Engineering Aspect ,Design for Local Road Network in Nepal

Let’s analyses few photos of roads

with

water and landslides


ekantipur

Occurred: 2nd of August 2014

Casualities :155

Physical damage :

120 houses (completely)

37 house (partially)

1 km Aranico highway washed off (Reopened November 2014)

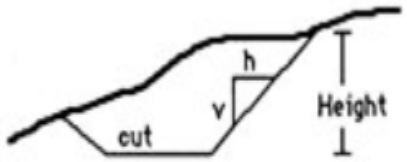
Unstable when Ground water table is at surface and pga is 0.1 g

1989 small landslide and cliff present

Minor slide visible adjoining the crown at 12/7/2017 (Google earth image) which could have triggered by extreme precipitation observed in June 28 2017

Expected Road Photos

Table 18. Maximum cut slope ratio for coarse grained soils. (USFS, 1973).

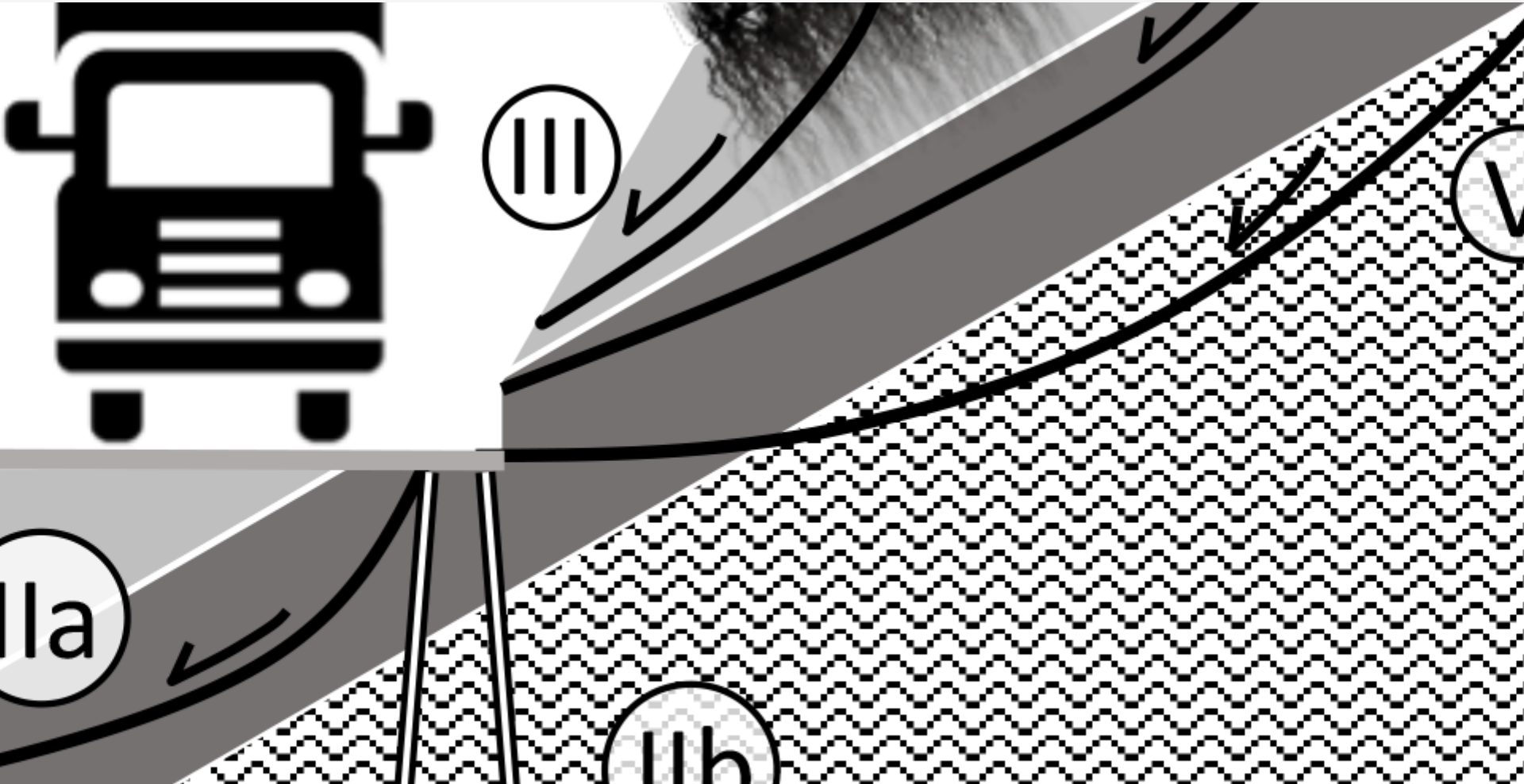


Soil Type	Maximum Cut Slope Ratio (h:v)			
	Low groundwater (below bottom of excavation)		High groundwater [1] (see page from entire scope)	
	loose [2]	dense [3]	loose	dense
GW, GP	1.5 : 1	85 : 1	3 : 1	1.75 : 1
SW	1.6 : 1	1: 1	3.2 : 1	2 : 1
GM, SP, SM	2 : 1	1.5 : 1	4 : 1	3 : 1

Table 19. Maximum cut slope ratio for bedrock excavation (USFS, 1973).

Rock type	Maximum Cut Slope Ratio	
	Massive	Fractured
Igneous (granite, trap, basalt, and volcanic tuff)	0.25.1	0.50:1
Sedimentary (massive sandstone and limestone;	0.25:1	0.50:1
interbedded sandstone, shale, and limestone;	0.50:1	0.75:1
massive claystone and siltstone)	0.75:1	1:1
Metamorphic (gneiss, schist, and marble;	0.25:1	0.50:1
slate);	0.50:1	0.75:1
(serpentine)	Special investigation	

rimary modes of potentially damaging mass movements caused by informal road c
avated material stored on the downslope side of the road; (II) deeper seated landsl
