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BORDER ROADS ORGANISATION

Pre-cast Cut & Fit Technology

India's First Indigenous CL-70 Double Lane Modular Bridge

Pre-Stressed Cable Anchor for Slope Stabilization

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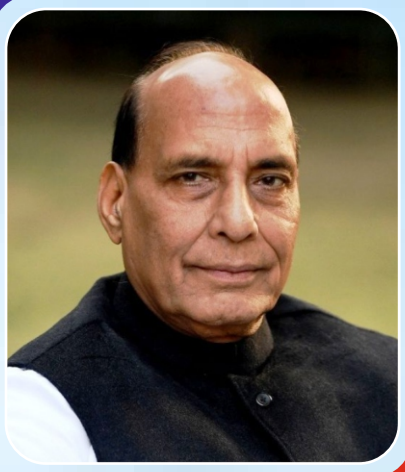


श्री राजनाथ सिंह
रक्षा मंत्री

संदेश

यह बड़े गर्व की बात है कि हमारे सीमावर्ती क्षेत्रों के अंतिम छोर तक कनेक्टिविटी प्रदान करने के लिए बी आर ओ अथक उत्साह से काम कर रहा है और स्थानों को आपस में जोड़कर लोगों को जोड़ने के लिए कठिन परिश्रम कर रहा है।

हाल वर्षों में हमने सड़क के बुनियादी ढांचे के विकास में बहुआयामी एवं गुणोत्तर वृद्धि देखी है। यह सड़क अवसंरचना के क्षेत्र में नवीनतम और परिवर्तनात्मक तकनीकियों के शानदार मेल के कारण संभव हो सका है। बी आर ओ ने इन नई तकनीकियों को दुर्गम क्षेत्रों और कठोर मौसम की परिस्थितियों में आत्मसात करने के लिए अनेकों पहल की है। ऐसी प्रतिकूल कामकाजी परिस्थितियों के बावजूद, मैं इन तकनीकियों को हमारे सीमावर्ती क्षेत्रों में सफलतापूर्वक सम्मिलित करने की बी आर ओ की भावना की सराहना करता हूं।

मैं बहुत प्रसन्न और आश्वस्त हूं कि ये नवीन तकनीकियाँ बुनियादी ढांचे के विकास के क्षेत्र में आवश्यक गति प्रदान करेंगी और कनेक्टिविटी एवं सामाजिक समावेशिता के माध्यम से हमारी सीमाओं कोएकी कृत करेंगी। मैं बी आर ओ को भविष्य के सभी प्रयासों के लिए शुभकामनाएं देता हूँ।

जय हिंद!

स्थान : नई दिल्ली

दिनांक : 14 सितम्बर 2022

(राजनाथ सिंह)

श्री अजय भट्ट
रक्षा एवं पर्यटन राज्य मंत्री

संदेश

पिछले 62 वर्षों में, बी आर ओ ने सीमावर्ती क्षेत्रों को कनेक्टिविटी प्रदान करने में महत्वपूर्ण भूमिका निभाई है। आज, राष्ट्र निर्माण में बी आर ओ के योगदान का अंदाजा सीमावर्ती क्षेत्रों में रहने वाले स्थानीय लोगों के चेहरे की मुस्कान से लगाया जा सकता है, जिनमें से कुछ सरकार की कई योजनाओं का लाभ उठा रहे हैं। इसके लिए बी आर ओ द्वारा प्रदान की गई सड़क संपर्कता के लिए धन्यवाद।

यह बहुत गर्व की बात है कि बी आर ओ सीमावर्ती क्षेत्रों में रहने वाली आबादी के आर्थिक विकास और सामाजिक उत्थान में असाधारण योगदान दे रहा है। मुझे यह देखकर प्रसन्नता हो रही है कि बी आर ओ प्रतिकूल कार्य वातावरण के बावजूद सड़क निर्माण में नवीनतम तकनीकियों को शामिल करके शानदार काम कर रहा है।

मुझे विश्वास है कि ये नवोन्मेषी तकनीकियाँ, बेहतर कनेक्टिविटी के माध्यम से हमारी सीमाओं को भीतरी इलाकों के और भी करीब लाएंगी। मैं भविष्य के सभी प्रयासों के लिए बी आर ओ की प्रशंसा एवं अधिक सफलता की कामना करता हूँ।

जय हिंद!

स्थान : नई दिल्ली

दिनांक : 14 सितम्बर 2021

(अजय भट्ट)

श्री गिरिधर अरमाने, भा.प्रशा.से.
रक्षा सचिव

प्रस्तावना

१. हमारे लिए यह बड़े गर्व की बात है कि बीआरओ उन क्षेत्रों में राष्ट्र निर्माण की दिशा में अत्यधिक योगदान दे रहा है, जहां कोई और जाने का साहस भी नहीं करता है।

२. मुझे यह देखकर प्रसन्नता हो रही है कि बीआरओ द्वारा अत्यधिक चुनौतियों के बावजूद, सड़क निर्माण में नवीनतम तकनीकियों को शामिल किया जा रहा है। सड़कों के सरफेसिंग कार्य के लिए सीमेंटिशियस बेस, सड़क स्थिरीकरण के लिए जियो सेल, ढलान स्थिरीकरण के लिए जियोसिंथेटिक्स का उपयोग, भारी वर्षा वाले क्षेत्रों में बिटुमिनस कार्यों के लिए प्लास्टिक कोटेड एग्रीगेट्स, अत्यधिक ऊंचाई वाले क्षेत्रों में एम-५० मॉड्यूलर ब्लॉक का उपयोग, स्वदेशी मॉड्यूलर ब्रिज, प्रीकास्ट कट एण्ड फिट तकनीक, हाल ही के दिनों में बीआरओ द्वारा उपयोग की जा रही नई तकनीकियों के कुछ उदाहरण हैं।

३. आने वाले वर्षों में, मुझे विश्वास है कि ये नवीन तकनीकियाँ बुनियादी ढांचे के विकास के क्षेत्र में खेल परिवर्तक के रूप में उभरेंगी। मुझे विश्वास है कि जो भी चुनौतियां होंगी, बीआरओ अपने दृढ़ संकल्प से उन सभी को दूर करेगा। बीआरओ द्वारा बहुत कुछ हासिल किया जा चुका है और आने वाले समय में बहुत कुछ हासिल किया जाना है। मैं भविष्य के सभी प्रयासों के लिए बीआरओ को और अधिक गौरव एवं सफलता की कामना करता हूँ।

स्थान : नई दिल्ली

जय हिंद!

गिरिधर

दिनांक : 30 नवम्बर 2022

(गिरिधर अरमाने)

राजीव चौधरी, वीएसएम
डीजीबीआर

प्रस्तावना

1. बी आर ओ देश के दूरस्थ, दुर्गम, अत्यधिक ऊंचाई, भारी वर्षा तथा अत्यधिक ठंड वाले क्षेत्रों में सड़कों, पुलों, सुरंगों एवं हवाई पट्टियों के निर्माण के लिए एक प्रमुख संगठन है और छह दशकों से अधिक समय से राष्ट्र को उल्लेखनीय सेवाएं प्रदान कर रहा है।

2. पिछले कुछ वर्षों से, बुनियादी ढांचे के विकास पर अधिक जोर देने के उद्देश्य से, उभरती हुई नई तकनीकियॉ सड़क निर्माण की प्रक्रिया को नया आकार प्रदान कर रही है। समय को ध्यान में रखते हुए बीआरओ ने इन नए तरीकों को आत्मसात किया है और दूर-दराज एवं दुर्गम क्षेत्रों में कार्यरत रहने के बावजूद, हम विभिन्न परियोजनाओं में कुछ नई निर्माण तकनीकों को लागू करने में सफल रहे हैं। आधुनिकीकरण के कुछ क्षेत्रों, नई तकनीकियों/उपकरणों के उपयोग एवं बीआरओ द्वारा लागू किए गए प्रगतिशील विचारों के बारे में इस प्रकाशन में विचार-विमर्श किया गया है।

3. यह हमारा निरंतर प्रयास होना चाहिए कि हम लगातार खुद को उन्नत करते रहें एवं नवीनतम तकनीकों को अपनाएं ताकि बीआरओ को देश की सबसे प्रमुख सड़क निर्माण एजेंसी बनाया जा सके।

जय हिन्द! जय बीआरओ !!

