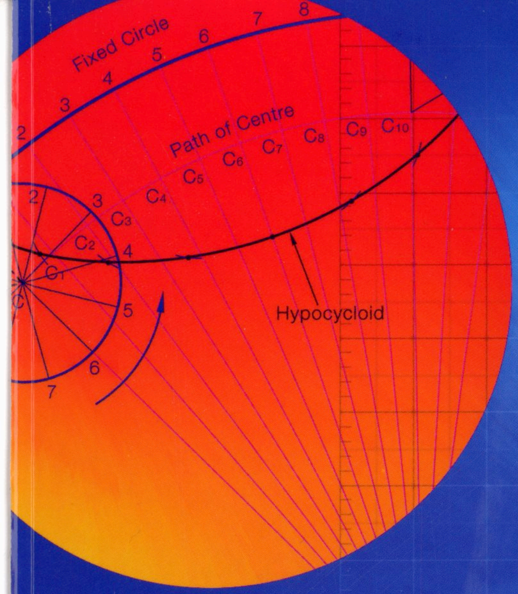
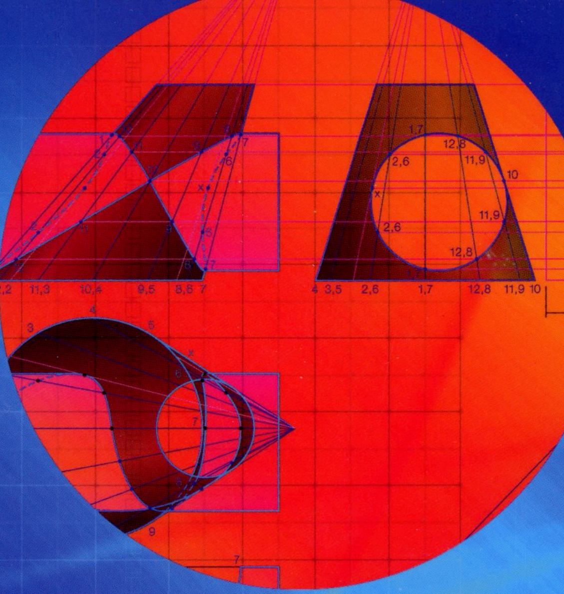
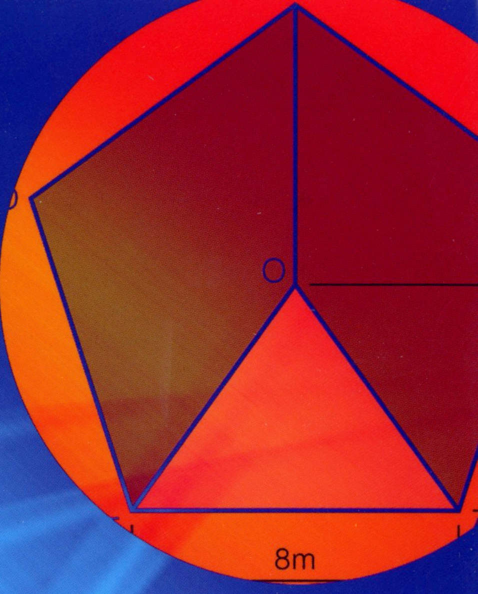
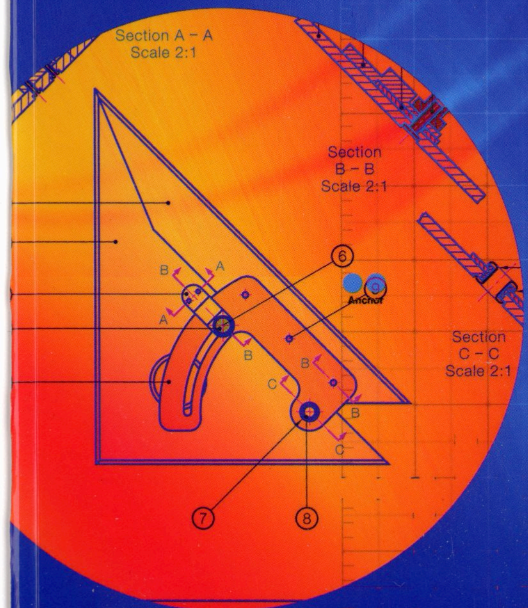


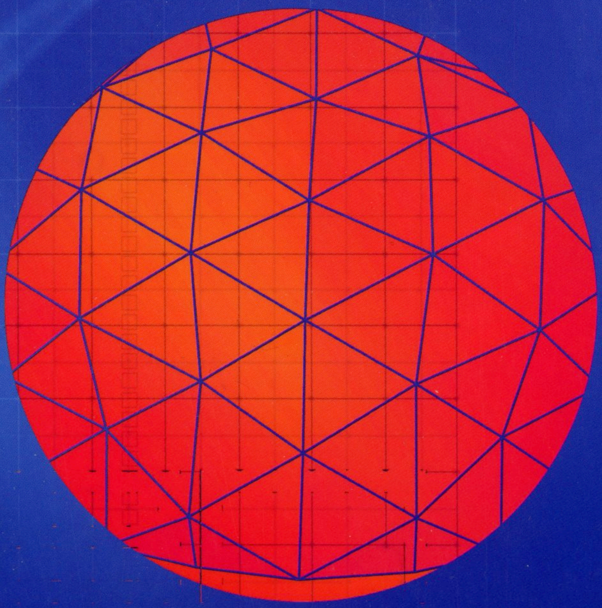


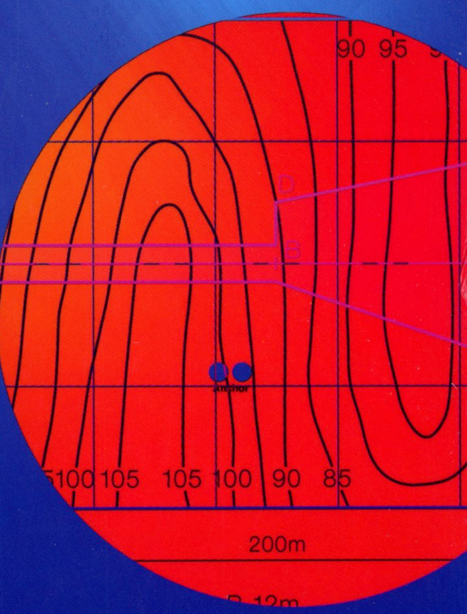


GRAPHICS IN DESIGN & COMMUNICATION 2

CAD AND APPLIED GRAPHICS







DAVID ANDERSON

19 Geologic Geometry

SYLLABUS OUTLINE

Areas to be studied (in an applied context):

• Appropriate symbols and notation. • Interpolation and plotting of contours. • Methods of showing slopes and gradients. • Profiles determined from contours. • *Use of skew boreholes in mining problems.* • Determining the true dip of ore strata. • *Determining the apparent dip of ore strata.* • Strike and thickness of strata. • Determination of outcrop. • Cutting and embankment sections for level constructions. • *Cutting and embankment sections for inclined constructions.*

Learning outcomes

Students should be able to:

Higher and Ordinary levels

- Understand concepts such as bearings, grid layout, true north etc.
- Interpolate and plot contours on a map for given data.
- Show profiles determined from contours.
- Determine cuttings and embankments for level roads and surfaces.
- Determine the true dip, strike and thickness of strata.
- Determine the outcrop profile for given strata.

Higher level only

- *Determine cuttings and embankments for inclined roads and surfaces.*
- *Determine the apparent dip of strata.*
- *Solve mining problems through the use of skew boreholes.*

Our studies to date have concerned us with drawings of man-made objects, be they machine parts or houses. This chapter will investigate the natural geological features of the earth, mapping of the earth's surface, mining, and finally the excavation works necessary for road building. Maps and map data are used throughout the course of the chapter. The accuracy of these maps and this data is extremely important in this type of work because of the scale of these earthworks projects.

