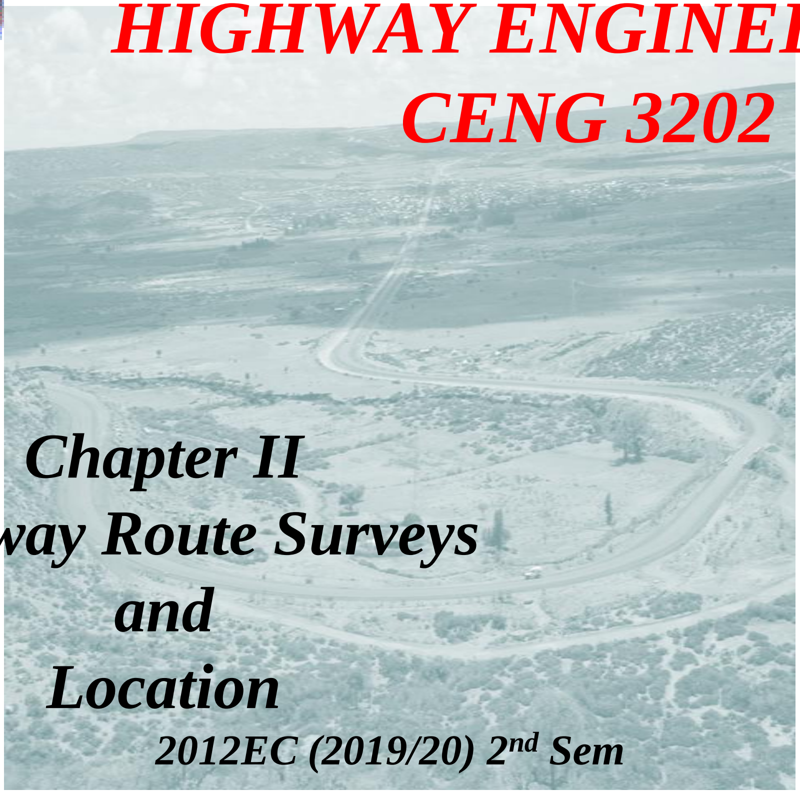
SCHOOL OF CIVIL AND ENVIROMENTAL ENGINEERING

HIGHWAY ENGINEERING I
CEGN 3202



Chapter II
Highway Route Surveys and Location

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Introduction

- **Alignment :-** The position or the layout of the central line of the highway.
  - Horizontal alignment includes straight and curved paths.
  - Vertical alignment includes curves and gradients.
- The aim of alignment selection process is to find a location for the new road that will result in the lowest total construction, land, traffic and environmental costs.
- Provide the basic information for structural design, as well as the economic analysis

Route Selection

- is to find a location for the new road that will result in the lowest total
  - Construction
  - land,
  - traffic,
  - and environmental costs.