(राजीव चौधरी)
लेफ्टिनेंट जनरल
डीजीबीआर और कर्नल कमांडेंट बीआरओ

स्थान : नई दिल्ली

दिनांक : 14 नवम्बर 2022

Construction of World's Highest motorable Road over Umling La using Non Frost Susceptible Sub Base

CONTENTS

INTRODUCTION

1. Border Roads Organisation (BRO) is entrusted to construct road infrastructure in the most forward and remote areas along the Northern and Eastern borders of the country under difficult weather and terrain conditions.

2. In recent times, road infrastructure sector has witnessed exponential growth in the country. This has resulted in multifold socio-economic development in the region. This has become possible due to infusion of latest technologies in the field of construction. These techniques are proving beneficial, productive and time saving with consistent focus on sustainable development. The use of such emerging technologies not only helps improving the pace of construction on ground, but also offers various benefits to all stakeholders, including road users.

3. BRO has been at the forefront in introducing latest technologies which are not only environment friendly but also cost effective. As BRO works in harsh and extreme conditions of temperature and terrain, these innovations have contributed towards resolution of many construction problems that have been affecting the roads being constructed on our borders.

4. This compendium entails some of the areas of modernisation and use of new technologies/equipments and innovative ideas implemented by the BRO. Use of these new technologies and techniques will definitely enable the BRO to make a breakthrough in not only increasing the pace and quality of construction in the BRO, but will also enable the Organisation to emerge as a leader in the construction industry in India in implementing new and cost-effective technologies over the next few years.

Use of Geocells on Sasoma-Saserla Road in Ladakh

CHAPTER 1

GEOCELLS IN SUB BASE/BASE COURSES

1. Optimally managing available natural and financial resources to construct high-quality roads and minimizing repairs and maintenance costs has always been a major challenge. A sustainable option is to stabilize pavement structures by using some stabilization techniques that improve pavement structural strength, reduce repair and maintenance costs, and use on-site or recycled materials. Geosynthetic reinforcement has been one of the established stabilization techniques for subgrade improvement and base reinforcement. There are different types of geosynthetic products (e.g. geotextiles, geogrids, geomembranes, geocells, geonets, geopipes, geofoams, geocomposites, etc.) available in the market. The design of Geocell be done as per guidelines given in IRC:SP:59-2019 "Guidelines for the use of Geosynthetics in road pavements and associated works"

2. Geocells are three-dimensional honeycombed cellular structures that form a confinement system when in-filled with compacted soil or aggregates. Geocells are made with polymeric materials such as HDPE, stabilised with carbon black. As geocells confine the sub base/base materials within their structure, the confinement action thereof increases elastic modulus of sub base and base courses considerably and results in reduction of thickness of sub base layers and binder course. In certain stretches of BRO roads, Geocells are being utilised to increase elastic modulus of sub base and base courses.

Use of Geocells on Hapoli-Sarli-Huri Road in Arunachal Pradesh

Use of Geocells on Hapoli-Sarli-Huri Road in Arunachal Pradesh

Use of Geocells on Balipara-Charduar-Tawang Road in Arunachal Pradesh

Use of Geocells on Sasoma-Saserla Road in Ladakh

Use of Geocells on Sasoma-Saserla Road in Ladakh

Geocell Works betweem Km 210- Km 255 on D-S-DBO Road in Ladakh

Geocell Works betweem Km 210- Km 255 on D-S-DBO Road in Ladakh

CHAPTER 2

NON-FROST SUSCEPTIBLE SUB-BASE

1. High altitude areas are primarily subjected to heavy snowfall and frost action which requires special consideration for design and construction of roads in such snow bound areas.

2. Frost heaving and subsequent thawing is extremely detrimental to pavements which occur primarily in two ways. Heaving in winters as the water in pores freezes and expands and collapsing of surface in summers as the ice lens thaws. IRC:SP:48-1988 "Hill Road Manual" provides guidelines for use of non-frost susceptible sub-bases for pavements in high altitude regions that remain snow bound in winter.

3. The soil on Chisumle–Demchok Road at an altitude of above 19000 ft with temperatures dipping to Minus 40 degrees Celcius in the winters is extremely prone to frost heaving. In order to ensure that the road remains durable and retains its smooth driveability throughout its design life, it had to be ensured that the pavement is free of the effects of heaving and thawing. Coarse aggregate with all particles about the same size is best suited for this purpose as it has pore size that are too open and porous to promote capillary flow. They should be free of fines which might fill voids and provide capillary channels around larger particles. Accordingly, layer composition here was chosen as NFSSB (larger particles with no sand as shown in the table below) rather than GSB which is normally used at lower altitudes. This has prevented the uneven settlement on Chisumle-Demchok Road due to frost heaving and freeze thawing.

Size of Aggregates (mm)	GSB (%)	NFSSB (%)
63-45	-	82.50
26.50	34.87	-
13.20	16.84	-
11.20	-	17.50
6.70	19.68	-
Sand	28.61	-

Laying NFSSB Layer on Chisumle-Demchok Road in Ladakh

Umlingla on Chisumle-Demchok Road in Ladakh

CHAPTER 3

CEMENTITIOUS SUB-BASE/BASE COURSES

1. For road bases, there are a variety of soils or granular materials available for construction, but they may exhibit insufficient properties (e.g. low bearing capacity, susceptibility to frost action, etc.), which then results in substantial pavement distress and reduction of the pavement life. However, addition of a suitable stabilizing agent such as cement, bitumen, lime or some non-traditional agents can improve the properties of the soil. Amongst these different stabilized materials, cement-bound materials develop quite a high stiffness and strength, and exhibit good performance for pavement serviceability and high durability. IRC:37-2019 "Guidelines for the design of flexible pavements" and IRC:SP:89-2010 "Guidelines for soil and granular material stabilization using cement, lime & fly ash" provides guidelines for use of cementitious bases in flexible pavements.

2. Cement-Treated Base (CTB) is a type of Soil-Cement consisting of an intimate mixture of native soils and/or manufactured aggregates with measured amounts of Portland cement and water that hardens after compaction and curing to form a strong, durable, frost-resistant paving material. CTB is versatile as it can be either mixed in-situ and compacted after blending, or mixed in a central plant where it is hauled to the placement area and spread on a prepared subgrade or subbase and compacted. A bituminous or Portland cement concrete wearing course is placed on top of the cured CTB to complete the pavement structure. Construction of large number of roads is being undertaken by BRO in Ladakh, Uttarakhand, Sikkim & Arunachal Pradesh using this technology.

