CHALLENGES AND SOLUTIONS IN HILL ROAD CONSTRUCTION : INDIAN EXPERIENCES

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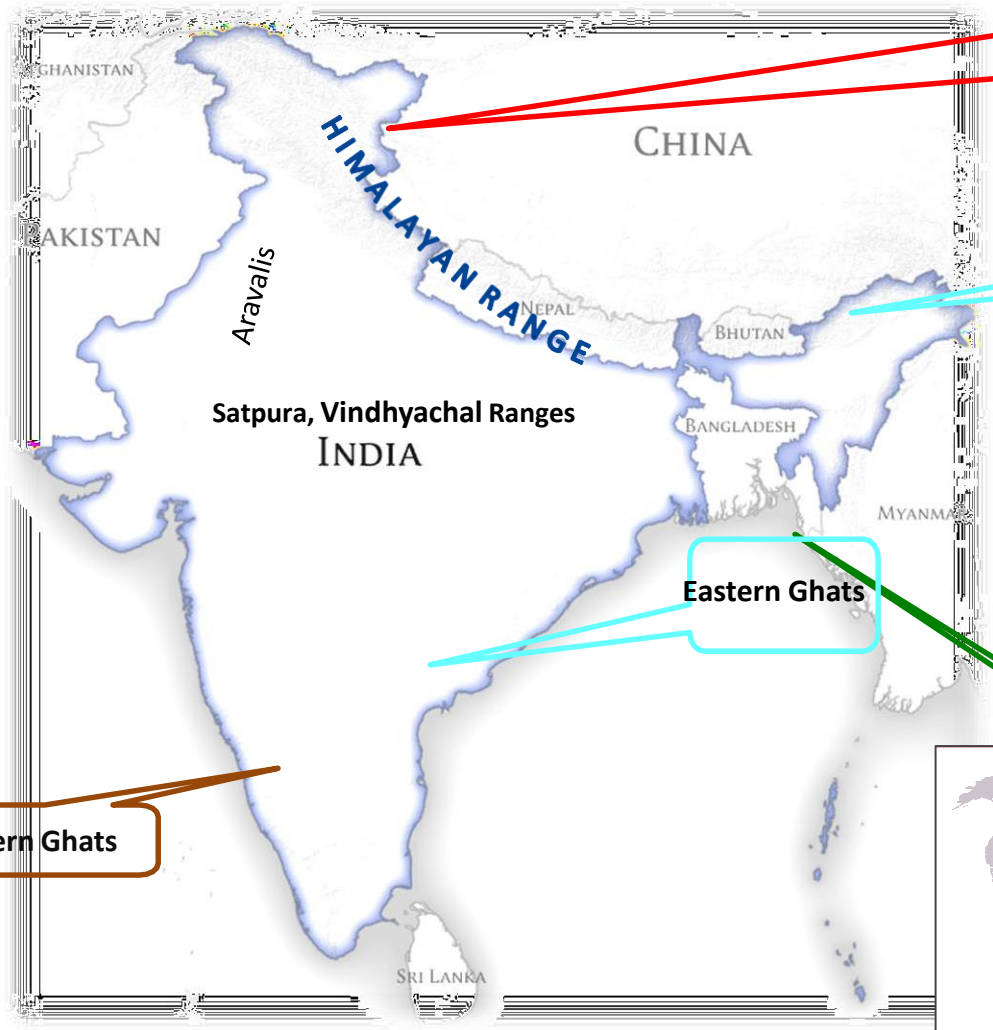
INTERNATIONAL CONFERENCE ON "NEW TECHNOLOGIES AND SUSTAINABLE MATERIALS IN CONSTRUCTION OF RURAL ROADS (LOW VOLUME ROADS) AND BRIDGES"

Pragati Maidan, New Delhi, 04th -06th May 2022

CONTENTS

- Background
  - Terrain & Topography
  - Challenges
- Pavement design and construction
- Sustainable technologies to tackle Challenges
- Case studies

