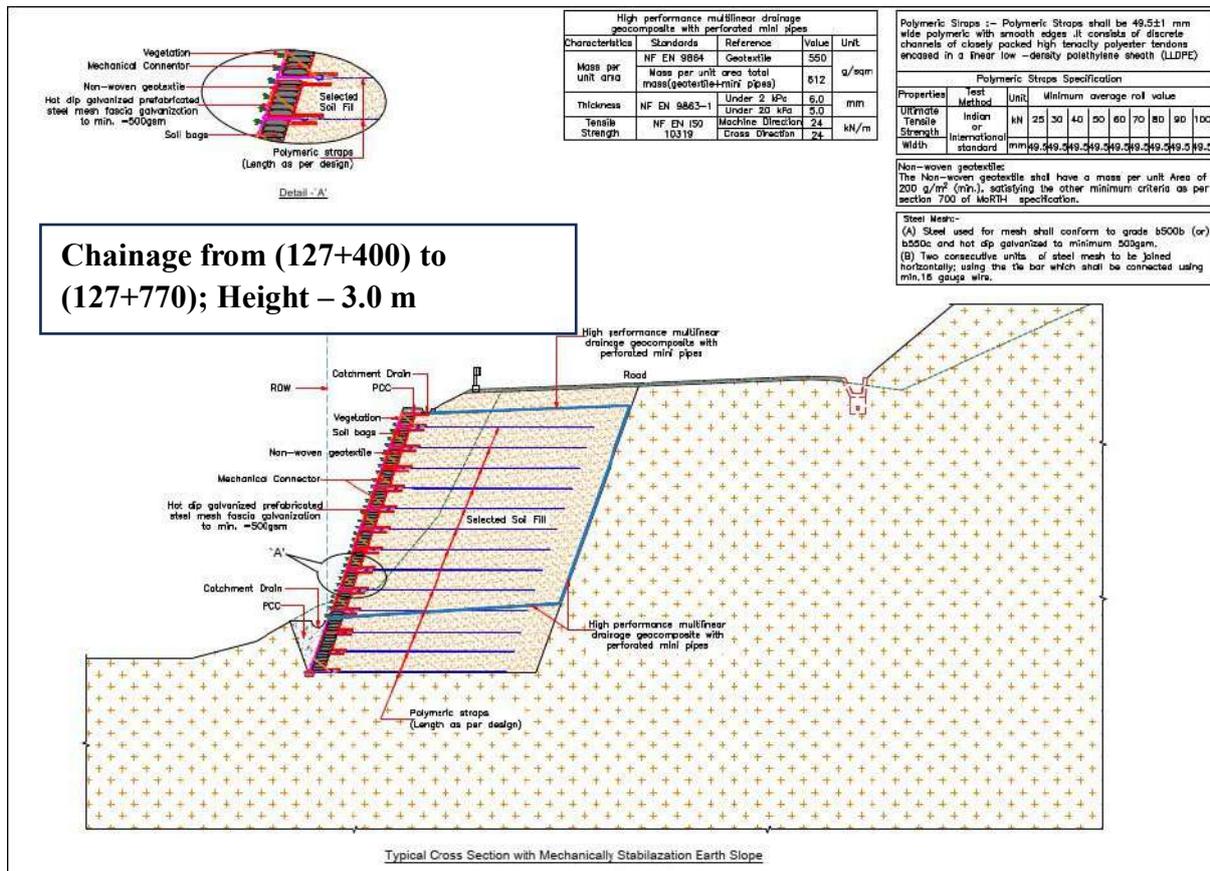




Fig. 74: View of problematic area between Ch. 127+475 and 127+770 km towards hill side



Fig. 75: Well exposed conglomerate formation mapped near Ch. 127+475 km towards hill side

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (127+880) to (127+900)

Length – 20 m

Height – 6.0 m

Proposed Solution:

1. Mechanically stabilised Earth wall

L-20

H-6

W-5

Area- 180

Fill vol- 900

2. Paved Shoulders

3. Increase in surface drains

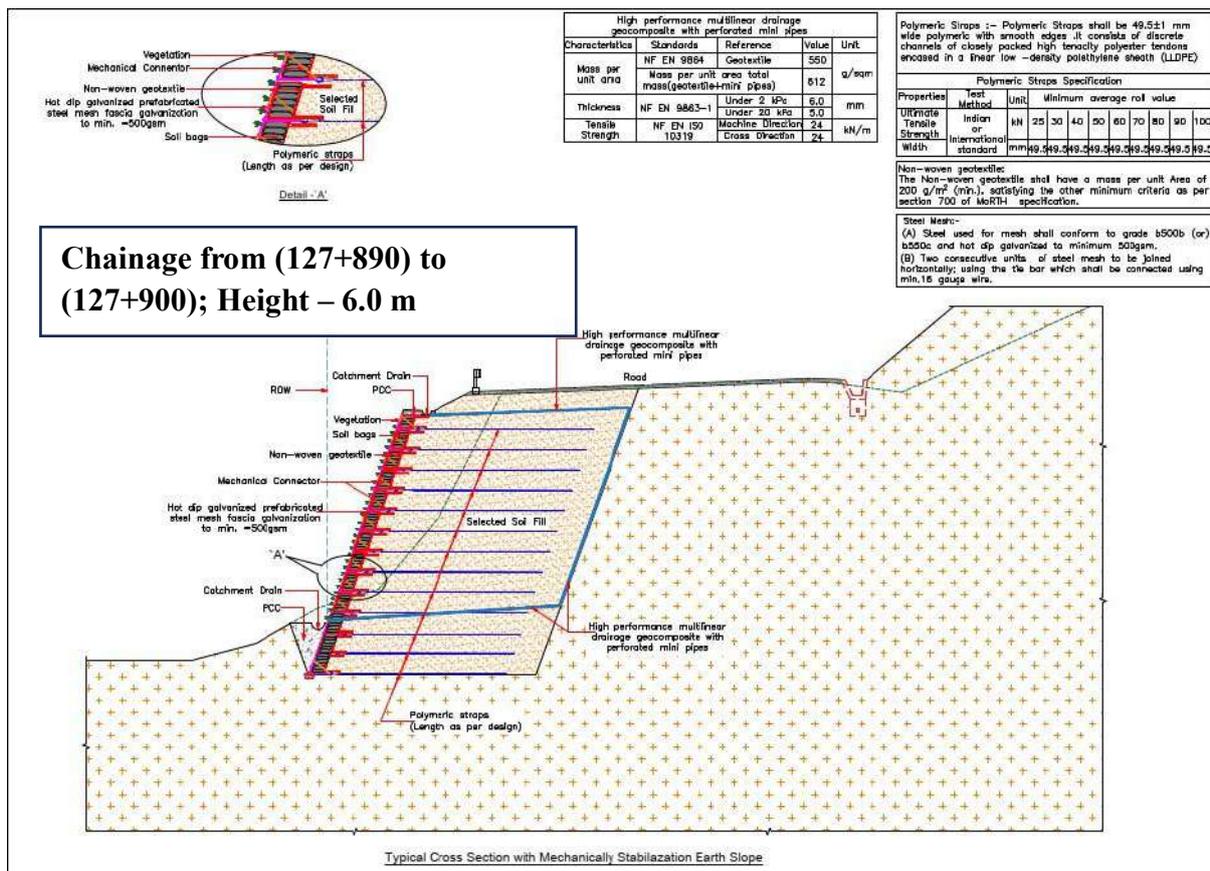




Fig. 76: The left-side portion of the road pavement near Ch 127+900 km failed and collapsed. The affected pavement sections shifted both horizontally and vertically. Heavy masonry retaining structure failed and divided in two parts and moved both horizontally and vertically.

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (127+945) to (127+980)

Length – 35 m

Height – 7.0 m

Proposed Solution:

1. Mechanically stabilised Earth wall (height of MSE wall to be 7m as per site verification)
2. Paved Shoulders
3. Plantation

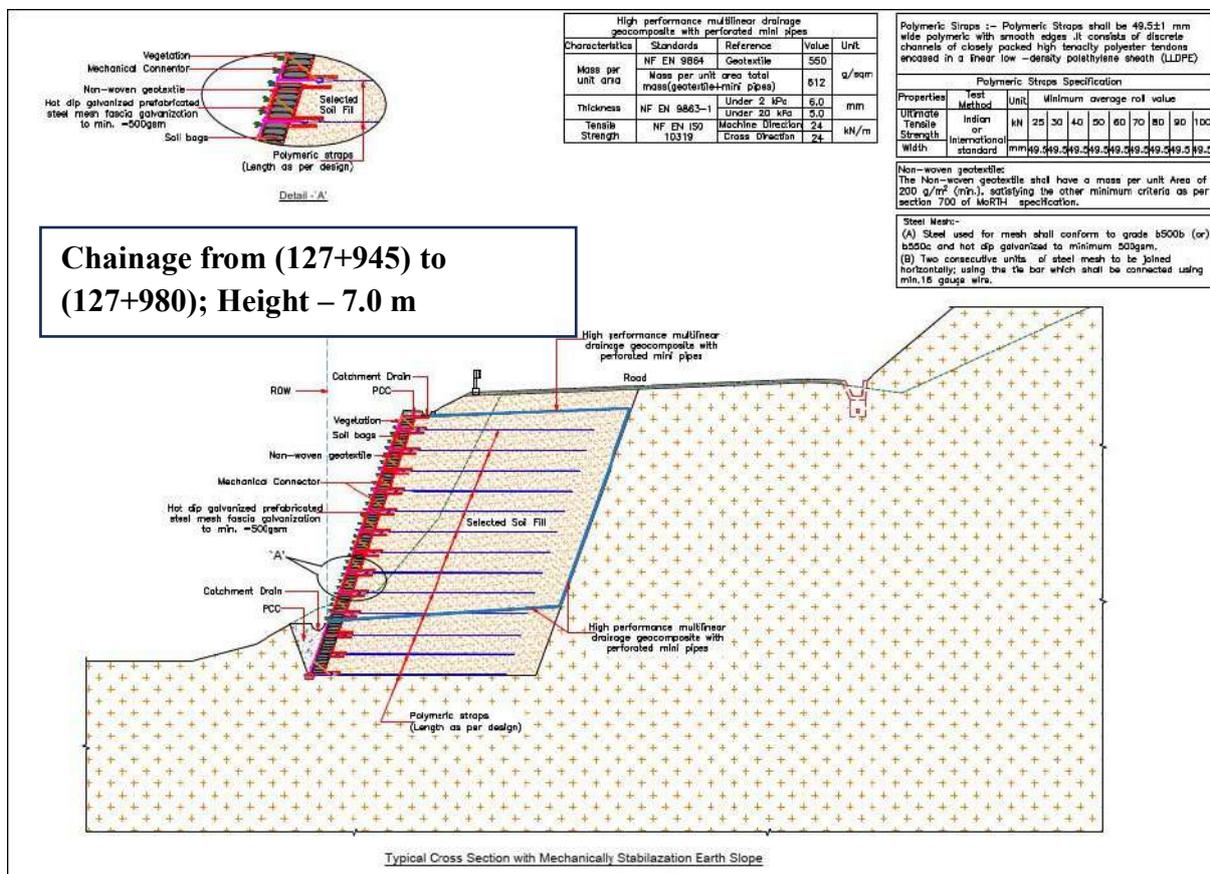




Fig. 77: Major subsidence was mapped on the left-hand side of the road near Ch 127+965 km, which may affect overall road stability

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (129+320) to (129+360)

Length – 40 m

Height – 10.0 m

Proposed Solution:

1. Soil nailing with 100 mm SFRS and perforated pipes (10 m ht)
2. Paved Shoulders
3. One row of grouting on the LHS at 3.0 m spacing and 5.0 m depth
4. Plantation



Fig. 78: Photographs are showing the various conditions of instability present on both sides of the road that is likelihood of landslide in roadside cut slopes and subsidence in fill or valley side near Ch. 129+350 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (129+960) to (130+035)

Length – 75 m

Height – 4.0 m

Proposed Solution:

1. Gabion Retaining Wall (4m ht) with perforated pipe.
2. Paved shoulders up to the edges of the road.
3. One row of grouting on the LHS at 3.0 m spacing and 5.0 m depth.
4. From Ch. 130+065 to 130+075 km (LHS), flexible retaining structure.
5. On the LHS, on both sides of the retaining structure, the drain should be channelized up to the ROW with a chute drain.
6. Plantation.



