

CHAPTER NO. 6

EARTH WORK

SPECIFICATION NO. 3.1--Silt Clearance

1. The clearance of silt which may be deposited in the channel or drain shall be taken up in systematic way, such Clearances being carried out in long lengths. Work of silt clearance between two control points of a channel shall be completed during one closure to avoid resiltng.

Method.

Before the actual work is started, designed levels upto which silt is to be Cleared shall be marked at every 250 feet (75 metres) interval at top pegs driven in the bed of the channel.

The spoil from silt clearances should preferably be spread out in the neighbouring borrow-pits, if these exist. If there are no borrow-pits or it is so desired by the engineer-in-charge, the spoil should be spread evenly along the back of the bank, thus widening and strengthening it. Care shall be taken that the spoil is not heaped up on the berm or top of the bank or thrown in lumps on the outside so that it may not be blown in by the wind.

2. Rate for silt clearance includes all the operations as mentioned above, and no extra allowance of wetness, slush or *daldal* is payable in addition to this rate.

Rate.

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General.

1. Unless otherwise specified, earthwork for embankments and cuttings shall be carried out systematically as described below. Modifications in operations and detailed specifications for earthwork for deep channels, high embankments or for fills in the vicinity of important masonry works shall be as specified or directed by the Executive Engineer.

Marking out.

2. The centre line shall first be pegged out and marked with a "dagh bel". All curves shall be properly laid out and the lines indicating the top of the cutting or the toe of the embankment shall then be set out. These lines should be ascertained from cross sections of the existing ground and the finished work. Reference pegs should also be driven into the ground at a fixed distance outside the pegs marking the top of the cutting or the toe of the embankment.

Profiles.

3. (a) **Road embankments:**—Permanent bench marks consisting of *pucca* masonry pillars shall be built at every $\frac{1}{2}$ furlong (100 metres) to indicate the finished formation level and edge of the bank. Cross section profiles of bamboo and string shall also be provided where so required by the engineer-in-charge at sufficiently close interval to guide the labour.

(b) **Channels, drains and bunds:**—Before commencing construction, complete profiles of the uncompacted portion of the designed embankments indicating finished section should be set up at 500 feet (100 metres) apart or at such intervals as directed by the engineer-in-charge. These profiles should be ten feet (3 metres) in length along the alignment. Ends of the profile banks should be stepped so that proper bond shall be achieved with earthfill laid afterwards.

Surface stripping.

4. Earthwork shall be carried out and finished in accordance with the drawings or as ordered by the Executive Engineer. Before placing the earthfill, the surface area of ground that will be covered by earthwork shall be cleared of trees and bushes, and the surface shall then be ploughed over.

Site clearance.

5. Clearing of shrubs brushwood, under growth and small trees not exceeding 1 foot (30 cm.) in girth measured at 4 feet (1.2 metres) above ground level shall be paid on acreage basis at the specified rate fixed by the Executive Engineer for jungle clearance according to the density of the jungle to be cleared. The rate shall be applicable to areas acquired for new canals and drains, extension of channels and drains, and for construction of roads and buildings. The work of

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jungle clearance will normally be done departmentally. The decision of the Executive Engineer shall be final as to whether the jungle clearance over any part of the work is to be especially paid for. Unless the fact of jungle clearance has been agreed to in writing before the commencement of the work, such omission shall be sufficient to warrant the conclusion that no special rate was necessary.

Cutting down of trees exceeding 1 foot (30 cm.) in girth shall be paid extra at the rate specified in the Schedule of Rates. The rate shall include lopping branches, trimming, removal not exceeding 300 feet (100 metres) and clearing site. When stumps are grubbed up in addition, the rate shall also include filling holes and levelling of ground.

Payment for grubbing of stumps will only be made when especially ordered by the Sub-Divisional Officer in cases where it is essential to remove the stumps.

Trees requiring to be cut will normally be sold as they stand. The purchase price shall include the purchaser's liability to cut or grub and remove the tree from Government land. Where these have not been sold, the trees cut and removed will be the property of the Government.

6. The contractor shall provide within the rate all materials for the profiles and laying temporary bench marks. 'Dag-belling' shall be paid extra where it is got done through the contractor. 'Dag-belling' for layout of borrow-pits shall be done by the contractor at his own cost. Temporary bench marks are those made of mud pillars with brick tops, or from jungle woods. Bench marks made entirely of brickwork or masonry shall be paid for by the department.