Like all subjects, geologic geometry has its own subject-specific terminology. A good starting point is to define and explain some of these terms with notes and diagrams.

Contours

A contour is a line on a map to locate all points of equal elevation. This elevation/height can be relative to sea level or a chosen datum height. Contours may measure elevations above or below this datum level. On a single contour all points have the same elevation.

(3) Draw a new auxiliary to show the sectional view. The vertical boreholes are projected to the strike/dip auxiliary and to this new auxiliary. Heights p, q, s and t are found from the strike/dip auxiliary and transferred to the new auxiliary. The apparent dip can be measured from the new auxiliary.

(4) The apparent dip can be calculated once the strike and dip are known.

$$\tan(\text{apparent dip}) = \tan(\text{true dip}) \times \sin(\text{angle between strike and direction of apparent dip})$$

$$\tan(\text{apparent dip}) = \tan 47° \times \sin \Theta$$

$$\tan(\text{apparent dip}) = \tan 47° \times \sin 149°$$

$$\tan(\text{apparent dip}) = 1.07 \times 0.52$$

$$\tan(\text{apparent dip}) = 0.56$$

$$\text{Apparent dip} = 29°$$

Earthworks for Inclined Roads

The earthwork problems that we have dealt with so far have involved level stretches of road and level, car parking sites. On a variable height site it is often more practical to design a sloping road because it can often reduce the amount of earth to be moved. By closely balancing the amount of cut and fill it can mean that the material removed in the cut can be used to build up the fill.

Plotting of Fill for a Sloping Road

Fig. 19.38 shows a road rising at a steep gradient. The road is to be built on a level plane. It can be seen that the amount of fill needed increases as the road rises. It can also be seen that the level lines along the embankment are parallel to each other but are not parallel to the side of the formation. They splay away from the road as it rises. The slope of the fill remains constant, so for a straight stretch of road it may be considered as a plane. This plane leans against the fill cone at the high end of the road and is tangential to it.

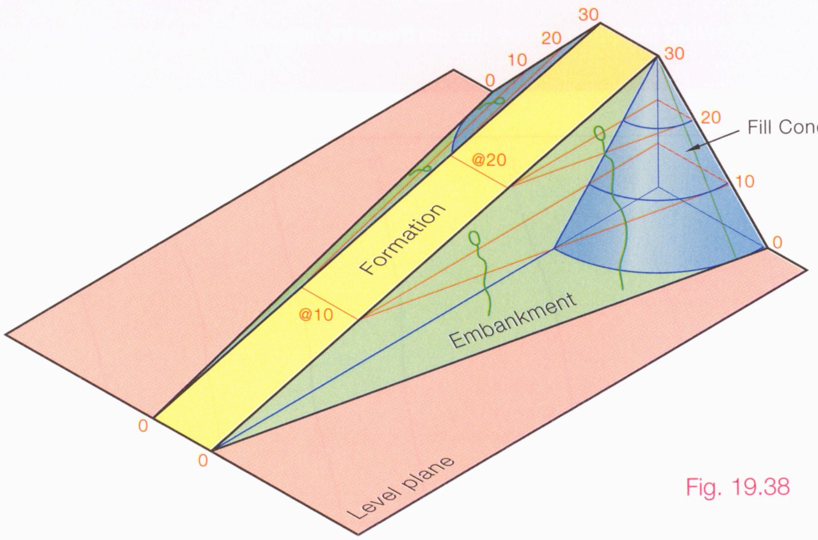


Fig. 19.38

HIGHER LEVEL

Plotting of Cut for a Sloping Road

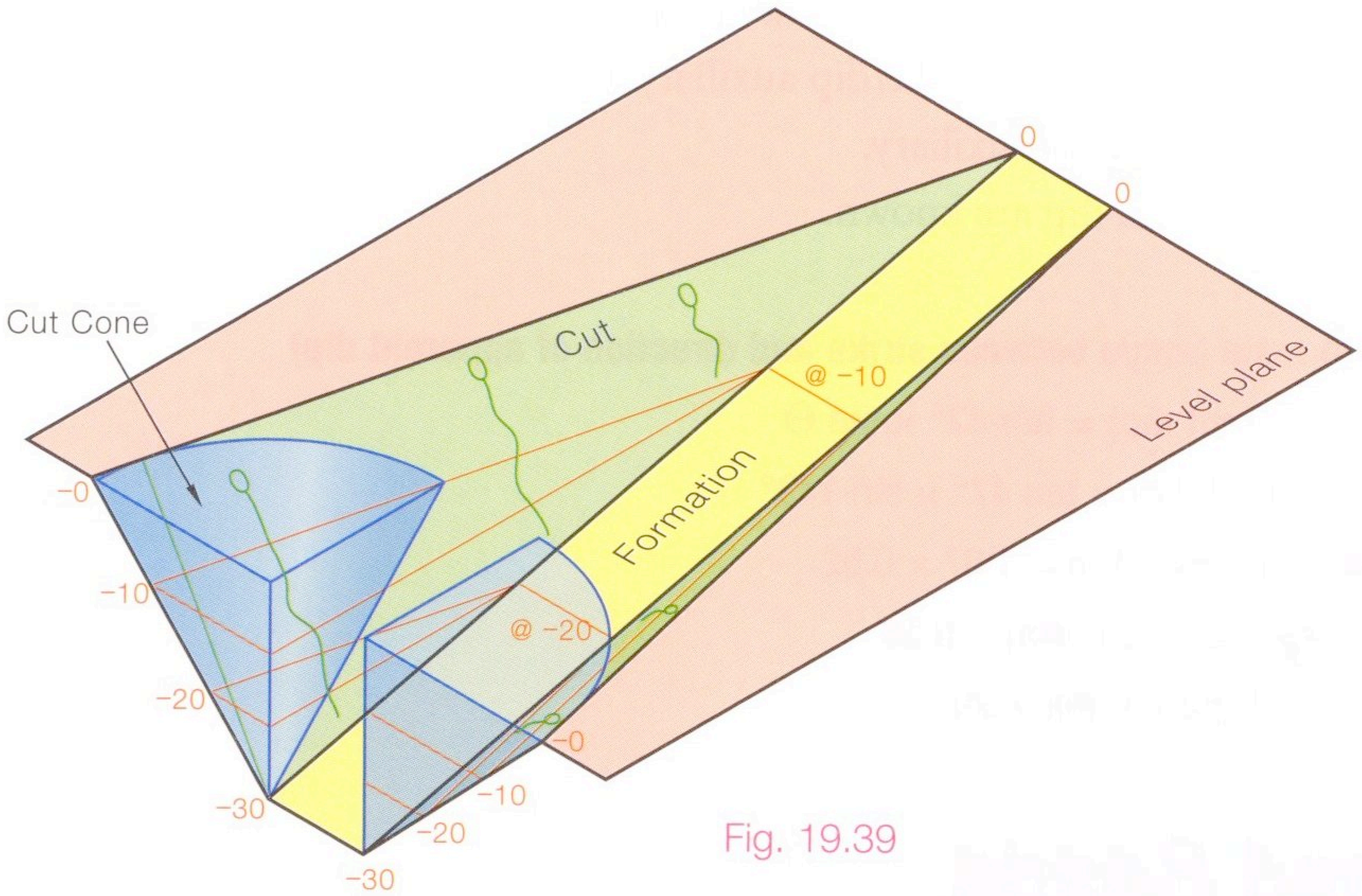


Fig. 19.39

The diagram Fig. 19.39 shows a road sloping downwards into a level plane. The cutting needed increases as the road level drops. Level lines along the cutting are parallel to each other but are not parallel to the sides of the formation. They splay away from the road as it falls. The cut can be considered to be a plane when the road is straight. This plane is tangential to the cut cone. The cut cone is an inverted cone as shown.