TERRAIN & TOPOGRAPHY

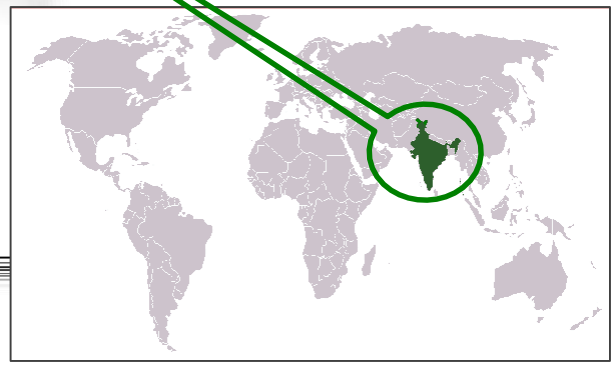


Great Himalayas
(Altitude varying from
500 m to 8000 m)
High Seismic Zone

High Rainfall
Upto 10000 mm
High Seismic Zone

Eastern Ghats

Western Ghats



TERRAIN & TOPOGRAPHY


YOUNG FOLD MOUNTAINS


UNSTABLE HILL SLOPES


DEEP GORGES


HEAVY GLACIATED AREA

CHALLENGES

- Northeastern and lower Himalayan region (altitude upto 8000 ft)
- Annual rainfall up to 10 m coupled with cloud bursts
  - Thick vegetation cover and wild life
  - Land slides, shooting boulders and rock falls
  - Sinking zones


CRACKS IN PAVEMENT SURFACE DUE TO EARTHQUAKE

CHALLENGES

- Formation cutting in saturated slopes
- Road alignment along the rivers more vulnerable to bank erosion
- Wearing course of bituminous pavements remains continuously wet for a long period

FLASH FLOOD IN RIVERS DUE TO CLOUD BURST

FORMATION BREACH

CHALLENGES

- Difficulty in execution of bituminous works
  - Less working period due to heavy rain fall
  - High percentage of entrapped moisture in aggregate
- Non availability of quality aggregates
  - Large lead for quality aggregates

SURFACING WORKS IN INCLEMENT WEATHER

WET PAVEMENT SURFACE

CHALLENGES

- Middle and Upper Himalayas (altitude beyond 8000 ft)
  - Extreme Cold Condition and low temperature up to (-) 50° C
  - Formation of Permafrost
  - Closure of roads during peak winter season
  - Wearing course of bituminous pavements gets damaged due to snow clearance by tracked equipments and vehicles

WINTER SNOW CLEARANCE

MOVEMENT OF VEHICLES WITH ANTISKID ARRANGEMENT

CHALLENGES

- Loss in efficiency of man and machinery
  - Less oxygen content in rarefied air
  - Frost bite, breathlessness, hypertension and mountain sickness
  - Conventional type of fuel not suitable for machineries
  - Engine get blocked in subzero temperature

FROST BITE

WINTER GRADE OIL

CHALLENGES

- Difficulty in induction of equipments to work sites and assembling them
- Freezing and thawing action of bituminous pavements
- Formation of ice lenses in granular layers
- Transverse cracks in bituminous pavements due to thermal stresses
- Eco sensitive zones
- Wild life sanctuaries and national parks