Laying out.

7. When there is appreciable side slope in the existing surface (that is in excess of 1 in 4,) the ground shall be trenched or stepped as directed by the Executive Engineer. If not otherwise specified, this work shall be paid for separately only if the contractor notifies the rate required by him and gets it settled in writing by the Executive Engineer before commencing work.

Stepping.

8. When there is both cutting and embankment, the spoil from the cutting shall, as far as is economical, be utilized for the filling. The Executive Engineer has the right to lay down from where the material for filling is to be obtained and has power to refuse to allow unsuitable matter to be put into the bank.

Source of filling.

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Borrow pit

9. Borrow-pits shall be used for obtaining soils for earthfills only where absolutely unavoidable. Preference should be given to spoil carried along the formation. No borrow-pits should be dug within 16 feet (5 metres) of the toe of the final section of the embankment after making due allowance for future development. All borrow-pits shall be dug to one depth. Unless allowed in writing by the Sub-Divisional Officer, no borrow-pit shall be greater than one foot (30 cm.) in depth. In all cases where the above instructions have been disregarded, the Executive Engineer reserves to himself the right to leave out of measurement all pits dug in unspecified area and to measure all pits greater than 1 foot (30 cm.) in depth as one foot (30 cm.). The Executive Engineer further reserves to himself the right to have such pits filled up at the contractor's expense. In exceptional circumstances where heavy filling is required or where large areas are not to be spoiled, the borrow-pits deeper than 2 feet (60 cm.) may be dug. In such cases, the distance from the toe of the embankment to the top edge of the pit shall not be less than 20 feet (6 metres).

Borrow-pits should not be dug continuously. Ridges of not less than 10 feet (3 metres) width should be left at intervals not exceeding 100 feet (30 metres). Small drains should be cut through the ridges, if necessary to facilitate drainage. The top layer of soil may be set aside for providing surface layer of banks, if the soil below the natural surface is found to be less suitable for this purpose. No borrow-pits in the irrigation channel shall be dug below bed level, unless ordered or permitted by the Executive Engineer.

Filling from drains

10. Wherever required, the contractor shall make his borrow-pits in the shape of catchwater or other drains, and shall get all this filling exclusively from such pits till the required drain is complete to the length, section and level prescribed by the Executive Engineer. The contractor shall only be entitled to extra payment for dressing the drain to profile and for such excess lead as may accrue.

Flood banks

11. Wherever any embankment is in the vicinity or parallel to river or revulet, all earth for the embankment should be borrowed, as far as possible from the river side. The inner edge of any borrow-pit shall not be less than 50 feet (15 metres) from the toe of the bank, the distance depending upon the magnitude and the duration of the flood to be withstood. Where earth is to be borrowed from rear or land side, a berm at least 80 feet (25 metres) wide shall be left between the borrow-pits and the toe of the bank.

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and Cuttings**

12. (a) All mud, slush and decayed or other vegetation shall be excluded from the filling and clods of earth broken upto a size smaller than a man's fist.

Filling to be in layers, materials.

(b) Filling shall be started from the outer edges working in towards the centre in slightly concave layers. The bank shall be laid to the full width including side slopes in layers not exceeding one foot (30 cm.) in thickness.

13. Filling in approaches to bridges in backing of abutments and in spandrils and haunches of arches shall proceed evenly with the masonry.

Filling to bridges.

14. Manual excavation in cutting for channels or roads shall be carried out in 2 to 5 feet lifts (0.6 to 1.5 metres) or as specified by the Executive Engineer, and for each chain, as far as possible each lift should be completed before starting on the lift below. All gangways, paths and steps shall be kept within the section so that their removal in the end leaves the section true to design. Thus the final dressing of slopes will consist of digging only and no filling or making up will be necessary.

Excavation in cutting for channels and roads.

15. All cuttings shall be taken out carefully to the precise dimensions shown on the drawings or ordered by the Executive Engineer. In case the bottom of the cutting has been taken out deeper than necessary by oversight or neglect of the contractor, the hollow shall be filled in at the cost of the contractor if desired by the engineer-in-charge. The filling shall be done with hard material like sand, mud concrete, kankar or ballast, etc. Nothing shall be paid for cutting made in excess of the desired profile.

Cuttings.