Fig. 19.40a shows ground contours at 5 m vertical intervals. AB is the line of a proposed roadway. The road has the following specifications.

(i) Formation width is 12 m.
(ii) Formation level at A is 70 m.
(iii) Gradient A to B is 1 in 15 rising.
(iv) Side slopes for cuttings 1 in 2.
(v) Side slopes for embankments 1 in 1.5.

On the drawing supplied, show the earthworks necessary to accommodate the roadway.

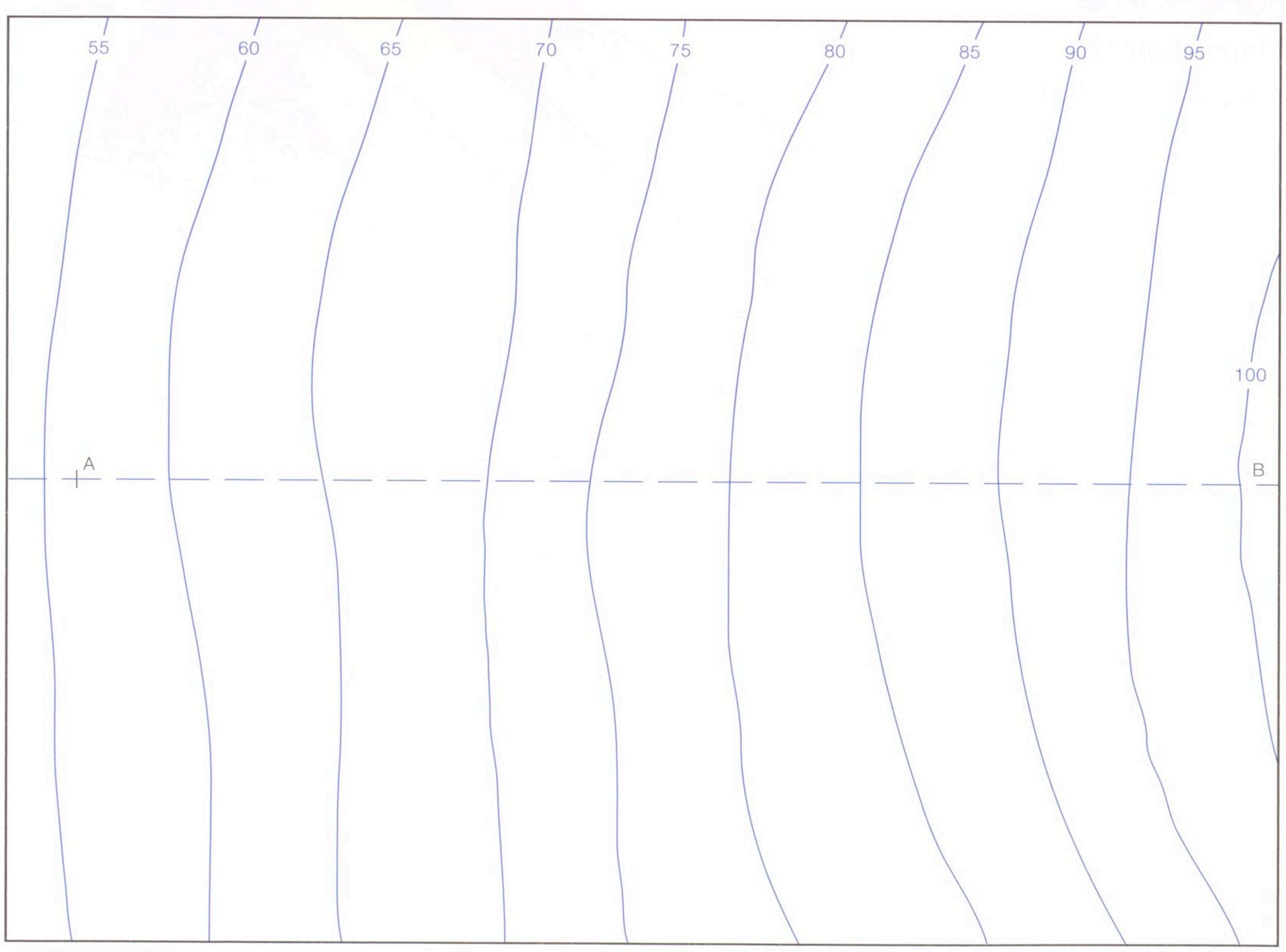


Fig. 19.40a

HIGHER LEVEL

(1) Draw in the formation sides 6 m each side of the centre line.

(2) The road is level from side to side so the 70 m level from A is projected to the sides of the formation.

(3) The road rises at 1:15. Travelling from A to B the road rises by 1 m for every 15 m travelled on the map. For the purpose of solving these problems we are only interested in altitudes that correspond to contour levels.

Locate a point C along the road that produces a rise of 5 m or 10 m or 15 m (a multiple of 5 m). By measuring 150 m from point A, a point C is found that has an altitude 10 m greater than A.

(4) Project C to the sides of the formation. The fill cones are drawn. These appear as semicircles on the map. The radius in this example will be 15 m. **Fill cones are drawn at the high end of the formation.**

The 15 m is calculated by looking at the change in altitude and relating it to the embankment ratio. For a rise of 1 m a horizontal distance of 1.5 m is travelled away from the formation side. For a rise of 1 m a horizontal distance of 1.5 m is travelled away from the formation side.

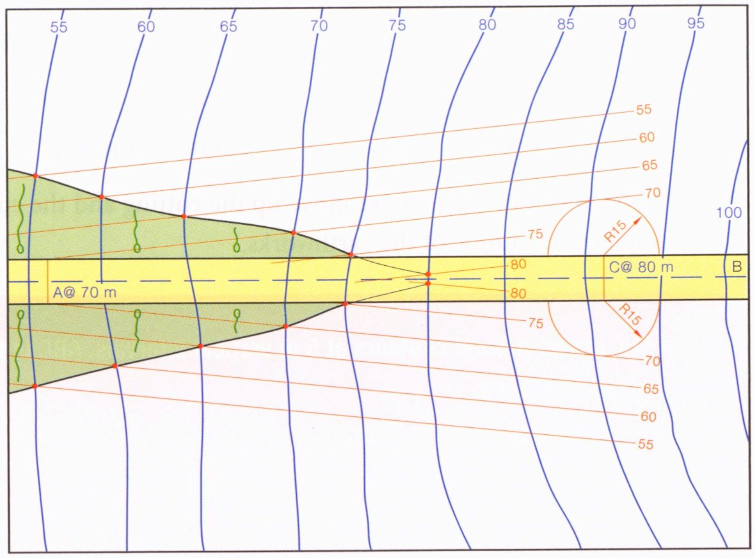


Fig. 19.40b

Fig. 19.41

Fig. 19.42

(5) Join the 70 m level on the side of the road as a tangent to the fill cone circle. This is a 70 m contour line along the embankment.

(6) Subsequent contour lines on the embankment will be parallel to this and 7.5 m apart on the map. Again, the figure of 7.5 m has been calculated from the fill ratio. The contours on the map are at 5 m intervals. To match these, the fill contours must be at 5 m intervals. A 5 m rise produces a 7.5 m horizontal spacing.

(7) Where the corresponding fill contours and map contours intersect gives points on the embankment edge.