Spreading CT Soil on Mahe-Debring Road in Ladakh

Preparing CTB Layer on Sumna–Rimkhim Road in Uttarakhand

Compacting CTB Layer on Sumna–Rimkhim Road in Uttarakhand

Preparing for Laying CTB Layer on Ghastoli-Rattakona Road in Uttarakhand

Spreading CT Soil on Ghastoli-Rattakona Road in Uttarakhand

Spreading CT Soil on Hapoli-Sarli-Huri Road in Arunachal Pradesh

Compacting CTB Layer on Hapoli-Sarli-Huri Road in Arunachal Pradesh

Spreading CT Soil on Mandala-Debrabu-Naga GG Road in Arunachal Pradesh

Compacting CTB Layer on Mandala-Debrabu-Naga GG Road in Arunachal Pradesh

CTB and CTSB Works on Ghastoli-Rattakona Road in Uttarakhand

CHAPTER 4

PLASTIC-COATED AGGREGATES IN BITUMINOUS WORKS FOR CONSTRUCTION OF PAVEMENTS

1. Safe disposal of waste plastic has been a very serious environmental problem around the globe and being a non-bio degradable material, it does not decay over time and even if dumped in landfills can pollute ground water and harm animals due to seepage and unsuspected grazing on landfills. The best method to utilize it, is to recycle plastic waste and one of the ways is to use it in road construction, which also enhances the quality of the surface.

2. There are two processes namely Dry process and Wet process for manufacturing of bituminous mixes using waste plastic. In dry process, processed waste plastic is added after shredding in hot aggregates where as in the wet process, processed waste plastic in the form of powder is added in the hot bitumen. Use of waste plastic should be 6 - 8 % by weight of bitumen. However, addition of waste plastic should not be considered as replacement of bitumen by same percentage from bituminous mix of wearing course. IRC:SP:98-2013 "Guidelines for the use of Waste Plastic in Hot Bituminous Mixes (Dry Process) in Wearing Courses" provides necessary guidelines for use of Plastic waste in surfacing works.

3. As an initiative to reuse the plastic waste, BRO has carried out trials to extensively use this technology in bituminous road construction not only in India but also in Bhutan. The technology has been successfully used in:-

(a) Resurfacing of 4.5 Km on Phuentsholing-Thimphu Road under Project Dantak in Bhutan.

(b) 2.5 Km resurfacing on Balipara-Charduar-Tawang road under Project Vartak and 1.0 Km resurfacing on Roing-Koronu-Paya road under Project Udayak in Arunachal Pradesh.

(c) Resurfacing of 5.22 Km on Hnathial-Sangau-Saiha Road under Project Pushpak in Mizoram.

(d) 2.0 Km Resurfacing on Hapoli-Sarli-Huri Road under Project Arunank in Arunachal Pradesh.

Laying of Bituminous Layer using Plastic Waste on Hnathial-Sangau-Saiha Road in Mizoram

Resurfacing on Phuentsholing–Thimphu Road in Bhutan

Laying of Bituminous Layer using Plastic Waste on Roing-Koronu-Paya Road in Arunachal Pradesh

Compaction of Bituminous layer on Roing-Koronu-Paya Road in Arunachal Pradesh

Completed Stretch using Plastic Coated Aggregates on Balipara-Charduar-Tawang Road in Arunachal Pradesh

Resurfacing on Balipara-Charduar-Tawang Road in Arunachal Pradesh

Collection of Plastic Waste for Resurfacing Works on Hapoli-Sarli-Huri Road in Arunachal Pradesh

Black Topping Using Plastic Waste on Hapoli-Sarli-Huri Road in Arunachal Pradesh

Inter Locking Concrete Blocks (ILCB) at Changla in Ladakh

CHAPTER 5

INTER LOCKING CONCRETE BLOCK PAVEMENTS

1. Inter Locking Concrete Blocks are pre casted concrete blocks of varied dimensions and can be interlocked horizontally and vertically as per use. ILCBs have been used by BRO on pavement of roads at mountain passes where heavy snowfall takes place and snow clearance operations by tracked Dozers leads to damages to bituminous layers. This concept of usage of ILCB at high altitude will give higher dividends in future. The periodic damage to roads in high altitude areas due to snow clearance operations results in disruption of sustained traffic as well as recurring exponential road maintenance cost. In addition, the wear and tear of equipment/vehicles due to damaged roads resulting from snow clearance operations in these areas, adds up to additional cost for maintenance of vehicles as well as riding discomfort. The technology will enhance the speed of construction in high altitude roads and dependence of conducive working season for construction of roads will be reduced. Overall, there will be a substantial reduction in the overall cost on adoption of this technology. IRC:SP:63-2018 " guidelines for the use of Interlocking concrete block pavement" and IS:15658-2006 "Precast Concrete Blocks for Paving- Specification" entails the details of use of ILCBs for pavement works.

2. **Advantages**.

(a) ILC blocks are factory made and they are of very high quality thus ensuring standardisation.

(b) Fast construction as they are delivered on site and laid directly.

(c) For traffic movement the ILCBs provide skid resistance.

(d) The blocks are un-affected from spillage of oil and thus ideal for bus stops and bus depots.

(e) Grey concrete blocks reflect light better than the black pavements, thus bringing down cost of street lights.

(f) Free from cracking phenomenon due to temperature changes.

(g) Lower cost than rigid pavement.

(h) Less pollution as heating of bituminous mixes is avoided.

ILCB Pavement at Changla Pass on Karu–Tangtse Road in Ladakh

ILCB Pavement between Km 57 to 60 at Mayudiya Pass on Roing-Hunli Road in Arunachal Pradesh

Laying of ILCB Pavement between Km 57 to 60 at Mayudiya Pass on Roing-Hunli Road in Arunachal Pradesh

ILCB Pavement on Balipara-Charduar-Tawang Road (Sela Top) in Arunachal Pradesh

ILCB Pavement on Y Junction-Nelya Road in Arunachal Pradesh

ILCB Pavement on Balipara-Charduar-Tawang Road (Tenga Market) in Arunachal Pradesh

ILCB Pavement on Bumla-Bumla PP Road in Arunachal Pradesh

ILCB Pavement on Katao-Bump IV Road in Sikkim

ILCB Pavement on Ragini-Ustad-Pharkian Gali Road in Jammu & Kashmir

Laying of ILCB Pavement on Srinagar-Sonamarg-Gumri Road in Jammu & Kashmir

CHAPTER 7

LINED DRAIN USING GEOSYNTHETIC CEMENTITIOUS COMPOSITE MAT

1. A new class of geosynthetics has recently emerged known as GCCMs (Geosynthetic Cementitious Composite Mats) defined by the ASTM D-35 committee in 2017 as 'a factory-assembled geosynthetic composite consisting of a cementitious layer contained within a layer or layers of geosynthetic materials that becomes hardened'. GCCMs consist of a three-dimensional fibre structure filled with a dry cement/concrete mix, overlaid by a hydrophilic filter layer and underlaid by a watertight membrane, which is typically a PVC or LDPE film. The material is delivered in its dry format and unrolled into place using similar installation techniques to traditional geosynthetics. Once in place, it is hydrated by spraying with water and the cement/concrete mix hardens. The result is a watertight polymeric film which is overlaid by a protective fibre-reinforced concrete layer, with a thickness typically between 5 and 13 mm. GCCMs are predominantly used for the lining of water channels for small scale drainage. . IRC:SP:59-2018 "Guidelines for use of Geo-synthetics in Road Pavements and Associated Works" provides guidelines for use of Geo-synthetics in drainage works.