16. "Deadmen" or "matams" or such other marks as the engineer-in-charge may direct shall be left at points indicated by him. These shall remain intact till measurements are completed, but final payments shall be deferred till all marks are removed. In case these are not removed, suitable deductions shall be made from the final bill. Where natural surface is regular, "deadmen" shall be left at equal intervals.

Deadmen.

17. Work before being finally measured shall be correctly brought up or carried down to proper level and otherwise completed in accordance with the specifications and drawings with the proper allowance of settlement. Until final measurements have been made, all banks and cuttings are to be maintained by the contractor, who will be held responsible for their transfer to the department in proper condition.

Maintenance by the contractor.

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Until the bank is finally measured, the contractor is responsible for all wastage or guttering due to rain and wind and wave wash. He is not responsible for unpreventable damage by floods, or cloud burst, in which case he shall only be due payment for actual earthwork washed away. No claim for any other loss or damage shall be entertained.

Irregularities in original surface.

18. No claim for inequalities in the original ground shall be considered, unless the contractor requests the Executive Engineer in writing to measure these before the start of the work and unless these inequalities have been so measured up.

Drainage of cuttings.

19. In excavating cuttings, special precautions shall be taken to ensure the start and progress of work in such a manner that the excavations may drain themselves to prevent delays occurring from water being trapped.

Spoil banks.

20. Spoil banks shall be laid according to plans approved by the Executive Engineer. Spoil shall be spread over the whole area available for the purpose in layers not thicker than one foot (30 cm.). Spoil banks should be dressed and finished to slopes shown on the drawings.

Spoil banks intended for plantations shall be provided with longitudinal and cross dowsels forming compartments 50 feet X 50 feet (15m. X 15m.) so that no rain water can flow off the spoil banks.

Wherever possible, good soil from excavation shall be set aside and laid at top.

Ownership of spoil.

21. All material got out of cuttings, and suitable for pitching, ballast or any other purpose shall be the property of Government and shall be stacked where directed by the Executive Engineer, within the limits laid down for the throwing of spoil. Contractor shall be paid extra for the labour involved in stacking and excess lead, if any.

Lead.

22. Lead shall be measured by the shortest practicable distance between the centre of gravity of excavated earth to that of placed earth. This will constitute the mean lead for the section. No cross leads whatsoever shall be measured and paid for.

Lift.

23. (f) **Non-metric units:**—The lift shall be measured from the centre of gravity of the excavated earth to that of placed earth. This shall constitute the mean lift for that section. For converting lift into horizontal lead, the lift upto 12 feet will be multiplied by 10 and from above 12 feet to 20 feet it will be squared and beyond 20 feet it will be multiplied by 20. When earth has to be carried over a spoil

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bank and dumped beyond it, the mean lift would be the difference in level between the centre of gravity of the excavated earth and top of the spoil bank omitting the dowel.

(ii) In metric units:—The lift shall be measured from the centre of gravity of the excavated earth to that of placed earth. This shall constitute the mean lift for that section. For converting lift into horizontal lead, the lift upto 4 metres will be multiplied by 10 and from above 4 metres to 6 metres, it will be squared and then multiplied by 3.25 and beyond 6 metres it will be multiplied by 20. When earth has to be carried over a spoil bank and dumped beyond it, the mean lift would be the difference in level between the centre of gravity of the excavated earth and top of the spoil bank omitting the dowel.

24. The rates for rehandling of recently deposited earthwork and gravel work after excavation shall be 20 per cent less on excavation rates. Earth work deposited before monsoon season which has had a full monsoon on it, will be considered as normal earth work for excavation. Normally the rehandling item shall be paid on the basis of original measurement of excavation. In case, it is not possible to do so and measurements have to be made of loose excavated soil, a twenty per cent deduction shall be made from measured quantities of spoil. This deduction shall not be made in case the loose rehandled soil is placed in layers as filling and in such cases the normal rules for measurement as specified in paragraph 26 shall apply.

Rehandling of earth work including gravel work.

25. Earthwork shall be classified as detailed below:—

Classification of earth work.

- (i) Ordinary soil.—Soil having dry bulk density less than 1.6 and all sandy soils.
- (ii) Hard soil.—Soil having dry bulk density as 1.6 and above except sandy soils.
- (iii) Wet soil.—Soil which is sufficiently wet so as to cause difficulty in excavation handling.
- (iv) Slush.—Wet clayey soil which will not support a man's weight.
- (v) Daldal.—Liquid mud which will flow like molasses.
- (vi) Gravel work.—All soils having admixture above 40 per cent of gravel or kankar in loose form in non-cohesive binding material and requiring occasional use of picks.