(8) Note how the embankment point on the 80 m contour line was found to help locate the exact point where the fill edge hit the road.

Moving out from the side of the road, we move down the bank and the fill contours must drop.

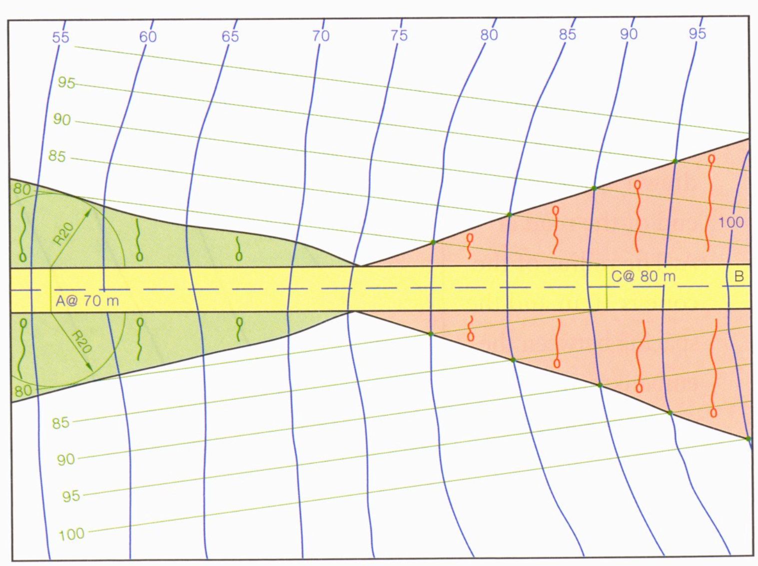


Fig. 19.43

HIGHER LEVEL

Cuttings

(9) The cutting cone is drawn at the low end of the formation. This cone will have a 20 m radius in plan. The 20 m is calculated by slotting the fall from C to A into the cutting ratio. 1:2 = 10:20

(10) Join the 80 m level at C as a tangent to the cut cone. This line forms the 80 m contour line on the cutting.

(11) Draw subsequent contour lines on the cutting parallel to this first line and 10 m apart.

1:2 = 5:10

Height between contours on map. / \ Width between cutting contours.

(12) Moving out from the road we move up the cutting and the cut contours must rise.

(13) Complete the outline of the earthworks.

Fig. 19.44a, shows ground contours at 5 m vertical intervals. ABC is the line of a proposed roadway. The road has the following specifications:

(i) Formation width is 12 m.

(ii) Formation level at A is 50 m.

(iii) Gradient A to B to C is 1 in 15 falling.

(iv) Side slopes for cutting 1 in 1.5.

(v) Side slopes for fill 1 in 1.

On the drawing, show the earthworks necessary to accommodate the road.

(1) Draw in the formation sides 6 m each side of the centre line.

(2) The road is falling 1:15 from A to B to C. We ignore the bend in the road and treat the straight stretch A to B. If we travel from A, a distance of 150 m, we will locate point D and will have fallen in altitude by 10 m.

(3) The fill cone is drawn at the high end of the road at A. The radius of the cone is 10 m and the spacing between the embankment contours will be 5 m.

