Province Government

Ministry of Physical Infrastructure Development

Transport Infrastructure Directorate (TID)

Hetauda, Makawanpur

Training Completion Report

On

″Quality Control in Road Works

1-3 September 2021 (16- 18 Bhadra 2078) Hetauda

Organized by:

Transport Infrastructure Directorate (TID)

Hetauda

Facilitated by:

Ram Babu Paudyal
Quality Control Expert – ***Individual Consultant***
Kathmandu

Acknowledgement

We highly acknowledged the support of Transport Infrastructure Directorate (TID) to organize this training program on "Quality Control in Road Works" held in TID Hetauda from 1- 3 September 2021. We would like to thank Dr. Sahadev Bhandari, Director for his patronage and support to conduct this training. Our sincere thanks to Er. Pushkar Pokharel, Senior Divisional Engineer for his support to organize this training. We also would like to express our gratitude to Mr. Hari Prasad Ojha, Engineer from TID and Mr. Rajesh Thapa, Account Officer, without whose support and cooperation this training would not have been materialized. We take this opportunity to express our humble gratitude to all the participants for sharing their knowledge and skills to each other. Last but not the least, we would like to thank all who supported directly or indirectly to accomplish the training successfully.

Er. Ram Babu Paudyal

Er. Sujit Dhital

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Background

One of the important infrastructures for the development of the country is the motorable road network that needs to proper supervision and quality control during the construction. Similarly Road Networks must be repaired and maintained in a regular basis. It is anticipated that the built roads serve the vehicles to run smoothly and ensure the quality of motorable roads for the design period and beyond. Basically, the design, construction and maintenance of Provincial Roads are the responsibility of the Transport Infrastructure Directorate (TID). It is realized that quality of work in the road sector has been compromised against the specification so the newly constructed roads have been badly affected resulting to the poor quality and workmanship and ever increasing required budget and manpower.

Province Government has established the Transport Infrastructure Directorate with the aim to ensure better quality road with in province. Its major responsibility is to plan and implement transport infrastructure as well as to regularly monitor and evaluate the work done in road sector implemented through different IDos.

To ensure quality of the roads, it is vital that the professionals who are involved in such work are qualified and motivated. The government's stride towards rapid development of quality roads infrastructure will be meaningful and appreciative if the responsible staff show better performance with their enhanced professional competency. The state of the art techniques and know how on the subject has to be imparted to the technical staff specially working in the TID and IDOs through adequate trainings.

Proper utilization of the limited financial support and qualitative construction work in time would provide needed service to the people. Quality control is important to provide safe and comfortable service to road users and reduce the need of early periodic maintenance. It is envisaged that the training of this type will motivate and enhance the capabilities of the technical staff and will help serve the purpose of TID for long term sustainability of the proposed and existing roads network.

This report has been prepared and submitted to TID for conducting a three days training on Quality Control in Road Works. It is understood that the proposed and existing road network is prone to have more traffic loads. In such situation more effort and professional input is necessary by the technical persons who are responsible for quality control. The institutional capacity building of the TID and IDOs is also important for the consistency in the quality of the roads. It is envisaged that this training focused on theoretical know how followed by practical experience sharing should definitely upgrade the professional competency of the participants representing various IDOs of the Province.

Objective

The training program has been developed with the main objective of capacity enhancement of the technical staff of the TID and IDOs for the quality control during road construction. . The training will impart the following knowledge and skill to the participants:

- Standard Specification for Road Construction
- Quality Assurance Plan (QAP)
- Quality Control in Excavation
- Quality Control during construction of Pavement : Sub base, Base and wearing course
- Quality Control of different types Retaining Structures: Masonry Wall and Gabion Wall and Plum Concrete Wall
- Quality Control of different types Drainage and Cross Drainage Structures
- Maintenance of Road and Quality Control during Maintenance
- Slope Protection and Bioengineering Measures
- Provide knowledge on different type of small-scale structures used in slope protection.
- Enhance knowledge about bioengineering techniques for erosion control.

Methodology

Before the start of the training, discussion was held with the trainers and the project proponent about the objective of the training program and the expected outcome of the training. The training was conducted in a very interactive manner with exchange of views and information between the trainer and the trainees. The training schedule was prepared based on Terms of Reference provided in consultation with the experts. It was ensured that all the relevant topics were covered in the training and the objective of the training was clear and would be fulfilled.

The training comprised of class room lectures with both theory and interactive sessions. The trainees were encouraged to raise questions and express their views. During the training, the trainees were familiarized with the subject matter through use of actual case studies as well as practical experience sharing. Each introductory session in major technical sessions were followed by discussions and interaction to make the trainees familiar with the subject matter and enable them to understand and evaluate the importance of quality in each activity of road construction. The training was conducted by the resource persons who are experts in Quality Control in Road works. .

Services delivered by the Training Provider:

- Prepare training course and schedule.
- Arrange resource person to deliver the training sessions.
- Provide handouts of resource persons in soft copies to all corresponding email addresses
- Submission of Training Completion report.

Services delivered by TID

- Approval of the training course and schedule
- Approval of the training venue.
- Nominated participants and ensure their participation for the training program
- Provided training hall/venue to accommodate 22 numbers of trainees for theoretical classes. The hall/venue was well ventilated through Air Conditioning with sufficient lighting system; protections from rain, wind, direct sunlight and external noise so as to ensure an appropriate learning environment
- Provided clear and comprehensive description of all services to be delivered (one orientation) by training provider
- Provided breakfast, lunch and snacks to the participants.
- Provided stationary and handouts to trainees
- Prepared and distributed training certificates to participants by the end of the training program.

- Made payment as per agreement as approved financial claims of the training provider

Training Venue and Time

The finalized date for Training was 1-3 September 2021 (16- 18 Bhadra 2078) as proposed by the TID. The Training was conducted in the Hall of TID starting from 8:30 and ended at 17:00 of each day.

Training session plan

The training session plan is attached in ***Annex 1.***

Synopsis of the training

Day 1

Opening Session

The opening session started with the welcome speech by Pushkar Pokhrel, Senior Divisional Engineer of TID, Firstly, he welcomed all the participants and thanked everyone for their valuable participation. He also presented the current practices and policies for quality control in road construction. After that, he requested the participants to gain the knowledge from the experienced resource person and implement the learnings during the construction of Roads.

The chief guest of the training opening session was Er. Sanjib Baral- Province Secretary from Ministry of Physical Infrastructure Development. He explained about the importance of Training and believed the contents of training will address the current expectation to the participants. He said that he was expecting such training from beginning in province and become happy to see the starting of training event from TID. He expressed the hope that the training events will be continued frequently in Province level. He continued his speech by instructing participants to clear all their doubts related to Quality Control and Maintenance of Road in the training. Finally, he concluded his speech by wishing good luck for the successful completion of the training program.

Dr. Sahdev Bhandari – Director of TID, delivered his opening remarks relating to the training. Firstly, he welcomed all the participants in the training. He mentioned that the training is basically envisaged to overcome the current issues related to quality in road construction. Next, he mentioned the publication of Survey Guide Line and Quality Control Manual just published by TID which would be beneficial to all engineers who are working under TID.

Sessions delivered in Day 1

1. **Specification and Test Frequency for Quality Control in Road Construction**
2. **Quality Assurance Plan**
3. **Specification and Test Frequency for Quality Control in Road Construction**
4. **DPR Checking, Setting out and Earthwork in Excavation**
5. **Collection of Sample for Lab tests, Interpretation of Test Result**

Resource person: Ram Babu Paudyal and Sujit Dhital

In this session, Sujit Dhital deliver the provision under specification for quality control. He focused in the gap in specification and points to be noted during the road construction as per new specification. Then Ram Babu Paudyal started the session briefing about Quality Assurance Plan and the procedure to make QAP. He also shared one example QAP with participants. Quality Control of Road is designed to enhance managerial and technical skills of the participants responsible for planning, managing and supervising road construction projects for more efficient, effective and high standard road construction works. It also focuses on up-to-date knowledge of quality standard and quality control issues of road construction as well as work processes in all construction phases that lead to better quality of road works. Which includes quality assurance in road works, contract management and inspection procedures, testing of construction materials such as concrete works, concrete aggregates, soil gradation, density and compaction, field compaction/density of subgrade, and asphalt material. Similarly current isues in DPR and precaution is to be taken before implementation of Road project based in DPR was discussed. In the fourth session, collection of samples of various activities of road construction was discussed

Day 2

Sessions delivered in Day 2

6. **Sub base base and Shoulder Construction**
7. **Design and Construction Procedure of Surface Dressing**
8. **Quality Control of Structures Masonry, Gabion and Plum Concrete Retaining Wall**
9. **Procedure for lab tests – Pavement**
10. **Construction Procedure of Pre mix Carpeting**

Resource person: Ram Babu Paudyal and Sujit Dhital

Ram Babu Paudyal started his session about construction procedure of Subbase base and shoulder as per recent Manual under quality control published by TID. In each construction activities the provision of testing prior to construction during construction and after construction was discussed. Similarly Sujit Dhital delivered the comprehensive session about detail procedure of DBSD. Session covering Quality Control of Structures i.e Random Rubble Masonry, Gabion and Plum

Concrete Retaining Wall was delivered by Ram Babu Paudyal. Real site photos and video were presented to make the participants more familiar about quality control of structures in this session. Sujit Dhital delivered the session about the procedure for different lab test. He focused in the suitability tests of Bitumen with detailed procedure. The procedure and quality control for laying the premix carpeting was the last session of the day. These sessions were very interactive as the participants raise various queries about the flexible pavement construction so the session was extended up to 18:30 of the day up on participants' request.

Day 3

Sessions delivered in Day 3

11. **Maintenance of Road and Quality Control Works in Road Maintenance**
12. **Marshal Mix Design**
13. **Slope Protection works including Bioengineering Measures**
14. **Construction Procedure of Asphalt Concrete Works**
15. **Quality Control Works for Rigid Pavement**

Resource person: Ram Babu Paudyal and Sujit Dhital

In this session, Ram Babu Paudyal discussed about Quality Control of Road maintenance work stating that Quality Control of Road maintenance work is designed to enhance managerial and technical skills of the participants who are responsible for planning, managing and supervising road construction projects. He also focused on up-to-date knowledge of quality standard and quality control issues of maintenance that lead to better quality of road and road side structures. Similarly Sujit Dhital described the Marshal Stability Test of Bitumen in Details. He explained the design of Asphalt Concrete is very important as each parameters during Marshal Test are closely related to each other. He described in detail construction procedure, points should be noted during the construction of Asphalt Concrete Road. The cause of slope failure and different types of slope protection measures including bioengineering was covered under the session 13. Ram Babu Paudyal delivered the session for slope protection and bioengineering works. Similarly he also delivered the session about quality control of Rigid Pavement Construction. He explained the failures of rigid pavement and types of maintenance to Rigid Pavement in detail with real site photographs.

Closing Session

The closing session was held on Friday 3 September 2021 (18 Bhadra 2078). The closing ceremony was chaired by Dr. Sahadev Bhandari- Director of TID.

Hari Prasad Ojha the Moderator of the closing session welcomed all the participants and guests in the closing ceremony of the training program. He expressed happiness for the successful completion of the program and further on the behalf of training provider congratulated all the participants for receiving such a useful training.

On Behalf of the participants, Ms Prativa Neupane and Mr. Bishnu Prasad Kafle presented their thoughts of the outcome and benefit of the training. They mentioned that the training was very useful and would greatly help the team in executing their job duties better in aspect of Quality Control in Road works.

The participants were then handed over certificate and training materials by the Director of TID. In his closing remarks he expressed his satisfaction over the successful accomplishment of this training with the contribution of the expert resource persons and management supports from other staffs of TID. He was confident that the training was rigorous, intensive but everyone enjoyed and learned a lot. He urged all the participants to utilize the knowledge which they have grabbed here in this training and to develop the sense of responsibility which will help in making their understanding of quality in road works more effective. He highlighted the strengths and possibilities of betterment of the training. In the end he thanked to the resource persons for their effort to make the training effective and successful.

Training outcome

7.1 Training Evaluation

After the completion of all the technical session, the participants were requested to provide a comprehensive evaluation of the overall training and how it met their expectation. They were also requested to give their feedback towards each topic covered during the training in terms of Content of the Session and presentation of Trainer. The participants were requested to provide their feedback/rate using the options

Fully Agree, Agree, Neutral, Disagree, Fully Disagree

100% of the participants believed that the objective of the training was clear and contents of the training were appropriate to fulfil the objectives.

70% of participants disagreed about the duration of training, the participants expressed their feedback that the training duration was very short to cover all the topic and they gave the feedback to make the training 7 days including field exposure and lab tests.

80% of participants are fully satisfied in terms of Resource Person Skill and delivery.

90% of participants are fully agreed in the method of presentation. Rest 10% suggested the lab visit, more videos and documentary during the presentation.

100% of participants believed that the provided handout and resource material are sufficient for the training.

About the venue of the training 80% evaluated that it was excellent while 10% thought it was ok and 10% thought it could be improved. In reference to the food, 90% thought it was excellent while 10% thought it was ok.

90% of participants believed that they have suitable environment to adopt the skill learnt from training in their work station while 10 % disagreed stating there is no environment to work focusing in quality control in their work station.

7.2 Suggestions for Improvement

The feedback of the entire training was filled up in individual questionnaire where the participants were asked to comment on the logistics, training quality and time allocation. They were asked to give appropriate suggestions do that trainings in the future could be improved. In addition to that the participants were asked to suggest for topics that will be helpful in the future the major comments and the suggestions can be summarized as follows.

Comments:

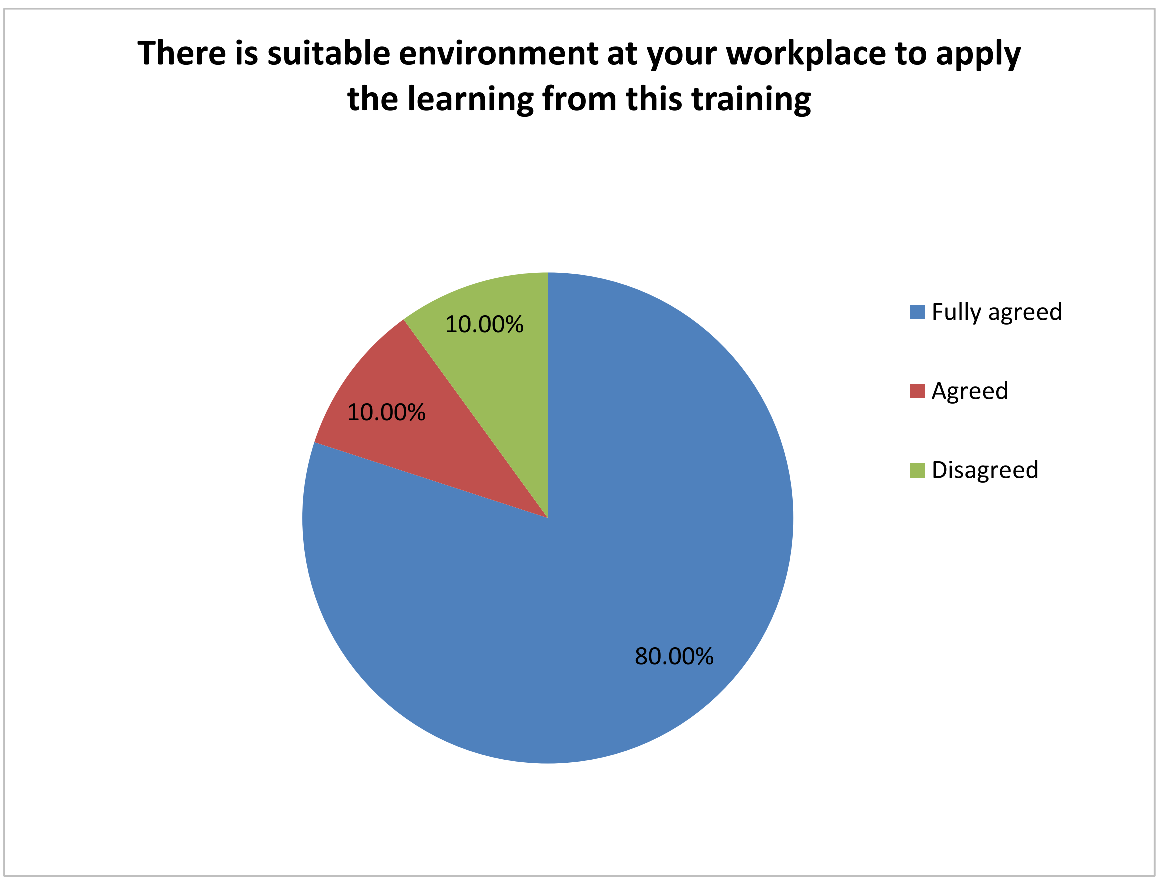
- The training could have been of 7 days – Residential
- Recreational activities could have been carried out

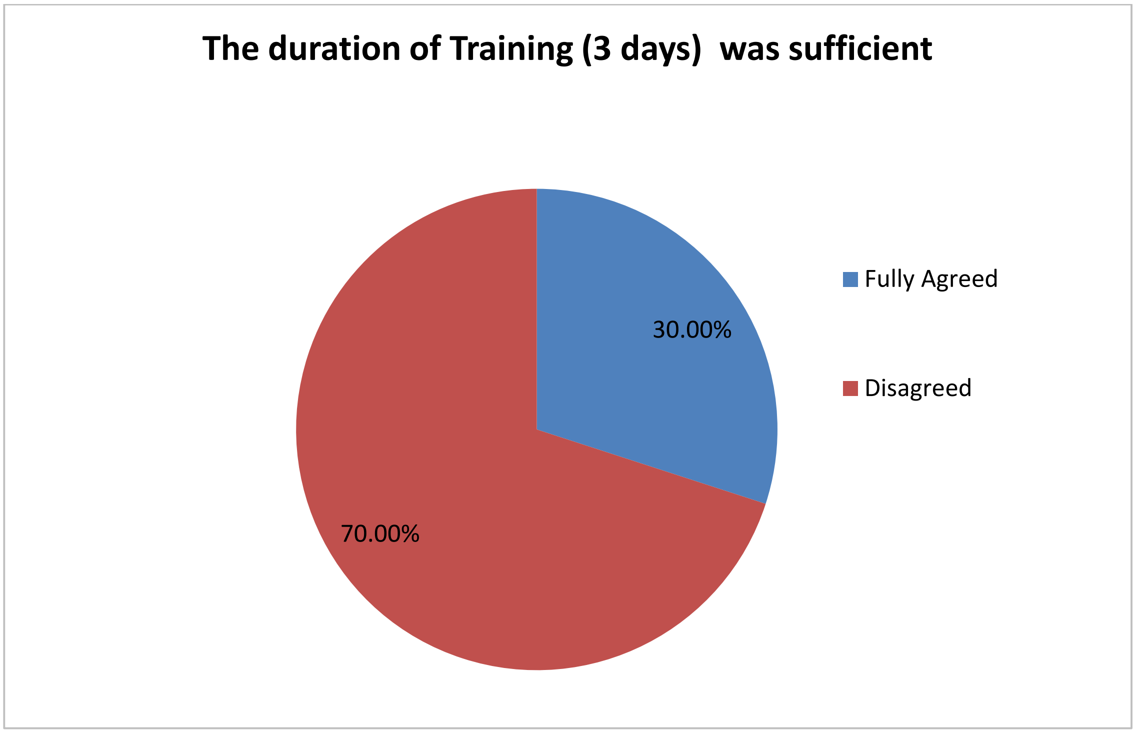
- Directory could be maintained so that the participants and the resource person can be in touch even after the completion of the training.
- Additional Classes in Asphalt Concrete , Rigid Pavement and field training to Bioengineering should be included

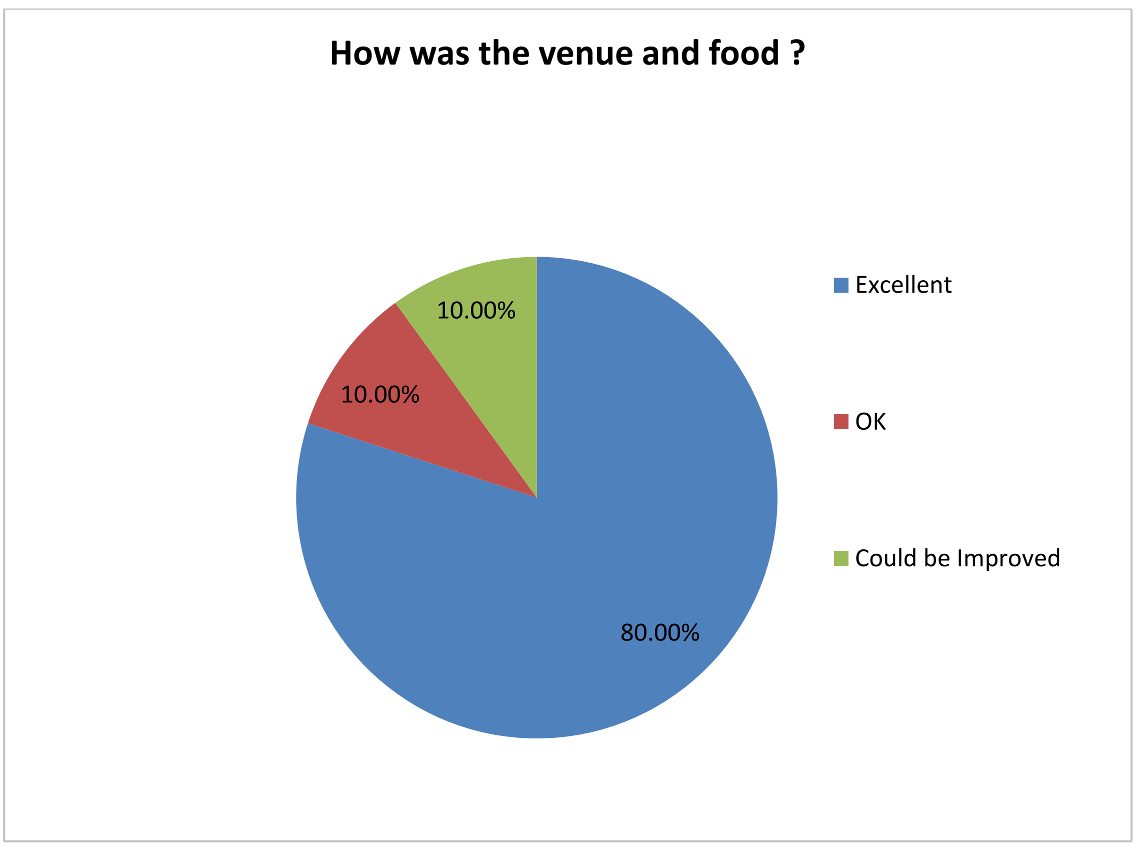
Suggestions for other topics:

- Training in Lab Test
- Training to all Technician of IDOs about Quality Control
- Orientation to Site staffs about quality control prior to mobilization of site
- Road Maintenance Planning and Implementation Training


This training met your expectation
0.00%
30.00%
70.00%
Fully Agreed
Agreed
Neutral


There is suitable environment at your workplace to apply the learning from this training
10.00%
10.00%
80.00%
Fully agreed
Agreed
Disagreed


The duration of Training (3 days) was sufficient
30.00%
70.00%
Fully Agreed
Disagreed


How was the venue and food ?
10.00%
10.00%
80.00%
Excellent
OK
Could be Improved

ANNEXURE

Annex 1: Training Schedule

Transport Infrastructure Directorate

Bagamati Province

Training on: Quality Control in Road Works

Day / Time	Day 1 16 Bhadra 2078(Wed)	Day 2 17 Bhadra 2078(Thu)	Day 3 18 Bhadra 2078(Fri)	Remarks
8:00 – 8:30	Registration and Breakfast			
8:30–10:00	Opening Session Pre training assessment Specification and Test Frequency for Quality Control in Road Construction Sujit Dhital	Sub base base and Shoulder Construction Ram Babu Paudyal	Maintenance of Road and Quality Control Works in Road Maintenance Ram Babu Paudyal	
10:00- 11:30	Quality Assurance Plan Ram Babu Paudyal	Design and Construction Procedure of Surface Dressing Sujit Dhital	Marshal Mix Design Sujit Dhital	
11:30 – 11.45	Tea Break			
11.45 – 13.15	Specification and Test Frequency for Quality Control in Road Construction Sujit Dhital	Quality Control of Structures Masonry, Gabion and Plum Concrete Retaining Wall Ram Babu Paudyal	Slope Protection works including Bioengineering Measures Ram Babu Paudyal	
13.15 – 14.00	Lunch Break			
14.00 – 15.30	DPR Checking , Setting out and Earthwork in Excavation Ram Babu Paudyal	Procedure for lab tests – Pavement Sujit Dhital	Construction Procedure of Asphalt Concrete Works Sujit Dhital	
15.30– 17:00	Collection of Sample for Lab tests, Interpretation of Test Result Ram Babu Paudyal	Construction Procedure of Pre mix Carpeting Sujit Dhital	Quality Control Works for Rigid Pavement Ram Babu Paudyal	Closing

Annex 2: Sample Evaluation Sheet

तालिम मूल्याङ्कन फाराम

"सडक निर्माणमा गुणस्तर नियन्त्रण सम्बन्धि तालिम कार्यक्रम "

तालिमको मूल्याङ्कन तथा सहभागी पृष्ठपोषणका लागि प्रश्नहरू :

यस तालिमको मूल्याङ्कन तथा पृष्ठपोषणबाट आगामी तालिम कार्यक्रमहरू थप प्रभावकारी बनाउन मद्दत गर्नेछ भन्ने आशा छ। त्यसैले तपसिलमा उल्लेखित प्रश्नावली राम्ररी अध्ययन गरेर सकेसम्म उदाहरण सहित सुझाव प्रदान गरिदिनु अनुरोध छ।

१. तालिम कार्यक्रमका उद्देश्य र विषयवस्तु	पुर्ण सहमत	सहमत	तटस्थ	असहमत	पुर्ण असहमत
१.१ तालिमका उद्देश्य स्पष्ट थिए।	✓				
१.२ तालिमका विषयवस्तु उद्देश्यसँग मेल खाने थिए।		✓			
१.३ "सडक निर्माणमा गुणस्तर नियन्त्रण सम्बन्धी जानकारी अद्यावधिक भयो।		✓			
१.४ तालिम अवधि ठिक थियो।		✓			

सुझाव
विषयवस्तु राम्रो थियो / तर अवधि थप दिएको भए राम्रो।

२. स्रोत व्यक्ति / सहजकर्ता	पुर्ण सहमत	सहमत	तटस्थ	असहमत	पुर्ण असहमत
२.१ विषयवस्तुमा राम्रो ज्ञान भएको।	✓				
२.२ विषयवस्तुको तयारी राम्रो थियो।	✓				
२.३ भाषा स्पष्ट र प्रस्तुती राम्रो थियो।	✓				
२.४ सहजीकरण र सामाग्रीको तालमेल गर्न सक्ने सिप थियो।	✓				
२.५ सहभागीलाई प्रोत्साहन गर्ने सिप पर्याप्त थियो।	✓				
२.६ सहभागीका प्रश्न तथा जीज्ञासा सम्बोधन भयो।		✓			
२.७ विषयवस्तु प्रस्तुतीका विधिहरु उपयुक्त थियो।		✓			

सुझाव
field visit

३. तालिम सामाग्री र अभ्यास	पुर्ण सहमत	सहमत	तटस्थ	असहमत	पुर्ण असहमत
३.१ पर्याप्त स्पष्ट र सान्दर्भिक थिए।	✓				
३.२ कार्यरत क्षेत्रमा प्रयोगमा आउने खालका थिए।	✓				
३.३ प्रस्तुत गरिएका सामग्रीहरु जानकारीमूलक, शिक्षामूलक र सुचनामूलक थिए।	✓				
३.४ प्रयोग गरिएका अभ्यास, सिकाइ सामग्री र विधिहरू उपयुक्त थियो।		✓			
३.५ तालिमका सामग्री समयसापेक्ष, अध्यावधिक थिए।		✓			

सुझाव थप Lab visit र प्रयोगहरु भए अझ राम्रो हुने थियो।

४. वातावरण तालीम हल, खाजा तथा अन्य सुविधा	पुर्ण सहमत	सहमत	तटस्थ	असहमत	पुर्ण असहमत
४.१ तालीम हलको व्यवस्था राम्रो थियो।	✓				
४.२ प्रशासनिक र अन्य सुविधा सन्तोषजनक थिए		✓			
४.३ खाना तथा खाजा सफा र स्वास्थ्यवर्धक थिए	✓				

सुझाव

५. सिकेका विषय अभ्यास गर्ने वातावरण	पुर्ण सहमत	सहमत	तटस्थ	असहमत	पुर्ण असहमत
५.१ तालिममा हासिल गरेका ज्ञान तथा सिपहरू आफू कार्यरत क्षेत्रमा प्रयोग गर्ने वातावरण छ।		✓			

सुझाव
[illegible] IDO मा lab को व्यवस्था हुनु।
[illegible]

६. तालिममा प्रस्तुत भएका सबैभन्दा मन परेका विषयवस्तुहरु उल्लेख गर्नुहोस्। जसले कार्यरत क्षेत्रमा वा पेशागत जीवनमा समेत सघाउ पुऱ्याउछ।

१. [illegible] layout
२. [illegible] pavement [illegible]
३. QC for rigid pavement
४. Bio-engg [illegible]
५. Slope stabilization [illegible]

७. तालिममा प्रस्तुत भएका विषयवस्तुहरु मध्ये कुनै सुधार गर्नुपर्ने भए उल्लेख गर्नुहोस्।

१. [illegible]
२. Theoretical भन्दा Practical [illegible]
३. Road survey र Design को [illegible]
४. Drain को Design [illegible]

८. आगामी दिनमा प्रदेश तहबाट सडक निर्माणमा गुणस्तर नियन्त्रण गर्नका लागि तालीम थप प्रभावकारी बनाउन के गर्नुपर्ला ?

१. [illegible]
२. [illegible]
३. practical र field visit को [illegible]
४. IDO का [illegible] technical person [illegible]

नाम थर : Birendra Kr. Bajracharya ठेगाना : ललितपुर

कार्यालय : IDO Lalitpur पद : इन्जिनियर [illegible]

मिति : २०७८।५।१८

समाप्त

हार्दिक धन्यवाद

Annex 3: Participant's Attendance

बागमती पूर्वाधार निर्देशनालयको आयोजनामा संचालन गरिएको सडक निर्माणमा गुणस्तर नियन्त्रण सम्बन्धि मिति २०८०.०५.१६ देखि २०८०.०५.१८ सम्म (तिन दिने) तालिममा सहभागीहरुको हाजिरी विवरण

सि.न	कार्यालय	सहभागी इन्जिनियरको नाम	मोबाइल नं.	इमेल	२०८०.०५.१६	२०८०.०५.१७	२०८०.०५.१८
१	भौतिक पूर्वाधार विकास मन्त्रालय	श्री पुष्पराम गुरु	9851108526	[illegible]			
२	पूर्वाधार विकास कार्यालय, चितवन	श्री बिरेन्द्र कु चौधरी	9845032500	[illegible]			
३		श्री विष्णु प्रसाद काफ्ले	9855045297	[illegible]			
४		श्री नबिन अधिकारी	9849673347	nabinadhikari@gmail.com			
५	पूर्वाधार विकास कार्यालय, नुवाकोट	श्री रबिन महर्जन	9841618803	[illegible]@gmail.com			
६		श्री रामानन्द महतो(अ.सि.ई था)	9841504056	[illegible]			
७	पूर्वाधार विकास कार्यालय, ललितपुर	श्री बिरेन्द्र बज्राचार्य	9841367110	[illegible]			
८		श्री रेनु श्रेष्ठ	9849146795	er.[illegible]@gmail.com			
९	पूर्वाधार विकास कार्यालय, काभ्रेपलान्चोक	श्री प्रतिभा न्यौपाने	9841986094	[illegible]@gmail.com			
१०		श्री पन्नदेव भट्ट	9851189684	[illegible]			
११		श्री दिपेन्द्र कुमार रोहित	9842238492	dkrohita@gmail.com			
१२	पूर्वाधार विकास कार्यालय, सिन्धुपाल्चोक	श्री रबिन खाती	9849751696	[illegible]			
१३	पूर्वाधार विकास कार्यालय, रामेछाप	श्री पुरुषोत्तम महर्जन	9843684128	[illegible]			
१४		श्री कुमार पुडासैनी	9841960573	Kumarp2073@gmail.com			
१५	बागमती पूर्वाधार निर्देशनालय	श्री हरि प्रसाद ओझा	9855047960	[illegible]			
१६		श्री टंक प्रसाद तिवारी	9860014197	tankatiwari38@gmail.com			
१७		श्री विराट वाग्ले	9841376538	wagleb[illegible]@gmail.com			
१८		श्री अभिषेक मानन्धर	9866593114	[illegible]@gmail.com			
१९		श्री बिजय के सी	9814391596	[illegible]			
२०		श्री आन्तोनिओ नेपाल	9855030177	[illegible]@gmail.com			
२१		श्री समुद्र शेरचन	9845638668	Samundra8668@gmail.com			
२२		श्री पवन पाण्डे (बि ई)	9864693796	[illegible]@gmail.com			

Annex 4: Trainer's Information

S.N	Name of the Trainer	Contact	Email
1	Ram Babu Paudyal	9841504124	ramb.paudyal@gmail.com
2	Sujit Dhital	9843421686	sujitdhital@gmail.com

Annex 5: Sample Certificate

Province Government

Ministry of Physical Infrastructure Development

Transport Infrastructure Directorate

Bagamati Province, Hetauda, Makwanpur

CERTIFICATE OF PARTICIPATION

This is to certify that

Mr. Birendra Kumar Chaudhary

has participated in training on

"QUALITY CONTROL IN ROAD CONSTRUCTION"

from 1st September 2021 to 3rd September 2021,

organized by *Transport Infrastructure Directorate, Bagamati Province.*

Mr. Ram Babu Paudyal
Resource Person

Dr. Sahadev Bahadur Bhandari
Acting Director
Transport Infrastructure Directorate,
Bagamati Province, Hetauda

Mr. Sanjeeb Baral
Secretary
Ministry of Physical Infrastructure Development,
Bagamati Province, Hetauda

Annex 6: Photographs

Picture 1: Opening session of the training

Picture 2: Er. Ram Babu Paudyal taking his session

Picture 3: Er. Ram Babu Paudyal taking his session

Picture 4: Sujit Dhital taking his session

Picture 5: closing ceremony

Picture 6. Interaction during tea break

Picture 7: Group photo of participants

Annex 7: Handouts

Specification and Test Frequancy for Quality control in Road Construction

Sujit Dhital
M.Sc Geotechnical Engineering
Contact : sujitdhital@gmail.com
9843421686

भैरहवा — विदेशी ठेकेदार, विदेशी लगानी र विदेशी प्राविधिकसहितको परामर्शदाता कम्पनी राखेर निर्माण गरिएको भैरहवा–लुम्बिनी सडक खण्ड ६ महिनामै भत्किएको छ। विस्तार गरिएको सडकमा ठूल्ठूला खाडल बनेका छन्। धेरै स्थान दबिएको छ। कालोपत्र उप्केर गिट्टी–बालुवा छरपस्ट छन्। सडकको दायाँबायाँ बनाइएका सर्भिस लेन ट्र्याक्टरले कोतरेर छाडेको जस्तै देखिन्छन्।

निर्माण सम्पन्न नहुँदै भत्किन थाल्यो पक्की सडक

१० भाद्र २०७८, बिहीबार — newsofnepal

ठेकेदार कम्पनीले कम गुणस्तरको काम गरेकाले कालोपत्र गरेको दुई महिनामै सडक भत्किएको स्थानीय अगुवा दुखीराम लोनियाले बताउनुभयो. Source: newsofnepal.com

छ महिनामै सडक भत्किएपछि अख्तियारद्वारा गुणस्तर छानविन सुरु

अख्तियारद्वारा गुणस्तर छानविन

Document

- Contract Agreement
  - Gcc
  - SCC
- BoQ
- Specification
- Drawing

Priority of the Document

The documents forming the Contract shall be interpreted in the following order of priority:

(a) Contract Agreement,

(b) Letter of Acceptance,

(c) Letters of Technical Bid and Price Bid,

(d) Special Conditions of Contract,

(e) General Conditions of Contract,

(f) Specifications,

(g) Drawings,

(h) Bill of Quantities (or Schedules of Prices for lump sum contracts), and

(i) Any other document **listed in the SCC** as forming part of the Contract.

Associated works

- Maintenance of road during construction and defect liability period
- Excavation
- Embankment filling/Back filling
- Retaining Wall Breast wall
- Drainage (Longititudial ,Cross) or Surface /Sub surface drain
- Sub Grade
- Sub Base
- Base
- Wearing course

Test prior to construction
Test during construction
Test after completion of works

Government of Nepal
Ministry of Physical Infrastructure and Transport
Department of Roads

STANDARD SPECIFICATIONS
FOR
ROAD AND BRIDGE WORKS

2073
With amendment 2075

Quality Control

- The Contractor shall provide, use and maintain on the Site, throughout the period of execution of the contract, a laboratory with adequate laboratory equipment operated by competent staff for carrying out tests required in accordance with these Specifications.
- The Contractor shall provide necessary co-operation and assistance in obtaining the samples for tests and carrying out the field tests as required by the Engineer from time to time
- For satisfying himself about the quality of the materials and work, quality control tests will also be conducted by the Engineer
- Unless stated otherwise, the cost of sampling and testing of various materials proposed to be used on the works for quality control according to the Specification requirements shall be deemed to be incidental to the work and no extra payment shall be made for the same

- Before commencement of the work, the Contractor shall demonstrate a trial run of all construction equipment for establishing their capability to achieve the laid down Specifications and tolerances to the satisfaction of the Engineer
- It shall preferably be located adjacent to the site office of the Engineer and provided with amenities like water supply, electric supply
- Unless otherwise stated in the contract the ownership of all laboratories and equipment shall revert to the Contractor.
- The number of tests recommended in Table 5.2 may be reduced at the discretion of the Engineer if it is felt that consistency in the quality of materials can still be maintained with reduced number of test.
- The Contractor shall submit Quality Assurance Plan (QAP) to the Engineer for his approval. The Quality Assurance Plan (QAP) shall be based on the detailed Program of the Works, and process oriented focus on defect prevention, as per Clause 115 of these Specifications

Road Maintenance(109)

- The Contractor shall be responsible for undertaking all routine maintenance of the existing road and all bridges on the road from the day the road is officially handed over to the Contractor until the issue of Defects Liability Certificate by the Engineer.
- The Contractor shall also carry out all the routine maintenance of the completed works from the time of their substantial completion until the Defects Liability Certificate is issued.
- The routine maintenance of the road shall include besides other, trimming vegetation, cleaning all culverts, ditches, borrow pits, road side drainage, drainage channels and any other obstructions including minor landslide (up to 20 m3 at one spot, with unlimited number of spots), cleaning road signs -----------------

- Maintenance of road in defects liability period quantified in months shall be paid as per contract price on lump sum basis. Maintenance of road during construction/rehabilitation period quantified in km-months shall be paid as per contract unit rate. The contract price and/or unit rate shall be the full and the final compensation to the Contractor as per Clause 112.

Payment(112)

- Unless otherwise specified in the contract the unit rates and /or price for the items as set out in the bill of quantities are full and final compensation to the contractor for --------------------
- Where the Bill of Quantities does not include the items mentioned in Section 100, no separate payment shall be made for such works.
- The costs in connection with the execution of the works specified herein shall be considered to be included in the related items of other works specified in the Bill of Quantities or shall be considered to be incidental to the works specified.

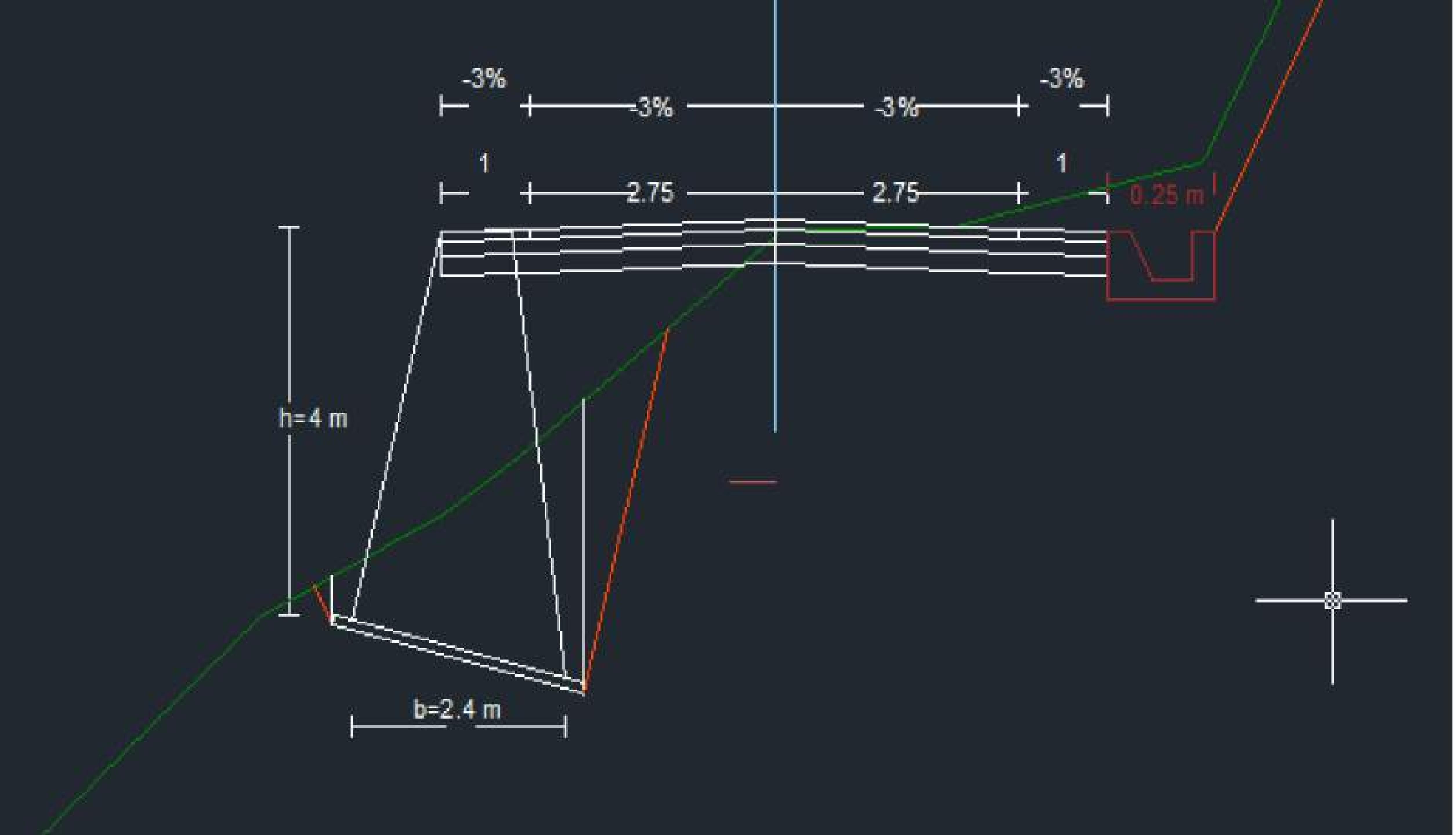
Earthwork in Cutting (905)

- When completed, the excavation slopes shall be true to the lines and levels as shown on the Drawing or directed by the Engineer. When completed, no point on slopes shall vary from the designated slopes by more than 150 mm measured at right angles to the slope, except where excavation is in rock, no point shall vary more than 300 mm from the designated slope.

Excavation in Foundation (907/2)

- Excavation shall be taken to the length and width of the lowest step of the footing and the sides shall be left to plumb where the nature of soil allows it. Where the nature of soil or the depth of the trench does not permit vertical sides, the Contractor at his own expense shall put up necessary shoring, strutting and planking or cut slopes to a safer to a safer angle or both with due regard to the safety of personnel and works and to the satisfaction of the Engineer. (907/2)

- In the event of excavation having been made deeper than that shown on the Drawing or as otherwise ordered by the Engineer, the extra depth shall be made up with concrete or masonry of the foundation grade at the cost of the Contractor(907/4)


-3%
-3%
-3%
-3%
1
2.75
2.75
1
0.25 m
h=4 m
b=2.4 m

Measurement (917)

- The quantities to be measured shall be the net cubic content of the voids formed by the removal of the materials enclosed between the bottom of the footing and existing ground level by a surface generated by vertical lines passing through the periphery of the bottom of the footing.
- No payment shall be made for any excavation other than the limited excavation described above. Excavation over increased width or length, cutting of slopes, removal of slides, shoring, shuttering and planking shall be deemed as convenience for the Contractor in executing the work and shall not be measured and paid for.
- Backfill to be measured shall be limited to this void only with due consideration of the nature of the structure.

Measurement (contd.)

- If the material obtained from road way excavation is used fully or partially in roadway filling, the quantities for roadway excavation and roadway filling shall be computed as below.:
  - The quantities of roadway excavation and roadway filling of the distances under reference shall be calculated separately adopting the method described as above in this Section.
  - The computed quantity of roadway filling shall be measured in roadway filling while difference between quantities of roadway excavation and filling shall be measured in roadway excavation.
  - The same excavated material shall not be measured both in roadway excavation and roadway filling.

Cut Slope how much ?

- Construct cut and fill slopes that are flat enough to be stable over time and that can be revegetated.”

Appropriate 0' values range between 25° and 40° for clayey and granular materials respectively. With low factors of safety (1.1-1.2) this gives side slopes of between 20° and 33°.

In mountain areas, where granular soils predominate, embankment side slopes are normally constructed to 1:1.5 (33°) assuming that the specifications for material size, drainage and compaction can be met (TRL Road Note 16, page 101)

General practice ???

Generally cut slope are adopted as

Ordinary Soil	1H: 2 V to 1H to 4V
Boulder mix soil /Hard soil	1H: 3 V to 1H to 5V
Soft Rock	1H: 6V
Hard Rock	1H: 10 V

Flatter slope is safer but Quantity and social issues ????

Backfilling

Pervious (902,908)

Unless otherwise specified in the contract, it shall of gravel, crushed gravel, crushed rock, natural sands, manufactured sands or combinations thereof. It shall conform to the grading limits

Grading Limits of Pervious Backfill

Sieve Size (mm)	Percentage Passing by Weight
40	100
10	45-100
2.36	25-80
0.60	8-48
0.075	0-6

General Fill (902-2-II)

Material shall comprise all that is acceptable in the accordance with the Contract for use in the Works and which is capable of being compacted in the manner specified to form a stable fill having side slopes as indicated in the Drawing. The material used in fill (except for rock fill) shall not contain rock fragments with dimensions of more than 75 mm

Unsuitable Material (902-2-III)

- “Unsuitable Material” shall mean other than suitable material and shall include: (a) Material from swamp, marshes or bogs; (b) Peat, logs, stumps, perishable material, organic clays; (c) Material susceptible to spontaneous combustion; (d) Material in a frozen condition; (e) Clay of liquid limit exceeding 70 and/or plasticity index exceeding 45

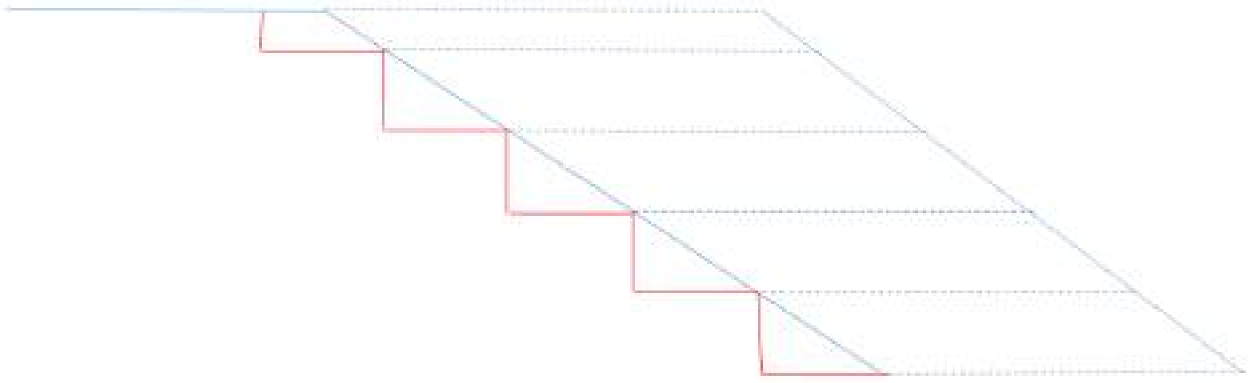
Embankment Fill(909)

- The maximum size of the coarse material in the mixture shall not exceed 75 mm for general earth fill.
- The limits of embankment shall be built sufficiently wider than the design dimension to facilitate in achieving required compaction nearby outer faces of the embankment. The surplus material shall be trimmed to conform the specified side slopes and width of the embankment.

Location	Depth below the formation level	Minimum Compaction (%MDD Heavy Compaction
Roadway Embankment	0-300	95
Roadway Cut	0-300	95
All other roadway fills and backfill not separately specified		93

Layers of material other than rock fill shall not exceed 150 mm compacted depth unless and until the Contractor can demonstrate to the satisfaction of the Engineer that he can successfully Compact layers of a greater thickness.

Benching (912)



- Existing slope

Less than 1V:4 H :

existing embankment shall be scarified to a depth of not less than 100 mm to ensure bond

More than 1V:4H

continuous horizontal benches, each at least 300 mm wide, shall be cut in existing slopes and the widened embankment shall be built up in successive layer of thickness 150 mm

Where the width of the widened portions is insufficient to permit the use of heavy

rollers, compaction to the specified density shall be carried out with the help of small vibratory roller/plate compactor/rammer or other approved methods.

Measurement of Earth works

- All roadway excavation including side drains, filling and backfilling compacted in place shall be measured in cubic meters by the average end area method as computed from the original and final cross-sections of the completed work.
- The Engineer shall compute the quantities by a volumetric method, if in his opinion, it is the best suited method to obtain an accurate determination.

Sub grade (1000)

- Formation Level The level of the top surface of the subgrade upon which pavement structures is built up.
- Subgrade Up to 500 mm below formation (Lowest level of pavement crust) level is designated as “subgrade”.
- Capping Layers Capping layers are layers of specified materials to be laid and compacted in the subgrade and below as required, in replacement of in-situ materials to achieve required CBR

Material Required for subgrade

- Materials for use in the subgrade shall
  - not contain particles larger than 60 mm.
  - have a CBR of not less than 5% measured after a 4-day soak on a laboratory mix compacted to 95% MDD (heavy compaction),
  - have a swell of less than 1%,
  - have plasticity index of less than 40% and an organic matter content less than 3%

Compaction Requirement (910)

Location	Depth below Formation Level (mm)	Minimum Compaction (%MDD Heavy Compaction
Roadway Embankment	0-300	95
Roadway Cut	0-300	95
All other roadway fills and backfill not separately specified		93

In cut areas, the subgrade shall be processed as necessary and compacted to the depth and compaction requirements as given above. In the event that the Contractor is unable to achieve the minimum compaction requirements below formation level he shall excavate and re compact in layer as necessary.

SECTION 2 METHOD SUITABLE FOR FINE-, MEDIUM- AND COARSE-GRAINED SOILS: LARGE POURING CYLINDER METHOD

7. SCOPE

7.1 This method covers the determination, in-place, of the dry density (in g/cm^3 or kg/m^3) of natural or compacted soil containing stones which make the test of Section 1 difficult to perform. This is an alternative method of test to Section 1 for fine- and medium-grained soils and should be used instead of that test for layers exceeding 150 mm but not exceeding 250 mm in thickness (*see* Note under **1.1**).

8. APPARATUS

8.1 Large Sand-Pouring Cylinder — similar in the essential details to that shown in Fig. 1.

8.2 Tools for Excavating Holes — suitable tools, such as bent spoon, dibber (*see* Fig. 3), large screw driver, pointed steel rod about 300 mm long and 5 to 10 mm dia with a wooden handle.

8.3 Cylindrical Calibrating Container — with internal diameter of 200 mm and an internal depth of 250 mm (*see* Note 1 under **4.2.2**) of the type illustrated in Fig. 6 fitted with a flange 75 mm wide and about 5 mm thick surrounding the open end. The volume of the container should be given to an accuracy of 0·15 percent.

8.4 Balance — accurate to 1 g.

8.5 Plane Surface — a glass plate or other plane surface about 600 mm square and 10 mm thick or larger.

8.6 Metal Containers — to collect the excavated soil and to take the supply of sand to fill the pouring cylinder. This may be provided with a suitable cover.

8.7 Metal Tray with Central Hole — a metal tray 450 mm square and 50 mm deep with a 200 mm dia hole in the centre.

9. MATERIAL (SAND)

9.1 Clean, uniformly graded natural sand passing the 1·00-mm IS Sieve and retained on the 600-micron IS Sieve shall be used. It shall be free from organic matter, and shall have been oven dried and stored for a suitable period to allow its water content to reach equilibrium with atmospheric humidity (*see* Note under **3.1**).

SECTION 1 METHOD SUITABLE FOR FINE- AND MEDIUM-GRAINED SOILS : SMALL POURING CYLINDER METHOD

1. SCOPE

1.1 This method covers the determination, in-place, of the dry density (in g/cm^3 or kg/m^3) of natural or compacted fine- and medium-grained soils for which a small sand-pouring cylinder is used. The method is applicable to layers not exceeding 150 mm in thickness (*see* Note).

NOTE — With granular materials having little or no cohesion, particularly when they are wet, there is a danger of errors in the measurement of dry density by this method. These errors are caused by the slumping of the sides of the excavated density hole and always result in an over-estimation of the density.

2. APPARATUS

2.1 Small Sand-Pouring Cylinder — similar in essential details to that shown in Fig. 1.

2.2 Tools for Excavating Holes — suitable tools, such as a scraper tool similar to that shown in Fig. 2 to make a level surface; bent spoon, dibber shown in Fig. 3.

2.3 Cylindrical Calibrating Container — with an internal diameter of 100 mm and an internal depth of 150 mm (*see* Note 1 under **4.2.2**) of the type illustrated in Fig. 4 fitted with a flange approximately 50 mm wide and about 5 mm thick surrounding the open end. The volume of the container should be given to an accuracy of 0·25 percent.

2.4 Balance — accurate to 1 g.

2.5 Plane Surface: Glass or Perspex Plate or Other Plane Surface — about 450 mm square and 9 mm thick or larger.

2.6 Metal Containers — to collect excavated soil. A convenient size is one about 150 mm diameter and 200 mm deep with a removable cover.

2.7 Cylindrical Steel Core-Cutter — of steel, 127·4 ± 0·1 mm long and 100 mm ± 0·1 mm internal diameter with a wall thickness of 3 mm bevelled at one end. One suitable type is illustrated in Fig. 5. The cutter shall be kept adequately greased.

2.8 Metal Tray with Hole — 300 mm square and 40 mm deep with a 100 mm hole in the centre.

Test Frequencies for Embankment and Sub grade

Material Identification, MDD,OMC and CBR	**For each new source and in every 1500 m3 or part of it**
MC	For each new source and in every 400m3 or part of it
Field Density	One set(3 test) per 1000 sqm

Each layer shall be compacted to a dry density equal to at least 95% MDD (heavy compaction).

Capping Layer (1004)

Where shown on the Drawing or where in-situ material in the subgrade in cutting does not meet the requirements, in-situ materials shall be replaced with selected material from cuttings or borrow pits.

- Material for use in the capping layers shall not contain particles larger than 75 mm and their percentage passing by weight the 0.075 mm sieve shall be less than 15%.
- The material shall have a CBR of not less than 15% measured after a 4-day soak on a laboratory mix compacted to 95 % MDD (heavy compaction), a swell of less than 1%, a plasticity index of less than 12%.
- Moisture content during compaction is between 95% and 100% of the Optimum Moisture Content
- Each layer shall be compacted to a dry density equal to at least 95% MDD (heavy compaction).

Granular Sub base(1201)

Gradings III and IV shall preferably be used in lower sub-base. Gradings V and VI shall be used as sub-base cum drainage layer. Where the sub-base is laid in two layers as upper sub- base and lower sub-base, the thickness of each layer shall not be less than 150 mm. Grading to be adopted for a project shall be as specified in the Contract.

Grading Envelope for Granular sub base material

Sieve Size As per IS designation (mm)	Percentage passing by weight					
	Grading I	Grading II	Grading III	Grading IV	Grading V	Grading VI
75	100				100	
53	80-100	100	100	100	80-100	100
26.5	55-90	79-90	55-75	50-80	55-90	75-100
9.5	35-65	50-80			35-65	55-75
4.75	25-55	40-65	10-30	15-35	25-50	30-55
2.36	20-40	30-50			10-20	10-25
0.85					2-10	
0.425	10-15	10-15			0-5	0-8
0.075	<5	<5	<5	<5		0-3

Physical Requirements for Granular Subbase

Physical properties	Test method	Requirement for Class I & II	Requirement for Class III , IV and maintenance work
Aggregate Impact Value (AIV)	IS 2386-4 or IS 5640	Maximum 40	Maximum 45
Liquid Limit	IS 2720-5	maximum 25	maximum 25
Plasticity Index	IS 2720-5	Maximum 6	Maximum 6
CBR at 95 % dry density (at IS 2720- part8)	IS 2720-5	Minimum 30 unless specified in the Contract	Minimum 25 unless specified in the Contract

Moisture content during compaction is between 95% and 100% of the Optimum Moisture Content (IS: 2720 Part 8).

Material shall be compacted to a dry density of at least 95% of MDD (IS: 2720 Part 8).

The compacted thickness of any layer laid, processed and compacted at one time shall not exceed 150 mm and when a greater compacted thickness is required, the material shall be laid and processed in two or more layers. The minimum layer thickness shall be 100 mm. (**1204-3**)

Functional Class of Road
Class I (ADT > 20000 PCU)
Class II (ADT > 5000- 20000 PCU
Class IIII (ADT 2000-5000 PCU
Class IV(ADT < 2000 PCU

Test Frequencies for Sub base

Material Identification, MDD,MC,OMC and CBR	For each new source and in every 400 m3 or part of it
Field Density	One set (3 test) per 1000 sqm

Crusher Run Base and Sub base (1204)

The material to be used for the work crushed rock. If crushed gravel/shingle is used, not less than 90 percent by weight of the gravel/ shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces.

Sieve size	Percentage Passing by weight	
	53 mm nominal size	37.5 mm nominal size
63 mm	100	
45 mm	87 – 100	100
22.4 mm	50-85	90 – 100
5.6 mm	25 – 45	35 – 55
0.71 mm	10 – 25	10 – 30
0.09 mm	2- 5	2-5

Physical Requirements

Table12.9: Physical requirement s of Coarse Aggregates for Crusher run material Base

	Test	Test method	Requirements
1	Loss Angeles Abrasion Value(LAA) Or Aggregate Impact Value (AIV)	IS: 2386 -4	40 max 30 max
2	Combined Flakiness and Elongation index	IS: 2386 -1	35 max
3	Water Absorption	IS: 1386 -3	2 % max
4	Liquid limit of material passing 425 micron	IS: 2720- 5	25 max
5	Plasticity index of material passing 425 micron	IS: 2720- 5	6 max

Note:

Test Frequencies for Crusher Run Sub Base and Base

Material Identification, MC, Gradation, Plasticity index	For each new source and in every 200 m3 or part of it
CBR, MDD, OMC, LAA/ AIV, Crushing ratio	For each new source and in every 1000 m3 or part of it
Field density	One set (3 test) per 1000 sqm

If the water absorption is more than 2 % , soundness test shall be carried out as per IS: 2386 -5 2.

To determine combined portion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particle s be separated out from the remaining (non flaky) stone metal. Elongation index is weight of elongated particles divided by total non flaky particles. The value of flakiness index and elongation index so found are added up.