oad drainage as water seepage can aid failures that include regolith (IIa), and freez
(IIb); (III) shallow failures close to the road caused by oversteepened road cuts th
dslides caused by oversteepening that include potentially stabilizing roots from veg
steepening by road cuts that may include bedrock.



Geometric Design of Roads

- Design standards
- Design criteria
- Engineering designing includes the elements of:
  - –Highway alignment
  - –Highway cross-section
  - –Adjacent roadside environment

Road Standards

- Geometric design practices of roads & streets are not entirely uniform for different roads. Each country/roads has their own standards for geometric design.
- Reasons behind this is:
  - Regional factor such as terrain, weather conditions, availability of construction materials, financial abilities etc.
- Nepal Rural/Road Standards, IRC series, AASHTO British codes/TRL Road Notes

Design Controls & Criteria

- Traffic safety considerations
- Functional classification of roadway
- Projected traffic volume and composition
- Required Design Speed
- Multimodal needs of the community
- Topography of the surrounding land
- Capital costs for construction
- Agency funding mechanism
- Human sensory capabilities
- Vehicle size & performance characteristics
- Public involvement, review and comment
- Environmental considerations
- Right of way impact and costs

Design speeds (km/h)

- National roads:
  - Level terrain 120
  - Rolling Terrain 80
  - Mountainous 50
  - Steep 40
- Feeder roads:
  - Level terrain 100
  - Rolling Terrain 60
  - Mountainous 40
  - Steep 30
- District roads:
  - Level terrain 60
  - Rolling Terrain 40
  - mountainous 30
  - Steep 25