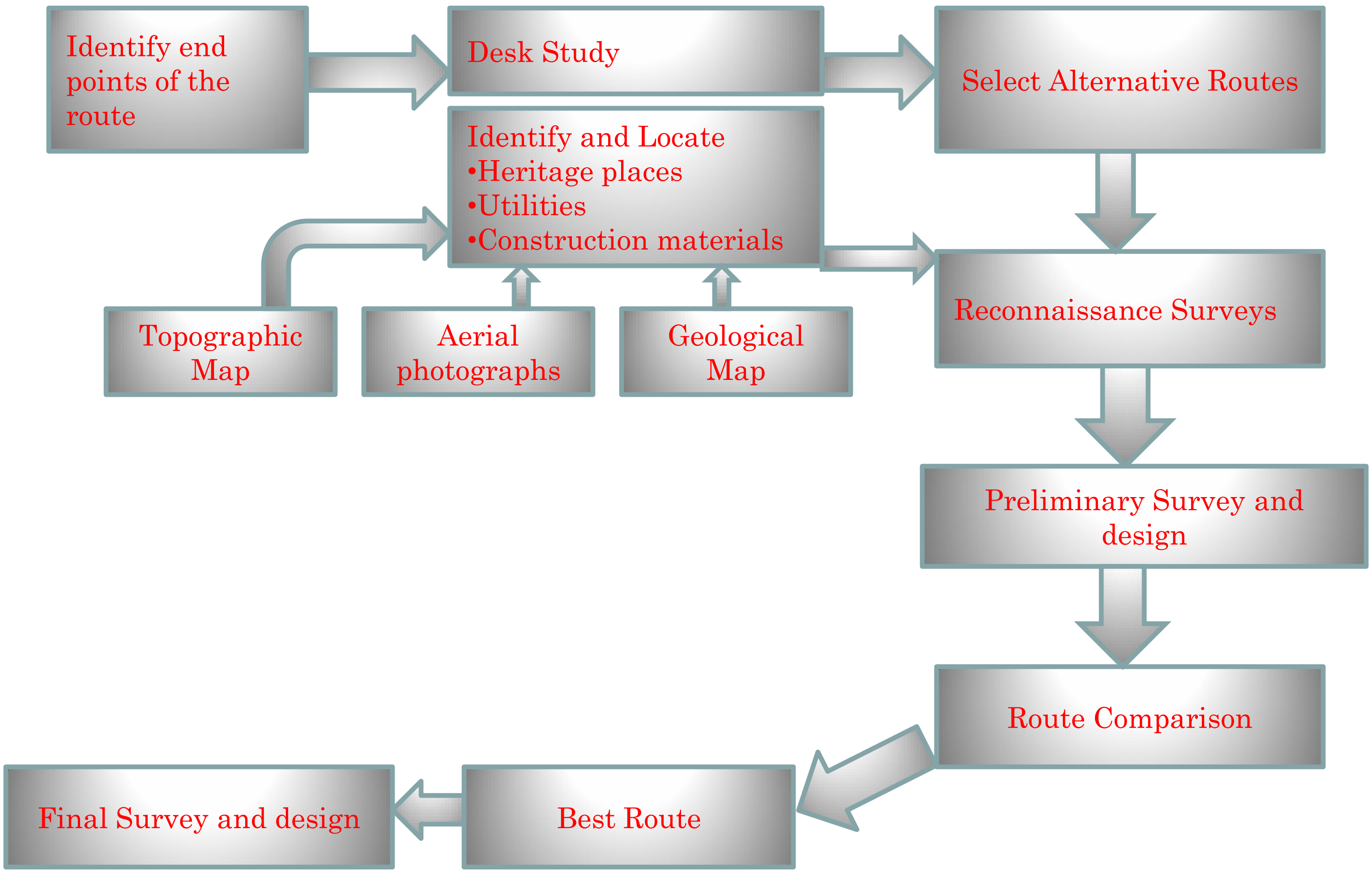
Design, Construction and Maintenance → terrain dependent

Short Road Alignment is not necessarily the easiest, quickest or most economical for construction and maintenance!

Route Selection Steps

- Know the termini points
- Identify and locate
- Conduct preliminary and reconnaissance surveys
- Select a corridor.
- Possible centerlines
- Examine each of the alternative alignment
- Final design

Route Selection Steps



Desk Study

- The desk study comprises a review of published and unpublished information concerning the physical, economic and environmental characteristics of a study area.

  - Published literature covering a range of topics including road construction and maintenance case histories and geological, economic and environmental reviews.
  - Topographical maps
  - Geological maps, agricultural soil maps and other natural resource maps; and
  - Aerial photography

Available information

- Topographic Maps scale 1:50,000 (EMA)
- Aerial photographs, approximate scale 1:50,000 (EMA)
- Geological Map of Ethiopia, scale 1:2,000,000 (GSE),
- Hydrological Map of Ethiopia, scale 1:2,000,000 (MOA)
- Land Use and Land Cover Map, scale 1:1,000,000 (MOA)

Alignment controls

- Topography
- Slope stability
- Flood hazard
- Erosion
- Environment

technical, economic, social and environmental

Controlling requirements of the route

Desk Study

- What are the constraints in regard to the beginning and ending points of the road?
  - Must these be at existing junctions in villages or towns? Are such junctions inadequate from a standpoint of skew or right-of-way? Do economic considerations such as amount of earthworks limit the alternatives?
- Through which villages must the route pass?
  - Must the route pass directly through these villages, or can linking roads connect the villages? If so, what are the implications to the villages in terms of lost trade?