Wet mix Macdam(1208)

This Clause covers procuring, furnishing and placing of approved crushed graded aggregate and granular material, premixed with water on top of the complete subgrade or subbase and constructing a subbase or base, as the case may be, in accordance with the requirement of this Specification. “Graded crushed stone” shall mean crushed stone with a smooth grading curve within a specified envelope.

Grading Envelopes for Wet mix Macadam

Sieve Size	Percentage passing by weight		
(mm)	Base	Subbase	
		S1*	S2*
53.0	100-	100	100
45.0	95-100	75-100	85-100
26.5		42-75	75-95
22.4.0	60-80	25-60	60-87
11.2.0	40-60	15-45	50-80
4.75	25-40	12-37	12-32
2.36	15-30	6-25	7-21
0.60	8-22	5-21	6-17
0.075	0-5	3-12	3-10

Physical Requirements

Physical Requirement for Materials for Wet mix macadam subbase/ base

Physical properties	Test method	Requirement for class I & II (Max %)		Requirement for class III, IV (max %)	
		Base (B1)	Sub base (S1)	Base (B2)	Sub base (S2)
Los Angeles Abrasion value (LAA) or Aggregate Impact Value (AIV)	IS: 2386-4 IS: 5640	40 30	45 35**	40**	45**
Combined Flakiness and Elongation index (Total)	IS: 2386-1	35			

* *B1, B2, S1 and S2 are classes of materials*

Testing frequency same as crusher run sub base and base

What to do ?

- Crushing ratio for the wet mix macadam not specified
- CBR value not specified for the both Crusher run material and wet mix macadam
- % of fine passing 75micron sieve in case of the wet mix macadam and passing 90 micron in case of the Crusher run base and sub base is insufficient .Possibility of the segregation of the base and sub base .
- If the thickness of single compacted layer does not exceed 100 mm, a smooth wheel roller of 80 to 100 kN weight may be used. For a compacted single layer up to 200 mm the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN or equivalent capacity.
- The speed of the roller shall not exceed 5 km/h. Each layer of material shall be compacted to not less than 98 per cent of the maximum density as determined by IS: 2720 (Part - 8).

Old Specification

- CBR Test : ???? Not specified
- % passing 0.09mm

Table 12.1: Grading Envelope for Gravel

Sieve Size (mm)	Percentage passing by weight
63.0	100
40.0	70-100
20.0	50-85
10.0	40-75
4.75	30-60
2.36	20-45
1.18	15-35
0.075	4-15

Table 12.4 Grading Envelopes for Graded Crushed Stone

Sieve Size (mm)	Percentage passing by weight		
	Base	Subbase	
		SB1*	SB2*
63.0	-	100	100
40.0	100	75-100	85-100
31.5	85-100	42-75	75-95
20.0	62-92	25-60	60-87
10.0	40-70	15-45	50-80
4.75	26-55	12-37	12-32
2.36	21-53	6-25	7-21
0.60	12-28	5-21	6-17
0.075	2-10	3-12	3-10

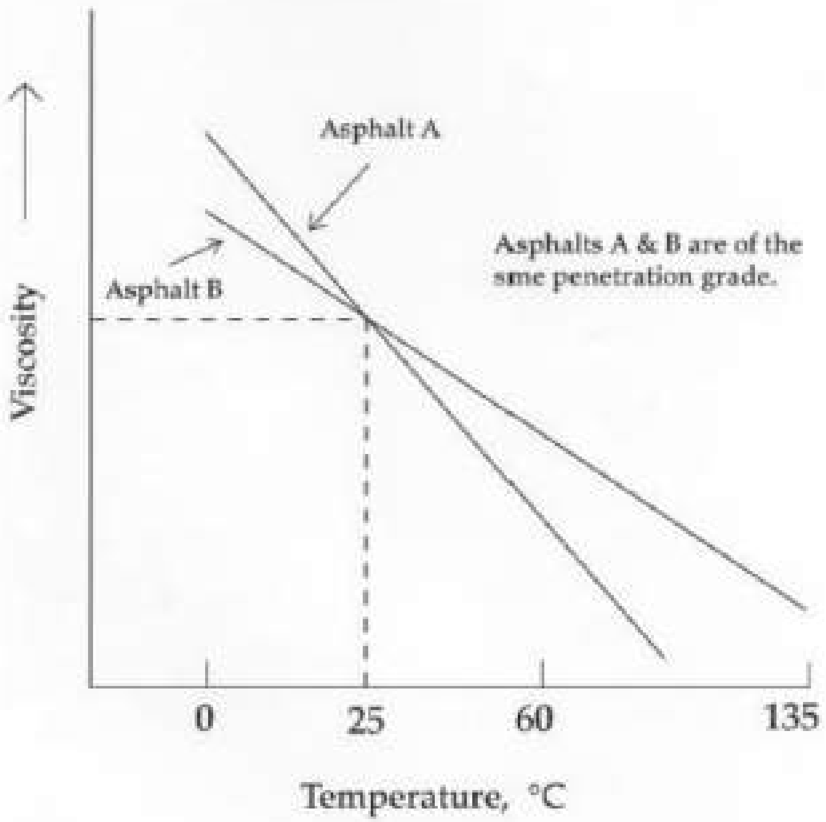
Table 12.3: Physical Requirements of Graded Crushed Stone

Tests	Base		Subbase
	B*	C1*	D1*
LAA Max. %	30	35	40
AIV Max. %	20	25	30
SSS Max. %	12	12	12
FI %	25	25	30
CBR Min. %	80	80	60
CR Min. %	100	80	30
PI Max.	NP	NP	6

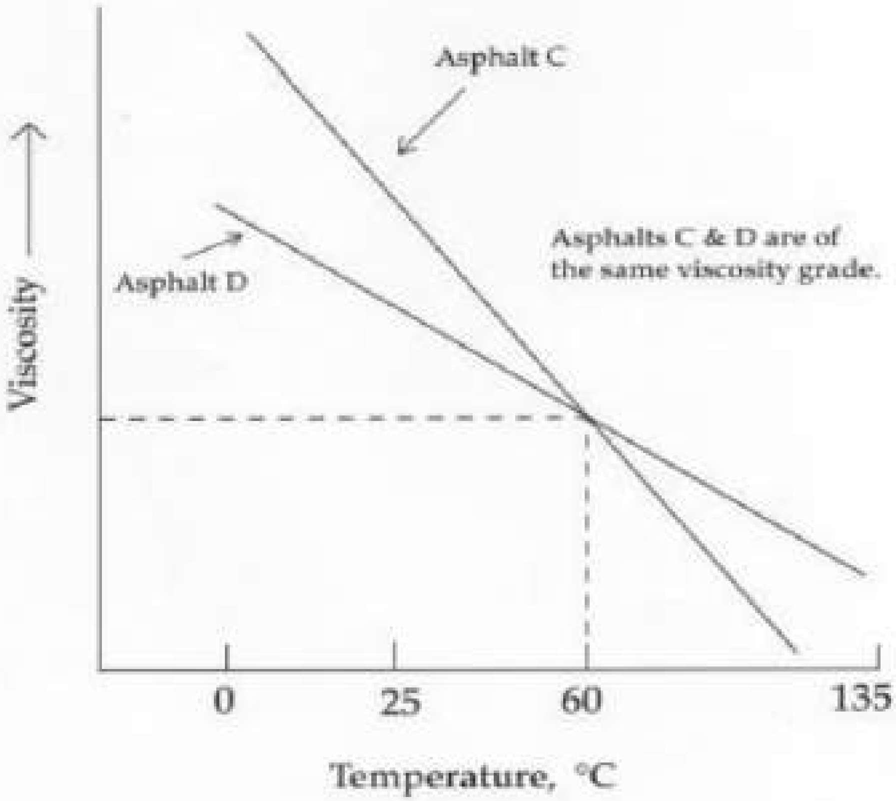
* B, C1 and D1 are classes of materials

Bitumen

- Penetration grade (not produced now)
- Viscosity Grade
- Before any bituminous binder is delivered to the site, the Contractor shall provide the Engineer with a certificate form the manufacturer that the material to be supplied complies in all respects with the relevant specifications. Engineer Accept the brand based on the provided certificate
- Brand acceptance does not mean that the bitumen to be delivar at site is approved . Contractor have to bear the risk of the material deliver at the site. Engineer's approval shall not relieve the contractor from his responsibilities for compliance with these specifications.
- Sample to be taken from the material deliver at the site and tested . Acceptance of the deliver lot after the test . Material shall pass all the regular test as mentioned in the specification .
- Any bituminous binder delivered in leaking or deteriorated containers shall be rejected



Viscosity
Asphalt A
Asphalt B
Asphalts A & B are of the
sme penetration grade.
0
25
60
135
Temperature, °C



Viscosity
Asphalt C
Asphalt D
Asphalts C & D are of
the same viscosity grade.
0
25
60
135
Temperature, °C

Test for Bitumen

S No.	Characteristics	Paving Grades				Method of Test
		VG10	VG20	VG30	VG40	Ref to
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Penetration at 25°C, 100 g, 5 s, 0.1 mm, Min	80	60	45	35	NS: 221:2047 (Part III)/ IS: 1203
ii)	Absolute viscosity at 60°C, Poises	800-1200	1600-2400	2400-3600	3200-4800	NS: 237:2050 (Part VIII)/ IS: 1206 -2
iii)	Kinematic viscosity at 135°C, cSt, Min	250	300	350	400	NS: 237:2050 (Part VIII)/ IS :1206-3
iv)	Flash point (Cleveland open cup), °C, Min	220	220	220	220	NS: 237:2049 (Part VII)/ IS: 1448-69
v)	Solubility in trichloroethylene, percent, Min	99	99	99	99	NS: 221:2047 (Part IV)/IS: 1216
vi)	Softening point (R&B), °C, Min	40	45	47	50	NS / IS: 1205.
vii)	Tests on residue from rolling thin film oven test:					
a)	Viscosity ratio at 60°C, Max	4	4	4	4	NS: 221:2046 (Part II)/ IS: 1206-2
b)	Ductility at 25°C, cm, Min	75	50	40	25	NS: 221:2046 (Part I)/ IS: 1208

Bitumen Selection Criteria

Lowest Daily Mean Air Temperature, °C	Highest Daily Mean Air Temperature, °C		
	Less than 20°C	20 to 30°C	More than 30°C
More than -10°C	VG-10	VG-20	VG-30
-10°C or lower	VG-10	VG-10	VG-20

VG	General Application (IRC 111-2009)	Equivalent PG
10	Used in spraying applications, and can be used in very cold regions. Also used for the manufacture of bitumen emulsion & modified bitumen	80-100
20	It is used in areas of cold climate & high altitude	
30	It is the most suitable for Indian road condition.	60-70
40	The area with high stress concentration like intersections of roads, truck parking, heavy traffic. It can be used in higher temperatures	30-40

- Both the highest daily mean air temperature and the lowest daily mean air temperatures mentioned above can be obtained for the weather station nearest to the project site.
- The department of hydrology and meteorology has data on daily mean high temperature for all 365 days in a year for all weather stations based on historical records
- This daily mean high temperature on a specific day is the same as daily "normal" high temperature for that day as usually reported in some newspapers. The highest of the 365 daily mean high air temperatures (which usually occurs on some day in May or June) is used
- The lowest daily mean air temperature (which usually occurs on some day in January) can also be obtained from department of hydrology and meteorology

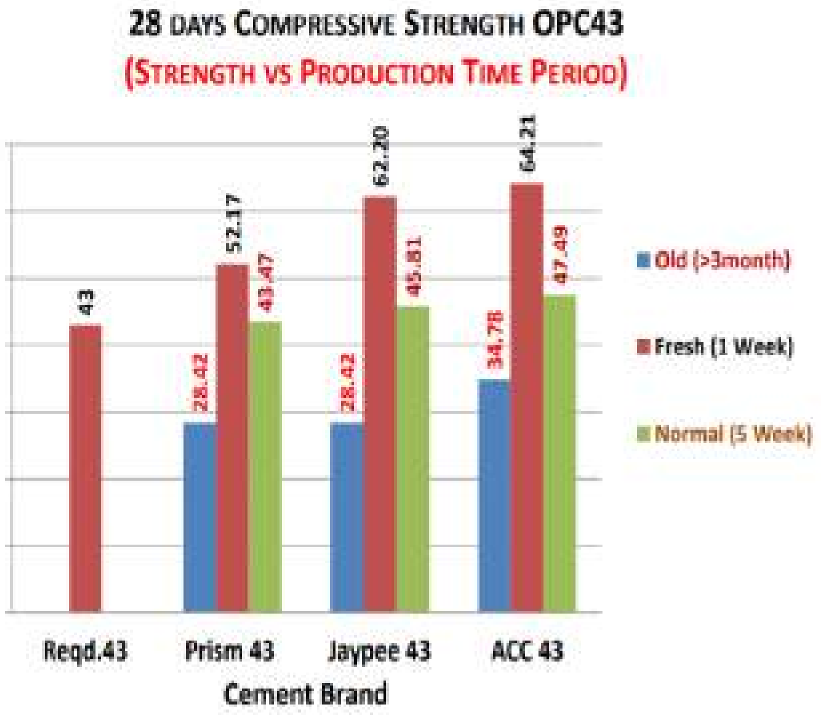
Which Bitumen Brand is to be used ??

Cement

Chemical and physical requirements for Ordinary Portland Cement, High Strength Portland Cement, Portland Slag Cement and Portland Pozzolana Cement shall be in accordance with NS: 49/IS: 269, IS: 8112, IS: 12269, IS: 455, IS: 1489 respectively.

Requirement on the Physical Characteristics of Cement (614)

S.N.	Physical Characteristics	OPC/ PSC	HSPC	Test Procedure
i)	Fineness, m^2/kg: (by Blaine's Air Permeability method)	225	225	
ii)	Setting Time:			NS 123
	(a)Minimum Initial Setting Time(minutes)	45	45	
	(b)Maximum Final Setting Time(minutes)	600	600	
iii)	Soundness by Lechatelier Method, mm, maximum	10	10	NS: 123
iv)	Compressive Strength:			
	Minimum average Compressive Strength of three mortar cube (N/mm^2)			
	(a) 3 days	16	27	
	(b) 7 days	22	37	
	(c) 28 days	33	53	



Manufacture Date ,
Store, Stacking
First in first out

Conservative samples for each supply and not less than every 200 t or part of it

Source : Jagdishwar Man Shrestha

MASONRY FOR STRUCTURES (2600)

Grading envelope for sand for Masonry work

Sieve size (mm)	Percentage passing by weight
4.75	100
2.36	90-100
1.18	70-100
0.6	40-100
0.3	5-70
0.15	0-15

The stone shall not absorb water more than 5 per cent. The specific gravity of the stone shall not be less than 2.50

Cement shall be ordinary Portland cement and shall comply with Clause 614. The mortar used in work shall have the strength not less than 5 N/mm2 or 7.5 N/mm2 at 28 days as specified.

Compressive Strength of Mortar: Every 10 cum of masonry of part of it

In case of mortared masonry, the total volume of mortar and spalls taken together shall not be more than 30% of the mortared masonry

The breadth of the stone on the bed shall not be less than 150 mm nor greater than 3/4 the thickness of the wall

All stones shall be carefully set with a bond stone provided at the rate of at least one to every 0.9 m2 of exposed face. Bond stones shall measure not less than 150 mm x 150 mm on the exposed face and not less than 450 mm in length or the full thickness of the wall, whichever is the less.

Concrete Works(2000)

- Cement
- Sand (fine aggregate)
- Coarse Aggregate
- Slump value
- Strength of concrete
- Mix design
- Round or crushed aggregate which is better and when

- Cement

Cement shall comply with the requirements of Clause 614. (Ordinary Portland Cement, High Strength Portland Cement, Portland Slag Cement and Portland Pozzolana

The floor shall be raised above the surrounding ground level not less than 30 cm and shall be so constructed that no moisture rises through it.

Stack of cement bags shall not exceed 8 bags in height.

Cement which has become hardened or lumpy or fails to comply with the Specification in any way shall be removed from the Site

Cement which is stored on site for longer than one month shall be tested in such laboratory for every 200 tons or part thereof and at monthly intervals thereafter.

Fine Aggregate

- Fine aggregate shall be clean hard and durable and shall be natural sand, crushed gravel sand or crushed rock sand complying with IS 383

Grading Requirement for fine aggregate

IS sieve designation (mm)	Percentage passing
10	100
4.75	90-100
2.36	75-100
1.18	55-90
0.60	35-59
0.30	8-30
0.15	0-10

Coarse Aggregate

(4) Coarse Aggregate

Coarse aggregate shall be clean hard and durable crushed rock, crushed gravel or natural gravel. Coarse aggregate shall be supplied in the nominal size called for in the contract and shall be of the grading as specified in Table 20.2.

Table 20.2 Grading Requirement for Coarse Aggregate

S.N	IS sieve Designation	Percentage Passing for Single Sized Aggregate of nominal Size						Percentage Passing for Graded Aggregate of Nominal Size			
		63 mm	40 mm	20 mm	16 mm	12.5 mm	10 mm	40 mm	20 mm	16 mm	12.5 mm
i)	80 mm	100						100			
ii)	63 mm	85-100	100								
iii)	40 mm	0-30	85-100	100				90-100	100		
iv)	20 mm	0-5	0-20	85-100	100			30-70	90-100	100	100
v)	16 mm				85-100	100				90-100	
vi)	12.5 mm					85-100	100				90-100
vii)	10 mm	0-5	0-5	0-20	0-30	0-45	85-100	10-35	25-35	30-70	40-85
viii)	4.75 mm			0-5	0-5	0-10		0-5	0-10	0-10	0-10
[illegible]	2.36										

The Contractor shall carry out routine testing of aggregate for compliance with the Specification during the period that concrete is being produced for the works. Frequency test shall be as follows:

		Test procedure	Frequency
Fine aggregate and	Grading Silt,Clay Contents and Organic Impurities	IS: 2386 Part 1 IS: 2386 Part2	1 set (3 nos) test for each 10 to 50 cum and additional test for each 50 cum of concrete
Coarse Aggregate	GradingSilt, Clay Contents and Organic Impurities	IS: 2386 Part 1 IS: 2386 Part2	1 set (3 nos) test for each 25 to 125 cum and additional test for each 125 cum

Flakiness index	Ordinary concrete	High Quality Concrete
Flakiness Index (Max)	25	15
LAA (max)	45	35
ACV (max)	30 pavement structre	45
Water absorption (max)	2	2
Alkali Aggregate Reactivity	shall comply with IS 456 when tested in accordance with IS:386 Part 7.	

Acceptance test : all test as mention in sub clause 2003 and 2004

Compressive Strength Test

- The test strength of the sample shall be the average of the strength of 3 cubes. The individual variation should not be more that ± 15 per cent of the average. If variation is more, the test results of the sample are invalid

Quantity	Frequency (set)
1-5	1
5.1-15	2
15.1-30	3
30.1-50	4
More than 50	Four plus one additional set for every 50 m3 0r part thereof

Acceptance Criteria

- The concrete shall be taken as having the specified compressive strength when both the following conditions are met:
- The mean strength determined from any group of four consecutive non overlapping samples exceeds the specified characteristic compressive strength by 3 MPa.
- Strength of any sample is not less than the specified characteristic compressive strength minus 3 MPa.
- The quantity of concrete represented by the test results include the batches from which the first and last samples were taken, together with all intervening batches

Gabion Works (2400)

- The specific gravity of the stone shall be not less than 2.50 and the stones shall not absorb water more than 5 percent.
- Tolerance on diameter of wire shall be ± 2.5 percent. The tensile strength shall be between 350 to 550 N/mm2
- gabion boxes shall be placed such that vertical joints are not continuous, but staggered
- The gabion boxes and gabion mattresses shall be laid in such a manner that the hinges of the lid will be on the lower side on slopes and on the outer side in walls.
- All the gabions exposed to outer surface shall be provided with bracing

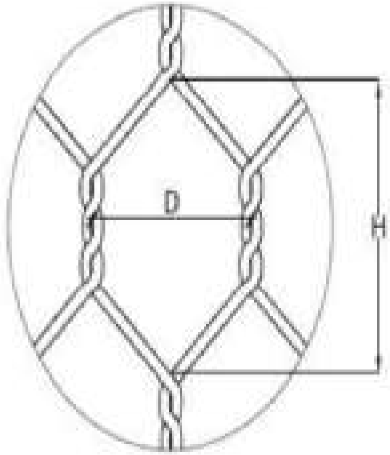


Table 24.1: Standard Size of Wire Mesh Gabions

Mesh Type (DXH)	10 X 12	8 X 10	6 X 8
'D', mm	100	80	60
Wire Type	Heavy Zinc coated		
Mesh Wire Dia., mm / SWG	3.25/10	3.25/10	2.64/12
Edge / Selvedge wire Dia., mm/ SWG	4.06/8	4.06/8	3.25/10
Lacing wire dia, mm/ SWG	2.64/12	2.64/12	2.03/14
Typical Sizes Length x Width x Height (m) / Number of diaphragms	Box Gabions: 3 x 1 x 1 / 2 Nos, 2 x 1 x 1 / 1 No, 1.5 x 1 x 1 / 0 No, 3 x 1 x 0.75 / 2 Nos, 2 x 1 x 0.75 / 1 No, 3 x 1 x 0.5 / 2 2 x 1 x 0.5 / 1 No , 1 x 1 x 0.5 / 0 Nos, ,3 x 1 x 0.3 / 2 2 x 1 x 0.3 / 1 No , 1 x 1 x 0.3 / 0 Nos, ,		
Tolerances in Size of Gabion Boxes	Gabion boxes ± 3%, mesh opening +16 % to - 4 %,		

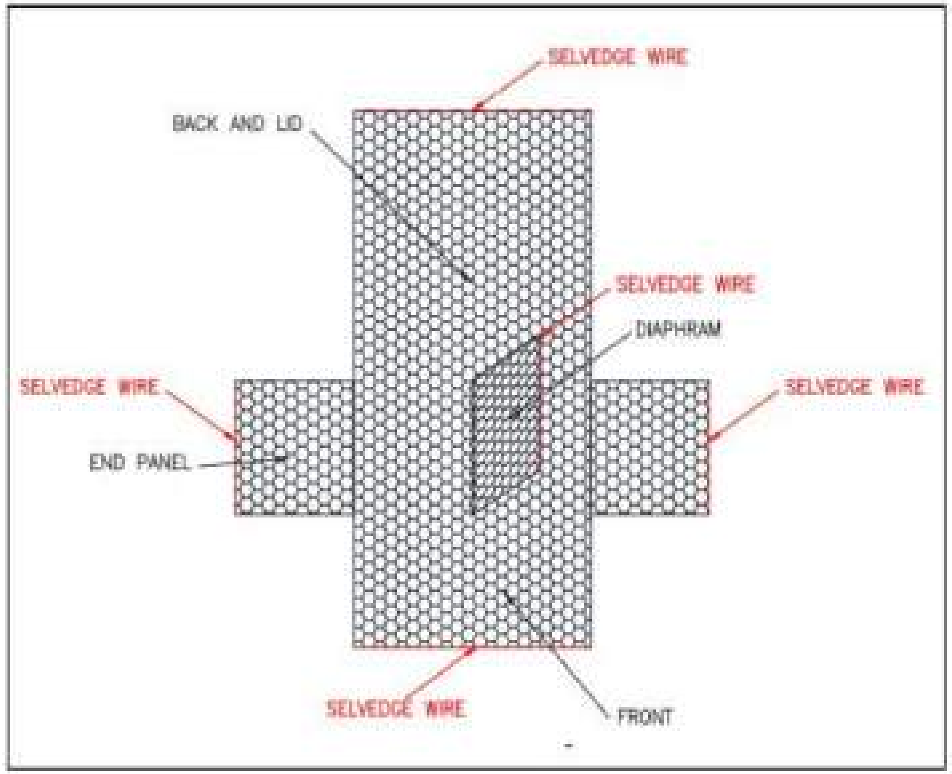


Fig 24.5 Components of Gabions

Selvedge Wire: a terminal wire used to edge the cut portion of wire mesh panel perpendicular to the double twist by mechanically wrapping the mesh wires around it (Fig 24.5).

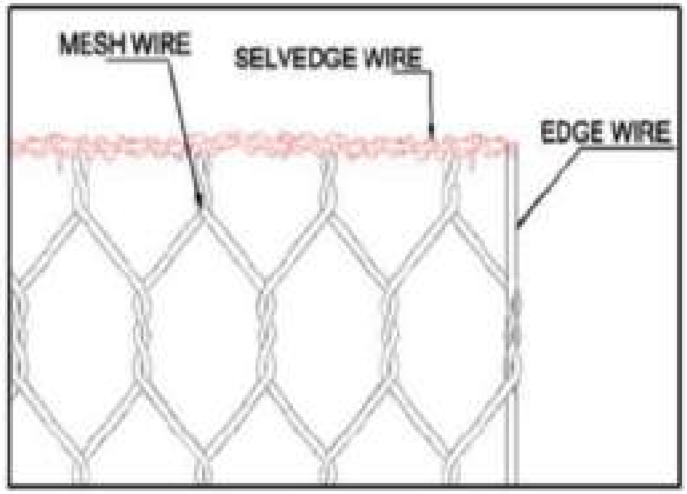


Fig. 24. 4 Mechanically Selvedging and Edge Wire

Mesh wire : 2.7 /3 Selvedge wire /edge wire : 3.4/3.9, Lacinge wire 2.2/2.4. Tolerance in box size : +/- 5% (in length breadth and height).

TABLE 1 CROSS-SECTIONAL AREA AND MASS

(Clause 5.2)

Nominal Size	Cross- Sectional Area	Mass per Meter Run
(1)	(2)	(3)
mm	mm^2	kg
4	12.6	0.099
5	19.6	0.154
6	28.3	0.222
7	38.5	0.302
8	50.3	0.395
10	78.6	0.617
12	113.1	0.888
16	201.2	1.580
18	254.6	2.000
20	314.3	2.470
22	380.3	2.980
25	491.1	3.850
28	615.8	4.830
32	804.6	6.310
36	1018.3	7.990
40	1257.2	9.860

TABLE 3 MECHANICAL PROPERTIES OF HIGH STRENGTH DEFORMED BARS AND WIRES

SI No.	property	Fe 415	Fe 415D	Fe 500	Fe 500D	Fe 550	Fe 550D	Fe 600
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	0.2 proof stress/yield stress, Min. N/mm^2	415.0	415.0	500.0	500.0	550.0	550.0	600.0
ii)	Elongation percent/Min. on gauge length 5.65√A where A is the cross-sectional area of the test piece	14.5	18.0	12.0	16.0	10.0	14.5	10.0
iii)	Tensile strength, Min	10 percent more than the actual 0.2 percent proof stress/yield stress but not less than 485.0 N/mm^2	12 percent more than the actual 0.2 percent proof stress/yield stress but not less than 500.0 N/mm^2	8 percent more than the actual 0.2 percent proof stress/yield stress but not less than 545.0 N/mm^2	10 percent more than the actual 0.2 percent proof stress/yield stress but not less than 565.0 N/mm^2	6 percent more than the actual 0.2 percent proof stress/yield stress but not less than 585.0 N/mm^2	8 percent more than the actual 0.2 percent proof stress/yield stress but not less than 600.0 N/mm^2	6 percent more than the actual 0.2 percent proof stress/yield stress but not less than 660.0 N/mm^2
iv)	Total elongation at maximum force ,percent/Min. on gauge length 5.65√A where A is the cross-sectional area of the test piece	-	5	-	5	-	5	-

TABLE 5 FREQUENCY FOR NOMINAL MASS, TENSILE, BEND AND REBEND TESTS

Nominal Size	Quantity	
	For casts/heats below 100 tonnes	For casts/heats over 100 tonnes
(1)	(2)	(3)
Under 10 mm	1 sample from each 25 tonnes or part there of	1 sample from each 40 tonnes or part thereof
10 mm to 16 mm inclusive	1 sample from each 35 tonnes or part thereof	1 sample from each 45 tonnes or part thereof
Over 16 mm	1 sample from each 45 tonnes or part thereof	1 sample from each 50 tonnes or part thereof

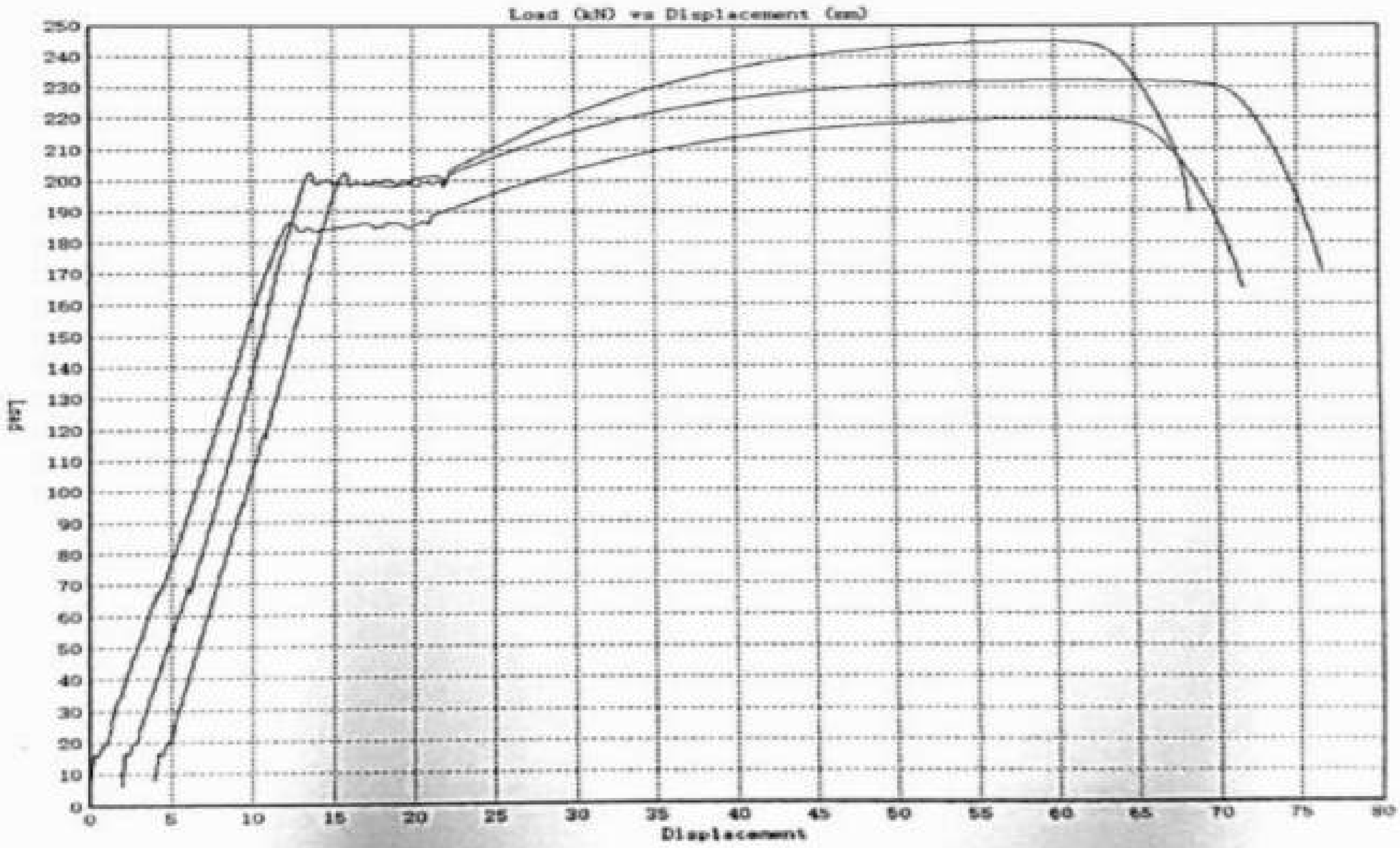
Nominal Diameter of Size – The diameter of a plain round bar/wire having the same mass per meter length as the deformed bar/wire

Effective Cross-Sectional Area of Deformed Bars and Wires

5.3.1 For bars/wires whose pattern of deformation is such that by visual inspection, the cross-sectional area is substantially area shall be the gross sectional area determined as follow, using a bar/wire not less 0.5 m in length. Gross cross-sectional area in mm^2 = w/ 0.007 85 L where, w = mass in kg weighed to a precision of 0.5 percent, and L = length in m measured to a precision of 0.5 percent

Type of Rebar: Ambe Steel

S.No.	Diameter (mm)	Nominal Diameter	% of Elongation	Yield Load (KN)	Yield Strength	Ultimate Load (KN)	Ultimate Strength
4-1	20	20.02	24.00	201.8	641.07	236.28	750.60
4-2	20	20.07	22.00	219.27	693.10	248.68	786.06
4-3	20	20.08	20.00	219.32	692.57	261.07	824.40



SUMMARY OF BACK FILL MATERIAL / EMBANKMENT FILL MATERIAL

Capping layer

Lab Ref no.	Date of Test	Sampled Location/Chainage	Type of Test				Remarks
			MDD	OMC	CBR	Specific Gravity	
			g/cc	%	(%)	g/cc	
NDO1/MDD-03	13-Jan-21	5+600-5+620	2.158	6.98%	22.91	2.62	
NDO1/MDD-04	15-Jan-21	6+600-6+590	2.157	6.53%	22.35	2.61	

Contractor: Lama Construction Pvt.Ltd	Employer: Infrastructure Development Office Lamjung
By:	Witness By:
Sr.Lab Technician	Sr. Lab Technician/Su-Engineer
Contract Manager	Project Manager

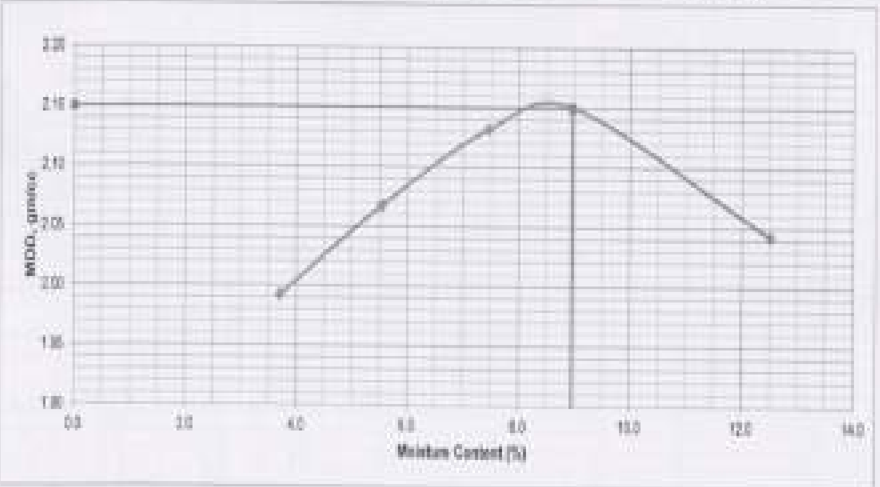
4. Sample Taken by:	Contractor
5. Test Standard:	IS 2720 Part

Sample No.	Container No.	Wt. of empty container,	Wt. of container+Wet soil,	Wt. of container+Dry soil,	Wt. of Water,	Wt. of dry soil,	Moisture Co
		A, gm	B, gm	C, gm	D=B-C, gm	E=C-A, gm	F=(D/E)x10
1	L-5	24.00	150	145.5	4.5	121.5	3.70
2	D-20	22.00	123	117.7	5.3	95.7	5.54
3	M-10	25.00	162	152.5	9.5	127.5	7.45
4	G-22	23.00	152	141.4	10.61	118.39	8.96
5	M-11	24.00	166	150.2	15.8	126.2	12.52

Sample No.	Empty wt. of mould+base Plate	Empty wt. of mould+base Plate+specimen	Wt. of compacted specimen	Volume of the mould	Bulk Density	Moisture Co
	P, gm	Q, gm	R=Q-P, gm	S, cm3	p=(R/S), gm/cm3	W, %
1	5936	10350	4414	2137	2.07	3.70
2	5936	10599	4663	2137	2.18	5.54
3	5936	10831	4895	2137	2.29	7.45
4	5936	10944	5008	2137	2.34	8.96
5	5936	10848	4912	2137	2.30	12.52

Optimum Moisture Content:	8.96%
Maximum Dry Densities (MDD):	2.150
Maximum Wet Densities:	2.343

Date of Test:	13-Jan-21	3. Location/source	5+600-5+620 Capping Liyar
		4. Sample Taken By:	Contractor
		5. Test Standard	IS 2720 Part 8



Comments:

Submitted By: Sr.Lab Technician		Verified / Approved By: Sr. Lab Technician/Sub Engineer
Contract Manager		Project Manager

CBR TEST

		Date of sampling	12-Jan-21	Sample Label Information: Capping Liyar	
		Location/source	5+600-5+620 Capping Liyar	Total Sample Taken (approx.), gm	18000
Lab Ref No.	ND21/SG/07	Date of Moulding	13-Jan-21	Sample Taken By	Jointly (Employer & Contractor)
		Date of Test	17-Jan-21	Test Standard	IS-2720, Part-16

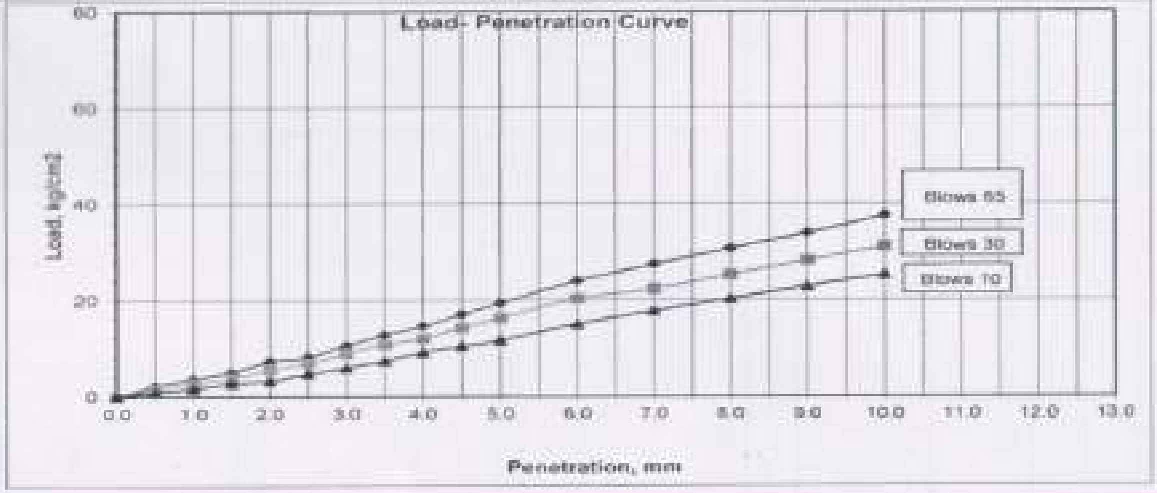
No. of Layers :- 5		Soaking Period: 96 hrs			Max. Dry Density (g/cc) :2.150				OMC (%) :8.96			Surcharge Weight: 5 kg			
Description	Unit	Test Condition: Unsoaked			Test Condition: Soaked			Description	Unit	Test Condition: Unsoaked			Soaked		
Mould No.		1	2	3	1	2	3	Mould No.		1	2	3	1	2	3
No. of blows per layer		65	30	10	65	30	10	Container No.		A-4	B-7	C-3	E-6	A-1	B-2
Wt. of wet sample + mould	gm	12380	11813	11692	12429	11719	11768	Wt. Container+Wet Soil (A)	gm	223.1	228	220.2	182.4	189.5	210.5
Wt. of mould	gm	7045	6976	6985	7045	6976	6985	Wt. Container+Dry Soil (B)	gm	207	214.1	206	170	177.4	197
Wt. of wet sample	gm	5335	4837	4707	5384	4743	4783	Wt. of water w_w = (A-B)	gm	16.1	13.9	14.0	12.4	12.1	13.5
Volume of mould	cc	2911.55	2878	2751.57	2911.55	2878	2751.57	Wt. of empty container C	gm	26.3	27.2	28.2	27.4	27.3	29.6
Wet unit wt.	gm/cc	1.836	1.681	1.711	1.849	1.648	1.74	Wt. of dry soil w_s = (B-C)	gm	180.7	186.9	177.8	142.6	150.1	167.4
Avg. moisture content	%	8.91	7.44	7.87	8.70	8.06	8.06	Moisture Content Mc = (ww/ws) X 100	%	8.91	7.44	7.87	8.70	8.06	8.06
Density (Dry Unit wt)	gm/cc	1.686	1.565	1.586	1.701	1.525	1.608	Average	%						

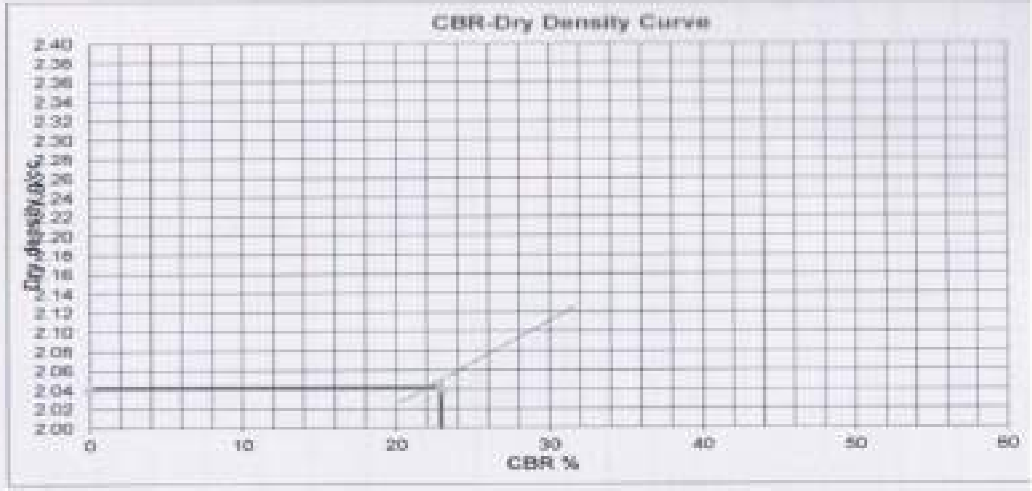
CBR Penetration results:		Proving Ring Calibration Factor: 3.59 Kg						Plunger Area : 19.635 cm2		
		No. of Blows: 65			No. of Blows: 30			No. of Blows: 10		
		Mould No. 3			Mould No.2			Mould No.1		
Penetration	Standard Load	Test Load		Load Intensity	Test Load		Load Intensity	Test Load		Load Intensity
mm	kg/cm²	Dial gauge	kg	kg/cm²	Dial gauge	kg	kg/cm²	Dial gauge	kg	kg/cm²
0		0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00
0.5	-	12.0	43.08	2.19	8.0	28.72	1.46	5.0	17.95	0.91
1.0	-	20.0	71.80	3.66	15.0	53.85	2.74	9.0	32.31	1.65
1.5	-	28.0	100.52	5.12	21.0	75.39	3.84	15.0	53.85	2.74
2.0	-	40.0	149.60	7.61	31.0	111.29	5.67	18.0	64.62	3.29
2.5	70	45.0	161.55	8.23	38.0	136.42	6.95	26.0	93.34	4.75
3.0		58.0	208.22	10.60	49.0	175.91	8.96	33.0	118.47	6.03
3.5		70.0	251.30	12.80	59.0	211.81	10.79	41.0	147.19	7.50
4.0		80.0	287.20	14.63	66.0	236.94	12.07	50.0	179.50	9.14
4.5		93.0	333.87	17.00	78.0	280.02	14.26	57.0	204.63	10.42
5.0	105	106.0	380.54	19.38	89.0	319.51	16.27	64.0	229.76	11.70
6.0		131.0	470.29	23.95	111.0	398.49	20.29	82.0	294.38	14.99
7.0		150.0	538.50	27.43	122.0	437.98	22.31	97.0	348.23	17.74
8.0		168.0	603.12	30.72	136.0	488.24	24.87	111.0	398.49	20.29
9.0		185.0	664.15	33.82	154.0	552.86	28.16	125.0	448.75	22.85
10.0	162	205.0	735.95	[illegible]	170.0	610.30	31.08	138.0	495.42	25.23

CBR TEST (Capping Layer)

Corrected Pressure, kg/cm²			
No. of Blows	65	30	10
At 2.5mm Penetration	8.23	6.95	4.75
At 5.0mm Penetration	19.38	16.27	11.70
Standard load at 2.5 mm penetration	70	70	70
Standard load at 5.0 mm penetration	105	105	105
CBR value at 95% of MDD:			
At 2.5mm Penetration	14.41		
At 5.0mm Penetration	22.91		
MDD At 95%	2.043		

Mould No.					
No. of Blows per Layer		No	65	30	10
CBR at 2.5mm Penetration		%	11.75	9.93	6.79
CBR at 5.0mm Penetration		%	18.46	15.50	11.14
Dry Density		gm/cc	1.69	1.50	1.59
Water Content		%	8.9	7.4	7.9
Swell	Initial Reading mm	mm	1.20	1.35	1.44
	Final Reading mm	mm	1.32	1.51	1.64
	Diff. in Reading		0.12	0.16	0.20
	Swell %		0.09	0.13	0.16





Comments:

[redacted]

Specification Limit

CBR≥ 5% at 95 % of MDD

Sr.Lab Technician

Submitted By:

Contract Manage

Sr. Lab Technician /Sub-Engineer

Verified / Approved By:

Project Manager

Weep Hole

- . Weep holes shall be provided with 100mm dia polythene pipe for structures in plain/reinforced concrete or brick masonry.
- In case of stone masonry, weep holes shall be 100 mm wide, 100 mm high or circular with 100 mm diameter.
- Weep holes shall extend through the full width of concrete/masonry with a slope of 1 vertical 20 horizontal towards the draining face.
- The spacing of weep holes shall generally be 1 m in either direction or as shown on the drawing with the lowest at about 150 mm above the low water level or ground level whichever is higher or as directed by the Engineer.
- Surfaces of the weep holes shall be smooth and it shall be ensured that the water is properly driven from the backfill.
- Unless otherwise specified, Weep holes shall not be paid separately. The contract unit rate for respective items shall be deemed to include costs for providing such holes.

Road Marking

- Road marking shall be of ordinary road marking paint hot applied thermoplastic compound, reflectorized paint or cold applied reflective paint as specified in the Contract. . Ordinary paint used for road marking shall comply with the requirements of NS 408/054 or confirm to IS 164.
- Where retro-reflective paint is required by the contract, the retro-reflective glass beads shall be applied by means of a suitable machine immediately after the application of the paint in one continuous operation. The rate of application of the beads shall be 0.8 kg/litter paint or such other rate as is specified in the contract

Reflectorizing Glass Beads

Type 1 beads are those which are constituent of the basic thermoplastic compound as per table 15.1 and Type 2 beads are those which are to be sprayed on the surface as specified in (6) application. The glass beads shall be transparent, colourless and free from milkiness, dark particles and excessive air inclusions. These shall conform to the requirements spelt out in: application Properties of Thermoplastic material"

Specific requirements of Reflectorizing Glass beads

(a) Gradation:

The glass beads shall meet the gradation requirements for the two types as given in Table 15.2

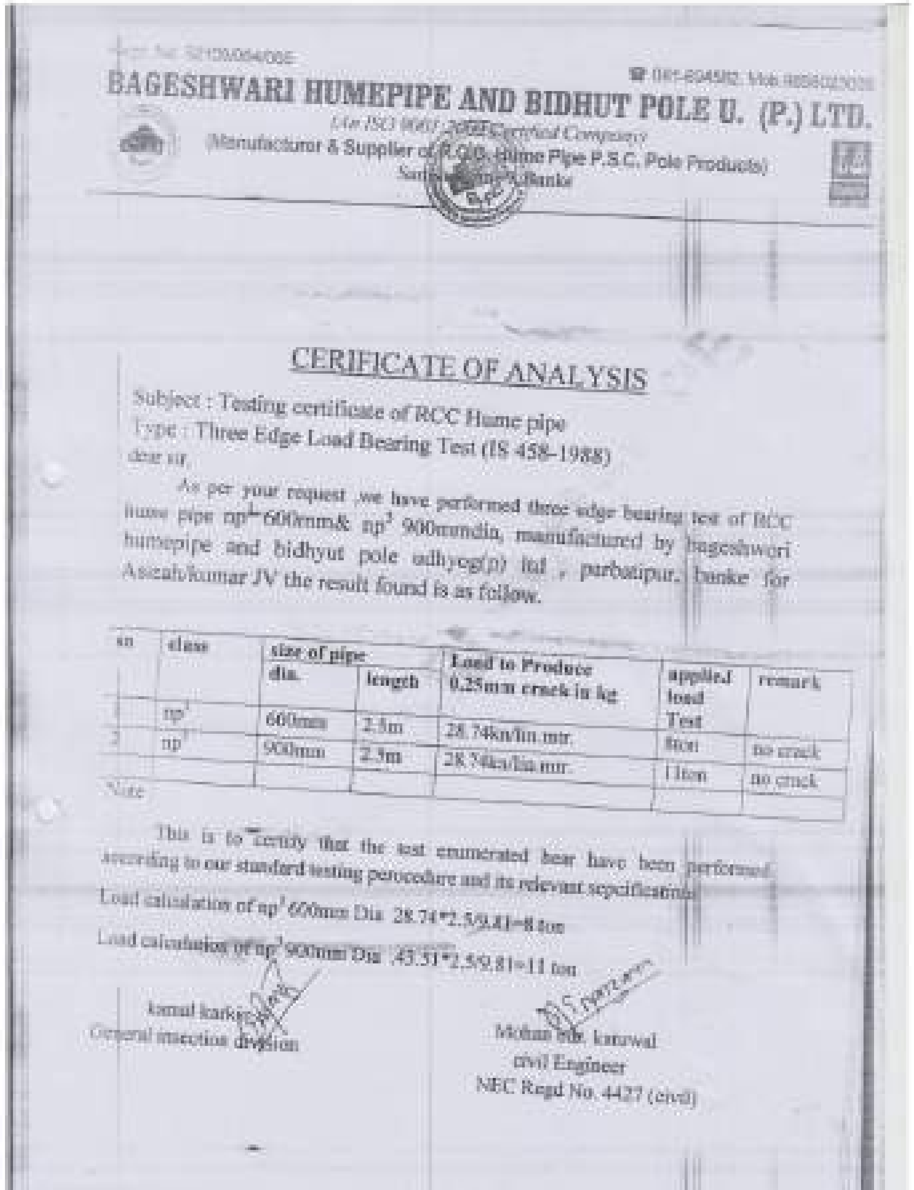
Table 15.2 Gradation Requirements for Glass Beads

Sieve size	Percent Retained	
	Type 1	Type 2
1.18 mm	0 to 3	
850 micron	5 to 20	0 to 5
600 micron	--	5 to 20
425 micron	65 to 95	--
300 micron	--	30 to 75
180 micron	0 to 10	10 to 30
Below 180 micron	--	0 to 15

Hume Pipe(701)

Nominal dia	Barrel thickness (mm)	Load to produce 0.25 mm crack(Kn/m)	Ultimate load(Kn/m)
300	40	15.5	23.25
600	85	28.74	43.11
900	100	43.11	64.67

Invention of precast pipe in Canada in , year 1920. It has capacity to take load of 21300kg , but as testing mechanism was not developed , they tested like this.To give confidence on strength of pipe . The inventor sat inside the pipe
photo IG credits:-full2civil



BAGESHWARI HUMEPIPE AND BIDHUT POLE U. (P.) LTD.

(An ISO 9001 Certified Company)

(Manufacturer & Supplier of R.C.C. Hume Pipe P.S.C. Pole Products)

Banke

CERIFICATE OF ANALYSIS

Subject : Testing certificate of RCC Hume pipe

Type : Three Edge Load Bearing Test (IS 458-1988)

dear sir,

As per your request ,we have performed three edge bearing test of RCC hume pipe np[1] 600mm& np[3] 900mmdia, manufactured by bageshwori humepipe and bidhyut pole udhyog(p) ltd , parbatipur, banke for Asezah/kumar JV the result found is as follow.

sn	class	size of pipe dia.	length	Load to Produce 0.25mm crack in kg	applied load Test	remark
1	np[3]	600mm	2.5m	28.74kn/lin.mtr.	8ton	no crack
2	np[3]	900mm	2.5m	28.74kn/lin.mtr.	11ton	no crack

Note

This is to certify that the test enumerated hear have been performed according to our standard testing perocedure and its relevant sepcifications.

Load calculation of np[3] 600mm Dia 28.74*2.5/9.81=8 ton

Load calculation of np[3] 900mm Dia 43.31*2.5/9.81=11 ton

kamal karki
General inspection division

Mohan Bdr. katuwal
civil Engineer
NEC Regd No. 4427 (civil)

W beam Crash Barrier (1511)

SN	Item	Requirement
1	W-beam guard rail :	Base Metal: The beam, end sections shall consist of sheet made of open hearth, electric furnace, or basic oxygen steel and shall meet the mechanical properties specified below. Length of rail -- 4.318 m/ 2.318 m Yield stress, minimum, 310 MPa; and Elongation, in gauge length (5.65X (sqrt of cross sectional area)) minimum, 15 percent.
2	C-Channel post:	Length of Post – 1800 mm. Yield stress , minimum 410 MPa;
3	C-Channel spacer	Length of Spacer– 330 mm. Yield stress , minimum 410 MPa
5	All fittings (Bolt , Nuts, :washer)	Confirm to IS 1364 and IS 1367

- The “W beam type safety barrier shall consist of steel post and a 3 mm thick “W” beam rail element. The steel post and blocking out spacer shall both be channel section of 75 mm X 150 mm & 5 mm thick. The rail shall be 70 cm above the ground level and post shall be spaced 2 m centre- to centre.
- The “W” beam, thrie beam, the posts, spacers and fasteners for steel barriers shall be galvanised by hot dip process (zinc coated 0.55 kg per square metre; minimum single spot) unless otherwise specified

The most common applications for 3 wave or thrie-beam guardrails are bridges on highways , or exit and entrance of tunnels on highways).


Thank YOU
If you don't know how to use them,
it will never be enough.

Transport Infrastructure Directorate
Bagamati Province

Training on Quality Control in Road Works

Session 2: Quality Assurance Plan (QAP)

Introduction

Key issues

Quality of constructed work are not meeting the satisfaction of Employer and Engineer

- towards contractual requirements defined by the contract documents mainly by drawings and specifications

Learning objectives

- Participants will be able to assure that all the steps of Quality control during planning, implementation and completion of construction activities

Points to be Discussed :

Quality Assurance Plan

Group work

- What type of quality control activities are being implemented in Province Level? Please mention the types of activities to control the quality, Current Practice, Challenges and Possible solution in following table

Definitions

Quality in construction is defined as "meeting or exceeding the requirement of client/owners i.e. specification"

Quality Assurance is ensuring that material and work meet certain thresholds of acceptability

Quality Assurance and **Quality Control** are two aspects of Quality Management

Quality Assurance is Not **Quality Control**. The **QA** is process oriented and **QC** is product oriented

Objectives

- To assure that all the steps of Quality control have been properly planned and implemented at the completion of each activity

- To assure that the completed works meet or exceed desired performance criteria/quality standards (specified in Drawings & Technical Specification which are part of the Contract Documents.)

Contents of Quality Assurance plan

- The recapitulative tests schedule and testing program detailing
- Estimate the number of tests to be carried out, list and number
- List of staffs assigned to the laboratory, their position and responsibility in the quality control procedure, their qualification and experience
- The list of sources of materials and/or manufactured article
- Quality Assurance Flow charts and Quality Assurance Work Procedure
- Organizational Breakdown , Communications , Reports , Record Keeping and Instructuction , NCR

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- The list of sources of materials and/or manufactured article
- Quality Assurance Flow charts and Quality Assurance Work Procedure
- Organizational Breakdown , Communications , Reports , Record Keeping and Instructuction , NCR

QA Implementation Plan

- The Plan, staffing arrangements and procedures will be explained to all staffs
- The contractor has to maintain test frequency of each item
- For special tests in offsite laboratory, should request in written and get written approval to conduct proposed test
- Example of Test Frequency

QA Implementation Plan

S. N	Material	Tests	Specification Limit /Requirements	Test Frequency	BoQ Quantity	No of Tests
1	Cement , Specification Clause no DOR 614	Setting Time	Initial – 45 Minutes Final – 600 min	200 T or Part of it	1000 T	5 Sets
2						

QA Implementation Plan

- Qualified Laboratories
- Verification Sampling and Testing – Personnel : Qualified and Competent

- Verification Sampling and Testing of Project Produced Material :Aggregates, PCC, Mortar, Base and sub-base materials

- Verification Sampling and Testing of Manufactured Material:GI wires, Geotextiles, Cement, Bitumen , Reinforcement etc

Planning for improvements

Planning of Construction Materials to the Site

working site will be neat and clean i.e. the construction material will not be scattered, cement and other materials in approved manner

Weekly/Monthly Testing Schedule

prepare weekly / monthly test plan of material and works, test schedule provides a clear picture of what to do and when to do?

Material Management Schedule

based on the project schedule

Planning for improvements

Planning of Construction Materials to the Site

working site will be neat and clean i.e. the construction material will not be scattered, cement and other materials in approved manner

Weekly/Monthly Testing Schedule

prepare weekly / monthly test plan of material and works, test schedule provides a clear picture of what to do and when to do?

Material Management Schedule

based on the project schedule

Roles and Responsibilities

Role of Sub Engineer / Assistant Sub Engineer

- Control of Quality and workmanship.
- Daily report of works, equipment, manpower and materials status relating to quality.
- Carryout joint measurement of quality works
- Carry out construction activities in accordance Method statement
- Inspection of materials upon receipt and reporting.
- Stop progress of work of any place that is non-complying the quality requirements in consultation with the QC Engineer.
-

Quality Control System

- Compliant testing for materials including laboratory trials
- Compliant testing for methods and equipment prior to commencement of work
- Control testing during construction (process control)
- carries out all necessary tests and reports to the Engineer
- demonstrates a trial run of all construction equipment for establishing their capability to achieve requirement

Quality Control Tests

- Materials prior to construction
- Quality of workmanship and works during construction
- Finished works after construction

Non Compliance and corrective Measures

- meet quality standard, workmanship and test frequencies for material and works. Nonconforming works and material shall be rejected.

Corrective Measures

- A detail list of the possible areas of non-compliance of the test results and possible corrective measures

Quality Control Tests- Material Prior to Construction

Sample : Asphalt Concrete Coarse Aggregate
Sourse : Samari River
Test Method : IS:2386 (Part I)1963

Date: 01-05-2021

IS Sieves mm	Tested Weight (gm)	Flakiness Index		Elongation Index	
		Passing on Flakiness Guage(g)	Retained on Flakiness Guage(g)	Passing on Elongation Guage(g)	Retained on Elongation Guage(g)
40-25	-	-	-	-	-
25-20	-	-	-	-	-
20-16	780.00	195.00	585.00	355.00	230
16-12.5	661.00	165.00	496.00	395.00	101
12.5-10	616.00	285.00	331.00	255.00	76
10-6.3	509.00	180.00	329.00	274.00	55
Total	2566	825	1741	1279	462

Flakiness Index = 32.15%   Elongation Index = 26.54%

Combined Flakiness Index & Elongation 58.69%

Quality Control Tests- Material Prior to Construction

Government of Nepal
DEPARMENT OF ROADS
Quality, Research and Development Centre
(Laboratory Unit)
CHAKUPAT, LALITPUR

Ref No.: ९०८८
Date: 2078.01.05

Subject: Bitumen Test Result

To:
Transport Infrastructure Directorate
Hetauda,Makawanpur

Contractor : Shree Mohdan / SBA JV,Kathmandu
Contract No.: TID/P3/W/R/078/77/02

With reference to your letter dated 2077.12.09, Ref.No:077/078-749, we are enclosing herewith Bitumen test results of provided sample of Bitumen.