2. Project Arunank utilized the technology to construct **lined drain on Road TCC–Taksing** over a stretch of two Km. The technology involves the following stages:-

Stage I. Unloading of Sealed Packages.

Stage II. Unrolling & Cutting.

Stage III. Placement & Fixing of Overlap Joints.

CHAPTER 8

STATE OF THE ART RUNWAY WITH SUB-SURFACE DRAINAGE SYSTEM

1. An adequate drainage system for the removal of surface and subsurface water is vital for the safety of aircraft and for the long service life of the pavements. Improper drainage results in the formation of puddles on the pavement surface which can be hazardous to aircraft taking off and landing. Poor drainage can also result in the early deterioration of pavements. The BRO is constructing two runways, one each at Barrackpore and Bagdogra in West Bengal. In the runway at Barrackpore, a State-of-the-Art sub-surface drainage system is being constructed. There are not many runways across the country with such a comprehensive sub-surface drainage system and the BRO can act as a repository of knowledge to impart training on this aspect of runway construction. IRC:SP:42-2014 "Guidelines on Road Drainage" and IRC:SP:59-2018 "Guidelines for use of Geo-synthetics in Road Pavements and Associated Works" provides guidelines for surface and sub-surface drainage works.

Sub-Surface Drainage System at Barrackpore Runway in West Bengal

Laying of Sub-Surface Drainage System at Barrackpore Runway in Progress

Testing of Sub-Surface Drainage System at Barrackpore Runway in Progress

CHAPTER 9

SLOPE STABILISATION TO MITIGATE LANDSLIDES

1. Slope stabilisation refers to any implemented technique that aims to stabilize an unstable or inadequately stable slope. The aim of slope stabilisation technique is to increase the factor of safety of a slope to a level that is considered adequate. IRC:SP:59-2018 "Guidelines for use of Geo-synthetics in Road Pavements and Associated Works", IRC:SP:48-1998 "Hill Road Manual" and IRC:SP:106 "Engineering Guidelines on Landslide Mitigation for Indian Roads" provides necessary guidelines for stabilization of slopes to prevent and alleviate landslides. The stabilisation techniques are divided in the following main categories:-

(a) **Removal and Protection**. It includes removing the unstable material that usually lies on the upper layer of the slope and placing protection means, (e.g. nets).

(b) **Support Stabilisation**. Structural support aims to increase the stability of the slope. This technique includes the implantation of pre-stressed anchors, rock bolts, piles, soil nailing geosynthetic reinforcement, retaining wall, shotcrete, etc.

(c) **Water Drainage**. The presence of water in the soil or rock mass causes increased pore water pressure and thus weakens the ties between the particles and causes slipping tendency and thus reduces the stability of the slope. In order to minimise this, drains are used to reduce water entry and control the ground water level.

2. **Advantages of Slope Stabilisation**.

(a) Slope stabilisation provides stability to hill slopes by checking erosion.

(b) Anchoring soils also accelerates the growth of vegetation which imparts stability.

(c) It increases the bearing capacity of hill slopes.

(d) It reduces flash flood erosion on hill slope.

(e) It helps in ecological replenishment of the hill slope.

3. Slope stabilisation is being carried out by both mechanical means and by using geotextiles throughout most of the projects of BRO depending upon the slope stability requirements based on soil strata.

Drapery with Hill Side Gabion Wall on Joshimath-Mana Road in Uttarakhand

Dynamic Rockfall Barrier on Joshimath-Mana Road in Uttarakhand

Secured Drapery with Micro Piling Work on Joshimath-Mana Road in Uttarakhand

Rockfall Embankment on Joshimath-Mana Road in Uttarakhand

Secured Drapery on Joshimath-Mana Road in Uttarakhand

Geo Web on Damchu Haa Link road in Bhutan

Biodegradable Coir Reinforced with Gabion Wall between Y Jn and Gelensiniak on Road TCC-Maza in Arunachal Pradesh

Rock & Bolt Method at Km 144.8 on Orang-Kalaktang-Shergaon-Rupa-Tenga Road in Arunachal Pradesh

Use of Geotextile Material on Kyachee GG-Nasar GG-Lungro GG (K-N-L) Road in Arunachal Pradesh

Use of Erdox-Cruciform Horizontal Consolidation Units on Kyachee GG -Nasar GG-Lungro GG (K-N-L) Road in Arunachal Pradesh

Pre-Stressed Cable Anchor on Approach Road to South Portal of Atal Tunnel in Himachal Pradesh

Reinforced Goemat on Approach Road to South Portal of Atal Tunnel in Himachal Pradesh

Hydro Seeding on Approach Road to South Portal of Atal Tunnel in Himachal Pradesh

CHAPTER 10

AVALANCHE PROTECTION STRUCTURES

1. Avalanche protection structures reduce the hazard that the avalanches pose to human life activities and property. The inhabitants of mountainous areas in snow zone have always been affected by the risk of avalanches and the need to live alongside this threat has led to attempts to mitigate the risk by constructing intricate systems of artificial structures.

2. The road from Palchan to South Portal of Atal tunnel of length 14.84 Km experiences heavy snow fall. This area is avalanche prone and a number of locations have been identified by Snow & Avalanche Study Establishment (SASE) for snow avalanches. To make this an all-weather road, avalanche protection structures have been provided by BRO. These structures will help in providing all weather connectivity to this road in snow bound area and boost economic growth as well. The following snow protection structures have been constructed by BRO on approach road to South Portal of Atal Tunnel:-

(a) **Snow Erodox**. The Snow Erdox structures are protection measures that are placed in the zones of avalanche initiation and stabilize the snowpack. These limit the volume of snow that can be mobilized, reducing the overall avalanche hazard risk. The Snow Erdox supporting structure is a modular unit with a single anchorage element. It features a cruciform facing panel structure made with steel beams which are hot dip zinc coated and suitably shaped to enable rapid jointing. One of the two beams is divided into two parts connected together in order to simplify the transportation of "folded units". The main advantages of Snow Erodox are as follows:-

(i) The structure is light, easy and fast to install even in the presence of snow and difficult topographical conditions.

(ii) It can withstand dynamic impacts (rock/ice falls).

(iii) It is adaptable to any slope morphology.

(iv) Low environmental impact.

(v) Low cost.

(vi) Almost maintenance free.

Snow Erodox System at Km 8.10 on Approach Road to South Portal of Atal Tunnel in Himachal Pradesh

Snow Erodox System at Km 13.50 onApproach Road to South Portal of Atal Tunnel in Himachal Pradesh

(b) Snow Galleries. Snow Galleries are direct defence measures for roads or highways in the middle zone of Avalanches. They protect roads against the effect of avalanches by bypassing them. A snow shed or avalanche gallery is a type of rigid snow-supporting structure for avalanche control to maintain passage in areas where snow removal becomes almost impossible. They can be made of steel, prestressed concrete frames, or timber. These structures can be fully enclosed, like an artificial tunnel, or consist of lattice-like elements. They are typically of robust construction considering the environment they must survive in. Snow protection is particularly important when routes cross avalanche "chutes", which are natural ravines or other formations that direct or concentrate avalanches. Snow galleries are built to provide safety for road users during snow fall, rainfall and other adverse climatic conditions.