Fig. 79: Downstream and a small debris slide view on the LHS between Ch. 130+065 to 130+075 km



Fig. 80: Downhill view of sinking area between Ch. 129+960 and 130+035 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (130+120) to (130+155)

Length – 35 m

Height – 2.0 m

Proposed Solution:

1. Gabion retaining wall of 2.0 m height and gabion breast wall of 2.0 m height area recommended, along with the paved shoulder on both sides.



Fig. 81: View of sinking area between Ch. 130+120 to 130+155 km on LHS

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (130+230) to (130+290)

Length – 60 m

Height – 9.0 m

Proposed Solution:

1. Soil nailing with 100 mm Steel Fiber Reinforced Shotcrete (SFRS) and perforated pipes. (9 m ht)
2. On the RHS, a gabion breast wall of 2.0 m height and the paved shoulders up to the edges of the road.



Fig. 82: View of the sifted part of the retaining wall in the sliding area at Ch. 130+240 m



Fig. 83: Photographs are showing the various conditions of instability present on both sides of the road that is likelihood of landslide in roadside cut slopes and subsidence in fill or valley side between Ch. 130+260 km.

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of Chainage from (130+485) to (130+515)

Length – 30 m

Height – 8 m

Proposed Solution:

1. Soil nailing with 100 mm SFRS and perforated pipes (8 m ht)
2. Grouted soil nailing

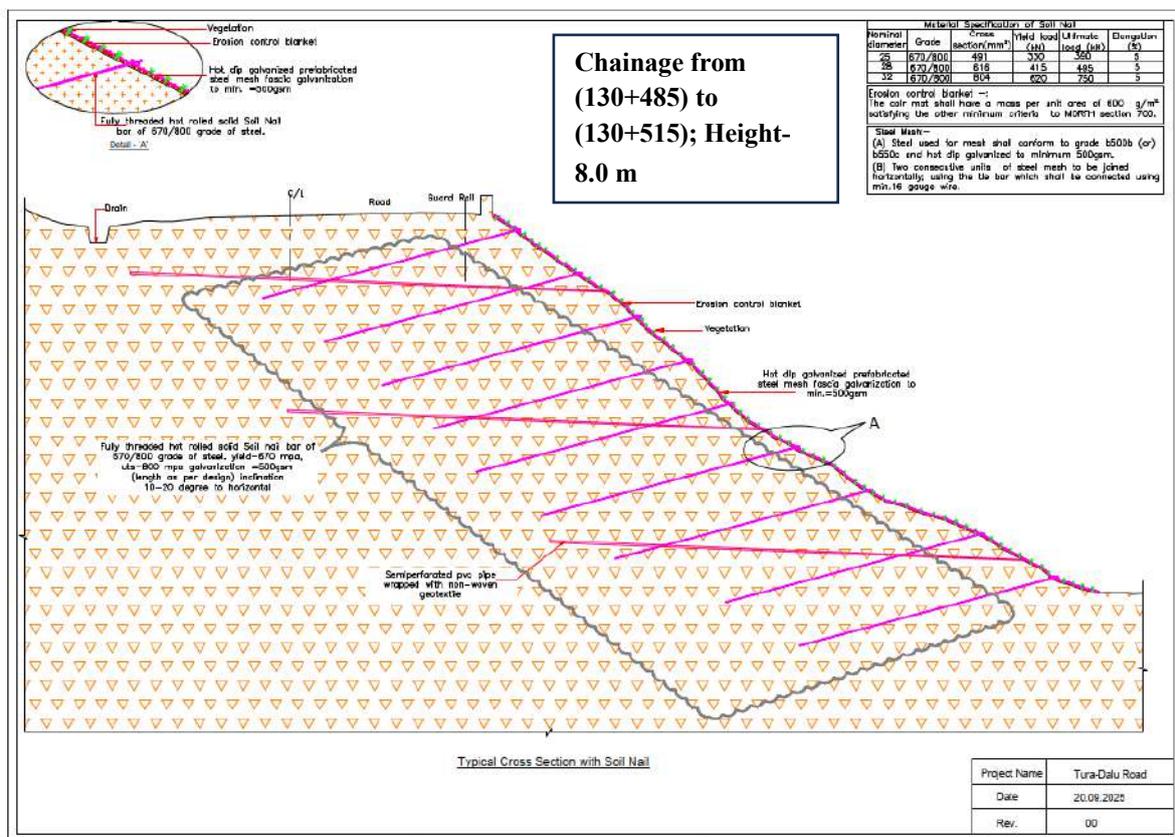




Fig. 84: View of sinking area between Ch. 130+485 to 130+515 km on LHS

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (130+680) to (130+764)

Length – 84 m

Height – 10.0 m

Proposed Solution:

1. Natural material and local vegetation
2. Grouted soil nailing



Fig. 85: View of sinking zone-63 between Ch. 130+680 and 130+764 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of

Chainage from (130+850) to (130+900)

Length – 50 m

Height – 4.0 m

Proposed Solution:

1. Gabion Retaining Wall (4m ht) with perforated pipe
2. Paved shoulders up to the road edge and side drain.



Fig. 86: Panoramic view of the sinking area between Ch. 130+850 and 130+900 km



Fig. 87: Downhill view of the sinking area at Ch. 130+730 and 130+900 km



Fig. 88: View of the right flank of the sinking area at Ch. 130+850 and 130+900 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of Chainage from (131+425) to (131+460)

Length – 35 m

Height – 6.0 m

Proposed Solution:

1. Gabion Retaining Wall (6m ht) with perforated pipe
2. Natural material and local vegetation
3. Paved Shoulders
4. Existing Structures

