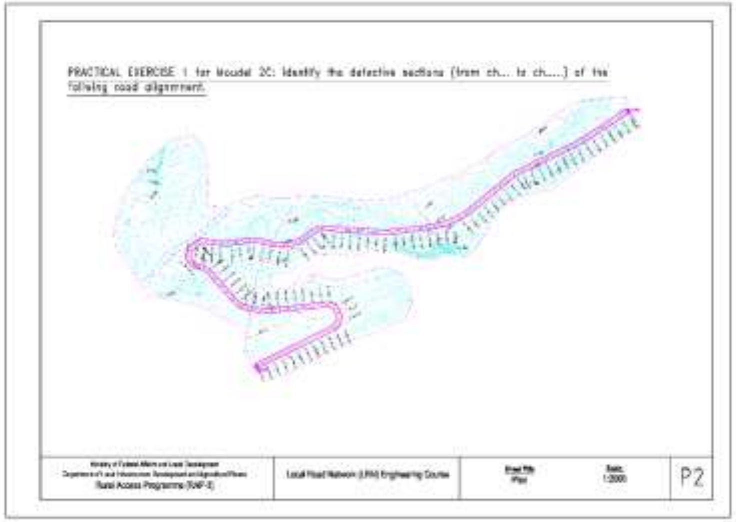
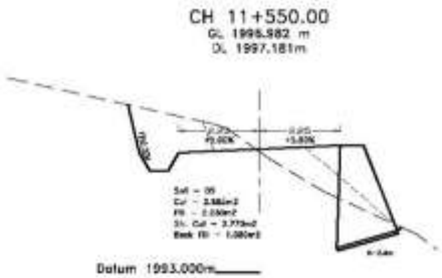
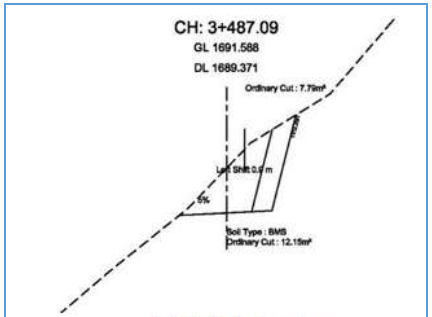
Overall Duration		3 hours 30 mins
Total Number of Slides		74
Plan for Practical Exercises	No.	3
	Duration	Practical 1 – 30 minutes (15 min for identifying the defects and 15 min for discussion) Practical 2 – 20 minutes (10 min for identifying defects and 10 min for discussion/presentation) Practical 3 - 20 minutes (10 min for identifying defects and 10 min for discussion/presentation)
	Timing within Presentation	Practical 1: Horizontal Alignment, slide no. 14, starts 27 minutes into presentation Practical 2: X-Section Design, slide no. 55 Practical 3: Design of Retaining Wall Drainage slide no. 56
Reference Material		"2C Reference Materials" Profile Diagram for Practical Retaining Walls Diagram for Practical

Slide Headings	Bullet Points	Key Messages	Time (mins)
1. Title Slide	***(2C) Stage 2 Survey and Design Detailing*** *Presentation for LRN Training* Presenter's Name Date of Presentation	Presenter introduces themselves and the module – 'Stage 2 Survey and Design Detailing'	1
2. Module Contents	• Detailed procedures of Stage 2 Survey • Stage 2 Design Overview • Key aspects of design of horizontal and vertical alignment and cross-section • Design of structures and drainage provisions • Optimisation of road alignment • Mass balancing/management • Quantity Surveying	• Module contents are as per list on slide	2
3. Detailed procedures of Stage 2 Survey	Start of new section (sub-title slide)	Introduce new section – 'Detailed procedures of Stage 2 Survey'	1
4. Stage 2 Survey Overview	• Carried out following completion of 2.5 m track opening • Correction of both horizontal and vertical alignment if there are errors in Stage 1 Survey • More precise than Stage 1 Survey as it is easy to capture ground features that are visible after phase I track opening	Purpose and timing of stage 2 survey design: • Timing: Immediately after completion of 2.5 m track	2

Slide Headings	Bullet Points	Key Messages	Time (mins)
		• Purpose: To produce precise design to suit the site requirements by making corrections/fine-tuning to the stage 1 design.	
5. Stage 2 Survey Steps	• Fix horizontal intersection points and run traverse survey using a total station • Design and setting out of horizontal curve in the field • Set CL peg @ 20 m interval in general, and additionally at BC, MC, and EC of horizontal curves • Profile survey along CL pegs with a level machine and fix bench mark @ 500 m interval (closed levelling)	Detailed Procedures of Stage 2 Field Survey • As per list on slide	3
6. Stage 2 Survey Steps Contd.	• Cross-section survey at CL pegs using tape and staff up to the right of way (10 m on either side from CL) and beyond in case of unstable slopes • Establish monuments for every fifth IP or at max. interval of 250 m with reference at field • Review the location of structures (retaining/toe/breast walls)	Detailed Procedures of Stage 2 Field Survey Contd. • As per list on slide • Cross-section survey CL pegs should be at 20m intervals • Monuments = benchmarks	2
7. Stage 2 Survey Steps Contd.	• Assess the requirements for cross-drainage structures • Identify possible disposal areas for excess mass • Identify potential quarry sites along the road alignment • Confirm all other works of the Stage 1 Survey	Detailed Procedures of Stage 2 Field Survey Contd. • As per list on slide	2
8. Correction of Stage 1 Errors and Fine-tuning of Road Alignment	• Correct excessive gradient sections of shorter lengths by shifting CL inwards or outwards • For longer sections, re-alignment may include introduction of new hairpin bends • For sections having sharp horizontal curves shift CL inward or outward and provide curve of adequate radius	Correction of Stage 1 Errors • Corrections for excessive gradients (those exceeding permissible limit i.e. 12%) – shift CL or realign • Corrections for sharp curves – shift CL while fixing IPs in order to achieve minimum radius i.e. 12.5 m	3
9. Correction of Stage 1 Errors and Fine-tuning of Road Alignment Contd.	• If there is gradient/radius problems on the hairpin bend, extend the bend beyond the current location or shift CL as required • Seek possibilities to reduce or avoid rock cutting or retaining walls when shifting CL of the existing track	Correction of Stage 1 Errors • Correction of gradient/radius problem on hairpin bends, as per point on slide • Seek to reduce or avoid rock cutting, or retaining wall construction	2

