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CHAPTER 6
EARTHWORK PLANNING
SECTION 25 – GENERAL

0601. To reduce the time and effort expended on earthwork:
- Avoid excavation in rock.
 - Balance cut and fill to avoid wasteful excavation.
 - Obviate uneconomical haulage.
0602. The chief earthwork tasks are:
- Forming cuttings through high ground.
 - Forming embankments over low ground.
 - Shaping the surface to correct formation levels.
 - Excavating drainage works.

Earthwork tasks therefore involve some or all of the following:

- Excavating or loosening.
- Loading.
- Transporting.
- Dumping.
- Spreading.
- Compacting.

Plant

0603. Types of earthmoving plant normally available to combat engineers and typical tasks for each type are listed below.

Type of plant	Typical tasks
Wheeled and crawler tractors	Clearing and cutting the subgrade, spreading material, and cutting ditches.
Motor graders	Trimming banks, cutting 'V' ditches, and shaping the formation.
Excavators	Cutting deep ditches, loading tippers.
Tippers	Carrying and dumping material.
Rollers	Compaction.

0604. Cuttings and embankments often interfere with the natural area drainage plan must be worked out at the outset, so that essential work can at once be carried

RESTRICTED

out, to prevent flooding and to avoid interference with construction, In particular, culverts should be built early to avoid delay in placing and compacting fill material Drainage construction is dealt with in Chapter 14.

0605. Swell, shrinkage and settlement- Excavation followed by tipping and compaction in a new place, involves changes in the volume of most natural materials.

- a. Excavated material splits up into fragments which are separated by voids. This causes an initial increase in volume known as “swell”.
- b. When tipped and compacted the voids in the excavated material are reduced. The consequent reduction of volume is known as “shrinkage”.
- c. “Settlement” is a process which may continue over a long period. It may be due to:-

- (1) Consolidation due to continued pressure, eg.an embankment under its own weight. This depends largely upon the methods used in tipping and compaction.

- (2) Consolidation of the soil underlying the embankment.

- (3) Subsidence through the displacement of the underlying soil, if it is of low bearing strength.

Allowances for swell, shrinkage and settlement in certain materials are given in Table 6.1.

0606. Angle of repose. The slope at which the sides of cuttings or embankments will stand varies with the material. Some details are shown in Table 6.2.

TABLE 6.1: SWELL, SHRINKAGE AND SETTLEMENT ALLOWANCES

Ser No	Material	Volume of 100 cu ft of material after excavation (cu ft)	Volume of 100 cu ft of material after final consolidation (cu ft)	Allowances for settlement of bank per foot of height	
				Bank thrown up loose (ft)	Bank raised under traffic (ft)
(a)	(b)	(c)	(d)	(e)	(f)
1.	Earth (loam or light sandy soil)	105	88	0.14	0.05
2.	Gravel or sand	100	92	0.08	0.05
3.	Clay	120	90	-.*	-.*
4.	Chalk	180	140	0.20	0.15
5.	Rock (small places)	150	140	0.15	0.10

* Not advisable to use for embankments except in small quantities as binder.

TABLE 6.2: ANGLE OF REPOSE

Ser No.	Material	Slope	Remarks
1.	Earth	1 in 1 (45°)	For cutting in firm earth thoroughly drained
2.	Earth	1 in 1 ^{1/2} (33°)	The natural angle of repose of loose earth not consolidated is about 1 in 2, and of compact earth about 1 in 1
3.	Shingle or dry sand	1 in 1 ^{1/2} (33°)	Loose sand unconsolidated lies about 1 in 2 ½
4.	Gravel	1 in 1 ^{1/2} (33°)	
5.	Chalk	1 in 1 (45°)	
6.	Rock	From 3 ½ in 1 (74°) to 1 in 1 (45°)	Soft and loose rock in cuttings

RESTRICTED

7.	Rock	From 4 in 1 (76°) to 1½ in 1 (57°)	For solid rock in cuttings according to the directions of the strata
8.	Clay	1 in 1 ^{1/2} (33°)	Well-drained
9.	Clay	1 in 2 (27°)	Normal
10.	Clay	1 in 4 (14°)	Wet

0607. Organization. Earthwork construction is dealt with in Chapter 13. planning should aim at a proper balance between digging output, haulage capacity and the placing of fill material.

a. Transport. In most soils except rock, speed of work is usually governed by transport arrangements. Some transport planning Figures are given in Tables 82 to 85.

b. Earth-moving plant. Descriptions, methods of employment and output Figures are given in RESPB No. 5c (WO Code No. 8632). Machines and haulage vehicles should work in teams, constituted to ensure that:-

(1) Haulage capacity is equal to the maximum digging output.

(2) Spreading and compacting can keep pace with deliveries of excavated material.

c. Hand labor. Output varies with the class of labor and with local conditions. Some planning Figures are given in Tables 86 to 89, but these should be used only as a guide. They relate to work over long periods under fair conditions; for task output Figures may be increased.

It is generally uneconomical to transport hand-excavated material in mechanical transport owing to the time taken in loading. With coolie labor, material is carried in baskets in head-loads, or by donkey. European labor uses wheel barrows: this method is very slow and the maximum depth of cut is limited to about 4 ft.