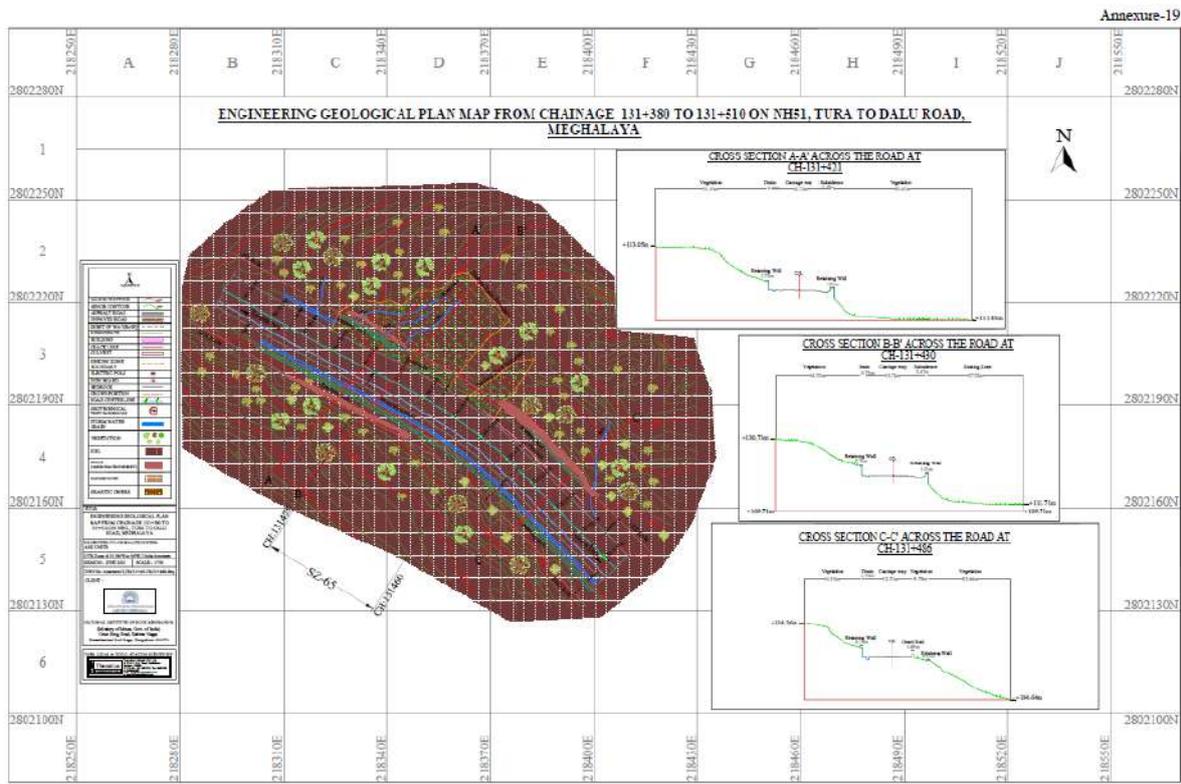




Fig. 89: Lateral & downhill views of the sinking area between Ch. 131+405 & 131+460 km on LHS



Fig. 90: View of breast wall provided at the uphill side of the affected area on RHS near Ch. 131+430 km



Fig. 91: View of retaining wall provided at the downhill side of the affected area on LHS near Ch. 131+430 km

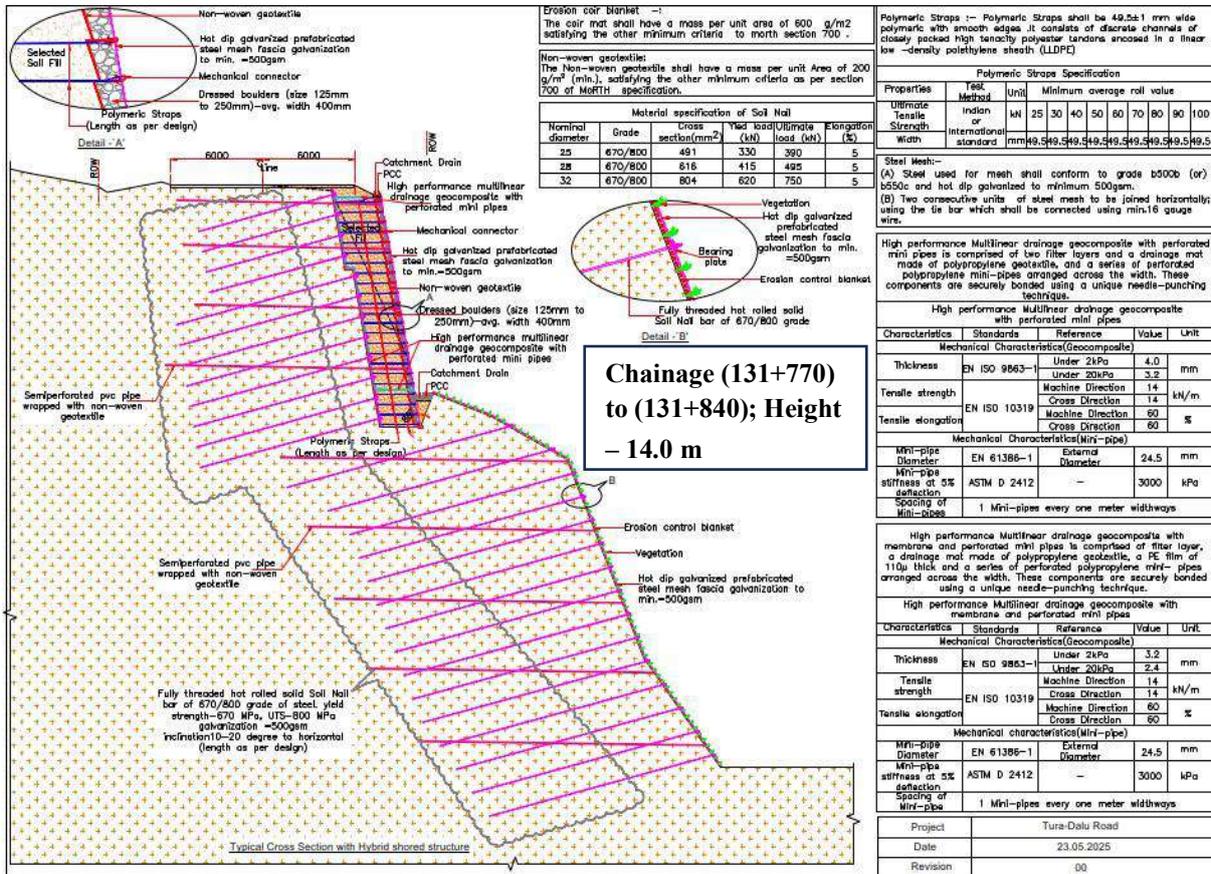
Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of Chainage from (131+770) to (131+840)

Length – 70 m

Height – 14.0 m

Proposed Solution:

1. Hybrid Shored Wall+Soil Nail
2. Paved shoulders up to the road edge and side drain.
3. Grouting



Erosion control blanket -
The car mat shall have a mass per unit area of 600 g/m² satisfying the other minimum criteria to north section 700.