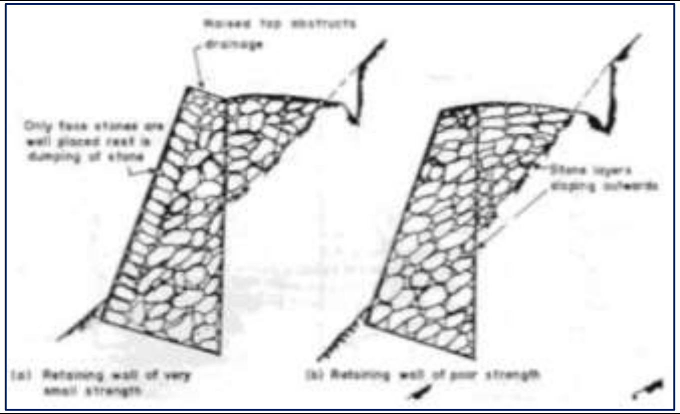
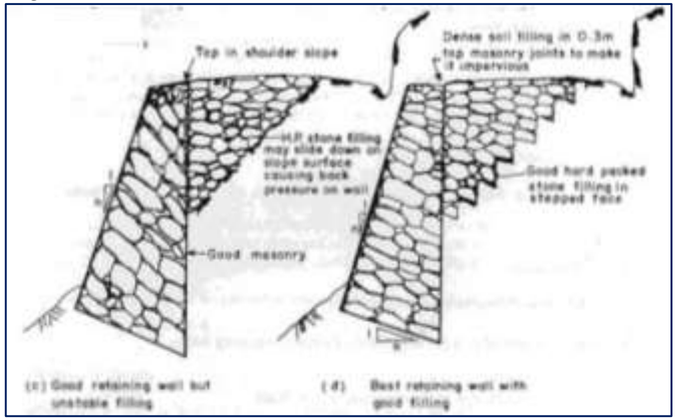
Slide Headings	Bullet Points	Key Messages	Time (mins)
		• For example, if there is high rock cutting which is impossible to be cut by RBGs in 3-4 years, shift CL on valley side with reduced cut as possible and make provision of a small wall if required • For example, in case of high retaining wall (mostly in full fill section) shift CL on mountain side and gain road width partly from cutting. • These are only examples – how much to shift or on what side to shift the CL is primarily governed by the cross-profile characteristics of the particular site.	
10. Key Aspects of Design	Start of new section (sub-title slide)	Introduce new section – 'Key Aspects of Design'	1
11. Stage 2 Design Overview	• Must follow DoLIDAR's Rural Road Standards • Refinement of both horizontal and vertical alignment with optimum balance of cut and fill and determination of site specific requirements of various on and off-road structures • Stage 2 Design is the final design for construction of road to full width along with the associated structures	An overview of stage 2 Design Principle • DoLIDAR's standards • Site specific design as site features are more visible and can be easily captured once the initial track opening to 2.5m is complete • Correction and refinement of both horizontal alignments with optimum balance of cut and fill	3
12. Key Aspects of Design of Horizontal Alignment	• Fixing of IPs and setting out of horizontal curves during survey in the field, locations of key points of horizontal curves – BC, MC, and EC – are fully defined w.r.t. IP on the design drawings (Plan) • To optimise cut/fill and retaining structures CLs may sometimes have to be shifted right or left, for which a proper record has to be maintained for re-setting out in the field later	Design Consideration – Horizontal Alignment • Horizontal curves designed/set out during survey • Optimised cut and fill balance and retaining structures • Explanation given for slide 9 suits here also, but the practice of CL shift in design office is not generally expected (should be exercised in the field during survey), however in some circumstances when the design looks extremely unusual and unbuildable, CL may have to be shifted for which field verification is necessary.	2

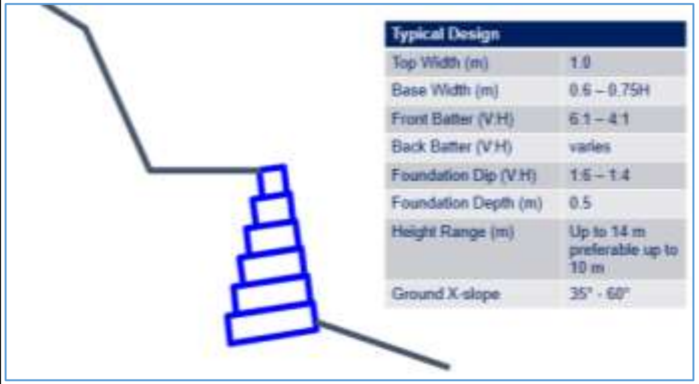
Slide Headings	Bullet Points	Key Messages	Time (mins)
13. Key Aspects of Design of Vertical Alignment	• Design grade line to obtain optimum balance of cut and fill • Avoid heavy cut and fill during design as it results in either huge surplus mass or high retaining walls • Fully define location of key point of vertical alignment – BC, MC, EC, highest and lowest points w.r.t. designed points of intersection	<u>Design Consideration – Vertical Alignment</u> • Design of grade line with optimum balance of cut and fill • N.B. – avoid heavy cut and fill at design stage, during implementation it results in huge surplus mass which requires spoil management, or high retaining walls, both of which increase the project costs greatly • Vertical curve to be designed with full description on location of key points w.r.t. point of vertical intersection	3
14. Practical Exercise 1: Horizontal	Figure 	<u>A section of road showing profile design</u> • Participants are given the improperly designed horizontal alignment shown on the slide, in which most of the road sections have been designed in high gradients and box cut • Participants should be asked to identify the major faults (chainage wise) in the design	15 (15 min for identifying the defects and 15 min for discussion)
15. Key Aspects of Design of Cross-section	• Ensure minimum changes to natural profile whilst keeping the cost minimum • Consider options for CL shift if possible to avoid huge cut or high retaining wall	<u>Design Considerations – Cross-section</u> • Ensure minimum changes to natural profile, keeps costs at a minimum • Optimise cut/fill balance and structures	2