Test Results

S.N.	Name of tests	Unit	Bitumen Grade: VG-30	
			Sample 1	**Specification limit as per Standard Specifications for Road & Bridge Works**
1	Penetration at 25°c,100 g,5s,0.1 mm, Min.	1/10mm	56	45
2	Softening Point (R and B) ,Min	°c	52.2	47
3	Solubility in Trichloroethylene, % min.	%	99.3	99.0
4	Flash Point (Cleavel and open cup), °C,Min.	°c	308	220
5	Kinematic Viscosity (at 135 °C)	Cst	538	350
6	Absolute Viscosity (at 60 °C)	Poise	1584.3	2400-3600

Note: The provided samples are taken by following members :-

On behalf of Office/ Consultant : Er. Shree Samundra Kumar Rokka

On behalf of Contractor : Shree Mahendra Poudel

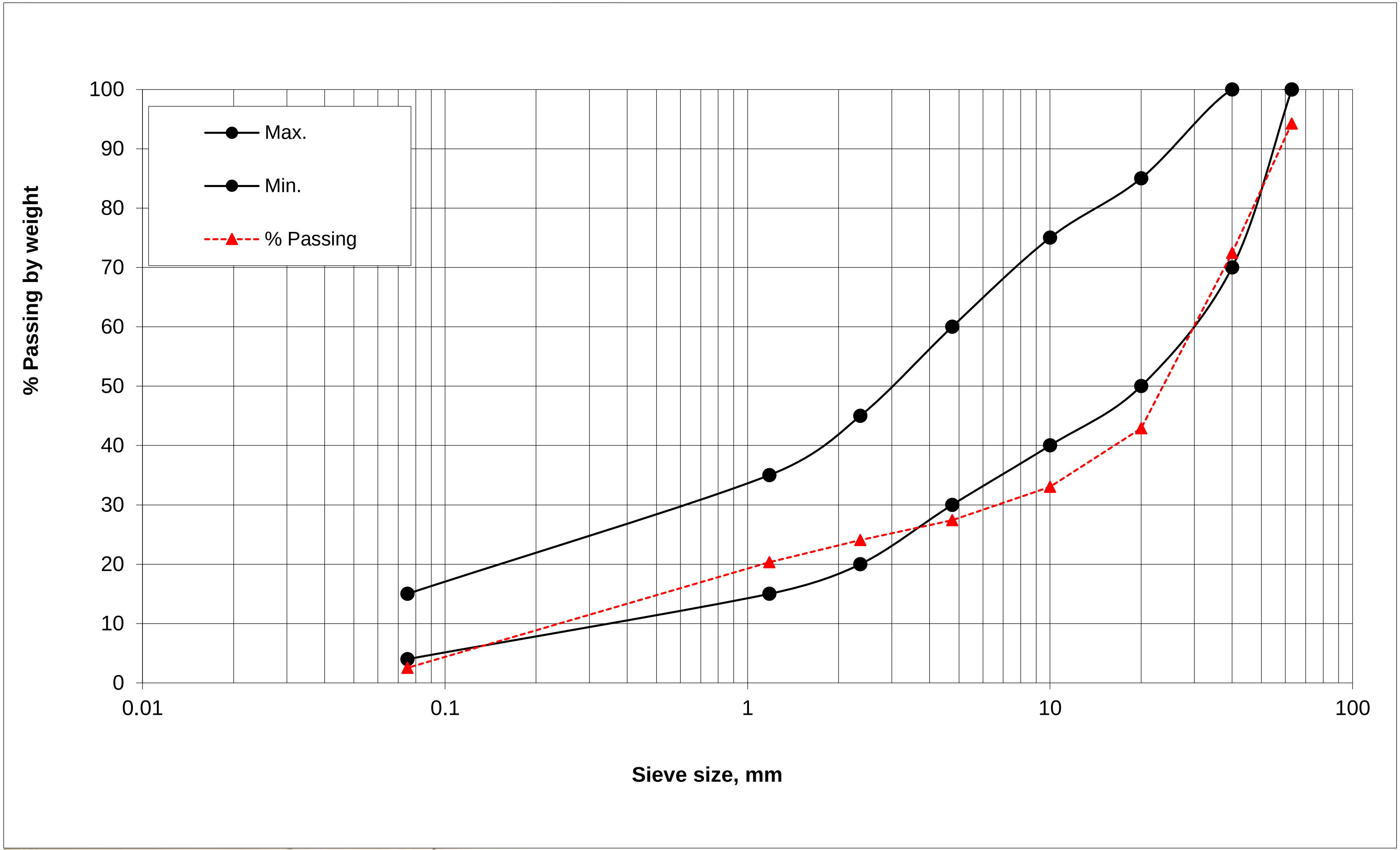
This report only represents the tested samples.

Babu Ram Sapkota

Laboratory Incharge

S.D.E.

Quality Control Tests- Material Prior to Construction



Quality Control Tests

Material Testing Laboratory

- recommended to establish one Material Testing Laboratory
- Laboratory must be established and fully equipped
- Laboratory equipment must be calibrated and tested
- Test formats must be prepared
- Laboratory Technician must be employed and trained

Field Density Test

Example of QAP with Method Statements

Case Study

The photo given is related to recently completed works of Dudhouli Rural Municipality of Sindhuli. Now we are going to discuss the issues challenges and possible solution to the quality of works analyzing the key feature of failure seen in this photo.

Case Study

Prepare Quality Assurance Plan of a project with following activities

- Sub base Laying
- Base Laying
- Asphalt Concrete Laying
- Plum Concrete Wall work

Transport Infrastructure Directorate
Bagamati Province

Training on Quality Control in Road Works

Session 4:Current Issues on Quality Control, *(DPR, Setting out , Excavation)*

Introduction

- This session designed to deliver the issues and challenges in local level
- Based on practical experience in the field, this session will list the common deficiencies of supervision and quality control

Key issue and Context

- DPR and Cost Estimate , Setting out
- Workmanship of the completed structures
- Quality of works are not acceptable , Sub Standard material
- Major activities for resilience i.e compaction , curing , Soaking of bricks , mixing of concrete
- Use of heavy machines for cutting in slopes, Side casting
- Skipping the structures from estimate to keep the construction work within Budget
- Tendency to accelerate the work in the last month of Fiscal year

Group Exercise

List out the major construction activities which are not working or damaged by disaster or any other reason in your Province level. Mention the quality control steps were taken during the construction. Suggest the possible intervention to bring back it functional.

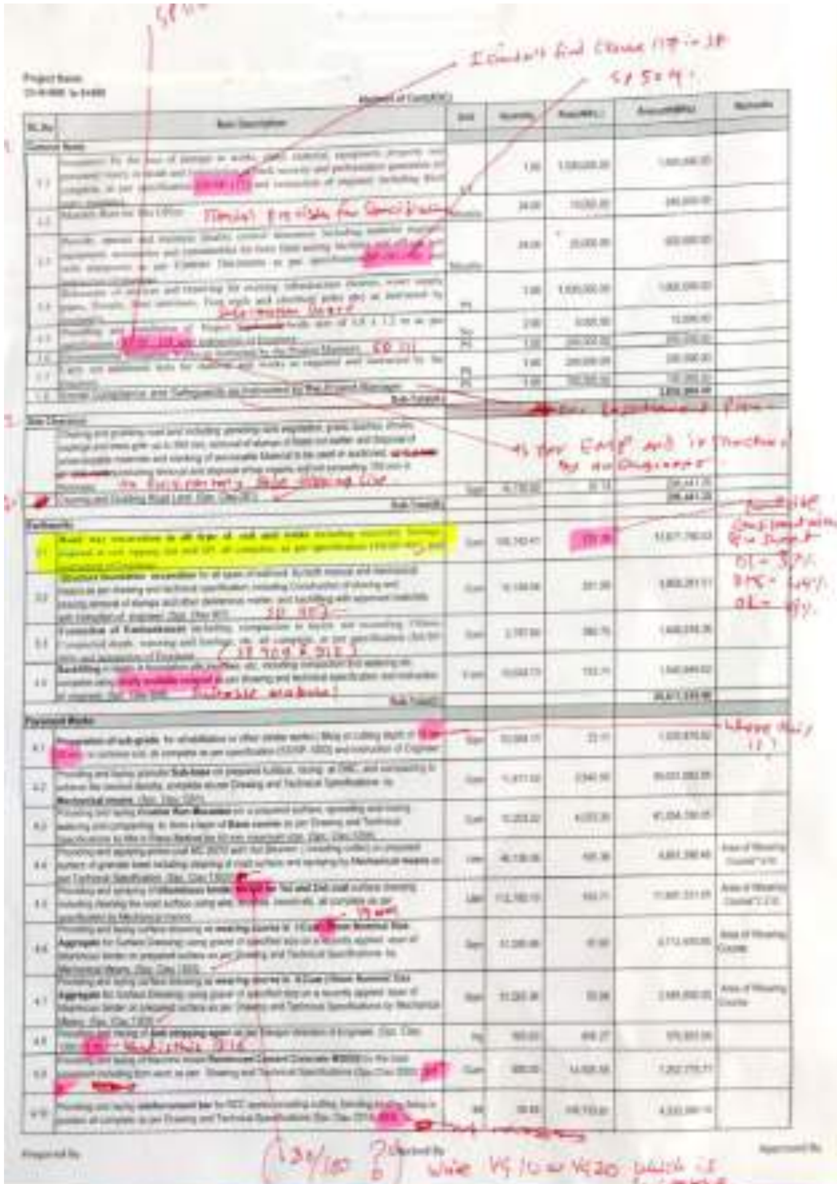
Hint: Please go through the example of hume pipe culvert given below

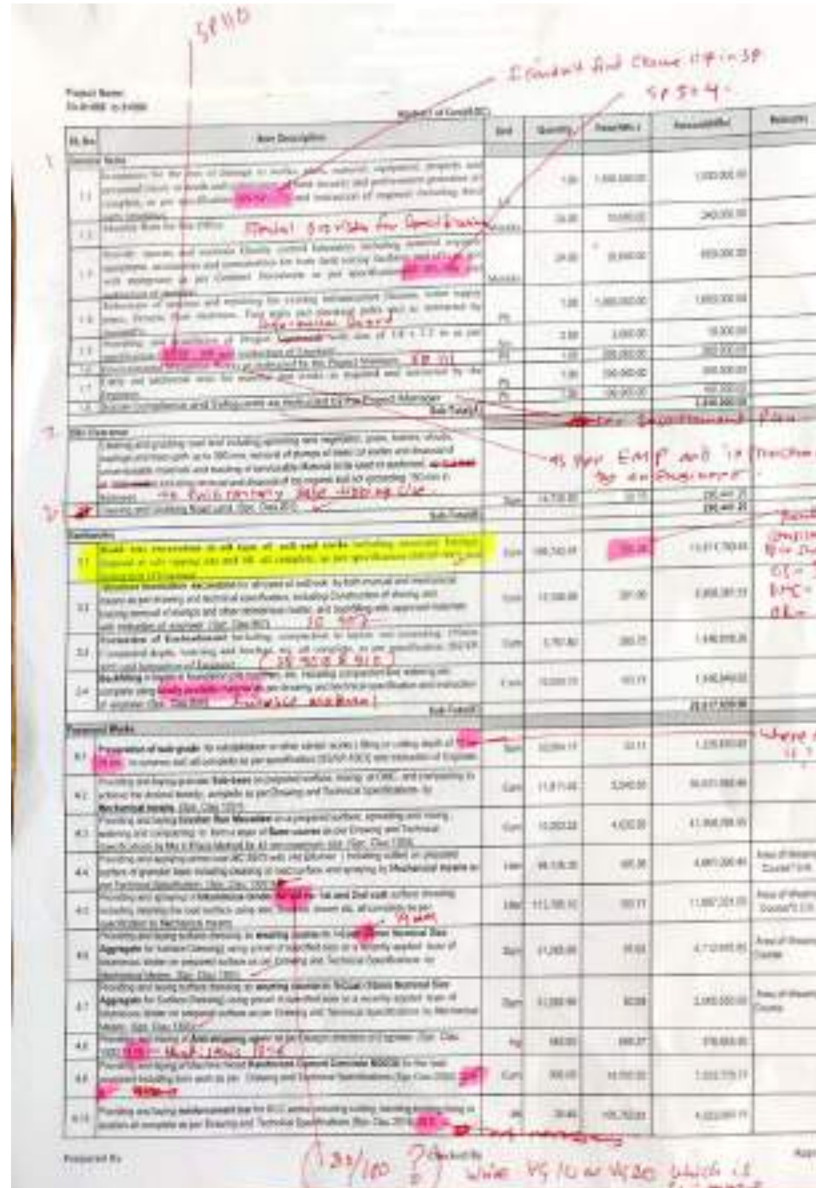
[*Hyperlinked Material\Group Exercise session 1 .docx*]()

DPR of The Project

- Not represent the real ground situation
- Lack of essential data , Water Management Structure and slope protection works
- Copy and Pasting , Just submit the document, missing of verification
- Not Consistent estimate in DPR , hard to float tender

BOQ





Estimate of The Project

- Comments on Estimate – Example from field

Action to be taken in future

Presentation and Verification of DPR , Layout must be done by Consultant in the field

Earthwork in Excavation

- Cut and through
- Use of Heavy Machine
- Side Casting
- Not following the Environmental Regulations

Earthwork in Excavation

Managing the earthwork in designated place

Photo : Ram Babu Paudyal , ADB – EEAP Okhaldhunga – Rumjatar Road

Earthwork in Excavation

Earthwork in Excavation in Structure

- Foundation Slope is to be maintained
- Foundation Depth of the structure
- Compaction in foundation bed

Earthwork in Excavation in Structure

Earthwork in Excavation in Structure

Workmanship

Masonry Wall

- Lack of Dressed Stones
- Cement Painting to cover the defects
- Stacking stones and throwing Mortar
- Lack of Curing

Material

Wall without dressed stones

Setting Out

- Compromise in Setting out
- Structure are not constructed with in frame
- Function of structure
- Aesthetic appearance
- Complain from public

Setting Out

Subgrade preparation

- Missing Vertical Control
- Tests for Subgrade Material – not giving importance
- Compaction – compromised
- Camber not maintained
- Left a month or more after completion and waiting for subbase layer

Sub base and base

- Missing level control
- Tests for Material –Missing suitability test , Tendency to accept the material which is already transported
- Compaction – compromised
- Camber not maintained
- Left a month or more after completion and waiting for another layer
- Maintenance of the surface before laying Prime coat

Wearing Course

- Suitability Tests
- Test of Binder
- Trail Section
- Compaction
- Temperature control
- Finishing surface – workmanship

Slope Protection

- Understanding – Bioengg is the key solution
- Root cause of slope failure , erosion , slide or mass movement
- Design of protection measures
- Precaution to take while cutting the soil mainly cutting slope
- Cutting in almost Vertical slope in soil is the bad practice to trigger soil erosion
- Water management along the cut slope

Compaction

- Compaction , Compaction and Compaction
- Soil will not get more strength unless we compact it
- Compaction in pavement – each layer
- Compaction in bed of foundation
- Compaction behind the structures

Compaction Issue

Compaction Issue

Compaction Issue

Curing

Photo : Ram Babu Paudyal , BK Road Bagamati

Mixing of Mortar and Concrete

Group Discussion

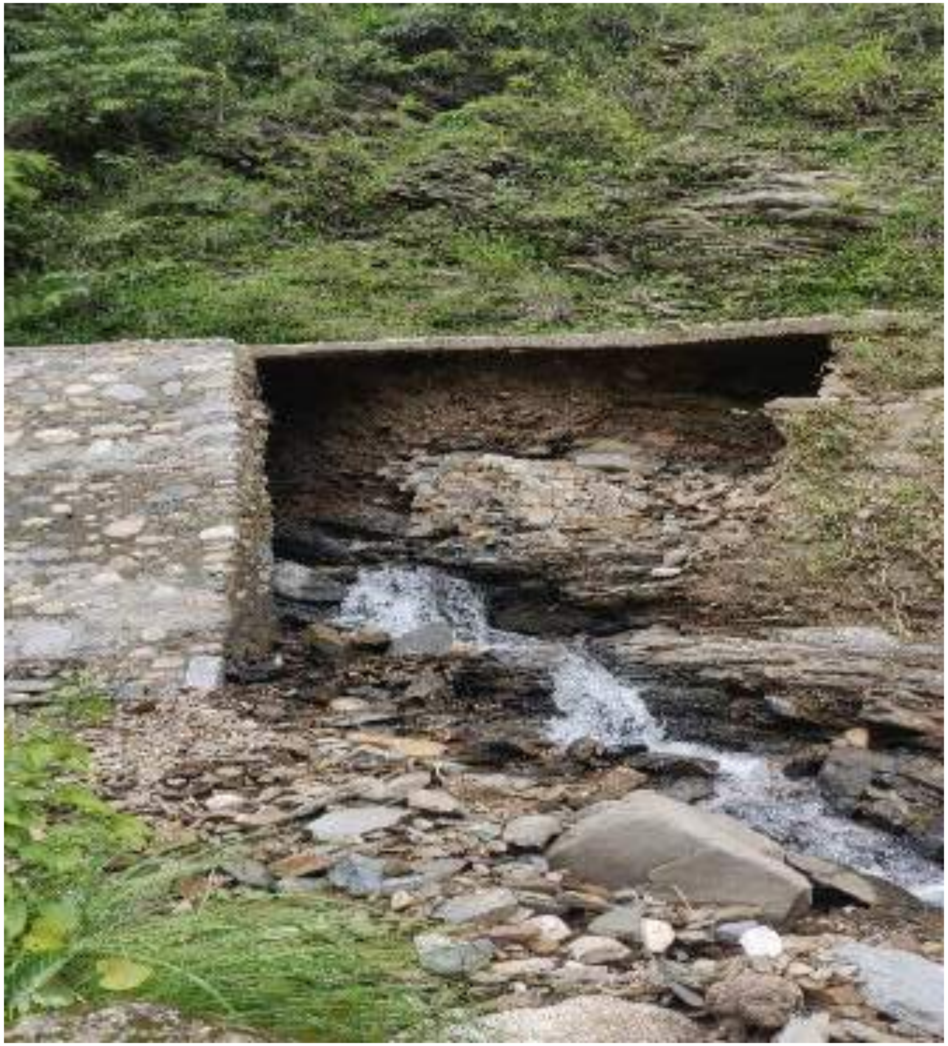
The photo given is related to common issues of quality control . Now we are going to discuss the issues challenges and possible solution to the quality of works analyzing the key feature of failure seen in these photos.

Group Discussion

Group Discussion

Group Discussion

Case Study



Group Discussion

Group Discussion

Group Discussion

Summary

- Excavation for Road – Cut and throw, - avoid the mass deposit in valley side, Excavated soil require to deposited in safe environmental tipping site
- Excavation for structure –Ensure proper compaction in foundation bed, Keying to ground is essential so excavation of ground for structure should be carried out with in proper layout
- Subgrade Preparation – Compaction and surface finishing of sub grade is most important. Place capping layer or carry out soil improvement if unsuitable material is found in subgrade.
- Sub base – Material should satisfy Grading envelope, Compaction should reach 95% of MDD.

Summary

- Base – Only used Crusher Run Base, Natural granular material for base is not accepted.
- Compaction and field density should be as per specification
- Wearing Course – Test of Bitumen, Site trails with specified materials and Temperature control is most important
- Structure – Layout, Material suitability and workmanship is most important. Hammer dressed stones for RRM, Compaction during the back fill, and use of filter material
- Gabion – Placing of tie wire and Horizontal bracing is missing, Use of dye to the boarder wire is very bad practice, Layer wise plan of Gabion Structure is most important
- Timing and design of bioengineering measures. Using same measures in every types of slope is not good practice

Transport Infrastructure Directorate
Bagamati Province

Training on Quality Control in Road Works

Session 5:Collection of Sample for Lab tests, Interpretation of Test Result

Introduction

- Collection of Representative samples is most important for Quality Control
- Interpretation of test result also important prior and during construction

Sampling from Pit Gravel , Sand and Soil

- Samples taken for tests to be used in the acceptance or rejection decisions by the client
- A 20 mm sieve with a recommended diameter of 450 mm.
- A basin approximately 500 mm in diameter
- A 70 kg sample will usually be enough but if the material is to be tested for more than one possible use
- bag of material and needs to be label in such a manner as to ensure the various sample bags can be identified

Sampling from Stockpiled Material

- Stockpiles are normally formed in layers.
- Care should be taken when sampling due to the inherent occurrence of segregation on stockpiled material.
- preferably not be sampled until it is thoroughly mixed
- Extract the material from each layer to make the sample representative
- Remove at least three scoops from the side of the stockpile and deposit it back on the stockpile away from the opening.

Sampling of Cement

- Container – Clean , Tight and have 5 kg capacity
- preferably not be sampled until it is thoroughly mixed
- Extract the material from each layer to make the sample representative
- Remove at least three scoops from the side of the stockpile and deposit it back on the stockpile away from the opening.

Sample Tag

a. Project- ………………………..……

b. Contract Identification No………....

c. Sample number ……………………..

d. Date of sampling ……………………..

e. Sampling material……………………

f. Depth …………………………..……

g. Location/Chainage ………………..……

h. Sample taken by ……………………

i. Tests to be performed ……………..

Session 4: Supervision and Quality Control of Road Works – Pavement

Introduction

- Effective supervision in Road construction work,
- Quality of work required to meet the minimum requirement as per specification
- Completed works must be sustainable and resilience throughout its service life.

Points to be Discussed

- Methodology and quality control methods of each major items in the road works
- quality of construction material, Quality control tests prior and during construction of road pavement

Group work

- List out the activities you are practicing during laying of Asphalt Concrete work, steps of supervision and quality control.

S.N	Name of Activity	Current Practice of Supervision	Current Practice of Quality Control
1	Asphalt Concrete Laying works		
a	Surface Preparation Prior to Prime Coat	Site visit and visual inspection of surface , approval for Prime Coat – Site Instruction	Confirm Field Density i.e 98% of MDD, Proof Rolling Suitability Test of Bitumen Calibration of Nozzle of distributor Site trial and tray test to confirm the spray rate
2			
a			
b			

JOINT CONSTRUCTION SURVEY

- Based on Design drawing developed during preparation of Detailed Project Report (DPR) & during procurement
- Contractor shall carry out the construction survey jointly with the engineer – Before Commencement
- Verify the design drawing at the field.
- Setting out of center lines and benchmarks
- Prepare the construction drawing
- Calculate the quantity of items as per the joint survey works

Photo: Ram Babu Paudyal , BK Road , Bagmati

CLEARING AND GRUBBING

- All the unsuitable materials should be cleared from the roadway , cutting, trimming, removing and disposing
- All trees, stumps within the excavation and embankment lines should be cut minimum of 500 mm below the sub-grade level.
- The depressions below the ground level should be filled in layers with suitable material and compacted to the specified density
- If soil is suitable for re-use shall be transported to suitable site and stacked for re-use

CLEARING AND GRUBBING

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Photo- Source Internet and ILO

ROADWAY AND DRAIN EARTHWORK (Earthwork Cutting)

- Set out the line of excavation after clearance of site
- Provide reference pillars/pegs for back cutting lines 1.5 m away from edge of formation on both hill and valley side
- The depressions below the ground level should be filled in layers with suitable material and compacted to the specified density
- The sides of excavated area should be trimmed
- The sub-grade prepared after cutting the formation should be checked for field density, 95 per cent of maximum Proctor density
- For Widening, shoulder should be removed to their full width and up to subgrade level.

Quality Control Subgrade

- The sub-grade is top 500 mm compacted layer in embankment or cutting
- Any fill material maximum dry laboratory unit weight not less than 16.5 kN/ m^3
- The size of coarse material in the soil not exceed 75 mm.

Field Quality Control tests during construction

S.N	Type of Test	Frequency
1.	Maximum Dry Density/ Optimum Moisture Content:	One test for each 1500 m^3
2.	Insitu Density Measurements (Each layer)	-do- (i) One test in each 1000 m^2
3.	Thickness of subgrade layer.	At random

Preparation of sub-grade with the help of grader

Finished Sub grade Layer

Finished Sub grade Layer

Photo: Ram Babu Paudyal , RAP 3 Morang

GRANULAR SUB-BASE

- If Material is from combination from different sources, mixing shall be done mechanically at stock piled yard
- Prepared subgrade surface requires rolling with two to three passes, Sprinkling water if necessary
- Repair/correct any defect on prepared sub-grade prior to laying the sub-base
- Sub-base material should be spread in layers not exceeding 150 mm compacted thickness.
- Compaction should be carried out at OMC, with a tolerance limit of ±2 %.
- Rolling shall be carried out longitudinally commencing from outer edge towards centre
- The shoulders should be constructed simultaneously

Laying of Sub base

Photo- Ram Babu Paudyal , RAP 3

Laying of Sub base

Photo- Ram Babu Paudyal , RAP 3

Laying of Sub base

Photo- Ram Babu Paudyal ,ADB EEAP

Laying of Sub base

Photo- Ram Babu Paudyal ,SEZ, Simara

CRUSHER RUN MACADAM BASE

- The aggregate should be uniformly deposited on the prepared surface
- Cover full width of carriageway to the specified depth
- Material shall be mixed by grading to full depth.
- Bring the materials from the edge to the centre forming windrows
- Spray the windrow with water if required
- The windrow is spread back the road depositing all the material to give the correct camber- Add Water to keep MC
- Compaction with the use of a smooth wheel roller of 80 to 100 kN or vibratory roller to 98 % of maximum dry density
- The compacted thickness of any layer laid should not be more than 150 mm

Quality Control Requirement

Material : shall be crushed rock, not less than 90 percent by weight retained on 4.75 mm , shall have at least two fractured faces

IS Sieve Designation (mm)	% passing by wt. 53 mm nominal size	% passing by wt. 37.5 mm nominal size
63	100	
45	87 - 100	100
22.4	50 - 85	90- 100
5.6	25 - 45	35-55
0.71	10- 25	10-30
0.09	2-5	2-5

Crusher Run Macadam Base

Photo- Ram Babu Paudyal , Buddhi Raj Baral ,ADB EEAP

Crusher Run Macadam Base

Photo- Ram Babu Paudyal, RAP 3 Morang

Quality Control Requirement

Material : Physical Requirements of Aggregates

Test	Value
1. LAA % Maximum	40
2. Aggregate Impact Value % Maximum	30
3. SSS % Max if water absorption > 2%	12
4. Combined Flakiness and Elongation Index % Max	35
5. Water Absorption % Maximum	2
6. CBR % Minimum	80
7. CR % Minimum	90
8. Plasticity Index of material passing 425 micron Maximum	NP

Quality Control Requirement

Tests Prior to Construction -Base Course

Test	Value
1. LAA % Maximum	40
2. Aggregate Impact Value % Maximum	30
3. SSS % Max if water absorption > 2%	12
4. Combined Flakiness and Elongation Index % Max	35
5. Water Absorption % Maximum	2
6. CBR % Minimum	80
7. CR % Minimum	90
8. Plasticity Index of material passing 425 micron Maximum	NP

Quality Control Requirement

Tests Prior to Construction - Base Course

Type of Tests	Frequency
Aggregate Impact Value Loss Angles Abrasion value	One test on representative sample from each source
Flakiness Index Test	-do-
Water Absorption Test	-do-
Soundness Test, if the water absorption exceeds 2%	-do-
Gradation	-do-
Atterberg Limits of portion of aggregate passing 425 micron sieve	-do-
Proctor Compaction Test (MDD, OMC)	-do-
CBR	-do-
Crushing Ratio (CR) Test	-do-

Quality Control Requirement

Tests During Construction - Base Course

Type of Tests	Frequency
Aggregate Impact Value Test, LAA Test	Once per 200 m^3 or part of it and change of source
Flakiness Index Test	-do-
Water Absorption Test	-do-
Crushing Ratio (CR) Test	-do-
Grading Test	-do-
Atterberg Limits of portion of aggregate passing 425 micron sieve	-do-
Soundness Test, if the water absorption exceeds 2%	Once per 500 m^3 or part of it and change of source
CBR	As required
Proctor Compaction Test (MDD, OMC)	Once per 1000 m^3 or part of it and change of source
Field Density test	Once per 1000 m^2 or part of it and change of source

Laying of Base

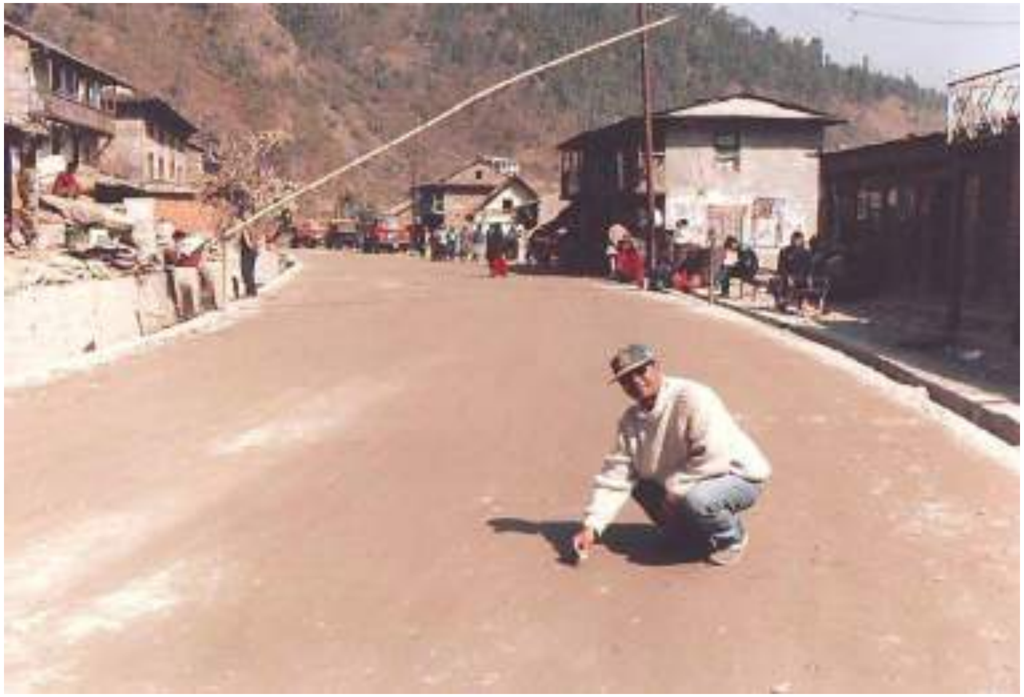


Photo- Ram Babu Paudyal

Preparation of base for bituminous course

Preparing an existing granular surface

- Surface shall be cleaned where a granular profile corrective course is to be provided prior to laying a bituminous course
- Should be cleaned of all loose material and dust by air jet or wire brushes
- Correct to line, level and camber within the tolerances
- Prior to laying the bituminous course the existing surface shall be approved by the engineer for line, level and density
- Primed with a suitable bituminous primer and a tack coat.

Preparation of base for bituminous course

Scarifying an existing bituminous surface

- Care about undue disturbance to the underlying layers
- The surface shall be cleaned and any pot holes and cracks should be repaired
- Pothole and Patch Repairs:. Layers below the level of bituminous construction should be replaced using material of equivalent specification
- Crack Sealing:The fine cracks (less than 3 mm in width) should be sealed by Fog Spray
- The wide cracks (more than 3 mm in width) should be filled with crusher dust
- Isolated areas, with wide cracks, shall be cut and patched

PRIME COAT

- The prime coat should be applied only on the top most Granular /CRM base layer
- Granular base surface should be cleaned by sweeping with mechanical brooms and/or washing or other approved means
- The primer should be sprayed uniformly, No hand spraying
- The application rate of cutback bitumen and percentage of cut back to be used - after field trials, optimum penetration (8 - 10 mm)
- The surface should be allowed to cure preferably for 24 hours
- Spraying Temperature : 50 - 70° C

Laying of Prime Coat

Photo- Ram Babu Paudyal

Quality Control Requirement

Material : Physical Requirements of Binder

Hyperlinked Material\S No.docx

Quality Control Requirement

Tests During Construction – Prime Coat

S.N	Type of Test	Frequency
1	Temperature of Binder, when cutback is to be used	Regularly
2	Rate of Spread of Binder	At least two tests per run
3	Percentage of cutter for making cutback	During making cutback

Tray Test and Dip Test

Photo- Ram Babu Paudyal, RAP 3 Morang

20 mm THICK PREMIX CARPET

- Apply a prime coat over the prepared base
- The tack shall be applied over primed surface prior to laying of the carpet
- Mixing should be thorough to ensure that a homogenous mixture is obtained
- Temperature of mixing should be in the range of 150^0 C to 163^0 C and that of aggregates 155^0C to 163^0C
- At the time of discharge of the mixture should be between l30°C and 160°C.
- Locate hot mix plant near the work site.
- The premixed material shall be spread on the road surface with rakes

20 mm THICK PREMIX CARPET

- Commence rolling with 80-100 kN rollers (three-wheel or tandem type), beginning from the edge and progressing towards the centre longitudinally
- Each pass should have an overlap of at least one-third of the track made in the preceding pass
- Correct any high spots or depressions noticed after the roller has passed

In case of open graded premix surfacing

- Provide a seal coat to the surface immediately after laying the carpet
- Ordinarily, the road may be opened to traffic after laying the seal coat

Quality Control Requirement

Material : Physical Requirements of Aggregates – Chips

Test	**Specification**
Flakiness index	Max. 35 %
Aggregate Impact Value	Max. 30 %
Loss Angles Abrasion value	Max. 40%
Soundness Sodium sulphate Max.	 12 %
Water Absorption	Max. 1 %
Coating and stripping of bitumen aggregate mixture.	Minimum retained coating 95 %

Quality Control Requirement

Material : Physical Requirements of Aggregates – Chips

IS Sieve Designation (mm)	Cumulative percent by weight of total aggregate passing	
	Type A	Type B
13.2	-	100
11.2	100	88 - 100
5.6	52 - 88	31 - 52
2.8	14 - 38	5 - 25
0.090	0 - 5	0 - 5

Type A grading is recommended for use in areas having rainfall more than 150 cm per year

Quality Control Requirement

Tests Prior to Construction

Type of Test		Frequency
1	Quality of Binder (Straight-run Bitumen)	As per Specification
2	Aggregate Impact Value Test	One test per each source identified
3	Combined Elongation and Flakiness Index Test	-do-
4	Water Absorption	-do-
5.	Soundness (SSS)	-do-
6	Gradation	-do-
7	Bitumen Stripping of Aggregate Test	One set of 3 specimen for each source of supply

Quality Control Requirement

Tests During Construction

Type of Test	Frequency
1. Grading of Aggregates	Once per 100 m^3 or part of it
2. Combined Flakiness and Elongation of Aggregate	- do -
3. LAA or AIV,	Once per 200 m^3 or part of it or change of source
4. Quality of Binder	One set of test for each 50 kl of supply and part of it
5. Binder Content before seal coat	At least two tests per day
6. Temperature of Binder	Regular close intervals
7. Thickness of layer	Regularly at close intervals

Hot Mix Plant

Photo- Ram Babu Paudyal, RAP 3 Morang

Temperature Control

Photo- Ram Babu Paudyal, RAP 3 Morang

Laying of Premix

Photo- Ram Babu Paudyal, RAP 3 Morang

Laying of Premix

Photo- Ram Babu Paudyal, RAP 3 Morang

Thickness Control in Loose

Photo- Ram Babu Paudyal, RAP 3 Morang

Thickness Control in Compacted Layer

Photo- Ram Babu Paudyal, RAP 3 Morang

Rectification

Photo- Ram Babu Paudyal, RAP 3 Morang

Final Inspection and Mesurement

Photo- Ram Babu Paudyal, RAP 3 Morang

Finished Surface

Photo- Ram Babu Paudyal, RAP 3 Morang

Finished Surface

Photo- Ram Babu Paudyal, RAP 3 Morang

Asphalt Concrete / Bituminous Concrete

- Construction in a single layer of bituminous concrete
- A single layer shall be 30 mm/40 mm/50 mm thick

Material

a) Bitumen :The bitumen shall be viscosity grade paving bitumen complying with the Indian Standard Specification IS: 73

b) Coarse Aggregates: crushed gravel not less than 95 percent by weight of the crushed material retained on the 4.75 mm sieve, shall have at least two fractured faces

c) Filler :Filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement

d) Fine Aggregate : crushed or naturally occurring mineral material, passing the 2.36 mm sieve and retained on the 75-micron sieve

e) Cement – if required

Quality Control Requirement

Material : Physical Requirements of Aggregates

Test	Specification
Grain size analysis	Max 5% passing 0.075 mm sieve
Combined Flakiness and Elongation Index	Max 35%
Los Angeles Abrasion Value or Aggregate Impact Value	Max 30% Max 24%
Soundness either: Sodium Sulphate or Magnesium Sulphate	Max 12% Max 18%
Polished Stone Value	Min 55
Water Absorption	Max 2%
Coating and Stripping of Bitumen Aggregate	Minimum retained coating 95%
Retained Tensile Strength	Min 80%

Quality Control Requirement

Combined grading of the coarse and fine aggregates and filler

Grading	1	2
Nominal size*	19 mm	13.2 mm
Thickness	50 mm	30-40 mm
IS Sieve (mm)	Cumulative % by weight	
37.5		
26.5	100	
19	90-100	100
13.2	59-79	90-100
9.5	52-72	70-88
4.75	35-55	53-71
2.36	28-44	42-58

Grading	1	2
Nominal size*	19 mm	13.2 mm
Thickness	50 mm	30-40 mm
IS Sieve (mm)	Cumulative % by weight	
1.18	20-34	34-48
0.6	15-27	26-38
0.3	10-20	18-28
0.15	5-13	12-20
0.075	2-8	4-10
Bitumen Content	Min 5.2	Min 5.4

Construction Methodology

- Marshall Mix design - Asphalt Institute Manual MS-2
- Preparation of base on which Asphalt Concrete is to be laid
- The tack shall be applied over primed surface prior to laying of the carpet
- Mixing should be thorough to ensure that a homogenous mixture is obtained
- Temperature of bitumen at the time of mixing should be in ^{0} Celsius

Bitumen Viscosity Grade	Bitumen Temperature	Aggregate Temperature	Mixed Material Temperature	Laying Temperature	Rolling Temperature
VG-30	150-165	150-170	150-165	140 Min	90 Min
VG-10	140-160	140-165	140-160	130 Min	80 Min

Construction Methodology

- The mixed material should be transported quickly to the site of work and laid uniformly by suitable means
- The premixed material shall be spread on the road surface with Paver
- Commence rolling, beginning from the edge and progressing towards the centre longitudinally
- Continue rolling operations till a smooth uniform surface is achieved , overlap of at least one-third of the track
- Prevent adhesion of the mixture to the rollers, Keep wheel Moist
- Correct any high spots or depressions noticed after the roller has passed over , removing and adding mix and compact

Asphalt Concrete Plant

Photo- Ram Babu Paudyal, BK Road

Control Room of Asphalt Concrete Plant

Photo- Ram Babu Paudyal, BK Road

Temperature Control in Field

Photo- Ram Babu Paudyal, RAP 3 Morang

Laying by Paver

Photo- Sujit Dhital

Finished Surface

Photo- Gmali , PDRF , Syangja

Finished Surface

Concreting in hole of core cutting

Photo- Sujit Dhital

Quality Control Requirement

Tests Prior to Construction

Type of Test		Frequency
1	Quality of Binder (Straight-run Bitumen)	One set of test for each 50,000 litre of supply and part of it
2	Aggregate Impact Value Test	One test per each source
3	Combined Flakiness and Elongation Index Test	-do-
4	Water Absorption	-do-
5	Soundness SS Max	-do-
6	Gradation	-do-
7	Bitumen Stripping of Aggregate Test	One set of 3 specimen for each source of supply

Quality Control Requirement

Tests During Construction

Type of Test	**Frequency**
1. Grading of Aggregates	Once per 100 m^3 or part of it
2. Flakiness of Aggregate	- do -
3. LAA or AIV	Once per 200 m^3 or part of it or change of source
4. Quality of Binder	One set of test for each 50000 liters supply and part of it
5. Binder Content	At least two tests per day
6. Temperature of Binder	Regular close intervals
7. Thickness of layer	Regularly at close intervals
8. Density of compacted layer	One test per 700 m^2 area

JOINT PLAIN CEMENT CONCRETE PAVEMENT

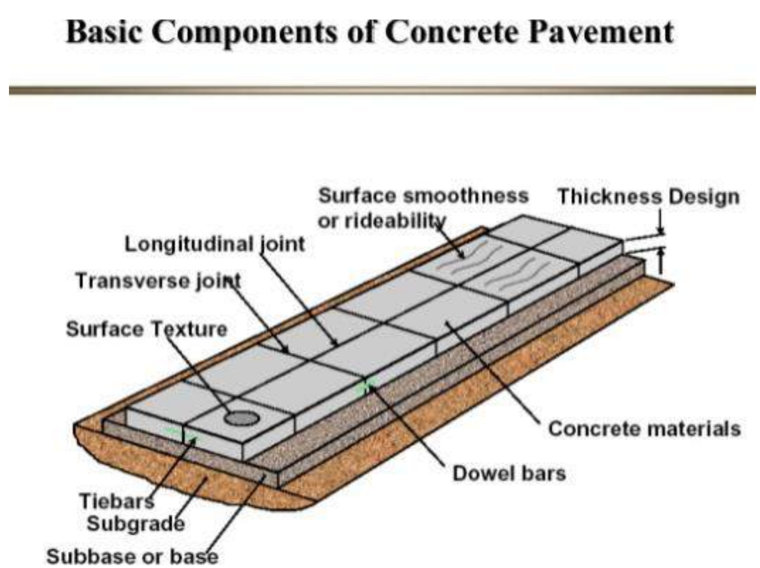
- JPCP is the most common type of rigid pavement
- Tie bars and dowel bars are provided for the transfer of wheel load from one to the neighboring concrete slabs
- Dowel bars are placed along the longitudinal direction
- Tie bars are placed along the transverse direction
- Approval of materials, plant, equipment and construction method
- Mix design based on laboratory trial mixes, 30 days Prior
- Minimum M 25 grade concrete is recommended
- Prepare the Sub-grade to the specified grades and cross-sections and compact to the design strength
- Lay granular Subbase or WBM of the specified type and thickness

JOINT PLAIN CEMENT CONCRETE PAVEMENT

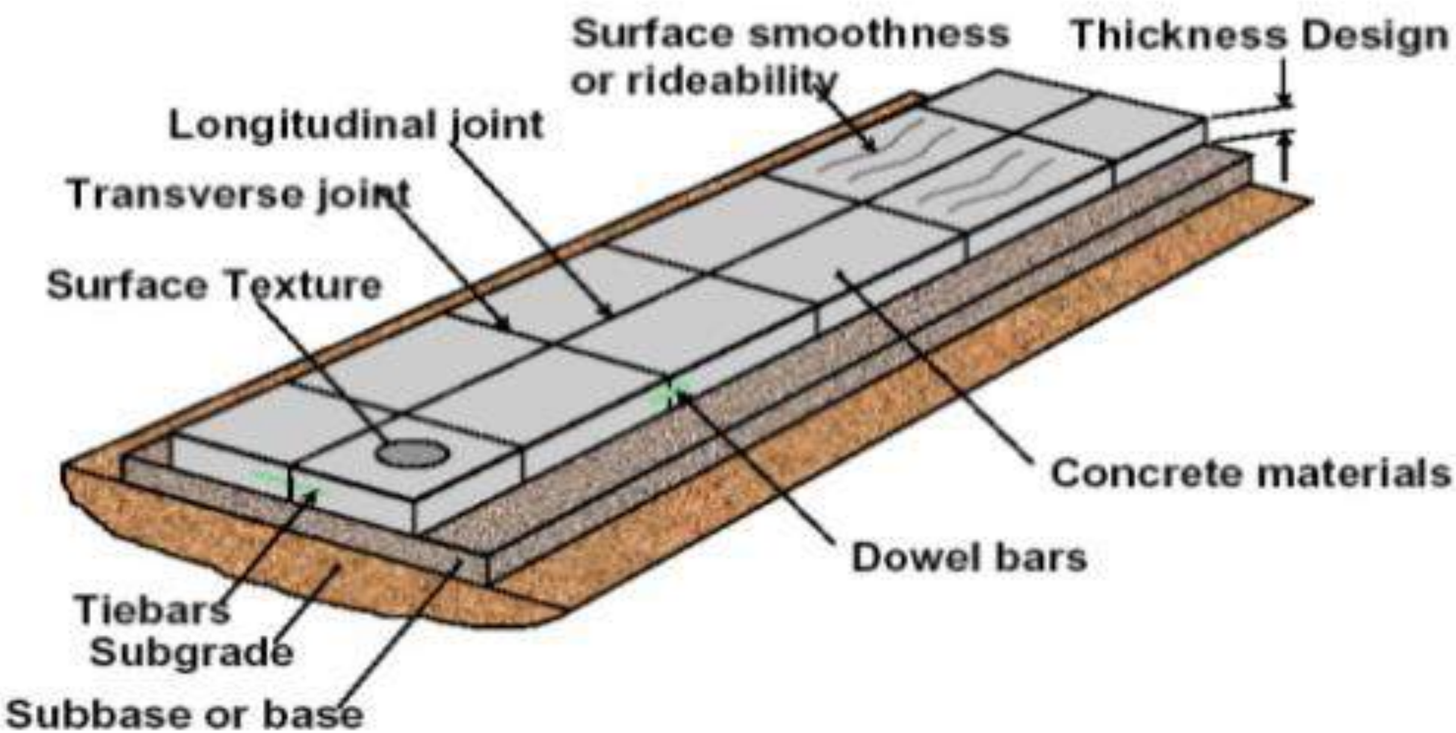
- Provide a separation membrane (125 micron thick plastic sheet/geo-textile) between sub-base/base and concrete slab
- Mark location and type of the joints on either side of the surface of the sub-base/base
- All side forms shall be of mild steel channels or fabricated plates with adjustable jacks , depth equal to the thickness of pavement
- Pavement concrete shall be produced near the site
- Readymade concrete conforming to the specified properties of strength and workability may also be used
- Check the slump of concrete. should be 30 mm ±10 mm
- Concrete shall be placed between the side forms and shall be leveled with rakes and shovels

JOINT PLAIN CEMENT CONCRETE PAVEMENT

- Compact concrete by a vibrator
- After completion , pavement shall be covered with wet Hessian cloth, or jute mats.
- After 24 hours , the slab shall be thoroughly wetted and then cured by pounding or sprinklers of water.



Basic Components of Concrete Pavement



Quality Control Requirement –JPCCP

Material

a) Cement : OPC ,

b) Admixtures: to improve workability and strength

c) Coarse Aggregates: LAA not more than 35%, ACV < 30%

Max size- < 20 mm,

d) Fine Aggregate : crushed or naturally occurring mineral material, passing the 2.36 mm sieve and retained on the 75-micron sieve

e) Water – clean and free from injurious amount of oil, salt, acid, vegetable matter

f) Dowel Bars: Plain mild steel bars 25 mm dia , 240 N/mm^2 , 500 mm long and spaced 250 mm c/c

g) Pre moulded Joint Filler:

Quality Control Requirement –JPCCP

Material

g) Pre moulded Joint Filler: Bitumen impregnated filler board/pre moulded synthetic joint filler board for expansion joints

20 mm thick of a firm compressible material

h) Joint Sealing Compound: Joint sealing compound shall be hot poured sealing compound type having flexibility, resistance to age hardening and durability.

Quality Control Requirement

Tests Prior to Construction – JPCCP

Material	Test / Check	Frequency
Cement	a)Setting Time b) Soundness c) Compressive strength	One test for 200 tonnes of cement - do – one set for 200 tonnes of cement (same brand and grade)
Coarse Aggregates	a)Gradation for PCC or RCC works b) Flakiness index c) Deleterious constituents d) Water absorption / content e) Aggregate Crushing value f) Soundness [if water absorption exceeds 2%] g) LAA , h) AIV	One set of test for each quarry source -do - If in doubt Once for each source of supply One test per source of supply - do – -do-

Quality Control Requirement

Tests Prior to Construction – JPCCP

Material	Test / Check	Frequency
Fine Aggregates	a) Gradation b) Deleterious Constituents	One test for each source of supply If in doubt, one test per source
Water	Normally potable water is good enough for making concrete. Determination of Impurities - Suspended matter - Organic - Inorganic - Sulphates - Chlorides	For large works If the quality is in doubt Samples taken from each source and tested at an approved test house
Concrete	Mix Design (for each work)	Well before the commencement of work and approved by Engineer

Quality Control Requirement

Tests During Construction - JPCCP

S. N	Tests / Check	Frequency
1	Concrete workability	One test per 3 cum of concrete
2	Strength of Concrete	Minimum 6 cubes (3 each for 7 day & 28 day strength)
3	Straightness of side forms (steel	To be checked daily
4	Size, spacing, paralleling of Dowel bars and Joints location	To be checked prior to casting of concrete at the location.
5	Batching and Mixing of materials	Check for measurements and proper mixing
6	Compaction equipment (Needle, Screed and Plate vibrators)	For continuous working and stand by arrangement
7	Levels and Alignment, width of pavement, pavement thickness , Depth of Dowel Bars	to be checked for each day’s work Regularly

Finished Surface

Photo- Ram Babu Paudyal

Finished Surface

Photo- Ram Babu Paudyal

Final Inspection

Photo- Ram Babu Paudyal

Finished Surface

Photo- Ram Babu Paudyal

Expressway – Rigid Pavement

Photo- Ram Babu Paudyal

Design and Construction of DBSD Road

Sujit Dhital

Contact No. 9843421686

Date : 30 Jan 2021

Out line of Presentation

- Component of Road Pavement
- Surface Dressing: What , Type and where to use and limitation
- Aggregate and bitumen : Physical properties and test to be conducted
- Prime coat
- Design Procedure for the spray rate
- Construction Procedure
- Photographs

Component of Road Pavement

- Subgrade
- Sub base
- Base
- Wearing course

Surfacing Option (Flexible Pavement)

Non Structural

- Sand Seal
- Otta Seal
- DBSD
- Premix carpet (20mm)
- -------

Structural

- Asphalt Concrete
- ------

Factors Affecting Choices

- Traffic Volume
- Riding Quality Required
- Operational Factor
- Safety
- Environmental Considerations
- Construction and Maintenance
- Properties of Available Aggregate
- Construction Cost
- Required Service Life

What is Surface Dressing ?

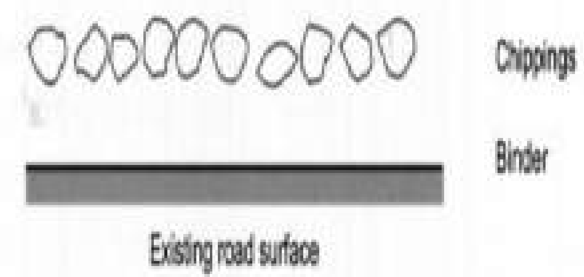
Surface dressing comprises a thin film binder, generally bitumen , which is sprayed onto the road surface and then covered with a layer of stone chippings.

- The Bituminous binder material is applied by a pressure distributor, followed immediately by an application of mineral aggregate, and finished by rolling.
- The thin film of binder acts as a waterproofing seal preventing the entry of surface water into the road structure.
- The stone chippings protect this film of binder from damage by vehicle tyres, and form a durable, skid-resistant and dust-free wearing surface.

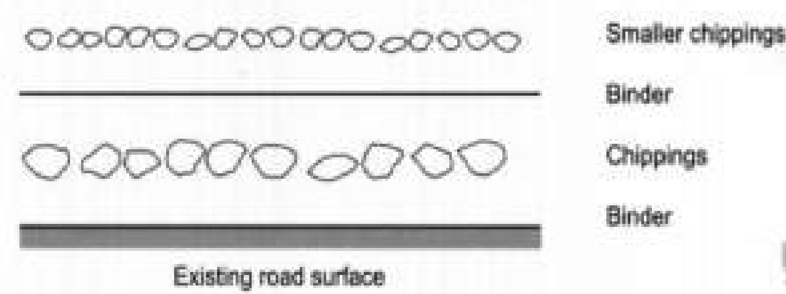
Type of Surface Dressing

Mainly Used Surface Dressing in Nepal

Single Surface Dressing

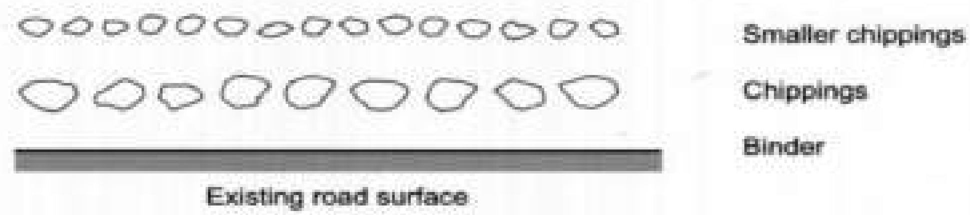


Double Surface Dressing

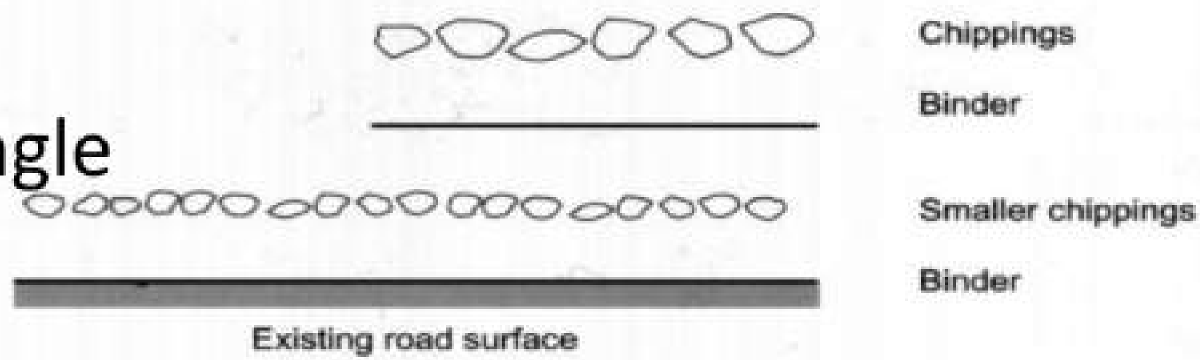


Surface Dressing Normally Not Used in Nepal

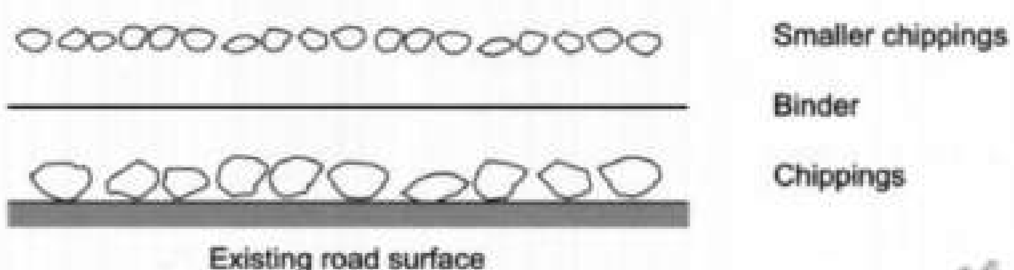
Racked In



Pad Coat Plus single



Sandwich



Where To Use

- Single Surface Dressing :

  When applied as a maintenance operation to an existing bituminous road surface a single surface dressing can fulfill the functions required of a maintenance re-seal, namely waterproofing the road surface, arresting deterioration, and restoring skid resistance

Double Surface Dressing :

- A new roadbase is surface dressed.
- Extra 'cover' is required on an existing bituminous road surface because of its condition (e.g. when the surface is slightly cracked or patched).
- There is a requirement to maximise durability and minimise the frequency of maintenance and resealing operations.

- 'Sandwich' surface dressings are principally used on existing binder rich surfaces and sometimes on gradients to reduce the tendency for the binder to flow down the slope.
- 'Pad coats' are used where the hardness of the existing road surface allows very little embedment of the first layer of chippings, such as on a newly constructed cement stabilised roadbase or a dense crushed rock base. A first layer of nominal 6mm chippings will adhere well to the hard surface and will provide a 'key' for larger l0mm or l4mm chippings in the second layer of the dressing.

- Racked in Surface dressing is recommended for use where traffic is particularly heavy or fast

Limitation

- Surface dressing does not contribute to the Strength of the Pavement Layer ie it has no structural significance.
- It can not improve the shape and riding quality of the surface which has become deformed specially due to fatigue.

Physical Requirement of Aggregate

- Aggregate used in Surface Dressing must be
  - Clean
  - Hard to resist crushing by traffic
  - Angular to give good surface texture
  - Of correct size to embedment
  - Durable to resist surface wear.

Test to be Performed

- Gradation
- Combine FI and Elongation
- LAA/AIV
- Durability (SSS or Magnisium soundness)
- Water Absorption
- Stripping Value
- Polish Value

Physical Requirements

Sieve Size	Percentage passing by weight			
	Nominal size			
	19	13	10	6
26.5	100			
19.5	85-100	100		
13.2	0-40	85-100	100	
9.5	0-7	0-40	85-100	100
5.6		0-7	0-35	85-100
4.75			0-10	
3.35				0-30
2.36	0-2	0-2	0-2	
0.6				0-10
0.075	0-1.5	0-1.5	0-1.5	0-1.5

Exercise

Sieve Size	Percentage passing by weight			
	Nominal size			
	19	Sample -1	Sample -2	
26.5	100	100	100	
19.5	85-100	92.5	98	
13.2	0-40	10	2	
9.5	0-7	3	0	
5.6				
4.75				
3.35				
2.36	0-2	1	0	
0.6				
0.075	0-1.5	0.5	0	

Recommended Nominal Max size of Aggregate

Type of Surface	Traffic intensity in Terms of No. of Vehicle per day in the lane under consideration		
	1000-2000	200-1000	20-200
Very Hard	10	6	6
Hard	13	10	6
Normal	13	10	6
Soft	19	13	13
Very Soft		19	13

Property	. Test	Specification / Requirement	Test Method
Cleanlines s (dust)	Grain size analysis	Max 1.5% passing 0.075 mm sieve	IS : 2386 (Part-1)
Particle shape	Combine Flakiness and Elongation Indices (Total)	Max 35 %	IS : 2386 (Part-1)
Strength	LAA or AIV	Max 35 .5 Max 27 %	IS : 2386 (Part-4

Property	Test	Specification / Requirement	Test Method
Durability	Soundness: Sodium sulphate or Magnesium sulphate	Max 12 % Max 18 %	IS : 2386 (Part-5)
Water Absorption	Water absorption	Max 1%	IS : 2386 (Part-3)
stripping of aggregate mix	Coating and stripping of aggregate mix	Coating and stripping of aggregate mix	IS: 6241
Polishing	Polished Stone Value	Min 60	BS:812-1 14

Determination of Combine Flakiness and Elongation Index

- Separate the flaky stone from the representative sample
- FI: Weight of flaky stone/Total weigth of representative sample
- Separate the elongated stone from the non flaky sample
- EI: Weigth of elongated stone /Wt of Non flaky stone
- Combine FI and EI= FI+EI

Bitumen

It is essential that good bonding is achieved between the surface dressing and the existing road surface. This means that non-bituminous materials must be primed before surface dressing is carried out.