AIR LIFTING OF COMPRESSOR

DOZER BEING ASSEMBLED MANUALLY

CHALLENGES

CHALLANGE OF CUTTING ROADS IN HARD ROCK

DRILLING IN VERTICAL HILL FACE

STEEP MOUNTAIN SLOPE

EQUIPMENT DAMAGED DUE TO ROCK SLIDE

CHALLENGES

CONSTR OF R/ WALL IN DEEP VALLEY

HILL SLOPE FAILURE DUE TO BANK EROSION

CUTTING FOR ALTERNATE ALIGNMENT

CHALLENGES

BAILEY BRIDGE COVERED UNDER SNOW

SNOW AVALANCHE SITE

SNOW CUTTER LESS EFFECTIVE IN ACCUMULATED SNOW

EFFECT OF FROST ACTION ON PAVEMENTS

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- **Pavement design and construction**
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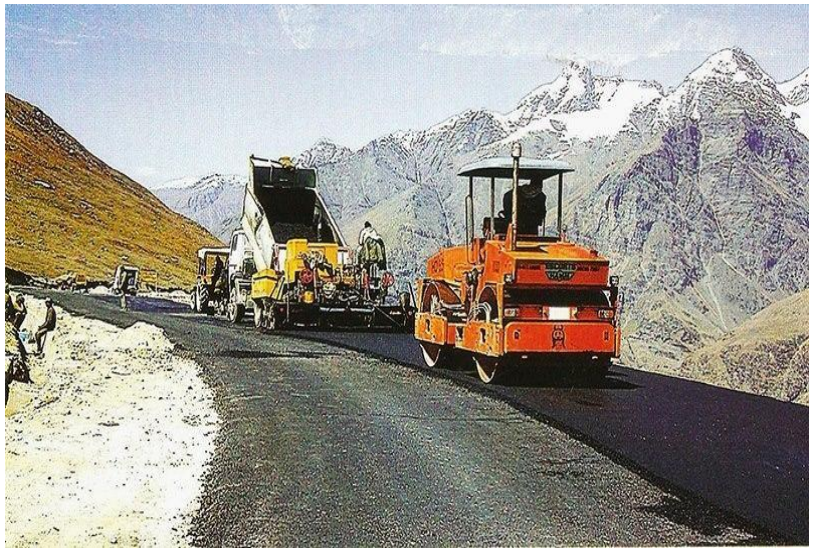
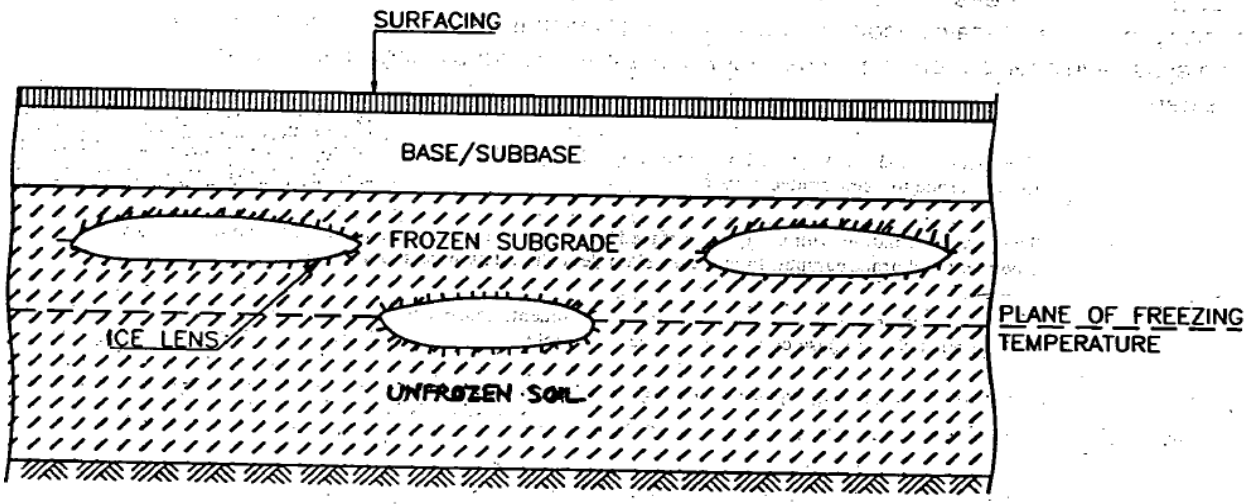


PAVEMENT DESIGN IN HIGH ALTITUDE AREAS

- Pavement design methodology- Subgrade strength and Traffic
- Pavement subjected to
  - Heavy snowfall
  - sub zero temperature
  - frost action
  - snow drifts and snow avalanches
  - Large variation in day and night temperature



Source : IRC:SP:48-1998 (Hill Road Manual)

PAVEMENT DESIGN IN HIGH ALTITUDE AREAS

- Factors influencing design of pavements

PLAINS	HIGH ALTITUDE
Subgrade strength	Terrain and Topography
Traffic Intensity	Snowfall Intensity and avalanches
Traffic growth	Temperature variation
Axle load	Frost action
Design life	Limited working period
	Subgrade strength
	Traffic Parameters