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When admixture of kankar or gravel is upto 40 per cent it will be called "earth work with admixture of shingle or kankar."

Classification of soils shall be according to the definitions given above for purposes of making provision in the estimates or for preparing analysis of rates. Wherever allowance for hardness, wetness etc., has been made, the estimate or analysis of rates as the case may be shall be approved by the Superintending Engineer before tenders are invited. The execution of work shall be on composite rate basis, including all allowances like hardness, wetness, slush, etc. While issuing notices for tenders, the Executive Engineers must clearly state that nothing extra will be payable to the contractors as allowances of any kind. The rates to be quoted in tenders should be specific item rates and not percentages above or below the scheduled rates for earthwork.

In case of works, which according to rules on the subject are permitted to be executed without calling tenders, allowances for hardness, wetness, slush etc. will be paid where called for with the prior specific sanction of the Superintending Engineer as specified in the Schedule of Rates.

Measurements.

26. The measurements of excavation in earthwork shall be made as follows:—

(a) Whenever the excavation is in trenches or from borrow-pits in fairly uniform ground, the measurements of cutting in trenches or borrow-pits shall be made. Deadmen or tell-tales should be left at suitable intervals to determine the average depth of excavation.

(b) When the ground is not uniform, levels shall be taken before the start and after the completion of the work and the quantity of excavation in cutting computed from these levels.

(c) Whenever it is not possible or convenient to take measurements from cutting or borrow-pits or it is so specified by the engineer-in-charge, the filling (consolidated or loose) shall be measured and deductions for shrinkage or voids made as detailed in paragraphs 27.

The following procedure may preferably be adopted in case of construction of irrigation channels, drains and earthen bunds, etc.

(i) In entirely cutting reaches where all earth work for embankment is available from the internal digging of the channel or drain and no borrow-pits are made at all, the

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final measurements will be based on the actual cross section of channel or drain dug below ground level.

- (i) In reaches where 20 per cent or less of the earthwork in banks is taken from borrow-pits and the remaining from the digging of the channel or drain section itself, in such cases also the final measurements may be based on cross sections of the channel or drain dug below ground level plus the borrow-pits measurements.
- (ii) In cases where more than 20 per cent of the earthwork in the banks is taken from borrow-pits, then all final measurements will be based on the completed bank measurements.

27. Deductions or extra allowances in the case of fills shall be made as follows :—

Deduction or
extra allowances
in case of fills.

(a) Ten per cent deductions shall be made from actual measured cubic contents in all cases of uncompacted fills to arrive at net cubic measurements.

(b) In case of fills which have been compacted by watering and rolling in 9 inch (25 cm.) layers, net cubic measurements shall be equal to actual measured cubic contents multiplied by the ratio of the average dry bulk density of the compacted fill to the average dry bulk density of the soil in the natural condition.

D. B. D's. for the purposes of measurements shall be observed at every 250 feet (75 metres) and one furlong (200 metres) in case of channels and roads, respectively.

(c) No deductions shall be made in the case of consolidated fills in confined situations like floors.

(d) Where measured in loose stacks or in carts or lorries a twenty per cent deduction shall be made from measured quantities of spoil.

(e) Where the embankment has passed through a full monsoon season before final measurements are taken and is in use for normal traffic, no shrinkage deduction shall be made. This position shall be brought on record by the Executive Engineer giving date of completion of work with the final date of measurement.

28. (i) Non-metric:—The length and breadth shall be measured correct to 0.1 foot if these are less than 100 feet and correct upto 1 foot

Method of
Measurements.

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if these are 100 feet and above. The depth shall be measured correct to 0.1 foot. The area shall be marked out correct to a square foot and cubical contents correct to a cubic foot.

(ii) Metric:—The length and breadth shall be measured correct to 0.01 metre if these are less than 25 metres, and correct up to 0.1 metre if these are 25 metres and above. The depth shall be measured correct to 0.01 metre. The areas shall be marked out correct to 0.01 square metre and cubic contents correct to 0.01 cu. metre.

Rate.

29. The rate for earthwork excavation shall include:—

- (a) setting out profiles, etc.,
- (b) forming (or leaving) deadmen or tell-tales in borrow-pits and their removal after measurements.
- (c) forming (or leaving) steps in sides of deep excavation and their removal after measurements.
- (d) removing slips or falls in excavations, and
- (e) bailing out water in excavation from rains.

