Module Outline: 2C Stage 2 Survey and Design Detailing

Headings	Description	Reference Documents
Stage 2 Survey Overview	• To be 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	1. RAP3 ToR for Stage 2 Survey, Design and IEE 2. Nepal Rural Road Standard, 2012 3. MRE Handbook (Part I and II), ICIMOD 4. Overseas Road Note 16 and 20 , ODA/TRL 5. Green Roads Best Practices Report, 1999, GTZ/SDC 5. Construction Guidelines for Low Cost Feeder Road, DoR,1995 6. Roadside Geotechnical Problems: A Practical Guide To Their Solution, DoR, 2007 7. IRC: SP48 Hill Road Manual, 1998
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) • Cross-section survey at CL pegs using tape and staff up to the right of way (10 m on either side from CL) and go 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) • 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	
Correction of Stage 1 Errors and Fine-tuning the Road Alignment	• Correct excessive gradient sections of shorter lenghs by shifting CL inwards or outwards (adjustments may have to be made on certain lengths extending beyond the defective sections) • For longer sections, re-alignment may have to done with introducing a new hairpin bends as well • For sections having sharp horizontal curves (i.e. less than the minimum requirement), shift CL inward or outward and provide curve of adequate radius • If there is gradient/radius problems on the hairpin bend, extend the bend beyond the current location or shift CL as required • If there is huge rock cutting or heavy retaining wall, seek possibilities to reduce or avoid by shifting CL of the existing track	
Stage 2 Design Overview	• DoLIDAR's Rural Road Standards as the guiding standard to follow • 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 (e.g. ret/breast/toe walls, drainage structures and protection works) • Stage 2 Design is the final design to be taken as the guiding document for construction of road to full width along with the associated structures	

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Key Aspects of Design of Horizontal Alignment	• Fixing of IPs and setting out of horizontal curves are performed during survey in the field, for which locations of key points of horizontal curves – BC, MC and EC is 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 at field later	
Key Aspects of Design of Vertical Alignment	• Design grade line to obtain optimum balance of cut and fill • No heavy cut and heavy fill is to be designed 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	
Key Aspects of Design of Cross-section	• Ensure minimum changes to natural profile whilst keeping the cost minimum • Consider the option of CL shift if there is huge cut or high retaining wall as far as the opportunities are available • Half cut and half fill is the preferred and ideal case which cannot be attained on all occasions and is only possible in relatively gentle slope, however in steeper slopes either heavy cut or high retaining wall does appear for which designer has to maintain a trade-off • For steep cross-sloped sections, the amount height/depth of CL cut/fill will determine the extent of cut and height of retaining wall, so it is wiser to minimise the CL cut/fill while drawing design grade lines	
Introduction	• Preferred option is low cost soft and flexible engineering structures (e.g. dry stone wall, gabion wall, composite wall, dry stone causeway and dry stone side drain) • Minimal use of rigid structures – cement mortared masonry and PCC/RCC	
Types of Retaining Structures/Protection Works	• Most commonly used retaining wall in RAP-built roads are: ✓ Dry stone wall ✓ Gabion wall ✓ Cement mortared wall ✓ Composite wall (combination of either two or three of dry stone, gabion and mortared masonry wall) • For retaining walls less than 10 m height, type designs are used for different range of height depending on the nature of site (soil type/moisture content/nature of backfill)	

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	• 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 • For retaining walls of height 10 m and above, full engineering design needs to be done based on the site conditions/soil characteristics	
Dry stone wall	• 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, breast any wall and other protection works • Used normally in those areas which remain dry in most part of the year • Min. top width is kept 0.60 m and base width 0.6 times the height (back face vertical/front face batter in 3V:1H) • 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	
Gabion wall	• Most suitable for poor foundation, wet soil, high ground water level and slope movement • Used generally when wall height exceeds 3 m • Can be constructed up to 14 m height but preferable is up to 10 m • Rear stepped configuration is appropriate for hill road	
Mortared masonry wall	• Generally not preferable in view of high cost in low cost road construction like ours • Used in those 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	
Composite wall	• Could 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 10 m, preferable to use 2nd type of composite wall in view of economy	
Protection Works/Preventive Measures	• Toe wall to retain excess mass on the valley side – designed mostly dry stone wall or in some cases gabion wall or combination of both • Breast wall to protect toe of unstable cut slope – both dry stone and gabion could be used depending on the	

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	cut height and soil characteristics – designed either as retaining or revetment wall • Check dam to reduce the gradient of Khola/Kholsi, to dissipate energy u/s and d/s of retaining wall across the natural water course/gully • Breast wall and sub-soil drainage system over water-logged slopes and unstable colluviums in slope which get saturated and liquefied in wet season • Cascade (gabion or dry stone) to train natural water courses of high gradient which passes near or crosses the road	
Drainage Systems	<u>Side drain</u> • not provided to full length of the road • Provide side drain for those sections with gradients > 7%, for water logged and wet land, paddy field, 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 • Side drain type – rectangular, trapezoidal, semi-trapezoidal, traiangular (tick type or v-shaped) – all could be lined or unlined • Most preferred 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 <u>Cross drain</u> • Most preferred options are: ✓ Causeways – dry stone or gabion mattress for shallow Kholsi (non-perennial) ✓ Vented causeway made of gabion crates for perennial water course crossing (considerable water depth say up to 0.5 m in dry season) ✓ Scupper – 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	
Introduction	• Hit and trial method of adjusting horizontal and vertical alignment to minimise the difference between cut and fill with optimum use of retaining structures with a view to ensuring minimum disturbances to the natural ground profile while keeping the overall cost minimum	
Optimisation of Horizontal and Vertical Alignment	• Setting design grade line with min. cut and min. fill (i.e. CL cut/fill is kept min. to the extent possible, in which the design grade line does not depart much from the ground profile line) • Shifting of CL to reduce difference between cut and fill area • Making analysis for steep cross slopes on whether full cut with provision of toe wall for retaining surplus	

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	mass is better than more cut/less fill with retaining wall still having to build toe walls on the valley side • Optimum balance between cut and fill will significantly lessen the burden of management of huge surplus mass	
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 • So, a proper mass management plan should be in place indicating at which locations mass becomes surplus and where to dispose the mass safely • 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) • 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 (tentative location need to be explored during field survey • Quantity and location of spoil containing structures (toe walls/check dams) has to be planned in conjunction with the haulage plan	
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 phase of construction • Should summarise the total labour days required for completion of the road along with the quantities of materials and tools • Calculate RBG workforce requirement based on the estimated labour days and available days of work during the entire project period • Also, assess if contractors are required to be deployed in view of inadequate RBG workforce available in the project area and speciality and criticality of some works	
	• 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 ✓ Fabrication of gabion boxes ✓ Supply of non-local materials (e.g. GI wires and gabion boxes, geo-textile, cement) ✓ Collection and quarrying of stone	

Headings	Description	Reference Documents
	✓ Transportation of soils and stones ✓ Environmental mitigation measures, reinstatement of public utilities ✓ Bioengineering works ✓ Local material/tools ✓ LRUC management cost	
Rate Analysis	• Use DoLIDAR norms • Use approved district labour rates • Use current market rates of non-local materials • The unit of rate analysis should exactly match the units of estimated quantities	
Estimating Procedures	• Standard practice to be followed • To be fully 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 locations • Gabion works – layer wise number of different box sizes, volume of stone filling and quantity of wires 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	