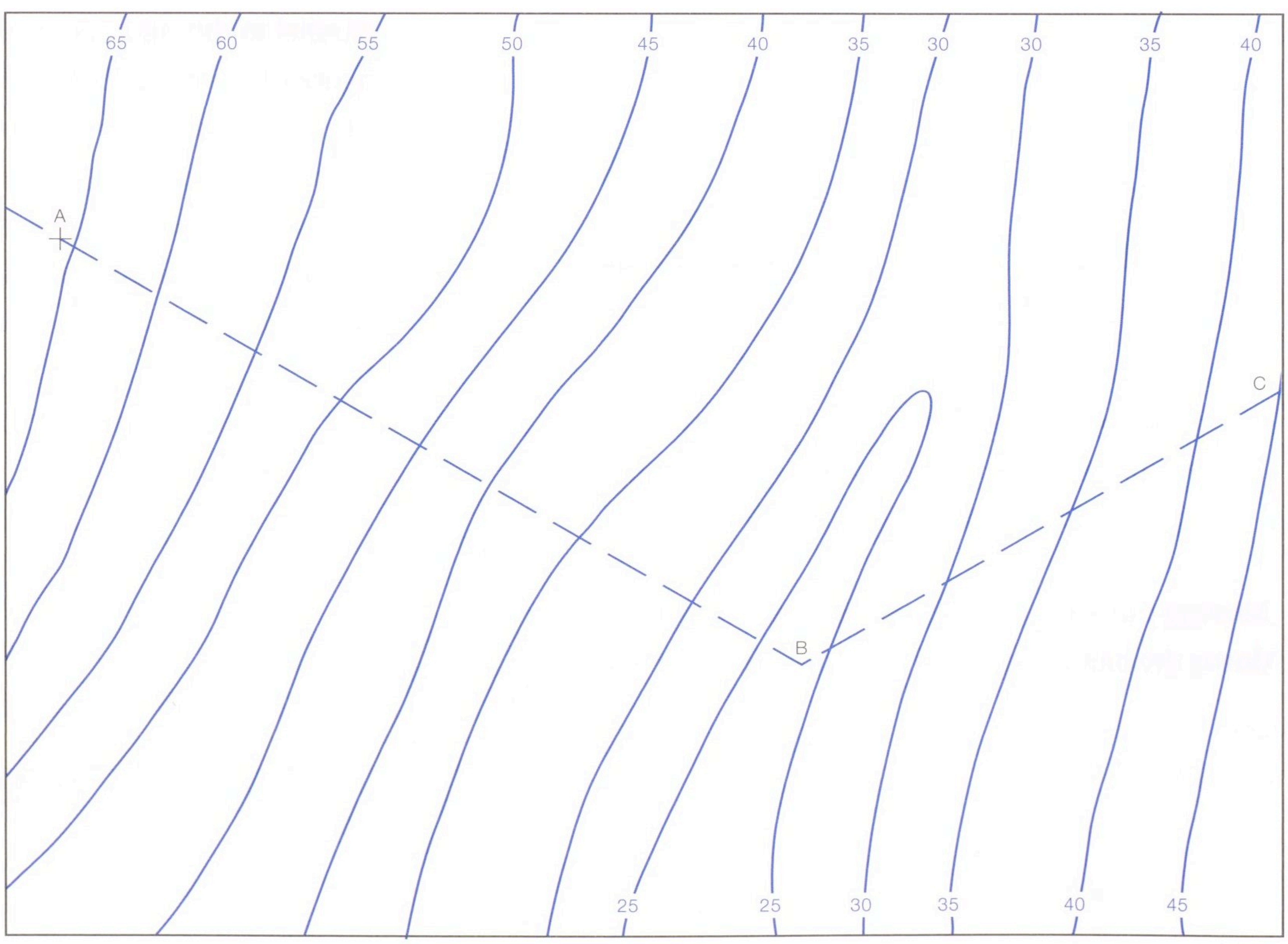


Fig. 19.44a

HIGHER LEVEL

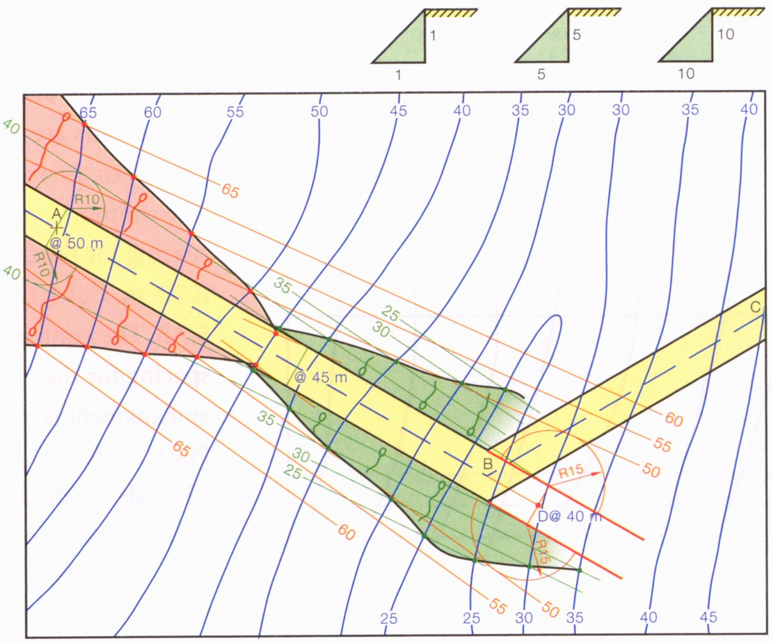


Fig. 19.44b

(4) The cut cone is always drawn at the lower end of the road. The cut cone will have a radius of 15 m and the spacing between the cutting contours will be 7.5 m.

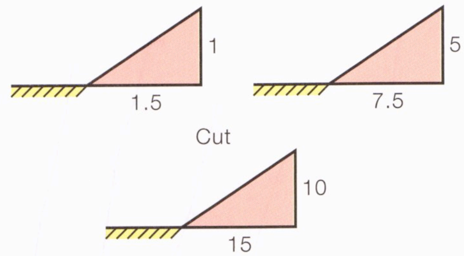


Fig. 19.44c

(5) Draw in the cut and fill for the first section of road A to D.

(6) Rotate point D about the corner O onto the other section of road. D is at an altitude of 40 m.

(7) Locate point E at an altitude of 45 m. D and E will be 75 m apart.

(8) Set up the cut and fill cones. The fill cone will be at the high end of the road, at E, and will have a radius of 5 m. The cutting cone will be at the lower end of the road and will have a radius of 7.5 m. Both of these are calculated from the cut and fill ratios.
Altitude difference between D + E = 5 m
Fill 1:1 = 5:5
Cut 1:1.5 = 5:7.5

(9) Complete the earthworks.

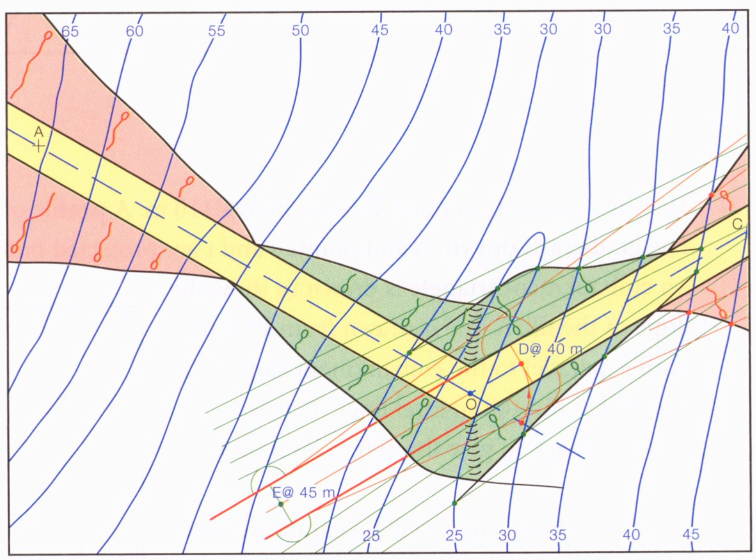


Fig. 19.45

Fig. 19.46a shows ground contours at 5 m vertical intervals. ABC is a roadway which widens onto a car parking area on one side. The road has the following specifications:

(i) Formation width 12 m.

(ii) Formation level at A is 100 m.

(iii) A to B is level, B to C is 1 in 10 rising.

(iv) Side slopes for cutting 1 in 1.5.

(v) Side slopes for embankments 1 in 1.

On the drawing show the earthworks necessary to accommodate the road and car park.

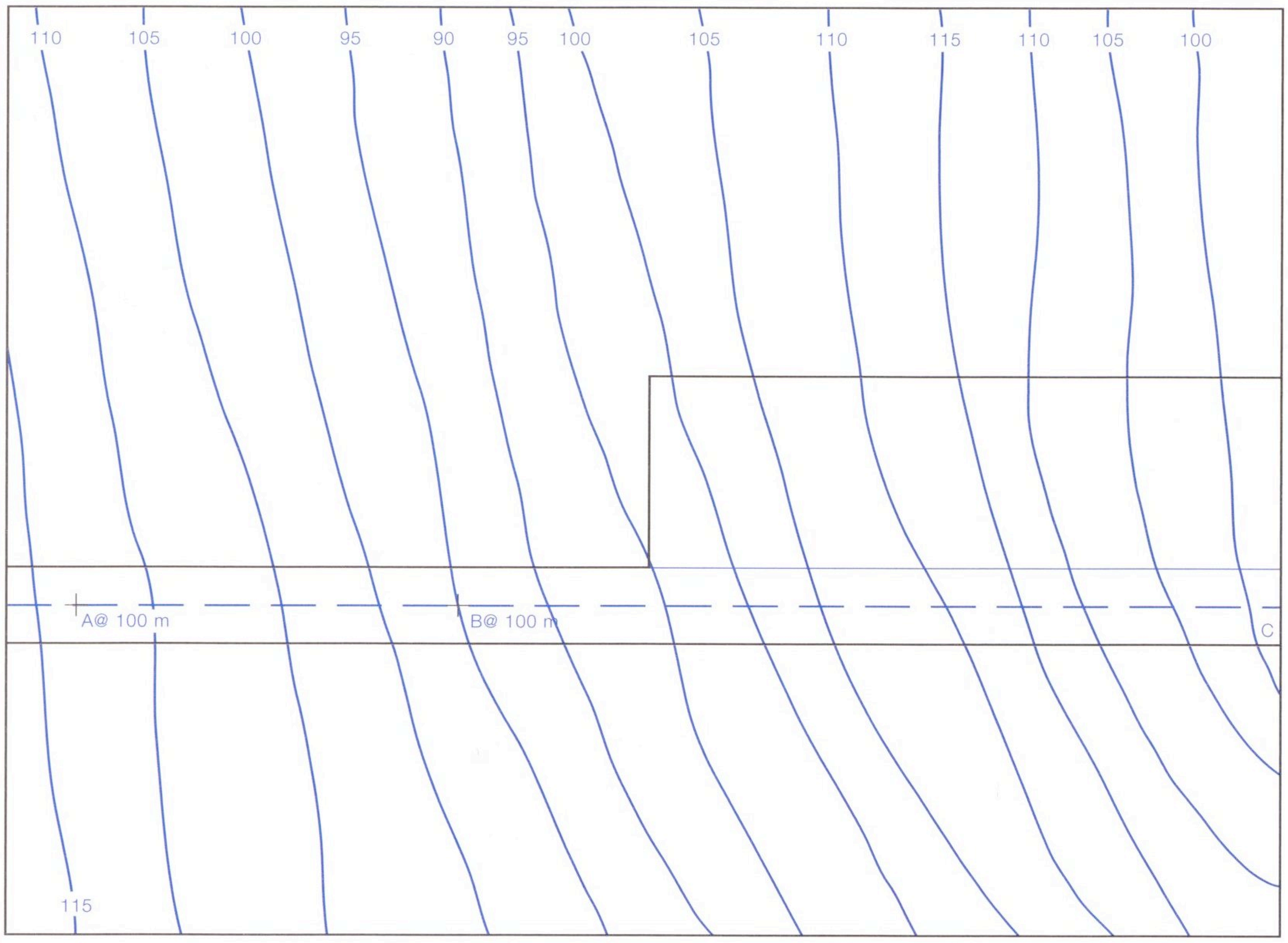


Fig. 19.46a

(1) A to B is level at 100 m. For level roads the cut and fill contours are parallel to the road. The contour spacing for the cut is 7.5 m. Cut 1:1.5 = 5:7.5. The contour spacing for the embankment is 5 m. Fill 1:1 = 5:5.