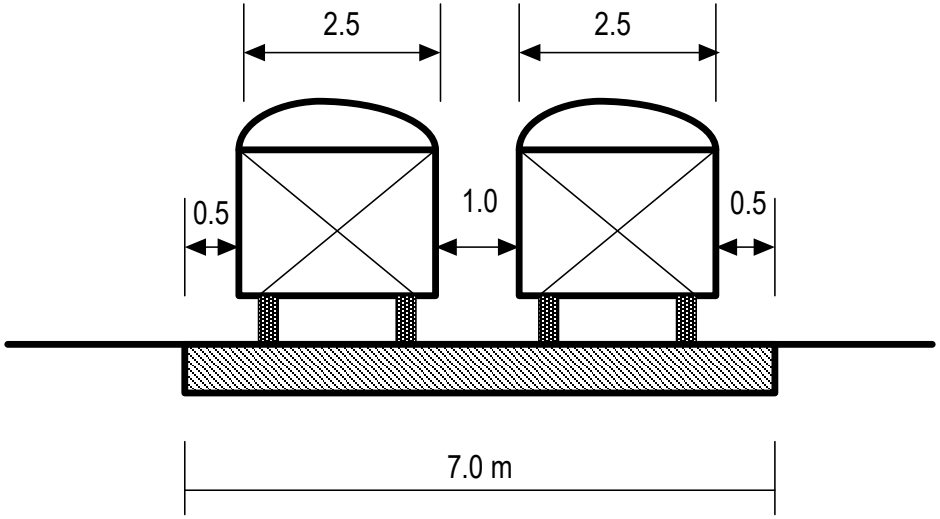
Cross Section Elements

- Traffic/travel lane
  - Single lane, two lane, three lane, four lane or wider, divided highways.
- Limited Access highway:
  - Multi-lane, access control improve capacity, increase safety, high speed.

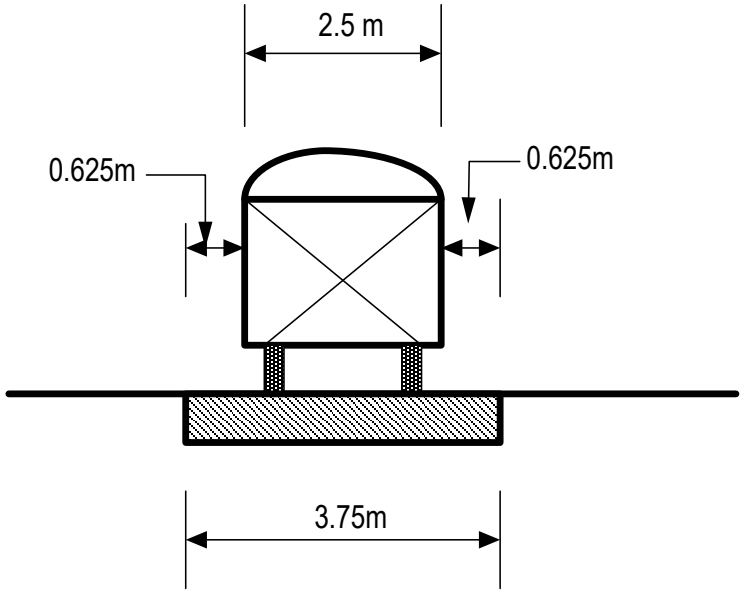
Cross slope/Camber/Pavement Crown

- Slope provided in the transverse direction to pavement.
- It depends on:
  - Type of the surface
  - Amount of the rainfall 1600mm avg,3345 Pokhara 300 Mustang
- Importance:
  - Prevent the entry of water from pavement
  - To remove water from the pavement surface quickly.
  - NRS Recommended values: Pavement type and Camber %
    - Bituminous pavement: 2% - 1.7% 2.5
    - Water bound Macadam: 2.5 – 2.0% -
    - Earth pavement: 4.0% - 3.0% 5.0
    - Gravel 4.0
    - Cement concrete 1.5-2.0