Controlling requirements con……

Desk Study

- If major rivers are to be crossed, what are the possible crossing locations, given constraints of topography and geology?
    - What are the economics of the alternative bridge sights with the corresponding road geometries?
- What is the desired design speed and design standard?
- How does this standard fit the terrain in terms of geometric parameters such

  as gradients, and horizontal and vertical curves?

Maximum Gradient for Design Standard

Design Element		Unit	Flat	Rolling	Mountain	Escarp't	Urban Peri-Urban
Design Speed		km/hr	120	100	85	70(2)	50
Width of running surface		m	2x7.3				2x7.3+
Width of shoulders		m	Table 2.2				
Minimum. Stopping Sight Distance	g = 0%	m	285	210	155	110	65
	g = 5%	m	330	240	175	120	70
	g = 10%	m	400	285	205	140	75
Minimum Horizontal Curve Radius(2)	SE = 4%	m	780	515	350	215	95
	SE = 6%	m	685	455	310	195	85
	SE = 8%	m	610	410	280	175	80
Transition Curves Required			Yes	Yes	Yes	No	No
Max. Gradient (desirable)		%	3	4	6	6	6
Max. Gradient (absolute)		%	5	6	8	8	7
Minimum Gradient		%	0.5	0.5	0.5	0.5	0.5
Maximum Super-elevation		%	8	8	8	8	4
Min. Crest Vertical Curve (1)		K	185	100	55	30	10
Min. Sag Vertical Curve		K	36	25	18	12	7
Normal Cross-fall		%	2.5	2.5	2.5	2.5	2.5
Shoulder Cross-fall		%	4	4	4	4	4
Right of Way		m	50	50	50	50	50

Notes

1 These values are based on an object height of 0.2m. Use of a different sized object (see Chapter 9) requires ERA approval.

2 The design speed on escarpments may be dictated by the severity of the terrain and the curve radius (plus curve widening) that can be achieved on the hairpin bends.

Source: ERA Geometric Design Manual 2013, for the rest please refer the ERA manual on Chapter two

Route Selection

- At least three route will be selected.
- The best route is selected by comparing the routes using different factors such as engineering, economical, social, environmental and administrative factors.

Guidelines for selection of alignment

- A direct alignment is recommended
- No steeper gradient and sharper curve
- Minimize using agricultural land(follow the existing if any)
- Least impact on environment
- Decrease the demolition of houses
- Avoid location near to school, play grounds and hospitals
- Avoid interferace with utility services: tele, electric, water lines
- Locate near source of material for embankment and pavement
- Avoid frequent crossing of railway lines
- Avoid areas with flooding, marshy land, lanslide
- Have to be right angle with river crossing
- Align the route with minimum earthwork

Site visit and survey

- When potential route corridors have been identified from the desk study analysis, then a reconnaissance survey is usually employed to verify interpretations, to help determine the preferred route, and to identify factors that will influence the feasibility design concept and cost comparisons.

Site visit team

- Highway Engineer
- Soils & Materials Engineer
- Hydrologist
- Chief Surveyor
- Bridge/Structures Engineer
- Environmentalist/Sociologist, and
- Local Administrative Personnel.

Reconnaissance Survey

- Terrain classification;
- Slope stability and the location of pre-existing land slides;
- Rock types, geological structures, dip orientations, rock strength and rip ability;
- Percentage of rock in excavations;
- Materials sources, presence and distribution;
- Water sources;
- Soil types and depth
- Soil erosion and soil erodibility;
- Slope drainage and groundwater conditions;
- Land use
- Likely foundation conditions for major structures;
- Approximate bridge spans and the sizing and frequency of culverts;

Reconnaissance survey

- **Flood levels and river training/protection requirements;**
- **Environmental considerations, including forest resources, land use impacts and socio-economic considerations;**
- **Verify the accuracy of the information collected during the desk study;**
- **The possibility of using any existing road alignments including local realignment**
- **Improvements; and**
- **Information on the physical accessibility to bridge sites and the proposed corridors**