S No.	Characteristics	Paving Grades				Method of Test
		VG10	VG20	VG30	VG40	Ref to
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Penetration at 25°C, 100 g, 5 s, 0.1 mm, Min	80	60	45	35	NS: 221:2047 (Part III)/ IS: 1203
ii)	Absolute viscosity at 60°C, Poises	800-1200	1600-2400	2400-3600	3200-4800	NS: 237:2050 (Part VIII)/ IS: 1206 -2
iii)	Kinematic viscosity at 135°C, cSt, Min	250	300	350	400	NS: 237:2050 (Part VIII)/ IS :1206-3
iv)	Flash point (Cleveland open cup), °C, Min	220	220	220	220	NS: 237:2049 (Part VII)/ IS: 1448-69
v)	Solubility in trichloroethylene, percent, Min	99	99	99	99	NS: 221:2047 (Part IV)/IS: 1216
vi)	Softening point (R&B), °C, Min	40	45	47	50	NS / IS: 1205.
vii)	Tests on residue from rolling thin film oven test:					
a)	Viscosity ratio at 60°C, Max	4	4	4	4	NS: 221:2046 (Part II)/ IS: 1206-2
b)	Ductility at 25°C, cm, Min	75	50	40	25	NS: 221:2046 (Part I)/ IS: 1208

VG	General Application	Equivalent PG
10	Used in spraying applications, and can be used in very cold regions. Also used for the manufacture of bitumen emulsion & modified bitumen	80-100
20	It is used in areas of cold climate & high altitude	
30	It is the most suitable for Indian road condition.	60-70
40	The area with high stress concentration like intersections of roads, truck parking, heavy traffic. It can be used in higher temperatures	30-40

Selection Criteria for VG Paving Bitumen Based on Climatic Conditions

Lowest Daily Mean Air Temperature, °C	Highest Daily Mean Air Temperature, °C		
	Less than 20°C	20 to 30°C	More than 30°C
More than -10°C	VG-10	VG-20	VG-30
-10°C or lower	VG-10	VG-10	VG-20

Prime coats

- A prime coat means a thin layer of low viscosity bituminous binder applied to an absorbent non-bituminous surface.
- Where a surface dressing is to be applied to a previously untreated road surface it is essential that the surface should be dry, clean and as dust-free as possible. On granular, stabilised surfaces a prime coat of bitumen ensures that these conditions are met

What Prime do?

- promote and maintain adhesion between the road base and a surface dressing by pre-coating the road base and penetrating surface voids.
- seal the surface pores in the road base thus reducing the absorption of the first spray
- strengthen the road base near its surface by binding the finer particles of aggregate together.
- provides the road base with a temporary protection against rainfall and light traffic until the surfacing can be laid

What and How Much?

- Low viscosity, medium curing cutback bitumens such as MC-30, MC-70, or in rare circumstances MC-250, can be used for prime coats (Asphalt Institute, 1983).

Grade of cutback binder	Permitted viscosity range (centistokes at 60ºC)
MC 250	250-500
MC 70	70-140
MC 30	30-60

- The correct viscosity and application rate are dependent primarily on the texture and density of the surface being primed.
- Low viscosity cutbacks are necessary for dense cement or lime stabilised surfaces, and higher viscosity cutbacks for untreated coarse-textured surfaces.
- Low porosity- Low viscosity
- High porosity- High Visocsity

Agency	Type of Surface	Type of Cutback	Rate of Spray (kg/sq.m)
DoR	WMM/WBM	MC 30	0.6-0.9
	Stabilized soil bases/ Crusher Run Macadam	MC 70	0.9-1.2

TRL

- The application rate is however, likely to lie within the range 0.3-1.1 kg/m2
- . Low viscosity cutbacks are necessary for dense cement or lime stabilised surfaces, and higher viscosity cutbacks for untreated coarse-textured surfaces.

Bitumen for Surface Dressing

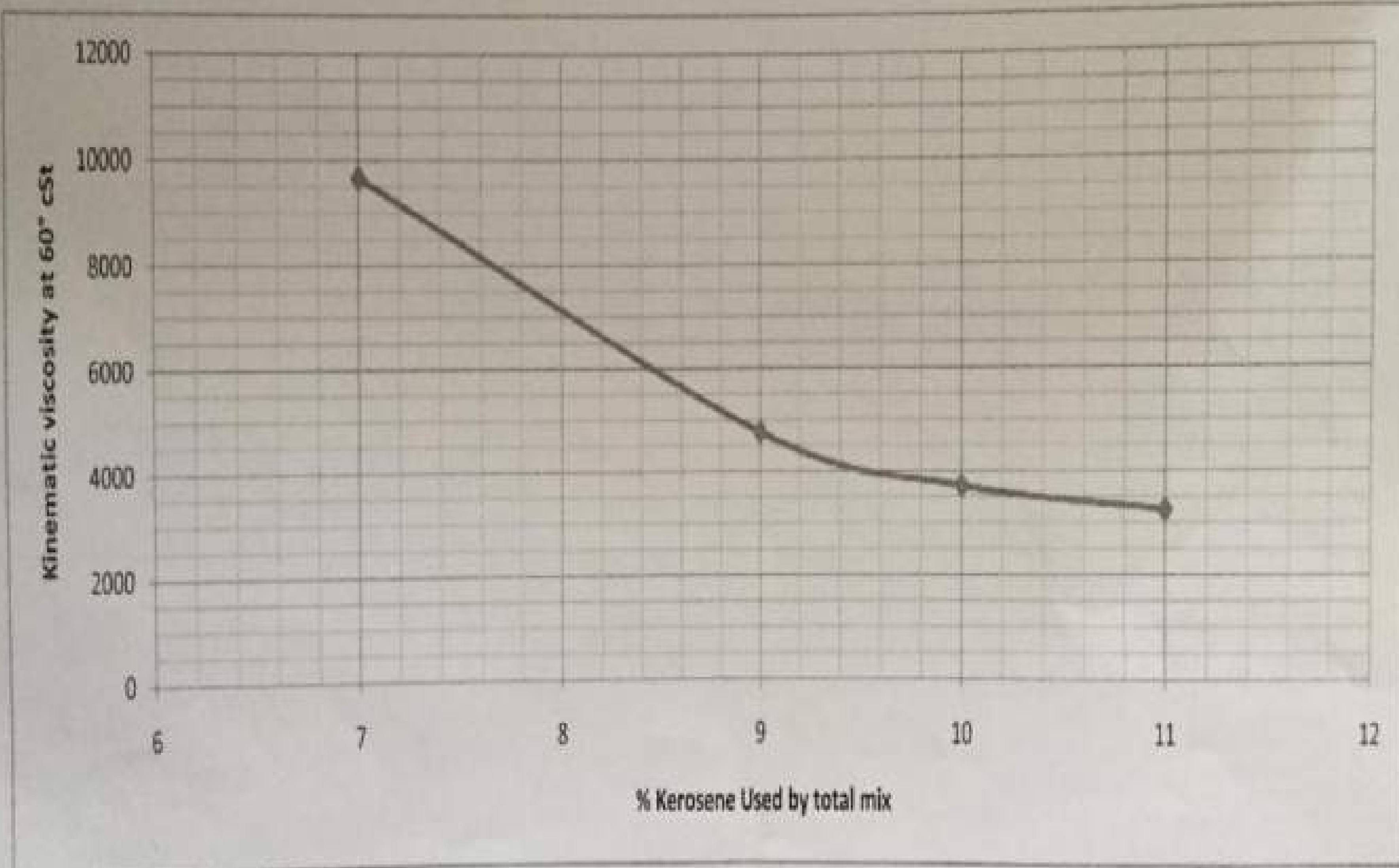
Bitumen used for SD must

- be capable of being sprayed
- 'wet' the surface of the road in a continuous film
- not run off a cambered road or form pools of binder in local depressions
- 'wet' and adhere to the chippings at road temperature
- be strong enough to resist traffic forces and hold the chippings at the highest prevailing ambient temperatures
- remain flexible at the lowest ambient temperature
- neither cracking nor becoming brittle enough to allow traffic to 'pick-off' the chippings; and
- resist premature weathering and hardening

MC 3000(viscosity in the range of 3000-6000 centi stroke at 60oc) grade cutback is normally the most fluid binder used for surface dressings. This grade of cutback is basically an 80/100 penetration grade or VG10 bitumen blended cutter Kerosene.

MIX DESIGN FOR MC-3000 CUTBACK GRADE

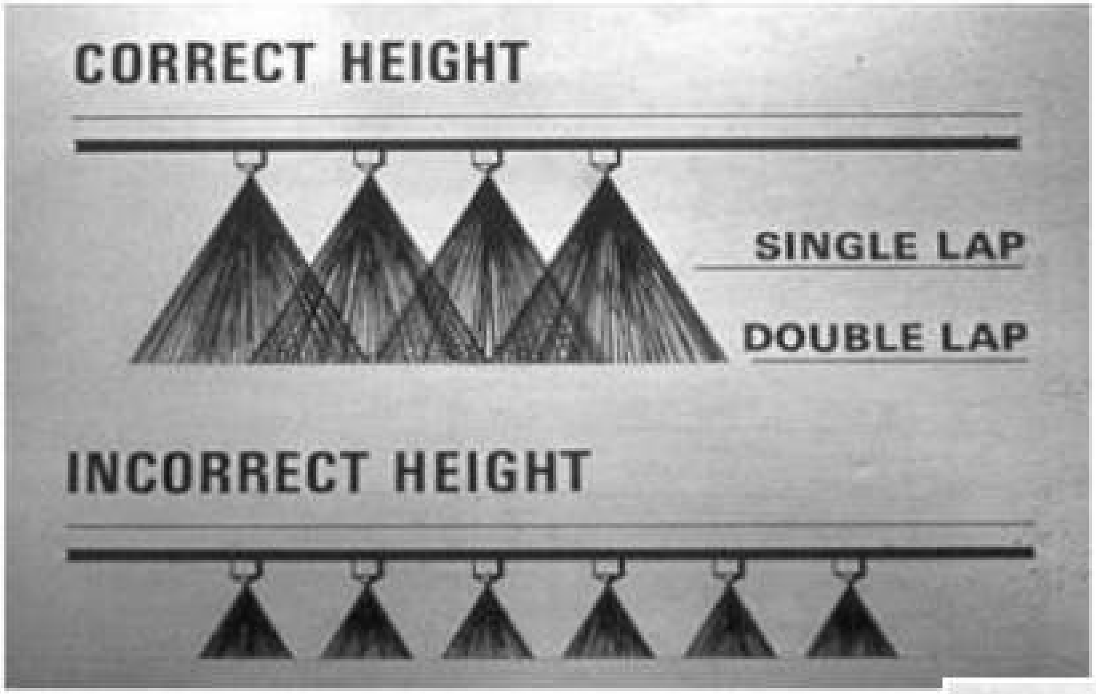
MIX DESIGN OF MC 3000 GRADE BITUMINOUS CUTBACK GRADE BY KINEMATIC VISCOSITY TEST RESULTS AT 60°C

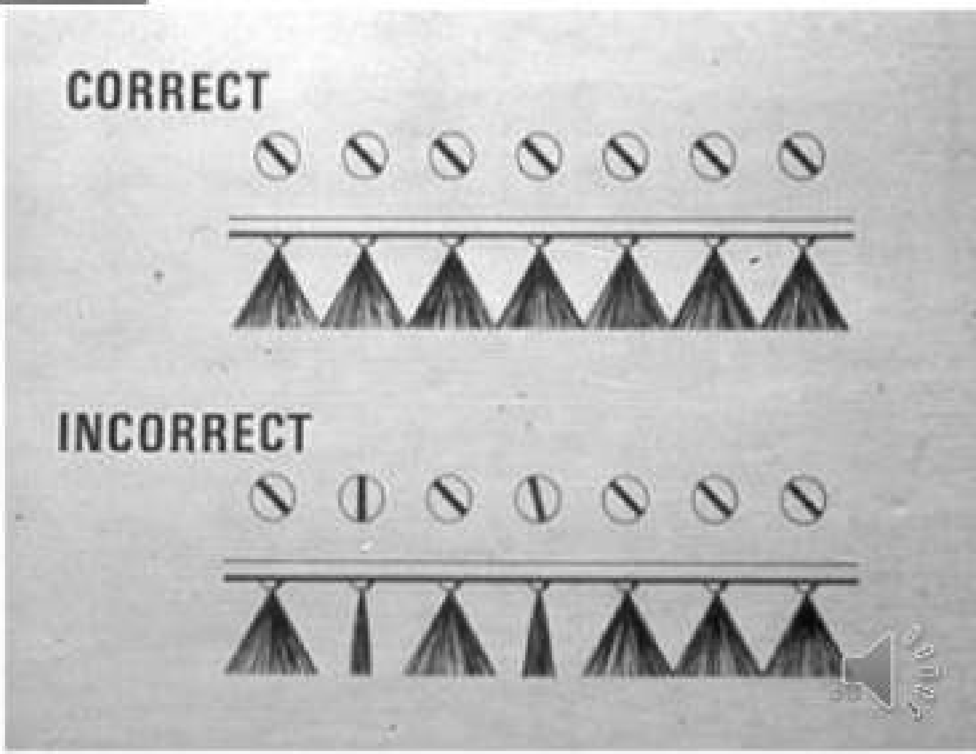


Cutback mix design for MC 3000 grade bitumen

For MC 3000 Kinematic viscosity should be = 4500 cst for this % Kerosene to be used = 9.17 % (by wt.)

FOR MC 3000 Kinematic Viscosity range is 3000 to 6000 Cst


CORRECT HEIGHT
SINGLE LAP
DOUBLE LAP
INCORRECT HEIGHT


CORRECT
INCORRECT

Determination of Bitumen Spray Rate

Basic Spray Rate is determine from two parameter

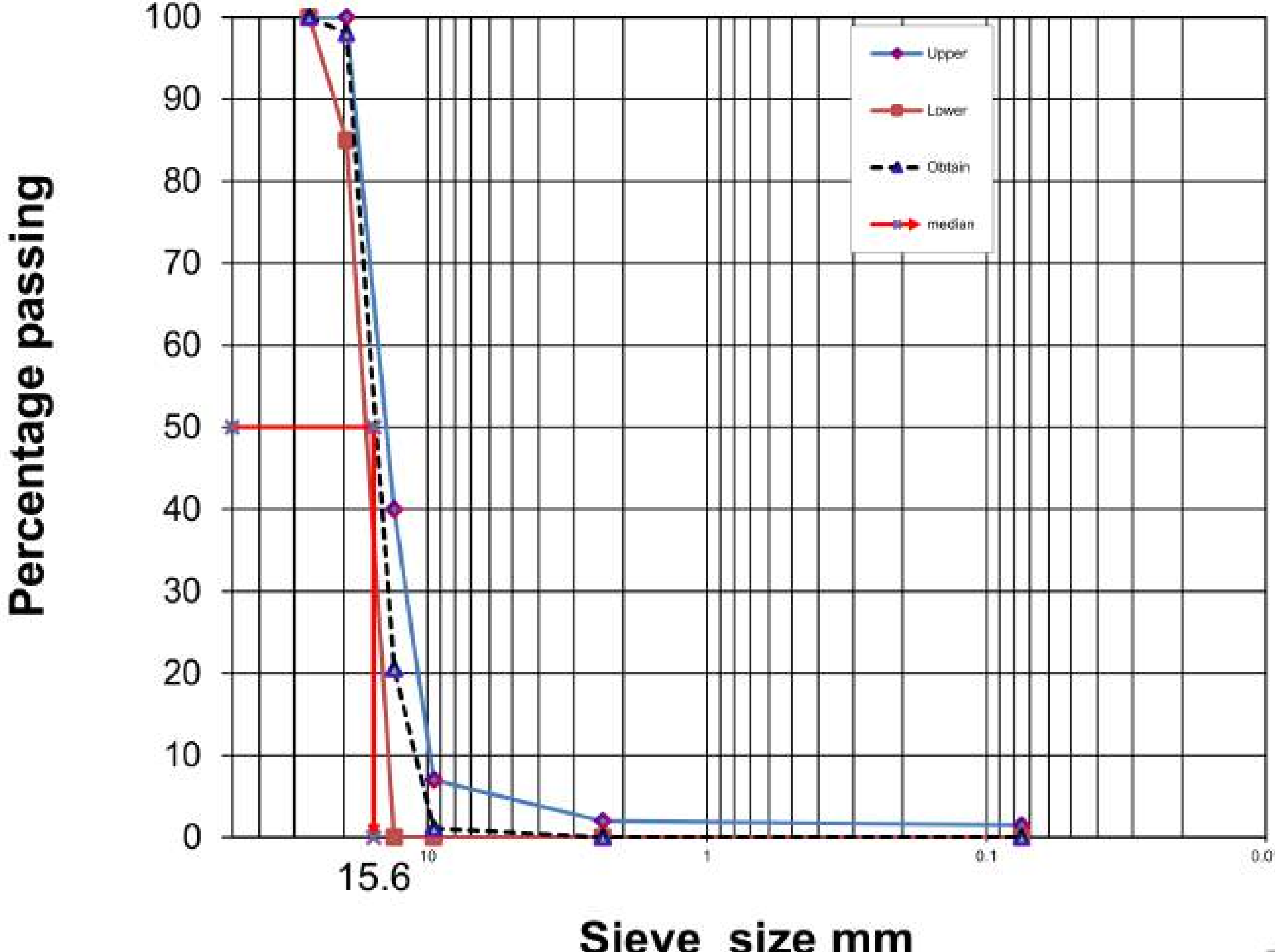
- Average Least Dimension (ALD)

  Method A

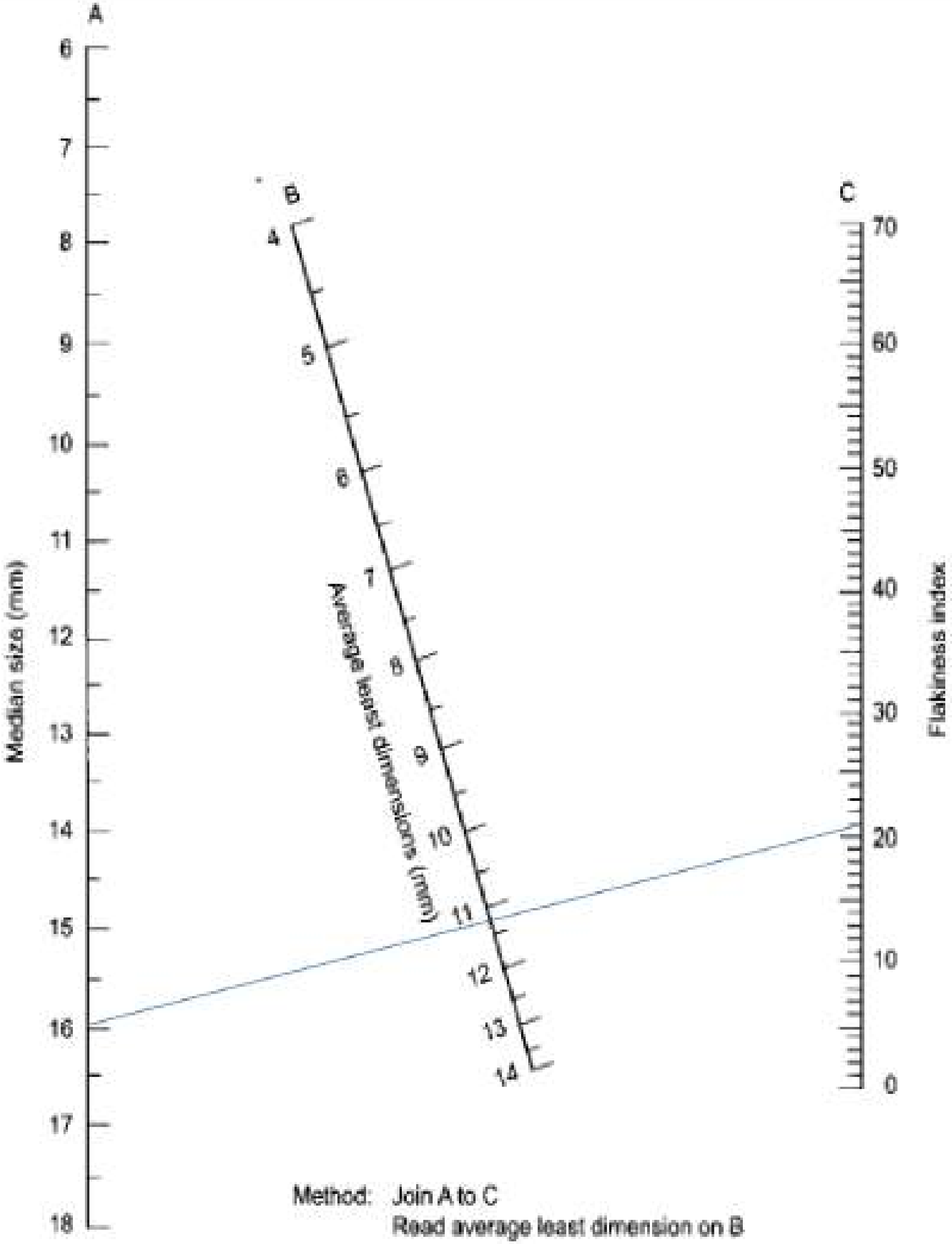
  - Median size :The sieve size through which 50 per cent of the chippings pass
  - FI

  Method B: A representative sample approximately 200 chippings. The least dimension of each chipping is measured manually and the mean value is ALD

- Overall weighing factor F



Percentage passing
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
15.6
Upper
Lower
Obtain
median
Sieve size mm


A
Median size (mm)
6
7
8
9
10
11
12
13
14
15
16
17
18
B
Average least dimensions (mm)
4
5
6
7
8
9
10
11
12
13
14
C
Flakiness index
70
60
50
40
30
20
10
0
Method: Join A to C
Read average least dimension on B

Over all weighing factor depend on

1. Total traffic (all classes)

Very light	0 - 50	+3
Light	50-250	+1
Medium	250-500	0
Medium- Heavy	500-1500	-1
Heavy	1500-3000	-3
Very Heavy	3000+	-5

2. Existing surface

Untreated or primed base	+6
Very lean bituminous	+4
Lean bituminous	0
Average bituminous	-1
Very rich bituminous	-3

3.Climatic conditions

Wet and cold	+2
Tropical (wet and hot)	+1
Temperate	0
Semi-arid (hot and dry)	-1
Arid (very dry and very hot)	-2

4.Type of chippings

Round/dusty	+2
Cubical	0
Flaky	-2
Pre-coated	-2

- For example, if flaky chippings (factor -2) are to be used at a road site carrying medium to heavy traffic (factor - 1) and which has a untreated prime (factor +6) in a wet tropical climate (factor +1) the overall weighting factor

  F=-2-1+6+1=4

- If the existing surface of the road is rough, it should be rated as 'very lean bituminous' even if its overall colour is dark with bitumen.
- When determining the rate of spread of binder for the second layer of a double surface dressing, the first layer should also be rated 'very lean bituminous'.

- if the proportion of commercial vehicles in the traffic stream is high (say more than 20 per cent) the traffic factor selected should be for the next higher category of traffic than is indicated by the simple volume count.

Determination of Basic Spray Rate

Basic rate of spread of binder.

- R= 0.625+(F*0.023)+[0.0375+(F*0.0011)]ALD

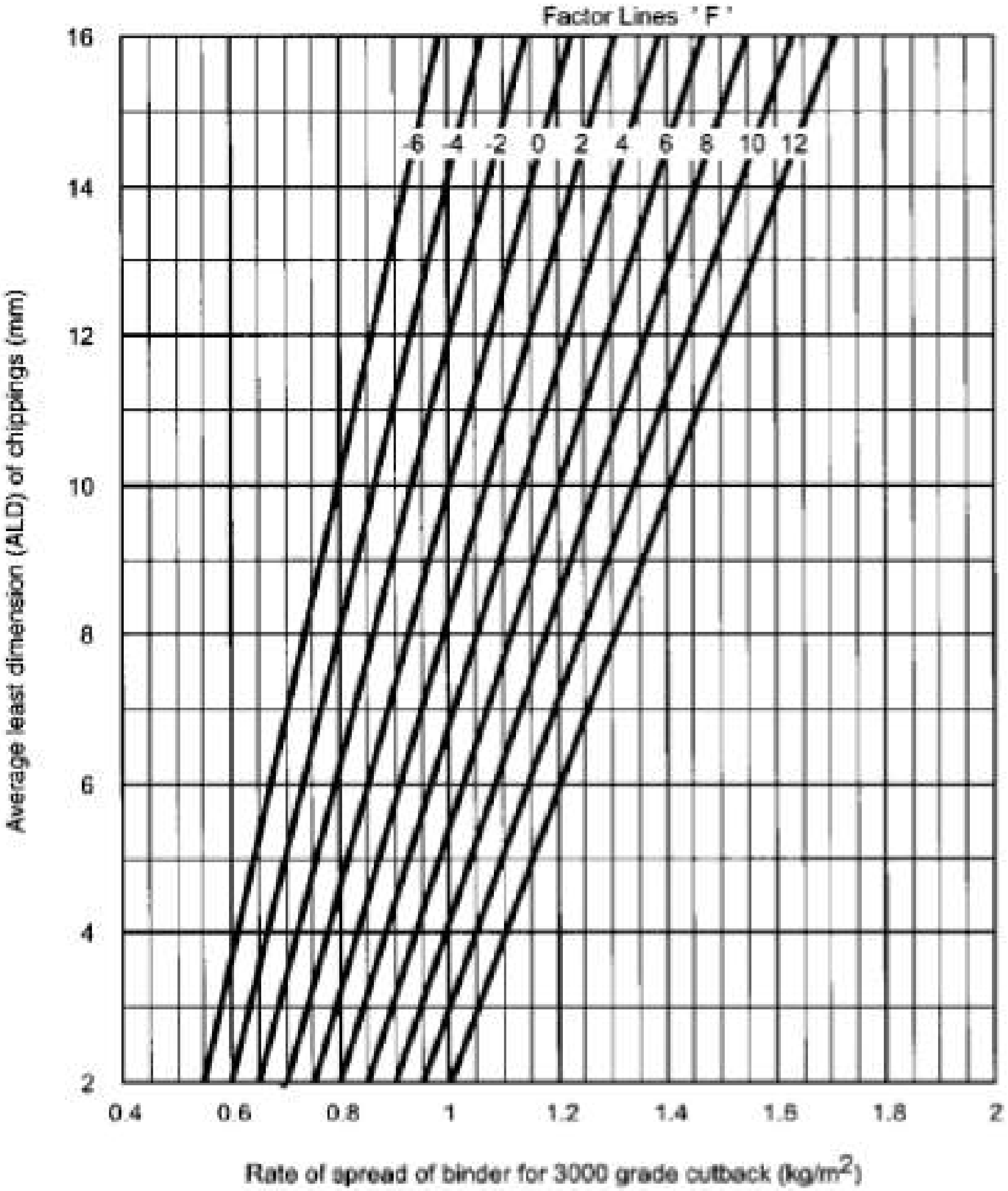
Where

F = Overall weighting factor

ALD = the average least dimension of the chippings (mm)

R = Basic rate of spread of bitumen(kg/m2)

- The basic rate of spread of bitumen (R) is the mass of MC3000 binder per unit area on the road surface immediately after spraying. The relative density of MC3000 can be assumed to be 1.0 and the spread rate can therefore also be expressed in l/m2


Factor Lines ' F '
-6 -4 -2 0 2 4 6 8 10 12
16
14
12
10
8
6
4
2
0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2
Average least dimension (ALD) of chippings (mm)
Rate of spread of binder for 3000 grade cutback (kg/m2)

Bitumen spray rate adjustment factors

Binder grade	Basic spray rate	Flat terrain moderate traffic speed	Down hill grades >3% High speed traffic	Uphill grades >3% ,, Low speed taffic
MC3000	R	R	R*1.1	R*0.9
300 pen	R	R*0.95	R*1.05	R*0.86
80/100 pen	R	R*0.9	R*0.99	R*0.81
Emulsion1	R	R*(90/%binder)	R*(99/%binder)	R*(8l/%binder)
% binder' is the percentage of bitumen in the emulsion.				

Adjustment factor for Increase Durability

- For roads on flat terrain and carrying moderate to high speed traffic it is possible to increase the spray rates obtained by applying the factors approximately 8 per cent.
- The heavier spray rate may result in the surface having a 'bitumen-rich' appearance in the wheel paths of roads carrying appreciable volumes of traffic.
- Additional binder should not result in bleeding and it can still be expected that more surface texture will be retained than is usual in an asphalt concrete wearing course

Maximum increases in bitumen spray rate for low volume roads

ALD of chippings (mm)	3		6		>6	
All traffic (vehicles/lane/day)	<20	20-100	<20	20-100	<20	20-100
Increase in bitumen spray rate (per cent)	15	10	20	15	30	20

It is important that these increased spray rates are adjusted on the basis of trial sections and local experience.

Aggregate Spray Rate

- Chipping application rate (kg/m2) =1.364*ALD
  for aggregate of loose density of1.35 Kg/m3
- Spray a single layer of chippings taken from the stockpile on a tray of known area. The chippings are then weighed, the process repeated ten times with fresh chippings, and the mean value calculated. An additional ten per cent is allowed for whipoff, Storage and handling losses

- Exposed binder remains after spreading the chippings, indicating too low a rate of application of chippings
- Chippings resting on top of each other, indicating too high an application rate.
- Best results are obtained when the chippings are tightly packed together in one layer thick
- Slight excess of chippings must be applied. Some will be moved by the traffic and will tend to fill small areas where there are insufficient chippings.
- Too great an excess of chippings will increase the risk of whip-off and windscreen damage

Approximate Rate of application

Nominal Aggregate Size	Bitumen Spray Rate	Aggregate cum/sqm
19	1.2	0.014-0.015
13	1	0.009-0.011
10	0.9	0.007-0.009
6	0.75	0.003-0.005
Spray rate are excluding the cutter and the Anti stripping agent		

Bitumen Distributor Calibration

Speed of distributor = S/(R*W)

Where S is the rate of delivery (mass) from the spray bar in kg/s

R is the design spray rate (mass) in kg/m2

W is the sprayed width in metres

The required speed will then be in **m/s.**

The calibration should then be checked dynamically as construction work progresses

Construction Procedure

Prime coat

- The surface to be sprayed shall be checked for line, camber and level, and the surface corrected, made good as necessary and approved by the Engineer
- The surface to be primed shall be thoroughly cleaned by sweeping with mechanical brooms or other approved means.
- All the fine particle at surface shall be removed using compressor

- Spray with water to dampen but in no case the surface shall be made saturated.
- No traffic shall be allowed on the prepared surface.
- Mark the edge of the surface to be primed
- Check Nozzle to give a uniform spray
- When commencing and stopping spraying, sheets of metal at least 2m wide shall be spread across the full width to be spread across the full width
- Check and record the Dip and temperature

- Place tray in place for checking the spray rate
- Inform operator about design speed and spray rate.
- Start Spraying the prime coat.
- If during spraying, a nozzle becomes blocked or develops a defect, the spraying shall be made good with a hand spray, and the machine repaired before further spraying is commenced.
- Check the spray rate from tray and immediately inform it to the operator if any correction in speed is required.

- After the application of Prime allow it to penetrate to the surface
- No traffic shall be allowed in the prime surface for at least for one hr. If traffic need to be open after this time sand blinding can be done.

Surface Dressing

- Before starting Surface dressing ensure that the depth of penetration of the prime should be between3-l0mm
- The road is thoroughly swept and road furniture such as manhole covers, reflective studs etc, is masked so as to prevent contamination with binder
- Ensure that binder is heated to required temperature, circulated and jets are checked for correct operation

- The range of spraying Temperature for binder is normally within the range of 140 to 170^{0}C
- Record the volume of Binder and temperature and the surface temperature.
- Inform to the distributor operator about spray rate and design speed
- Place the tipper with chips ready to follow the distributor and roller to follow the chips spreader.
- Cut-off sheets of paper or other material are placed at the beginning and end of the spray run
- Position the laboratory staff with tray and balance for tray test.

- Instruct the distributor operator for the spray of the binder at predetermined speed.
- The chip spreader, tippers and the rollers should follow closely behind the distributor.
- The chip spreader, tippers and the rollers should follow closely behind the distributor.
- Spraying should he stopped if the chipping operation is delayed for any reason
- A strip of binder 150mm wide is left un-chipped at the edge of the lane to allow for the overlap of the adjacent run of the distributor.

- After 6-8 pass of the PTR and back chipping where needed traffic can be open with control speed.
- Continue the works for second lane or run
- At end of day works record the dip and temperature again.
- Speed control and other traffic warning signs are left in position along the length of the new surface dressing.
- Removing excess chippings within 24 to 48 hours of the construction of a dressing

- Care must be taken with brooming to avoid damage to the new dressing and it is usually best to do this work in the early morning.
- Where a second surface dressing is specified, the first surface dressing shall be left open to traffic for a minimum period of 21 days and preferably a longer period before applying the second surface dressing unless special approval is obtained from the Engineer for a shorter period.

Payment of Bitumen

- Designed/instructed rate of application in litres corrected to 15.6°C.
- Actual rate of application measured through tray tests computed in litres corrected to 15.6°C.
- Actual consumption in the specified area sprayed measured in litres corrected to 15.6°C by dip stick reading of the distributor.
- The lowest value of the above three methods shall be adopted for payment
- Anti-stripping agent and Cutter shall be separately measured in litre.

Conversion Factor

- ASTM D 4311-04

$A = 1.0094684142(6.33413410744 * 10^{4} * T) + (1.45710416212 * 10^{-7} * T^{2})$

Where A= volume correction factor

T ($^{\circ}$c)= temperature of binder

Temperature ($^{\circ}$c)	Factor	Temperature ($^{\circ}$c)	Factor
165	0.9089	172	0.9048
166	0.9083	173	0.9043
167	0.9077	174	0.9037
168	0.9072	175	0.9031
169	0.9066	176	0.9025
170	0.9060	177	0.9019
171	0.9054	178	0.9014

- Calculation sheet


AMW




Bitumen
1/30/2021



2021/2/24 14:20


2021/2/24 14:20


04/02/2014 15:16

Thank YOU

Transport Infrastructure Directorate
Bagamati Province

Training on Quality Control in Road Works

Session 8:Quality Control of Structures

Session 5: Supervision and Quality Control of Road Works – Structure

General Stone Masonry Work (Random Rubble Masonry)

- Check the cross slope & check the foundation level
- Dress the stones of required size
- Hack the top surface of the foundation block
- Spread a layer of mortar of 12 mm, M10 150 mm
- Placing loosed mortar on the course and pouring water upon it to fill the gaps is not allowed
- Use of bond stones
- Provide weep holes to masonry structures higher than 2 m
- Size of weep hole not less than 80 x 150 , Staggered 1 m slope 1:20

General Stone Masonry Work (Random Rubble masonry)

- Weep hole Position lowest one at about 150 mm above the low water level or bed level whichever is higher
- Provide concrete coping of 150 mm thickness over the masonry
- Commence curing as soon as the mortar or pointing/ plastering has hardened sufficiently, Min 7 Days

Photos from the construction Site – Common Issues

Unacceptable – RRM : photo from FVR- RBP

Cement Painting, lack of dressed stone , line level out

Vertical Joint Undressed stone, Non uniform Mortar Thickness,

Photo: Ram Babu Paudyal , BK Road , Bagmati

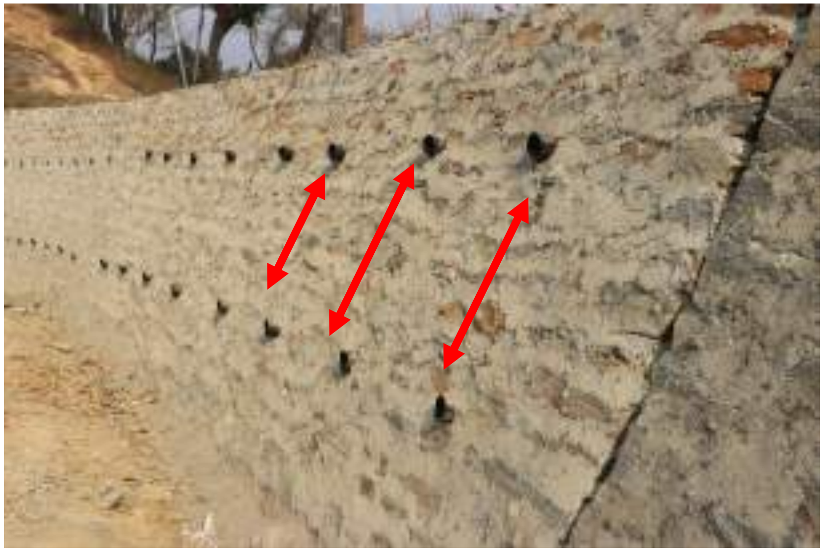
Vertical Joints in RRM

Photo: Ram Babu Paudyal , BB Road , Bagmati

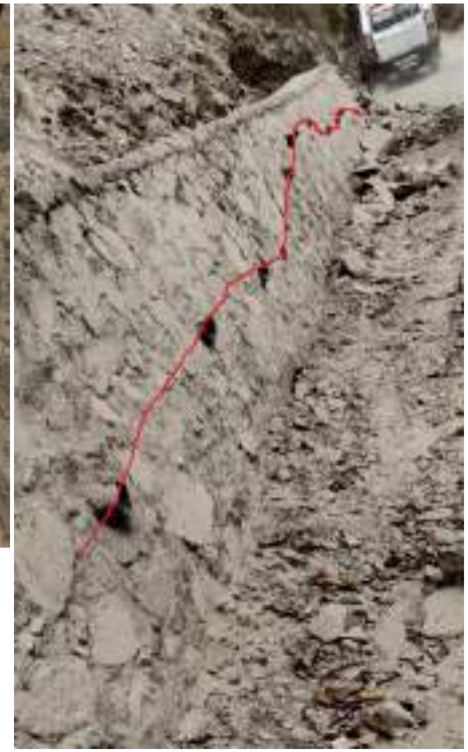
Stone are not dressed, No Line and Level

Photo: Ram Babu Paudyal , BK Road , Bagmati

Real Photos from the construction Site – Common Issues



RRM : photo from FVR- RBP



Weep hole, wrongly placed ,
Lack of supervision

Alignment and Spacing,
opening and size , slope

Photo: Ram Babu Paudyal , BK Road , Bagmati

Quality Control – Stone Masonry

Material

- **Stone -**LD 150 mm , L= 3*LD or Wall Width , H = 300 mm, WA =5%, , Sp Gravity= 2.5
- **Sand-** Clean , free from Organic Material, not more than 5% of clay silt or fine dust , Gradation 4.75 mm – 0.15mm (25-1)
- **Cement –** OPC, hand feel tests , observations

Manufacture Date

Requirements on Physical Characteristics of Cement

S.N	Physical Characteristics	OPC/PSC
1	Fineness (m^2/kg)	225
2	Initial setting Time (Minutes) minimum	45
3	Final setting Time (Minutes) maximum	600
4	Soundness (mm)	10
5	Compressive Strength: Minimum Average Compressive Strength of 3 mortar cubes (N/mm2)	
	3 days	16
	7 days	22
	28 days	33

Test Prior to Construction

S.N.	Material / Work	Test / Check	Frequency
1	Stones	a) Shape and Dimension b) Water absorption/Sp .gr	3 samples on receipt at site
2	Cement	Setting time of cement	1 samples of same type and grade of cement
3	Sand	a) Gradation b) Deleterious materials and organic impurities	3 samples for each source of supply,
4	Water	If impurities are present test is necessary	If doubt Samples taken at each source tested
5	Mortar for Joints (Mix Design)	a) Mix proportions for different works b) Compressive Strength	As required 6 samples of cubes for each type of cement & source of sand

Test during Construction

S.N.	Material / Work	Test / Check	Frequency
1	Bond and Plumbness	For stability and appearance with plumb	For each course
2	Laying in Mortar	Horizontality of courses verticality and staggering of joint	- do -
3	Individual Course	Height of course and Joint thickness and laying	- do -
4	Top of coping (If provided)	Sloping to drain off water	Daily
5	Mortar for Joints	a) Mix proportions (Control on quantity of cement by weight) b) Compressive Strength	Each batch 6 samples of cubes for each 10 m^3 of work or part of it

Wall with Dressed Stone

Photo: Ram Babu Paudyal , EEAP - OKH

Wall with Dressed Stone

Photo: Ram Babu Paudyal ESCLRIP ADB

Proper Line using String

Proper Line using Wooden frame and String

Photo: Ram Babu Paudyal ESCLRIP ADB

Demonstration Site

Frequent Site Monitoring for Supervision and Quality Control

Photo: Ram Babu Paudyal ESCLRIP ADB

Check the final finishing with Site Visit

Photo: Ram Babu Paudyal ESCLRIP ADB

Check the final finishing with Site Visit

Photo: Ram Babu Paudyal – DRD -ADB

Rectification

Photo: Ram Babu Paudyal ESCLRIP ADB

Brickwork For Structures

- Check the cross slope & check the foundation level
- Soak all bricks Min 1 hour , skin dry before actual laying
- Hack the top surface of the foundation block
- Spread a layer of mortar of 12 mm,
- Lay all brickwork in English bond, with frogs up
- Use of bond stones
- Provide weep holes to masonry structures higher than 2 m
- Size of weep hole not less than 80 x 150 , Staggered 1 m slope 1:20

Brickwork For Structures

- Weep hole Position lowest one at about 150 mm above the low water level or bed level whichever is higher
- Provide concrete coping of 150 mm thickness over the masonry
- Commence curing as soon as the mortar or pointing/ plastering has hardened sufficiently, Min 7 Days

Quality Control – Brick Masonry

Material

- **Brick -**Size : 230*110*50 mm – Preferred , Burnt Clay Bricks , Min Comp Strength – 8 N /mm^2 (individual) - 10 N /mm^2 for Average of 5 ,WA =20%, ,
- **Sand-** Clean , free from Organic Material, not more than 5% of clay silt or fine dust , Gradation 4.75 mm – 0.15mm (25-1)
- **Cement –** OPC, hand feel tests , observations

Test Prior to Construction

S.N.	Material / Work	Test / Check	Frequency
1	Bricks	a) Colour and Dimensional check b) Water absorption c) Compressive strength	3 samples at random at source 3 samples at source 5 samples at random at source
2	Cement	Setting time of cement	1 samples of same type and grade of cement
3	Sand	a) Gradation b) Deleterious materials and organic impurities	3 samples for each source of supply,
4	Water	If impurities are present test is necessary	If doubt Samples taken at each source tested
5	Mortar for Joints (Mix Design)	a) Mix proportions for different works b) Compressive Strength	As required 6 samples of cubes for each type of cement & source of sand

Test during Construction

S.N.	Material / Work	Test / Check	Frequency
1	Bond and Plumbness	For stability and appearance with plumb	For each course
2	Laying in Mortar	Horizontality of courses verticality and staggering of joint	- do -
3	Individual Course	Height of course and Joint thickness and laying	- do -
4	Top of coping (If provided)	Sloping to drain off water	Daily
5	Mortar for Joints	a) Mix proportions (Control on quantity of cement by weight) b) Compressive Strength	Each batch 6 samples of cubes for each 10 m^3 of work or part of it

GABION MASONRY FOR STRUCTURES

- Assemble the gabion boxes Dress the stones of required size
- Fix shape and size by stretching its all sides and fix the diaphragms
- Spread a layer of mortar of 12 mm, M10 150 mm
- Lay the gabion boxes as required in header bond by tying to adjacent
- Lay the Geo-textile at the back of the gabion boxes to cover the length and height including footing of the wall.
- Fill the gabion boxes with stones with proper bonding in three equal layers
- The filling is carried out by placing individual stones into the gabion by hand in courses

GABION MASONRY FOR STRUCTURES

- Bond stone provided at the rate of at least one to every 0.9 m^2 of exposed face
- Bond stone -not less than 150 mm x 150 mm on the exposed face; and not less than 450 mm in length
- Lay the gabion boxes as required in header bond by tying to adjacent
- No loose stones is allowed to tipped,
- Filling the interior with un laid stones shall not be permitted
- Horizontal bracing wires :at 330 mm

GABION MASONRY FOR STRUCTURES

- Cover the upper faces (Lid) and tie by gabion wires by looping the wires on the selvedge wires of adjacent panels
- Measure the dimensions of the filled boxes
- Take the level of the top of the wall
- Cover the entire wall by the Geo-textile already provided covering the footing
- Backfilling with suitable materials. Compact the backfilling in layers not exceeding 150 mm of compacted thickness
- Achieve 95% MDD of the backfill from bottom to top.

Unacceptable Gabion Works

Photo: Ram Babu Paudyal – Sindhuli

Photos from the construction Site – Common Issues

Unacceptable Gabion Works

Photo: Samar Khanal

Photos from the construction Site – Common Issues

Unacceptable Gabion Works

Photo: Samar Khanal

Photos from the construction Site – Common Issues

Unacceptable Gabion Works

Photo: Samar Khanal

Position and Method of Horizontal Bracing

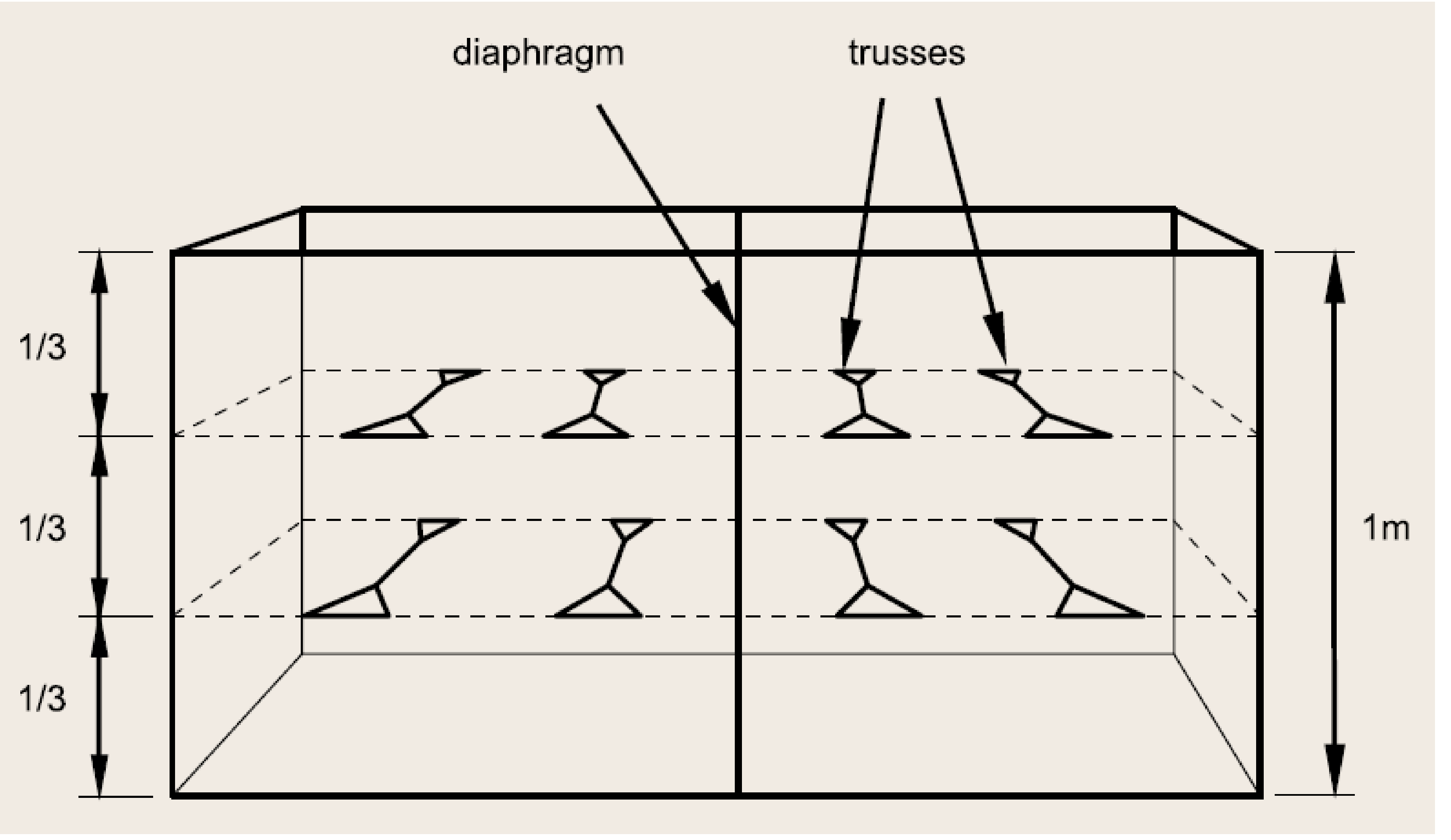


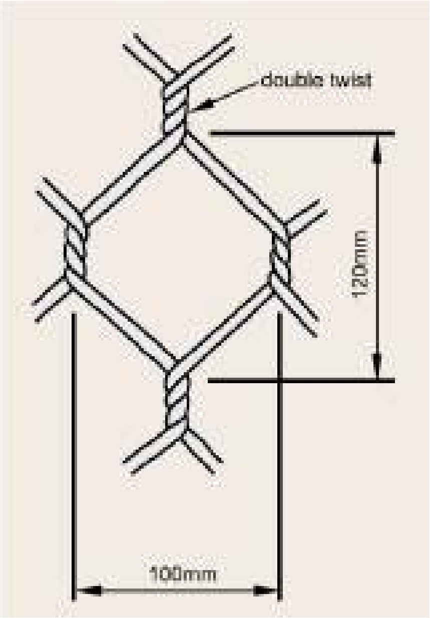
Photo: ILO

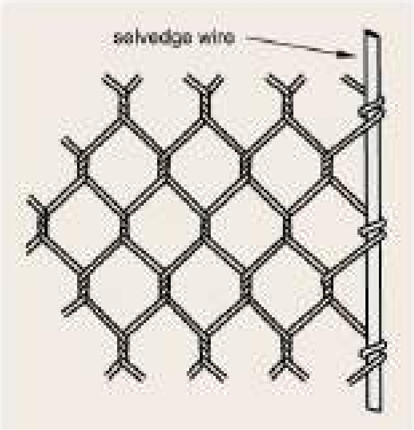
Quality Control – Gabion Masonry

Material

- **Stone -**hard, sound, free from cracks, decay, and weathering, Do not use stones with round surface, LD 150 mm , L= 3*LD or Wall Width , H = 300 mm, WA =5%, , Sp Gravity= 2.5
- **Gabion Wire –** Heavy coated, Hexagonal Mesh, Selvedge wire – 2 gauge heavier than mesh wire, Mesh – 2.7 mm, Selvedge – 3.4 mm, lacing 2.2 mm , Tolerances in Size 5%

Gabion Boxes





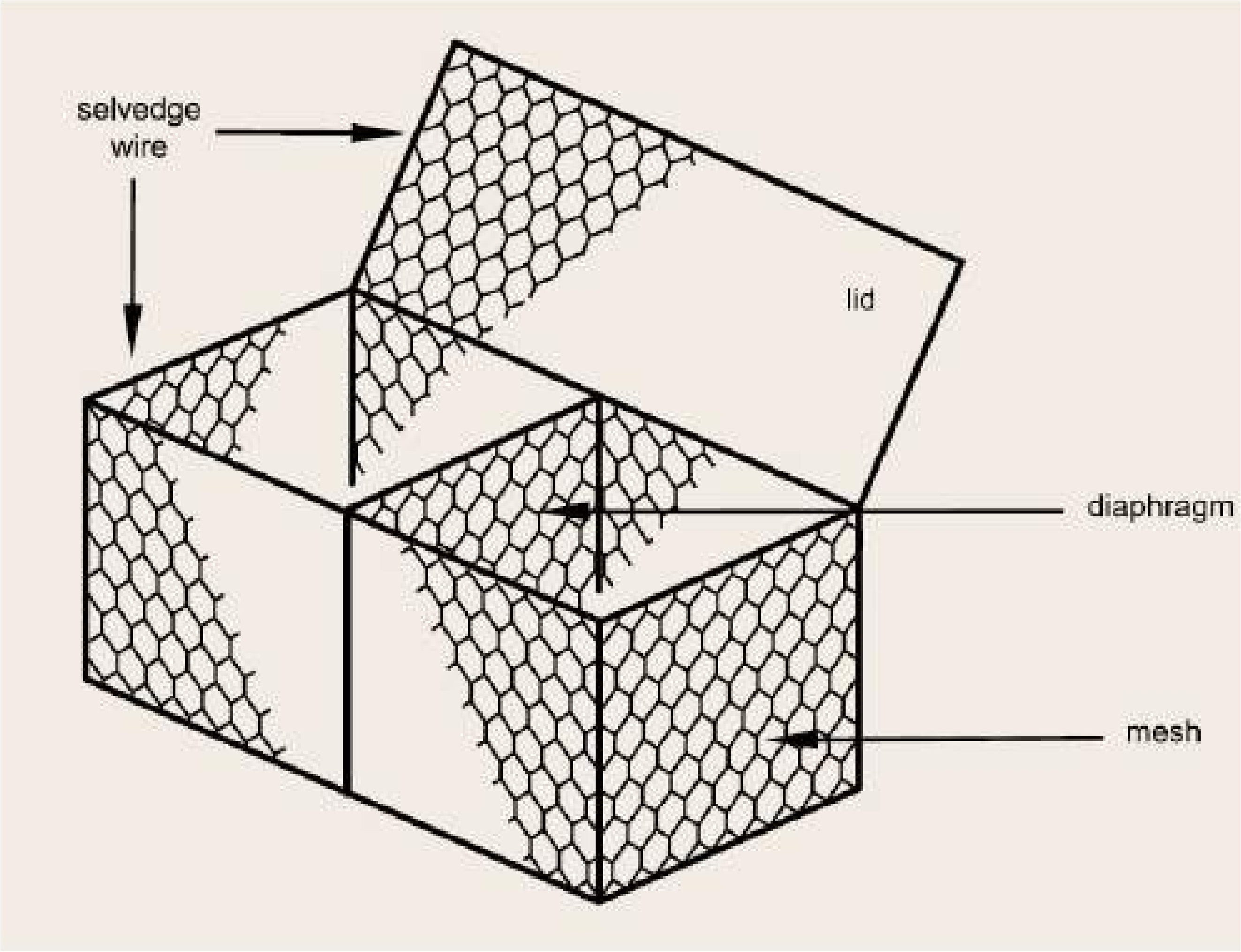
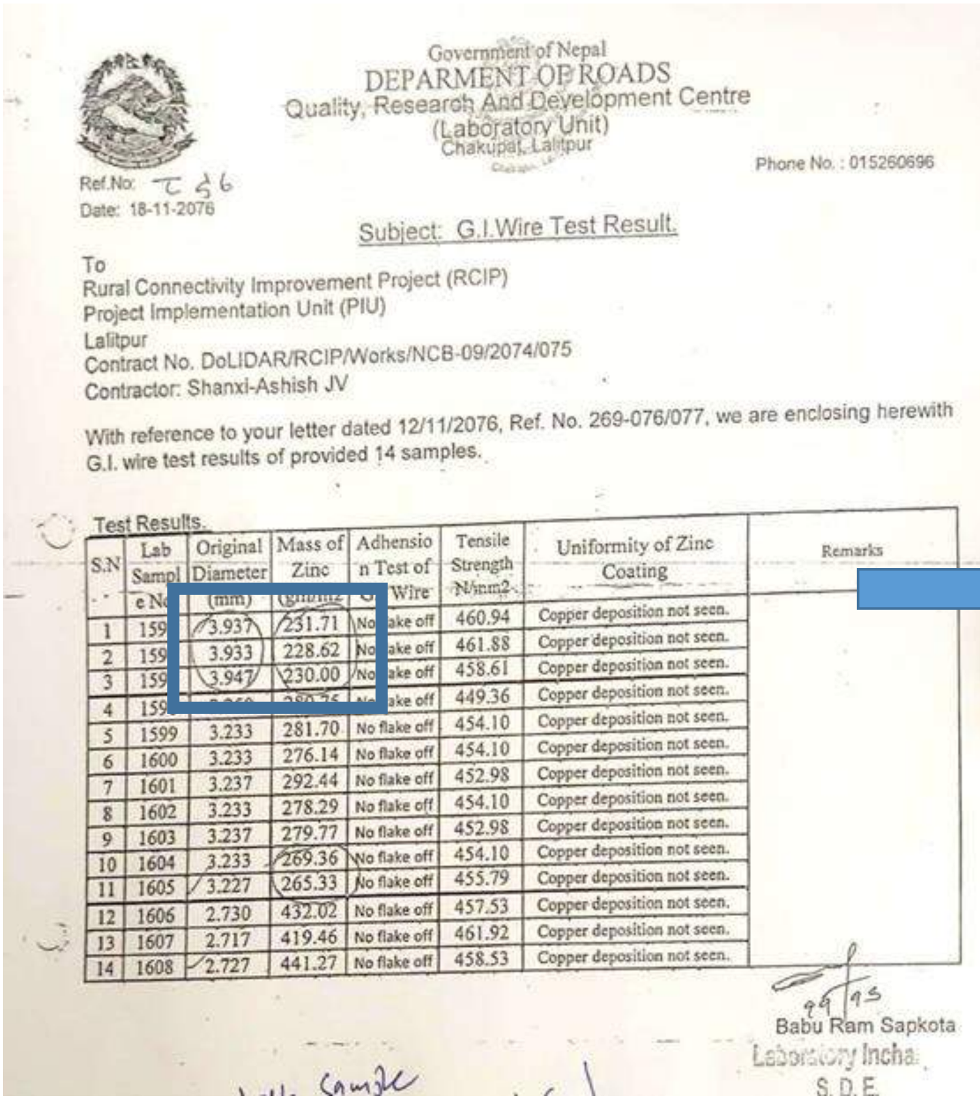


Photo: ILO

Test Prior to Construction

S.N	Material / Work	Test / Check	Frequency
1	Stones	a) Shape and Dimension b) Water absorption	3 samples, Once for each stock
2	Gabion wire	Diameter, Tensile Strength, Mass, Uniformity and adhesion of Zinc coating	As per specification Page 24-11 TS – 350 -550 mpa
2	Gabion crates	Size and mesh size	Before Procurement after fabrication

Lab Test Report of Gabion Wires



Government of Nepal
DEPARMENT OF ROADS
Quality, Research And Development Centre
(Laboratory Unit)
Chakupat, Lalitpur

Phone No. : 015260696

Ref.No: ट 56
Date: 18-11-2076

Subject: G.I.Wire Test Result.

To
Rural Connectivity Improvement Project (RCIP)
Project Implementation Unit (PIU)
Lalitpur
Contract No. DoLIDAR/RCIP/Works/NCB-09/2074/075
Contractor: Shanxi-Ashish JV

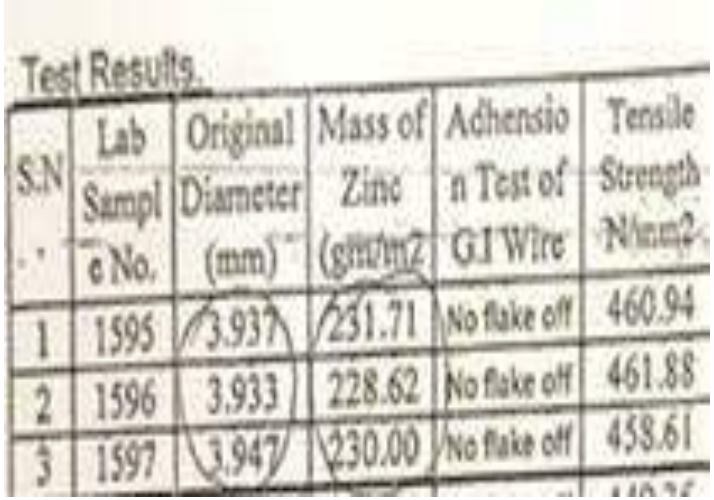
With reference to your letter dated 12/11/2076, Ref. No. 269-076/077, we are enclosing herewith G.I. wire test results of provided 14 samples.

Test Results.

