Module (Course Syllabus) Catalogue

2023-2024

College/ Institute	Erbil Technical Engineering College	
Department	Highway Engineering Department	
Module Name	Highway Geometric Design & Planning	
Module Code	HGD503	
Degree	Technical Diploma [ ] Bachelor [*] High Diploma [ ] Master [ ] PhD [ ]	
Semester	5th	
Qualification	Master Degree	
Scientific Title	Assistant Lecturer	
ECTS (Credits)	6	
Module type	Prerequisite [ ] Core [*] Assist. [ ]	
Weekly hours	4 hours/week	
Weekly hours (Theory)	(4)hr Class	(162)Total hrs Workload
Weekly hours (Practical)	( )hr Class	( )Total hrs Workload
Number of Weeks	16	
Lecturer (Theory)	Glpa Ali Mahmood	
E-Mail & Mobile NO.	glpa.mahmood@epu.edu.iq	
Lecturer (Practical)	---	
E-Mail & Mobile NO.		
Websites		

Course Description	• Highway planning involves the estimation of current and future traffic volumes on a road network. Highway engineers strive to predict and analyse all possible civil impacts of highway systems. Some considerations are the adverse effects on the environment, such as noise pollution, air pollution, water pollution, and other ecological impacts. • Geometric design and traffic engineering. The most appropriate location, alignment, and shape of a highway are selected during the design stage. Highway design involves the consideration of three major factors (human, vehicular, and roadway) and how these factors interact to provide a safe highway. Human factors include reaction time for braking and steering, visual acuity for traffic signs and signals, and car-following behavior. Vehicle considerations include vehicle size and dynamics that are essential for determining lane width and maximum slopes, and for the selection of design vehicles. Highway engineers design road geometry to ensure stability of vehicles when negotiating curves and grades and to provide adequate sight distances for undertaking passing maneuvers along curves on two-lane, two-way roads. **Geometric Design** Highway and transportation engineers must meet many safeties, service, and performance standards when designing highways for certain site topography. Highway geometric design primarily refers to the visible elements of the highways. Highway engineers who design the geometry of highways must also consider environmental and social effects of the design on the surrounding infrastructure. There are certain considerations that must be properly addressed in the design process to successfully fit a highway to a site's topography and maintain its safety. Some of these design considerations include: • Design speed • Design traffic volume • Number of lanes • Level of Service (LOS) • Sight Distance • Alignment, super-elevation, and grades • Cross section

	• Lane width • Horizontal and vertical clearance
Course objectives	By the end of this course, students will: **1. Understand Geometric Design Fundamentals**: Gain a deep understanding of the principles that govern the geometric design of highways, Including laying out potential routes, design of the alignment, cross sections and intersections, evaluation of earthwork requirements, and safety considerations. **2. Apply Design Standards**: Familiarize yourself with national and international design standards, such as AASHTO, and learn how to apply them effectively in highway design projects. **3. Utilize Design Software**: Upon completion, students have all of the tools to begin a basic design of a highway, and the background necessary to readily begin learning a variety of computer software packages that assist in the details of highway geometric design. **4. Assess Safety Considerations**: Evaluate the safety aspects of highway design, including the identification and mitigation of potential hazards. **5. Integrate Sustainability**: Explore sustainable practices in highway design, including considerations for environmental impact, energy efficiency, and community integration.
Student's obligation	**Attendance:** Attendance is important so that discussions and sharing ideas are promoted. A student will lose points for unexcused absence. Absences for illness, family emergencies, or other unavoidable reasons may be excused by the instructor. **Homework Policies:** Students requested to match deadlines for submitting their homework's and reports and assignments given by the lecturer. Late homework will have the following penalties: up to 1 day late: 20% of the total points; up to 1 week late: 50% of the total points; after 1 week: no credit. **Quiz:** Students should be prepared for sudden quizzes.
Required Learning Materials	Notes and printed handouts are given to the students. The lectures will be given with the aid of presenting word, pdf, PowerPoint presentations, and clarifying points with the aid of white board whenever necessary. Teaching videos may also form part of the lectures.