Snow Gallery at Km 4.14 on Approach Road to South Portal of Atal Tunnel in Himachal Pradesh

Snow Gallery at Km 8.77 on Approach Road to South Portal of Atal Tunnel in Himachal Pradesh

Snow Gallery at Km 9.13 on Approach Road to South Portal of Atal Tunnel in Himachal Pradesh

CHAPTER 11

PRECAST CONCRETE TECHNOLOGY (CUT & FIT TECHNOLOGY)

1. Precast concrete construction plays a major role in the era of modernism and contemporary architecture. The application of precast methods can lead to the efficient utilization of resources and also reduces the time duration and cost of construction. Precast construction includes various structural components which are standardized and manufactured in plants or yards in a location and transported to the site location for its assembly. Moulds of standardized structural components are used for their mass production maintaining good quality. IRC:SP:102-2014 "Guidelines for Design & Construction of Reinforced Soil Walls" and IRC:122-2017 "Guidelines for Construction of Precast Concrete Segmental Box Culverts" provide details for construction of precast concrete elements, that could further be suitably modified to other precast elements used in permanent works.

2. BRO worksites are located alongside the most difficult and harsh terrains of the world. These areas typically have very limited working season and completion of road projects in a time bound manner therefore becomes a huge challenge for BRO. In order to overcome these challenges and enhance the pace of construction of the road, BRO has started incorporating Cut & Fit technique in road construction. The basic idea of cut and fit construction is to precast all elements of the road in a casting yard under ideal quality environment while the formation cutting of road is done as a parallel activity. With this technique, sequential construction is replaced with parallel construction activity to shorten the overall project duration. While a lot of work has been done on the pre cast culverts, pavements, Reinforced Earth walls etc, but a comprehensive approach to have all pre-cast elements of the road is yet to be pioneered.

3. BRO has executed a pilot project in Arunachal Pradesh with all the pre cast elements i.e. protective structures, culverts, drains and pavements. This technique turns out to be economical if cyclic maintenance cost and escalation due to typical time over run of conventional road construction is taken into account. This technique has been used for the first time in BRO on Along-Yingkiong Road in AoR of Project Brahmank.

4. Similarly, Project Himank in Ladakh has also adopted construction of pre-cast box culverts, which has been found to be extremely useful in speeding up construction and averting/reducing disruptions to traffic. Such culverts can be casted even in winters under suitable conditions when no work is possible at site.

Fixing of Pre-cast Breast Wall on Along-Yingkiong Road in Arunachal Pradesh

Fixing of Pre-cast Drain on Along-Yingkiong Road in Arunachal Pradesh

Drilling Pre-cast Breast Wall on Along-Yingkiong Road in Arunachal Pradesh

Anchoring Pre-cast Breast Wall on Along-Yingkiong Road in Arunachal Pradesh

Reinforced Earth Wall Panel Fitting on Along-Yingkiong Road in Arunachal Pradesh

Reinforced Earth Wall under Construction on Along-Yingkiong Road in Arunachal Pradesh

Unloading of Precast Box Culvert Segments in Ladakh

Loading of Precast Box Culvert Segments in Ladakh

Construction of Pre-cast culvert in Ladakh

Casting of Precast Pavement Panels in Arunachal Pradesh

CHAPTER 12

MODULAR BRIDGES OF LOAD CLASS-70

1. Modular bridges are fabricated in factories and delivered to the field in a modules to be quickly assembled on site. These bridges can use a variety of superstructure types such as trusses, plate girders or rolled girders. Double lane Modular steel bridges being used in the BRO comprise of longitudinal trusses formed of modular rectangular steel panels having top & bottom chord fabricated from roller channel section and inbuilt welded web channel in diamond shape having appearance similar to Bailey panels, connected end to end with transverse cross girders spanning between them that support steel decked roadway.

2. GRSE in a Joint Venture with the BRO has produced a CL-70R Modular Bridge of single lane carriageway. The bridge of span 190 ft has been launched in Dharasu-Gangotri road at 1/3rd of the cost of imported bridge. BRO has also launched a CL-70R Modular Bridge of double lane carriageway. The bridge of span 140 ft has been launched on Flag Hill-Dokala Road which is the first of its kind in the country. It was launched during snow fall at an altitude of 11,000 ft. The bridge is reusable and portable and can be launched within 45 days on permanent abutments.

3. In view of its cost effectiveness and time saving in construction, Border Roads Organisation and Garden Reach Shipbuilders & Engineers (GRSE) Ltd signed a Memorandum of Understanding (MoU) on 15 March 2022 at New Delhi for two-years for fabrication, supply, erection and launching of 27 double lane galvanised modular bridges of 7.5 meters carriageway width with IRC Load Class 70. One of the most important and critical advantages of the MoU will be the time factor as these bridges can be launched within 45 days of handing over the site by the units. This will certainly be a game-changer in road infrastructure development in the country especially in remote and inaccessible areas.

CL-70 Modular Bridge (Single Lane) on Dharasu-Gangotri Road in Uttarakhand

CL-70 Modular Bridge (Double Lane) on Flag Hill-Dokala Road in Sikkim

CHAPTER 13

CARBON NEUTRAL HABITATS IN UT OF LADAKH

1. Carbon Neutral Habitats are the ones that do not increase the amount of Carbon dioxide in the atmosphere and the design, construction and operations do not contribute to emissions of greenhouse gases that causes climate change. They are powered by renewable sources of energy like solar or wind.

2. These habitats entail decentralized energy production mainly from renewable energy sources coupled with energy efficient buildings, optimized water cycle coupled with recycling waste water and waste management. This is achieved by taking into account the orientation and shape of buildings, natural ventilation, trombe wall as a thermal mass, insulation envelope, layout of the habitats and well oriented pathways to optimally utilize natural resources.

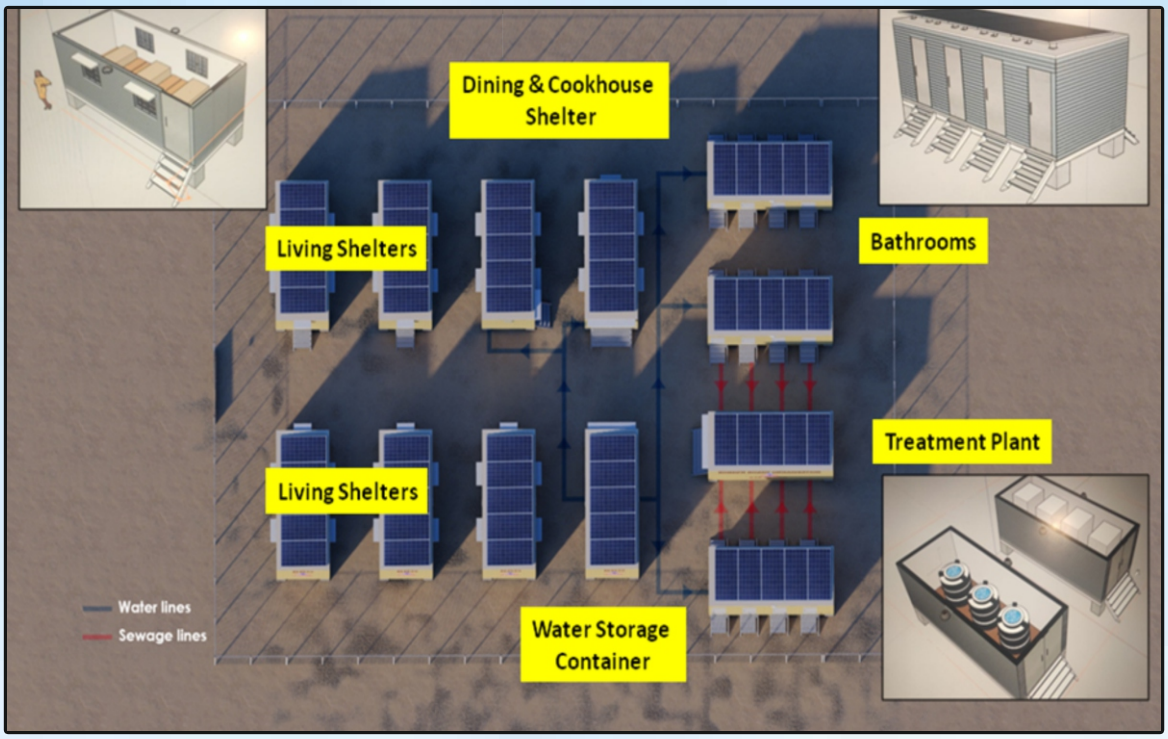
3. BRO has taken this initiative as a pilot project at various locations in Eastern and Western Ladakh. Based on the terrain in Ladakh, three models of habitats have been designed:-