S.N.	Lab Sample No.	Original Diameter (mm)	Mass of Zinc (gm/m2)	Adhension Test of G.I Wire	Tensile Strength N/mm2	Uniformity of Zinc Coating	Remarks
1	159[illegible]	3.937	231.71	No [illegible] ake off	460.94	Copper deposition not seen.	
2	159[illegible]	3.933	228.62	No [illegible] ake off	461.88	Copper deposition not seen.	
3	159[illegible]	3.947	230.00	No [illegible] ake off	458.61	Copper deposition not seen.	
4	159[illegible]	[illegible]	[illegible]	[illegible] ake off	449.36	Copper deposition not seen.	
5	1599	3.233	281.70	No flake off	454.10	Copper deposition not seen.	
6	1600	3.233	276.14	No flake off	454.10	Copper deposition not seen.	
7	1601	3.237	292.44	No flake off	452.98	Copper deposition not seen.	
8	1602	3.233	278.29	No flake off	454.10	Copper deposition not seen.	
9	1603	3.237	279.77	No flake off	452.98	Copper deposition not seen.	
10	1604	3.233	269.36	No flake off	454.10	Copper deposition not seen.	
11	1605	3.227	265.33	No flake off	455.79	Copper deposition not seen.	
12	1606	2.730	432.02	No flake off	457.53	Copper deposition not seen.	
13	1607	2.717	419.46	No flake off	461.92	Copper deposition not seen.	
14	1608	2.727	441.27	No flake off	458.53	Copper deposition not seen.	

99/15

Babu Ram Sapkota
Laboratory Incha
S.D.E.



Test Results.

S.N.	Lab Sample No.	Original Diameter (mm)	Mass of Zinc (gm/m2)	Adhension Test of G.I Wire	Tensile Strength N/mm2
1	1595	3.937	231.71	No flake off	460.94
2	1596	3.933	228.62	No flake off	461.88
3	1597	3.947	230.00	No flake off	458.61

Photo: Ram Babu Paudyal – DOR

Test during Construction

S. N.	Material/ Work	Test / Check	Frequency/ Stage
1	Assembling of Gabion Crate	Size of Crate, Lacing as per specification,	During laying
2	Filling of crate with stone	For stability and appearance with plumb bob and bracing as specified	While laying each course
3	Securing Lids of gabion crate	Lacing and binding the of panels, filling of stone	While closing the led after completion of stone filling
4	Gabion wire	Diameter, Tensile Strength, Mass, Uniformity Zinc coating	Each lot of gabion received at site

Photos from Construction Sites

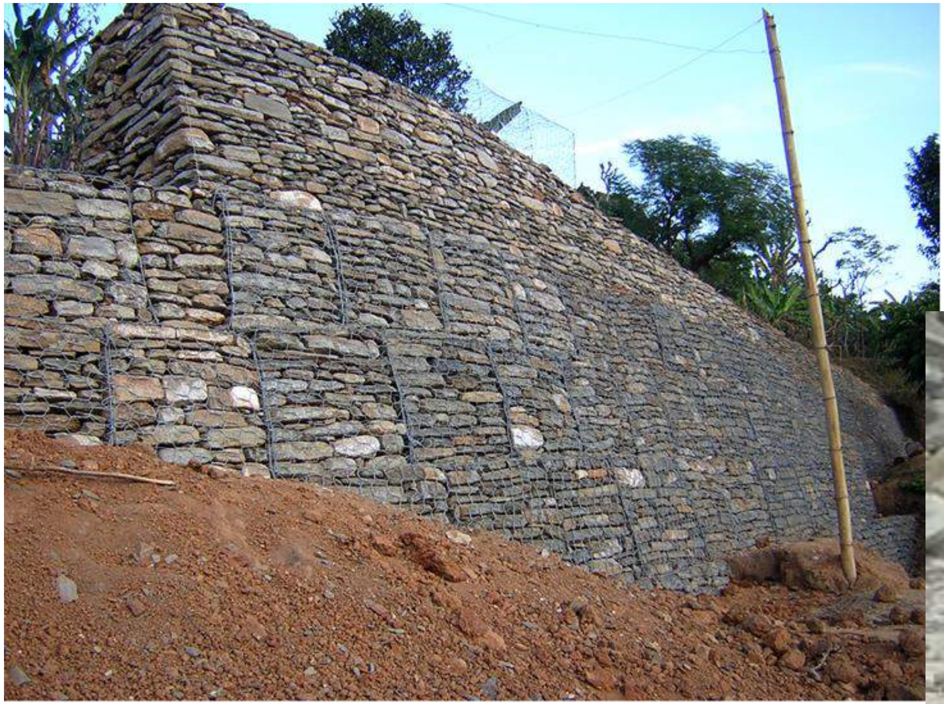


Photo: Ram Babu Paudyal , RDSPL Lamjung , EEAP Gorkha

Photos from Construction Sites

Photo: Ram Babu Paudyal , RPN Lamjung ,

Photos from Construction Sites

Photo: Ram Babu Paudyal , RPN Lamjung ,

Gabion Wall with River Boulder

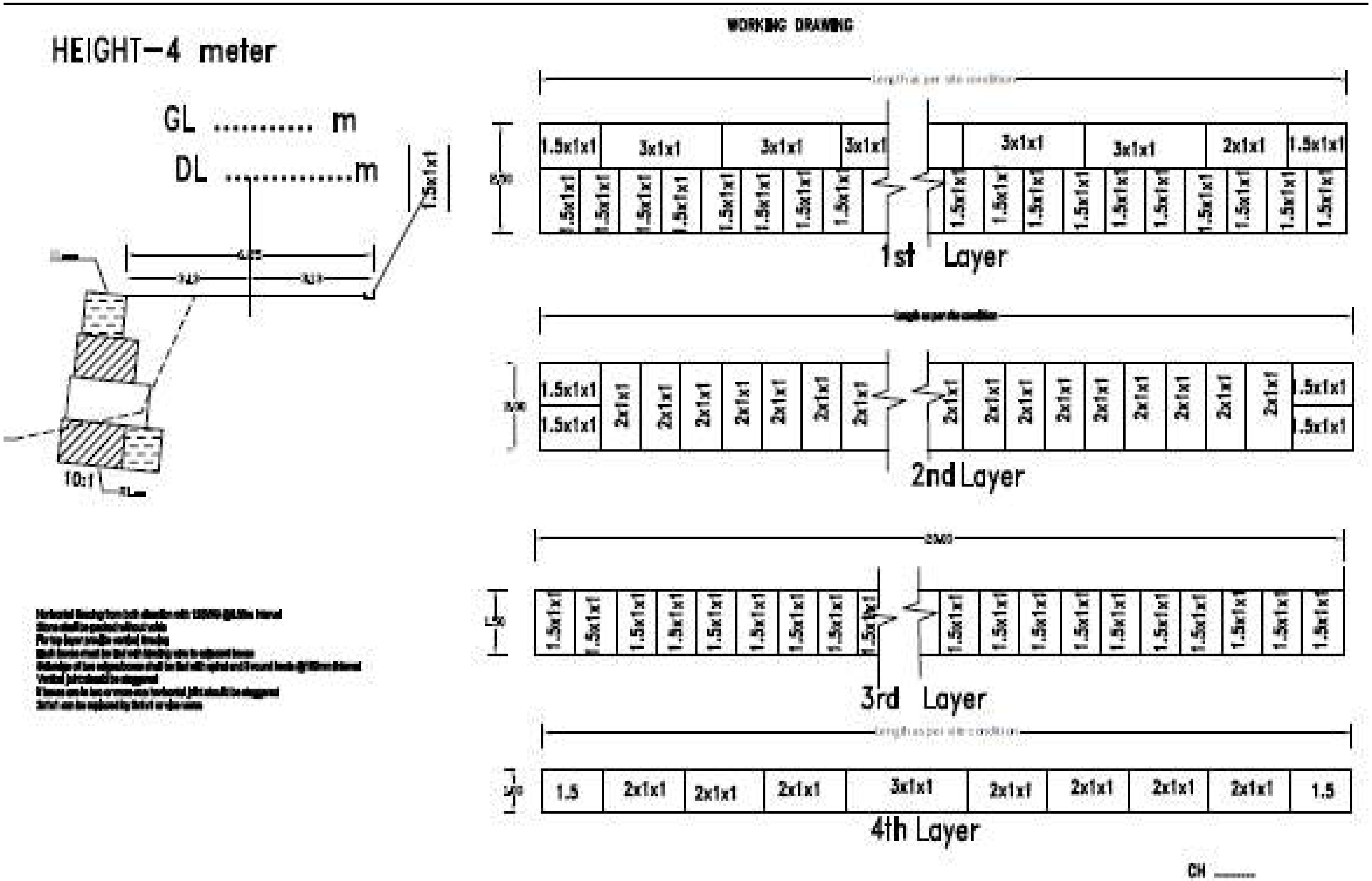
Photo: Samar Khanal - Sindhuli

Demo Block of Gabion for Quality Control

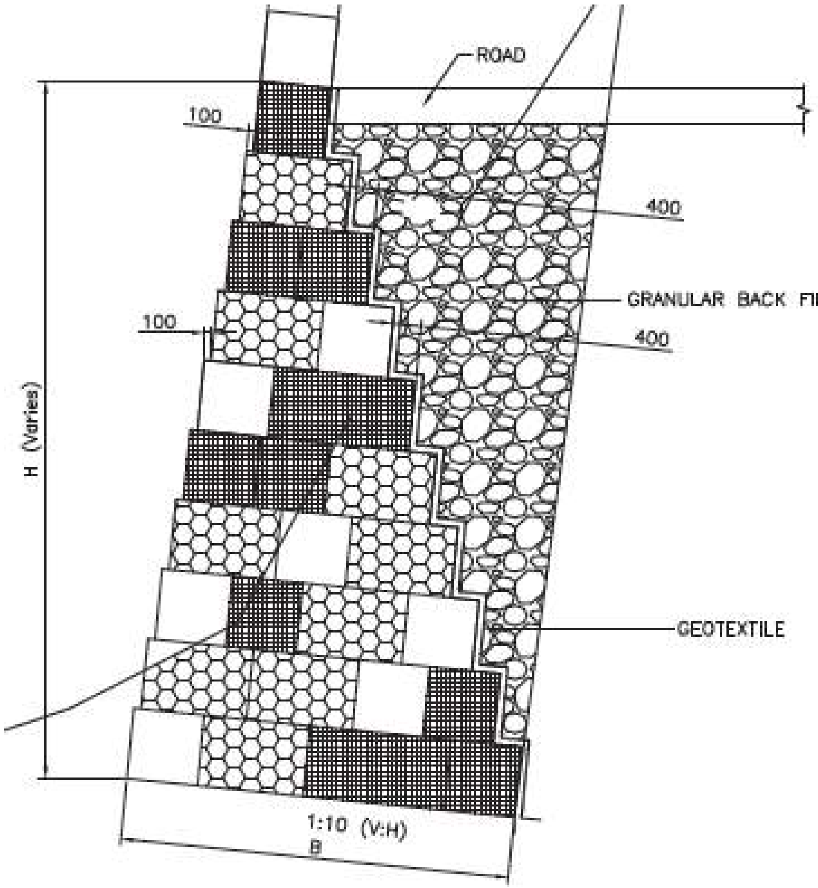
Photo: Ram Babu Paudyal , EEAP ADB, Gorkha

Photo: Ram Babu Paudyal ,Samar Khanal

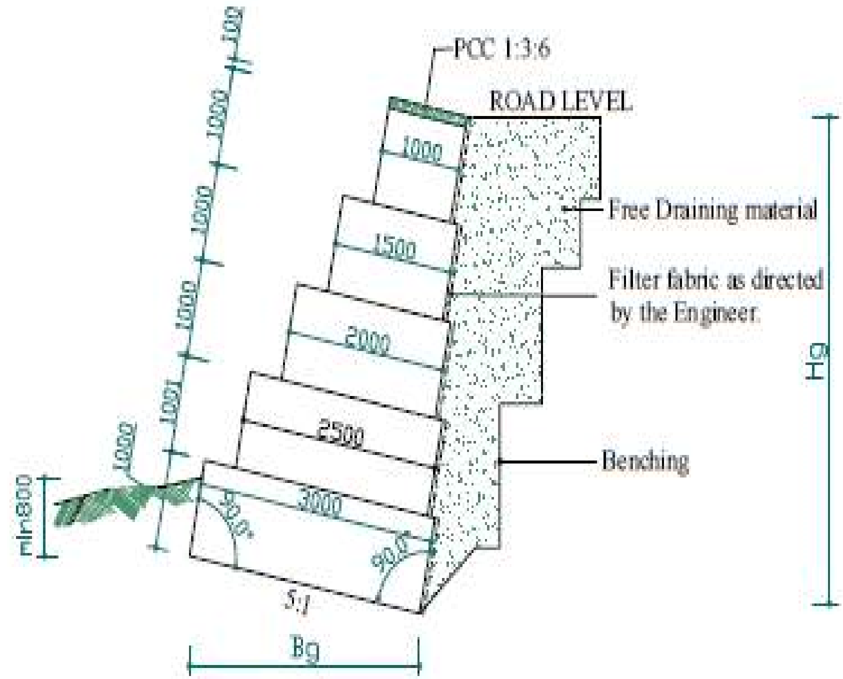
Layer wise Plan and Section of Gabion is most essential before layout



Layer wise Plan and Section of Gabion is most essential before layout



GRAVITY GABION WALL (Back Batter)



Profile 1

Bracing in Gabion Wall

Please write email for reference material

Plum Concrete Wall

- Please write email for reference material

Cross Drainage Structures - Pipe Culvert

- Width of pipe bed is cut minimum of 150mm on either side of pipe not exceeding one-third the diameter of pipe and should be as vertical as possible
- Replace unsuitable material of foundation
- In Rocky areas , Excavate only 200 mm below the bottom
- The minimum bed slope for pipe bed shall be 1:20

Bedding

- M15 Concrete –if height of fill is more than 4 m
- continuous layer of well compacted sand, or approved granular material, passing 4.75 mm sieve if height of fill less than 4 m – thickness minimum 75 mm , 450 mm for expansive soil

Cross Drainage Structures , Pipe Culvert , Slab Culvert and Causeways)

- Lay the pipes on the prepared foundation, commencing from outlet and proceed towards the inlet.
- Fill the jointing space with1:2 cement
- cover the joint with wet jute to make the joint damp at least for four days.
- Back fill trenches, On top of pipe up to 300 mm, thoroughly ram, tamp or vibrate the soil in two layers
- Provide minimum cushion of 600 mm or the diameter of pipe whichever is greater
- In case of Cushion Can not be Provided, enclose the pipe in M 10 concrete of specified thickness not less than 200 mm

Test Prior to Construction

S.N	Material / Work	Test / Check	Frequency
1	Concrete Pipe	- Dimensions - Manufacturing defects - Tolerances - Three edge bearing test	At factory before delivery Manufacturer's certificate

Test During Construction

S.N	Material / Work	Test / Check	Frequency
1	Bedding	• Materials (As per Spec) • Length, width and thickness • Top and bottom levels	While laying
2	Laying and Jointing of pipe	• Invert level • Longitudinal gradient • Spacing • Jointing of pipes • Damage to pipe during laying	Before back filling Before laying pipe

Test During Construction

S.N	Material / Work	Test / Check	Frequency
3	Backfill	Filling of trench on both sides (simultaneously) Tamping around pipe	During filling earth / granular material around pipe after laying
4	Cushion over pipes	Thickness	While filling

Photo: Ram Babu Paudyal, RAP , RAIDP

Material Testing Procedure

By

Sujit Dhital

1.Maximum Dry Density and Optimum Moisture Content

- **AIM:** To determine the maximum dry density and the optimum moisture content of soil using heavy compaction as per IS: 2720(Part 8) - 1983.(Modified Proctor)

Principle :Increase in density of soil due to compaction depend upon

- moisture contain of soil
- Compaction effort

The increase in moisture contain will increase the dry density first and then decrease with further increase in moisture contain.

The *M/C* at which the soil attain the max. dry density is called the optimum moisture contain(*OMC*) and the density is called Maximum dry density(MDD)

Apparatus

- Cylindrical metal mould - 100mm dia.and 1000cc volume or 150mm dia. and 2250cc volume (height-127.3mm)
- Balances - 20kg capacity, sensitive to 1g and the other of 500g capacity, sensitive to 0.01g
- Rammer :5cmDia circular face,weigth-4.89 kg,drop 45cm

- Oven –capable to maintain 105 -110 c.
- Steel straightedge - 30cm long
- IS Sieves of sizes - 4.75mm, 19mm

Choice of Mould

If the material retained on 4.75 mm sieve is less than 20%, use 100 mm diameter mould and if the material retained on 4.75 mm sieve is more than 20%, use the mould of 150 mm diameter

Preparation of Sample

- Take the air dried sample of soil of about 20 kg for 1000 cc mould or 45 kg for 2250 cc mould.
- Sieve this soil sample through 20 mm and 4.75 mm sieves.
- Calculate the percentage retained on 20 mm and passing from 4.75 mm sieve.

5.

- Mix the both the soil sample retained on and passing from 4.75 mm sieve thoroughly obtained homogenous mixture.
- For Heavy Compaction take about 2.8 kg for the 1000 cc mould or 6.5 kg 2250 cc mould.
- Mix the soil sample with so that the moisture content to about 2% for coarse-grained sand and 4 % for fine-grained soils.

Test Procedure

- *Clean, dry and grease lightly the mould* and base plate. Weigh the mould with base pate(w1)
- Fit the extension collar and place the mould on a solid base.
- *Compact the wet soils in 5 equal layers* with rammer of 4.89 kg with 25 blows in each layer blows for 100 mm ϕ mould and 56 blows for 150 mm ϕ mould.

11.

- Trim sample evenly at the top edge of mould using the straight edge flushing with the top of the mould. Fill the voids in the surface of compacted sample with loose soil collected from around the base plate.
- Weigh the mould with soil and base plate (w2)
- Obtain a representative soil sample from the bottom, middle and top for water content determination(w)

- Break up the remainder of the sample. Add the broken up sample to the remainder of the sample being used for the test.
- Add water to the sample to increase the overall moisture content by about 2-3% Continue compacting samples with moisture contents increasing by roughly 2-3% until there is a drop or no change in the calculated wet density.

- Enter all records (observations) in Work Sheet.
- Calculate the wet/dry density as

$$\gamma = \frac{(w_2 - w_1)}{v} \qquad \gamma_d = \frac{100 * \gamma}{100 + w}$$

- Plot γ_d vs w for all test and obtain MDD &OMC

test format.xlsx

6. Field Density (Sand Replacement Method)

Aim: To determine the in situ density of soil by sand replacement method

Apparatus:

- Sand-pouring cylinder
- Cylindrical calibrating container
- Bent spoon,Hammer,Chiseal,
- Glass plate - 450mm square and 9mm thick

- Containers
- Metal tray - 300mm square and 40mm deep with a 100mm hole in the centre

- Balance
- Moisture Meter
- Sand passing through 1mm and retain in o.6mm

Procedure

Calibration of apparatus

- Fill the pouring cylinder with sand upto about 10mm of the top. Weigh it (W1) and maintain it through out the test.
- Allow the volume of sand equivalent to that of the excavated hole in the soil (or equal to that of the calibrating container) run out of the cylinder under gravity.

- Close the shutter of the pouring cylinder
- Placed the cylinder on a plain surface, such as a glass plate.
- Open the shutter of the pouring cylinder
- Close the shutter When no further movement of sand takes place
- Remove the cylinder carefully
- Collect the sand left on the plain surface and weight to nearest gram(W2)

- Repeat the process thrice and the mean weight (W2) taken.
- Determine the internal volume (V) in ml of the calibrating container by measuring the internal dimension.
- Fill the pouring cylinder to constant weight (w1)
- Place the cylinder concentrically on the top of the calibrating container

- Opened the shutter and allow the sand to run out.
- Close the shutter when no further movement of sand takes place
- Weight the pouring cylinder to the nearest gram.
- Repeat the process thrice and the mean weight (W3) taken.

- Weight of sand (Wa) , required to fill the calibrating container

$$W_a = W_1 - W_3 - W_2$$

- The bulk density of the sand (γ_s) is calculated as

$$\gamma_s = \frac{Wa}{V}$$

Determination of Soil density

- Place the metal tray with centre hole on the plat surface
- Dig the hole to the depth of 15cm and take out all the material from the hole and weight it
- Sieve the sample from 19mm sieve
- Weight the material retain.
- Determine the moisture contain by using rapid moisture meter.

- Place the pouring cylinder with sand (Total weight W1) in such a way that base of the cylinder covers the hole concentrically
- Open the shutter of the cylinder dnd allow the sand to flow.
- No vibration is allowed in and around the area during the pouring of sand.
- Close the shutter when no further movement of sand take palce

- Remove the cylinder take the weight (W4)
- Fill the data in the calculation sheet and determine the dry density as mentioned
- test format snrtp.xlsx

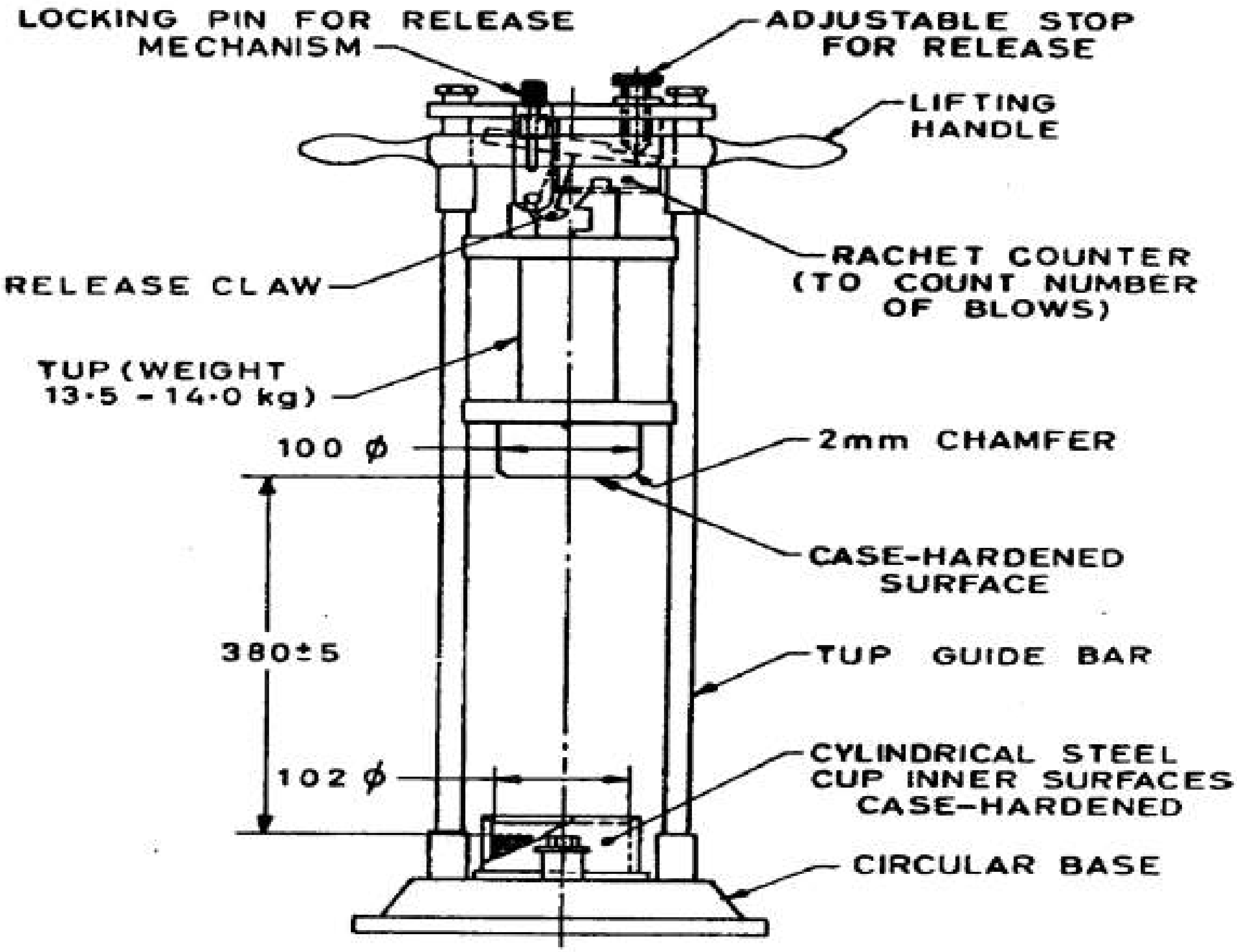
2.Aggregate Impact Value(AIV)

AIM: To determine the aggregate impact value of coarse aggregates as per IS: 2386 (Part IV) - 1963.

Apparatus

Impact testing machine

Sieves o - 12.5mm, 10mm and 2.36mm



All dimensions in millimetres.

FIG. 2 AGGREGATE IMPACT TEST MACHINE

- A cylindrical metal measure of 75mm dia. and 50mm depth
- A tamping rod of 10mm circular cross section and 230mm length, rounded at one end
- Oven

Preparation of Sample

- The test sample should Passing through 12.5mm and Retention on 10mm Sieve
- The sample should be oven-dried for 4hrs. at a temperature of 100 to 110oC and cooled to room temp.

Procedure

- Fill the measure in three equal layer by giving 25 strokes by the tamping rod.
- Determine t weight of the aggregates in the measure to the nearest gram (Weight 'A').
- The cup of the impact testing machine should be fixed firmly in position on the base of the machine

- **Place** whole of the test sample in cup of Machine and compact by 25 strokes of the tamping rod.
- Raise the Hammer to 380 ± 5 mm above the upper surface of the aggregates in the cup and allowed to fallfreely onto the aggregates.
- Provide 15 such blows, each being delivered at an interval of not less than one second.

- Remove the sample and sieved through a 2.36mm IS Sieve.
- Weight the fraction retain(B) and Passing through the sieve('C).
- If (B+C) is less than (A) by more than onegram, the result should be discarded and a fresh test done.

Calculation of AIV

$$AIV = \frac{(A-B)}{A} \%$$

OR

$$AIV = \frac{C}{A} \%$$

3.Aggregate CrushingValue (ACV)

- To determine the aggregate crushing value of coarse aggregates
- as per IS: 2386 (Part IV) - 1963.
- **APPARATUS**
- Steel Cylinder
- Cylindrical measure and plunger
- Compression testing machine
- Sieves of sizes - 12.5mm, 10mm and 2.36mm

Sample Preparation

- The aggregates passing through 12.5mm and retained on 10mm IS Sieve are oven-dried at temperature of 100 to110oC for 3 to 4hrs.
- About 6.5 kg of sample is required
- Fill the cylindrical measure in 3 layers, each layer tamped with 25 strokes of a tamping rod.
-

iv)

- The weight of aggregates is measured (Weight 'A').
- Place the cylinder of the test apparatus in base plate
- Place the weighted sample in three layer each layer tampped 25 time with tamping rod
- Level the surface of the aggregates and the insert the Plunger.

- Placed the apparatus in the compression testing machine
- Apply the load at a uniform rate so as to achieve 40t load in 10 minutes
- After applying load released the load
- Sieve the sample through a 2.36mm Sieve
- Weight the fraction retain in the sieve (Weight'B') and passing through sieve (Weight "C")

- Weight passing the sieve is expressed as the % of originals sample
- Conduct two tests and report the average value as ACV

$$ACV = \frac{(A-B)}{A} \%$$

4.Specific Gravity and Water Absorption

Aim: to determine the Sp. Gravity and Water absorption of the aggregate

Principal: Sp. Gravity/Water absorption ars also consider to be a measure for the strength of the agg.

Sp gravity ↑ Strength ↑

Water absorption ↑ Strength ↓

Apparatus

- Hook Balance
- Oven
- Wire basket
- Container
- Tray and Absorbent Cloth

Procedure

- Take two kg of Sample. Wash,remove the fine and drain the water

- Keep the sample in wire basket and immerge in water(5cm above the top of basket) at temp22-32°c
- Lift the basket 25 mm above the base of tank and drop.
- Continue Lifting and dropping for 25 @1 drop per sec.
- Keep the basket and agg immerse in water for 24 hr.

- After 24 weight the basket and sample in water (w1)
- Place the agg. in an absorbent sheet and make it surface dry. Do not expose in direct sun light.
- Weight the empty basket in water after jolting in water for 25 times(w2)
- Weight the surface dry aggregate(w3)
- Dry the agg. Keeping it in oven for 24 hr. and take the wegth (w4)

Calculation

$$\text{Specific Gravity} = \frac{W_4}{W_3-(W_1-W_2)}$$

$$\text{Water absorption} = \frac{W_3-W_4}{W_4} * 100\ \%$$

5. LAA

Sieve Size (mm)		Mass of Indicated Sizes (g) Grading						
Passing	Retained on	A	B	C	D	E	F	G
80.00	63.00	-------------	-	-----	-----	2500*	--	--
63.00	50.00	-------------	-	-----	-----	2500*	--	--
50.00	40.00	-------------	-	-----	-----	5000*	5000*	--
40.00	25.00	1250	-	-----	-----	-------------	5000*	5000*
25.00	20.00	1250	-	-----	-----	-------------	--	5000*
20.00	12.50	1250	2500	-----	-----	-------------	--	--
12.50	10.00	1250	2500	-----	-----	-------------	--	--
10.00	6.30	------------	-	2500	-----	-------------	--	--
6.30	4.75	------------	-	2500	-----	-------------	--	--
4.75	2.36	------------	-	-----	5000	-------------	--	--
	Total	5000	5000	5000	5000	10000±200	10000±200	10000±200
No of Spheres		12	11	8	6	12	12	12

* Tolerance of ± 2% permitted

Specimen No	Grade	No. of Charge	No. of Revolution	Weight Before Test (gm)	Weight in grams after test		% wear	Mean Wear (%)
					Retained on 1.7 mm seive	Passing 1.7 mm seive		
1	A	12	500	5000	3485	1515	30.30	30.43
2	A	12	500	5000	3472	1528	30.56	

6. CBR test

The ratio expressed in percentage of force per unit area required to penetrate a soil mass with a circular plunger of 50 mm diameter at the rate of 1'25 mm/min to that required for. corresponding penetration in a standard material.

The ratio is usually determined for penetration of 2.5 and 5 mm. Where the ratio at 5 mm is consistently higher than that at 2'5 mm, the ratio at 5 mm

is used.

Apparatus: Moulds with Base Plate, Stay Rod and Wing Nut, Collar 3.3 Spacer Disc Metal Rammer Expansion Measuring Apparatus adjustable stem with perforated plates and tripod, Weights

Loading Machine - With a capacity of at least 5 000 kg and equipped with a movable head or base which enables the plunger to penetrate into the specimen at a deformation rate of 1.25 mm/min-

.

The machine shall be equipped with a load machine device that can read to suitable accuracy

Penetration Plunger,Dial Gauges - Two dial gauges reading to 0'01 mm.

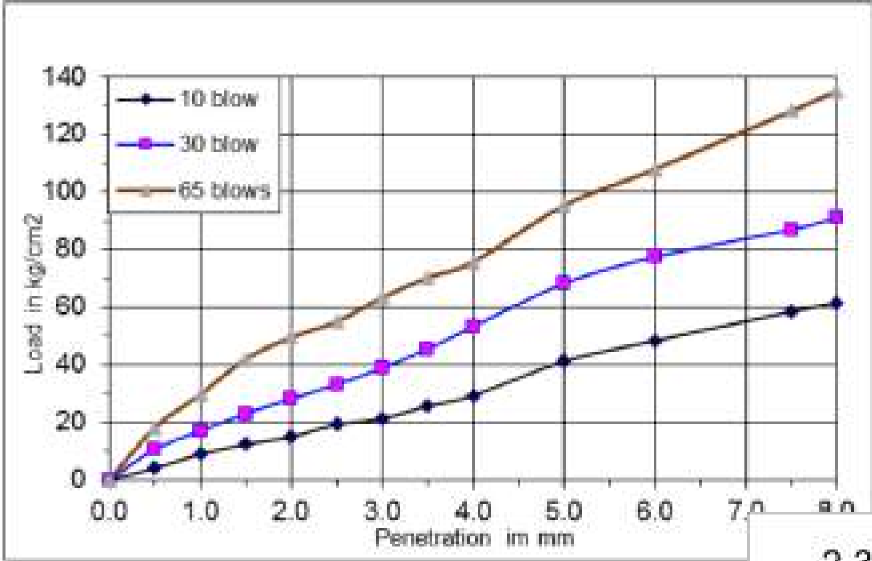
3.10

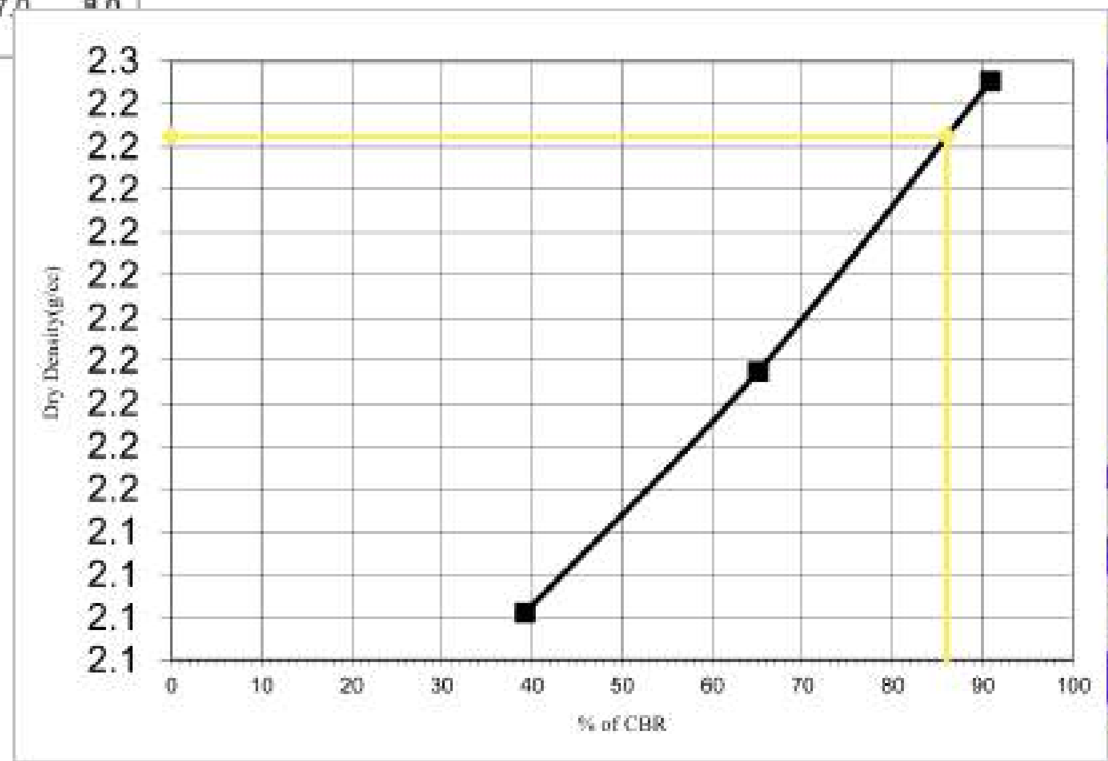
Sieves - 47'5 mm IS Sieve and 19 mm IS 3.11 Miscellaneous Apparatus

Penetration (mm)	Standard Load, kg/cm2	Mould No. -11			
		Test Load		Corrected Load, kg/cm2	CBR %
		Dial gauge(Div.)	kg		
0.0		0	0.0	0.00	
0.5		14	79.2	4.03	
1.0		31	175.3	8.93	
1.5		43	243.2	12.39	
2.0		52	294.1	14.99	
2.5	**70**	67	379.0	19.31	**27.59**
3.0		74	418.5	21.33	
3.5		89	503.4	25.65	
4.0		102	576.9	29.40	
5.0	**105**	143	808.8	41.21	**39.25**
6.0		168	950.2	48.42	
7.5		203	1148.2	58.51	
8.[illegible]		214	1210.4	61.68	

Penetration Depth	Unit Standard Load	Total Standard Load
(1)	(2)	(3)
mm	kg/cm^2	kgf
2·5	70	1 370
5·0	105	2 055

Calculation sheet


10 blow
30 blow
65 blows
Load in kg/cm2
Penetration im mm
0
20
40
60
80
100
120
140
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0


Dry Density(g/cc)
% of CBR
2.3
2.2
2.1
0
10
20
30
40
50
60
70
80
90
100

7. Test of Bitumen

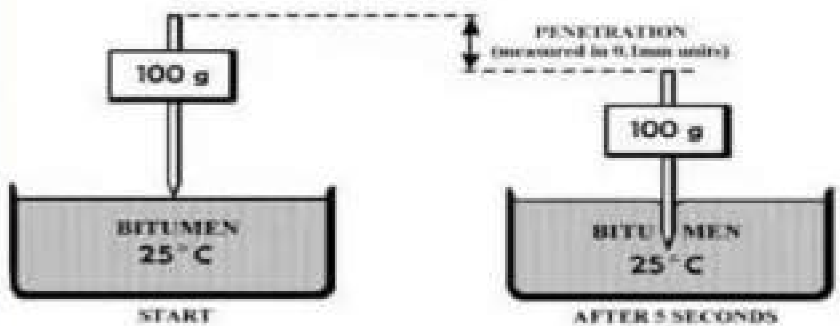
- Test required
  - Penetration at 25^{o}c
  - Absolute viscosity at 60^{o}c
  - Kinamtic Viscosity at 135^{o}c
  - Flash point
  - Solubility in trichloroethylene
  - Test on residue from rolling thin oven test
    - Viscosity ratio at 60oc
    - Ductility at 25 oc

Penetration Test

Penetration test of Bitumen determines the **hardness or softness of bitumen** by measuring the **depth in millimeter** to which a standard loaded needle will penetrate vertically in five seconds while the temperature of the bitumen sample is maintained at 25 0C

- Apparatus Required

Penetometer,Penetration Needle,Sample cup,Water bath ,Thermometer, Heater

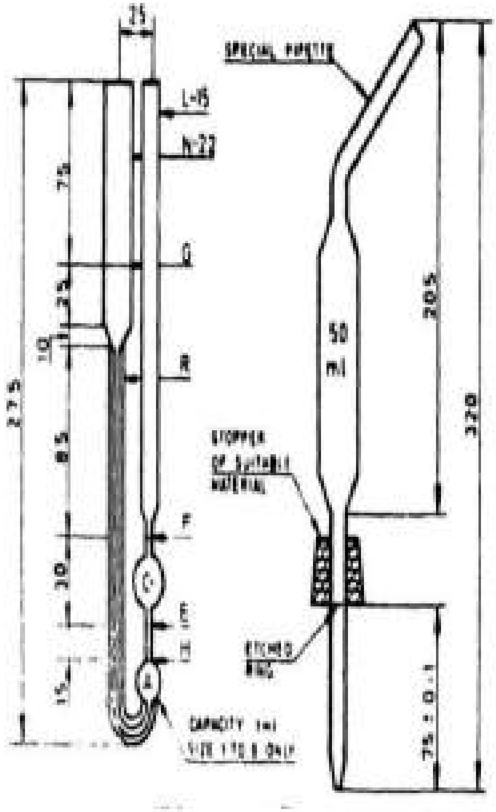


- Penetration value is the average of 3 penetration value which do not differ by more than the following
-

Penetration value	0-49	50-149	150-249	25-350
Max difference between highest and lowest value	2	4	6	8

Kinematic Viscosity

Viscometer Tube



Viscometer Bath

Pour sample through tube N just above filling mark G, allow to flow freely through capillary taking care that the liquid column remains unbroken until the lower mark H and then arrest its flow by closing the timing tube with a cork or rubber stopperintube L.Add more liquid, if necessary to bring the upper meniscus slightly above mark G. After allowing the sample to attain bath temperature and any air bubble to rise to the surface (usually about 20-30 min is required), gently loosen the stopper allowing the sample to flow until it is approximately at the lower filling mark H and press back the stopper to arrest flow. Remove the excess sample above filling mark G by inserting the special pipette until its cork rests on top of the tube N and apply gentle suction until air is drawn through. The upper meniscus shall coincide with mark G.

Allow the viscometer to remain in the constant temperature bath for a sufficient time to ensure that the sample reaches temperature equilibrium. It takes 25 minutes 100°C and 30 minutes at 135°C. Remove the stopper in the tube N and L respectively and allow the sample to flow by gravity. Measure to the nearest 0.1 s the time required for the leading edge of the meniscus to pass from timing mark E to timing mark F. If this efflux time is less than 60 s select a viscometer of smaller capillary diameter and repeat the operation

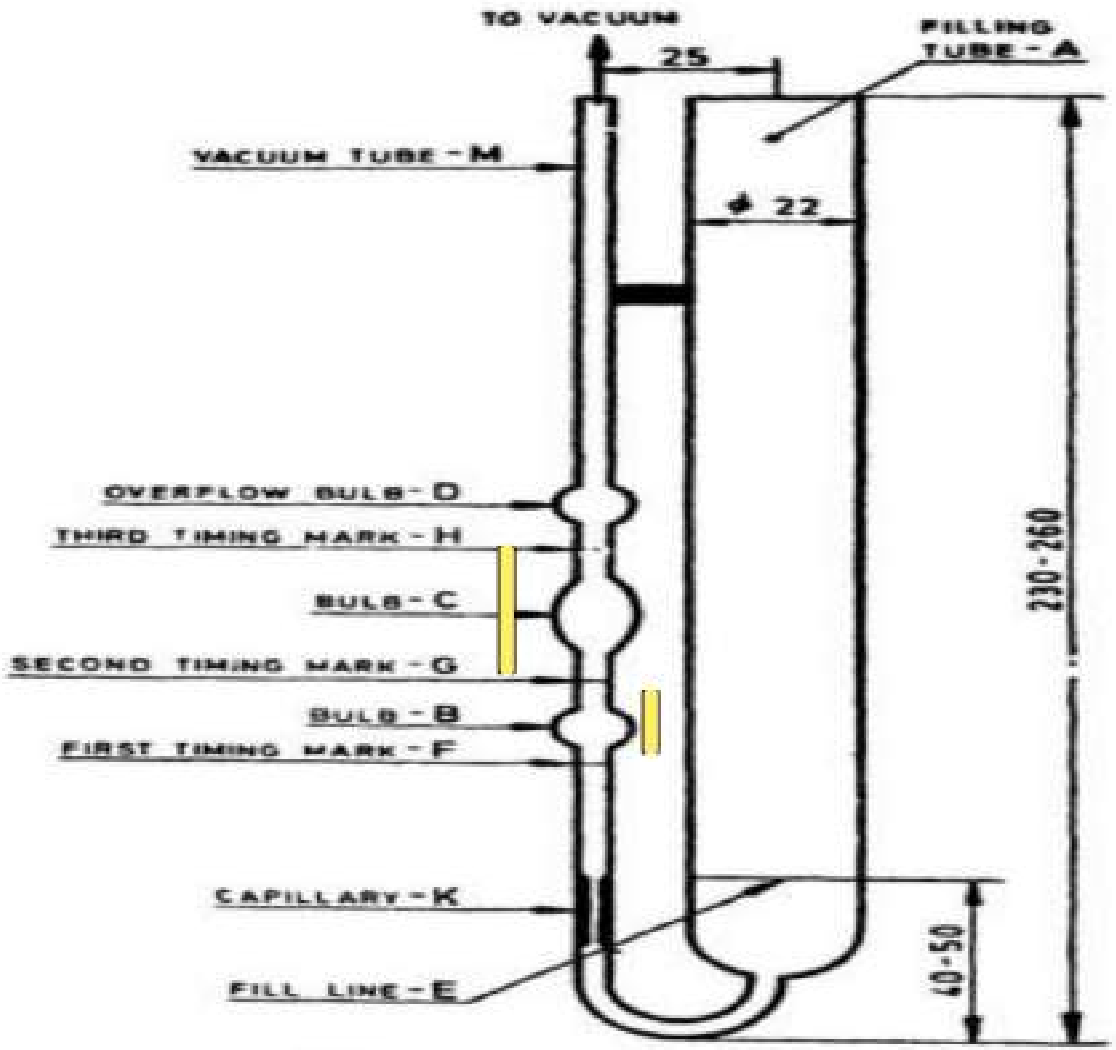
- Sample temperature : less than 90 and more than softening point
- Weight of sample = 20 gram
- Kinematic viscosity cSt= Ct

Where C: Calibration constant of the viscometer ,cSt

t: efflux time in sec

Absolute Viscosity

- Cannon-ManningVacuums Viscometer
- AsphaltInstituteVacuum Viscometer
- Modified Koppers Vacuum Viscometer
- Apperatus
  - Temperature bath
  - Pressure system (30±0.05 cm of mercury)
  - Thermometer and timing device



All dimensions in millimetres.

FIG. 1 CANNON-MANNING VACUUM CAPILLARY VISCOMETER

Viscometer Size No.	Approximate Calibration Factor 30 cm Hg Vacuum Poises per s		Viscosity Range Poises		
	Bulb B	Bulb C			
10	2.0	0.6	36	to	800
11	6.0	2.0	120	to	2 400
12	20.0	6.0	360	to	8 000
13	60.0	20.0	1 200	to	24 000
14	200.0	60.0	3 600	to	80 000

For all viscometer sizes the volume of measuring bulb *C* is approximately three times that of bulb *B*. The viscosity ranges correspond to a filling time of 60 and 400 s for both measuring bulbs.

$$\text{ViscosityPoises} = K_b t_b + K_c t_c$$

where
K=selected calibration factor,in poise per second;
and
t =flow time, in seconds.

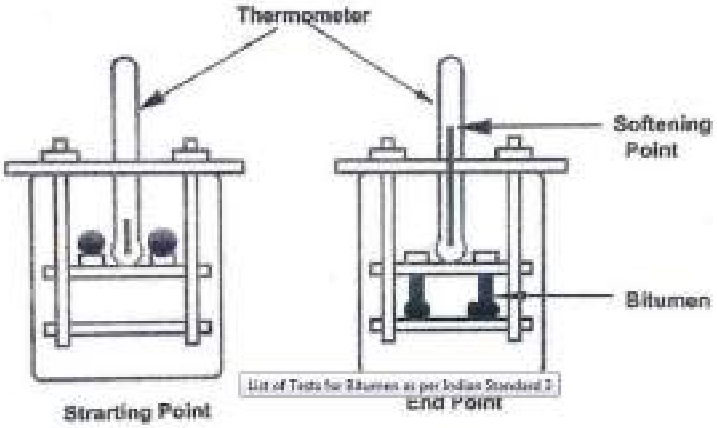
Flash Point

- Temperature where the flash appear at any point on the surface of bitumen.
- The flash point measures the tendency **to form a flammable mixture with air** while the fire point indicates the tendency of sustained burning.
- Corrected flash point : FP+0.03(760-atmospheric pressure) and report it to nearest 2^{0}c

Solubility in Trichloroetylene

2gm of bitumen and
100 ml of
trichloroethylene

Softening Point (Ring and Ball)



A steel ball is placed upon the bitumen sample and the liquid medium is heated at a rate of 5°C per minute. Temperature is noted when the softened bitumen touches the metal plate which is 25mm below.
Generally, higher softening point indicates lower temperature susceptibility and is preferred in the hot climate.

Viscosity ratio

Viscosity Ratio — It is the ratio of viscosity of residue from rolling thin film oven test to unaged bitumen, both measured at 60°C.

Rolling Thin Film Oven (RTFO) Test **measures the effect of heat and air on a moving film of hot mix asphalt binder**, simulating short-term aging that occurs during production and paving operations.

This is important for investigating and predicting early age HMA pavement behavior and distress.

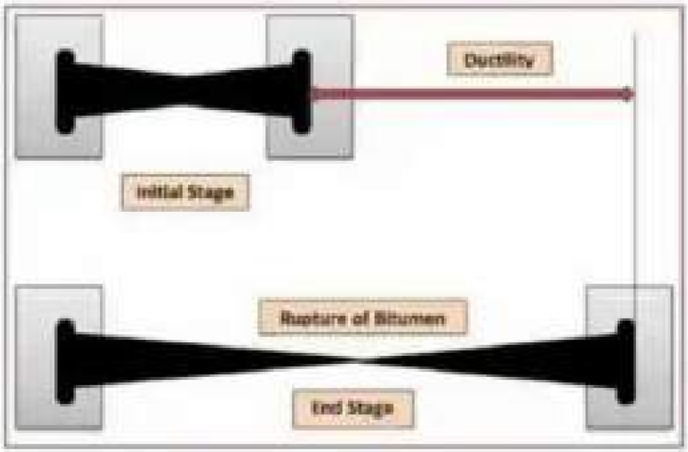
How to Do RTFOT

- Place the bitumen in glass bottle , and plasced them in specially designed oven
- Rack slowly rotate the bottle maintaining the test temperature of 323^{o}C
- *Air* is blown to the bottle for few second in every rotation
- Test is continued for 75 min
- Loss of bitumen is determined

- Bitumen and heated and poured in another tin for further testing
  - Viscosity ratio and ductility
- High percentage loss indicate that binder might be prove to age hardening, shrinkage and cracking

Ductility

- Ductility Test Apparatus conducts ductility tests of bituminous materials to **measure the elongation of a binder specimen before failure**.
- The ends of a molded specimen are pulled apart in a liquid-filled trough at speed of 5 cm per minute
- Temperature of liquid shall be 25 °c


Ductility
Initial Stage
Rupture of Bitumen
End Stage

THANK YOU

Construction Procedure of Premix Carpet

Sujit Dhital

Contact : 9843421686

Date : 2 Sept.2021

Premix Carpet

- Premix Carpet (PMC) is a type of bituminous mix which is commonly used as overlay on urban section and as a surface course on low volume road
- Type of Premix Carpet
  - OPEN-GRADED PREMIX SURFACING
  - CLOSE-GRADED PREMIX SURFACING/MIXED SEAL SURFACING
    - Type A
    - Type B

- Open graded premix carpet is similar to open graded asphalt friction course (OGFC) used (in western countries) to over bituminous concrete to provide skid resistance
- Sand seal coat is usually provided over PMC (open graded) to prevent entry of water (India and Nepal)
- Close graded premix carpet have low permeability than the open graded premix carpet with sand seal.
- Type A. grading is recommended for use in areas having rainfall more than 150 cm per year. In other areas Type B grading may be used.
- Close graded premix is also known as Mixed Seal Surfacing

Material for Premix Carpet

- Binder
- Aggregate
  - Coarse aggregate (Open graded premix carpet)
  - Coarse and fine aggregate (close graded premix carpet)

Binder

The binder shall be viscosity grade bitumen of a suitable grade as specified in the Contract, or as directed by the Engineer, and satisfying the requirements of IS: 73. For selection of grade of bitumen guidance may be taken from Table below .

S No.	Characteristics	Paving Grades				Method of Test
		VG10	VG20	VG30	VG40	Ref to
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Penetration at 25°C, 100 g, 5 s, 0.1 mm, Min	80	60	45	35	NS: 221:2047 (Part III)/ IS: 1203
ii)	Absolute viscosity at 60°C, Poises	800-1200	1600-2400	2400-3600	3200-4800	NS: 237:2050 (Part VIII)/ IS: 1206 -2
iii)	Kinematic viscosity at 135°C, cSt, Min	250	300	350	400	NS: 237:2050 (Part VIII)/ IS :1206-3
iv)	Flash point (Cleveland open cup), °C, Min	220	220	220	220	NS: 237:2049 (Part VII)/ IS: 1448-69
v)	Solubility in trichloroethylene, percent, Min	99	99	99	99	NS: 221:2047 (Part IV)/IS: 1216
vi)	Softening point (R&B), °C, Min	40	45	47	50	NS / IS: 1205.
vii)	Tests on residue from rolling thin film oven test:					
a)	Viscosity ratio at 60°C, Max	4	4	4	4	NS: 221:2046 (Part II)/ IS: 1206-2
b)	Ductility at 25°C, cm, Min	75	50	40	25	NS: 221:2046 (Part I)/ IS: 1208

VG	General Application	Equivalent PG
10	Used in spraying applications, and can be used in very cold regions. Also used for the manufacture of bitumen emulsion & modified bitumen	80-100
20	It is used in areas of cold climate & high altitude	
30	It is the most suitable for Indian road condition.	60-70
40	The area with high stress concentration like intersections of roads, truck parking, heavy traffic. It can be used in higher temperatures	30-40

Selection Criteria for VG Paving Bitumen Based on Climatic Conditions

Lowest Daily Mean Air Temperature, °C	**Highest Daily Mean Air Temperature, °C**		
	Less than 20°C	20 to 30°C	More than 30°C
More than -10°C	VG-10	VG-20	VG-30
-10°C or lower	VG-10	VG-10	VG-20

Physical Requirements of Coarse Aggregate(CPMC)

Property	Test	Specification	Method of Test
Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075 mm sieve	IS:2386 Part I
Strength	LAAor AIV	Max 30% Max 24%	IS:2386 Part IV
Durability	Soundness either: SodiumSulphate or Magnesium Sulphate	Max 12% Max 18%	IS:2386 Part V
Polishing	Polished Stone Value	Min 55	BS:812-114

Property	Test	Specification	Method of Test
Water Absorption	Water Absorption	Max 1%	IS:2386.Part Ill
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%	IS: 6241
Water Sensitivity	Retained Tensile Strength*	Min 80%	AASHTO 283

* If the minimum retained tensile test strength falls below 80 percent, use of anti stripping agent is recommended to meet the requirement

Fine aggregate

- Fine Aggregates The fine aggregates shall consist of crushed rock, or natural sand or a mixture of both. These shall be clean, hard, durable, un-coated, mineral particles, dry; and free from injurious, soft or flaky particles and organic or deleterious substance
- The coarse and fine aggregates shall be so graded or combined as to conform following gradation for the close graded premix carpet (cpmc)

Combine Gradation of Aggregate(CPMC)

IS Sieve Designation (mm)	Cumulative Percent by Weight of Total Aggregate Passing	
	Type A	Type B
13.2	-	100
11.2	100	88-100
5.6	52-88	31-52
2.8	14-38	5-25
0.090	0-5	0-5

Proportioning of Materials

The total quantity of aggregates used for Type A or B close-graded premix surfacing shall be 0.27 cubic meter per square meter area.

Aggregate Requirement for the Open graded premix

Property	Test	Requirement	Test method
Cleanliness	Grain size analysis	Max. 5% passing 0.075 micron	IS:2386 Part I
Particle shape	Combined Flakiness and Elongation Indices	Max. 35%	IS:2386 Part I
Strength	Los Angeles Abrasion Value or	Max. 40%	IS:2386 Part IV
	Aggregate Impact Value	Max. 30%	IS:2386 Part IV
Durability	Soundness (Sodium or Magnesium)	5 cycles	
	Sodium Sulphate	Max. 12%	IS:2386 Part V
	Magnesium Sulphate	Max. 18%	IS:2386 Part V
Water absorption	Water absorption	Max. 2%	IS:2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate	Min. Retained Coating 95%	IS:6241
Water sensitivity	Retained Tensile strength*	Min. 80%	AASHTO 283

Water absorption shall be limited to a maximum of 1 percent. The Polished Stone Value, shall not be less than 55, when tested as per BS: 812-114.

Nominal Stone size 13.2 mm (passing 22.4 mm sieve and retained on 11.2 mm sieve) 0.18 m^3

Nominal Stone size 11.2 mm (passing 13.2 mm sieve and retained on 5.6 mm sieve) 0.09 m^3

Bitumen Requirement

- Prime coat

Type of Surface	Type of Cutback	Rate of Spray (kg/sq.m)
WMM/WBM	MC 30	0.6-0.9
Stabilized soil bases/ Crusher Run Macadam	MC 70	0.9-1.2

- Tack coat

Type of Surface	Rate of Spray (kg/sq.m)
Bituminous surfaces	0.40-0.60
Granular surfaces treated with primer	0.50- 0.60
Cement concrete pavement	0.60-0.70

- Bitumen for premix 22.0 kg and 19.0 kg per 10 square meter area of 20mm thickness for Type A and Type B surfacing respectively.
- For open graded premix carpet bitumen requirement is 14.6 kg for 10 square meter area of 20mm thickness

Weather Limitation

Laying shall be suspended when

- Water is present at surface
- Rain is imminent ,during the rain, fog, dust storm
- When the base/binder course is damp;
- When the air temperature on the surface where the material is to aid is less than $10^{o}c$
- When the wind speed measured 2 m above the surface is more than 40 Km/hr

Mixing, Laying and Rolling Temperature for Bituminous mix

Grade	Bitumen Temp.	Aggregate Temp.	Mixed Material Temp.	Laying Temp	Rolling temp
VG40	160-170	160-175	160-170	150 min	100 min
VG30	150-165	150-170	150-165	140 min	90 min
VG20	145-165	145-170	145-165	135 min	85min
VG10	140-160	140-165	140-160	130 min	80 min

Surface Preparation

- The underlying surface on which the bituminous surfacing is to be laid shall be prepared, shaped and conditioned to the specified lines, grade
- Before prime coat is applied the dust layer in the surface shall be removed out.
- While using mechanical broom and compressor care shall be taken such that the base aggregate shall not dislodged
- After brooming out slight water to suppress the dust will be beneficial
- No traffic shall be allowed in the prepared surface .

- Mark the edge for the priming
- The prime or tack coat shall be sprayed on to it at the specified rate.
- If during spraying, a nozzle becomes blocked or develops a defect, the spraying shall be made good with a hand spray, and the machine repaired before further spraying is commenced.
- After the application of Prime allow it to penetrate to the surface
- No traffic shall be allowed in the prime surface for **at least for one hr**. If traffic need to be open after this time sand blinding can be done.
- Depth of penetration of the prime should be between3-l0mm
- On the day of premix carpet tack coat is applied on the surface with the appropriate equipment

Preparation of Premix

- Hot mix plant of appropriate capacity and type shall be used for the preparation of the mix material
- The difference in temperature between the binder and aggregate shall at no time exceed 14°C
- Mixing shall be thorough to ensure all particles of the aggregates are coated uniformly.
- The mix shall be immediately transported from the mixer to the point of use in suitable vehicles or hand barrows

Laying and Compaction

- The pre mixed material shall be spread on a previously prepared surface by a paver unless specified otherwise in the Contract to the desired thickness, grades and cross fall (camber).
- Excessive use of blades or rakes shall be avoid
- Rolling shall begin at the edge and progress towards the centre longitudinally
- On super elevated and uni-directional cambered portions, it shall progress from the lower to upper edge parallel to the centre line of the pavement.
- When the roller has passed over the whole area once, any high spots or depressions, which become apparent, shall be corrected by removing or adding premixed materials

Laying and Compaction (contd.)

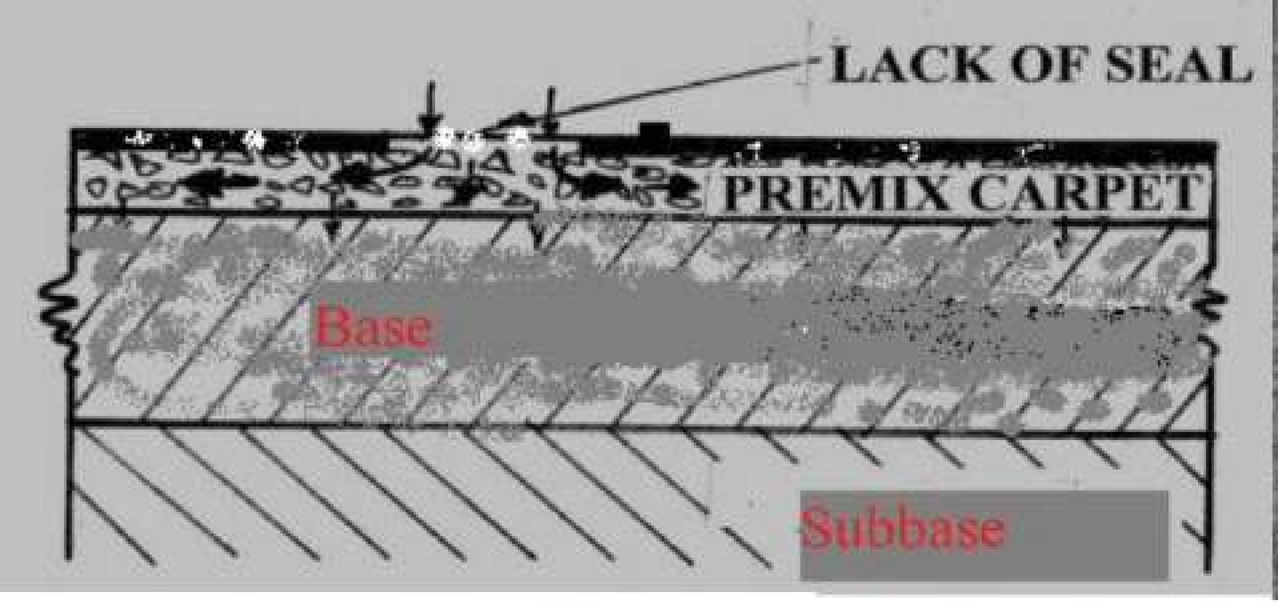
- Rolling shall then be continued until the entire surface has been rolled and **till the roller marks eliminated**
- In each pass of the roller the preceding track shall be overlapped uniformly by at least one third width
- The roller wheels shall be kept damp to prevent the premix from adhering to the wheels.
- **No** fuel/lubricating oil be used
- Rollers shall not stand on newly laid material
- Rolling operations shall be completed before the temperature of the mix falls below the rolling temperature(80 for VG10 and 100 for VG 40)
- Sand seal shall be applied immediately after the finishing of compaction of open graded premix carpet

Opening to Traffic

- For Close-graded premix surfacing, Type A or B Traffic may be allowed after completion of the final rolling when the mix has cooled down to the surrounding temperature. Speed restrictions may be imposed at initial stages.
- In case of the Open graded premix carpet the traffic shall be allowed in the following day after the application of seal coat.