Non-woven geotextile:
The Non-woven geotextile shall have a mass per unit Area of 200 g/m² (min.), satisfying the other minimum criteria as per section 700 of MoTH specification.

Nominal diameter	Material specification of Soil Nail			Elongation (%)
	Grade	Cross section (mm ²)	Yield load (kN) / Load (kN)	
25	670/800	491	330 / 390	5
28	670/800	616	415 / 495	5
32	670/800	804	620 / 750	5

Polymeric Straps :- Polymeric Straps shall be 49.5±1 mm wide polymeric with smooth edges. It consists of discrete channels of closely packed high tenacity polyester (arcone) arranged in a linear low-density polyethylene sheath (LLDPE)

Properties	Test Method	Unit	Polymeric Straps Specification								
			Minimum average roll value								
Ultimate Tensile Strength	Indian or International standard	kN	25	30	40	50	60	70	80	90	100
			49.5	54.9	59.9	64.9	69.9	74.9	79.9	84.9	89.9
Width		mm	49.5	54.9	59.9	64.9	69.9	74.9	79.9	84.9	

Steel Mesh:-
(A) Steel used for mesh shall conform to grade B500b (or) B550c and hot dip galvanized to minimum 500gsm.
(B) Two consecutive units of steel mesh to be joined horizontally using the tie bar which shall be connected using min.16 gauge wire.

High performance Multilayer drainage geocomposite with perforated mini pipes is comprised of two filter layers and a drainage mat made of polypropylene geotextile and a series of perforated polypropylene mini-pipes arranged across the width. These components are securely bonded using a unique needle-punching technique.

High performance Multilayer drainage geocomposite with perforated mini pipes

Characteristics	Standards	Reference	Value	Unit
Mechanical Characteristics(Geocomposite)				
Thickness	EN ISO 9863-1	Under 2kPa	4.0	mm
		Under 20kPa	3.2	
Tensile strength	EN ISO 10319	Machine Direction	14	kN/m
		Cross Direction	14	
Tensile elongation	EN ISO 10319	Machine Direction	60	%
		Cross Direction	60	
Mechanical Characteristics(Mini-pipe)				
Mini-pipe Diameter	EN 61386-1	External Diameter	24.5	mm
Mini-pipe stiffness at 5% deflection	ASTM D 2412	-	3000	kPa
Spacing of Mini-pipes	1 Mini-pipes every one meter widthways			

High performance Multilayer drainage geocomposite with membrane and perforated mini pipes is comprised of filter layer, a drainage mat made of polypropylene geotextile, a PE film of 110µ thick and a series of perforated polypropylene mini-pipes arranged across the width. These components are securely bonded using a unique needle-punching technique.

High performance Multilayer drainage geocomposite with membrane and perforated mini pipes

Characteristics	Standards	Reference	Value	Unit
Mechanical Characteristics(Geocomposite)				
Thickness	EN ISO 9863-1	Under 2kPa	3.2	mm
		Under 20kPa	2.4	
Tensile strength	EN ISO 10319	Machine Direction	14	kN/m
		Cross Direction	14	
Tensile elongation	EN ISO 10319	Machine Direction	60	%
		Cross Direction	60	
Mechanical characteristics(Mini-pipe)				
Mini-pipe Diameter	EN 61386-1	External Diameter	24.5	mm
Mini-pipe stiffness at 5% deflection	ASTM D 2412	-	3000	kPa
Spacing of Mini-pipes	1 Mini-pipes every one meter widthways			

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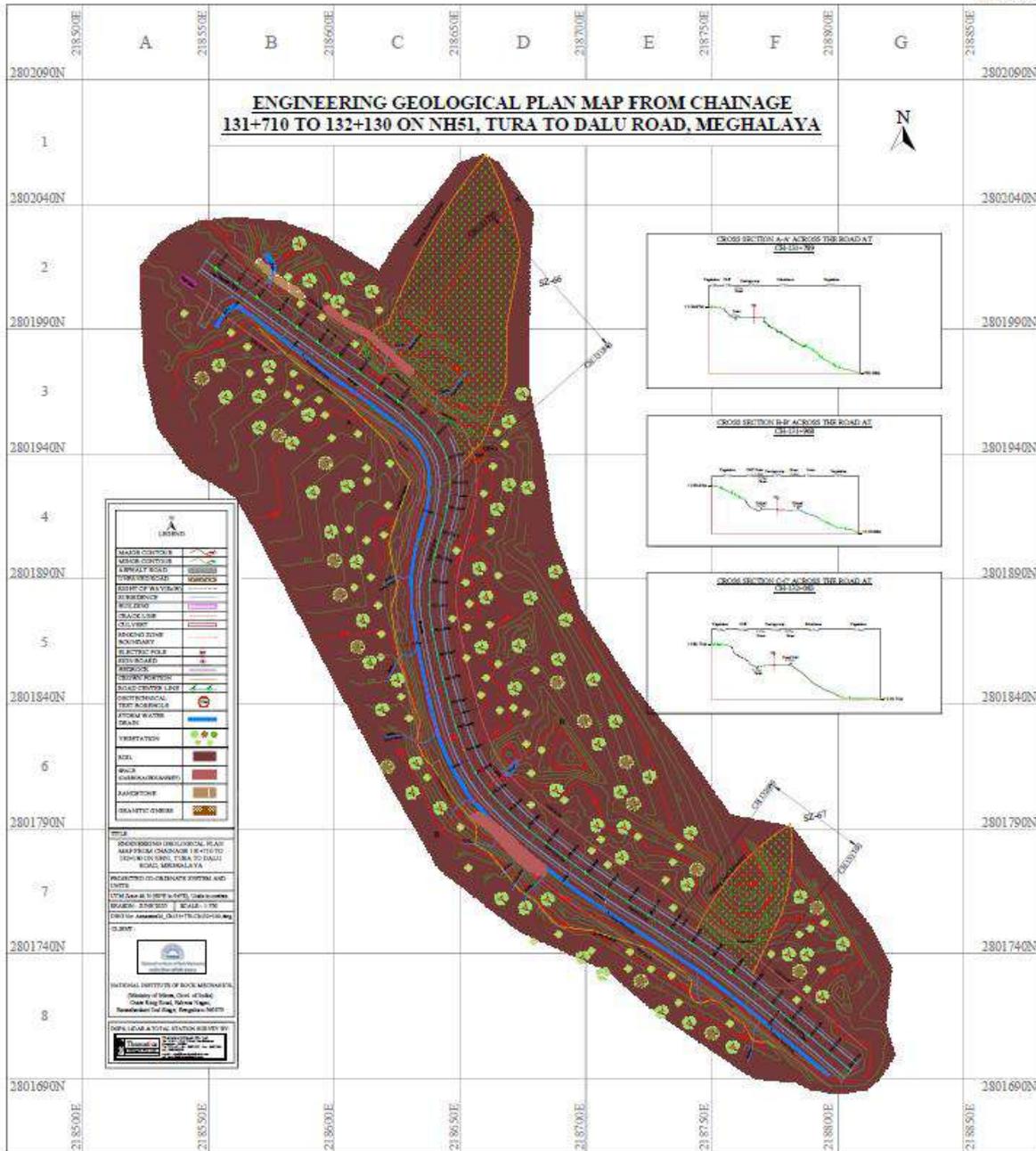