Evaluation	Task		Weight (Marks)	Due Week	Relevant Learning Outcome
	Paper Review		---	Depending on activity given	Each activity will give storm braining and additional knowledge to the subject
	Assignments	Homework	10%		
		Class Activity	2%		
		Report			
		Seminar	6%		
		Essay			
		Project	10%		
	Quiz		8%		
	Lab.				
	Midterm Exam		24%		
	Final Exam		40%		
	Total		100%		

Specific learning outcome:

Upon successful completion of this course, students will be able to:

1. Develop detailed highway geometric designs for various project scenarios, taking into account factors like traffic flow, safety, and environmental impact.

2. Apply the latest design standards and guidelines to create roadways that meet regulatory requirements and industry best practices.

3. Begin learning computer-aided design (CAD) and other software tools to draft and analyze highway designs.

4. Perform safety assessments and propose improvements to enhance the safety of existing highway infrastructure.

Course References:

- American Association of State Highway and Transportation Officials, (2018). A Policy on Geometric Design of Highways and Streets, AASHTO.
- Garber, N. J. & Hoel, L. A., (2014). *Traffic and highway engineering*, Cengage Learning.

- Useful references:

	– Mannering, F., Kilareski, W. & Washburn, S., (2013). *Principles of highway engineering and traffic analysis*, John Wiley & Sons. – Brockenbrough, R.L. and Boedecker, K.J., 2003. *Highway engineering handbook: building and rehabilitating the infrastructure*. McGraw-Hill Professional. ▪ Magazines and review (internet): Federal Highway Administration (FHWA), Flexibility in Highway Design, (1997), U.S. Department of Transportation, USA. Available on < http://ttap.colostate.edu/Library-/FHWA/FHWA-PD-97-062.pdf>. [Accessed: 05 December 2008]

Course topics (Theory)	Week #	Learning Outcome
1) The Transportation Planning Process. • This lecture explains how decisions to build transportation facilities are made and highlights the major elements of the process.	1 28/9/2023	
2) Selection of route location of Highways. • The objectives of highway planning. • Principles of Highway Location. • Highway Planning Studies. • Requirements of an Ideal Alignment. • Factors Controlling Alignment. • Engineering Surveys. • Activities in Route Design.	2 4/10/2023	
3) Earthwork. • Assigned: Assignment #1	2&3 5-11/10/2023	
4) Highway classification. • Functional Classification. • Design Controls and Criteria. • Assigned: Assignment #1	3 12/10/2023	
5) Capacity and Level of Service for Highway Segments. • Two-Lane Highways. • Two-Way Segments. • Directional Segments. • Assigned: Assignment #1 **Week # 4: Due: Assignment #1** **Quiz # 1** **In Class Assignment**	4 (18-19)/10/2023	

6) Geometric Design of Highway; Design Controls and Criteria. • Elements of Geometric Design. • Stopping Sight Distance. • Decision Sight Distance. • Passing Sight Distance. • Assigned: Assignment #2	5 25/10/2023	
7) Design of horizontal curves. • Simple Horizontal Curve • Horizontal Alignment. • Horizontal Curve Fundamentals. • Transition Curve. • Travelled-Way Widening on Horizontal Curves • Curve Radii Based on Stopping Sight Distance. • Assigned: Assignment #2 **Week # 5: Due: Assignment #2** **In Class Assignment**	5 & 6 (26/10 to 2/11)/2023	
8) Design of vertical curve. • Vertical Alignment. • Fundamentals of Parabolic curve. • Minimum Length of Vertical Curve. • Combined Sag and Crest Vertical Curves. • Assigned: Assignment #3 • **In Class Assignment** • **Assigned: Project**	7 (15-16)/11/2023	
9) Cross section elements. • Traveled Way • Lane Widths • Shoulders • Rumble Strips • Roadside Design • Curbs • Traffic Barriers • Medians • Frontage Roads **Week # 8: Due: Assignment #3** **Quiz # 2**	8 (22-23)/11/2023	
10) At grade intersections. • At-grade intersections. • Alignment and Profile	9 (29-30)/11/2023	