Some Facts

- Water is number one enemy of bitumen.
- Water-trapping mixes fail prematurely especially during monsoons.
- This is simple common sense and not rocket science
- PMC is prone to intrusion of water which may further lead to pore pressure under traffic
- Due to moisture induced distress pothole and stripping of the aggregate take place.
- Sand seal over PMC prevent the entry of the water to some extent
- Non uniformity of sand seal due to manual method may not able to seal the surface completely


LACK OF SEAL
PREMIX CARPET
Base
Subbase


No Sand Seal


Moderate Sand Seal


Adequate Sand Seal


Bitumen Concrete
(Grade-2)

Finding of Research in India by Rajan Choudhary and team

- Permeability of PMC with no seal coat was found to be 25 time the MSS and 15 time after the seal coat application
- Critical permeability of $125*10^{-5}$cm/sec for dense graded hot mix asphalt (US standard)

Mix type	Average air voids (%)	Average permeability ($\times 10^{-5}$ cm/s)
PMC (without seal coat)	18.1	24159
MSS-A	12.6	761
MSS-B	13.6	907

Seal coat application (%)	Permeability ($\times 10^{-5}$ cm/s)
100	10967
75	12972
50	14889
0	22200

Photographs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JCB


12/03/2014 13:13


07/01/2014 15:13

Failure or Success

“American roads are good not because America is rich, but America is rich because American roads are good.” - John F. Kennedy

Transport Infrastructure Directorate
Bagamati Province

Training on Quality Control in Road Works

Session 11: Quality Control in Road Maintenance

Introduction

Current Practice

- Focused in New Construction and improvement
- Low Priority to Maintenance
- Insufficient budget allocation to operation and Maintenance

Effect

- Life and service of infrastructure is deteriorated
- Accessibility to service centers and Agricultural land became limited
- Transportation, O & M cost increases
- Unsafe, mostly during disaster i.e accident in road

Common problem in Roads

Sessions

Session I: Objective of Maintenance, Improvement and New Construction, Road Maintenance

Session II: Maintenance Planning

Session III: Implementation of Maintenance Activities – Road

Session IV: Repair, Maintenance and Up-gradation of Building

Session V: Maintenance of Community Infrastructure – Irrigation Canal, Trail Bridge and Water Supply Scheme

Session 11 a: Objective of Maintenance,

Improvement and New Construction, Types of Road Maintenance

Session 1: Objective of Maintenance, Improvement and New Construction, Type of Road Maintenance

Session Objective:

- Enhance the knowledge about Importance and types of Maintenance ,

Session Time: 90 Minutes

Discussion Points:

- Objective of Maintenance
- Difference among Maintenance , Improvement and New Construction
- Introduction to Road Maintenance

Group exercise: understanding of Maintenance, Improvement or New Construction

S. N	Name of the Construction activities	Maintenance , Improvement or New Construction	Remarks
1	Re- gravelling works in Road Section	Maintenance	Example
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			

General Definitions

- **MAINTENANCE:** ‘*the process of preserving the original condition or function of an asset*’
- **IMPROVEMENT:** ‘*addition or change that makes something better than it was before*’
- **NEW CONSTRUCTION:** ‘*the work of building*’

Maintenance Objectives

- Prevention:
  - Aimed at slowing down the rate of deterioration
  - E.g. continuous water management
- Correction:
  - Repair after the road has deteriorated
  - Bring the asset back close to its original condition
  - Results in lower travel times & costs
  - E.g. patching potholes in gravel road

Maintenance Definitions 1

❖**Emergency** - works that are to be carried out due to unexpected and sudden blockage of roads that stop vehicular movement due to natural disasters

- **Routine** - small maintenance works to be carried out in all seasons on all roads on a regular basis

Activities under Routine Maintenance

- Clearing of small landslides (<5m3)
- Clearing of drains
- Clearing of culverts
- Clearing under bridges
- Cutting and clearing of vegetation
- Cleaning of traffic signs and road furniture
- Cleaning of weep holes in retaining walls
- Maintenance of bioengineering features

Implementation of Routine Maintenance

Timing

- carried out throughout the year
- Most work is required just before and during the rainy season.

Cost estimation

- fixed amount per kilometer per year

Implementation

- No skilled labour is required
- RMG or UC , Performance Based Contract

- **Recurrent - small maintenance works that are carried out a few times a year in all roads to repair minor damage resulting from traffic and rainfall**

Activities under Recurrent Maintenance

- Repairs of rills/gullies in the road surface
- Repairs of ruts in the road surface
- Repairs of potholes in the road surface
- Repairs of corrugation of the road surface
- Repairs of backfills over culverts
- Creation of diagonal water bars across the road surface to avoid water flowing over the road
- Repairs of minor damage to retaining walls (e.g. replacing stones, fixing gabion wire)
- Repairs or replacement of traffic signs and road furniture

Implementation of Recurrent Maintenance

Timing

- Repeated a few times a year in different road sections, depending on need
- Most work is carried out in the dry season

Cost estimation

- Average quantities of work are largely predictable
- fixed amount per kilometer per year

Implementation

- No skilled labour is required
- RMG or UC , Performance Based Contract

❖**Specific -** **spot treatments and improvements and repairs that do not occur every year or in every road, and which are very specific in nature and location**

Activities under Specific Maintenance

- Dry stone pitching of short section
- Gravelling of short section
- Sealing of short section
- Blacktopping of short section
- Creation or large repairs to dry-stone retaining wall
- Raising of embankment over short section
- Shoulder improvement
- Slope stabilization and bio-engineering
- Removal of hanging cliff/rocks

Implementation of Specific Maintenance

Timing

- carried as needed out in a few road sections in different parts
- Most work is carried out in the dry season

Cost estimation

- Rapid Condition Survey to determine the volume of specific maintenance
- unit rates and the corresponding work volumes

Implementation

- Skilled labour is required
- Small Contractor or Users Committees

Periodic- Maintenance works to be carried out in intervals of years and of large-scale

Activities under Periodic Maintenance

- Repairing corrugations by dragging
- Repairing corrugations and loss of camber by grading
- Re-gravelling of road surface and shoulder (in existing gravel road)
- Resealing (in existing blacktop road)
- Surface dressing (in existing blacktop road)
- Placing an overlay (in existing blacktop road)
- Placing road markings
- Re- gravelling of road shoulder
- Painting of steel parts

Implementation of Periodic Maintenance

Timing

- repeated in a road every few years, depending largely on the surface type and traffic volume
- Work is carried out in the dry season

Cost estimation

- Rapid Condition Survey to determine the Length and volume of maintenance
- unit rates and the corresponding work volumes

Implementation

- Skilled labour is required
- Small or Medium Contractors

Improvement- road works in existing roads aimed at introducing significant and extensive changes to a road

Activities under Improvement

- Rehabilitation
- Widening
- Gravelling
- Blacktopping
- Bridge ,Slab culvert, Pipe Culvert, Cause Way construction
- Masonry/ Gabion wall construction
- Lined drain construction
- Raising of embankment
- Realignment of short section (e.g. in case of steep gradient)

Implementation of Improvement Activities

Timing

- Carried out as needed, improvement needs are identified every 5 years as part of (MTMP)

Cost estimation

- MTMP Survey of the full Municipality Roads
- The MTMP Report defines the different improvement works
- Based on MTMP work volumes, the estimated costs will be determined using current unit rates.
  Implementation
- Contract, mobilizing equipment and skilled labour

New Construction - **the construction of new roads linking up the settlement, service centers and other important places that are currently without road access**

Activities under New Construction

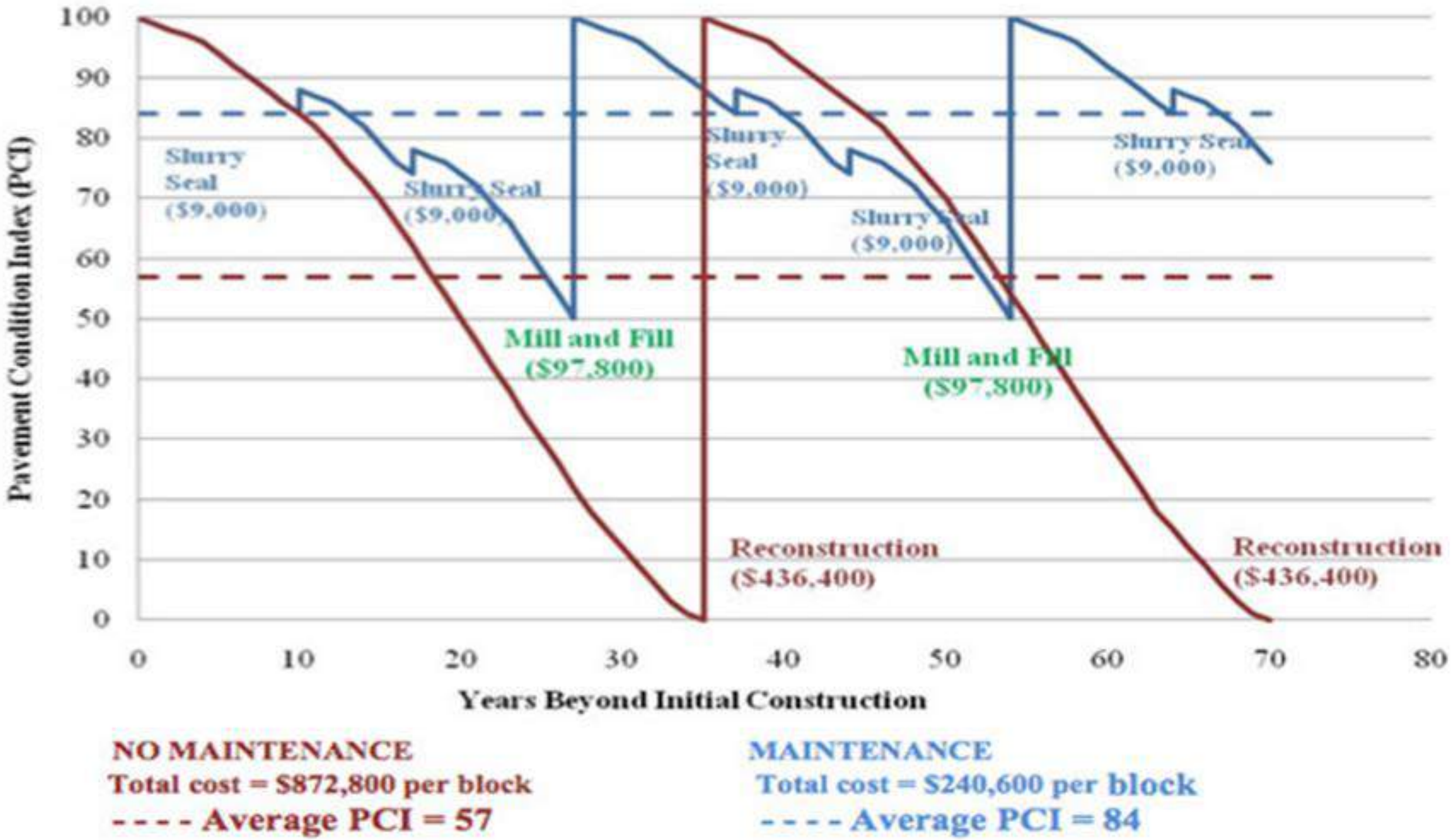
- Opening up (earthen standard)
- Gravelling
- Bridge construction

Implementation of New Construction Activities

Timing

- Dry Season ,
- first constructed to an earthen standard, and later improved to a gravel or blacktop standard
- **Cost estimation**
- MTMP Report defines the new construction works
- Based on MTMP work volumes, the estimated costs will be determined using current unit rates.
  Implementation
- Contract, mobilizing equipment and skilled labour , Unskilled Labour for track opening (LEP Approach)

Case Study


Pavement Condition Index (PCI)
100
90
80
70
60
50
40
30
20
10
0
Slurry
Seal
($9,000)
Slurry Seal
($9,000)
Mill and Fill
($97,800)
Slurry
Seal
($9,000)
Slurry Seal
($9,000)
Mill and Fill
($97,800)
Slurry Seal
($9,000)
Reconstruction
($436,400)
Reconstruction
($436,400)
0
10
20
30
40
50
60
70
80
Years Beyond Initial Construction
NO MAINTENANCE
Total cost = $872,800 per block
- - - - Average PCI = 57
MAINTENANCE
Total cost = $240,600 per block
- - - - Average PCI = 84

Individual Exercise or Questionnaire

1. **What are the Specific objectives of Maintenance**
   a) Improvement
   b) Prevention
   c) Correction
   d) All of the above
2. **Routine Maintenance activities are carried out**
   a) Once in the year
   b) Before Rain Start
   c) After Monsoon
   d) Throughout the year

Individual Exercise or Questionnaire

3. Gravelling of short section of a road falls under

a) Emergency Maintenance
b) Specific Maintenance
c) Improvement
d) Recurrent Maintenance

4. Cost Estimation of Periodic Maintenance is carried out by

a) fixed amount per kilometer per year
b) the volume of quantity and Corresponding rates
c) Length of Road Section and rate from MTMP
d) Lump Sum basis

Individual Exercise or Questionnaire

5. Initial Environment Examination may not require for

a) Specific Maintenance

b) Routine and Recurrent Maintenance

c) Emergency Maintenance

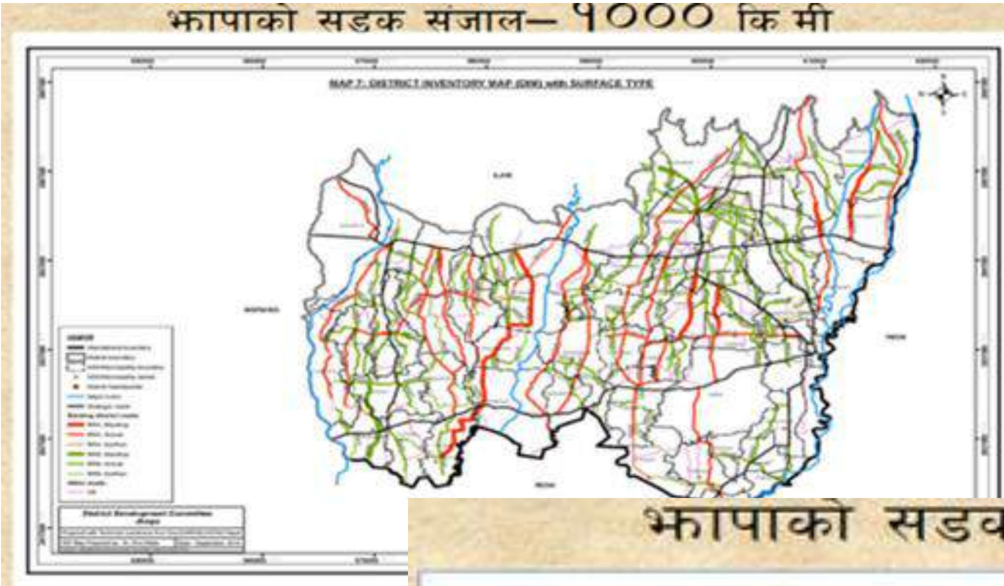
d) Improvement and New Construction

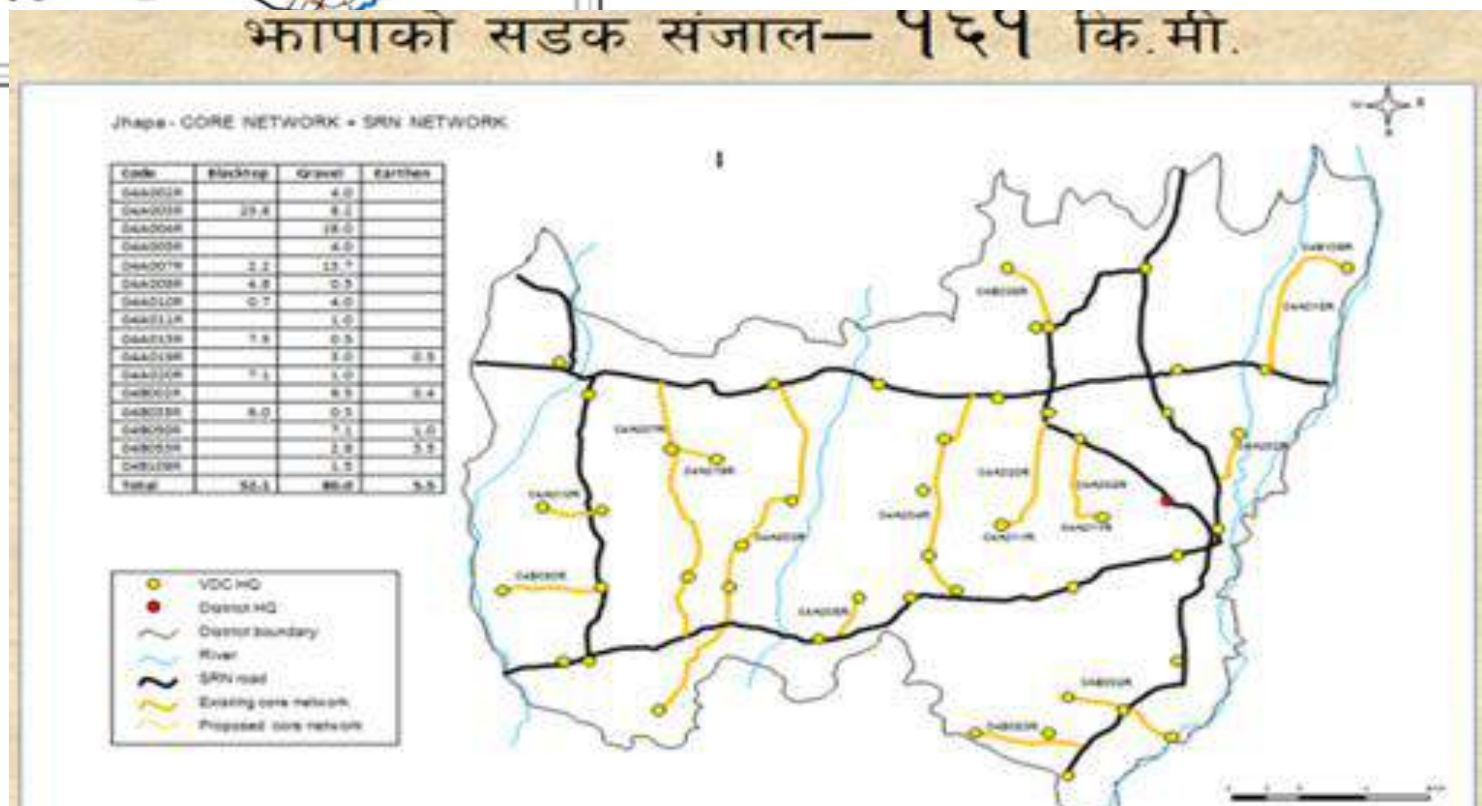
Effectiveness of Maintenance

- Most effective/cost effective when applied to roads already in good condition
- For a small investment keep the good roads good
- Diverting funds from good to bad roads will result in more good roads becoming bad
- Put new roads under immediate maintenance

Session 11 b: Maintenance Planning

Importance of planning in relation to the preparation of PTMP





MTMP – Municipal Transport Master Plan

- a prioritized list of interventions for the Municipal Roads
- estimated budget for the 5-year MTMP period
- Adjustment of the plan according to the actual budget and requirements

ARAMP – Annual Road Asset management Plan

- annual implementation plan for the Provincial Roads
- maintenance requirements are defined in greater detail
- estimated budget for every year period
- provides a prioritized list of interventions

What does ARAMP do?

- Details the annual plan from PTMP
- Combines maintenance, improvements and new construction in a single Plan
- Refines maintenance needs, uses; survey (emergency, specific & periodic), averages (routine & recurrent)
- Predicts the fund balance available for any Improvements & new Construction – allocates as per PTMP

Road inventory

- ❑ Carry out for all roads in the Municipality
- ❑ Record basic information of each road
- ❑ surface type (earthen, gravel, blacktop, other)
- ❑ Road Condition :
  - Good/Fair - Road is passable by normal car
  - Poor - Road is only passable by 4x4, bus, truck or tractor
  - Bad/Impassable - Road is not passable to 4-wheeled motorized vehicles

Rapid Condition Survey

- Each year after monsoon, update preliminary cost estimate of only Emergency, Specific and Periodic maintenance
- feed data to prepare ARAMP
- Routine & Recurrent not required to assess (directly use average rate)

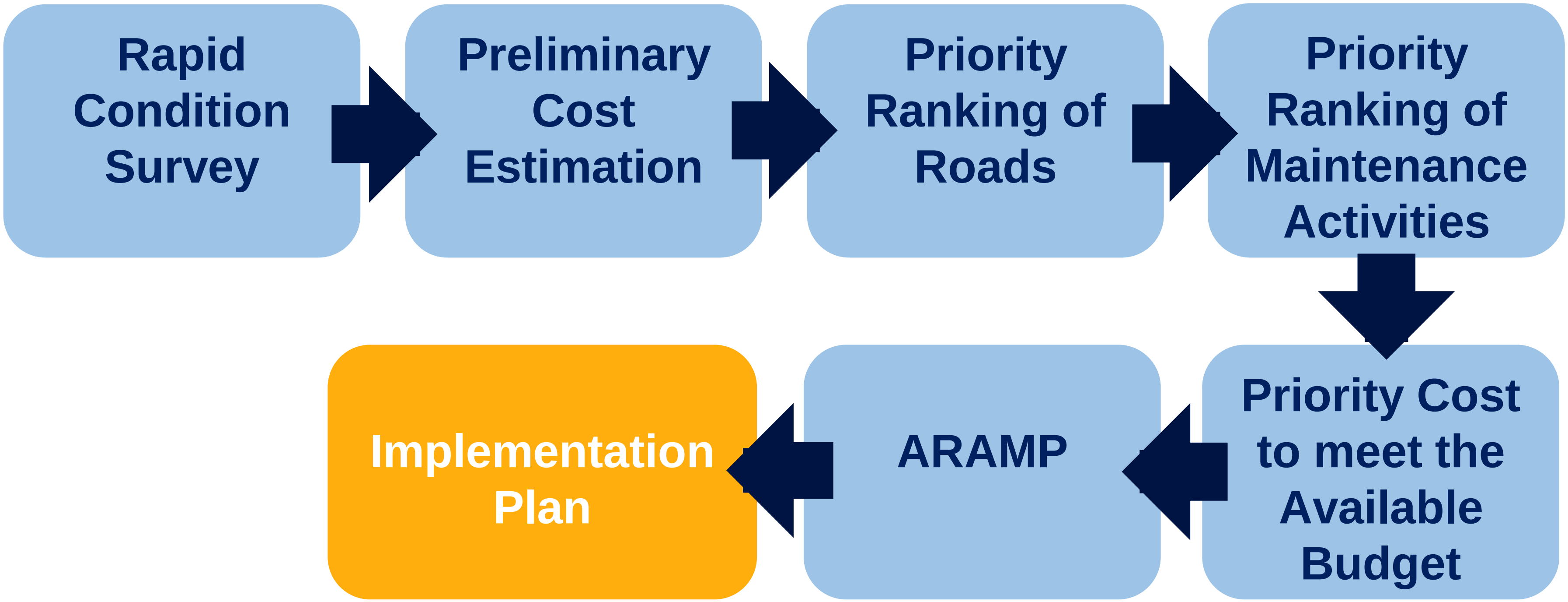
Rapid Condition Survey

- Use as a basis to propose treatments for defects.
- Record traffic data to prioritize conservation activities on ‘cost/vehicle’
- First priority will be given to budget for conservation (routine, recurrent, specific, & periodic)
- Remaining budget will be used for Imp & new road based on ‘cost/pop

Road inventory and Rapid condition survey forms

Write email for Forms and Format for Rapid Condition Survey

Overview of Maintenance Planning



Asset Management Intervention & Priorities

Category / Rank	Intervention	Remarks
1. Maintenance / Conservation	Emergency Maintenance	Immediate Reopening
	Routine / Recurrent Maint.	Continuous Care
	Specific Maintenance	'Spot works' at critical sections
	Periodic Maintenance	Extensive renewal e.g. re-gravelling
2. Improvements	Rehabilitation / Upgrading	Mainly earthen to gravel
3. New Construction	Brand new or completing partially built road	To reach unconnected VDCs

Summary

- Prepare and update PTMP
- PTMP is most essential for effective Maintenance
- Carryout Rapid Condition Survey after the Monsoon before starting to estimate of maintenance activities
- Prepare ARAMP with reference to PTMP with in allocated budget for Maintenance

Session 11 c: Implementation of Maintenance Activities – Road

Introduction

Current Practice

- Maintenance activities are not implemented in planned way
- Lack of Supervision to maintenance activities
- Negligence in quality control specifically for maintenance activities

Effect

- Assets is not functioning well even after maintenance
- Waste of Money and time , loss of credibility
- Burden to Municipality
- Suffering to get access, comfort and timely service

Representative situation of road to most of the Municipalities

Improved and Maintained Section of Ghumti – Jyamire Road , Syangja

Causes of Deterioration of Roads

- Landslides

- Clear Landslide
- Emergency or Routine Maintenance

Causes of Deterioration of Roads

- Defects due to lack of Water Management

- Manage water
- Routine and Recurrent Maintenance

Causes of Deterioration of Roads

- Defects due to lack of Water Management

- Manage water , create drain , Catch and divert surface run off
- Routine and Recurrent Maintenance

Causes of Deterioration of Rural Roads

- Absence of Structure
- Place gabion or Masonry Structures
- Specific and Emergency Maintenance

Causes of Deterioration of Roads

- Defects due to lack of Water Management , Ruts forming , subgrade Material and Compaction
- Manage water , create drain , Fill the ruts, maintain camber
- Recurrent Maintenance and specific Maintenance

Causes of Deterioration of Roads

- Defects due to lack of Water Management , Ruts forming , subgrade Material and Compaction
- Manage water , create drain , Fill the ruts, maintain camber
- Recurrent Maintenance, specific Maintenance and improvement

Causes of Deterioration of Municipal Roads

- ❑ Climatic and Environmental Effects
- ❑ Poor Drainage Management
- ❑ Lack of Routine Repair and Maintenance
- ❑ Improper Use of Vehicles
- ❑ Lack of necessary quality standards in design, construction and repair/maintenance work

Ruts and Depressions

Location

- wheel tracks of vehicles
- local areas (depressions)

Main Causes

- Insufficient foundation or pavement strength
- Inadequate stability of the bituminous surface

Remedies

- filling in to the ruts and depressions ,< 5 cm
- local restoration –deep rutting

Rut and Depression

Before

After

Restoration of Rain Cuts

Location

- Shoulder and even in pavement of earthen road

Main Causes

- Inappropriate side slope and lack of compaction

Remedies

- Clear loose soil and refill
- Carryout layer wise compaction, Armor the slope by Bioengg or turfing

Maintenance of Slopes and Drains

Location

- Cut slope and drains

Main Causes

- Improper cut slope , absence of headwall and erosion towards the drain

Remedies

- Clear, reshape and re-grade
- Stabilize the slope
- Proper Level to the drain bed

Pot holes

Location

- In Road Surface

Main Causes

- Gradation, compaction and sub surface flow
- **Remedies**
- Cut and remove the material from defective portion
- Fill with proper material and compaction

Pot holes

- Before

- After

- Before Maintenance

- After Maintenance

Flexible Pavement Maintenance

Surface defects

fatty surfaces, smooth surfaces, streaking and hungry surfaces

Cracks

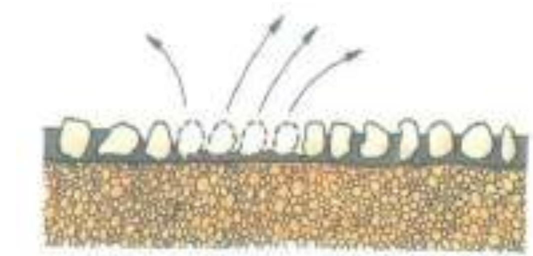
hair-line cracks, alligator cracks, longitudinal cracks, edge cracks, shrinkage cracks and reflection cracks

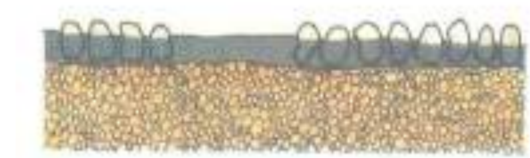
Deformation-

slippage, rutting, corrugation, shoving, shallow depressions, settlements and upheavals

Disintegration

stripping, loss of aggregates, raveling, pot-holes and edge breaking





Single Bituminous Surface Treatment

Flexible Pavement Maintenance – Periodic

Premix Carpeting

Rigid Pavement Maintenance

Transverse Crack

Causes:

Slab curl

Curing

Cures

Crack Seal

Full depth rigid repair

Retrofit the Dowel Bar

Rigid Pavement Maintenance

Longitudinal Crack

Causes:

Waiting too long to cut center joint

Sub Soil Settlement

Cures

Joint Sealing

Full depth replacement

Sub surface Stabilization

Rigid Pavement Maintenance

Pumping

Causes:

Water , Fines

Lack of Load Transfer

Cures

Under Sealing

Full depth rigid repair

Concrete Pavement Grinding

Rigid Pavement Maintenance

Transverse Joint Spalling

Causes:

Improper dowel alignment

Lack of joint seal

Incompressibles in joint

Cures

Crack & Joint Seal

Bonded Patching

Full-depth patching

Rigid Pavement Maintenance

Scaling

Causes

- Improper finishing technique

Cures

- Grinding
- Asphalt overlay
- Bonded resurfacing
- Partial depth patch

Rigid Pavement Maintenance

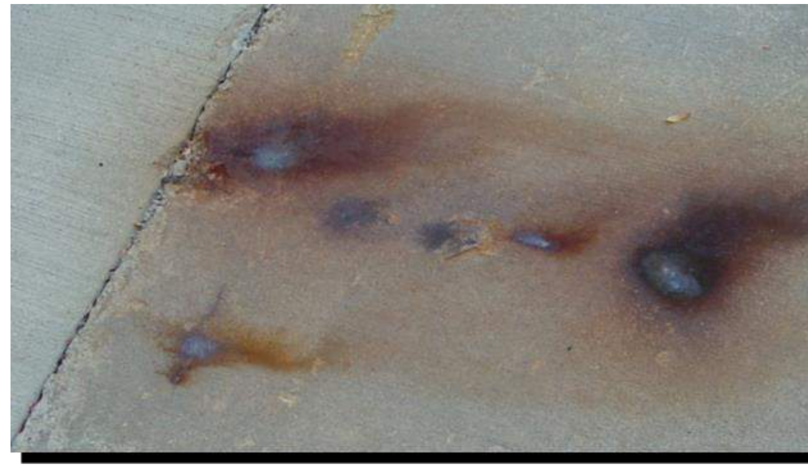
Shallow Reinforcing

Causes

- Reinforcing Steel too close to surface

Cures

- Asphalt overlay or patch
- Replacing steel & partial or full depth repair



Maintenance of Cause Ways

Check for adequacy of waterway

Examine major damages

Check the approaches for erosion/wash out

Check any damages to downstream protection works

Maintenance of Road Signs

- should be inspected at least four times a year both in day and night
- proper position and kept clean
- Tree branches, plantations, weeds shall not be allowed to obscure

Maintenance of Road Signs

- Should be inspected , here is wrong direction

Summary

- Supervision and quality control arrangement for maintenance should be same as the implementation of new construction or rehabilitation.

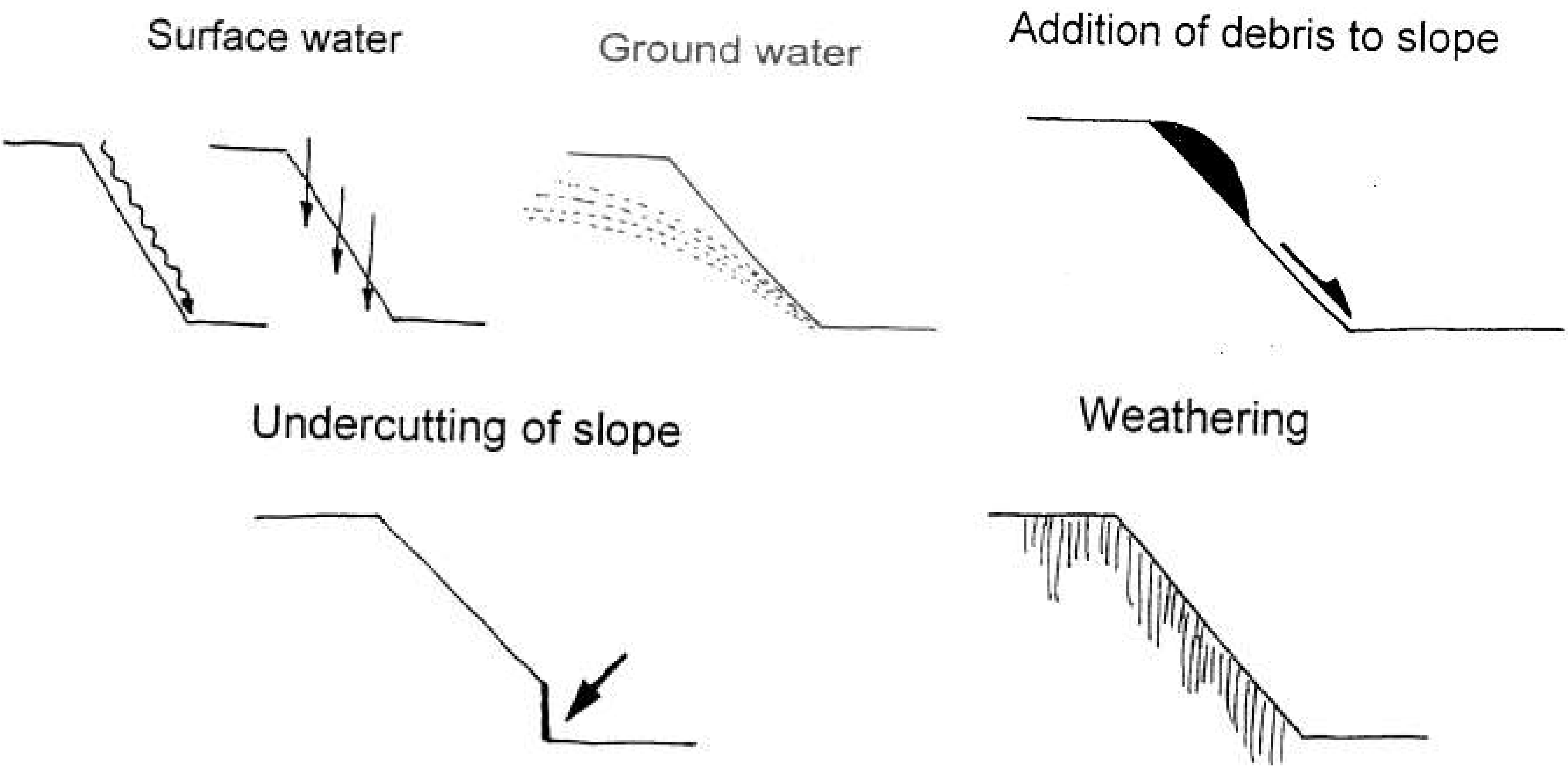
- Maintenance activities should be implementing after analyzing causes of defects with appropriate methods of maintenance

Transport Infrastructure Directorate
Bagamati Province

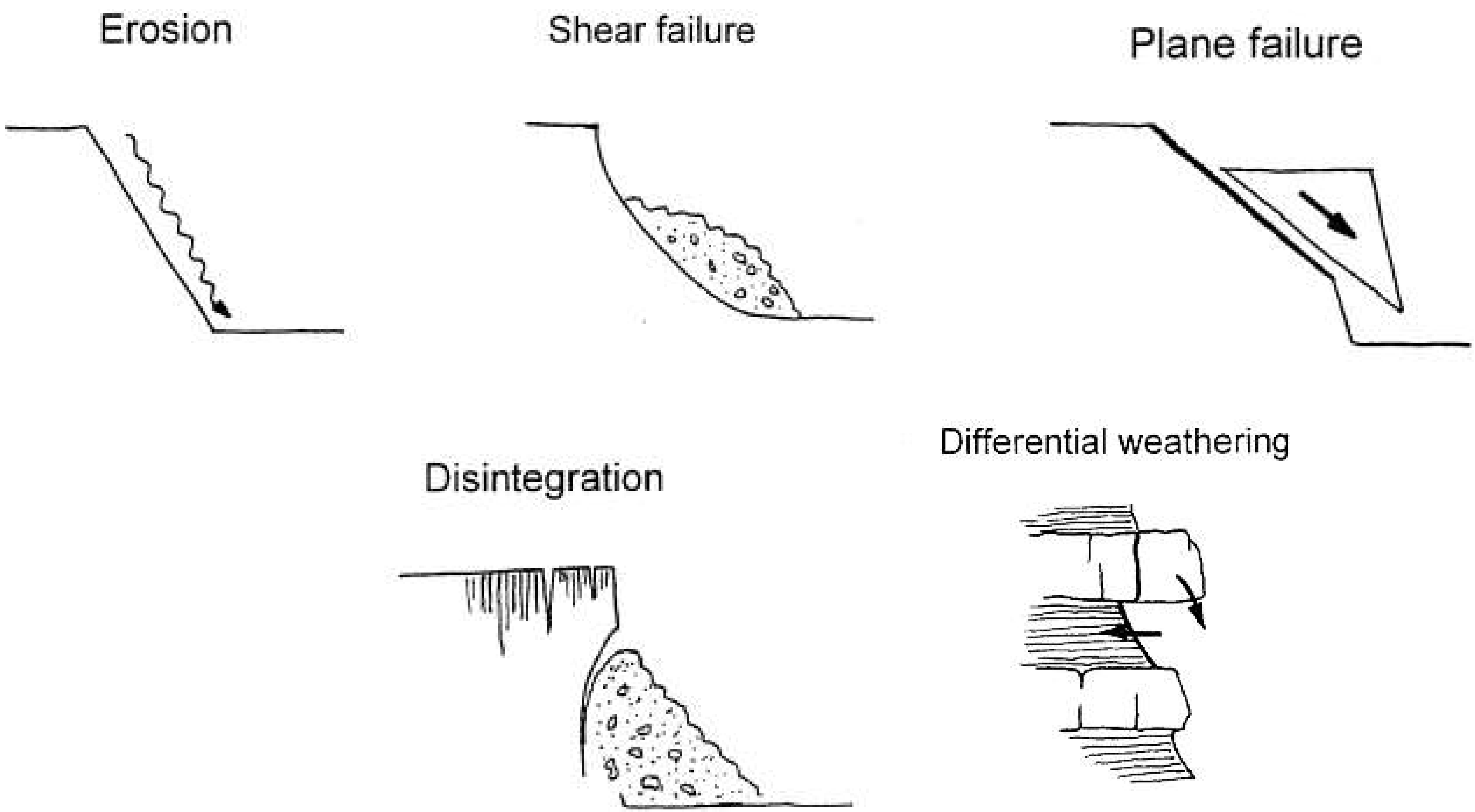
Training on Quality Control in Road Works

Session 12: Slope Protection and Bioengineering Works

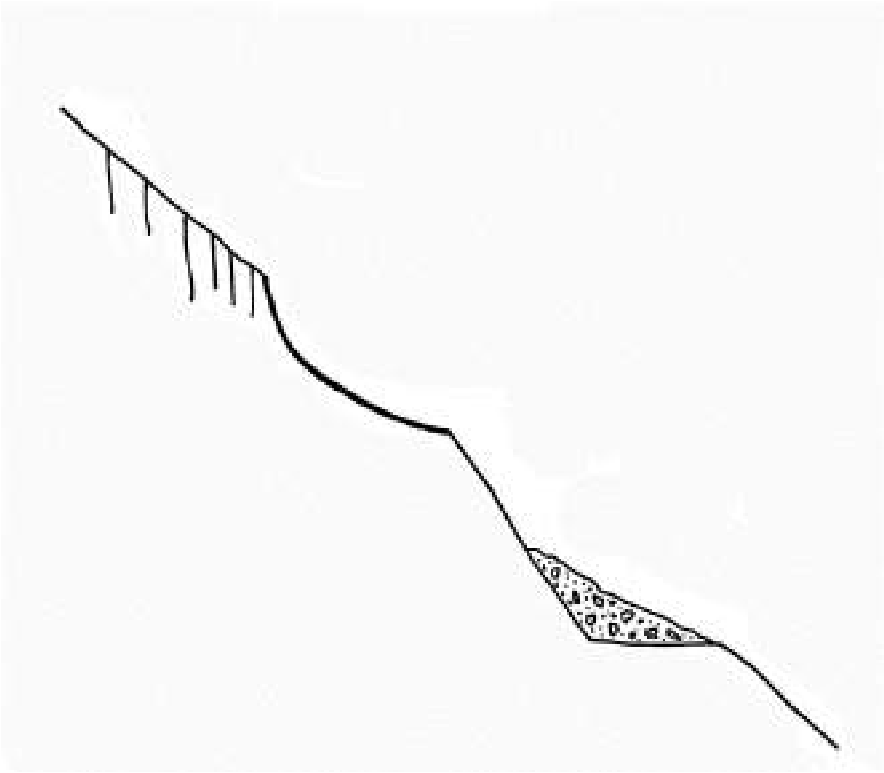
Causes of Slope Failure



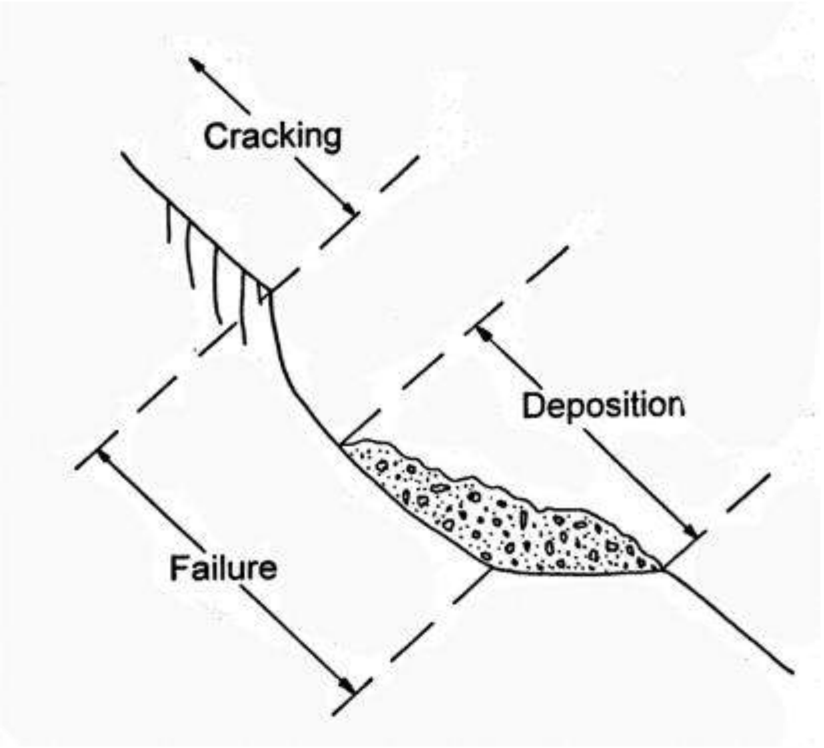
Mechanisms of Slope Failure



Mechanisms of Slope Failure Contd.

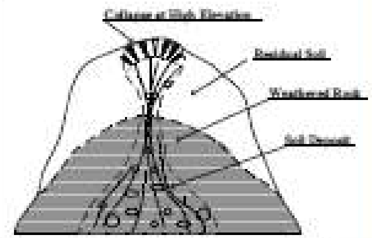
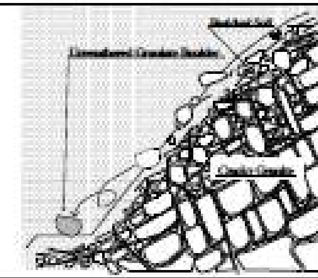
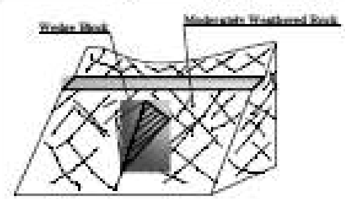
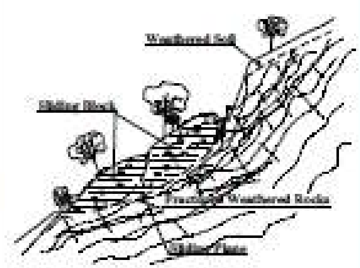


Landslide Zone



Landslide without Zone of Transport

Table 2.1: General Features of Slope Failure

FAILURE TYPE	Characteristics	SCHEMATIC ILLUSTRATION
1. Collapse (CL)	- Collapsing materials are residual soils and highly weathered or jointed rocks. - Prone to occur onsteep slopes. - Mostly triggered by rainfall infiltration - Similar to slump failure in some cases. - Size is generally less than1,000m ^{3}	
2. Rock Fall (RF)	- Free fall or rolling down of hard rocks and boulders - Occur on steep slope and cliff. - Falls occur due to gravity and joints failure. - Size is generally less than 5 m^3.	
3. Rock Mass Failure (RM)	- Materials are hard jointed rocks. - Failure modes include wedge slide, plane slide and toppling. - Size is generally more than 5,000 m^3	
4. Landslide (LS)	- Materials may be soils, debris and or highly weathered rocks. - Marked by gentle and deformed topographic features -Mainly influenced by increased pore-water pressure by infiltration -Size is generally more than 5,000 m^3.	

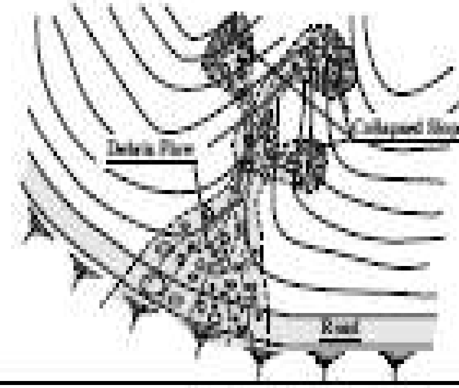
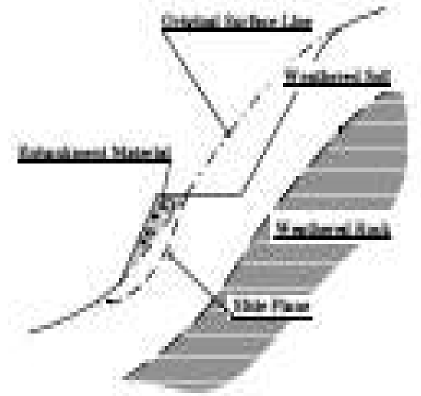
5. Debris Flow (DB)	- Rapid flow of boulder, gravel, sand, silt and clay mixed with large quantity of water. - Occurs in a contributory area that contains collapsible slopes	
6.Embankment Failure (EB)	- Slump or collapse of embankment slope, - Settlement of road surface - Scouring of toe part	

Table 2.2: Countermeasures for Slope Failures

Category	Group
Control Measures	Earthworks: Cutting and Filling, Bio-Engineering: Various methods of vegetation and small scale engineering work in the slope and its vicinity, Water Management: Surface and Sub-surface drainage
Restraint Measures	Slope Work: Stone pitching, Frame work, Anchoring: Rock bolt, Nailing and Ground anchor, Walls and Resisting Structures: Gabion, Stone masonry, Frame wall etc., Protection work: Rock Fall Wire-net, Check Dam, Piling Work: Steel pipe, Pile Shaft work
Alternative Works	Re-alignment of Road: Route relocation or Re-alignmentby Bridge or Tunnel

BIO-ENGINEERING

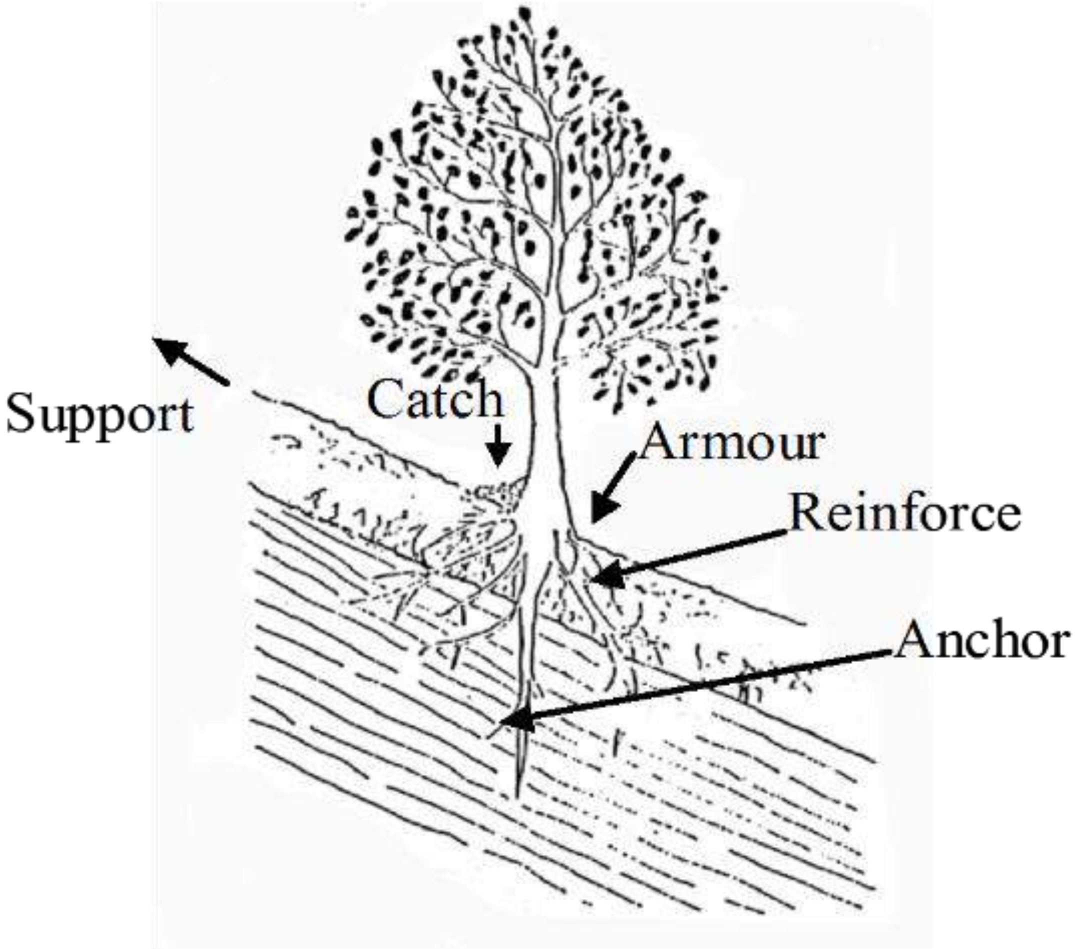
Definition

- Bio-engineering is the use of living vegetation, either alone or in conjunction with civil engineering structures and non-living plant material, to reduce shallow-seated instability and erosion on slopes

Functions of Bio-Engineering Structures

- *Catch*: Stop material falling or sliding down a slope
- *Armour*: Protect surface from erosion
- *Reinforce*: Hold particles together and reduce risk of shallow seated movement
- *Anchor*: Reduce risk of deeper-seated movement
- *Support*: Hold material on slope
- *Drain*: Remove excess water

Engineering Functions of Vegetation



Types of Vegetative Structures

- ❖Fascines
- ❖Shrub planting
- ❖Tree planting
- ❖Bamboo planting
- ❖Horizontal grass planting
- ❖Diagonal grass planting
- ❖Grass Seeding
- ❖Brush Layering

Design Aspects of Vegetative Structures 1

System	Functions	Method of Operation	Applications and Site Requirements
Fascines	Catch, support, drain	Woody bundle, dense stems, porous, can drain soil if laid down slope	Consolidated debris slopes, <45
Shrub Planting	Catch, armour, reinforce, anchor, support	Bunchy leaves, multiple stems, lateral roots, root cylinder, tap roots	Any slopes < 45
Tree Planting	Armour, reinforce, anchor, support	Lateral and near vertical rooting systems, root cylinder	Any debris slopes <45, gully side slopes
Bamboo Planting	Catch, armour, reinforce, support	Dense poles, massive rooting systems, dense leaves, grows all year	Slope <35, base of slope, erodible slopes, preferably wet places

Design Aspects of Vegetative Structures 2

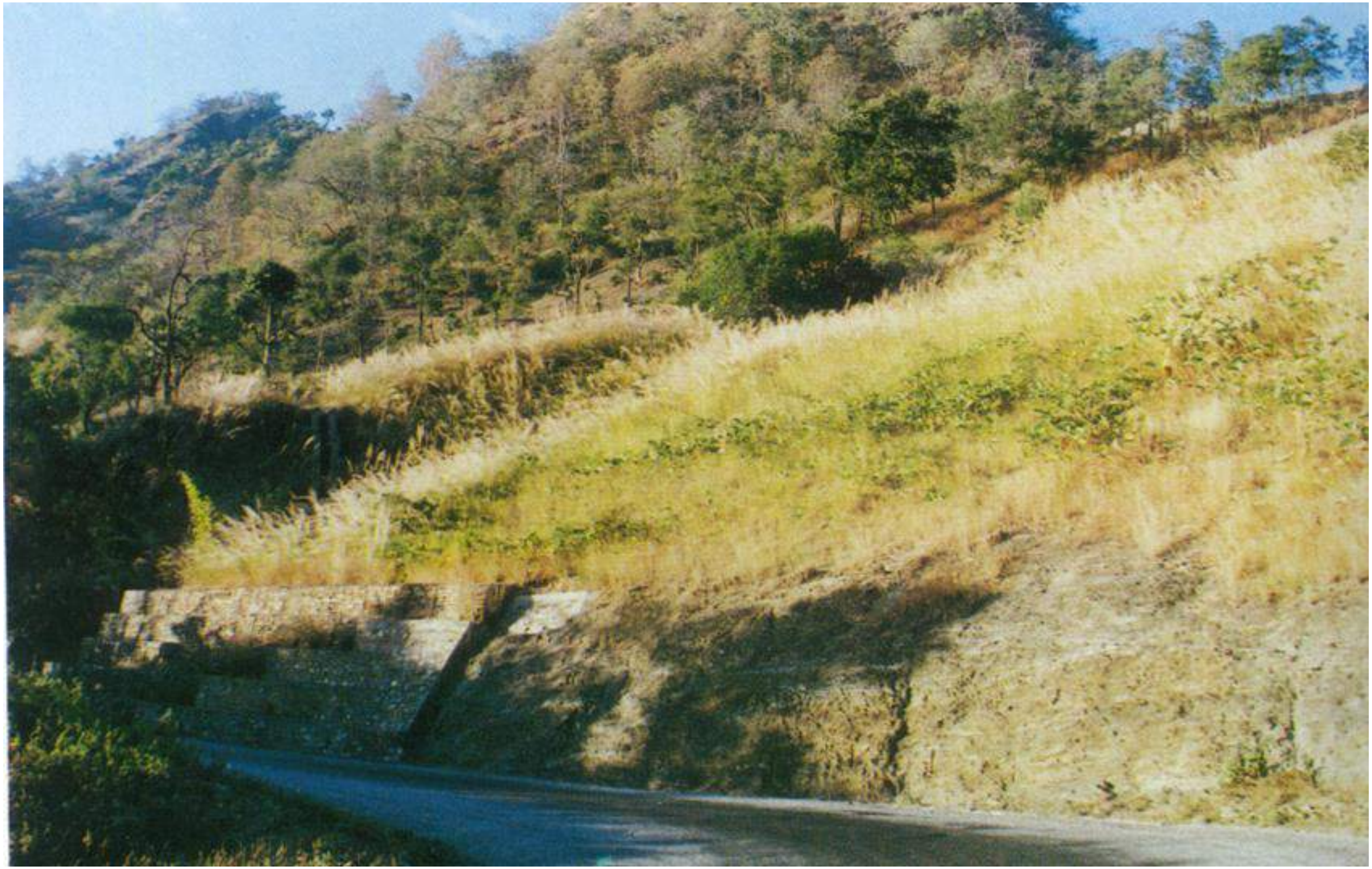
System	Functions	Method of Operation	Applications and Site Requirements
Horizontal grass planting	Catch, reinforce, support	Dense line retards surface water flow	Dry, slope <45, erodible, cut slope
Diagonal grass planting	Catch, reinforce, support	Dense line guides water along the line	Wet, permeable, fine, cut slopes
Grass seeding	Catch, reinforce, support	Dense grass, mat, rooting system	Consolidated debris slopes <45
Brush layering	Catch, reinforce, support	Dense line, strong buried branches retard surface and shallow ground water flow	Slope <45, dry, erodible and consolidated debris