Fig. 92: Lateral view of landslide at Ch. 131+800 km Fig. 93: Downhill view of the landslide at Ch. 131+800 km



Fig. 94: View of sedimentary formations of the affected area & minor coal seems mapped at Ch. 131+770 km & 131+840 km



Fig. 95: View of the left and right flanks of the affected area at Ch.132+060 to 132+100 km



Fig. 96: View of RHS side of the affected area between Ch.132+060 to 132+100 km

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of Chainage from (132+830) to (132+875)

Length – 45 m

Height – 6.0 m

Proposed Solution:

1. Gabion Retaining Wall (6m ht) with perforated pipe.
2. Grouting.

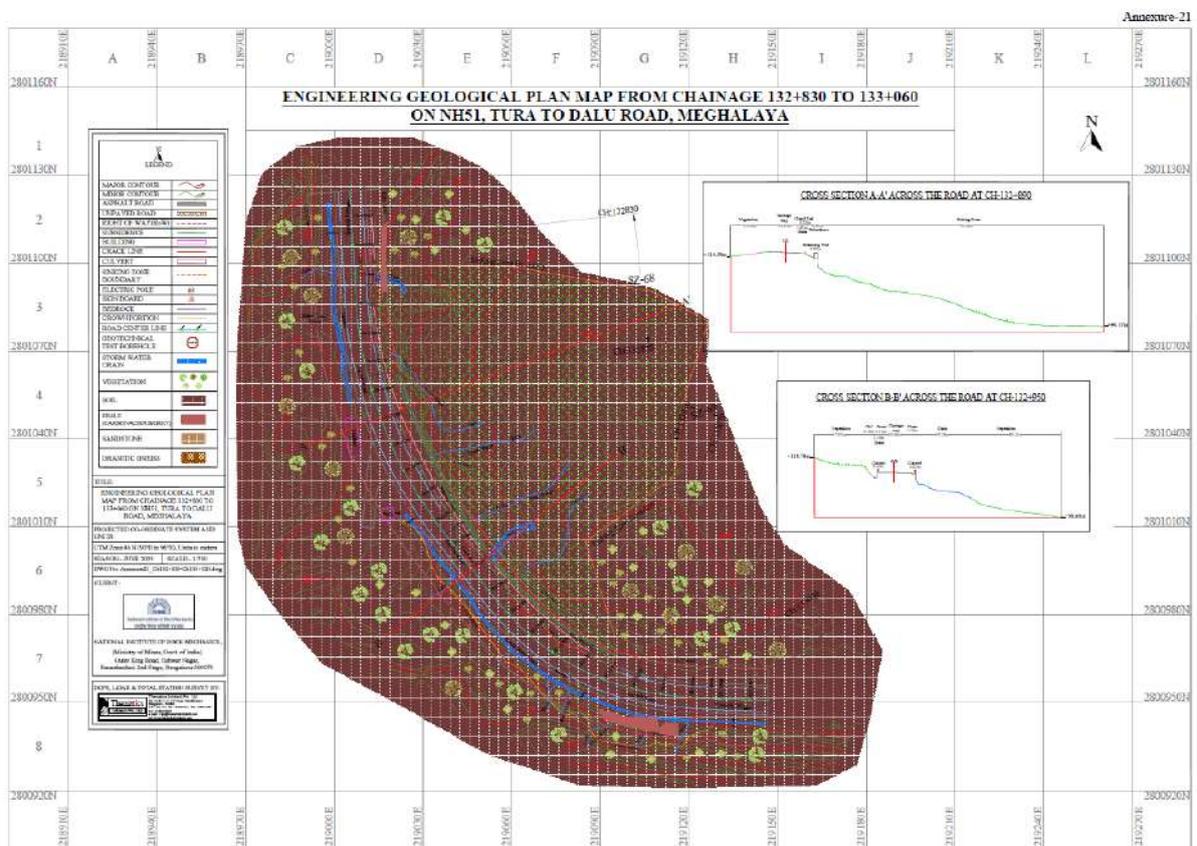




Fig. 97: View of sinking area at Ch. 132+830 km



Fig. 98: Downhill view of the sinking area from Ch. 133+010 to 133+020 km



Fig. 99: View of cracks developed at the road level from Ch. 133+010 to 133+020 km