• Intersection Sight Distance • Types of Intersection Control • Turning Roadways and Channelization		
11) Grade Separations and Interchanges • Three-Leg Designs. • Four-Leg Designs. • Other Interchange Configurations. • General Design Considerations. • Ramps	10 & 11 (6-7-13)/12/2023	
12) Drainage and drainage structures. • Surface Drainage • Highway Drainage Structures • Sediment and Erosion Control • Hydrologic Considerations • Unit Hydrographs • Hydraulic Design of Highway Drainage Structures • Subsurface Drainage **Week # 12: Due: Assignment #4** **Due: Project** **In Class Assignment**	11 & 12 (14-20-21)/12/2023	
Project Discussion & Seminar	13	

Questions Example Design

Sample of examination paper and ideal solution is attached at the end of the course module

Extra notes:

External Evaluator

I hereby confirm that all syllabuses given in the attached course modules is sufficient to cover required subjects, areas and titles needed for students regarding the study year.

Q1.) (20 Marks)

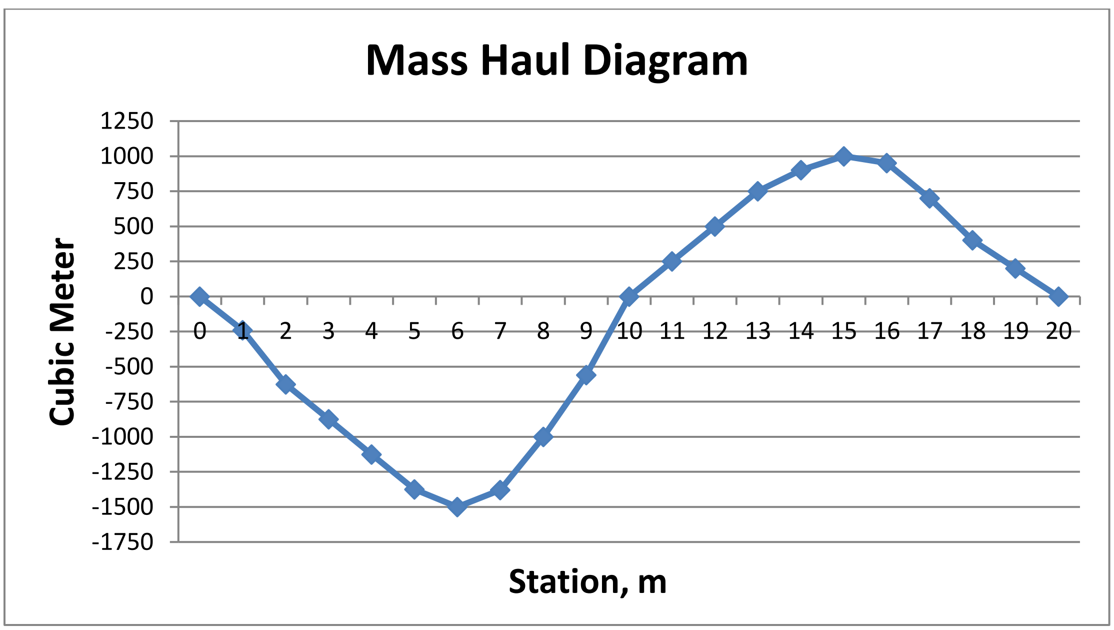
For the data shown in the table below,

a) Calculate the mass diagram ordinates for the net cut and fill volumes.
b) Draw the mass haul diagram.
c) Calculate and show the overhaul distance, and the limit of economical haul distance on the mass diagram given the cost of overhaul is 2000 IQ/m3 per station and the cost of borrow is 6000 IQ/m3. Assume the free haul distance is 500 m.

Sta. (m)	Net Volume (m^3)		
	Cut (+)	Fill (-)	Mass Diagram Ordinate
0+00		240	
1+00		385	
2+00		250	
3+00		250	
4+00		250	
5+00		125	
6+00	120		
7+00	380		
8+00	440		
9+00	560		
10+00	250		
11+00	250		
12+00	250		
13+00	150		
14+00	100		
15+00		50	
16+00		250	
17+00		300	
18+00		200	
19+00		200	
20+00			

Solution:

Sta. (m)	Net Volume (m^3)		
	Cut (+)	Fill (-)	Mass Diagram Ordinate
0+00		240	0
1+00		385	-240
2+00		250	-625
3+00		250	-875
4+00		250	-1125
5+00		125	-1375
6+00	120		-1500
7+00	380		-1380
8+00	440		-1000
9+00	560		-560
10+00	250		0
11+00	250		250
12+00	250		500
13+00	150		750
14+00	100		900
15+00		50	1000
16+00		250	950
17+00		300	700
18+00		200	400
19+00		200	200
20+00			0



$$A.H.D = \frac{500 + 1000}{2} = 750\ m$$

$$O.H.D = A.H.D - F.H.D$$

$$O.H.D = 750 - 500 = 250\ m$$

$$Total\ O.H.D = 250 * 2 = 500\ m\ for\ both\ sides$$

$$L.E.H.D = F.H.D + max.O.H.D$$

$$max.O.H.D = \frac{Borrow\ charge}{Cost\ of\ Overhaul}$$

$$max.O.H.D = \frac{6000}{2000} = 3\ st. = 300\ m$$

$$L.E.H.D = 500 + 300 = 800\ m$$

Q2.) (20 Marks)

A minor road intersects a major four-lane divided road with a design speed of 60 km/h, a median width of (2 m), and lane width of (4m). The intersection is controlled with a stop sign on the minor road. If the design vehicle is single-unit truck (SU-9), determine the minimum sight triangle distances (a and b) required on the major road that will allow a stopped vehicle on the minor road to safely turn left, right and crossing the major road, if the approach grade on the minor road is (-4%). Also determine the design elements of all right turning curves. **See Figure 1.**

Solution:

Case B1— Left Turn from the Minor Road:

- $a_1 = 4.4 + 0.5\ lane\ width = 4.4 + 0.5 * 4 = 6.4m$
- $a_2 = 4.4 + 4 + 4 + 2 + 2 = 16.4m$
- $b = 0.278 * V_{major} * t_g$ → From Table (9-5): $t_g = 9.5\ sec$ For two lane highway with no median and with grades of 3% or less.
- t_g should be adjusted for four lane divided highway and with grades greater than 3%:

  For median = 2m, which is half of a lane (4m).

  - For four lane divided highway: $t_g = 9.5 + 0.7 + \frac{0.7}{2} = 10.55\ sec$
  - For grades = 4%: $t_g = 10.55 + (0.2 * 4) = 11.35\ sec.$
- $b = 0.278 * 60 * 11.35 = 189.318m$

Case B2— Right Turns from the Minor Road:

- $a_1 = 4.4 + 0.5\ lane\ width = 4.4 + 0.5 * 4 = 6.4m$

- $b = 0.278 * V_{major} * t_g$→From Table (9-7): $t_g = 8.5\ sec$ For two lane highway with no median and with grades of 3% or less.
- t_g should be adjusted for grades greater than 3%:

  - For grades = 4%: $t_g = 8.5 + (0.1 * 4) = 8.9\ sec$.
- $b = 0.278 * 60 * 8.9 = 148.452\ m$.

Case B3— Crossing the Major Road from a Minor Road approach:

- $a_2 = 4.4 + 4 + 4 + 2 + 2 = 16.4m$
- $b = 0.278 * V_{major} * t_g$→From Table (9-7): $t_g = 8.5\ sec$ For two lane highway with no median and with grades of 3% or less.
- t_g should be adjusted for four lane divided highway and with grades greater than 3%:

  - For four lane divided highway: $t_g = 8.5 + 0.7 + \frac{0.7}{2} = 9.55\ sec$
  - For grades = 4%: $t_g = 9.55 + (0.1 * 4) = 9.95\ sec$.
- $b = 0.278 * 60 * 9.95 = 165.966\ m$.

Right turning roadways:

- From Table (9-15) for angle of turn = 75° and SU-9, Simple Curve Radius = 17 m.
- From Table (9-18) for angle of turn = 105° and SU-9 which is case B, Three-Centered Compound Curve Radii = (46, 11, 46) m, and offset = 3.5 m, width of lane = 8.8m, Approximate Island Size = 6 m2.
- From Table (9-15) for angle of turn = 75° and SU-9, Simple Curve with taper, Radius = 14 m, offset = 0.6 m and Taper (L:T) = 10:1.
- From Table (9-16) for angle of turn = 105° and SU-9, Three-Centered Compound Curve Radii = (30, 11, 30) m, and symmetric offset = 1 m.