(2) The side of the car park, st, will also be level. By looking at the levels it can be seen that fill will be required. The difficulty is that since B to C is rising 1:10, the level of edge st is not known.

(3) Measure 100 m from point B to locate D@110 m. A profile of the road and car park are taken between B and D. The gradient is drawn in and points s and t are projected onto the sloping line.

(4) An embankment triangle is drawn to show the slope of the fill. A line is drawn from st in the profile, parallel to the embankment slope. This line strikes the 100 m level lines. This is projected back to give the 100 m level on the fill.

(5) Other fill contour lines will be parallel to this and at 5 m spacings.

(6) All remaining sides of the formation are sloping. Set up the cut and fill cones at B and D. Fill cone at high end of formation and of radius 10 m. Cut cone at low end of formation and of radius 15 m. Spacing of contours 5 m for fill and 7.5 m for cut.

(7) Complete the earthworks as shown.

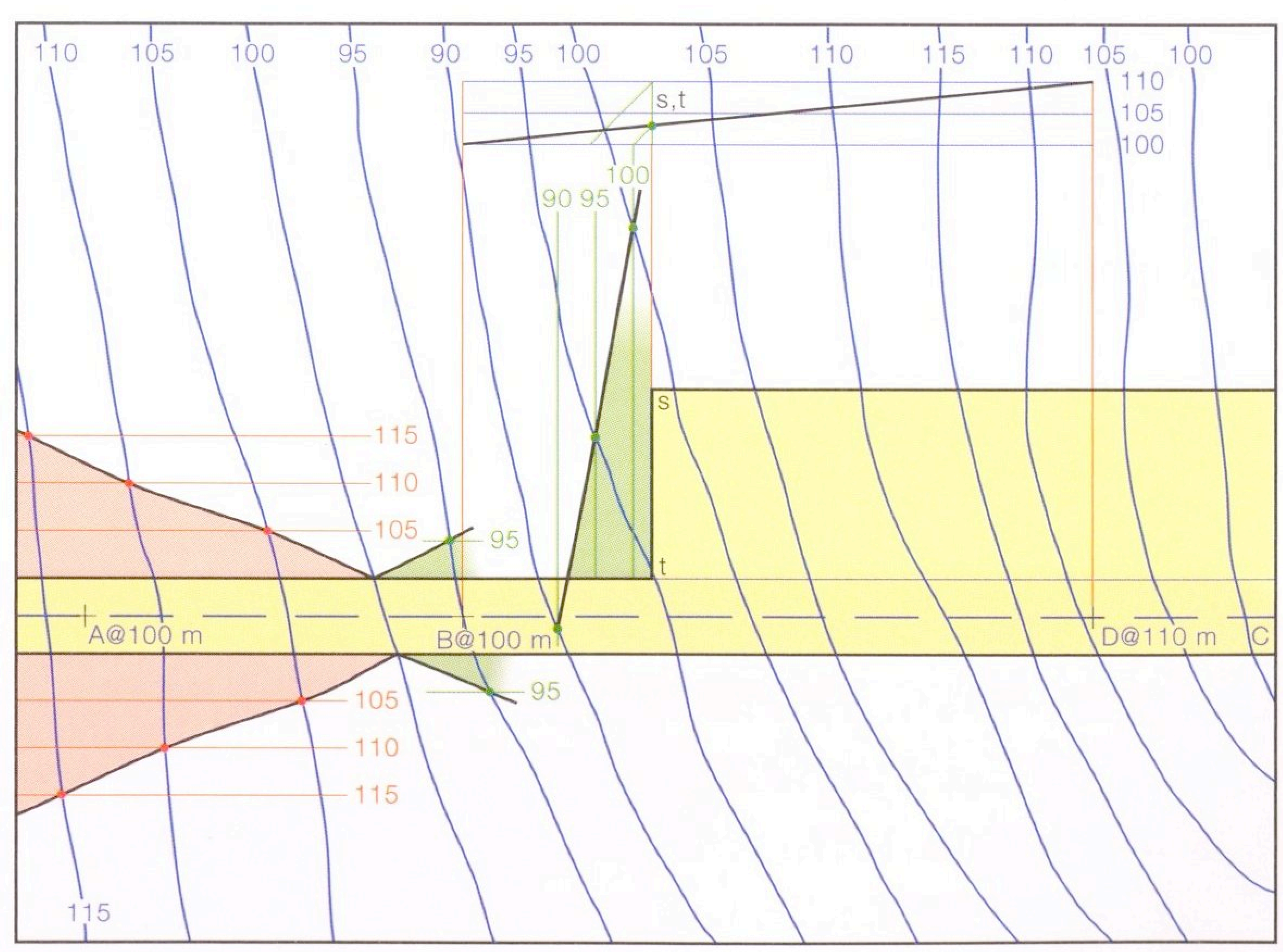


Fig. 19.46b

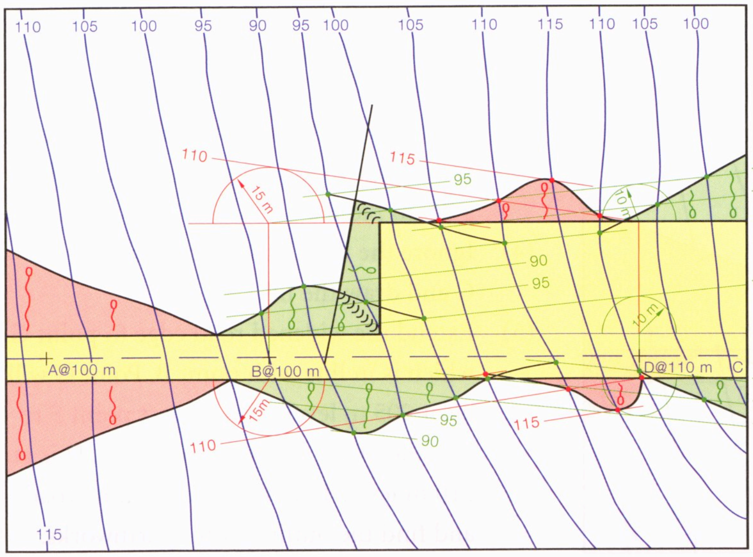


Fig. 19.46c

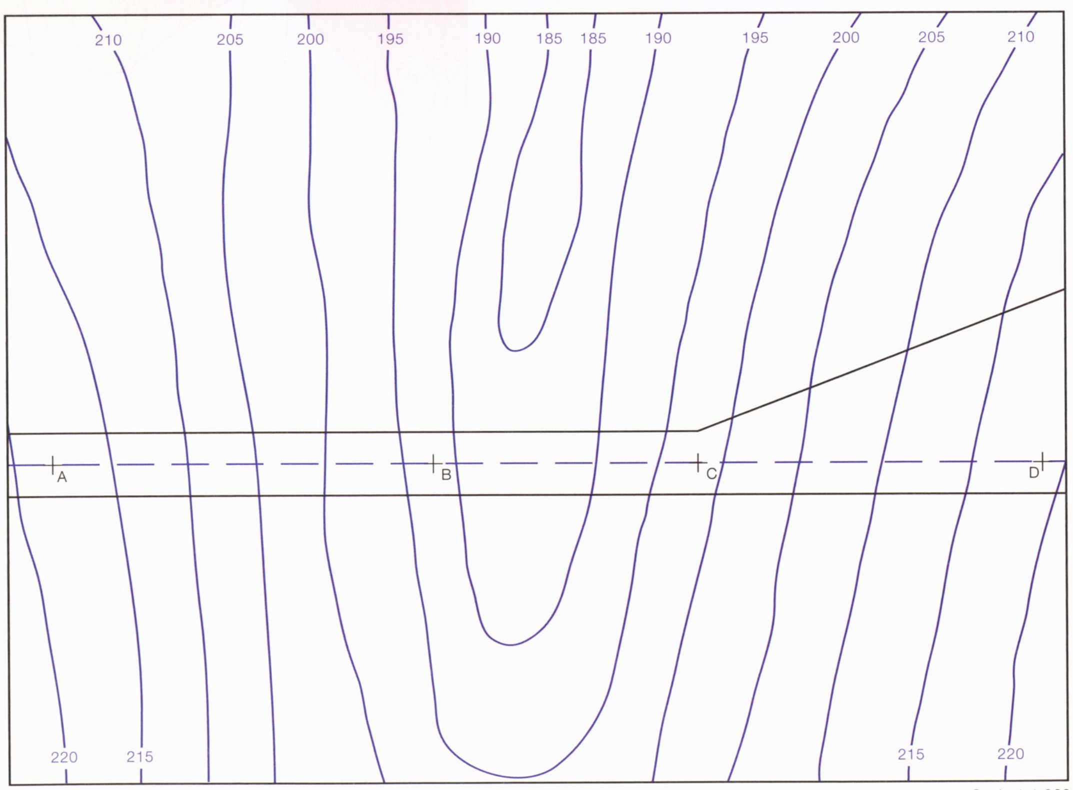
Fig. 19.47 shows ground contours at 5 m vertical intervals. ABCD is a proposed roadway that widens from C to D. The road has the following specification:

- **(i) A to C formation width of 12 m.**
- **(ii) Formation level at B is 205 m.**