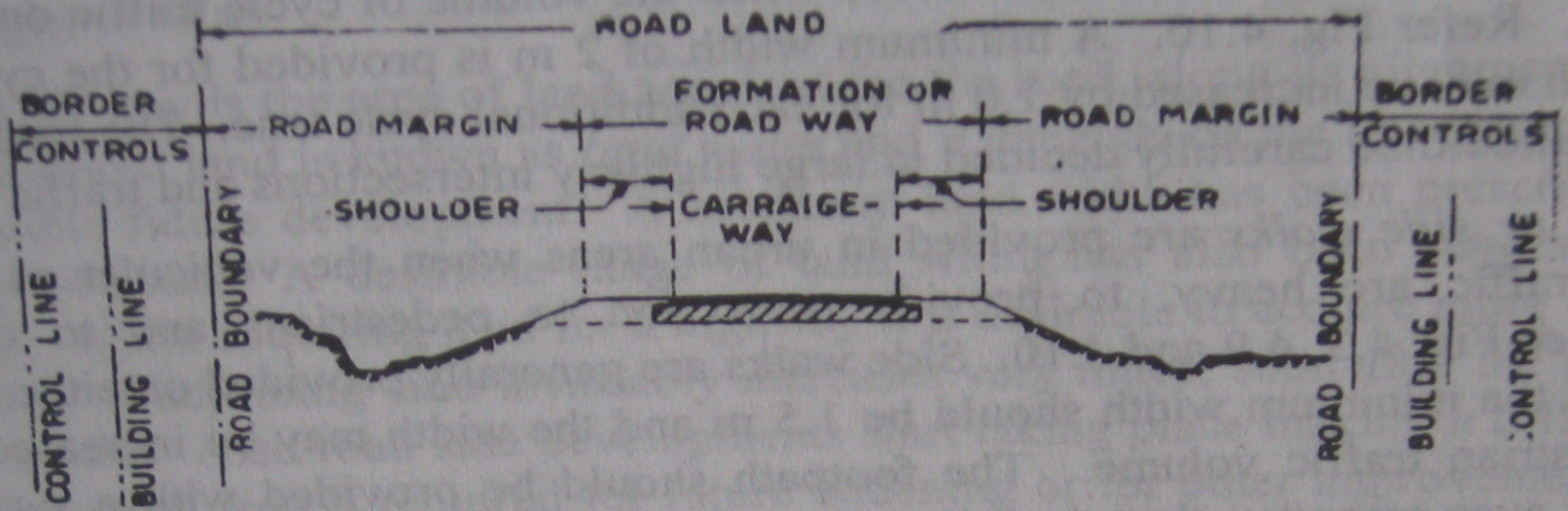
Width of the pavement



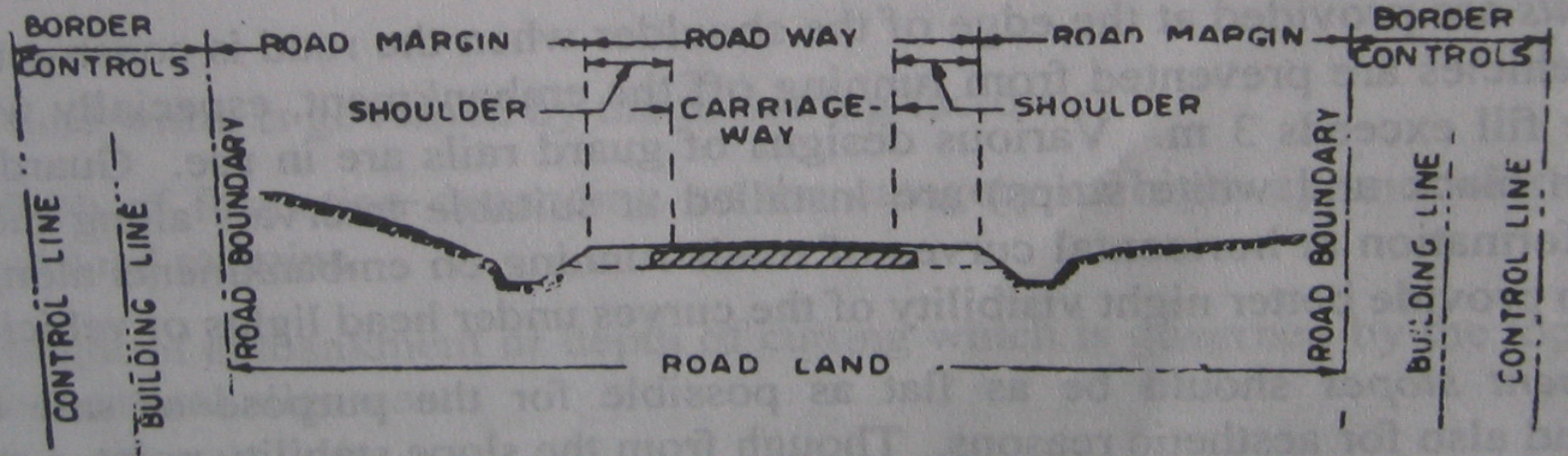
Double lane pavement



Single pavement



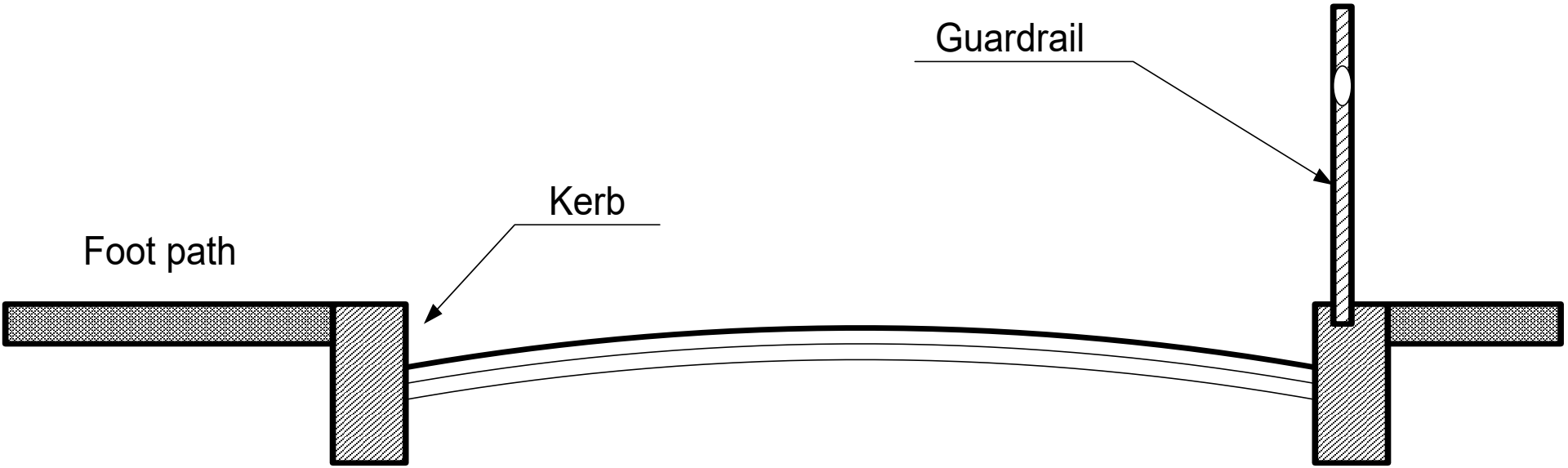
(a) IN EMBANKMENT



(b) IN CUTTING

Kerb & Footpath

- **Kerb & Footpath are provided for urban roads They may be of different shpae and size. They separate physically the carriageway and footpath or may be provided for separating directional traffic flow.**



Drainage Ditches

- Depending upon the site drainage ditches may be provided on one or both side of the road.
- Shape and location should not create hazardous to traffic.
- In urban areas they are generally covered.