The rate shall not include jungle clearance and cutting down of trees, which shall be measured and paid for separately. The pumping out of water caused by springs, sub-soil water, canal or river seepage, and broken water mains or drains for which the contractor is not responsible, is not included in the rate.

SPECIFICATION NO. 6-3—Dressing of Earthwork

Dressing of earthwork shall be executed in exact accordance with the cross section. Slopes shall be as per design and there shall be no concavity in case of fills and no convexity in case of cuttings.

SPECIFICATION NO. 6-4—Pudding

Composition.

1. Puddle shall consist of stiff clay containing nearly 20 per cent sand by weight. So called "sodium clays", containing sodium carbonate shall generally be preferred. If an adequate quantity of sand is not present in the clay, a suitable amount of sand may be mixed with the clay after it has been weathered and pulverised.

Preparation of puddle.

2. The clay should be dry and exposed to the sun and pulverised with rammers. Additional sand, if necessary, shall be uniformly mixed with the powdered clay two days previous to that on which the clay is required for use. The clay and sand mixture should be wetted and thoroughly worked up in a pug mill or puddled under men's feet into a plastic mass.

Consolidation.

3. The puddle shall be carried in baskets or wheel barrow as considered suitable. Each batch shall be well consolidated with rammers or trodden under feet until it is thoroughly integrated with the batch already in place. Stones, bricks, roots, grass, etc., shall not be allowed to remain in the puddle.

Use.

4. Puddle shall be used in embankment cores, cut-off trenches, impervious blankets, etc. where and when specified by the engineer-in-charge.

Measurement.

5. Measurements of clay puddle shall be recorded before hand by measuring the space where puddle work is to be done. After completion, the officer in charge shall certify that the work is completed in accordance with the measurements already recorded.

**SPECIFICATION NO. 6-5—Earthwork Excavation
of Foundations**

1. Before starting excavation in close proximity to an existing structure, trial pits should be dug to ascertain the depth and nature of its foundations, and no excavation should be made which might endanger the stability of the structure without adequately timbering the side of the cutting. Shoring should be used in all cases where the depth of the excavation exceeds its distance from an existing structure.

Stability of existing structures.

2. Foundation trenches shall be taken out to the exact width of the widest part of the foundations, the sides of the trench shall be left plumb where the nature of soil admits of it, but they must be sloped back or shored up carefully where the soil shows a tendency to fall in. No excavated material shall be placed within 3 feet (one metre) from the edge of any trench.

Excavation.

3. If, however, the contractor without the sanction of the engineer-in-charge, makes the excavation deeper or wider, than shown in drawings or specified, he shall fill up at his own expense, the extra depth or width with concrete or coarse sand as the engineer-in-charge may direct.

Depth and width.

4. The bottom of the foundation trenches shall be perfectly level both longitudinally and transversely and on completion shall be slightly watered and well rammed. Where stepping is indicated on the drawings or is ordered by the engineer, it must be squarely trenched out. If any soft places come to light on inspection or by ramming, they shall be dug out and dealt with as ordered by the Executive Engineer.

Finish.

5. All materials and labour required for fencing in and protecting against risk of accidents due to open excavation shall be provided by the contractor.

Precautions.

6. The contractor shall arrange bailing out water in the foundations or trenches accumulated due to rains. The pumping out of water caused by springs, sub-soil water, canal or river seepage, and broken water mains or drains for which the contractor is not responsible shall be arranged by the department and the cost for the same is not included in the rate.

Pumping.

7. Should rocks or remains of old buildings be met with, the material shall be removed unless specifically ordered otherwise by the Executive Engineer. Blasting will not be allowed without the permission in writing of the Executive Engineer. In case, where the Executive Engineer considers blasting is essential, the extra rate, if any, to be paid shall be fixed in writing before the work is put in hand.

Obstructions.