Q3.) (20 Marks)

A horizontal curve on a highway has a superelevation of 6%, coefficient of side friction of (0.10), and a central angle of 40 degrees. The PT of the curve is at station 322 + 50 and the PI is at 320 + 08. What is the safe speed of this curve and what is the station of the PC?

Then find the other geometric design elements of the circular curve: Long chord, Length of the middle ordinate, Length of the external distance, Length of the curve, Degree of the curve.

Solution:

$$T = St.PI - St.PC = 32008 - St.PC$$

$L = St.PT - St.PC = 32250 - St.PC$

$R = \frac{T}{tan\frac{\Delta}{2}} = \frac{32008 - St.PC}{tan\frac{40}{2}}$ and $R = \frac{L}{\frac{\pi}{180}\Delta} = \frac{32250 - St.PC}{\frac{\pi}{180}*40}$

So that $\frac{32008 - St.PC}{tan\frac{40}{2}} = \frac{32250 - St.PC}{\frac{\pi}{180}*40}$

Which gives $St.PC = 317 + 44.25$

$T = 32008 - 31744.25 = 263.75m$

$R = \frac{T}{tan\frac{\Delta}{2}} = \frac{263.75}{tan\frac{40}{2}} = 724.59m$

$V^2 = R * 127(e + f_s) = 724.59 * 127(0.06 + 0.1)$

$V = 120\ km/h$

- $LC = 2R * \sin\frac{\Delta}{2} \rightarrow LC = 2 * 724.59 * \sin\frac{40}{2} \rightarrow LC = 495.65\boldsymbol{m}$
- $M = R - R\cos(\Delta/2) = 724.59 - 724.59(\cos 20) \rightarrow M = 43.7m$
- $E = R\left[\left(\frac{1}{\cos(\Delta/2)}\right) - 1\right] \rightarrow E = 724.59\left[\left(\frac{1}{\cos(40/2)}\right) - 1\right] = 46.5m$
- $L = R * \Delta * \frac{\pi}{180} = 724.59 * 40 * \frac{\pi}{180} = 505.86m$
- $D_c = \frac{1747.5}{R} = \frac{1747.5}{724.59} = 2.41°$

Q4.) (20 Marks)

A sag vertical curve connects a –1.5% grade with a +2.5% grade on a rural arterial highway. If the criterion selected for design is the minimum stopping sight distance, and the design speed of the highway is 112 km/h, a=3.41 m/sec2, and perception reaction time is 2.5 sec, compute the elevation and station of the curve at 23-m stations (interval) if the grades intersect at station (475 + 00) at an elevation of 90 m. Also determine the elevation and station of the low point.

Solution:

$$SSD = 0.278 * V * t + \frac{V^2}{254\left(\frac{a}{g} \mp G\right)}$$

$$SSD = 0.278 * 112 * 2.5 + \frac{112^2}{254\left(\frac{3.41}{9.81} - 0.0125\right)} = 231\ m$$

- Assume $S < L$ $\qquad L_{min} = \frac{AS^2}{(120+3.5S)}$

$$L_{min} = \frac{|2.5 + 1.5| * 231^2}{(120 + 3.5 * 231)} = 230\ m$$

- $S > L$ $\qquad L_{min} = 2S - \frac{(120+3.5S)}{A}$

$$L_{min} = 2 * 231 - \frac{(120 + 3.5 * 231)}{4} = 230\ m$$

- Location of the low point: $\qquad K = \frac{L}{A}$

$$K = \frac{230}{4} = 57.5$$

$$x_l = K * |G_1| = 57.5 * |-1.5| = 86.25\ m$$

$$Station\ of\ lowest\ point = St.PVC + x_l$$

$$St.PVC = 47500 - \frac{230}{2} = 47385m = 473 + 85$$

$$Station\ of\ lowest\ point = 47385 + 86.25 = 47471.25 = (474 + 71.25)$$

$$\text{elev. PVC} = 90 + (0.015 * 115) = 91.725\ \text{m}$$

- $y = \frac{0.025-(-0.015)}{2*230} x^2 + (-0.015)x + \text{elev. PVC}$

Station	X (m)	y (elevation) m
473+85 (PVC)	0	91.725
474+08	23	91.426
474+31	46	91.219
474+54	69	91.104
474+71.25 (L.P)	86.25 (x_l)	91.078
474+77	92	91.081
475+00 (PVI)	115	91.15
475+23	138	91.311
475+46	161	91.564
475+69	189	91.909
475+92	207	92.346
476+15 (PVT)	230	92.875