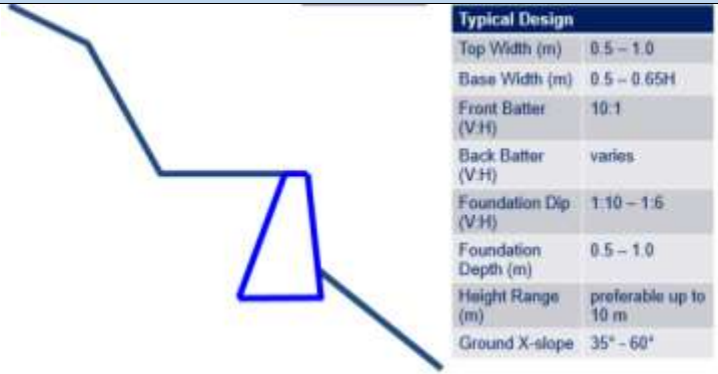
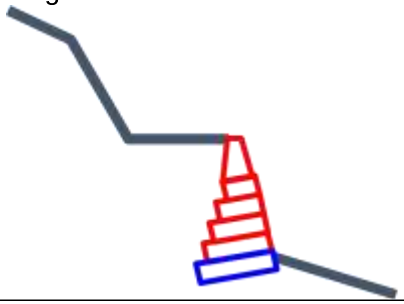
Slide Headings	Bullet Points	Key Messages	Time (mins)
	• Half cut and half fill is the preferred and ideal case • Minimise the CL cut/fill while drawing design grade lines	• Shift CL if possible to avoid imbalanced cut/fill	
16. Design of Cross-Section: Schematic Diagram 1	Figure  Balanced Section	• A cross-section design with a balance between cut and fill – ideal and most preferable situation • For gentle x-slope (up to 25%), generally no retaining wall is required for cut fill balance. The most important thing to be noted here is that high amount of cut or fill at CL point (as designed in the profile) is the major factor governing the mass balance. • For a cross-section with high cut or fill at CL point, it is almost impossible to achieve a balanced section irrespective of the magnitude of the x-slope. • The design shown in the figure has zero cut or fill at CL point and lies in gentle x-sloped terrain, as a result it has been possible to achieve a balanced section. • So, reducing the level difference between original ground line and the design line is the most crucial aspect in the profile design.	2
17. Design of Cross-Section: Schematic Diagram 2	Figure  Full Cut Section	• A cross-section design in full cut – generally not preferable • Though it is not preferable to have such full cut section, it does appear in the design either due to carelessly designed profile or due to unavoidable circumstances that the design line should be fixed with considerable height of cut to meet the standards.	2

Slide Headings	Bullet Points	Key Messages	Time (mins)
18. Design of Cross-Section: Schematic Diagram 3	Figure  Full Fill Section	• A cross-section design in full fill – generally not preferable • Such section with full fill is common in areas where the road has to cross depressions and Kholas/Kholsis; and in lower parts of a hairpin bend. • The extent of the fill is dependent on how appropriately the design line is set in the profile as elaborated in previous slides.	2
19. Design of Structures	Start of new section (sub-title slide)	Introduce new section – 'Design of Structures'	1
20. Introduction	• Preferred option is low cost soft and flexible engineering structures • Minimal use of rigid structures – cement mortared masonry and PCC/RCC	<u>Guiding Principles</u> • Extensive use of low cost and softline/flexible structures e.g. dry stone masonry, gabion wall etc. • Use rigid structures only in unavoidable cases, e.g.in areas of steep rocky slope where it is difficult to excavate adequate foundation width for gabion wall, on the bank of river/big Khola etc.	2
21. Types of Retaining Structures/Protection Works	• Most commonly used retaining wall types on RAP-built roads are: ○ Dry stone walls ○ Gabion walls ○ Cement mortared walls ○ Composite walls (combination of either two or three of the above)	<u>Types of Structures</u> • As per list on slide (most commonly used on RAP roads)	3
22. Types of Retaining Structures/Protection Works Contd.	• For retaining walls less than 10 m height, type designs are used for different range of height depending on the nature of site • MRE handbook, TRL's Road Note 16, Green Road Best Practice Report and any relevant DoR and DoLIDAR's publications are to be used as a reference for design	<u>Design Requirement for Structures</u> • Type design for wall less than 10 m height based on the best practices so far • Refer to various literatures published by relevant organisations in road sector including RAP – as per 2nd point on slide	2