- **(iii) A to B is 1 in 10 rising, B to D is 1 in 15 rising.**
- **(iv) Side slopes for cutting 1 in 2.**
- **(v) Side slopes for embankment 1 in 1.5.**

On the drawing show the earthworks necessary to accommodate the road.

(1) A to B is 1 in 10 rising. B is at 205 m. Measure toward A for 50 m to point E which will be at 200 m.

(2) Draw the cut and fill cones at B and E and deal only with this section of road. The difference in altitude between B and E is 5 m, therefore the cut cone has a radius of 10 m and the fill cone has a radius of 7.5 m.



Scale 1:1,000

Fig. 19.47

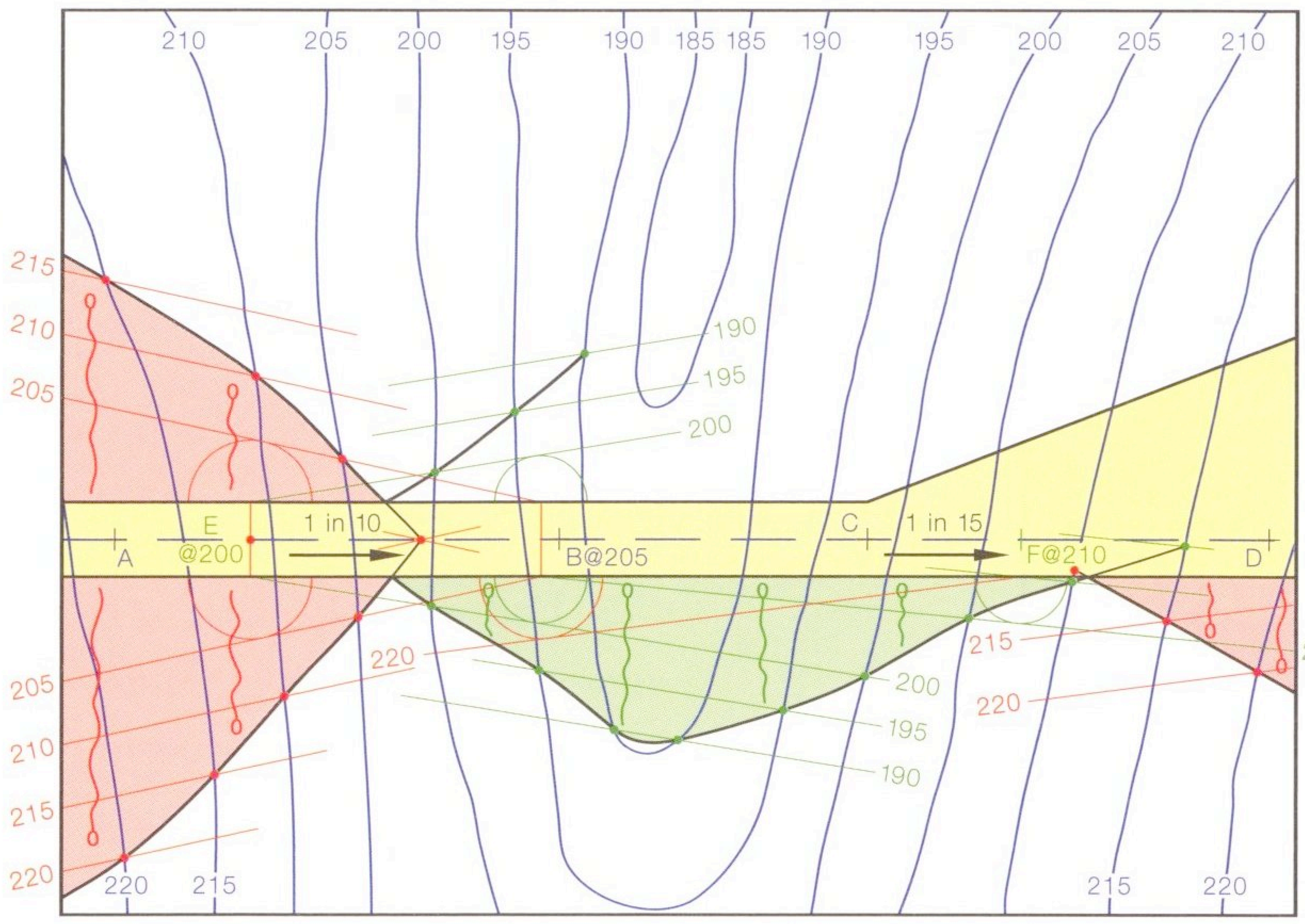


Fig. 19.48

(3) the slope of the road changes at B to 1 in 15 rising. Measure from B to F for 75 m. Point F will be at a 210 m level. Set up the cut and fill cones at B and F. The cut cone has a 10 m radius. The fill cone has a 7.5 m radius.

(4) Ignore the fact that the road widens at C and draw the fill.

(5) Extend the widened road edge to point G which is in line with point B. Point G will be at 205 m level. Also project point F to the side of the widened road at H. H is at 210 m level. Treat GH as a separate road and find the outline of the earthworks.

(6) The cut cone at G will be 10 m radius, the fill cone at H will be at 7.5 m radius. The spacing between the cut contours is 10 m and the spacing between the fill contours is 7.5 m.