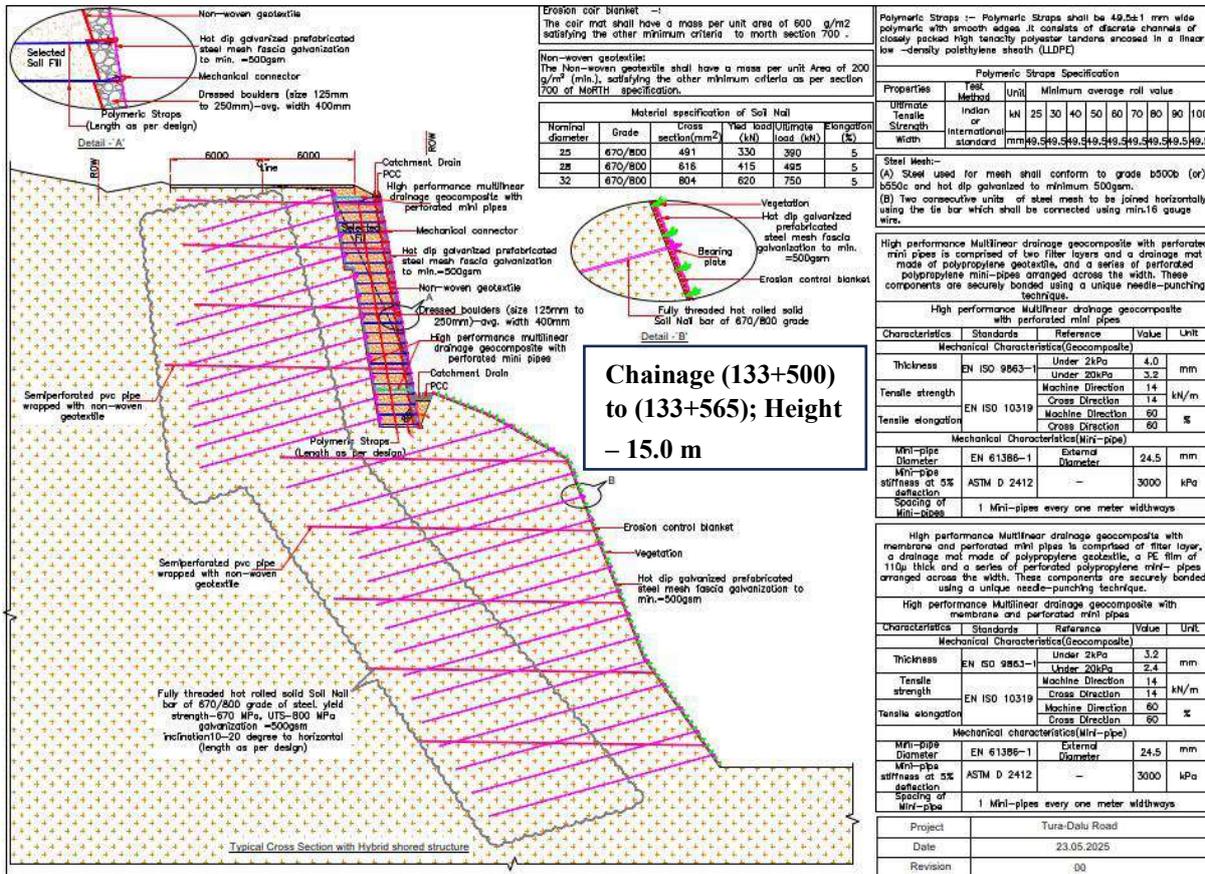
Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of Chainage from (133+500) to (133+565)

Length – 65 m

Height – 5.0 m

Proposed Solution:

1. Soil nailing with 100 mm SFRS and perforated pipes. (5 mt ht)
2. Paved shoulders
3. Grouting



Material specification of Soil Nail

Nominal diameter	Grade	Cross section(mm ²)	Yield load (kN)	Ultimate load (kN)	Elongation (%)
25	670/800	491	330	390	5
28	670/800	618	415	495	5
32	670/800	804	620	750	5

Polymeric Straps Specification

Properties	Test Method	Unit	Minimum average roll value								
Ultimate Tensile Strength	Indian or International standard	kN	25	30	40	50	80	70	80	90	100
Width		mm	49.5	49.5	49.5	49.5	49.5	49.5	49.5	49.5	49.5

Mechanical Characteristics(Geocomposite)

Characteristics	Standards	Reference	Value	Unit
Thickness	EN ISO 9863-1	Under 2kPa	4.0	mm
		Under 20kPa	3.2	mm
Tensile strength	EN ISO 10319	Machine Direction	14	kN/m
		Cross Direction	14	kN/m
Tensile elongation	EN ISO 10319	Machine Direction	60	%
		Cross Direction	60	%

Mechanical Characteristics(Mini-pipe)

Characteristics	Standards	Reference	Value	Unit
Thickness	EN ISO 9863-1	Under 2kPa	3.2	mm
		Under 20kPa	2.4	mm
Tensile strength	EN ISO 10319	Machine Direction	14	kN/m
		Cross Direction	14	kN/m
Tensile elongation	EN ISO 10319	Machine Direction	60	%
		Cross Direction	60	%

Project	Tura-Daku Road
Date	23.05.2025
Revision	00

Ch. 133+520km



Fig. 100: View of landslide between Ch. 133+520 to 133+565 km



Fig. 101: View of CC drain and breast wall between Ch. 133+520 and 133+565 km



Fig. 102: Lateral and downhill view of debris failure from Ch. 138+720 to 138+780 km



Fig. 103: View of the slope failure at LHS (uphill side) from Ch. 138+720 to 138+780 km



Fig. 104: View of exposed geological formation nearby the landslide affected area on LHS of the road

Proposed Mitigation Measures Based on Site Conditions and NIRM Recommendation of Chainage from (139+240) to (139+280)

Length – 40 m

Height – 3.0 m

Proposed Solution:

1. Gabion Retaining Wall (3m ht) with perforated pipe on the valley side.
2. Gabion Breast Wall (4m ht) with perforated pipe on the hillside.
3. Two rows of grouting towards the RHS
4. Paved Shoulders