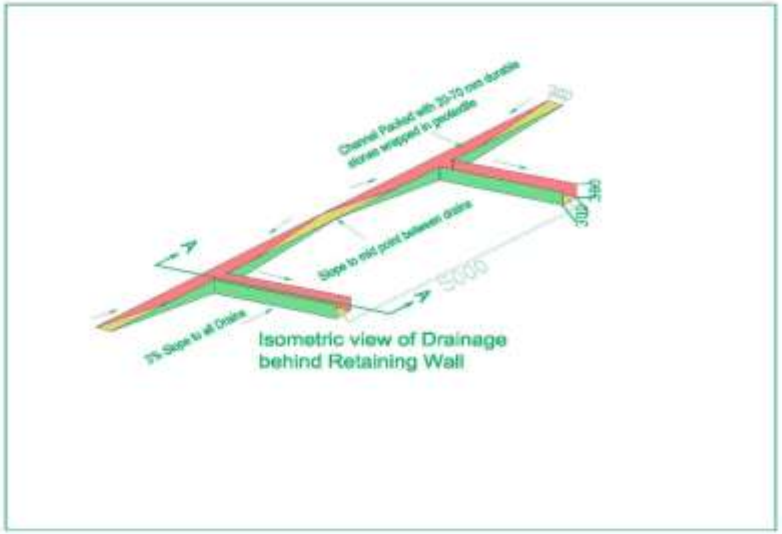
Slide Headings	Bullet Points	Key Messages	Time (mins)
	• For retaining walls of height 10 m and above, full engineering design needs to be done based on the site conditions/soil characteristics	• For walls with height 10 m and above, a full engineering design must be carried out	
23. Dry Stone Walls	• Limiting height is generally 3m, but can go up to 5 m depending on the site conditions and availability of good quality of stone and workmanship • Can serve the purpose of retaining, toe, or breast wall and other protection works • Used normally in areas which remain dry for most of the year	<u>Design Considerations – Dry stone wall</u> • As per points on slide	2
24. Dry Stone Walls Contd.	• Min. top width is 0.60 m and base width must be 0.6 times the height (back face vertical/front face batter follows 3V:1H ratio) • Key considerations to be made in construction: ○ Use of appropriate size stone (bond/block stones and spalls) ○ Proper bonding (interlocking) ○ Maintaining proper batter of outer and inner face	<u>Design Considerations – Dry stone wall Contd.</u> • As per points on slide	2
25. Dry Stone Walls: Design	Figure + Table  **Typical Design** Top Width (m): 0.6 – 1.0 Base Width (m): 0.5 – 0.7H Front Batter (V:H): 3:1 Back Batter (V:H): Vertical - 10:1 Foundation Dip (V:H): 1:3 Foundation Depth (m): 0.5 Height Range (m): Up to 5 m preferable 3m Ground X-slope: <35°	• Typical Design of Dry Stone Wall with Design Details • Limiting height – 3 m • Mostly in dry areas • Can be used as composite with gabion wall • Back face mostly vertical • Front face batter 3V:1H	2
26. Dry Stone Wall Construction	Figure	• Examples of low strength/poorly constructed dry stone walls • (a) on left of diagram: very poor - Only face stones properly placed, others not in proper bonding,	2

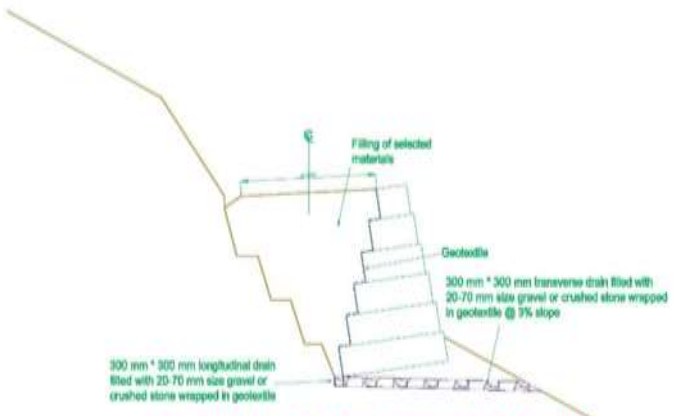
Slide Headings	Bullet Points	Key Messages	Time (mins)
		raised top obstructing drain and no benching in backfilling • (b) on right of diagram: poor - stone layer sloping outward and no benching in backfilling	
27. Dry Stone Wall Construction Contd.	Figure 	• Examples of a good (c) and best (d) dry stone walls • (c) on left of diagram: good – proper laying of stone parallel to foundation base and still lacking proper benching in backfilling • (d) on right of diagram: best – proper laying of stone, dense soil filling on the top of wall and stable backfill with proper benching	2
28. Gabion Walls	• Most suitable for areas with poor foundation, wet soil, high ground water level, and slope movement • Used generally when wall height exceeds 3m • Can be constructed up to 14m height but preferred max. height is 10m • Rear stepped configuration is appropriate for hill roads	<u>Gabion Wall – Design Considerations</u> • Sites – where it is required? Or most appropriate, as per list on slide (areas with poor foundation, wet soil, high ground water level, and slope movement) • Height ranges – generally 3 – 10 m	3

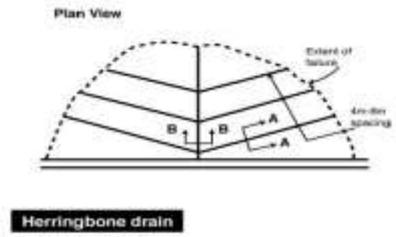
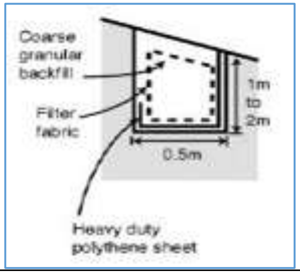
Slide Headings	Bullet Points	Key Messages	Time (mins)
		• When there is a possibility to have stepped foundation (benching) in hard rock strata we can go up to 14 m height. • Configuration – rear stepped suitable for hill roads	
29. Gabion Walls: Design	Figure + Table  Typical Design Top Width (m): 1.0 Base Width (m): 0.6 – 0.75H Front Batter (V:H): 6:1 – 4:1 Back Batter (V:H): varies Foundation Dip (V:H): 1:6 – 1:4 Foundation Depth (m): 0.5 Height Range (m): Up to 14 m preferable up to 10 m Ground X-slope: 35° - 60°	• Typical Design of Gabion Wall with Design Details • Rear stepped configuration appropriate in hill road in view of the limited cross-sectional width • Top width 1 m and base width 0.6 to 0.75 times height • Inward inclined foundation and gabion layer to be laid parallel to foundation base	3
30. Mortared Masonry Walls	• Generally avoided due to high cost vs. low cost road construction in RAP3 • Used in areas where ground slope is steep and adequate base width is difficult to achieve in rocky sections • Also preferable as retaining wall along the bank of river/big Khola (at least up to high flood level) where wires of gabion boxes are likely to be broken by boulder-carrying floods	<u>Design Consideration – Mortared Masonry</u> • Generally avoided – due to high cost • It may be unavoidable and preferable in some sites such as steep rocky section, along the bank of river or bid Kholas.	2
31. Mortared Masonry Walls: Design Sketch	Figure + Table	• Typical Design of Mortared Masonry with Design Details • Preferred in steep terrain where sufficient foundation with cannot be achieved for gabion wall • Weep holes to be provided for drainage to backfill • Greater quality control required than in gabion wall due to use of cement/sand mortar • Design details as presented in the table	2