(a) Model-1: Semi Permanent Integrated Insulated Habitats.

(b) Model-2: Container Based & Transportable Integrated Insulated Mobile Habitats.

(c) Model-3: Heated and Insulated Tents for Short Duration and Transportable Habitats.

4. The aim is to provide dignified and suitable habitats with better health parameters due to lower risk of cold injuries and better hygiene & sanitation to the labourers in Ladakh resulting in greater productivity and work satisfaction. By using renewable sources of energy, we aim to reduce dependency on fossil fuels for heating and lighting purposes and reduce environmental and water contamination by using hygienic waste disposal system.

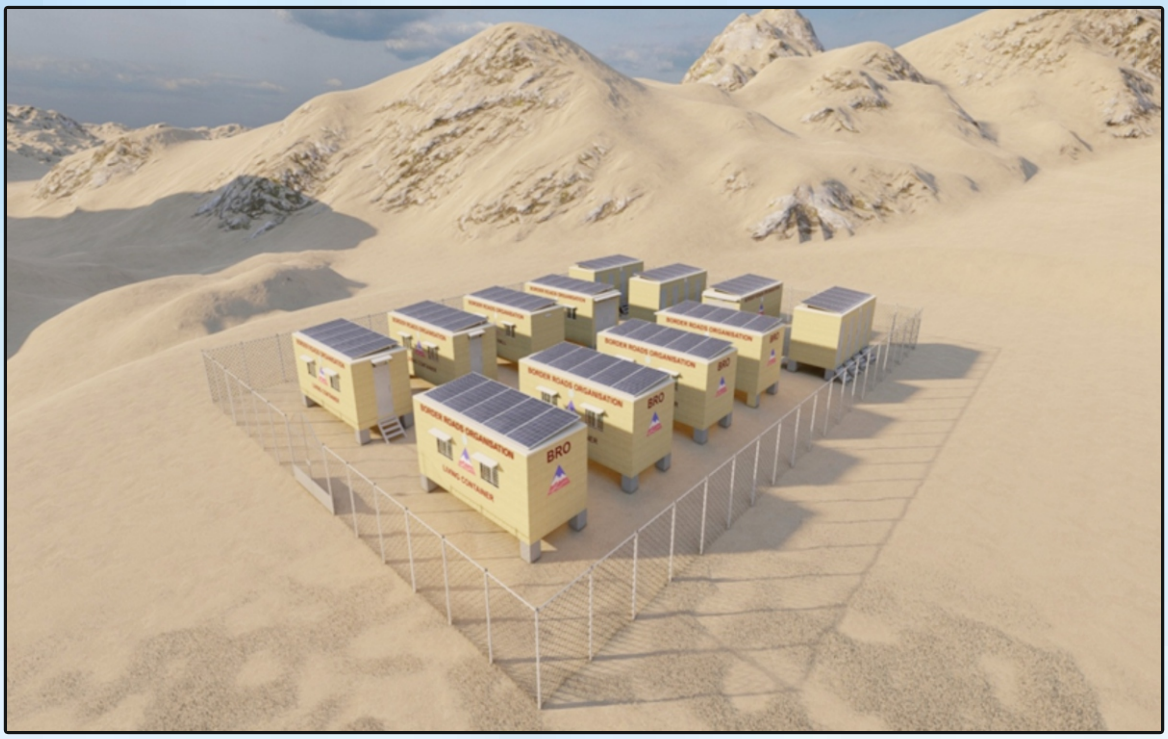


A Typical Design Layout of Carbon Neutral Habitat

Model-1: Semi Permanent Integrated Insulated Habitat

Front and Side View of Integrated Insulated Habitat

South Facing End for Thermal Gain



Model-2: Container Based & Transportable Integrated Insulated Mobile Habitat

Model-3: Heated and Insulated Tents for Short Duration and Transportable Habitat

Centrally Heated Tents for Snow Clearance Detts in Eastern Ladakh

Inside View of Centrally Heated Tents for Snow Clearance Detts in Eastern Ladakh

Container Based & Transportable Integrated Insulated Mobile Habitat in Ladakh

CHAPTER 14

MOBILE CONTAINERIZED ACCOMMODATION

1. Snow clearance has been one of the major tasks by BRO in the border areas to facilitate the movement of security forces and their logistic requirements which in addition also helps in keeping the population of border areas connected with the main stream during winters. Snow clearance operations take considerable time to get the roads through for traffic movement and in order to reduce the time of snow clearance operations over treacherous terrain and inhospitable weather conditions, mobile containerized accommodations are being utilized by the BRO.

2. Mobile containerized accommodation is a prefabricated container mounted on a long body vehicle or any vehicle with sufficient space. The prefabricated container is fitted on the vehicle and it serves as a moving shelter for personnel working under harsh climatic conditions, thus reducing the movement of men and machine to detachments/nearby units and increasing efficiency. Apart from reducing time, such accomodation increases the safety of men and materials too. It is fitted with heating arrangements like Bukhari and electric fittings with a 5 KVA Gen set to provide immediate relief from harsh winters during working hours. Overall, the mini mobile accommodation has contributed immensely in snow clearance operations. Snow clearance of Leh-Manali highway in the AoR of Project Himank was completed using such mobile accommodation, due to which snow clearance operations could be completed in a faster time frame and with enhanced safety.

Mobile Containerized Accommodation in Ladakh

Conveyance of Mobile Containerized Accommodation in Ladakh

Front View of Mobile Containerized Accommodation in Ladakh

CHAPTER 15

INDUCTION OF NEW GENERATION EQUIPMENT IN BRO

1. To facilitate the induction of new generation equipment/vehicles/ plants in BRO, 52 firms participated in the CEs Equipment Management Conference in Dec 2021 for the first time in the history of BRO. BRO also participated in EXCON-2022, Asia's biggest Construction Equipment Exhibition held at BIEC, Bangalore from 17-21 May 2022. As of now, Nine NCNC trials of new generation construction equipment have been completed and another six trials to include Route Guidance System for Snow Cutter, 20 Ton Hydraulic Wheel Loader, Drum Cutter attachment for Hydraulic Excavator, Cold starting device etc are underway to check their suitability in BRO's working environment. A brief description of some of these new Generation Equipment/Vehicles/Plants is given in the succeeding paragraphs.

2. **Tele-Operated Dozer**. A remotely operated Dozer BD-50 developed by CVRDE/DRDO has been tested in Himachal Pradesh. It is equipped with Human Machine Interface (HMI) which can be carried by any person or mounted on any B-vehicle.