Q5.) (20 Marks)

Calculate superelevation runoff and tangent runout for a Horizontal Curve which have four lane each of (4m width) with no median, Design speed = 100 km/h, elevation of point PC = 600m and station = 202+00, maximum superelevation = 6%, draw superelevation along the road for the main station (on tangent and curve) where the critical changes of the road section are taken place, also show all necessary elevations and stations at the critical road sections, knowing that normal cross slope is (2%), and the longitudinal grade = –4%. Use rotation about centreline method.

Best of Luck

Glpa Ali Mahmood

Examiner

Note:

- The drawing is not to scale.
- All dimensions are in meter.

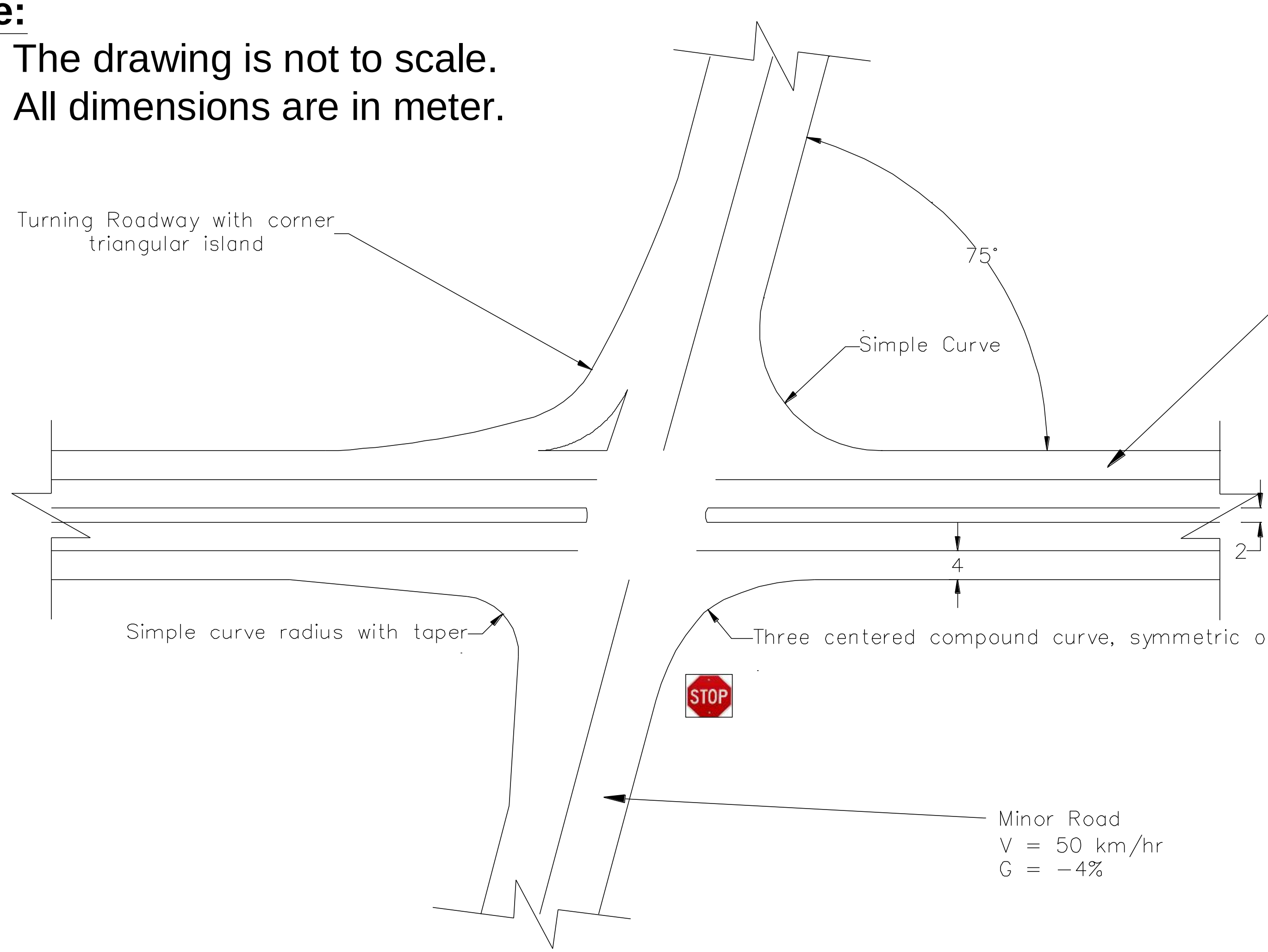
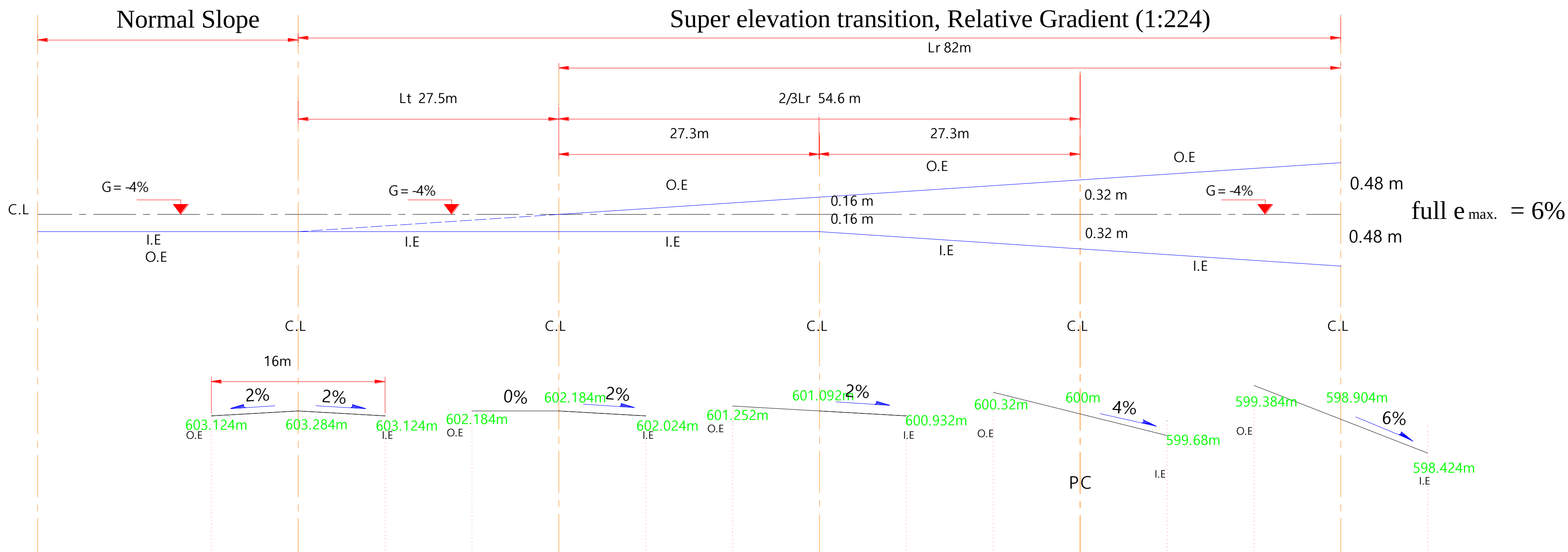


Figure 1

Q5.) Solution:

- $L_r = \frac{W*n1*e_d*b_w}{\triangle} = \frac{4*2*6*0.75}{0.44} = 82\ m$
- $L_t = \frac{e_{NC}}{e_d}\ L_r = \frac{2}{6} * 82 = 27.5\ m$



Sta. (m)		201+17.9			201+45.4			201+72.7			202+00			202+27.3	
E elev. (m)	603.124	603.284	603.124	602.184	602.184	602.024	601.252	601.092	600.932	600.32	600	599.68	599.384	598.904	598.424