Highway Pavement

Civil Engineering Department

4th stage, 2nd Semester, 2019-2020

1st Lecture: Vertical Alignment

Lecturer:

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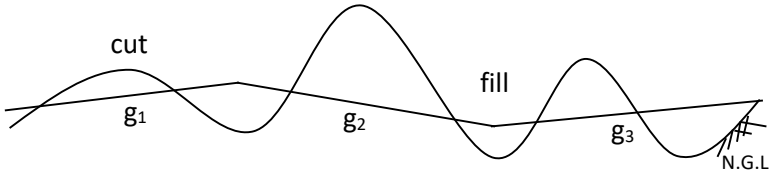
Vertical Alignment

الاقواس الشاقولية



- Grade line
  - Max نحدد درجة الميل و السرعة التصميمية
  - Min لضمان تشكيل منتظم للمركبات و لضمان تصريف المياه

The grade line is shown on a profile taken along the centerline of the highway, and is a series of straight lines connected by parabolic vertical curves to which the straight lines are tangent. In establishing this grade line, the designer must ensure economy by keeping earthwork quantities to the minimum consistent with meeting sight distance & other design requirements.

In mountainous country, the grade may be set to balance excavation against fill, as an aim toward least overall cost. In flat country, the grade will be approximately parallel to the ground surface, but sufficiently above it to allow surface drainage and, where necessary, to permit the wind to clear drifting snow. Under all conditions, smooth grade lines should be the goal of the designer.

When two grade lines having a different in rate of more than ½ percent intersect, a vertical curve is used for a proper transition. Maximum grades are recommended on the basis of design speed control.

The effect of grades on truck speeds is much more pronounced than on speeds of passenger cars.

- Parabolic curve

نربط الطرق بمنحني محدب او مقعر و نحاول ان يكون (الحفر = الدفن)

- Max grade: (for uniform operation of traffic)

  Depends on: 1. Topography (Terrain)

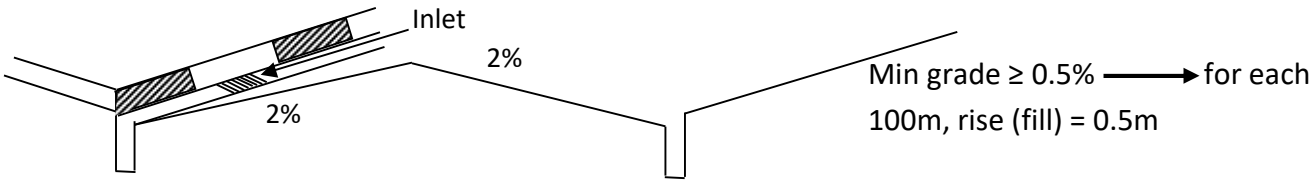
  2. Design speed

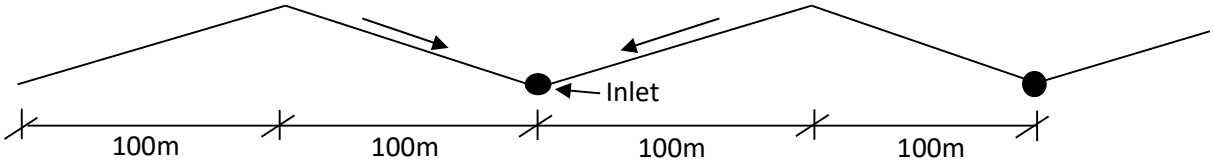
Topography	Design speed (Km/hr)							
	60	70	80	90	100	110	120	130
Flat	5%	5%	4%	4%	3%	3%	3%	3%
Rolling	6%	6%	5%	5%	4%	4%	4%	4%
Mountain	8%	7%	7%	6%	6%	5%	5%	5%

- Max design speed 130 km/hr = 5% (max grade)

- Min grade: (control of drainage in flat area for curbed road)

  في المناطق الخارجية يمكن ان يكون صفر اما في المدن فيجب ان نضع ميل طولي لتصريف مياه الامطار