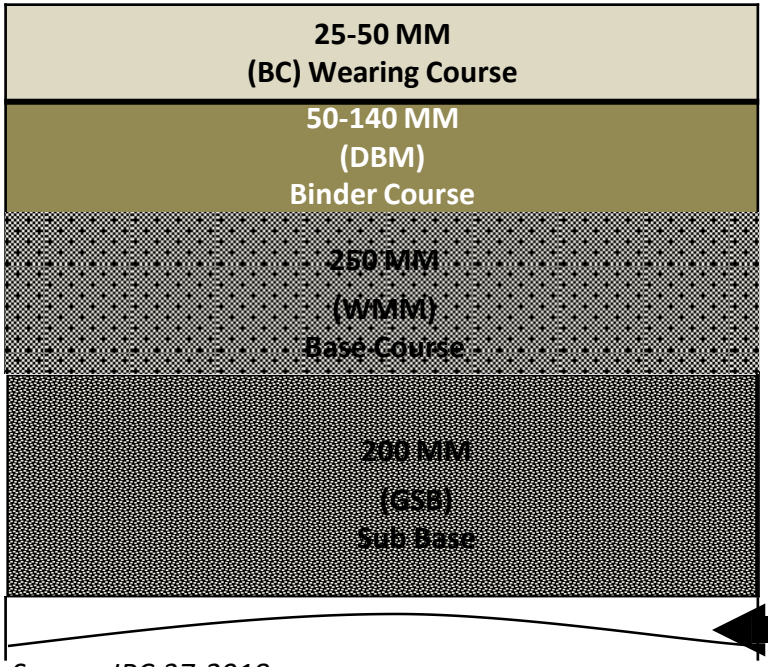
HIGH TRAFFIC INTENSITY IN PLAIN AREAS

LOW TRAFFIC INTENSTITY IN HIGH ALTITUDE

PAVEMENT DESIGN IN HIGH ALTITUDE AREAS

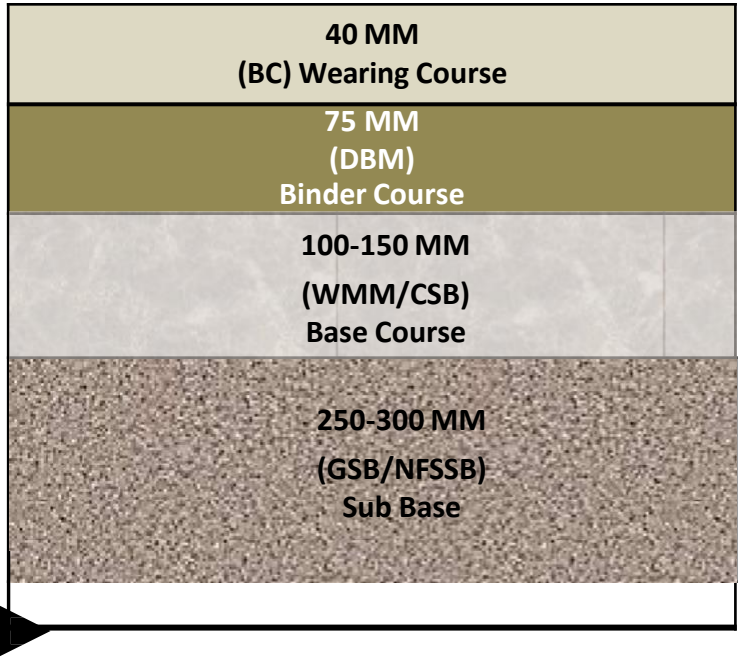
- Minimum thickness of pavement (565 mm)provided to reduce the effect of frost action
- Softer grade of bitumen used VG-10
- Cutback / cationic emulsions also used

PAVEMENT SECTION IN PLAINS



Source: IRC:37-2018
Tentative guidelines for design of flexible pavements

PAVEMENT SECTION IN HIGH ALTITUDE



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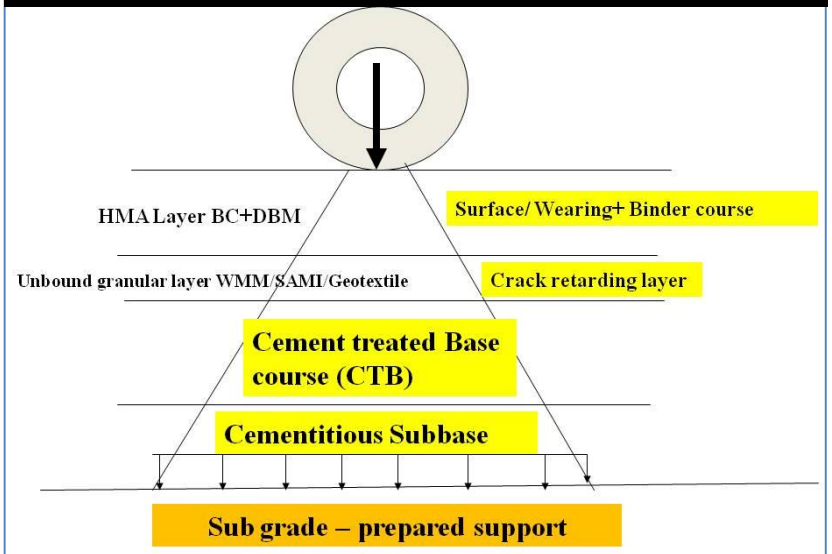
CEMENT TREATED BASES (CTB)

- CTB -intimate mixture of soils and/or aggregates with Portland cement and water
- Mixed in situ or in a central plant using selected material
- Chemical additive compounds are available in market
- Used as per site conditions after characterizing the available material or aggregate to ensure proper dosage of stabilizing agent