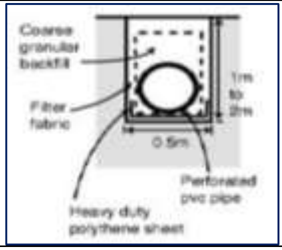
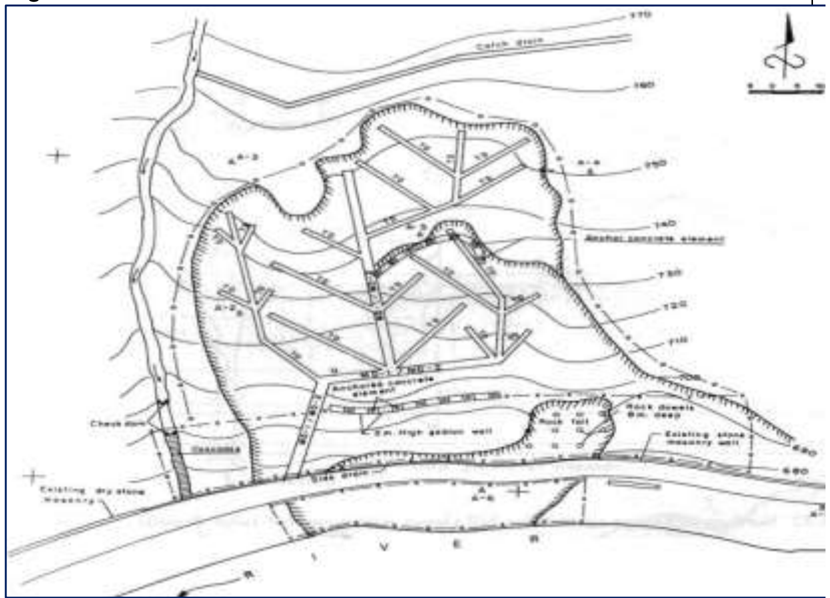
Slide Headings	Bullet Points	Key Messages	Time (mins)
			
32. Composite Walls	• Can be a combination of: ○ Dry stone wall and gabion wall ○ Dry stone, gabion, and mortared masonry ○ Dry stone and mortared masonry (banded mortared masonry) • When height is above 10m, preferable to use 2nd type of composite wall in view of economy	<u>Composite Wall</u> • Wall designed as a combination of any two or more of above three types of wall, as per list on slide • Above 10m, dry stone, gabion, and mortared masonry combination most cost effective	2
33. Composite Walls: Design	• Combination of Dry stone and Gabion wall – top 1-2 m height built with dry wall • For design dimension, refer to respective and gabion and dry wall + figure 	• Typical Design of composite walls • Objective is to minimise gabion quantity, upper 1 to 3 layers could be replaced with dry stone wall • Design configuration as shown in the sketch	2

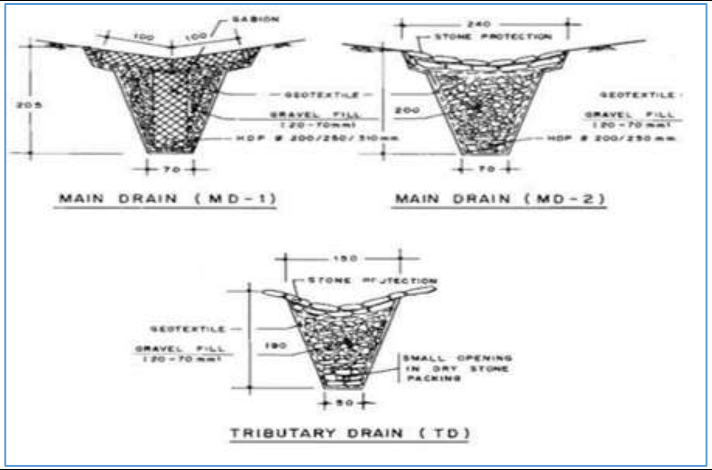
Slide Headings	Bullet Points	Key Messages	Time (mins)
34. Composite Walls	Photos 	• Left Photo: Composite wall (gabion +dry wall) • Right Photo: Composite wall (cement mortared masonry +gabion wall + dry wall)	2
35. Composite Wall – Banded Mortared Masonry: Design	Figure + Table 	• Design of Banded Mortared Masonry • Objective is to reduce the cost of full cement masonry wall • Design details as shown in the table	2
36. Drainage behind and below Retaining Wall	Figure	<u>Drainage behind and below Retaining Wall</u> • Required for wall of height 5 m and above, and in all cases of high water table and seepage areas irrespective of wall height • Purpose is to prevent foundation base from softening due to accumulated water and to release pore water pressure to some extent • Longitudinal drain filled with gravel or crushed stone running along the wall at the bottom back of the foundation base • Transverse drain at regular interval to drain out water from the L-drain	2

Slide Headings	Bullet Points	Key Messages	Time (mins)
			
37. Drainage behind Retaining Wall (for high water table and seepage areas)	Figure	• Section drawings showing how transverse and longitudinal drains are positioned in relation to the retaining wall.	2

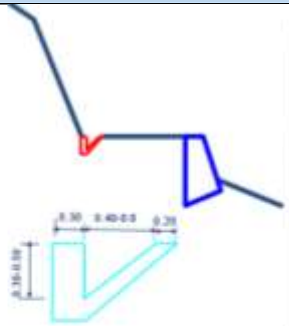
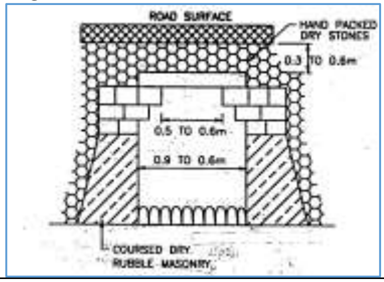
Slide Headings	Bullet Points	Key Messages	Time (mins)
	 Section A-A (with front stepping of gabion)		
39. Sub-soil Drains 1	Figure	<u>Sub-soil Drains</u>	2