Grass Planting 1

Grass Planting 2

Grass Seeding 1

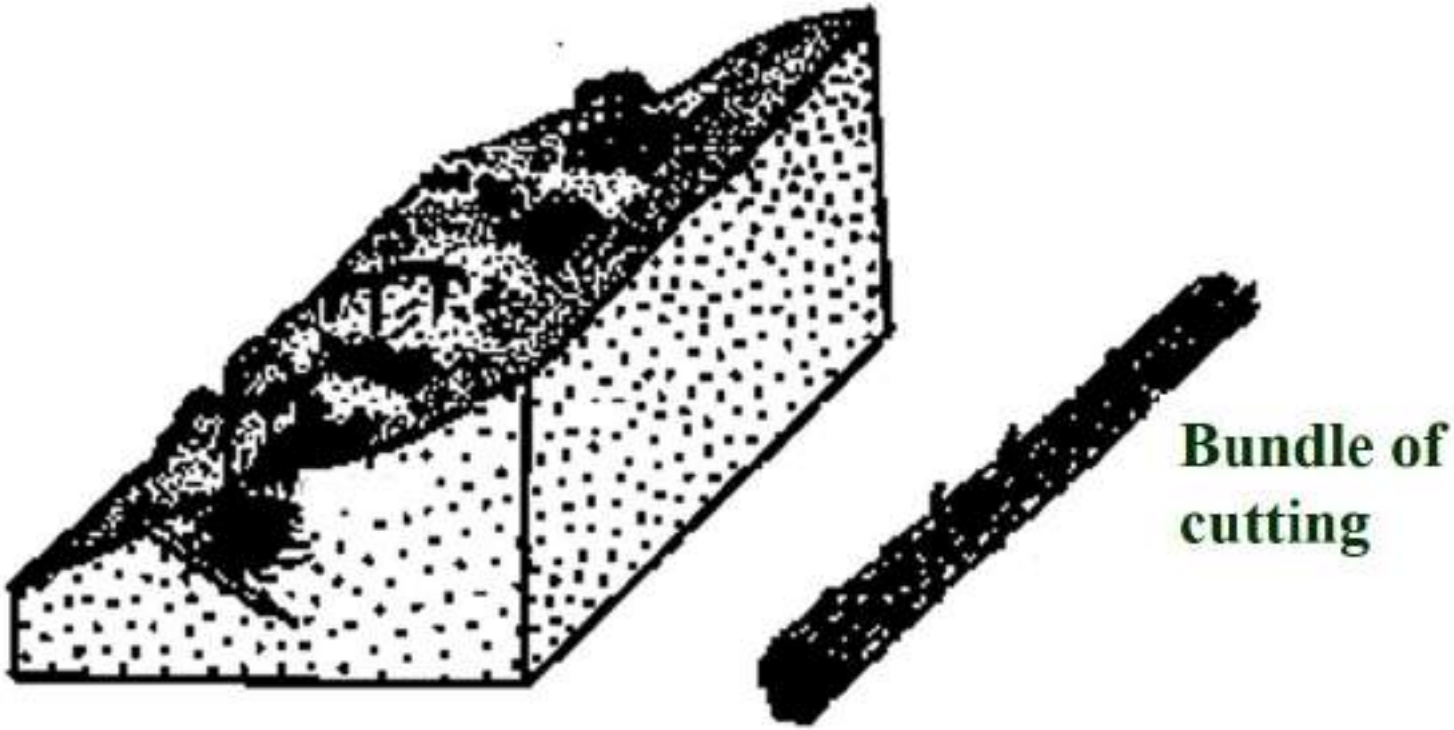
Grass Seeding 2



Brush Layering 1

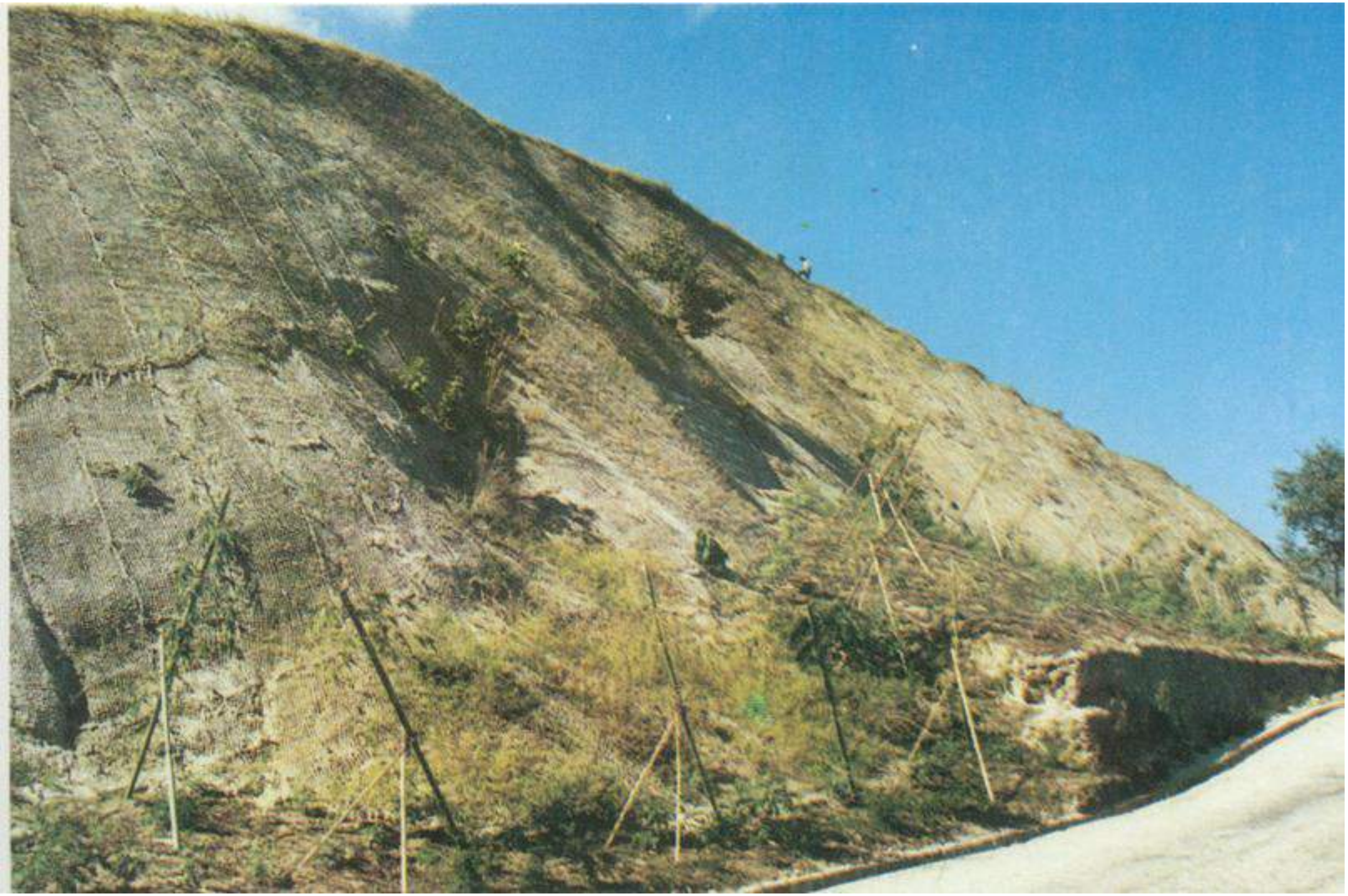
Brush Layering 2

Fascines



Fascines

Bamboo Planting



Shrub Planting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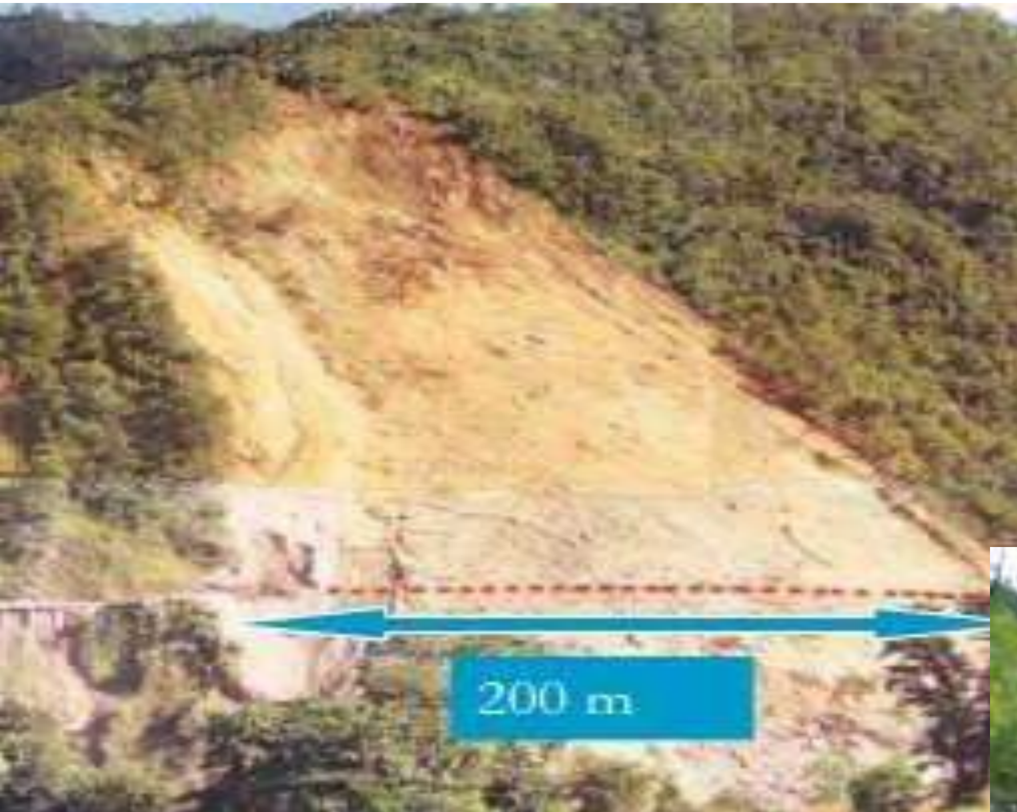
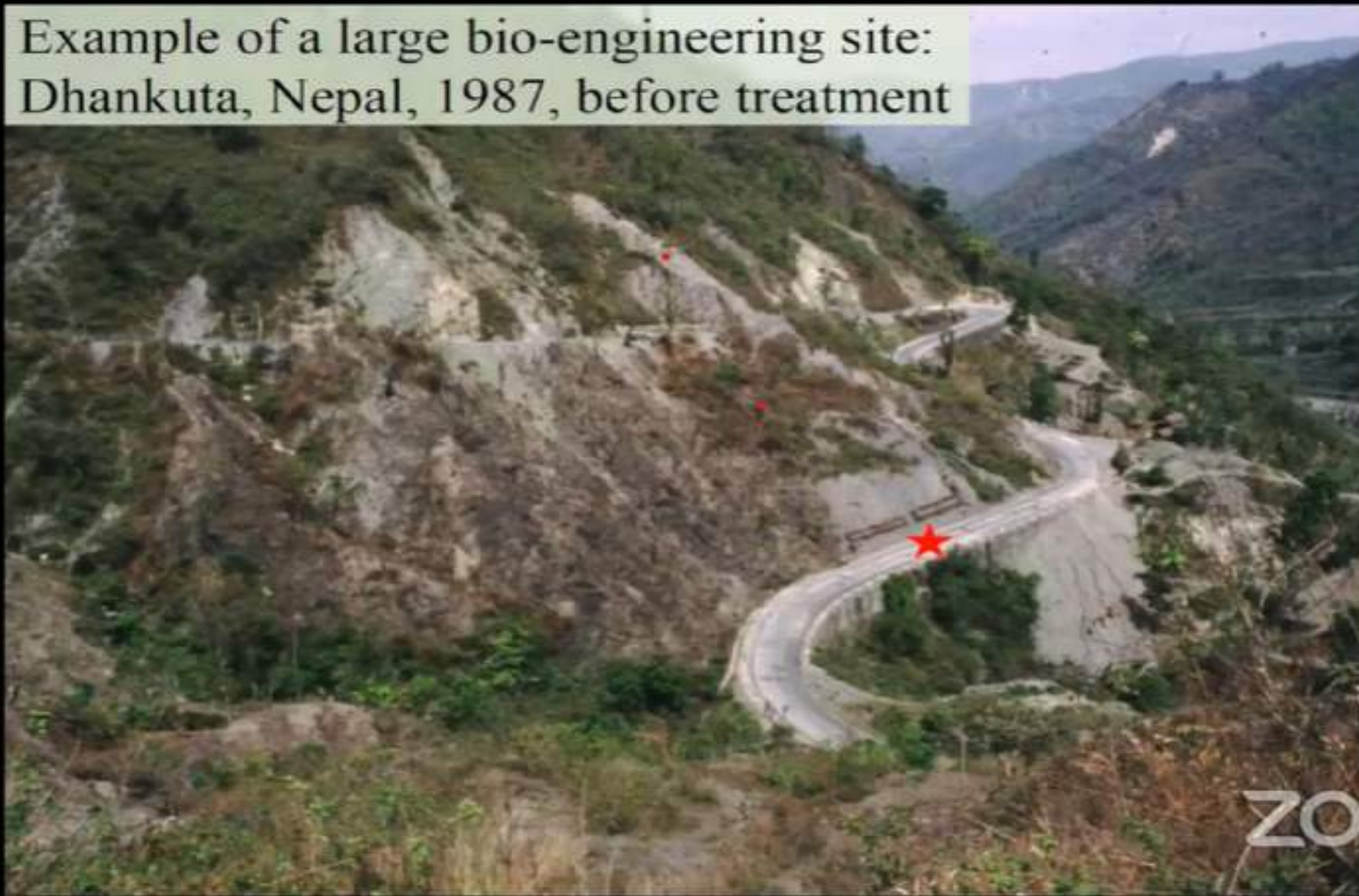


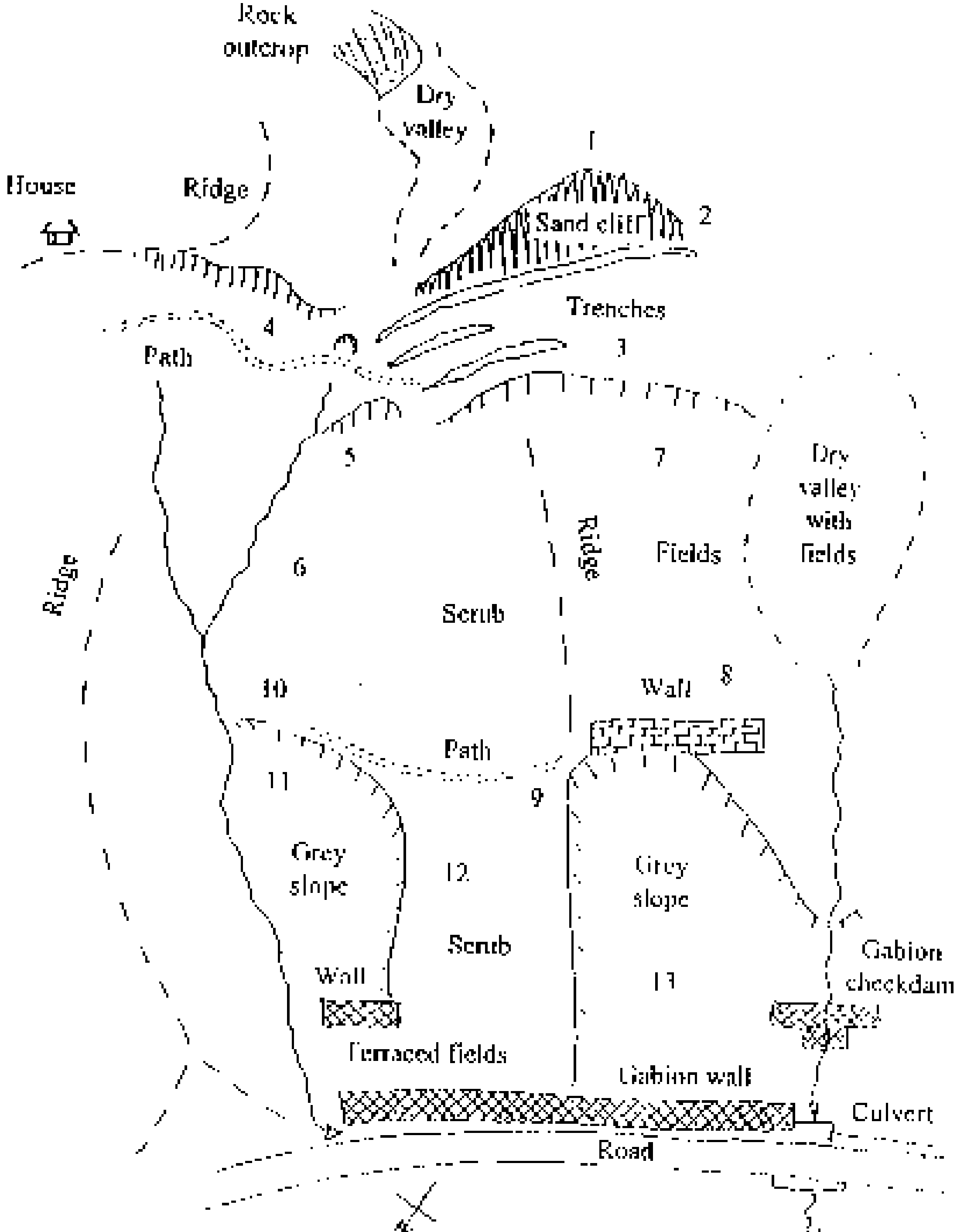
Krishnavir Landslide before Bioengineering

Krishnavir Landslide after Bioengineering

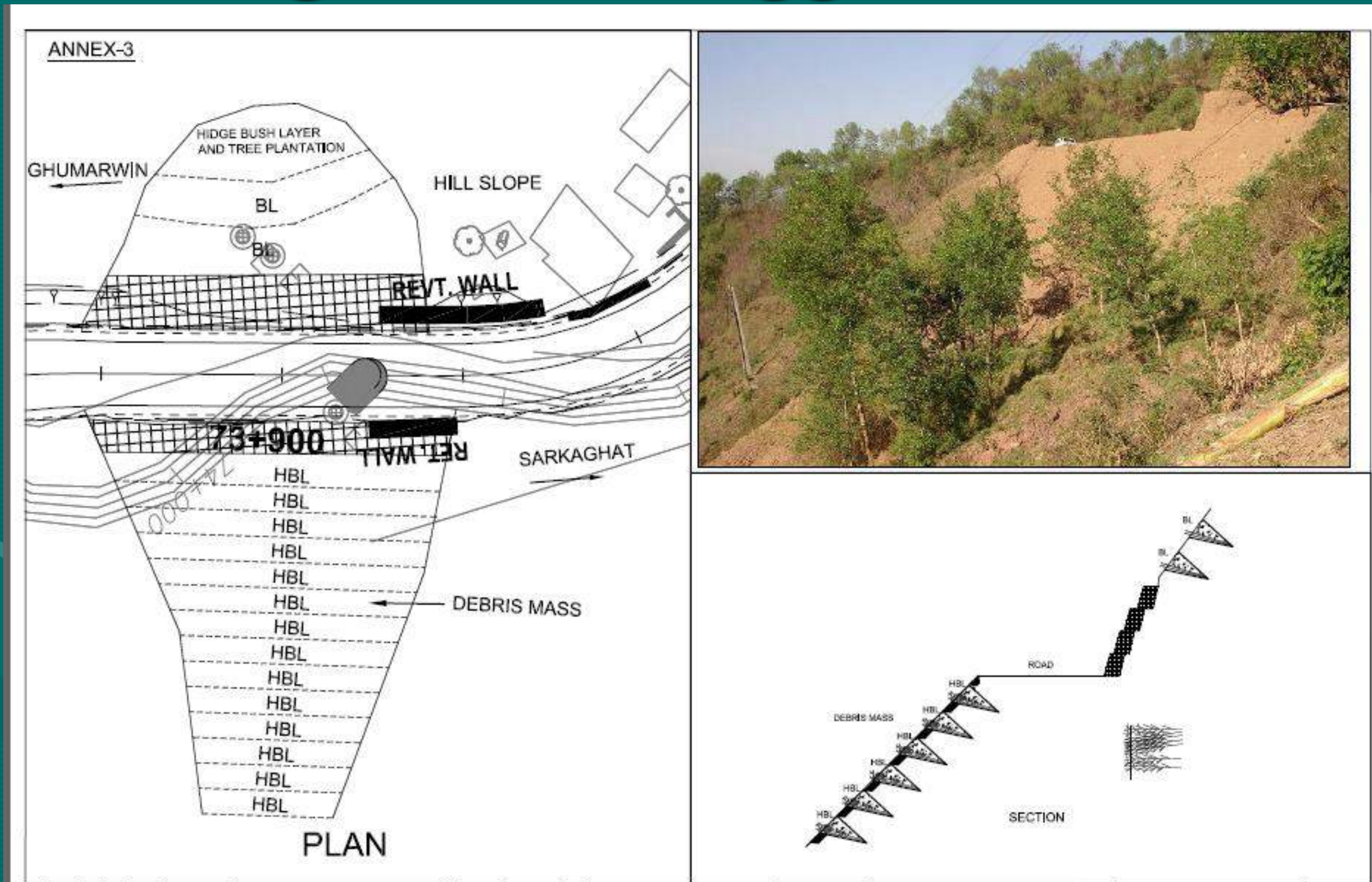

Example of a large bio-engineering site:
Dhankuta, Nepal, 1987, before treatment


Example of a large bio-engineering site:
Dhankuta, Nepal, 1987, after treatment

Sketch of Landslide after mapping



Design of Bioengg structures



Construction steps of Hedge-brushlayers: digging of terrace, inlay of plant material, soil covering

Trimming of slope for Bio-Engineering Purpose

Preparation of Grass slip for plantation

Plantation of Khar as Bio-Engineering

Fencing to Protect plant from Grazing

Prevention to erosion on slope by using bioengineering in conjunction with Bamboo Wattle Fence.

Plantation of Grass Slips

Bioengg site protected from grazing

Bio engineering work along down hill side of road section to prevent probable erosion on slope.

Seed

- Broadcasting
- Direct sowing in holes
  - Suitable for sandy site
  - for armouring and reinforcing

Seedling

- Tree and shrub planting
- Slope up to 30 degree.
- Spacing 1m * 1m
- Engineering function
  - Support, anchor and reinforce

Grass planting

1. Horizontal line of grass planting

- Spacing:
  - Line to line

  = 100 cm –if the slope angle of the slope is<30^0

  = 50 cm –if the slope angle of the slope is30^0 –45^0

  = 30 cm –if the slope angle of the slope is>45^0

  Plant to plant 10 cm

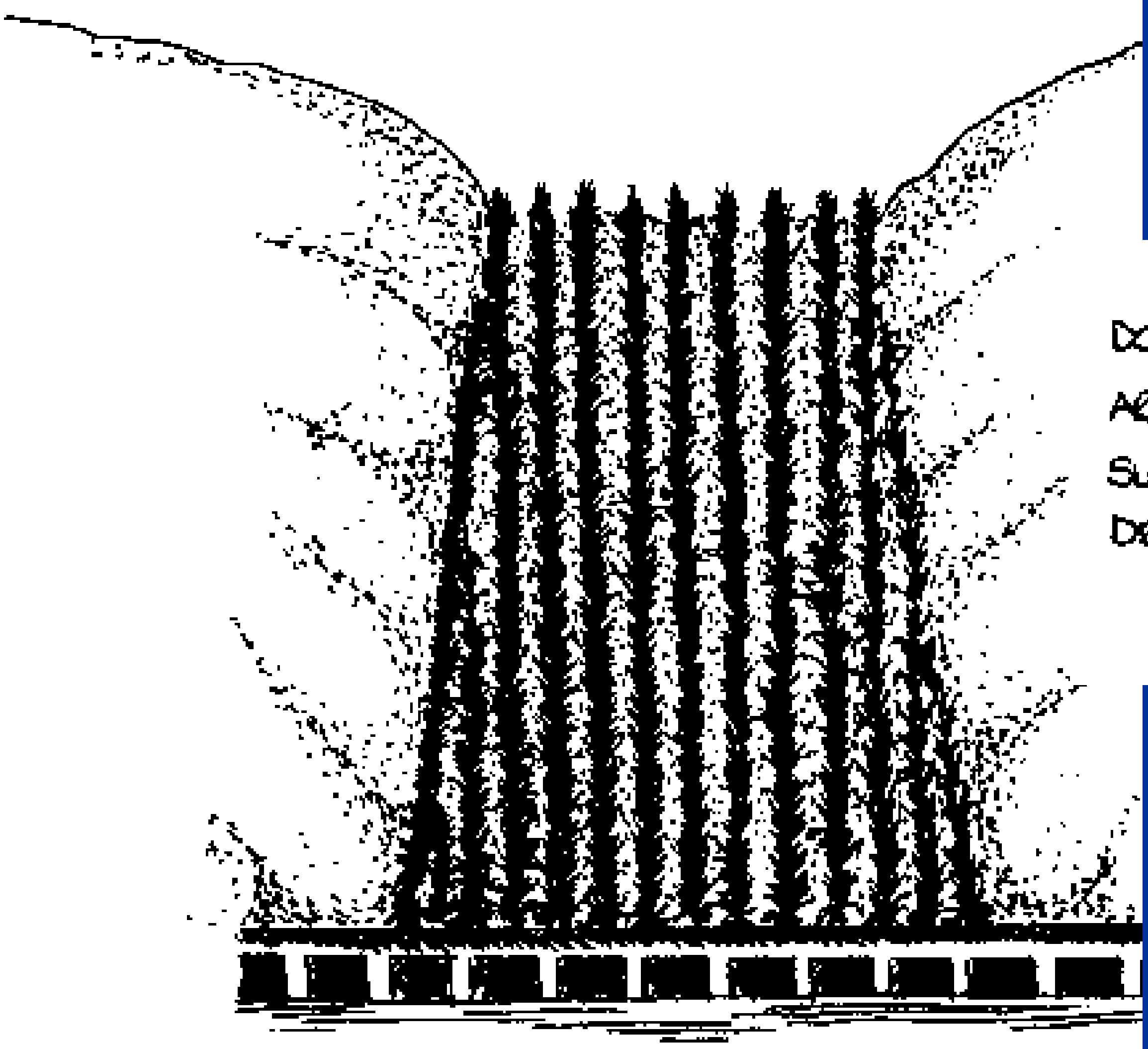
  - main function : catch, armoring and reduce surface run off

Horizontal line of grass plantation

Grass planting continued

- Vertical line of grass planting
- Spacing:
  - Line to line 50 cm
  - Plant to plant 10 cm
  - function : surface drainage, reduce infiltration and armour
  - On slopes up to 65 degree, clay type soil.
  - Limitation: likely to develop rills.

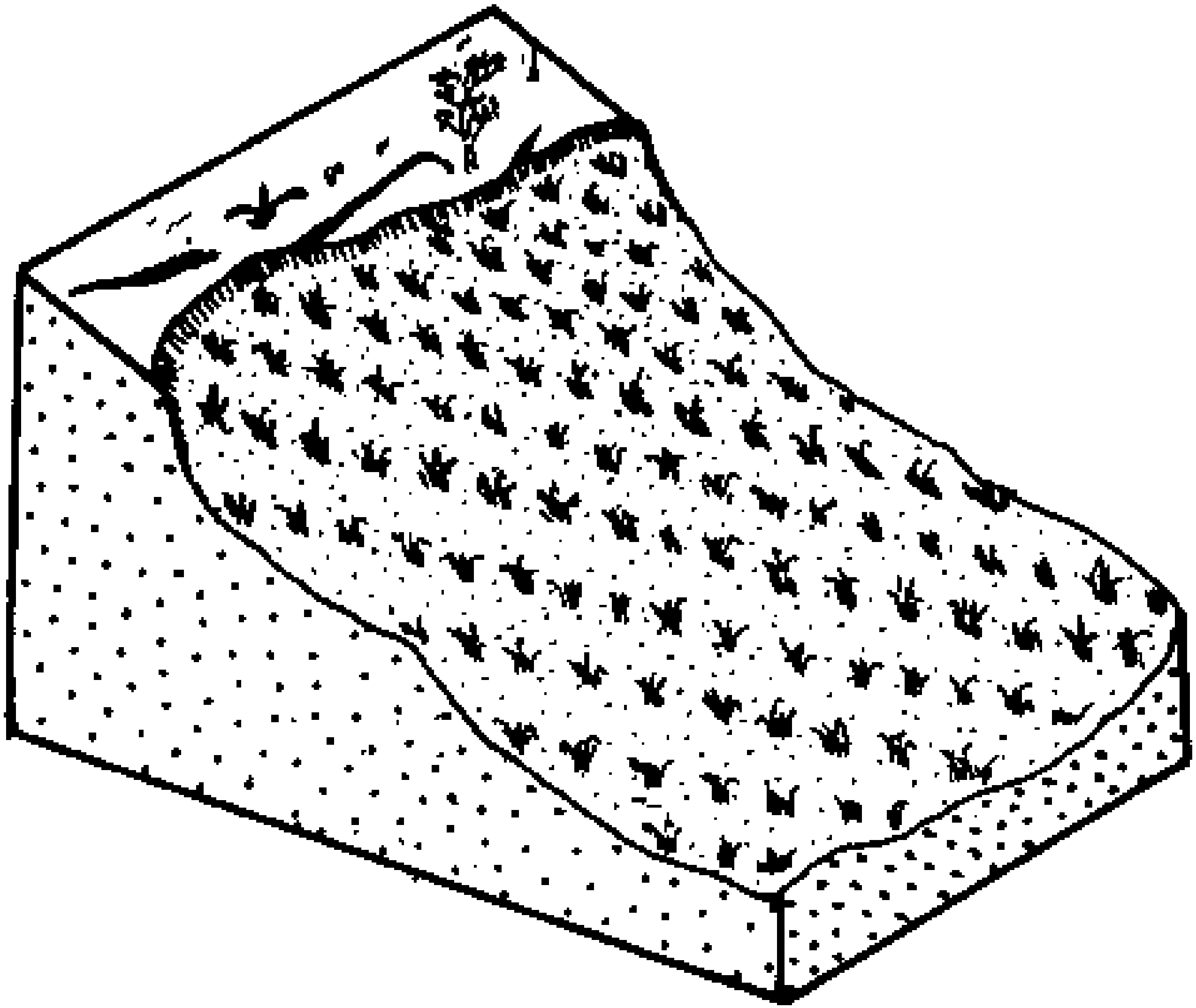
Down Slope Grass Plantation



DOWNSLOPE LINES OF GRASS ARMOUR AND REINFORCE THE SLOPE WHILE IMPROVING SHALLOW DRAINAGE.

Grass planting continued

- Diagonal line of grass planting
- Spacing:
  - Line to line 50 cm
  - Plant to plant 10 cm
  - function : surface drainage, reduce infiltration and armour, catch
  - On slopes up to 65 degree, damp sites.



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Diagonal Line of Grass Plantation

Grass planting continued

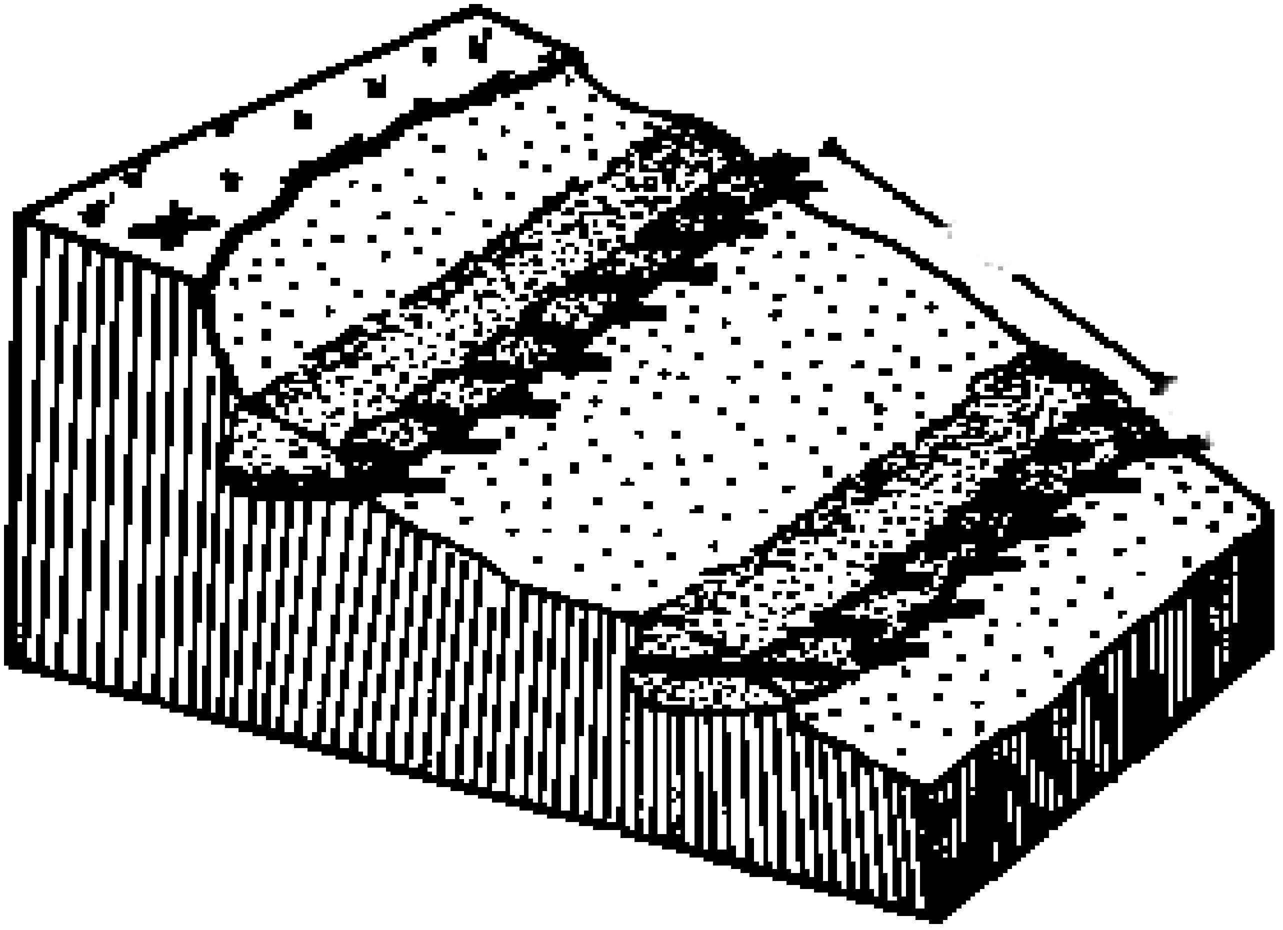
- Chevron and herringbone pattern of grass planting
- Widely used in new gully and ridge
- Spacing:
  - Line to line 50 cm
  - Plant to plant 10 cm
- Function: drain and armour.

Herringbone pattern of grass plantation

Grass planting continued

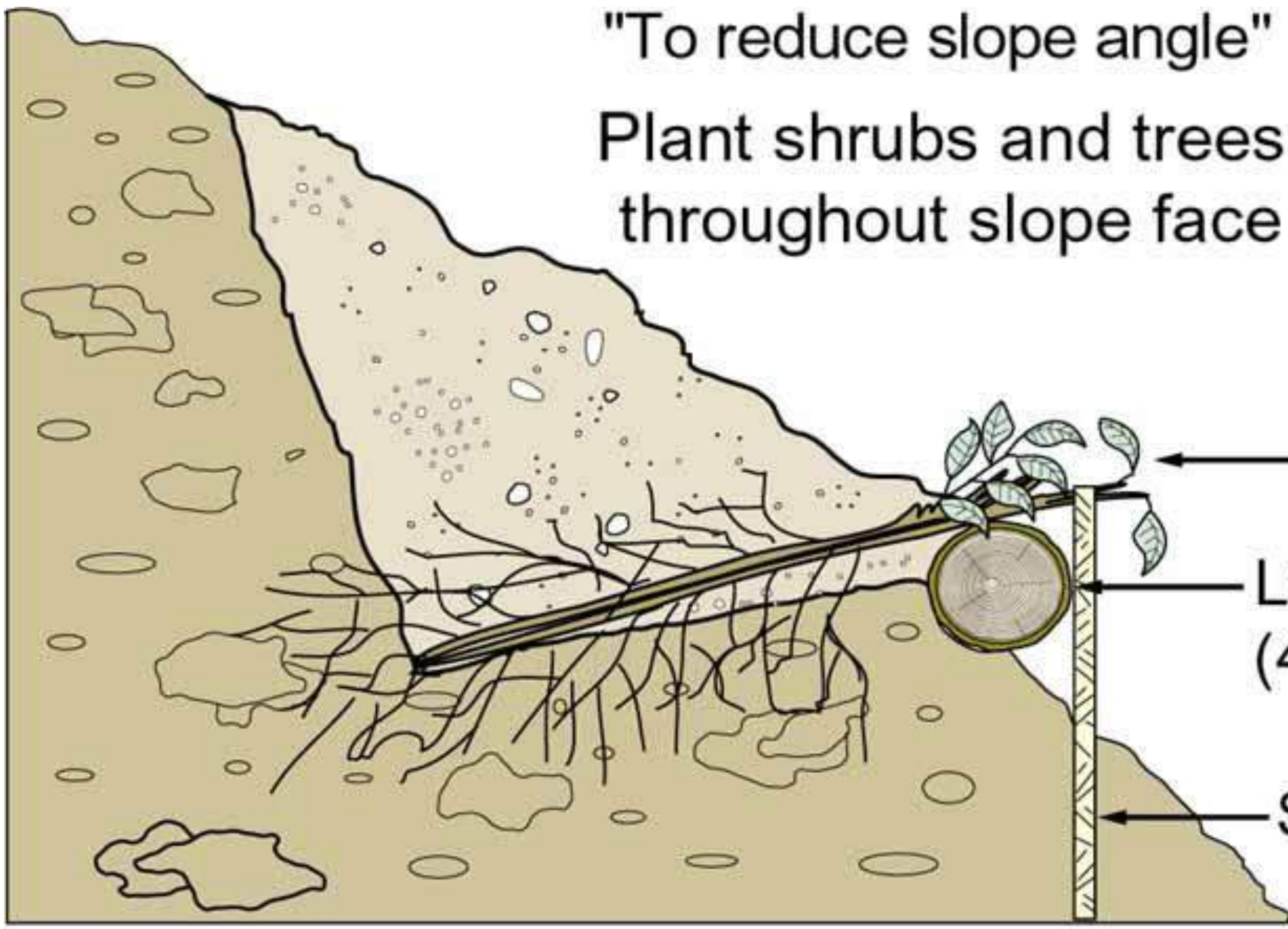
- Random grass planting
- Spacing : 10 cm * 10 cm
  - On slopes between 45 to 60 degree and 15 m slope length.
  - Function: armour and reinforce.

VEGETATIVE SYSTEMS



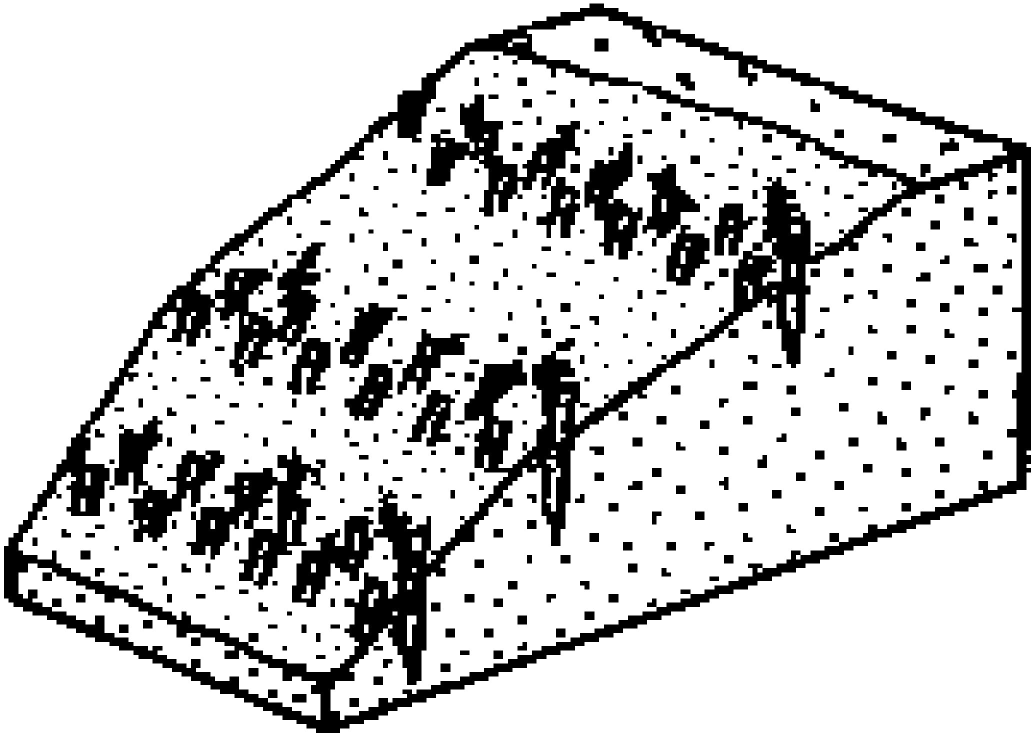
Brush Layering

Brush layering

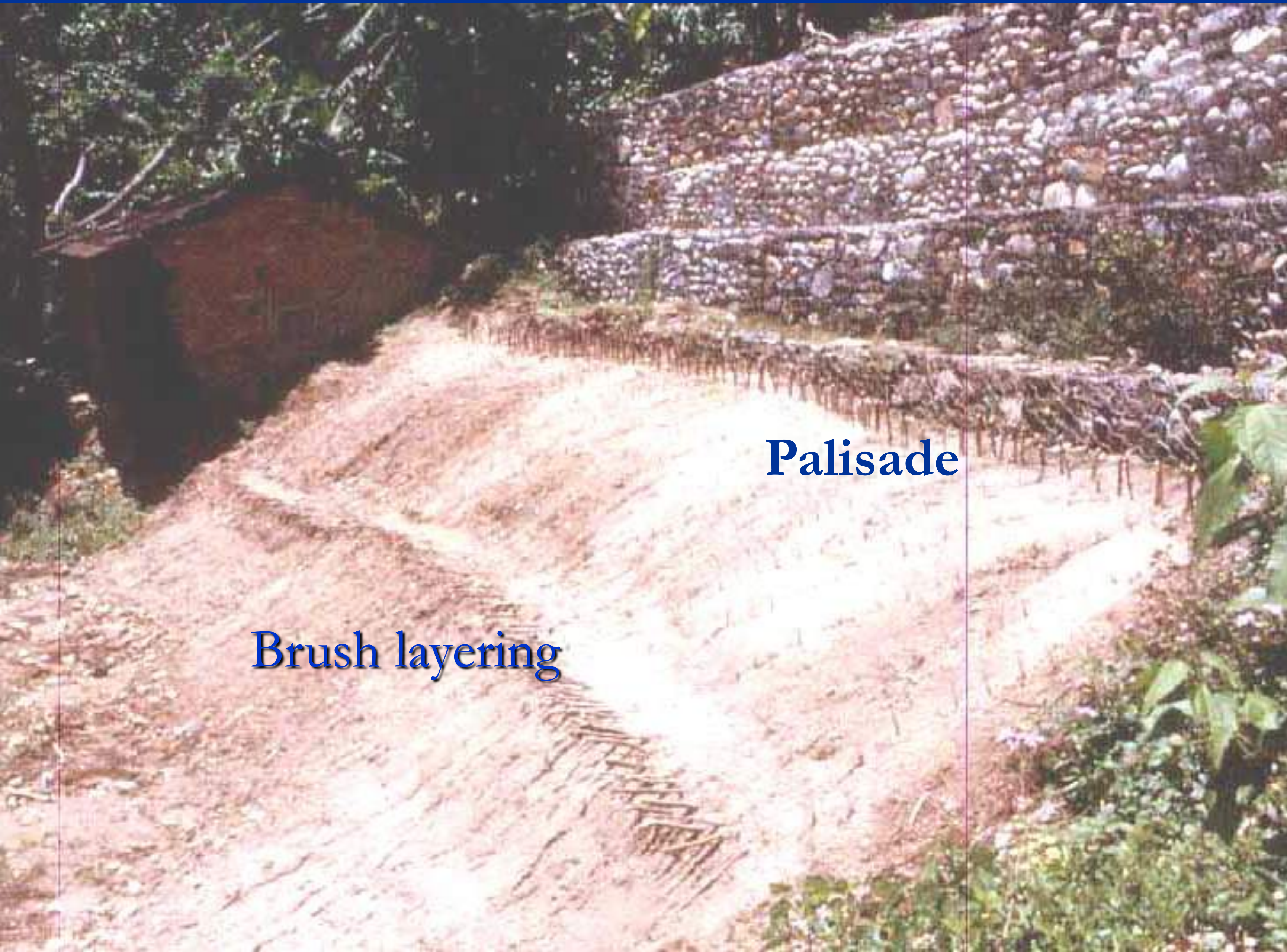


Brushlayer with log terrace

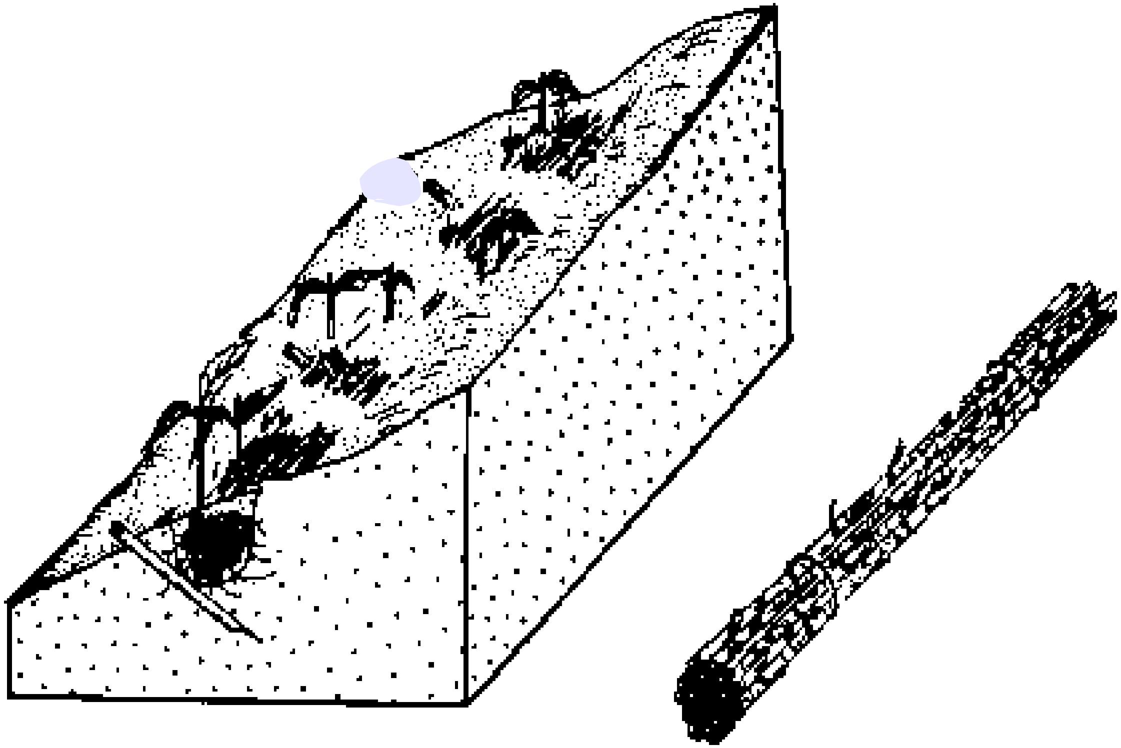
VEGETATIVE SYSTEMS



Palisade

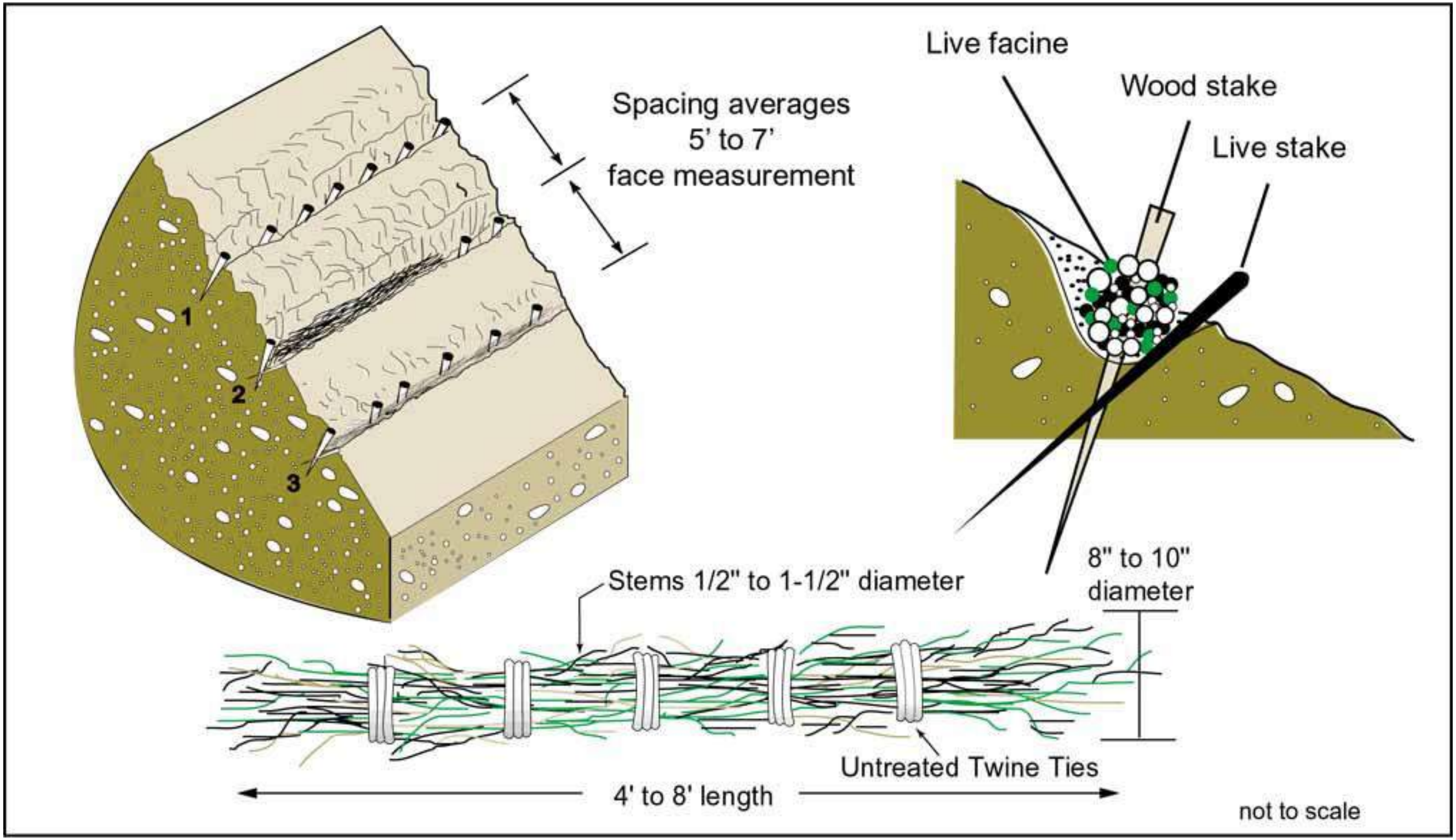

Palisade
Brush layering

VEGETATIVE SYSTEMS



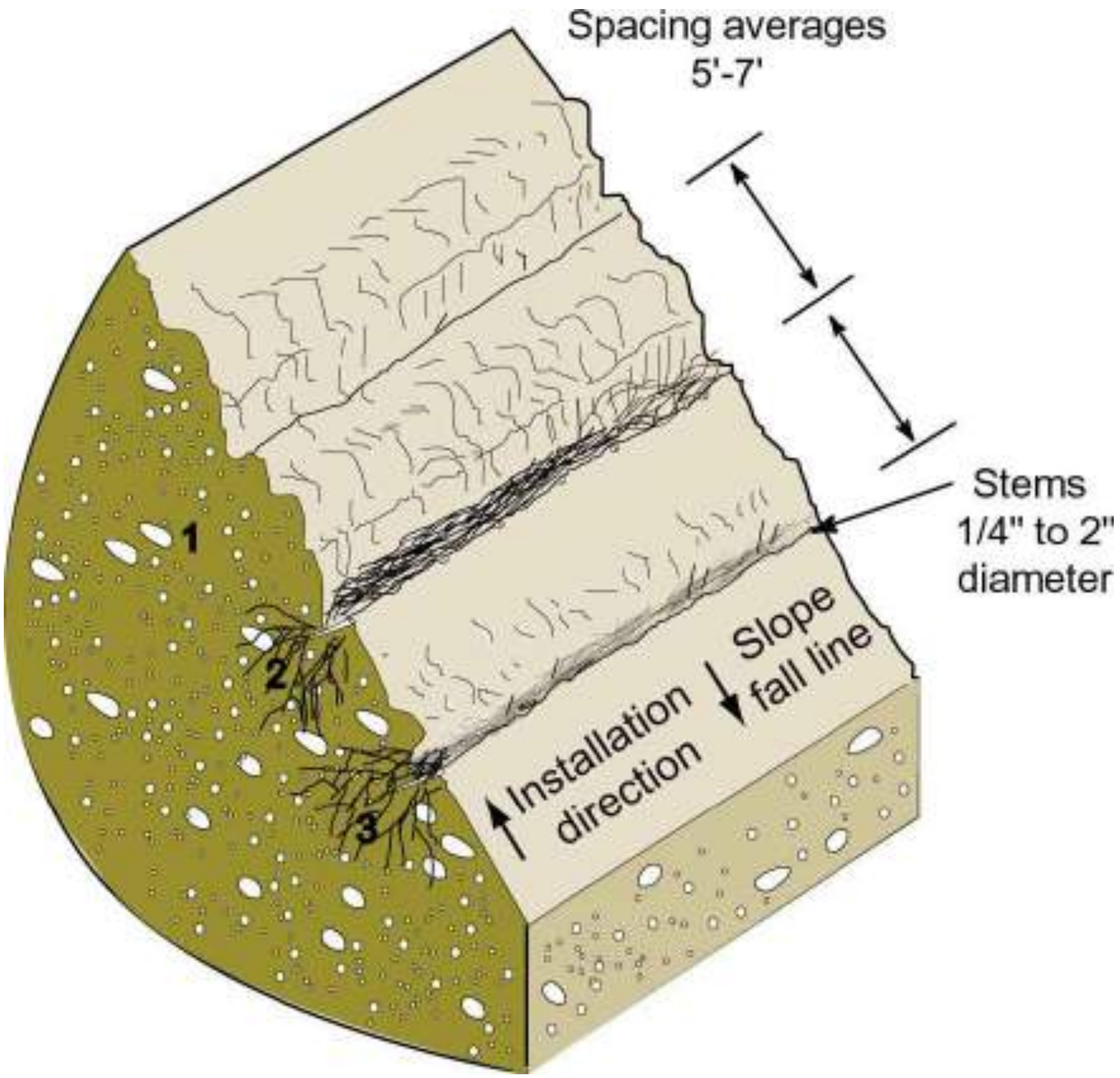
Fascines

Fascines

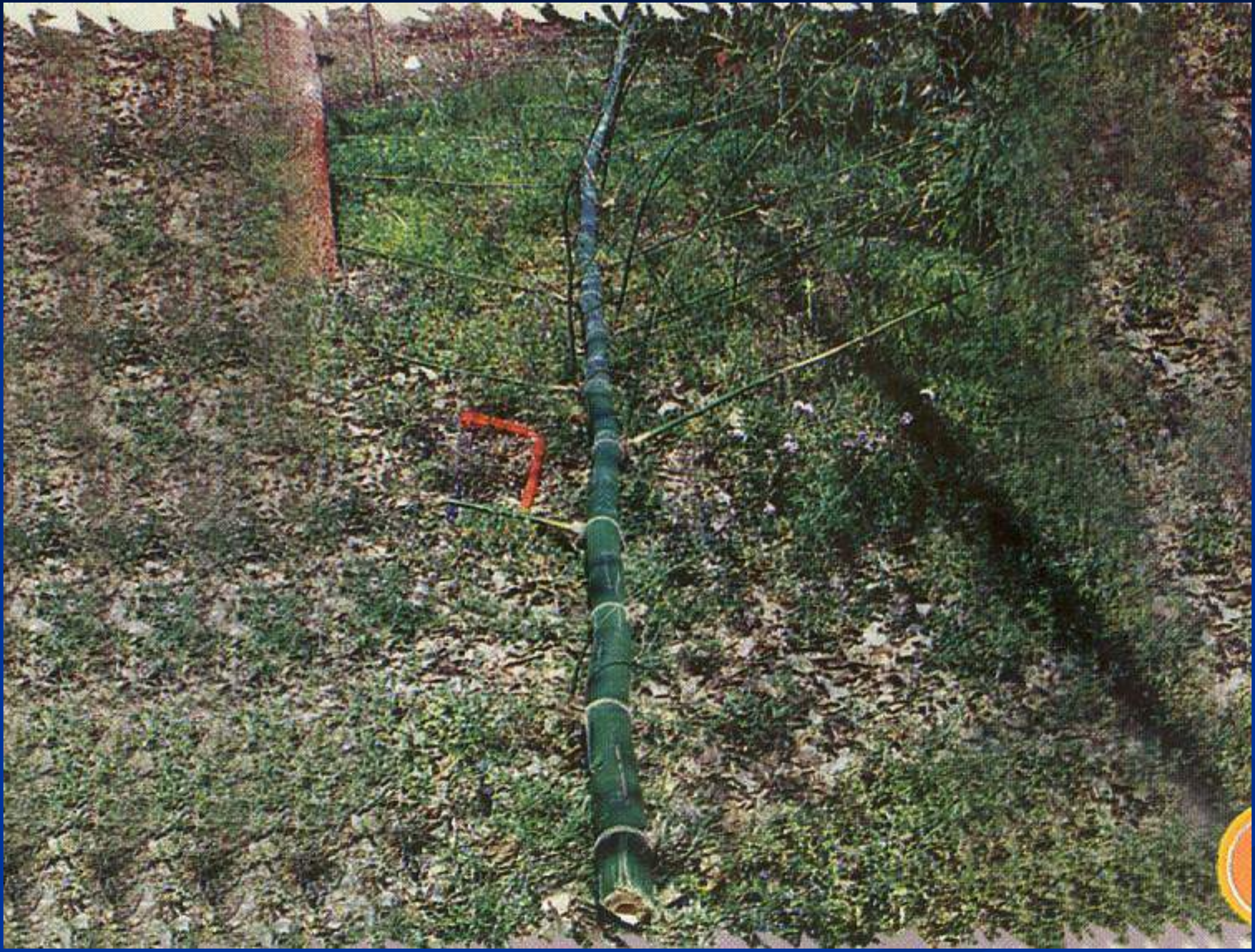


Spacing averages
5' to 7'
face measurement
1
2
3
Live facine
Wood stake
Live stake
Stems 1/2" to 1-1/2" diameter
8" to 10"
diameter
Untreated Twine Ties
4' to 8' length
not to scale

Fascines



Spacing averages 5'-7'
Stems 1/4" to 2" diameter
1
2
3
Slope fall line
Installation direction



END

Asphalt Concrete

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Arrangement of Presentation

- General
- Design (Marshal Mix Design)
- Construction Procedure
  - Production
  - Laying
  - Testing

General

- It is the mixture of carefully proportioned coarse aggregate fine aggregate, mineral filler and bitumen
- Some time called as Bitumenous Concrete
- It is the highest quality of surface in the group of flexible pavement

Steps Involved in Mix Design Process

- Selection of aggregates
- Selection of aggregate gradation
- Proportioning of aggregates to meet the required gradation
- Selection of bitumen binder and its grade
- Preparation of Marshall specimens
- Testing of the specimens (Density, Stability and Flow)
- Density - Voids Analysis
- Determination of Optimum Bitumen Content (OBC)

Ingredient

- Bitumen
- Coarse Aggregate
- Fine Aggregate
- Mineral filler

Requirement of Bitumen

- The bitumen shall be viscosity grade paving bitumen complying with the Indian Standard Specification IS: 73, modified bitumen complying with IS: 15462 or as otherwise specified in the Contract.

S No.	Characteristics	Paving Grades				Method of Test
		VG10	VG20	VG30	VG40	Ref to
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Penetration at 25°C, 100 g, 5 s, 0.1 mm, Min	80	60	45	35	NS: 221:2047 (Part III)/ IS: 1203
ii)	Absolute viscosity at 60°C, Poises	800-1200	1600-2400	2400-3600	3200-4800	NS: 237:2050 (Part VIII)/ IS: 1206 -2
iii)	Kinematic viscosity at 135°C, cSt, Min	250	300	350	400	NS: 237:2050 (Part VIII)/ IS :1206-3
iv)	Flash point (Cleveland open cup), °C, Min	220	220	220	220	NS: 237:2049 (Part VII)/ IS: 1448-69
v)	Solubility in trichloroethylene, percent, Min	99	99	99	99	NS: 221:2047 (Part IV)/IS: 1216
vi)	Softening point (R&B), °C, Min	40	45	47	50	NS / IS: 1205.
vii)	Tests on residue from rolling thin film oven test:					
a)	Viscosity ratio at 60°C, Max	4	4	4	4	NS: 221:2046 (Part II)/ IS: 1206-2
b)	Ductility at 25°C, cm, Min	75	50	40	25	NS: 221:2046 (Part I)/ IS: 1208

VG	General Application	Equivalent PG
10	Used in spraying applications, and can be used in very cold regions. Also used for the manufacture of bitumen emulsion & modified bitumen	80-100
20	It is used in areas of cold climate & high altitude	
30	It is the most suitable for Indian road condition.	60-70
40	The area with high stress concentration like intersections of roads, truck parking, heavy traffic. It can be used in higher temperatures	30-40

Selection Criteria for VG Paving Bitumen Based on Climatic Conditions

Lowest Daily Mean Air Temperature, °C	Highest Daily Mean Air Temperature, °C		
	Less than 20°C	20 to 30°C	More than 30°C
More than -10°C	VG-10	VG-20	VG-30
-10°C or lower	VG-10	VG-10	VG-20

Aggregate

The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on· 2.36 mm sieve.