PAVEMENT CRUST USING CTB



PROPRIETARY CEMENTITIOUS STABILISER FOR CTB

CEMENT TREATED BASES (CTB)

ADVANTAGES

- Thinner pavement section, stiffer subbase and base
- Lowers life cycle cost
- Effective in heavy rainfall areas where pavement is wet throughout the year
- ***IRC:SP- 89 (Part II)-2018 "Guidelines for design of stabilised pavements (Part II)"***
- ***IRC:37-2012 "Tentative Guidelines for Design of Flexible Pavements" advocate use of CTB in the interest of saving the environment***

STABILIZATION WORKS IN PROGRESS

FINISHED STABILIZED PAVEMENT SURFACE

CEMENT TREATED BASES (CTB)

GEOSYNTHETICS

- Synthetic materials manufactured for Geotechnical and geo environment engineering application
  - Geotextiles
  - Geogrids
  - Geonets
  - Geomembranes
  - Geoweb / Geo Cells
  - Band drains

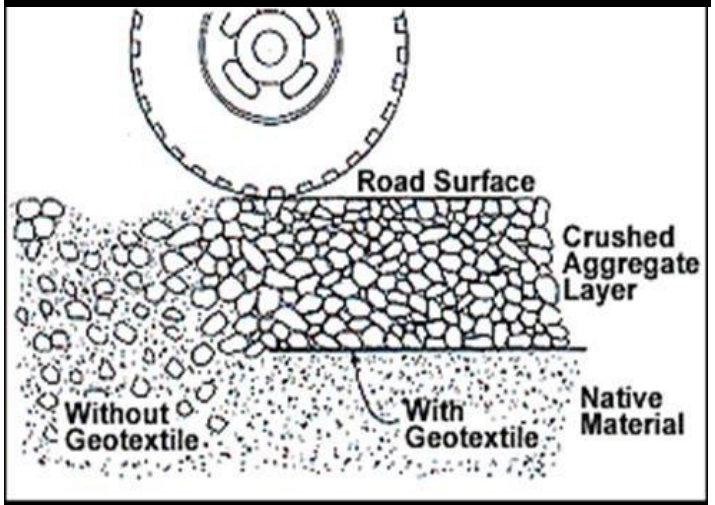
USE OF GEOCELL IN BASE COURSE

REINFORCING SUBGRADE WITH GEOWEBS

ADVANTAGES

- Distribute direct load coming from wheel
- Provide strength to weak subgrade soils
- Enhances drainage performance
- Effective in sinking zones & weak subgrade stretches in hills
- ***IRC:SP:59-2019 "Guidelines for Use of Geotextiles in Road Pavements and Associated Works"***
- ***IRC:37-2018"Tentative Guidelines for Design of Flexible Pavements" advocate use of Geosynthetics***

DIAGRAM EXPLAINING GEOTEXTILE FUNCTIONS



COMPACTION OF BASE WITH GEOCELLS

GEOSYNTHETICS

PAVEMENT COMPOSITION FOR 5 MSA : FLEXIBLE Vs GEOCELL

CBR Value (%)	Type of Design	Pavement Composition (mm)						Reduction in Total Thickness (mm)	Reduction in thickness Bitumen layer (mm)
		GSBC (mm)	GSBC with GEO (mm)	WMM (mm)	DBM (mm)	BC (mm)	TOTAL (mm)		
2	Conventional Layer	200	-	350	95	40	685	(-) 110	(-) 35
	Geo Cell	-	200	275	60	40	575		
3	Conventional Layer	200	-	300	75	40	615	(-) 140	(-) 15
	Geo Cell	-	150	225	60	40	475		
4	Conventional Layer	200	-	200	70	40	510	(-) 95	(-) 20
	Geo Cell	-	150	175	50	40	415		
5	Conventional Layer	150	-	200	60	40	450	(-) 70	(-) 10
	Geo Cell	-	150	150	50	30	380		
6	Conventional Layer	150	-	150	70	30	400	(-) 45	(-) 20
	Geo Cell	-	100	175	50	30	355		
7	Conventional Layer	150	-	150	70	30	400	(-) 60	(-) 10
	Geo Cell	-	100	150	60	30	340		
8	Conventional Layer	150	-	150	50	30	380	(-) 50	-
	Geo Cell	-	100	150	50	30	330		
9	Conventional Layer	150	-	150	50	30	380	(-) 50	-
	Geo Cell	-	100	150	50	30	330		
10	Conventional Layer	150	-	150	50	30	380	(-) 50	-
	Geo Cell	-	100	150	50	30	330		

COLD MIX

- Cold mix technology-mixture of bitumen emulsion/foamed bitumen and aggregate
- Prepared in a concrete mixer or cold mix plant or a modified hot mix plant.