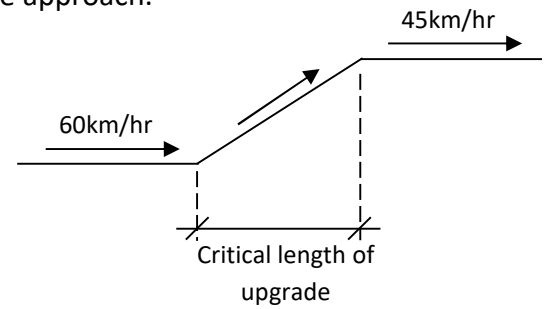


Longitudinal profile ⟵ داخل المدن

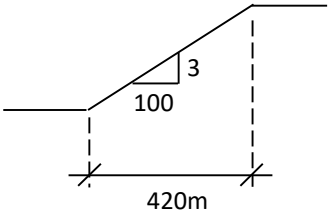
Rural في الطرق الخارجية

- ***Critical length of upgrade***

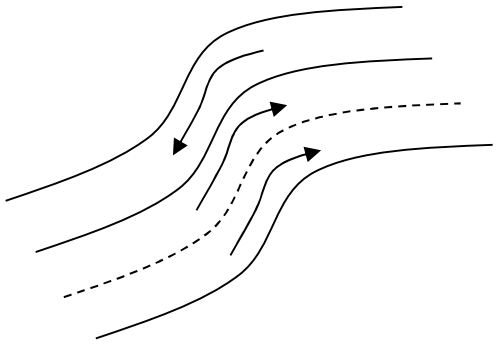
Max length in the upgrade direction that causes a reduction of 15km/hr in the speed of loaded trucks in comparison with that at the approach.



Grade (%)	*Critical length of upgrade (m)*
3%	420
4%	300
5%	240
6%	180
7%	150



Climbing lane: additional lane in the direction of upgrade needed where the critical length of upgrade is exceeded.

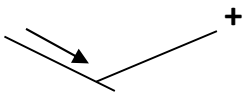


Down grade ⟶ Emergency Escape Ramp.

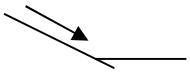
On long descending grade: Emergency escape ramp suggested to stop out of control vehicle.

Types:

1. Ascending

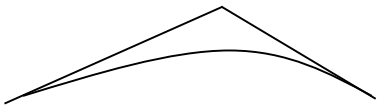


2. Level



3. Descending

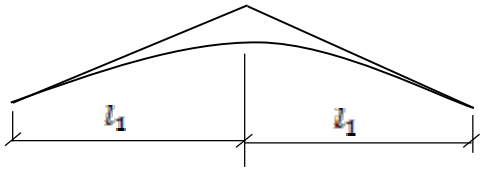
Parabolic Vertical Curves:



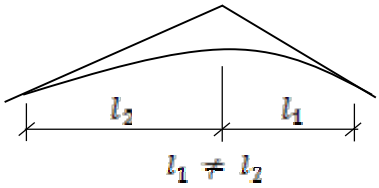
Crest

Sag

Types: Symmetrical curve or unsymmetrical



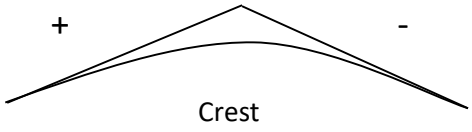
Symmetrical

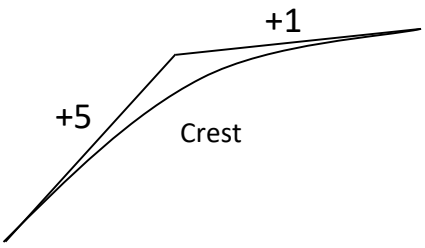


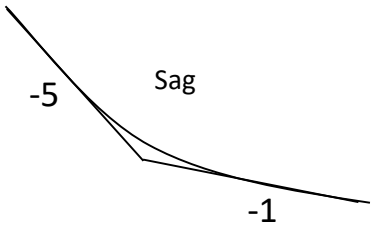
Unsymmetrical

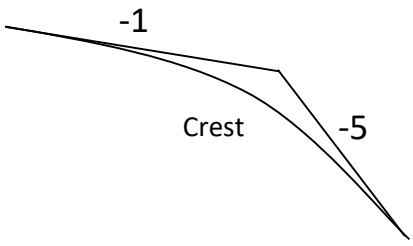
Parabolic symmetrical curve:

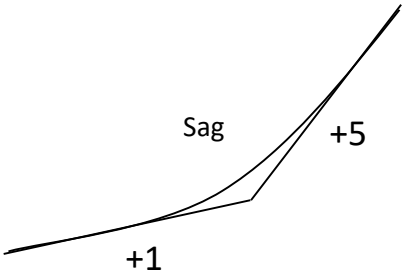
Types:











اذا تشابهت الاشارات نعتمد على قيمة الميل

Properties:

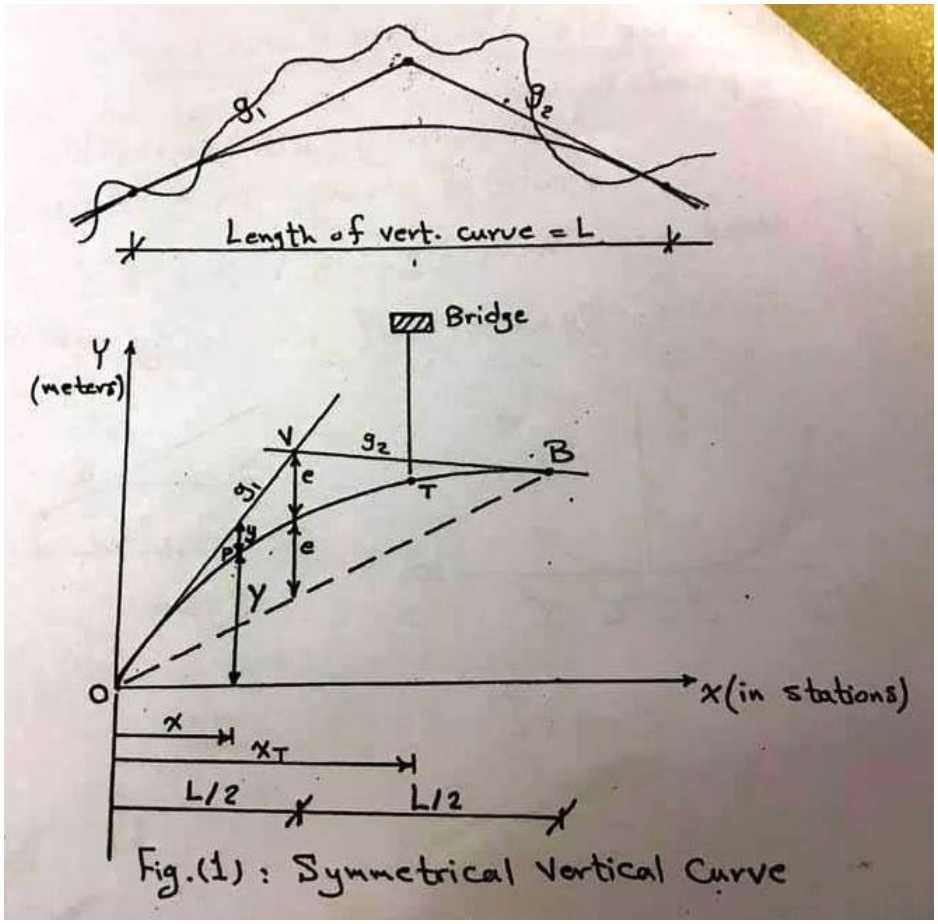
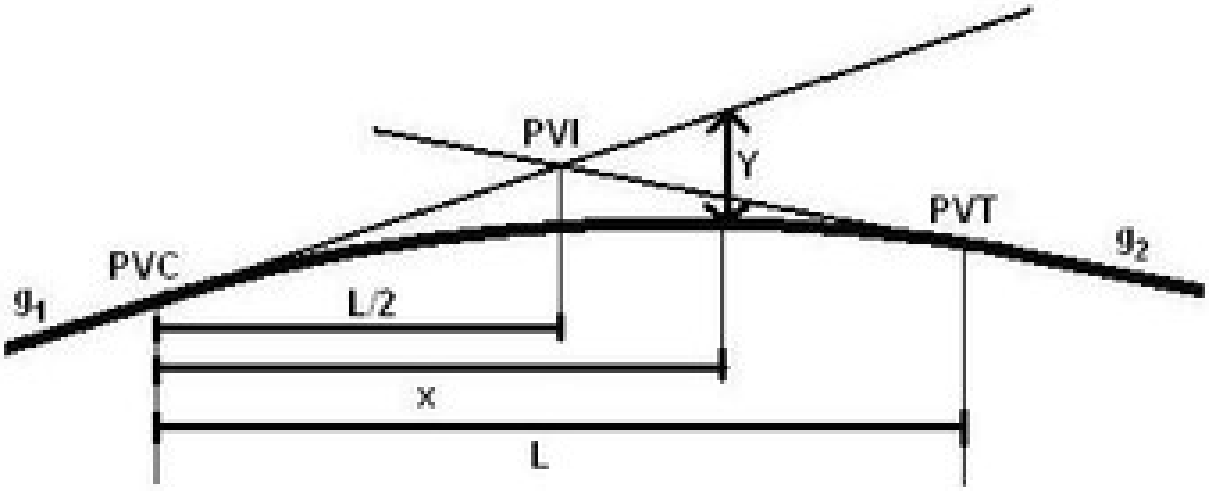


Fig.(1) : Symmetrical Vertical Curve



1. Distances are measured horizontally and vertically

2. Rate of change in slope with distance is constant = r

3. e = e

L= length of vertical curve measured horizontally.

St. = station = 100 m

1 St. = 1+00

g_1, g_2 = percent longitudinal grades or slopes of tangents.

+g = upgrade, -g = downgrade

A = algebraic difference in grades = $g_2 - g_1$

r= rate of change in grade per station (or 100m) = A/L

P.V.C. (PVC) (BVC) = point of beginning of vertical curve = Point of vertical curvature

P.V.I. (PVI) = point of vertical intersection or vertex = Point of vertical Intersection

P.V.T. (PVT) (EVC) = point of vertical tangency = end of V.C.

Δy = difference in elevation between tangent & curve

Δe = difference in elevation at P.V.I.

X = horizontal distance in stations from P.V.C. or P.V.T. to the required point.

Y= elevation of point on curve