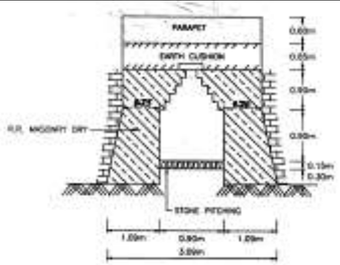
Slide Headings	Bullet Points	Key Messages	Time (mins)
		• Constructed on unstable slopes where slope failure/movement is likely to occur due to water table rising above • Purpose is to draw down the water table and consequently to control/prevent the ground water movement in upper layers • System is composed of drains of rectangular sections in herring bone pattern with a main drain and a set of branch drains • Branch drain serves the purpose of collecting ground water whereas the main drain is to drain off the water into road side drain • Branch drains collect water from upstream of it and then feed into the main drain, laying of plastic sheet is done differently for branch and main drain (as shown in the sketch) to facilitate the collection and flow of water	
40. Sub-soil Drains – Section A-A	Figure 	• Coarse granular materials is filled in the drain by wrapping in geotextile • Heavy duty polythene is laid on the bottom and side/s of the drain to facilitate the flow of water	2
41. Sub-soil Drains – Section B-B	Figure	• Coarse granular materials is filled in the drain by wrapping in geotextile • Heavy duty polythene is laid on the bottom and side/s of the drain to facilitate the flow of water	2

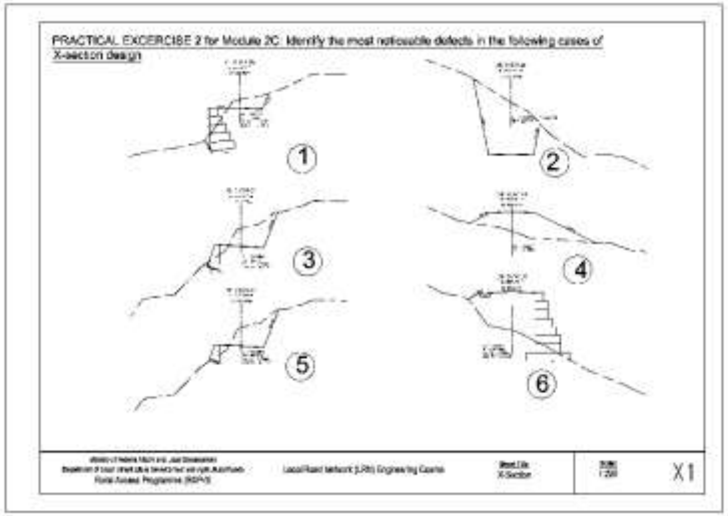
Slide Headings	Bullet Points	Key Messages	Time (mins)
			
42. Sub-soil Drains and other Protection Work (For Stabilisation of Big Landslide)	Figure 	• Diagram shows an Integrated System of Sub-soil Drain, Catch Drains, Rock Dowels, side drains and other protection works to stabilise a big unstable slope on the mountain side of a road section	2
43. Sub-soil Drains and other Protection Work Contd. (For Stabilisation of Big Landslide)	Figure	• Main Drain 1 – Fill with gravel wrapped in geotextile and gabion bolster (rect. section) and HDPE pipe at the bottom to carry water collected from tributary drain • Main Drain 2 – same as 1 except no bolster strengthening	2

Slide Headings	Bullet Points	Key Messages	Time (mins)
		• Tributary Drain – fill with gravel wrapped in geotextile small dry stone channel at the bottom to channelize flow of water into main drain	
44. Protection Works/Preventive Measures	• <u>Toe wall to retain excess mass on the valley side</u> – designed mostly as dry stone wall or in some cases gabion wall or combination of both • <u>Breast wall to protect toe of unstable cut slope</u> – both dry stone and gabion could be used depending on the cut height and soil characteristics – designed either as retaining or revetment wall	<u>Various Protection/Preventive Measures</u> (dry wall or gabion wall alone or in combination) • Toe wall – to retain excess soil mass • Breast wall – to protect cut slope	3
45. Protection Works/Preventive Measures Contd.	• <u>Check dam</u> to reduce the gradient of Khola/Kholsi, to dissipate energy u/s and d/s of retaining wall across the natural water course/gully • <u>Breast wall and sub-soil drainage system</u> over water-logged slopes and unstable colluviums in slopes which get saturated and liquefied during rainy season • <u>Cascade (gabion or dry stone)</u> to train natural water courses of high gradient which pass near or cross the road	• Check dam – to reduce gradient of Khola or to protect retain. Wall • Breast wall and sub-soil drainage system – To protect slope by proper management of ground water • Cascade – to train natural water course passing across or near the road	3
46. Protection Works/Preventive Measures: Photos	Photos	• A series of toe walls to retain surplus excavated mass on the valley side with other slope reinforcement measures (e.g. horizontal line of gabion bolster + bioengineering works)	2

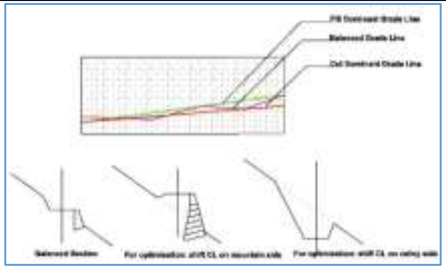
Slide Headings	Bullet Points	Key Messages	Time (mins)
			
47. Drainage Systems	Start of new section (sub-title slide)	Introduce new section – 'Drainage Systems'	1
48. Side Drains	• Not provided to full length of the road • Provide side drain for sections with gradient > 7%, for water logged and wet land, paddy fields, hairpin bends • For all sections, except at sharp curves and hairpin bends, provide 5% outward slope to road surface to allow natural cross flow of water	<u>Side Drain Provision</u> • Not provided on full length, natural cross flow water by making road surface inclined outward @5%) • Provided only for those sections exceeding 7% gradient and in wet/waterlogged/hairpin bend areas	2
49. Side Drains Contd.	• <u>Side drain type</u> – rectangular, trapezoidal, semi-trapezoidal, triangular (tick type or v-shaped) – all can be lined or unlined • Most common for district roads is dry stone lined tick type drain • Runoff from side drain to be drained off within 200 m into natural gully/Kholsi or other non-cultivated lands	• Various cross sections of drain are exist but tick type (triangular) section is preferred for RAP roads • In particular dry stone tick type is most used for district roads • Runoff needs to be directed to natural gullies/Kholsi, or other non-cultivated lands	2
50. Side Drains: Photos/Diagrams	Figure + Photo	• Diagram and photo of example dry stone tick type drain as preferred for RAP roads • Typical dimensions of drain are provided in diagram	2