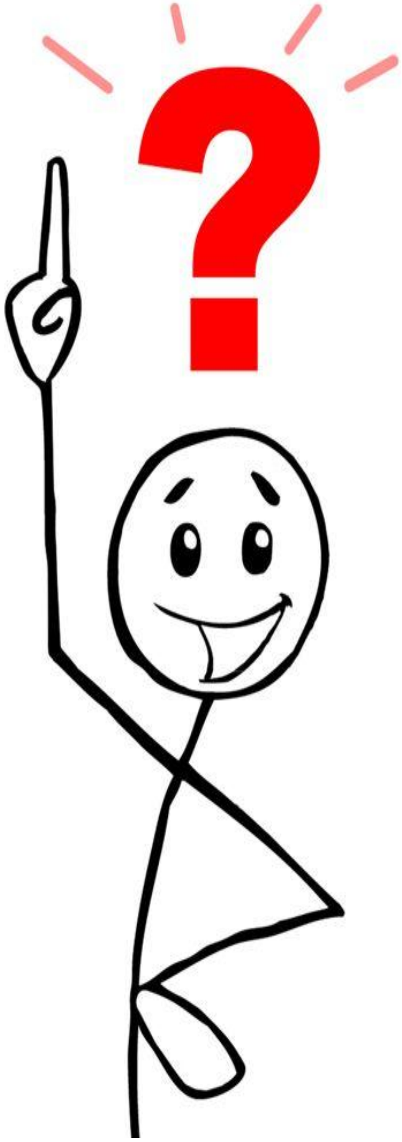
Results of these studies are presented in a reconnaissance report

When Selecting the best route.

- **Length:** the shortest distance is preferable
- **Mean Gradient:** the least is taken. However, the relation of minimum grade may be the inverse to the shortest length route.
- Which follows the **existing track** (if any)? Makes survey and construction easier and may indicate the route of least earthworks.
- Which alternative follows the least **severe terrain** type? Rolling terrain for example has less construction and vehicle operating cost than mountainous terrain.

Preliminary Location Survey

- The first step is the carrying out of a baseline traverse
- To furnish data for a profile of the baseline, levels should be taken at all marked stations, as well as at all important breaks in the ground. Elevations should also be noted at all cross roads, streams, and other critical points on the line.
- After the baseline has been pegged and levels run over it, the topography elevations may be taken by one of the several methods, i.e. cross sectional leveling. These are done at the same time as the profile levels.
- At the same time locations of all trees, fences, building and important elements are noted so that they can be shown on the preliminary map.



Comparison of Alternative routes

- Cost Benefit Analysis
- Multi-Criteria Analysis

Cost Benefit Analysis

- **Cost Benefit Analysis (CBA) is a well established technique for comparing the costs and benefits of a project in monetary terms.**
- **CBA compares the costs (capital and recurrent) of road investment with the resultant benefits to road users. These benefits primarily comprise vehicle operating cost savings, travel time savings, reductions in accident costs and future maintenance expenditure.**

The principal output parameters of CBA

- **Net Present Value (NPV) of proposed scheme: total discounted benefits –total discounted costs**

- **Benefit/Cost Ratio (BCR) – ratio of discounted benefits to discounted costs**

- **Internal Rate of Return (%) (IRR) – discount rate at which NPV = 0**

Multi-Criteria Analysis and Cost-Effectiveness Analysis

- Multi-Criteria Analysis has been developed to combine both quantified and non-quantifiable benefits
- Multi-Criteria Analysis (MCA) involves the ranking of route alternatives on the basis of their performance against a set of criteria.
- It is subjective

Example

Analysis criteria	Alternative 1			Alternative 2			Alternative 3		
	Rank	Weight	Score	Rank	Weight	Score	Rank	Weight	Score
Economic evaluation	3	50	150	1	50	50	2	50	100
Environmental evaluation	2	30	60	3	30	90	3	30	90
Development	3	10	30	2	10	20	1	10	10
Public transport	3	5	15	2	5	10	2	5	10
Accessibility/ Severance	1	5	5	2	5	10	3	5	15
Overall score	-	-	260	-	-	180	-	-	225

Source: TRL - Overseas Road Note 5 "A Guide to Road Project Appraisal"