3. **Direct Methanol Fuel Cell Hybrid Power Solution**. The equipment has been trial evaluated in Ladakh and Arunachal Pradesh. Direct Methanol Fuel Cell (DMFC) is a green energy power generating device which converts chemical energy to electrical energy by using Methanol as the fuel. It has extremely low fuel consumption and will lead to major savings in fuel and related cost of logistics.

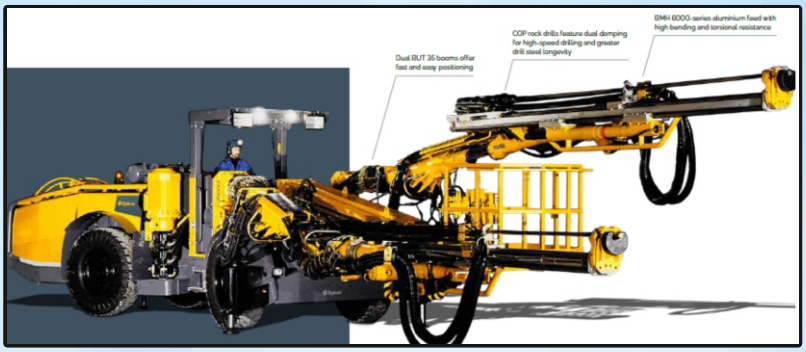
4. **JCB Telehandler**. JCB Telehandler machine is a highly maneuverable equipment with a Telescopic Boom which can be fitted with numerous attachments at its end to enable several operations at extended height or reach with safety and ease. The telehandler will find huge applications in road construction and tunnelling operations as multi-utility construction equipment.

5. **Pothole Repair Machine**. The machine is used for swift repairing of cracks, potholes, shoulders, fissures, etc. This is an automatic with single man operated machine.

6. **Automatic Batching and Mixing Plant**. Fully-automatic concrete batching & mixing plant can be used for cold mix and for producing homogenous concrete.

7. **Shotcrete Machine**. Shotcrete Machine has earned a reputation for excellence and expertise built on a commitment to application-oriented engineering and customer service. This machine is useful in concreting work of tunnelling, mining and other civil construction.

8. **Boomer Rock Drill**. It is a robust face drilling rig for tunneling and mining operations for safe underground working environment.



9. **Self-Loading Concrete Mixer**. A self-loading concrete mixer is a machine that can self-load aggregates, weigh the batch, blend concrete, transport, and place it wherever required. It is hence a stand-alone machine that can complete the concrete mixing task by demanding a single person to operate the machine.

10. **Spider Excavator**. Spider Excavator is a unique machine which can climb steep slopes and perform the work of an excavator on difficult terrain where standard excavators can't work. This can be used for slope stabilisation/ excavation/lining works and reduce the dependence on manpower.

11. **Road Reclaimers**. Road Reclaimers pulverize the asphalt layer and mix it with the underlying base to stabilize deteriorated roadways. The reclaimers can add asphalt emulsions or other binding agents during pulverization or during a separate mix pass.

12. **Elevating Scrapers**. This is a self-loading hauling system with the added ability to mix and homogenize material. This equipment also excels at fine finish grading work.

13. **Super Long Front Excavator.** BRO has recently procured 12 Super Long Front Hydraulic Excavators. These 65 ton category excavator with 23.5 m boom are one of a kind in the country and have been specially made for BRO by Tata Hitachi to help us address all defence preparedness requirements on the Western Front and will be used for maintenance & desilting of DCBs as a replacement of the obsolete draglines.

DC 400 Drilling Machine

CHAPTER 16

PRODUCTS UNDER CONSIDERATION FOR USE IN BRO

1. In collaboration with IOC R&D Centre, Faridabad, BRO has taken a lead to test certain concepts/products/technologies such as Polybag Bitumen, Warm Mix Bitumen in HAAs, use of CRMB-55 in High Precipitation Areas, Ready Mix Bitumen and use of Recycled Geo-Synthetic Material which will be advantageous when implemented in specific working conditions of BRO. A brief description on some of these products is given in the succeeding paragraphs.

2. **Polybag Bitumen**. VG-10/VG-30 bitumen is packed in 25 Kg, two layered specially designed polybag, one inner polymer bag for filling and outer bag for ease of handling. The inner bag has been specially engineered & designed to melt along with the bitumen. The use of polybag eliminates wastage of 3-4% of bitumen for end user in drum filling and saves 4-7% fuel required for steel drums heating/melting. The package is easier to handle at actual worksite and saves extra labourer for handling/use of mechanical handling devices. The packaging is environment friendly and less carbon emission leading to reduced pollution. Polybags are stackable, thus allow optimum use of space in storage & transport. The cost per MT of bitumen in barrel or in polybag is same. A in-house Cost-Benefit Analysis of the two packaging in terms of wastage, saving of fuel and amount collected by auction of empty barrels was carried out and it is observed that the cost benefit of Polybag Bitumen is approx ₹ 1000 per MT. Adoption of use of Polybag Bitumen can revolutionise the system of bitumen transport & handling in BRO.

3. **CRMB-55**. Crumb Rubber Modified Bitumen (CRMB) is a high storage stable CRMB developed with reduced separation. CRMB is a special type of bitumen whose properties have been improved by the addition of crumb rubber & special types of

additives like hydrocarbon materials, resins etc. CRMB is considered as an ideal binder to overcome the concurrent problems of ravelling, rutting, undulations, cracking, bleeding, shoving and pot-holing of bituminous pavement.

4. **Warm Mix Additives**. Warm-mix asphalt is the generic term for a variety of technologies that allow the hot mix producers to lower the temperatures at which the material is mixed and placed on the road. Warm mix additives (WMA) reduce the

bitumen viscosity making them workable at low mixing temperatures (<145^{0}C). Organic additives like wax (natural or synthetic) and amino additives are added to bitumen to ease the workability at lower temperature.

5. **Ready Mix** M/s IOCL R&D Centre has developed a readymade mix using Cutback bitumen. It is stable for more than six months, easy for laying, economic and can be applied in any season and ideal for remote and hilly areas.

6. **XtraGreen Diesel**. Indian Oil expanded its bouquet of differentiated offerings with the introduction of its all-new high-performance diesel brand – XtraGreen. One of the cleanest diesel fuels across the globe, XtraGreen offers higher fuel economy and reduced noise. The higher cetane number of XtraGreen has led to better combustion & longer durability as compared to conventional fuel, while Particulate Matter (PM) emissions have decreased by about 7% (under simulated road load driving conditions).

PAH content in particulate matter is estimated to plummet by nearly 3%, considerably reducing carcinogenicity of diesel exhaust emissions. The Diesel Multi-Functional Additive (DMFA) added in XtraGreen reduces carbon monoxide emissions by 12%, while a 5% decline has been observed in emission of nitrogen oxides. Third-party testing agencies have also reported a nearly 6% increase in fuel economy. A new age eco-friendly fuel, XtraGreen has been critical to driving the Nation with sustainable and eco-friendly energy solutions.

7. **Smart Life Poles**. The product comprises of sets of two poles fitted with radars which detect simultaneous approaching vehicles on hair-pin bends in ghat section and alert the drivers by making a sound similar to sound of a horn or honk with cautioning light. The innovation seeks to address the problem of major accidents on sharp hair-pin

bends in ghat sections where vehicles coming from opposite direction of the bend collide or loose balance and fall into deep gorges, primarily due to over speeding and their inability to detect approaching vehicles from the other side.