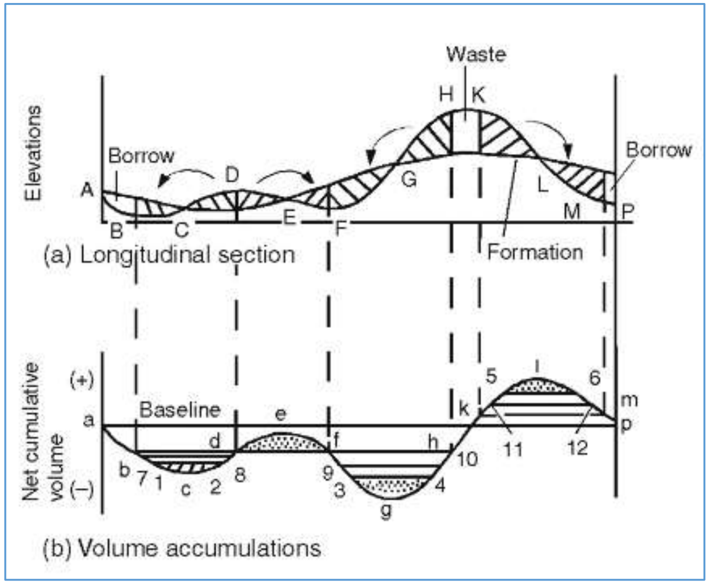
Slide Headings	Bullet Points	Key Messages	Time (mins)
	 		
51. Cross Drains	• Preferred options are: ○ <u>Causeways</u> – dry stone or gabion mattress for shallow Kholsi (non-perennial) ○ <u>Vented causeway</u> made of gabion crates for perennial water course crossing (considerable water depth say up to 0.5 m in dry season) ○ <u>Scupper</u> – dry stone or combination of dry stone and gabion – suitable for deep Kholsi/gully (non-perennial) • Minimal use of RCC pipe and slab culvert except in unavoidable cases	<u>Cross-drain Provisions</u> • Preferred options is dry stone causeways and scupper, in view of achieving low cost for light traffic volume roads • Minimal use of RCC pipe and slab culvert – avoided mostly because of high cost, could be unavoidable in case the road has to cross irrigation canal or where the road has to cross the perennial stream in such narrow space a gabion or dry stone structure erected is not stable	2
52. Cross Drains: Schematic Diagrams Scupper	Figure 	• Dry Stone Scupper – Configuration I • Side wall made of coursed rubble masonry • Hand packed stone 60 cm ht. above the stone slab	2
53. Cross Drains: Schematic Diagrams Scupper	Figure	• Dry Stone Scupper – Configuration II • Side wall made of random rubble masonry • Compacted earth cushion above the stone slab	2

Slide Headings	Bullet Points	Key Messages	Time (mins)
		• Side wall section is so tapered that small length stone slab is sufficient compared to preceding design	
54. Cross Drains: Scupper	Photos 	• Photos show Gabion Scupper	1
55. Practical Exercise 2: Design of Cross-section	Figure	<u>Given are six cases of X-Section design</u> <u>Participants to identify the major design faults</u> <u>Defects:</u> Case I: Unstable positioning of structure due to foundation base being inclined outward Case II: Steep cut slope – it should be at least 2V:1H for ordinary soil. Case III: Top width of dry stone wall of height 2.5 m is too small (around 50 cm) – it should be between 80 and 100 cm. Case IV: Unchecked embankment on valley slope – there should a small wall at the toe. Case V: Insufficient depth of foundation for the toe of dry wall – it should be at least 50 cm.	20 (10 min for identifying defects and 10 min for discussion/presentation)

Slide Headings	Bullet Points	Key Messages	Time (mins)
		Case VI: Improper configuration of wall, dry stone drain on filled mass – base width should be at least 4.5 m for 8 m high wall, gradually tapering above by 0.5 m per 1 m height, foundation base should be inclined inward rather than horizontal for the sake of stability •	
56. Practical Exercise 3: Design of Retaining Wall Drainage	Figure	<u>Given is defective design of retaining wall drainage Participants to identify the major design faults</u> 1. There is no slope on the horizontal drain to facilitate flow of water. 2. There is inward slope of transverse drain which destabilise the structure due to softening of the base resulting from the accumulated water. 3. Well graded gravel reduces the permeability	20 (10 min for identifying defects and 10 min for discussion/presentation)
57. Optimisation of road alignment and mass balancing/management	Start of new section (sub-title slide)	Introduce new section – 'Optimisation of road alignment and mass balancing/management'	1
58. Longitudinal Mass Balance	Photos	• Photo shows longitudinal mass balance in and around a hairpin bend	2

Slide Headings	Bullet Points	Key Messages	Time (mins)
			
59. Introduction	• Optimisation process involves trial and error method to adjust grade line, cross-section and plan of the road • Objective is to achieve best possible design in terms of slope stability, min. environmental damage, ease of construction, and cost • Optimum use of retaining structures • Ensures minimum disturbance to the natural ground profile • Keeps the overall cost to a minimum	Design Optimisation • As per points on slide	3
60. Optimisation of Horizontal and Vertical Alignment	• Setting design grade line with min. cut and min. fill and with balanced cut and fill to the extent possible • Shifting of CL to reduce further difference between cut and fill even in balanced grade line to reduce high cut and heavy retaining wall if any	Design Optimisation • As per points on slide	2
61. Optimisation of Horizontal and Vertical Alignment Contd.	• Analyse steep cross slopes to determine whether full cut with provision of toe wall for retaining surplus mass is better than more cut/less fill with retaining wall and toe walls built on the valley side • Optimum balance between cut and fill will significantly lessen the burden of mass management which exists when there is huge surplus excavated materials	Design Optimisation • As per points on slide	2
62. Optimisation of Horizontal and Vertical Alignment Contd.	Figure	• A schematic diagram showing how a properly designed grade line (min CL cut/fill) helps in producing better cross-section design • Balancing of cut and fill on grade line in profile is crucial.	3