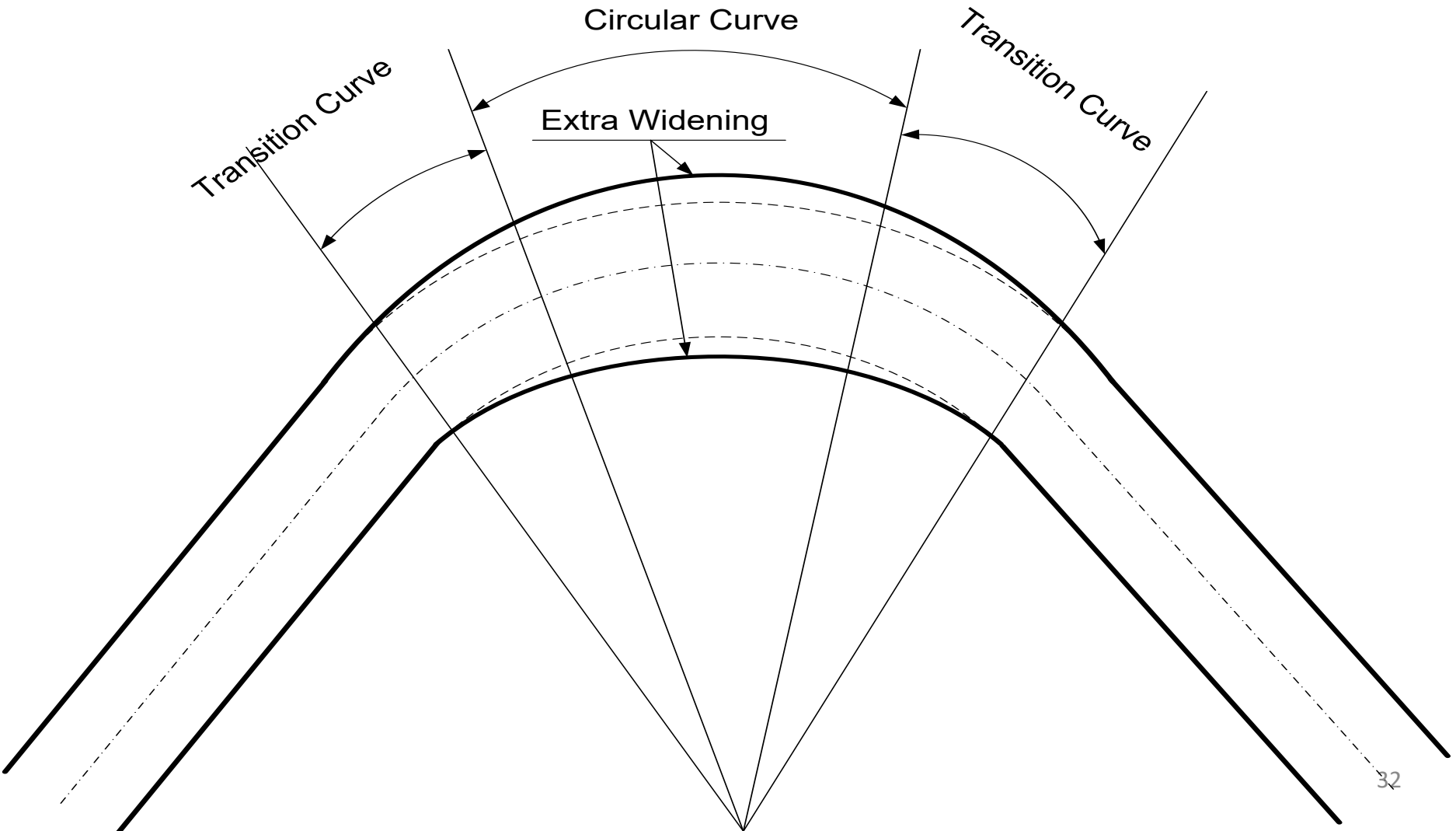
Right-of-way

- Area of land acquired for the road along its alignment.
- Nepal Road standard:
  - National highway 25 m on either side of the road center line.
  - Feeder roads: 15 m on either side of the road center line.
  - District roads: 10 m on either side of the road center line.

Superelevation

- To encounter the effect of centrifugal force and to reduce the tendency of the overturn or skid the outer edge of the pavement is raised with respect to the inner edge.
- Superelevation/cant/banking is the transverse slope at the horizontal curve.

Transition Curve



Gradient Standard

- Maximum gradient for trunk road:
  - Mountainous 8%
  - Rolling 6%
  - Plain 5%
- Maximum gradient for feeder roads
  - Mountainous 10%
  - Rolling 8%
  - Plain 7%
- Maximum gradient for District roads
  - Mountainous 12%
  - Rolling 10%
  - Plain 7%

Typical slope failures

Common slump and slide failures in irrigated lands

Slope Management on roads

- Toe wall slope retention at cut face
- Minimise cut in steep / weathered rock cliffs – instead opt for road-side structure
- Allow nature to work on unstable or unsafe-to-work slopes (site dependent)
- Provide sub-surface drains in slopes
- Use check walls for safe spoil disposal
- Maximise bio-engineering treatment on select cut faces and downslopes

Slope treatment measures -

Toe protection wall

To maintain original slope angles (slope material and terrain dependent)

Constraint: Land-take and budgets

Water management

- Lined side drains more effective in loops and on high gradient
- Stone soling of road in ‘khets lands’ and side drains
- Subsurface and catchment drains to divert run-off from slide prone slopes
- Rigid structure in unstable plane?