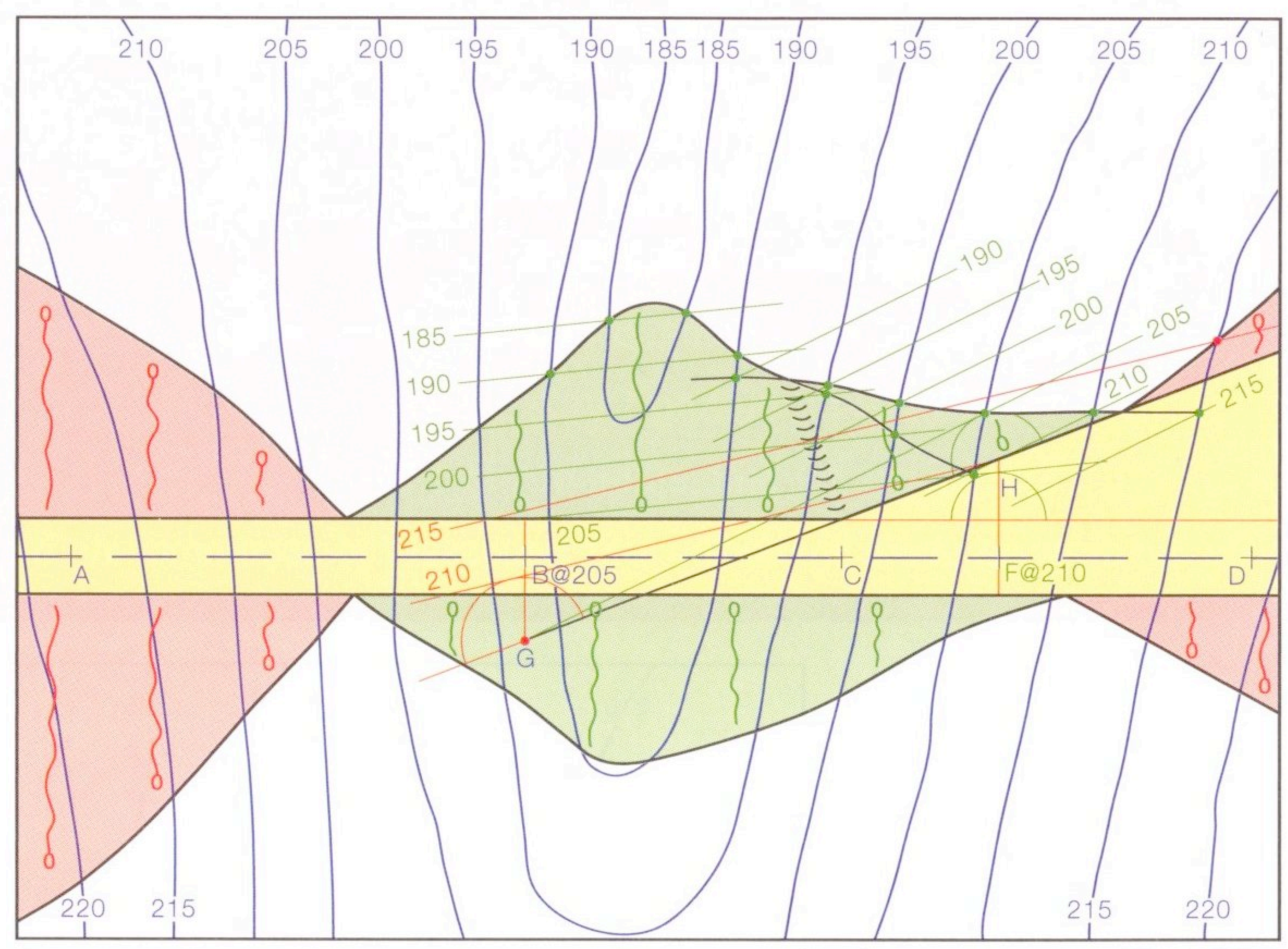


Fig. 19.49

Activities

DEFINITIONS

Q1. Explain the following terms:

(i) contour,
(ii) contour interval,
(iii) bearing,
(iv) profile,
(v) gradient.

Q2. Explain the difference between magnetic north and true north.

PROFILES

Q3. To a scale of 1:1,000 redraw the portion of the map shown in Fig. 19.50.

(i) Draw a profile of the line AB.

(ii) Determine the gradient of the slope at C in an easterly direction.

(iii) If a vertical mast 20 m high stands at point A, is it visible from point B on the ground?

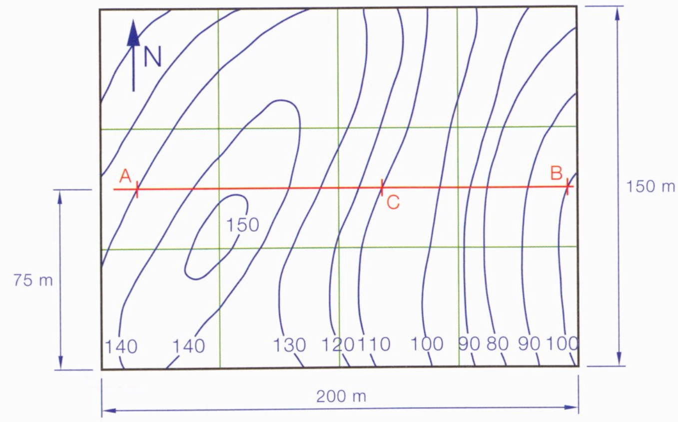


Fig. 19.50

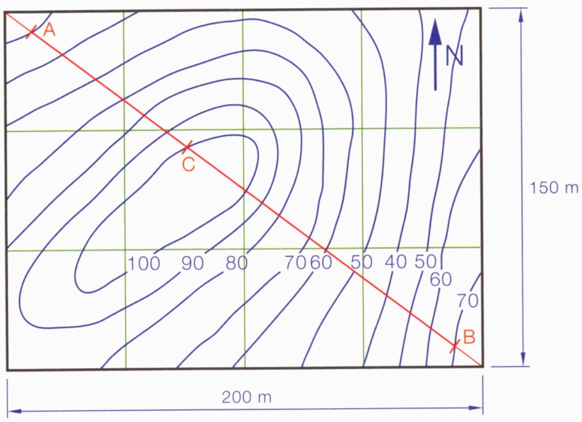


Fig. 19.51

Q4. To a scale of 1:1,000 redraw the portion of the map shown in Fig. 19.51.

(i) Find the profile of the line AB.

(ii) Determine the gradient at point C in the AB direction.

(iii) How tall does a vertical object at C need to stand in order to be seen from point B?

Q5. To a scale of 1:1,000 redraw the portion of the map shown in Fig. 19.52.

(i) Draw a profile along the line AB.

(ii) Determine if a building, standing at C, and having a vertical height of 30 m, is visible from the ground from point D.

(iii) Determine the gradient at E in a westerly direction.

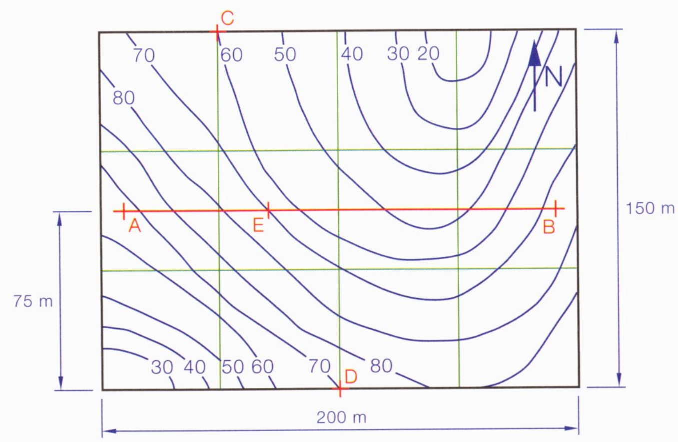


Fig. 19.52