It shall be clean, hard, durable and cubical shape, free from dust and soft organic and other deleterious substances.

Property	Test	Specification	Method of Test
Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075 mm sieve	IS:2386 Part I
Strength	LAAor AIV	Max 30% Max 24%	IS:2386 Part IV
Durability	Soundness either: SodiumSulphate or Magnesium Sulphate	Max 12% Max 18%	IS:2386 Part V
Polishing	Polished Stone Value	Min 55	BS:812-114

Property	Test	Specification	Method of Test
Water Absorption	Water Absorption	Max 2%	IS:2386.Part Ill
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%	IS: 6241
Water Sensitivity	Retained Tensile Strength*	Min 80%	AASHTO 283

* If the minimum retained tensile test strength falls below 80 percent, use of anti stripping agent is recommended to meet the requirement

Fine Aggregates

Fine aggregates consist of crushed or naturally occurring mineral material, or a combination of the two, passing the 2.36 mm sieve and retained on the 75-micron sieve.

These shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter.

PI shall not exceed 4

Filler

- Filler consist of finely divided mineral matter such as rock dust, hydrated lime or cement approved by the Engineer.

IS sieve (mm)	Cumulative % Passing
0.6	100
0.3	98-100
0.075	85-100

Grading	1	2
Nominal aggregate size*	19 mm	13.2 mm
Layer thickness	50 mm	30-40 mm
IS Sieve[1](mm)	Cumulative % by weight of total aggregate passing	
45		
37.5		
26.5	100	
19	90-100	100
13.2	59-79	90-100
9.5	52-72	70-88
4.75	35-55	53-71
2.36	28-44	42-58

1.18	**20-34**	**34-48**
0.6	15-27	26-38
0.3	10-20	18-28
0.15	5-13	12-20
0.075	2-8	4-10
Bitumen content % by mass of total mix	Min 5.2*	Min 5.4**

Issues

- Minimum thickness for the single lift of dense graded asphalt mixture is
  - 4* NMAS for the Coarse graded aggregate
  - 3* NMAS for the fine aggregate

NMAS: one size larger than the first sieve to retain more than 10% of the material(Asphalt mix design : MS-2 Seventh Edition)

Maximum aggregate size : One size larger than the NMAS

Minimum thickness when 19 mm aggregate is used

*4*19=76 mm for the coarse gradation*

*3*19=57 mm for the fine gradation*

Minimum thickness when 13.2 mm aggregate is used

*4*13.2 =52.8 mm for the coarse gradation*

*3*13.2=39.6 mm for the fine gradation*

- How to define Coarse and Fine Gradation

Primary control Sieve Define the Coarse and fine Gradation

NMAS	Primary control sieve
37.5	9.5
25,19	4.75
12.5,9.5	2.36
4.75	1.18

If 50% or more of the individual aggregate gradation passes the primary control sieve of the combine blend it will be consider as fine aggregate .

- Specification

19 mm NMAS – thickness is 50 mm

13.2 mm NMAS thickness is 30-40 mm

If you go for the fine gradation the thickness some how is near to the above relation but can not match in case of coarse aggregate

Hence recommended for the fine gradation in both case

Design of Asphalt concrete

The design of asphalt concrete mixes primarily consists of three basic steps these includes

- **Selection of aggregates**
- **Selection of binder and**
- **Determination of optimum binder content**

Requirements of Bituminous Mixtures

- Must be workable at application temperature
- Be able to resist permanent deformation
- Be able to resist Cracking
- Impermeable to ingress of water to lower layers
- Durable under prevailing traffic and environment
- Contribute to pavement strength
- Resistant to skidding in wert condition
- Use local materials
- Cost effective

Properties Considered in Mix Design

- Stability
- Durability
- Impermeability
- Workability
- Flexibility
- Fatigue
- Skid resistance

Stability

- It is the ability of mix to resist deformation under sustained loads
- A stable pavement maintain the shape and smoothness under repeated loading
- Stability of mix depend on internal friction and Cohesion
- Angular agg. with rough surface – High stability
- Stability requirements should be high enough to handle projected traffic adequately
- Too high a stability value produces a pavement that is too stiff , may crack and therefore less durable than desired.

Causes and Effects of Low Stability

Cause	Effect
Excess bitumen in mix	Corrugations, rutting and flushing /bleeding
Excess medium size sand in mixture	Tenderness during rolling and for period after construction, difficulty in compacting.
Rounded aggregate, little or no crushed surfaces	Rutting

Durability

Durability is the ability to resist factor such as change in asphalt due to polymerization/ oxidation, disintegration of aggregate and stripping of aggregate due to weather ,traffic or combination

Durability can be increase by

- using maximum bitumen content
- using a dense gradation of stripping-resistant aggregates
- designing and compacting the mixture for low permeability

Causes and Effects of Poor Durability

Cause	Effect
Low asphalt content	Dry Surface or raveling
High void content through design or lack of compaction	Early hardening of bitumen followed by cracking or Disintegration
Water susceptible (hydrophilic) aggregate in mixtures	Films of bitumen strip from aggregate leaving an abraded, raveled

Impermiability

- It is the resistance of pavement to the passage of air and water into or through it.
- Even though void content is an indication for the potential for passage of air and water through a pavement, the character of these voids is more important than th number of voids.
- The degree of impermeability is determined by the size of the voids, whether or not the voids are interconnected, and the access of the voids to the surface of the pavement.
- Virtually all bituminous mixtures used in road construction are permeable to some degree

Causes and Effects of Permeability

Cause	Effect
Low bitumen content	This bitumen films will cause early aging and raveling
High voids content in design mix	Water and air can easily enter pavement causing oxidation and disintegration
Inadequate compaction	Will result in high voids in pavement leading to water infiltration and low strength

Workability

- Workability describe the ease with which a paving mix can be placed and compacted.
- Can be improved by changing the mix design parameter, aggregate source and/or gradation
- Harsh mixtures (mixtures containing a high percentage of coarse aggregates) have a tendency to segregate during handling and also may be difficult to compact.
- Too high a filler content can also affect workability . It can cause the mix to become gummy, making it difficult to compact.

- Mixture that can be too easily worked or shoved are referred as tender mix.
- Tender mix are too unsuitable to place and compact
- too low a temperature will make a mix unworkable, too high temperature may make it tender .
- Bitumen contain and grade also affect the workability

Causes and Effects of Poor Workability

Cause	Effect
Large maximum-sized particles	Rough surface, difficult to place
Excessive coarse aggregates	May be hard to compact
Too low a mix temperature	Uncoated aggregate, not durable, rough surface, hard to compact
Too much medium-sized sand	Mix shoves under roller, remains tender
Low mineral filler content	Tender mix, highly permeable
High mineral filler content	Mix may be dry or tender, hard to handle, not durable

Flexibility

- It is the ability of an a bituminous pavement to adjust to gradual settlements and movements in the subgrade without cracking.
- An open-graded mix with high bitumen content is generally more flexible than a dense-graded, low bitumen content mix.
- Need for the more flexibility may conflict with the stability requirements

Fatigue Resistance

- It is the resistance to repeated loading under wheel loads.
- Air voids and bitumen viscosity have a significant effect on fatigue resistance.
- As the percentage of air voids increases, pavement fatigue life is drastically shortened.
- A pavement containing bitumen that has aged and hardened significantly has reduced resistance to fatigue.
- Thick, well supported pavements do not bend as much under loading as thin or poorly supported pavements do.

Causes and Effects of Poor Fatigue Resistance

Cause	Effect
Low asphalt content	Fatigue cracking
High design voids	Early aging of asphalt followed by fatigue cracking
Lack of compaction	Early aging of bitumen followed by fatigue cracking
Inadequate pavement thickness	Excessive bending followed by fatigue cracking

Skid Resistance

- It is the ability of and bituminous surface to minimize skidding or slipping of vehicle tires, particularly when wet.
- For good skid resistance, tire tread must be able to maintain contact with the aggregate particles instead of riding on a film of water on the pavement surface (hydroplaning).
- Best skid resistance is obtained with rough-textured aggregate in a relatively open-graded mixture.
- Besides, having a rough surface the aggregates must resist polishing (smoothing) under traffic.
- Unstable mixtures that tend to rut or bleed present serious skid resistance problems.

Causes and Effects of Poor Skid Resistance

Cause	Effect
Excess asphalt	Bleeding, low skid resistance
Poorly textured or graded aggregate	Smooth pavement, potential for hydroplaning
Polishing aggregate in mixture	Low skid resistance leading to accidents on wet surface

Conclusion

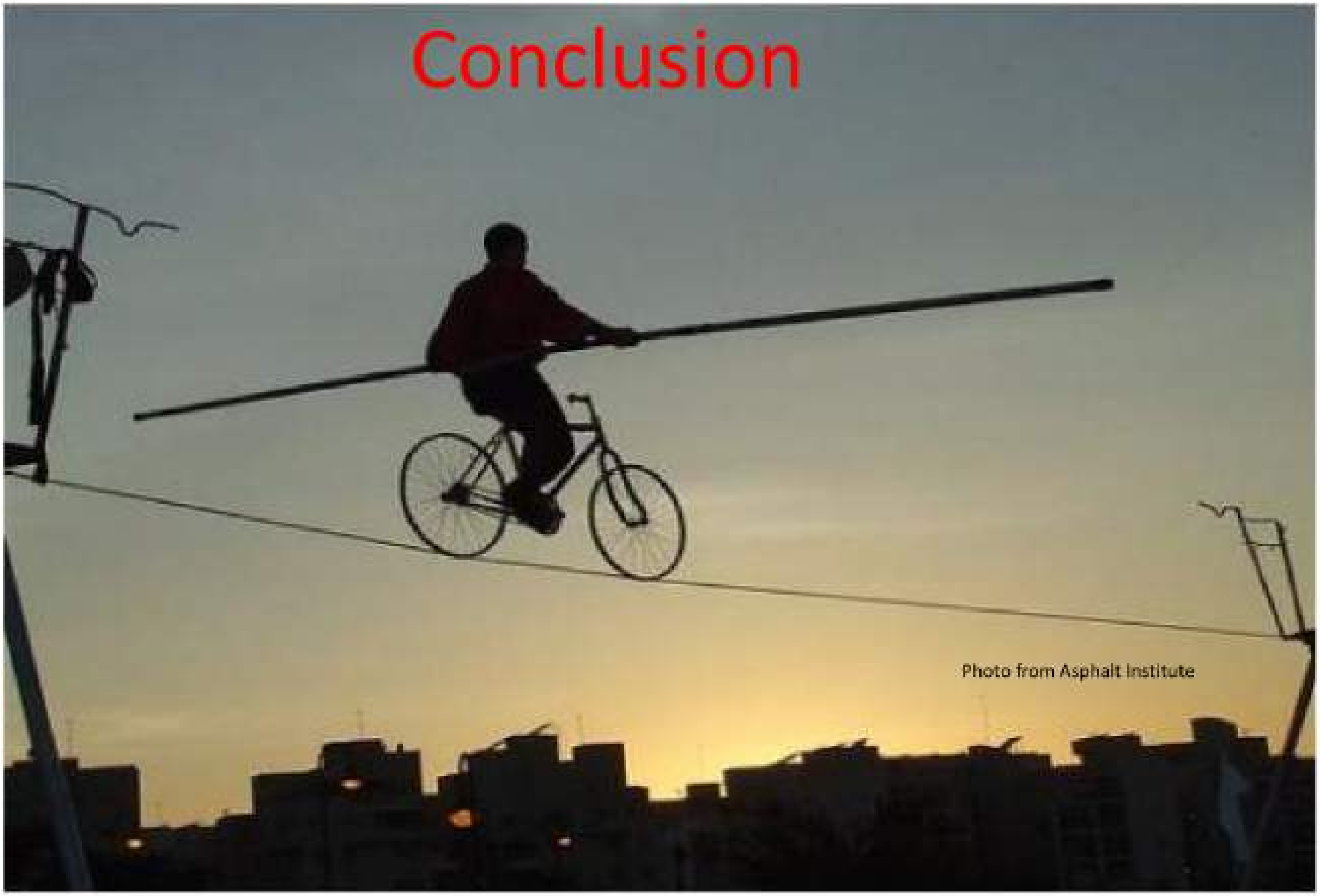


Photo from Asphalt Institute

Mix Design Methods

- Hubbard Field (1920s)
- Hveem (1930s)
- Marshall (1940s)
- Super Pave (1990s)

History of Marshal Test

- Concept was Develop by Bruce Marshal former Bituminous Engineer associated with Mississippi State High way
- Marshal test in present form was originated in 1943 by US Army crops of Engineers.

Apparatus

- Mould Assembly : Cylindrical moulds(6.4 cm(2.5 inch) height and 10.2 cm (4 inch) diameter) consisting of base plate and collar
- Compaction Pedestal and Hammer : 4.54 kg weight and a free fall of 45.7 cm
- Braking Head : inside radius of curvature of 5 cm
- Sample Extuder
- Loading Machine
- Flow Meter


CYLINDRICAL MOULD
7.5 cm
(Height)


BREAKING HEAD


RAMMER
4.54 Kg
(Weight)
Droppe
from

Preparation of Specimen

- The coarse aggregates, fine aggregates and the filler material should be proportioned and mixed as per the dry mix design
- The required quantity of the dry mix is taken so as to produce a compacted bituminous mix specimen of thickness 63.5 mm approximately
- Approximately 1100 g of aggregates and filler is taken to get a standard specimen
- Minimum three specimen per binder content

- The dry mix of aggregates and filler is heated to a temperature of 150 to 160°C
- The compacted mold assembly and rammer are cleaned and kept preheated to a temperature of 100 to 140°C
- The bitumen is heated to a temperature of 150°C to165°C
- Samples are prepared with the first trial percentage of bitumen
- The mixing temperature of the VG 10 ,VG 20 & VG 30grade is about 160 ,165°C & 170° C

Compaction of the Specimen

- The mix is placed in the mold and compacted by a rammer with about 75 blows on each side
- The weight of hammer is 4.54 kg and height of fall is 457 mm
- The compacting temperature may be about 130 C for VG 10 ,135°C for VG 20 140 C for VG 30 grade bitumen
- The compacted specimen should have a thickness of63.5±1.3 mm

Sample Extraction

- The compacted specimens are extracted using a Sample Extractor after the curing time
- Sample extractor is designed for fast extrusion of samples from compaction mounds
- At least three specimens should be prepared at each trial bitumen content which may be varied at 0.5% increments
- As soon as the specimen cool to room temperature bulk specific gravity of specimen is determined.

Loading and Testing

- The specimens to be tested are kept immersed in water in a thermostatically controlled water bath at 60 ± 1 °C for 30 to 40 minutes.
- Take out the specimen from the water bath and place it in the breaking head
- Place the breaking head in Marshall testing machine
- Load is applied on the breaking head by the loading machine at the rate of 5 cm per minute at 60° C

Stability and Flow value

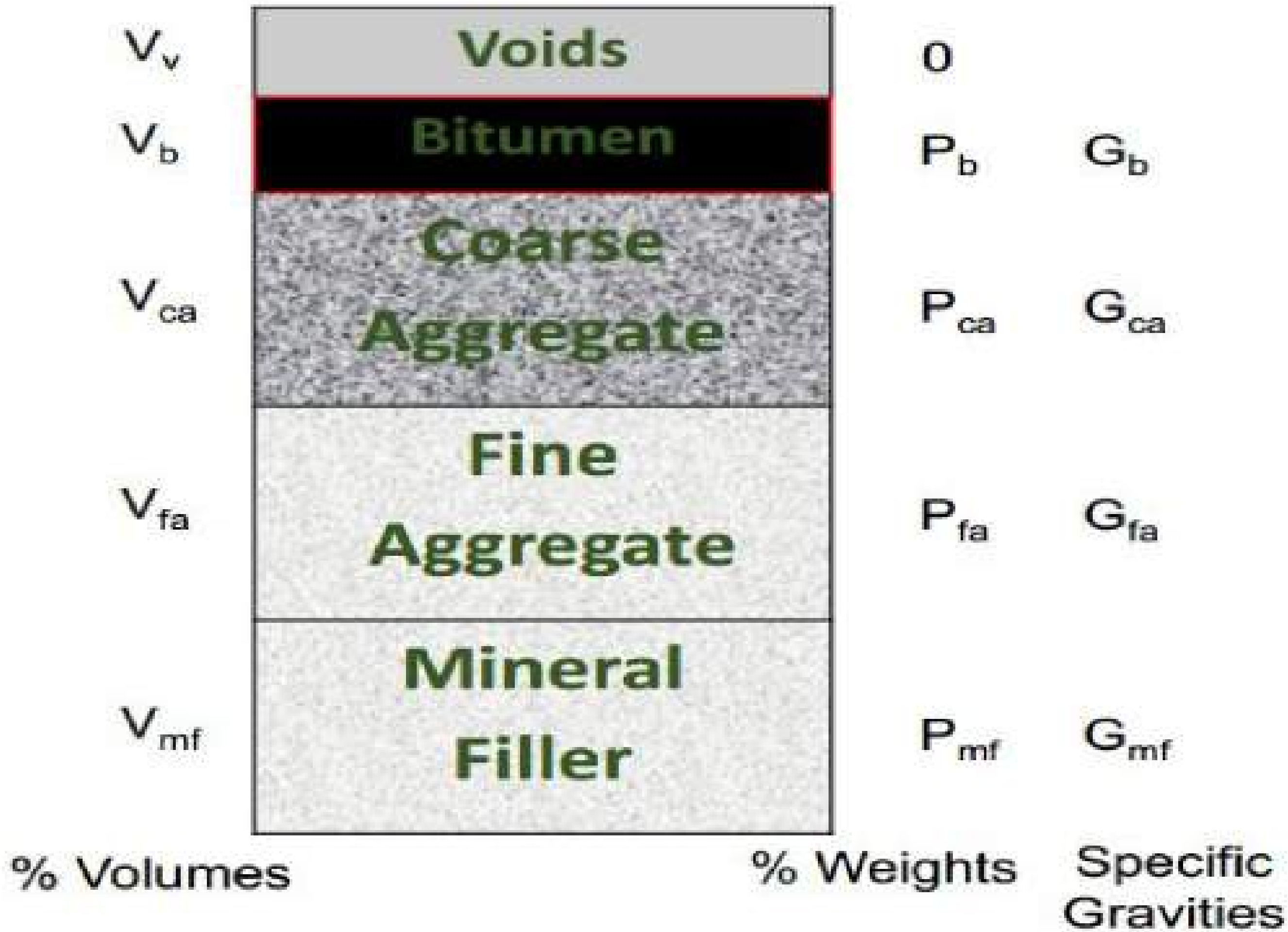
- Stability value is the load taken by the specimen at the failure
- Flow value is the deformation of the specimen at failure
- Record stability either by proving ring or load cell display unit
- Record the flow by the dial gauge or displacement cell attached to the breaking head

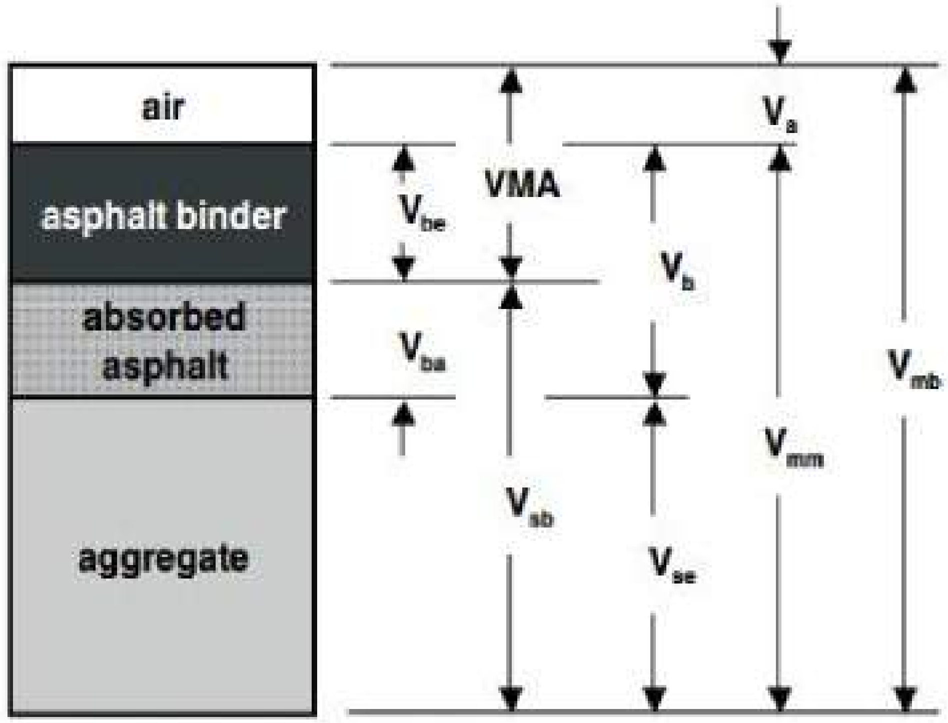
Correction to Stability value

Volume of specimen in cm^3	Approximate Thickness of Specimen in mm	Correction Factors
457-470	57.1	1.19
471-482	58.7	1.14
483-495	60.3	1.09
496-508	61.9	1.04
509-522	63.5	1.00
523-535	65.1	0.96
536-546	66.7	0.93
547-559	68.3	0.89
560-573	69.9	0.86

When the specimen height is not exactly 63.5 the stability value need to be corrected with the correction factor

Weights and Volumes in a Compacted Specimen





V_{be} = Volume of effective asphalt binder
VBE = Effective asphalt content, percent by volume
V_{ba} = Volume of absorbed asphalt binder
VBA = Absorbed asphalt binder, percent by total mix volume
V_{ma} = Volume of voids in mineral aggregate
VMA = Voids in mineral aggregate, percent by volume
V_{sb} = Volume of aggregate, bulk (including all permeable surface pores)
V_b = Volume of asphalt binder, total
VB = Total asphalt binder content, percent by volume
V_{se} = Volume of aggregate, effective (excluding surface pores filled with asphalt)
V_a = Volume of air voids
VA = Air void content, volume percent
V_{mm} = Volume of aggregate and asphalt
V_{mb} = Volume of specimen, total

Density Void Analysis

- Bulk density of compacted mixture (Gmb)
- Bulk specific gravity of aggregate (Ga)
- Theoretical maximum specific gravity (Gt)
- Percent air voids in the final mix (Vv)
- Percent air voids in mineral aggregates (VMA)
- Percent aggregate voids filled with bitumen (VFB)

Bulk specific gravity of compacted mixture

- By weighing in air and water : if the specimen has impermeable surface(ASTM D 2726)
- Gmb= W/(W–Ww)
- Where, W & Ww= weight of the specimen in air and water

- By weighing paraffin coated specimen in air and water : if the specimen has open impermeable surface (ASTM D 1188)

$$G_{mb} = \frac{W}{W' - W'_w - \frac{(W' - W)}{G_p}}$$

- W’ = weight of coated specimen in air
- W’w= weight of coated specimen in water
- Gp= specific gravity of paraffin coating at 25 0C

Bulk specific gravity (Ga) of aggregate

$$G_a = \frac{P_{ca} + P_{fa} + P_{mf}}{\frac{P_{ca}}{G_{ca}} + \frac{P_{fa}}{G_{fa}} + \frac{P_{mf}}{G_{mf}}}$$

P = percentages by weight of aggregates
G = Bulk specific gravities of aggregates

Theoretical Maximum Specific Gravity (Gt) of the mix

$$G_t = \frac{100}{\frac{P_{ca}}{G_{ca}} + \frac{P_{fa}}{G_{fa}} + \frac{P_{mf}}{G_{mf}} + \frac{P_b}{G_b}}$$

Voids in Final Mix $V_v = 100 * \frac{(G_t - G_{mb})}{G_t}$

- Void in Mineral Aggregate

$$VMA = 100 - \frac{G_{mb}P_a}{G_a}$$

- Aggregate void filled with Bitumen

$$P_a = P_{ca} + P_{fa} + P_{mf}$$

$$VFB = 100 * \frac{(VMA - V_v)}{VMA}$$

Gmm(Gt)=A/(A+D-E)

Where :Gmm: Theoretical maximum specific gravity

A= Mass of oven dry specimen in air

D= Mass of container filled with water at 25oc

E=Mass of container with specimen filled with water at 25oc

Air Voids

Air voids," when applied to asphalt concrete, means small pockets of air that exist within the asphalt binder and between aggregate particles. Air void content does not include pockets of air within individual aggregate particles, or air contained in microscopic surface voids or capillaries on the surface of the aggregate

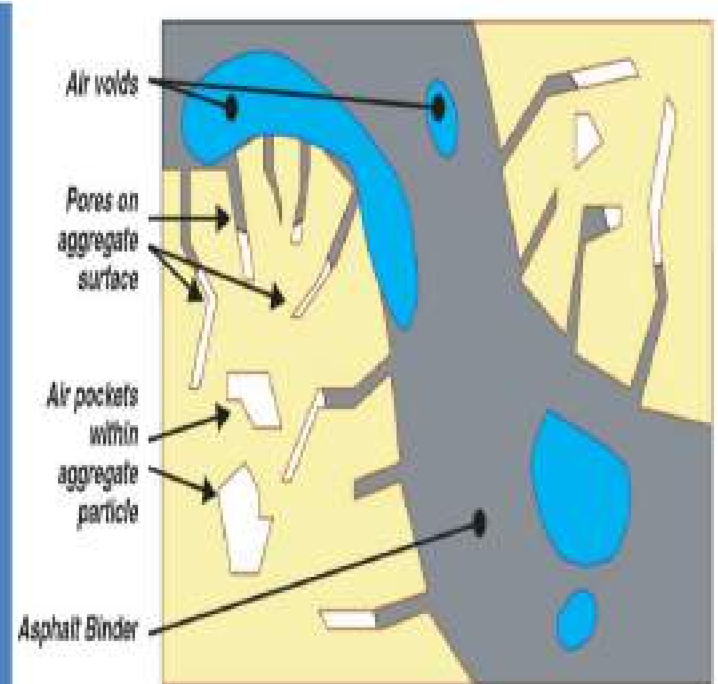


Figure 5-2. **Air in asphalt concrete.** *Air can exist in pores on the aggregate surface, pockets within aggregate particles, or voids within the asphalt binder or between the binder and aggregate particles. Only the last type of air is included in the air void content of asphalt concrete mixtures.*

Void in Mineral Aggregate(VMA)

Voids in the mineral aggregate (VMA) refers to the space between aggregate particles in an asphalt concrete mixture. VMA is also often used to characterize loose aggregate, but its meaning is exactly the same—the volume percentage of space between aggregate particles. VMA is numerically equal to the air void content plus the effective binder content by volume

Figure 5-4. ***Voids in mineral aggregate.*** *Dark and light gray areas represent aggregate particles, black area asphalt binder and white areas air voids; voids in mineral aggregate (VMA) is composed of asphalt binder and air voids—black and white areas.*

Void filled with Bitumen/Asphalt (VFB/VFA)

- Voids filled with asphalt (VFA) is the percentage of VMA filled with asphalt binder—the balance is air voids.
- VFA is calculated by dividing the effective binder content by the VMA and multiplying by 100%.

Effective Binder Content

- The term "effective binder content," abbreviated as Vbe, is used to describe the amount of asphalt binder in a mixture not including that absorbed by the aggregate.
- For example, if the total asphalt content of a mixture is 5.3% by weight, and the aggregate absorbs 0.4% binder by total mix weight, the effective binder content of this mixture is 5.3 −0.4 =4.9%.

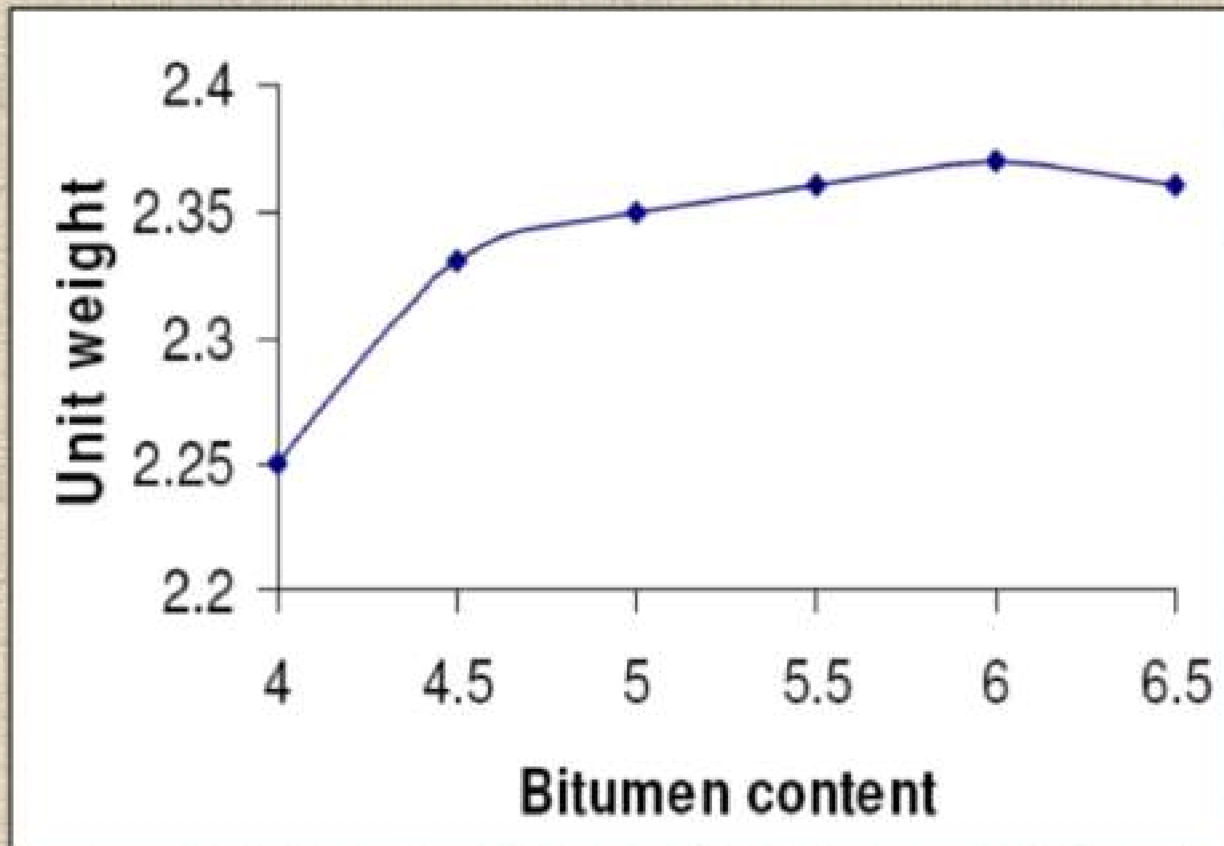
OPTIMUM BITUMEN CONTENT (OBC)

Following are plotted

- Unit weight vs. bitumen content
- Marshall stability vs. bitumen content
- Percent voids in mix vs. bitumen content
- Percent aggregate voids filled with bitumen vs. bitumen content
- Flow values vs. bitumen content

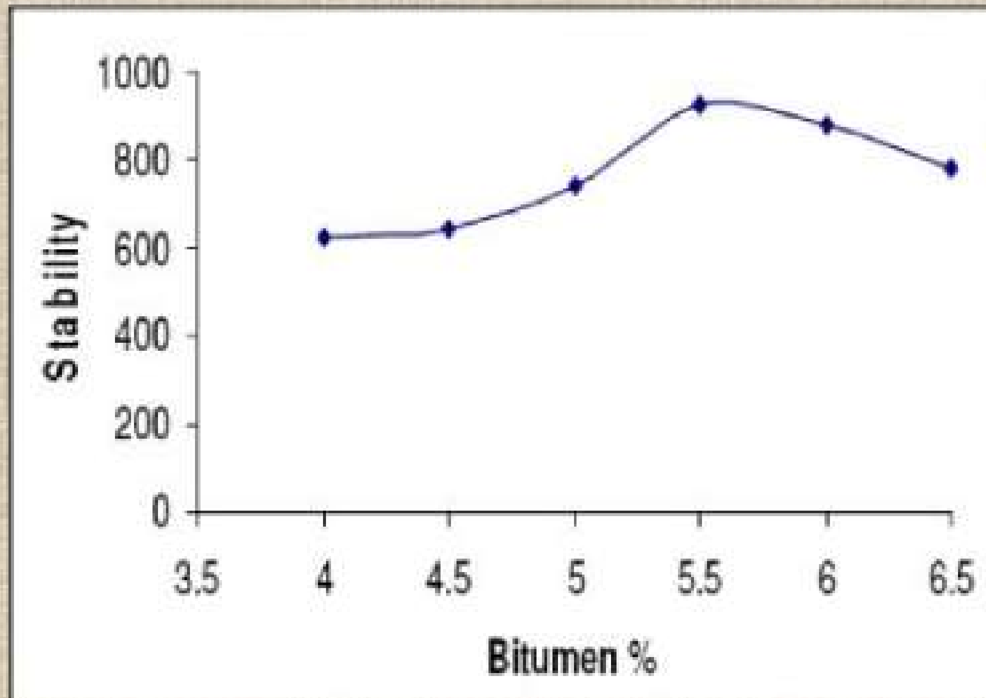
Unit weight vs. Bitumen content

Bitumen content	Unit Weight
4	2.25
4.5	2.33
5	2.35
5.5	2.36
6	2.37
6.5	2.36



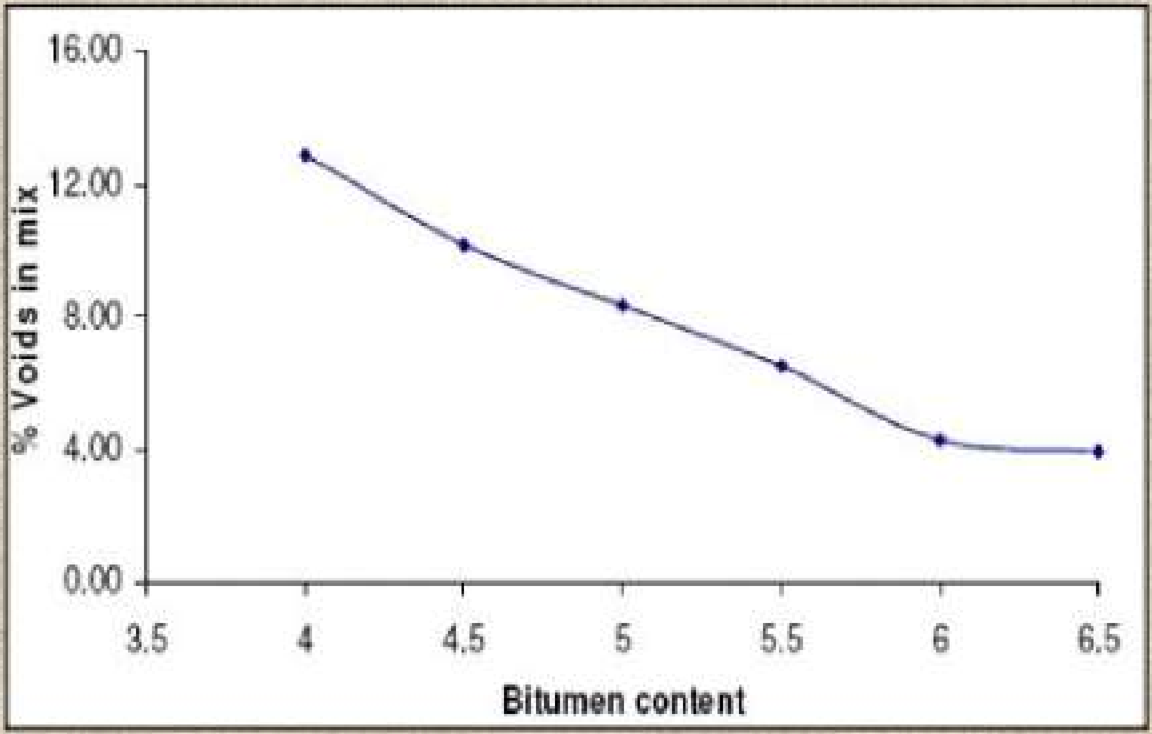
Stability vs. Bitumen content

Bitumen Content	Stability
4	622.432
4.5	643.955
5	746.205
5.5	928.704
6	884.22
6.5	780.458



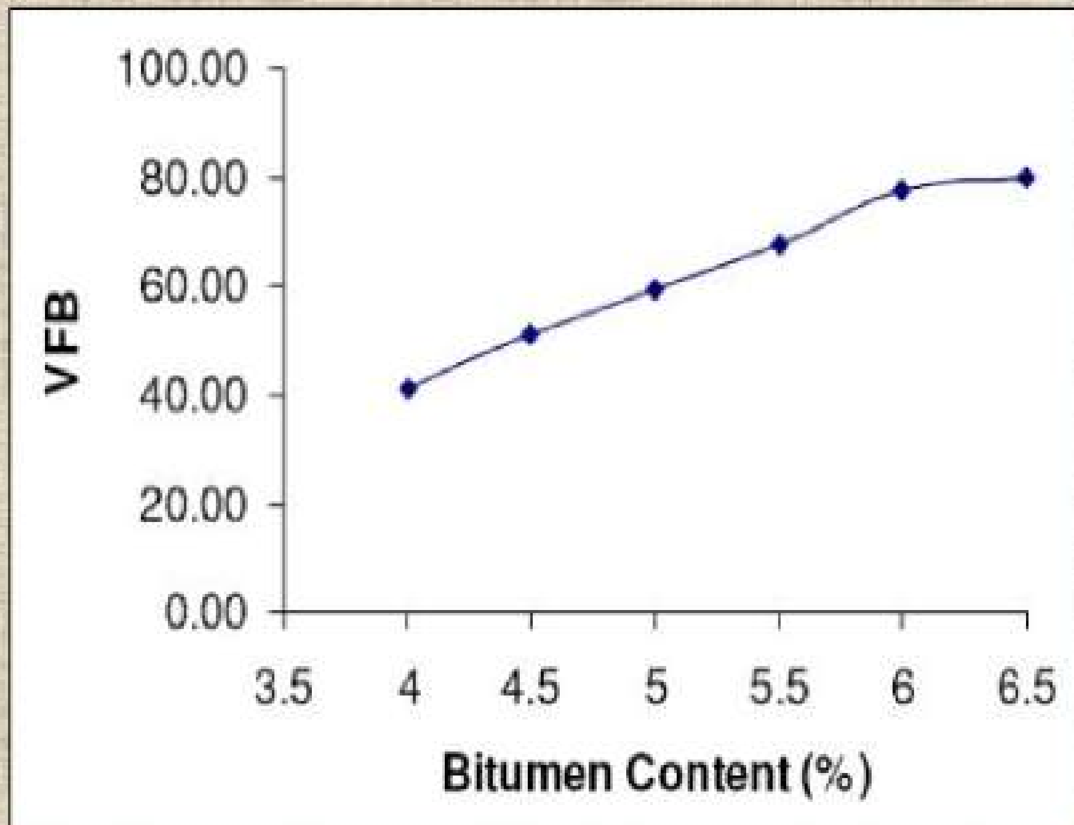
% voids in mix vs. Bitumen content

Bitumen content	V_v
4	12.85
4.5	10.16
5	8.35
5.5	6.51
6	4.26
6.5	3.96



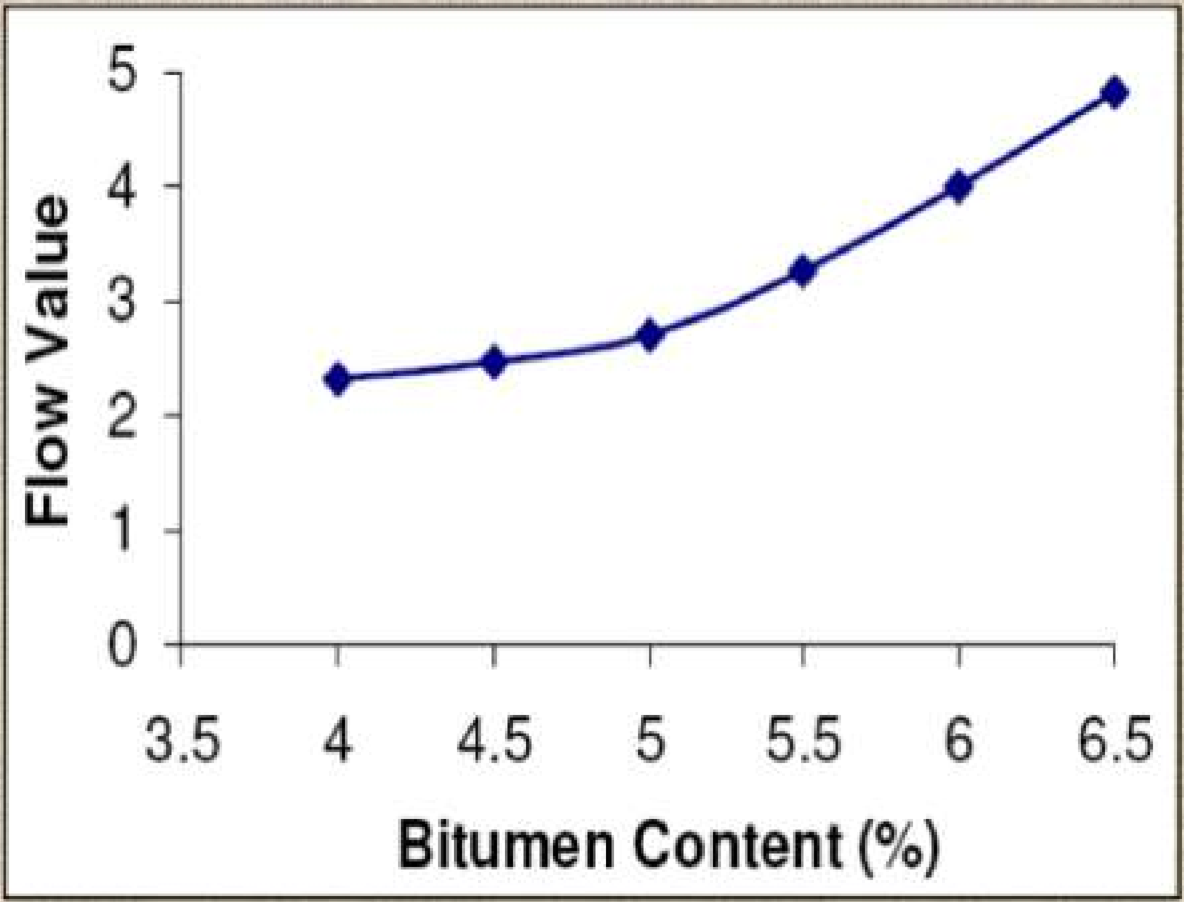
VFB vs. Bitumen Content

Bitumen content	VFB
4	41.43
4.5	51.41
5	59.14
5.5	67.40
6	77.80
6.5	80.26



Flow value vs. Bitumen content

Bitumen Content	Flow Value
4	2.33
4.5	2.48
5	2.72
5.5	3.27
6	4.01
6.5	4.82



Required Parameters

- Property Requirement Minimum Stability (kN at 60^{o}C) 9.0
- Marshall Flow 2- 4 mm
- Compaction Level (No. of Blows) -75 blows on each of the two faces of the specimen
- Percent Air Voids 3 – 5
- Percent Voids Filled With Bitumen (VFB) 65 – 75
- Coating of aggregate: 95%
- Tensile strength ratio: 80% minimum

- Void in mineral aggregate

Nominal Maximum particle size	Minimum VMA % related to design % air void		
	3	4	5
26.5	11	12	13
37.5	10	11	12

Optimum Bitumen Content

- Determine the bitumen content at 4% air void
- If the calculated and measured properties at this bitumen content meet the mix design criteria then the binder content at 4% air void is the optimum binder content for the mix design

Design Adjustment

Result	Probable Solution
Low void and low stability	Add coarse aggregate and reduce the asphalt content if possible
Low void and satisfactory stability	Increase the aggregate
High void and satisfactory stability	Increase the mineral dust
Satisfactory void but low stability	Improve the aggregate quality
High void but low stability	Improve the quality of aggregate with increase mineral filler

Tensile strength Ratio

- Tensile Strength (st): 2000*p/(pi*t*d)
  where

  St: tensile strength in kpa

  P : maximum load in N

  T: specimen thickness

  D: specimen diameter

Tensile strength Ratio(TSR)=S2/S1

Where

S2=average tensile strength after moisture and freeze thaw conditioning

S1=average tensile strength in dry condition.

specimens measuring 4 inches (100 mm) in diameter and 2.56 inches (65.0 mm) in height. specimens are loaded until failure at a rate of 2 inches per minute (50.8 mm per minute)

Conditioning of Sample

- Saturate the sample to 70-80 %saturation level by applying vacuum
- Freezing and thawing of sample by placing the sample at -18 °c for 16 hour
- Place the sample in water bath for 24 hr at 60°C
- Place the sample in water bath for 2 hr in 25°c

Production and Quality Control

Asphalt Plant

- Asphalt Plant is an assembly of mechanical and electronic equipment where get blended, heated, dried and mixed with bitumen to produce asphalt mix meeting specific requirements

Plants can be categorized as

- Batch plant
- Drum mix plant

Batch Mix Plant

Batch Mix	Drum Mix
Production In Batch	Continuous Production
Suitable for producers who work for several clients at the same time, because the specifications can be easily changed, while maintaining a high level of quality.	Suitable for single type of production as there is no interruption in the production cycle as the rhythm of production is not broken into batches.
Weight of aggregate after drying	Wt before drying and provision of manual moisture correction.
Presence of screen for better control in aggregate gradation	Initial control in gradation before feeding into drum
Bitumen is metered by weight through load cells in the weigh hopper calculated on the basis of the specifications and the actual weight of the aggregates.	metering is generally volumetric through a litre-counter subsequent to the feed pump.
Mixing time can be varied depending upon type of material	Mixing time is constant irrespective of material produced

Pre- works

- Job mix formula : contractor need to submit the job mix formula at least 21 days before the start of works
- Plant Trials: Once the Job mix formula is approved plant trials is carried out in order to ensure that plant can produce the uniform mix conforming to the approved Job mix formula. Certain variation is permitted depending upon the specification.
- Site trial: After plant trail is successful the site trial is carried out in section of minimum 100 sqm out of the construction area . Contractor will demonstrate that his working method shall be adequate to achieve the design requirements

Weather Limitation

Asphalt concrete laying shall be suspended when

- Water is present at surface
- Rain is imminent ,during the rain, fog, dust storm
- When the air temperature on the surface where the asphalt is to aid is less than 10°c
- When the wind spped measured 2 m above the surface is more than 40 Km/hr

Laying and Compaction

- Cleaning of underlying layer by air compressor before the commencement of asphalt concrete laying activities.
- Preparation of necessary equipment at laying site.
- Transportation of the AC mix by tipper. Mix is covered for the preservation of temperature and contamination.
- Application of tack coat before laying asphalt concrete mix.
- Delivery of AC mix on the hopper of the mechanical paver to start asphalt concrete laying.

- Checking of temperature of mix before delivering, during laying and before compaction.

Grade	Bitumen Temp.	Aggregate Temp.	Mixed Material Temp.	Laying Temp	Rolling temp
VG40	160-170	160-175	160-170	150 min	100 min
VG30	150-165	150-170	150-165	140 min	90 min
VG20	145-165	145-170	145-165	135 min	85min
VG10	140-160	140-165	140-160	130 min	80 min

- During the laying of the asphalt concrete mix, a good coordination between the equipment and labors shall be maintained.
- Checking of laid loose thickness manually and adjust immediately the thickness if necessary.
- Follow up level corrections by skilled labors.
- Perfect finishing of the asphalt concrete layer before compaction by skilled and unskilled labor team for the level corrections at joints while laying on next lane
- Initial compaction of the asphalt concrete layer by steel roller(less than 5 Km/hr) as close as possible to the paver

- Follow up compaction by pneumatic roller. The rolling shall be continued until the voids measured in the completed layer are within the appropriate range.
- Final rolling by the steel wheel roller to eliminate the marks from previous rolling
- The minimum temperature of the mixture at the time of completion of rolling shall be not less than 80oC.
- Average density after compaction shall not be less than 92 % of average theoretical maximum specific gravity Gmm
- Cutting the edge of previously laid mix with edge cutter for laying the mix on next lane or to continue laying on same lane on next day. The edge cut should be perfectly vertical.
- Core sample of the previously laid mix is taken out with the help of core cutter for further necessary laboratory tests

Segregation

Premature Distress

- **Raveling**
- **Frost Damage**
- **Potholes**

Weaker Aggregate Structure and Gradation

Weaker Mix

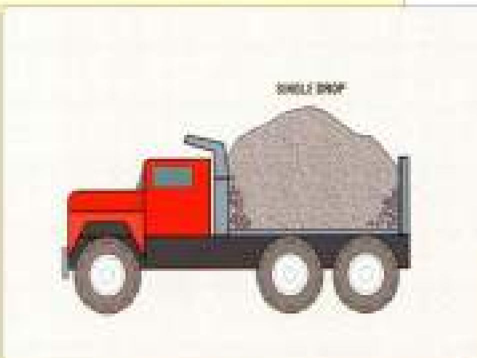
Higher Voids

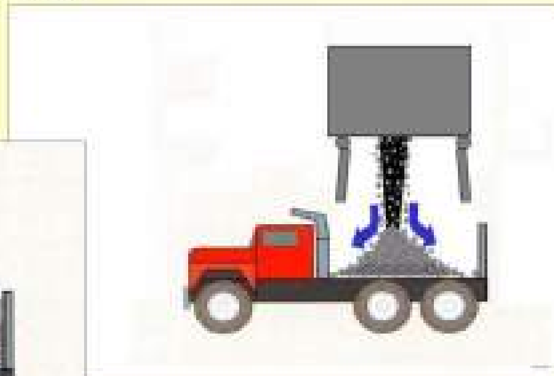
Segregation

- **Mix design**. The key mix design parameters in determining segregation susceptibility are gradation and asphalt content. Specifically, open-graded mixes and low asphalt binder content mixes are particularly prone to segregation.
- **Stockpiling.** If aggregate is loaded on top of a conical stockpile then larger aggregate sizes are more likely to roll to the outside and bottom.
- **Asphalt plants**. Key portions of the plant generally concerned are
  - Cold feed bins. Bins may not feed uniformly.
  - Batch plant hot bins. Dust may collect on the wall and discharge in large concentrated slugs.
  - Drum mixers. Large particles will generally flow through a drum mixer more quickly than smaller particles.
  - Surge and storage bins. Situations such as an off-set discharge chute, angled material flow from the discharge chute, and excessively large bin openings can lead to segregation.
- **Truck loading and unloading**. Loading trucks in one large dump may cause the larger aggregate sizes to roll to the outside and bottom.
- **The asphalt paver**. Segregation occurs as a result of hopper operation, auger speed, and disruptions in paver movement.

Truck Loading Segregation – how does it happen?

- Dribbling the material
- Single drop





Truck Loading Segregation – how is it prevented?

- No dribbling, no topping off
- Multiple Drops

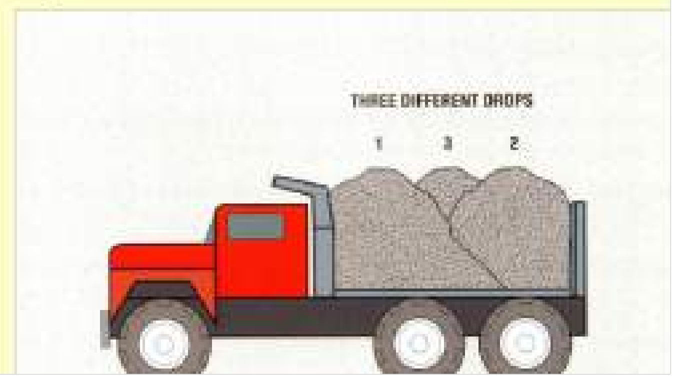


Figure 12.
Use Numerous Small Piles.

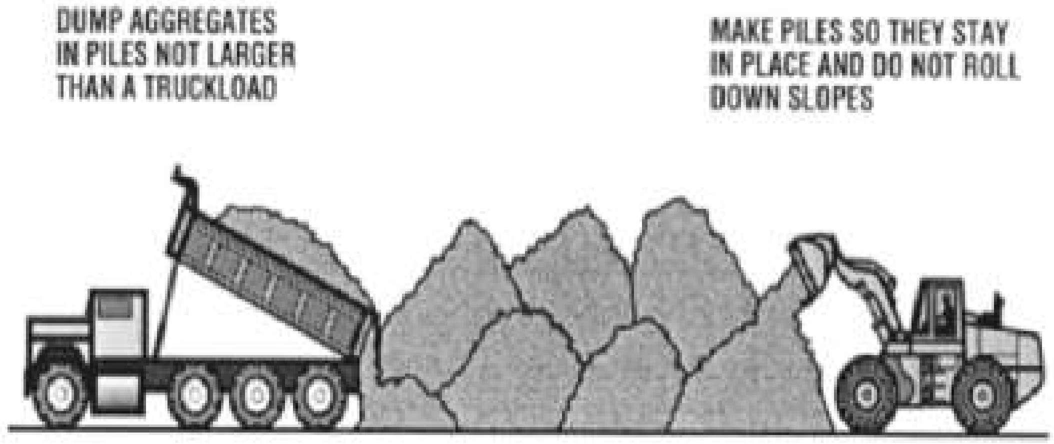
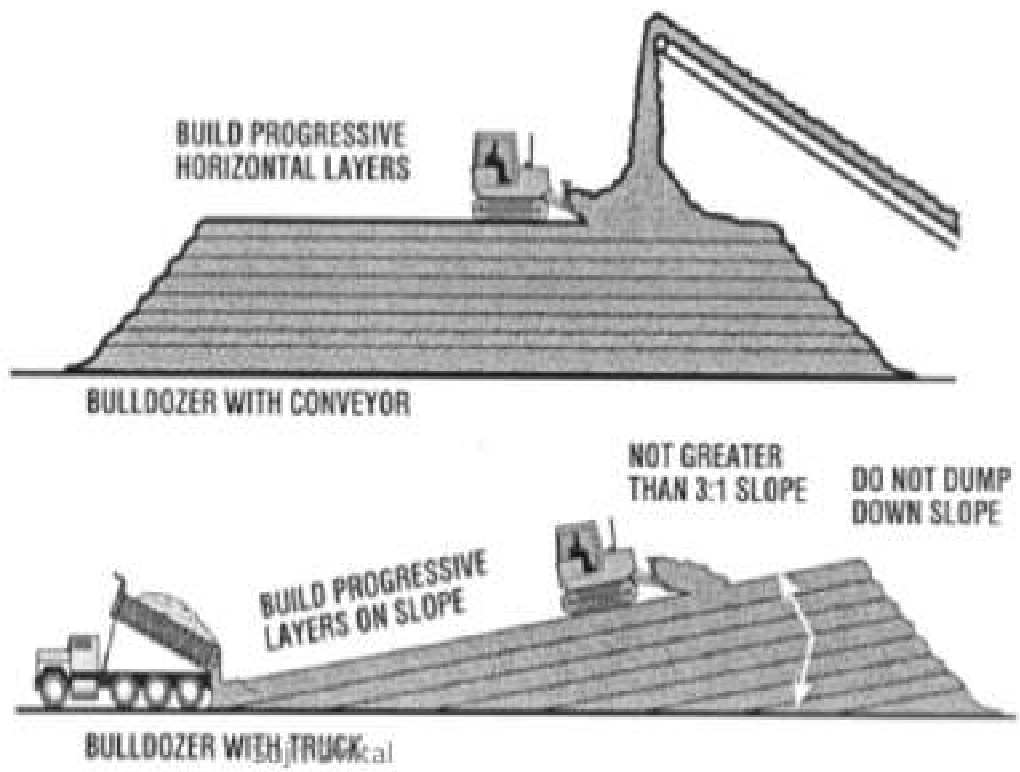


Figure 13.
Build Stockpiles in Layers.



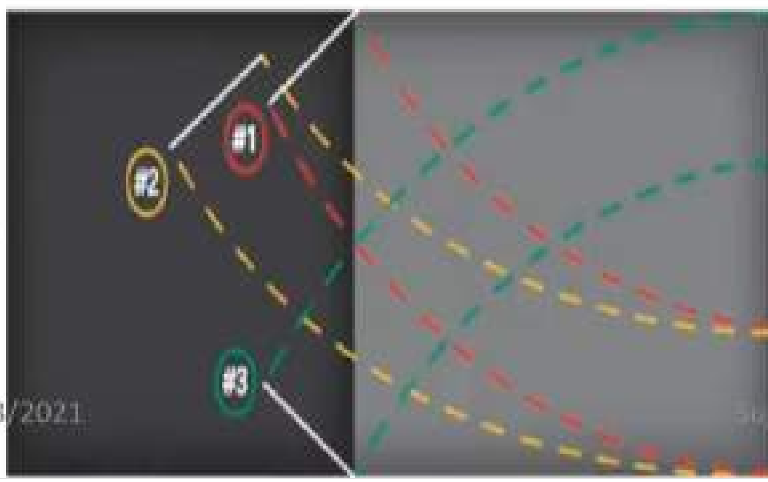
Transverse joint

- Straight edge tells the story
- Too high – more rolling may help
- Too low – hand work needed to fill in

Good Transverse Joint Starting Point

Transverse Joint Rolling Pattern

hot



cold

Transverse Joint Rolling Pattern

Longitudinal joint

Roll on the hot side about 6 inches away from the joint as . With this method the roller can be operated in the vibratory mode. The next pass would roll down the 6-in. wide mound that is left between the surface that is rolled and the cold side. Care has to be taken with this process to ensure that when the 6-in. strip is rolled no cracks develop. If not done correctly there is a tendency to develop a crack on either side of the 6-in. strip.

- A second method is to place the roller on the cold mat and overlap approximately 6 in. on the hot side. With this method the roller must operate in the static mode to ensure that no damage is done to the cooled HMA. This method applies a large amount of pressure to the material in the 6 in. overlap, resulting in improved density at the joint

- A third method is to roll on the hot side and overlap about 6 in. on the cold side. The vibrator can be on during this process

Testing Frequencies

Test	Frequency
Quality of Binder as per IS73(paving bitumen)	Certificates from suppliers. One set of tests for each 50,000 litres of supply or part of it
AIV/LAA, Flakiness and Elongation index, Soundness test (SSS),	Once per 500 cum and change in source.
Sand equivalent, Plasticity Index, Polished stone value	Once test for each source and change in source.
Mix grading, for individual constituent and mixed aggregate from dryer	One set consisting of three for each 400 ton of mix subject to minimum of two test per day per plant
Stability and void analysis of mix including theoretical max specific gravity of loose mix ,flow, void, density, binder content	

Testing Frequencies

Test	Frequency
Density of Compacted layer	One test per 700 sqm area
Control temperature of binder in boiler, aggregate in the dryer, mix at the time of laying and roll	As required

Sujit Dhital


SHOT ON MI A1
MI DUAL CAMERA
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2021.2.18 08:07
9/3/2021


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CONTROL PANEL UNIT
2021/3/10 16:00


9/3/2021
Sujit Dhital
2021/2/10 14:19


9/3/2021


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