Vegetative structures practiced on roadside slopes of Nepal

1. Grass seeding or broadcasting	2. Palisades	3. Shrub planting
4. Diagonal lines of grass planting	5. Tree planting	6. Vegetated riprap
7. Down ward lines of grass planting	8. Bamboo planting	9. Brush layering
10. Chevron lines of grass planting	11. Fascines	12. Live staking
13. Herring bone lines of grass planting	14. Live check dam	15. Horizontal lines of grass planting
16. Random pattern of grass planting		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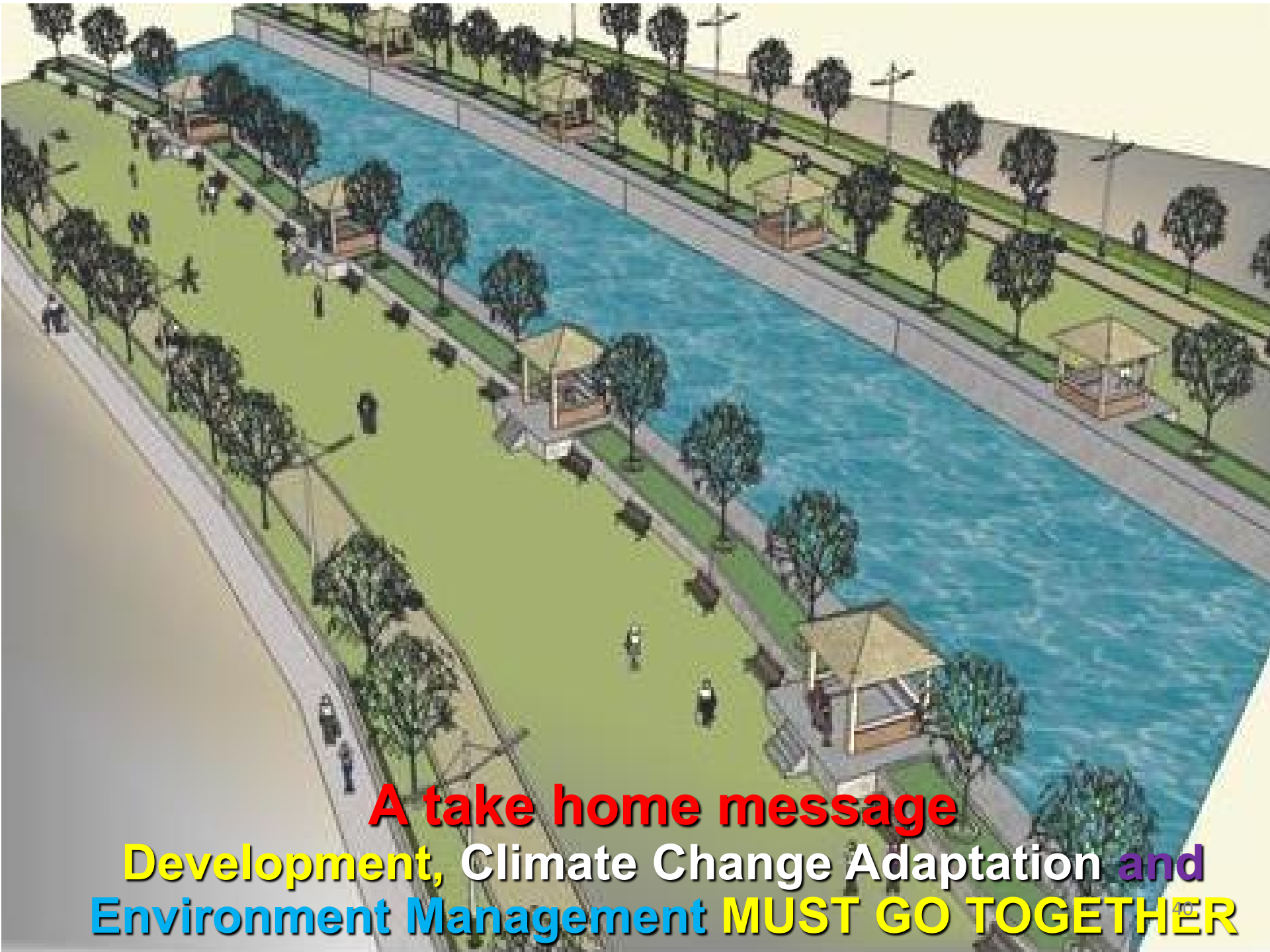

A take home message

Development, Climate Change Adaptation and Environment Management MUST GO TOGETHER

THANK
YOU
So much!