ADVANTAGES

- Suited for construction of roads in remote, isolated and cold climate areas with minimum logistic support
- Alleviates problem of temperature in cold and hilly areas

PRODUCTION OF COLD MIX IN CONCRETE MIXER

PRODUCTION OF COLD MIX IN MODIFIED HMP

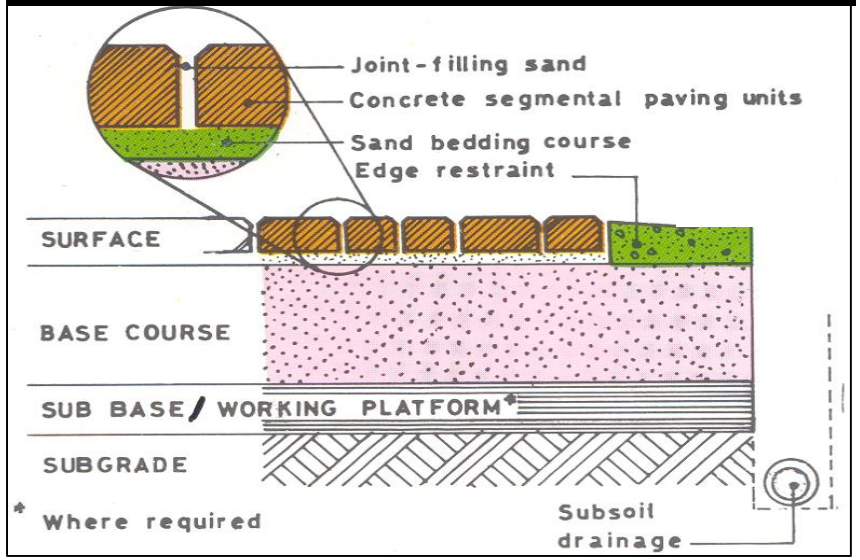
COLD MIX

INTERLOCKING CONCRETE BLOCK PAVEMENT (ICBP)

- Consists of a layer of cement concrete paver blocks (CPB)
- Properly laid over well compacted bedding sand laid over soil subgrade, sub-base and / or base course
- Adequate lateral confinement or support be ensured by providing suitable edge strip or beam or kerb at the end of paved area

CONCRETE BLOCK

CROSS SECTION OF ICBP



INTERLOCKING CONCRETE BLOCK PAVEMENT (ICBP)

ADVANTAGES

- Eco-Friendly Technology
- No effect of climate for construction.
- No Need for Site Curing- Instant Opening to Traffic
- Highly effective in Snow Bound Areas

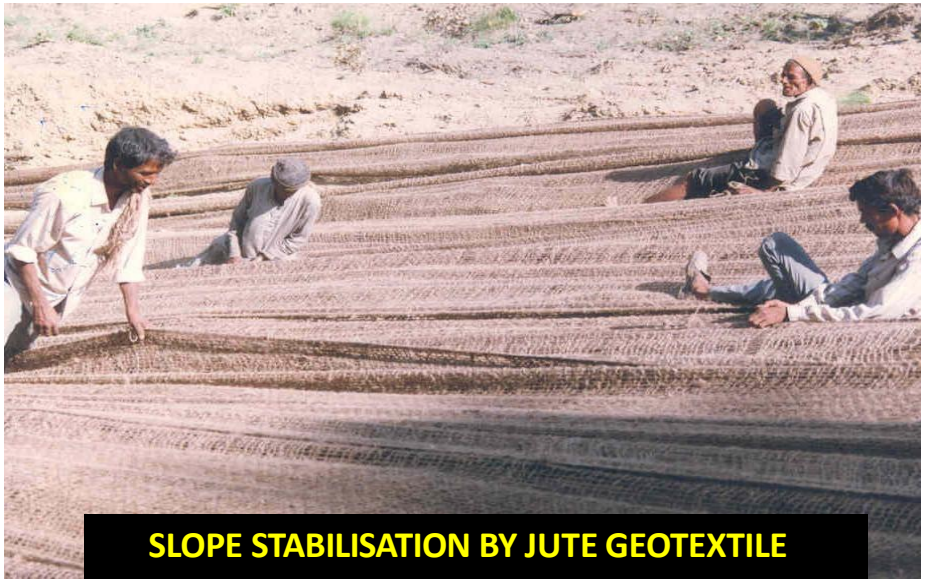
- ***IRC:SP-63-2018 "Guidelines for the use of Interlocking Concrete Block Pavement"***
- ***IS 15658:2021 "Precast Concrete Blocks for Paving — Specification"***

