

SECTION 11 –GRADIENT

0305. Any particular gradient can be described in three ways:-

- At unit rise or fall in a number of unit of horizontal distance (e.g. 1 in 20) British practice.
- As a percentage (e.g. 5 percent grade)-American practice.
- As an angle (e.g. $2^{\circ} 51\frac{1}{2}'$).

The relationship between these three methods is given in Table 3.5, in which column (c) shows the angle of slope to be used when setting out with the Abney level.

TABLE 3.5 – COMPARATIVE GRADIENTS

Inclination (tangent)	Percent	Angle of slope		Rise in ft per mile
		Degrees	Minutes	
(a)	(b)	(c)	(d)	(e)
One in-1	100.0	45	0	-
3	33.3	18	26	760
6	16.7	9	28	880
8	12.5	7	$7\frac{1}{2}$	660
10	10.0	5	43	528
12	8.3	4	46	440
15	6.7	3	49	352
18	5.6	3	11	293
20	5.0	2	$51\frac{1}{2}$	264
25	4.0	2	$17\frac{1}{2}$	211
30	3.3	1	$54\frac{1}{2}$	176
40	2.5	1	26	132
60	1.7	0	$57\frac{1}{4}$	88
80	1.3	0	43	66
100	1.0	0	$34\frac{1}{2}$	53
150	0.7	0	23	35
200	0.5	0	$17\frac{1}{2}$	26

0306. Definitions. Maximum gradient is the steepest permissible gradient on the road in question.

Ruling gradient is the gradient limit within which the engineer tries to design the road.

0307. Limiting gradients.

- a. Maximum and ruling gradients are governed by the ability of traffic to maintain the average speed for which the road is designed. Comparatively steep gradients have to be accepted on mountain roads, since easy gradients generally mean either an un-due amount of earthwork or a considerable increase in the length of the route.
- b. Limiting gradients for mechanical transport are given in Table 3.6, and those applicable to animal transport in Table 3.7.
- c. On gradients steeper than 1 in 20 water tends to run down the road surface and ditches may be damaged by scour unless check-dams are provided.
- d. A minimum gradient of 1 in 250 (preferably 1 in 150) should always be provided to ensure adequate drainage.

TABLE 3.6 – GRADIENTS – MECHANICAL TRANSPORT

Class of gradient	Normal country	Mountainous Country		
		Normal traffic	Tank transporters	Jeep and carrier tracks
(a)	(b)	(c)	(d)	(e)
Ruling	1 in 30	1 in 15	1 in 25	1 in 6
Maximum	1 in 15	1 in 10	1 in 15	1 in 4

TABLE 3.7 – LIMITING GRADIENTS – ANIMAL TRANSPORT

Ser No.	Animal	Pack		Draught	
		Maximum gradient*	Ruling gradient	Maximum gradient*	Ruling gradient
(a)	(b)	(c)	(d)	(e)	(f)
1.	Horse or pony	1 in 6	1 in 10	1 in 10	1 in 20
2.	Mule	1 in 5	1 in 6	1 in 10	1 in 15
3.	Camel	1 in 8	1 in 18	-	-
4.	Bullock	1 in 8	1 in 10	1 in 10	1 in 20

* Maximum gradients for animal transport are only permissible over short distance. Very steep grades should always be followed by level stretches on which animals can rest.

0308. Gradients on curves:- On all curves, gradient should be reduced as far as practicable. On a slight curve, for example a ruling gradient of 1 in 15 should be eased to a gradient not steeper than 1 in 17 ½ . On sharp bends the gradient should never exceed 1 in 25.

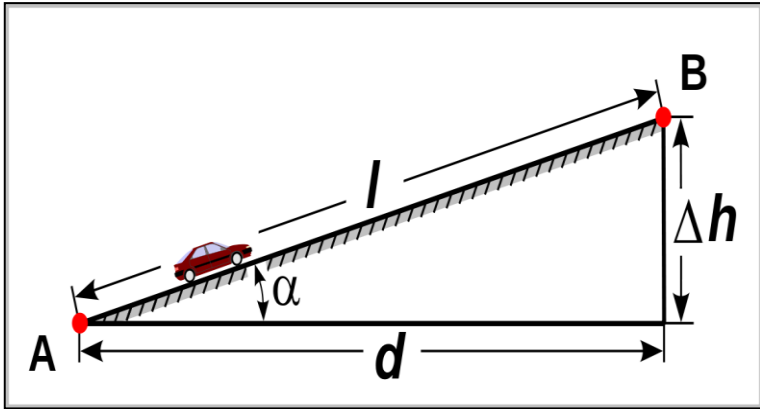


Figure 3-1 (a): Gradients

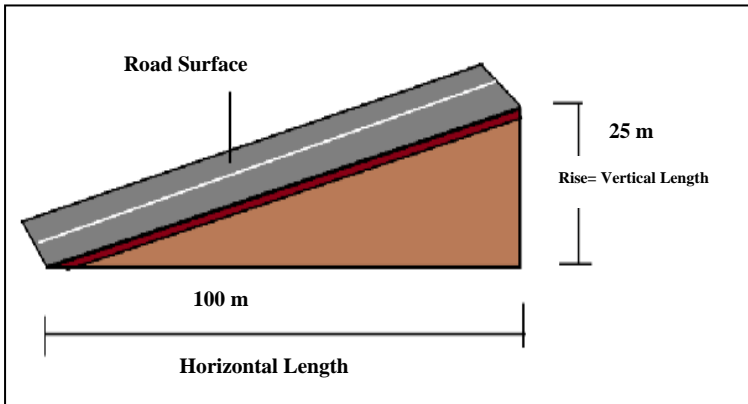


Figure 3-1 (b): Gradients