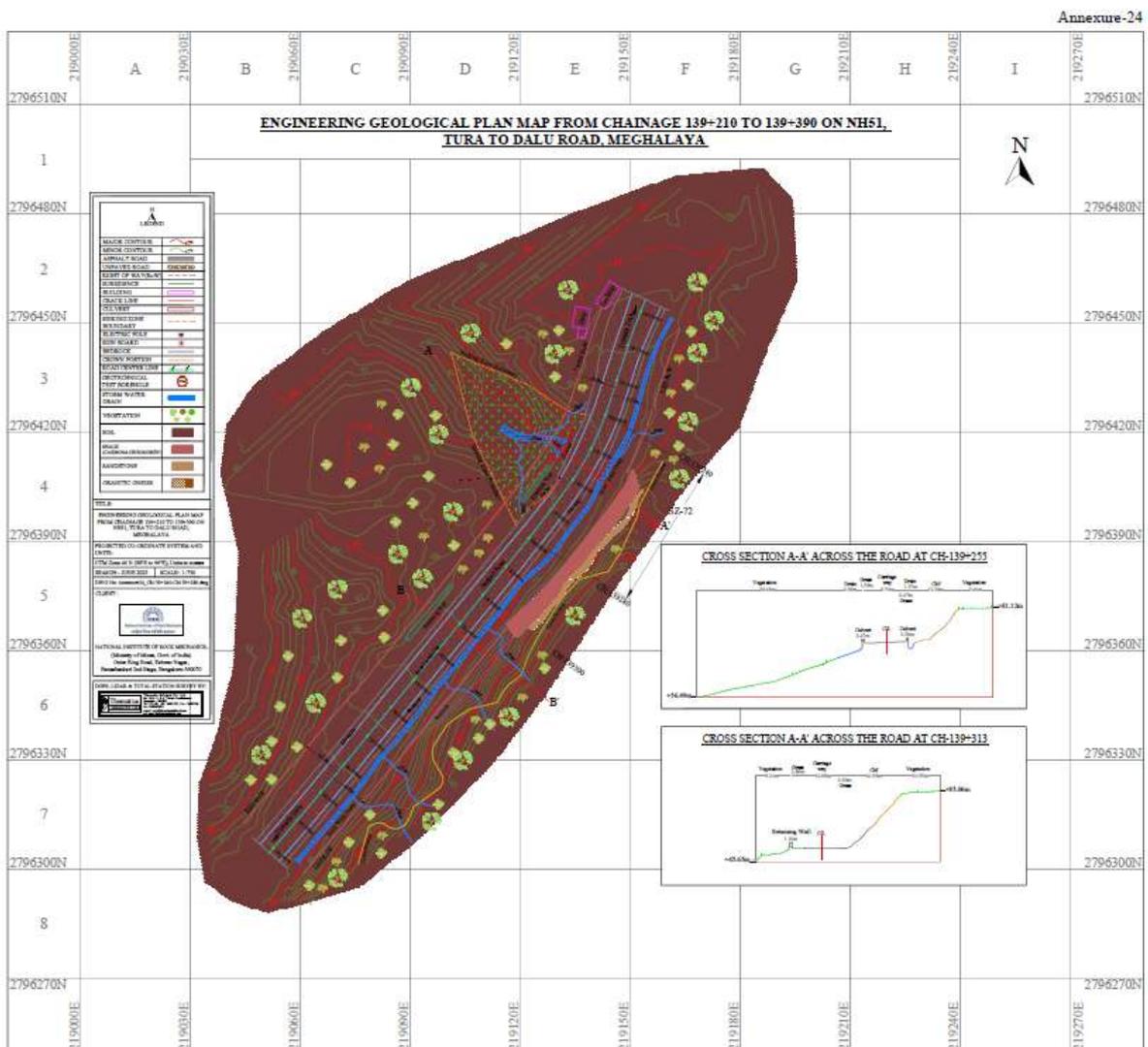




Fig. 105: View of sinking area between Ch. 139+240 and 139+280 km

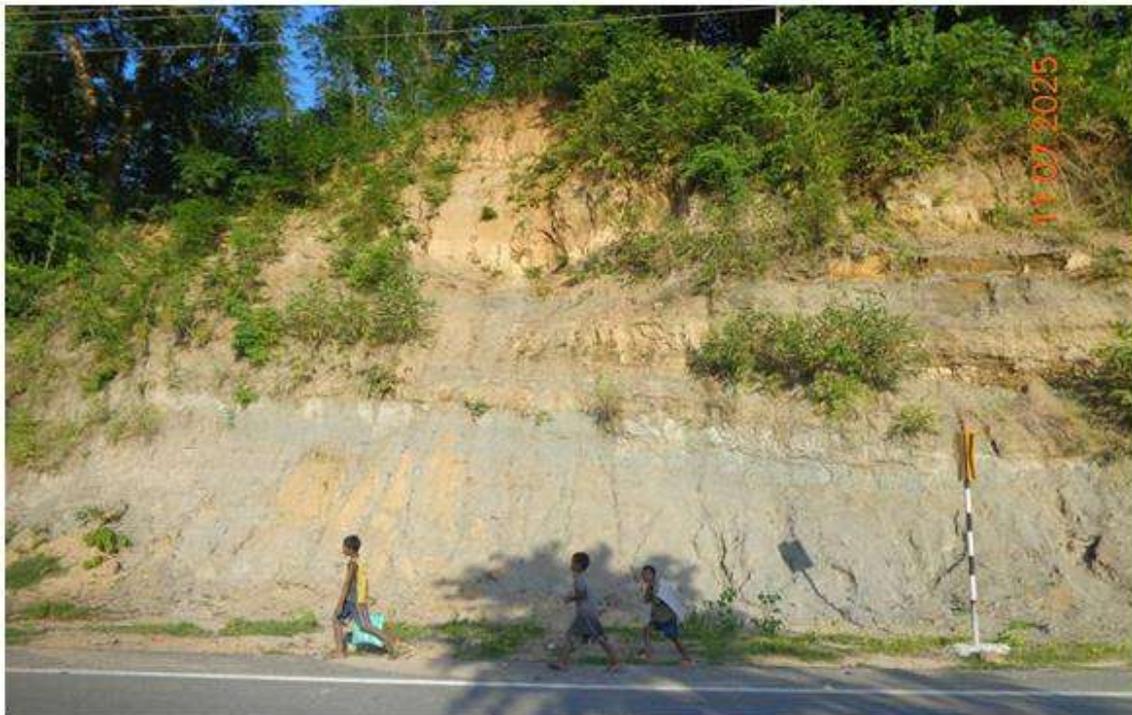


Fig. 106: View of the hill slope on LHS between Ch. 139+240 and 139+280 km