CONCRETE PAVER BLOCK MACHINE

CONSTRUCTION OF ICBP IN SNOW BOUND AREA

INTERLOCKING CONCRETE BLOCK PAVEMENT (ICBP)

DEVELOPMENTS



SLOPE STABILISATION BY JUTE GEOTEXTILE

GABION WALLS

DRUM DIAPHRAGM WALLS

USE OF SILENT EXPLOSIVE

DEVELOPMENTS

SWING BARRIERS FOR PROTECTION AGAINST SHOOTING STONES

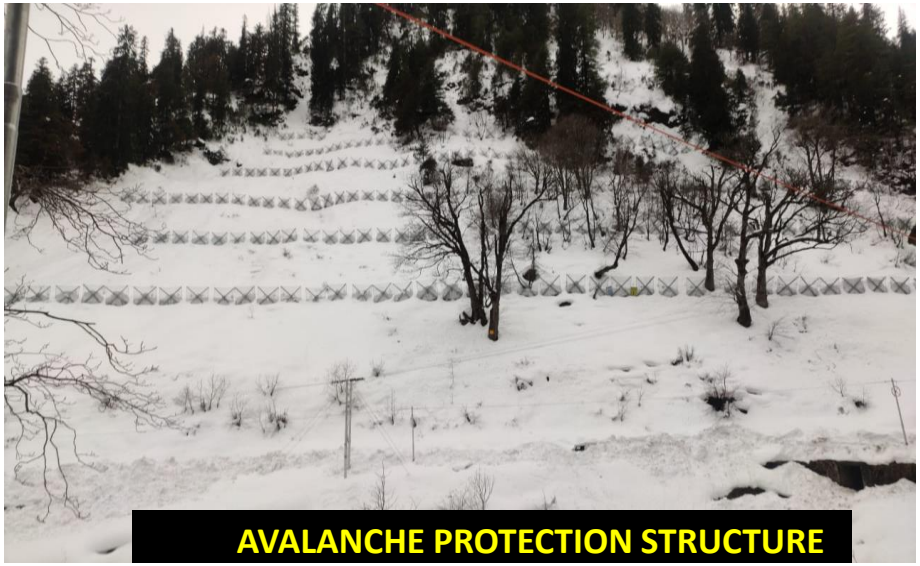
BIOTECHNICAL AND DRAINAGE MEASURES

GEO FLEX RUBBER MAT

INTERLOCKING CONCRETE BLOCK PAVEMENTS

DEVELOPMENTS

SNOW GALLERY



AVALANCHE PROTECTION STRUCTURE

ATAL TUNNEL

ATAL TUNNEL

DEVELOPMENTS

WORLDS HIGHEST MOTORABLE ROAD AT UMING LA PASS 19300 FT

ZOZILA PASS

SELA TUNNEL

SELA TUNNEL

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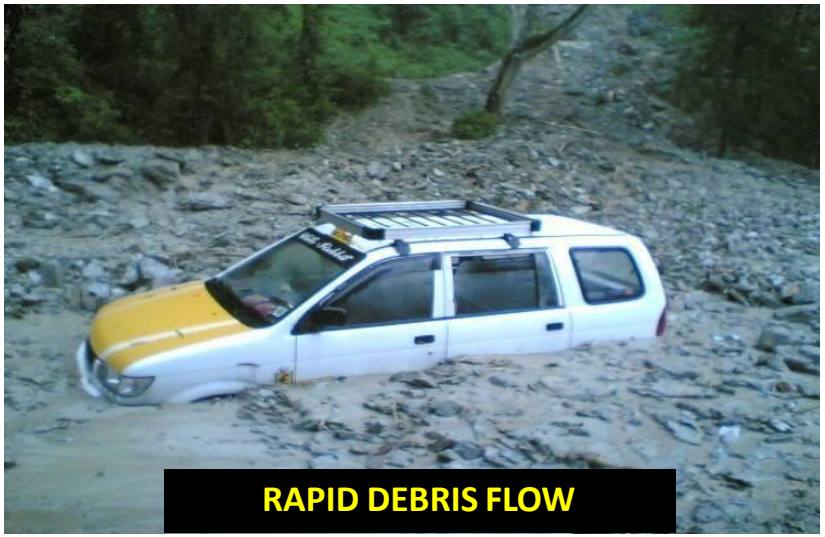
CASE STUDY 1