Final Location Survey

- Control Establishment: GPS
- BM Leveling: Level
- Traversing: Total Station
- Cross-Sectional Leveling: Total Station

Control Establishment: GPS

Instrument: Differential GPS

- First you should buy EMA point near the project area (at least two)
- Use this point as a reference to establish control points along the route.
- GPS control points are established at a maximum of 5 km interval.
- Static GPS measurments are used
- The east and north coordinate of the points are taken from GPS, the height is determined by BM leveling

BM Leveling

Instrument:Level

- Along the road at interval of 300 – 500 m intermediate bench marks will be established.
- Between two consecutive BM a loop level will be done (the allowable error of tolerance is sqrt (D) cm where D is the distance of the level work in km.
- This step helps to determine the elevation of all bench marks including those established by GPS.

Traversing

Instrument: Total Station

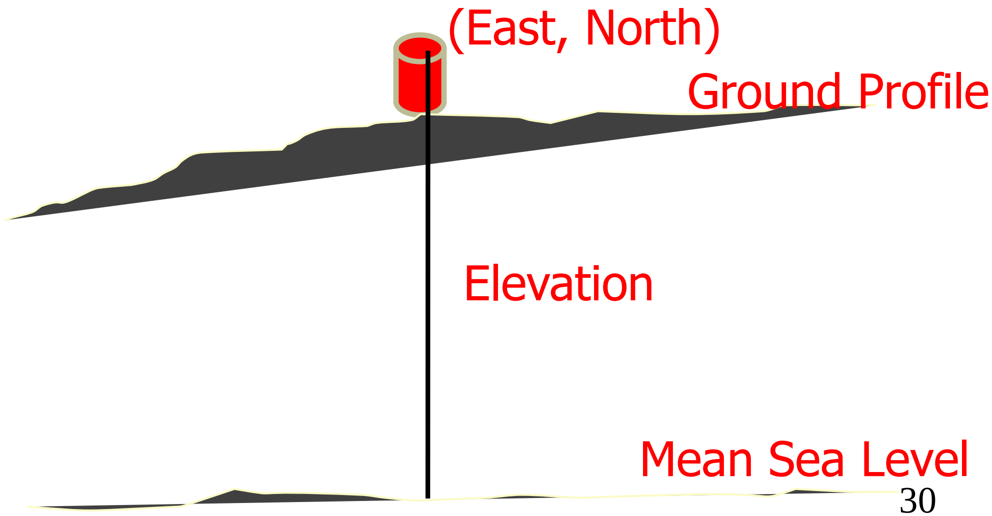
- Using this method the east and north coordinates of the intermidiate bench marks are determined using the GPS as a starting and finishing point of the traverse.

- The error tolerance is 1:20,000, thefore for 5 km distance only 25 cm error of closure allowed.

GPS, Level and Total Station

- All East and North coordinates of the bench marks are determined: GPS and Total Station

- All the elevation of the bench marks are detemined: Level



Cross-sectional leveling

Instrument: Total Station

- At straight portion of the road, 60 m corridor, 30 m from the center line
- At curved portion and river crossing, 100 m corridor, 50 m from the center line (if there is existing road)
- Usually collected at interval of 20 m.

Cross-sectional data

No	CODE	DESCRIPTION
1	RER	EDGE OF ROAD RHS
	REL	EDGE OF ROAD LHS
2	CL	CENTER OF ROAD
3	TLP	TELEPHONE POLE
4	EP	ELECTRIC POLE
5	BLD	BUILDING
6	TUKUL	TUKUL
7	WT	WATER TAP /BONO/
8	TREE	TREE
9	SPL	SPOT HEIGHT
10	FNCE	FENCE
11	WDFCE	WOODEN FENCE
12	W-FCE	WIRE FENCE
16	HWL	CULVERT HEAD WALL
17	RVTL	RIVERTOP LHS
18	RVTR	RIVERTOP RHS
19	RVBL	RIVER BOTTOM LHS
20	RVBR	RIVER BOTTOM RHS
22	RCL	RIVER CENTER
24	WPL	PIPE LINE
25	BRDG	BRIDGE

Final Location Survey for Existing Route