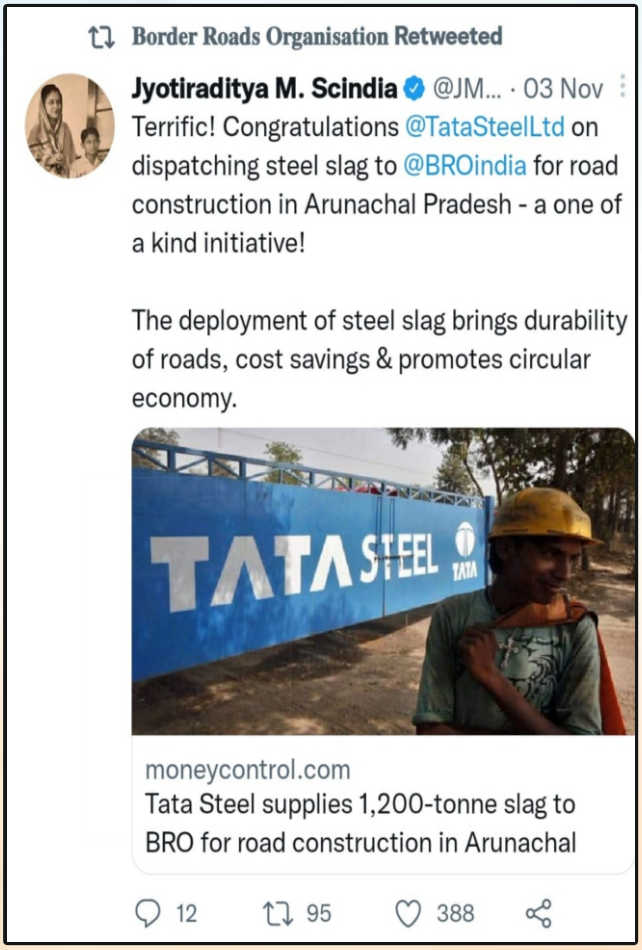
CHAPTER 17

USE OF STEEL SLAG

1. The Border Road Organisation (BRO) has undertaken construction of a pilot road stretch in Arunachal Pradesh using steel slag which can withstand heavy rains and adverse climatic conditions. Creating durable roads along strategic areas could become easier if this is found to be successful. The road constructed by use of steel processed slag not only increases the durability but also helps in reducing the cost of construction as slag-based materials have better properties than natural aggregates. The use of processed steel slag in road construction is also expected to reduce greenhouse gas emissions and carbon footprint in road construction activities and is in line with India's commitment to the United Nation's Sustainable Development Goal to build resilient infrastructure through inclusive and sustainable industrialisation and green technologies.

2. A Multi-Disciplinary Expert Group (MDEG) has been constituted to undertake trials and study the technology related to use of steel slag for construction of road. BRO has undertaken resutrfacing of road Joram-Koloriang in Arunachal Pradesh using steel slag instead of the conventional aggregates. The road is being prepared in technical consultation with CSIR-CRRI & Steel Slag from Tata Steel. The Hon'ble MoS for Science & Technology and Earth Sciences, Dr Jitendra Singh virtually flagged-off first Railway Rack carrying approximately 1600 MT steel slag from Tata Steel Plant, Jamshedpur on 02 Nov 2022. The initiative is in line with the Govt's vision of creating Wealth from Waste through application of Science & Technology and focused towards infrastructure development in far flung areas of the North-Eastern States. On successful trials of this technology, the BRO will work out a long-term logistic arrangement for construction of steel slag roads in strategic areas. This initiative taken by BRO has also been lauded by the Hon'ble Prime Minister.

Tweet by Hon'ble PM



Tweet by Hon'ble Steel Minister

Virtually Flagging-off first Railway Rack of Steel Slag by Hon'ble MoS for Science & Technology and Earth Sciences, Dr Jitendra Singh

Processed Steel Slag Aggregate

CHAPTER 18

WHITE TOPPING TECHNOLOGY

1. White Topping is a Portland Cement Concrete (PCC) overlay that is constructed on top of an existing bituminous road. This overlay acts as a long-term alternative for the rehabilitation or structural strengthening of roads. A pilot project of white topping for rehabilitation of road pavement is underway on Tuting – Bona Road under Project Brahmank in Arunachal Pradesh which experiences heavy rainfall.

2. **Advantages.**

(a) Prevents rutting, structural cracks and potholes, which provides a safer and faster commute.

(b) Improves the structural capacity of existing bituminous pavements.

(c) Initial budget is slightly more than bitumen roads but the life-cycle cost is far lower than both bitumen and concrete roads.

(d) With a turnaround time of just 14 days, it's much faster than the turnaround time for concrete roads.

(e) Improves visibility and commuter safety at night by enhancing light reflectance. This reduces the illumination load of any road, thereby saving energy (20-30%).

(f) Reduces pavement deflection, resulting in less vehicular fuel consumption (10-15%) and thus, reduced emissions.

(g) Lowers vehicular braking distance, making it safer in both dry and wet surface conditions.

(h) Reduces the urban heat island effect by absorbing less heat, in turn, lowering the energy consumption for air conditioning in urban buildings.

(j) White Topped pavements are 100% recyclable and can be crushed and reused at the end of their life.

Rehabilitation of Existing Bituminous Pavement using White Topping Technology on Tuting-Bona Road in Arunachan Pradesh

CONCLUSION

1. Technological innovations are transforming all sectors. The road sector is also seeing adoption and implementation of innovative technologies. Durable roads with long life and low maintenance are a priority now. In order to bear the increasing traffic load and to overcome various challenges such as cost overruns and congestion, the sector will have to develop new materials, processes and technologies. This would require dedicated research and development by both the government and private sector. The key task, however, will be adoption and implementation of the new technologies and methodologies developed through R&D.

2. The value of introducing innovative technologies in the construction of roads is immense. They significantly reduce costs and time to repair roads, increase the service life of roads and provide external compliance time. All innovative technologies are developed taking into account the negative impact of external factors; they therefore are environmentally friendly and safe. The main task that now stands in the way of the development of the road industry is to create conditions under which the construction of high-quality roads with long maintenance-free life will be beneficial for all. Of course, in this matter, the rejection of outdated materials and the transition to a new stage of development, which is characterized by the use of innovative technologies and solutions is of particular importance. Contrary to sustainable opinion, innovations in construction can be economically viable. After all, new materials significantly extend the life of the roadway, eliminating the need for frequent repairs. Experts and scientists agree that the use of innovative materials becomes economically viable over the life cycle cost resulting in huge savings in the long run.

3. As an Organisation, it shall be our constant endeavor to adopt new and innovative technologies in the high altitude, remote, inaccessible and permafrost regions where we work so that the best quality roads are constructed in the shortest possible timeframe to connect the farthest and most remote areas to the mainland and usher in prosperity to these regions.

We are sure, that together we can, and together we will!

Biodegradable Coir Reinforced with Gabion Wall between Y Jn and Gelensiniak on Road TCC-Maza in Arunachal Pradesh

BEACON DEEPAK CHETAK SAMPARK HIRAK HIMANK SHIVALIK YOJAK VIJAYAK

VARTAK DANTAK SWASTIK SEWAK PUSHPAK UDAYAK SETUK ARUNANK BRAHMANK

CONNECTING PLACES - CONNECTING PEOPLE