Slide Headings	Bullet Points	Key Messages	Time (mins)
		• The level difference between original ground line and design grade line should be kept minimum as far as possible. • The three x-section design sketches show that how the magnitudes of CL cut/fill affects the x-section design in the same cross-profile characteristic – 1st having balanced cut and fill, 2nd and 3rd being in full fill and in full cut respectively.	
63. Mass Haul Diagram and Mass Management Plan	• Balancing mass within the road width both longitudinally and transversely is almost impossible in steep mountain terrains using labour-based approach • A proper mass management plan should be in place indicating at which locations mass becomes surplus and where to dispose the mass safely	<u>Mass Haul Diagram and Mass Management Plan</u> • Mass haul diagram is a graphical representation of surplus/deficit volume of soil along the road and is a valuable tool for road engineer to plan and manage soil mass (both excess and deficit) • Proper mass management plan should be in place for all works • Balancing mass within the road width both longitudinally and transversely is almost impossible in steep mountain terrains using labour-based approach – Provision of spoil-containing wall is therefore necessary to manage the surplus mass.	3
64. Mass Haul Diagram and Mass Management Plan Contd.	• Mass haul diagram is a graphical representation of distance on X-axis and cumulative difference of cut and fill volume on Y-axis • Longer haulage distance is not practical in labour-based construction approach (max. up to 500 m)	<u>Mass Haul Diagram and Mass Management Plan Contd.</u> • As per points on slide	2
65. Mass Haul Diagram and Mass Management Plan Contd.	• Based on the mass haul diagram, prepare a haulage plan showing from where to where (haulage distance) and what quantity of mass is to be transported and determine/locate disposal area	<u>Mass Haul Diagram and Mass Management Plan Contd.</u> • As per points on slide	2

Slide Headings	Bullet Points	Key Messages	Time (mins)
	• Quantity and location of spoil containing structures (toe walls/check dams) has to be planned in conjunction with the haulage plan		
66. Mass Haul Diagram	Figure  	• A schematic diagram showing different components of a mass haul diagram and their significance • Base line – horizon. line of no accumulated cut or fill • Mass haul diagram falling below the base line has accumulated fill (-) and that lying above base line has accumulated cut (+) • Downward gradient of the diagram represent increase in fill (decrease in cut) whereas upward gradient shows decrease in fill (increase in cut), the crest point indicates the changes form cut to fill or vice a versa corresponding to the Longitudinal Section. • Balancing line – any line running parallel to base line and joining the two points on the diagram, a number of balancing line can be drawn – the gap between two consecutive balancing lines represent either surplus (waste) or deficit (borrow) in fig (b): "bdfh" and "km" are two balancing lines • The mass haul diagram gives a clear picture where surplus mass is going to be created and where is the deficit of soil and hence helps in mass management	4
67. Quantity Surveying	Start of new section (sub-title slide)	Introduce new section – 'Quantity Surveying'	1
68. Introduction	• Computation of volume of works and corresponding costs by adopting standard practice of estimating based on the current rates of labour, materials, and tools • Estimates to be prepared for different phases of construction	<u>Quantity Surveying:</u> • Definition as per first point on slide • Phase wise estimates to be prepared – how many phases are there? What are the phases?	2

Slide Headings	Bullet Points	Key Messages	Time (mins)
	• Should summarise the total labour days required for completion of the road along with the quantities of materials and tools	• Estimates should clearly show the total labour days requirement/no. of RBGs and quantities of tools and materials	
69. Introduction Contd.	• Calculate RBG workforce requirement based on the estimated labour days and available days of work during the entire project period • Assess if contractors are required to be deployed where an inadequate RBG workforce is available in the project area and special, and critical, nature of some works	Quantity Surveying Contd.: • As per points on slide	2
70. Introduction Contd.	• Categorise works as per DoLIDAR's norms and specifications (if a work item not found in DoLIDAR norms, DoR's relevant items could be referred to) • Major item of works ○ Tree cutting of different girth ranges ○ EW in excavation (OS, HS, OR, MR, HR, MS) ○ EW in filling with hand compaction ○ Structures: dry stone wall, gabion filling works, dry stone soling	Quantity Surveying Contd.: • As per points on slide • Major items of work as per list on slide	2
71. Introduction Contd.	○ Fabrication of gabion boxes ○ Supply of non-local materials (e.g. GI wires and gabion boxes, geo-textile, cement) ○ Collection and quarrying of stone ○ Transportation of soils and stones ○ Environmental mitigation measures, reinstatement of public utilities ○ Bioengineering works ○ Local material/tools ○ LRUC management cost	Quantity Surveying Contd.: • List of major items of work continued on slide	2
72. Rate Analysis	• Use DoLIDAR norms • Use approved district labour rates • Use current market rates of non-local materials	• Rate analysis should be conducted as per points on slide	3

Slide Headings	Bullet Points	Key Messages	Time (mins)
	• The unit of rate analysis should exactly match the units of estimated quantities		
73. Estimating Procedures	• Standard practice to be followed • Must be based on design drawings • EW cut/fill – adopt mean area method and should be continuous chainage wise and excavation quantity to be classified as per norms • Structures – dry stone masonry, drain, causeway – mean area method to be adopted for each discrete location	Estimating procedures • Standard method of estimating and costing in highway engineering can be found in any academic book • Standard Specifications of Road Works (DoR) and (DoLIDAR) also explain the method of measurement and quantity calculation. • Procedures for EW cut/fill and structures as specified on slide	3
74. Estimating Procedures Contd.	• Gabion works – layer wise number of different box sizes, volume of stone filling, and quantity of wire in kg • Quantities of stone for structures – to be analysed as quantity available from excavation, quantity net to be brought from outside, quantity to be collected – breaking not required and quantity to be quarried – breaking/excavation required) • Transportation of stones and soils – quantities and corresponding haulage distances	Estimating procedures Contd. • Procedures for gabion works, quantities of stone, transportation of stone/soils as specified on slide	2
75. End	End of Presentation	15 minutes allowed at end of presentation for questions from participants	15