CONSTRUCTION OF CUT AND COVER TUNNEL FOR MITIGATION OF PERPETUAL LAND SLIDE

- Active rock cum debris perpetual slide
- Rapidly moving slurry water with mud, rock, vegetation & debris
- Height of crown of slide from road surface- 400 m
- Length of road affected by slide –120 m
- Breach of road communication during monsoons

VIEW OF LAND SLIDE

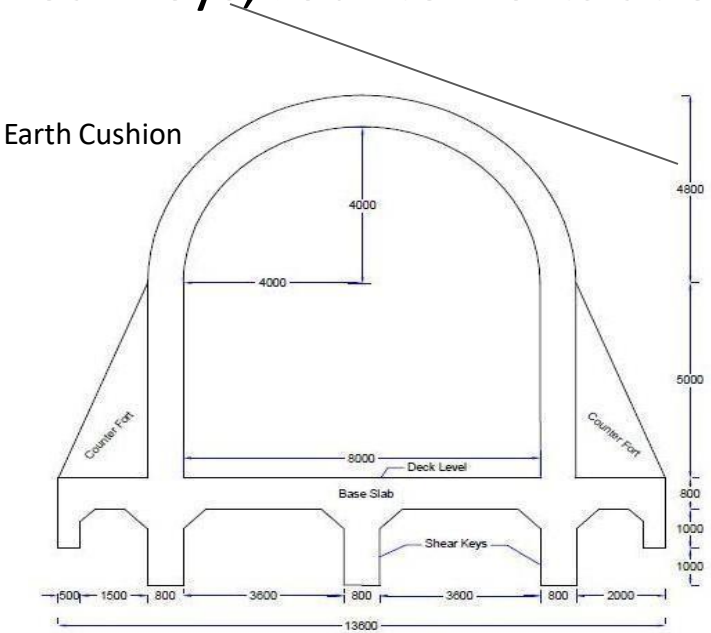


RAPID DEBRIS FLOW

CONSTRUCTION OF CUT AND COVER TUNNEL FOR MITIGATION OF PERPETUAL LAND SLIDE

➢Salient features of cut & cover tunnel structure

- Concrete structure 800 mm thick, M 30 grade
- Base width -13.5 m
- Shear keys,Counter forts at every 5 m
- 123 m length
- 4 m dia semi circular roof
- Tunnel Height - 9 m
- Carriageway width – 8 m



TYPICAL X-SECTION OF CUT & COVER TUNNEL

REINFOCEMENT PLACEMENT FOR SHEAR KEYS

CONSTRUCTION OF CUT AND COVER TUNNEL ACROSS PERPETUAL LAND SLIDE

PREPARATION OF BASE

REINFORCEMENT OF SHEAR KEYS & SLAB

CONCRETING OF BASE SLAB

SIDE WALLS WITH COUNTERFORTS

CONSTRUCTION OF CUT AND COVER TUNNEL ACROSS PERPETUAL LAND SLIDE

ERECTED GANTRY FOR CONCRETING OF SEMI CIRCULAR ROOF

FINISHED CURVED ROOF

VIEW BEOFRE CONSTRUCTION

VIEW AFTER CONSTRUCTION

CASE STUDY 2

RESTORATION OF LINE OF COMMUNICATION AFTER FLASH FLOODS

- A village in in upper Himalayas hit by Flash flood in Feb 2021
- Two Hydel projects and one 90 mtr major bridge demolished
- 13 villages cut off, 200 killed or missing
- Connectivity restored in 26 days by launching a Bailey Bridge 200ft (TDR). Appx cost -3.50 Crs

SITE OF BRIDGE BEFORE FLASH FLOOD

SITE OF HYDEL PROJECT BEFORE FLASH FLOOD

VIDEO CLIP OF BRIDGE WASHED OUT

RESTORATION OF LINE OF COMMUNICATION AFTER FLASH FLOODS

RESTORATION OF LINE OF COMMUNICATION AFTER FLASH FLOODS


ENHANCING OUT PUT IN HARD ROCK
BITUMINOUS WORKS IN EXTREME COLD WEATHER CONDITIONS
SINKING ZONES
?
EARTHQUAKE RESISTANT PAVEMENTS
SHORT TUNNELS AND CUT & COVER STRUCTURES
FLASH FLOOD & RIVER BANK EROSION
STABILISATION TECHNIQUES AT HIGH ALTITUDES


ATAL TUNNEL
WELCOME
TO THE
WORLD'S
LONGEST
HIGHWAY
TUNNEL
ABOVE
10,000 FT

JAI HIND