SPECIFICATION NO. 6-5—Earthwork Excavation
of Foundations

- Rock foundations.** 8. If rock foundation is secured, the excavation shall be done in such a manner as to allow the rock to be exposed and prepared for receiving the concrete or masonry. All loose and disintegrated rock or thin strata shall be stripped to a clean bed acceptable to the engineer-in-charge.
- All seams or crevices shall be cleaned out and filled with concrete or mortar which shall be paid for separately.
- Completion.** 9. The contractor shall report in writing the completion of the foundation trenches to the engineer-in-charge, and no concrete or masonry may be commenced without that officer's sanction in writing.
- Measurement.** 10. The measurement of excavation shall be taken as the area in plan of the bottom of the foundation trench, multiplied by the depth of the foundation. Excavation for slopping the sides shall not be paid for unless this work has been approved in writing by the Executive Engineer.
- Method of measurement.** 11. Method of measurement shall be as laid down in paragraph 26 of specification No. 6-2.
- Rate.** 12. The rate for excavation shall cover:—
- (i) lift, lead and removal of excavated material as specified in the Schedule of Rates;
- In case of plains if the depth of foundations or disposal of surplus soil is more than that specified in item no. 6.6 of Common Schedule of Rates Volume I, extra payment at the rate specified in item 6-2 (c) shall be made for the additional lead or lift. Additional lift shall be calculated only for earthwork below 6 feet (2 metres) depth from top of excavation.
- (ii) dressing of bottom and sides of trenches;
 - (iii) filling the space between the masonry and the sides of the trenches with the excavated earth, laid in 6 inches (15 cm.) layers watered and rammed in accordance with the specification No. 6-6; and
 - (iv) the provision of drains through the spoil banks, as may be required to prevent drainage accumulating round foundation trenches in the event of rain.

SPECIFICATION NO. 6-6—Earth Filling

1. As soon as the engineer or sectional officer in charge has measured the work in the foundations, the space in the trenches with good earth (not unbroken clods) laid in 6 inch (15 cm.) layers. Each layer shall be sprinkled with water and thoroughly rammed before the next one is laid. No filling shall be commenced without the permission of the engineer-in-charge, which must be obtained in writing.

Filling.

2. Where there is likelihood of rain, the earth filling may closely follow the masonry until ground level is reached, but the contractor shall only do this after receiving the written permission of the engineer-in-charge.

Rain.

3. Where concrete foundations are brought up in reducing offsets it will be necessary to bring the earth filling up with the form walls but in such cases special care shall be taken that no earth is allowed to fall on the concrete surface, on which further concrete is to be laid.

Offsets.

4. Filling under floors shall be done in the manner specified for filling trenches, as soon as the brickwork or masonry is completed up to plinth level. Only sandy soil, free from salts, organic or other matter and white ants shall be used for such filling. Where there is black cotton soil, this shall be removed to a depth of two feet (60 cm.) as it is liable to absorb moisture and expand and thus ruin a floor.

Filling under floors.

SPECIFICATION NO. 6.7—Earthwork Over Roofs

Quality of earth.

1. Good earth conforming to specification no. 3.2 and free from salts, organic or other foreign matter shall be used. Silty loam soils with plasticity index 10—12.5 and sand content 10—20 per cent shall be preferred. Ramming of the earth to dry bulk density 1.4—1.6 shall be carried out by the ordinary method of compaction.

Rate.

2. Rate includes breaking of clods, ramming, watering, dressing, lead and lift as provided in the Schedule of Rates.

SPECIFICATION NO. 6-8—Repairs to Earthwork

1. Where ravines or 'gharas' have formed in canal, or road banks bunds, ramps, etc., the ravines, holes or 'gharas' should be fully opened up to the bottom by digging steps not more than $1\frac{1}{2}$ feet ($\frac{1}{2}$ metre) deep in the sides and removing all the fallen or loose lumps of earth. All brushes grass, roots, etc., shall also be removed from the ravine. Filling shall be carried out by placing level layers of earth not more than 6 inches (15 cms.) deep. The earth in each layer should be free from clods, roots, grass, brickbats and other debris and it shall be compacted with rammers, as directed. Before placing a new layer, the surface of the layer below shall be cleared of debris and loose earth. At the end of a day's work, the top layer should be flooded to a depth of 2 inches (5 cm.) and the work should be kept constantly wet to help its consolidation.

Ravines in
banks.

The work of opening 'gharas', refilling, watering and ramming should normally be got done through regular gangs. If the quantum of work is beyond the capacity of regular gangs, these may be reinforced with temporary labour which should be employed departmentally on daily wages. However, in case of exceptionally heavy work of 'gharabandi' or when there is emergency, work of earth filling in 'gharas' may be got done through a contractor after obtaining the approval of Executive Engineer in writing. In all such cases, opening of 'gharas', dressing, watering and ramming shall be done by temporary departmental labour or by regular gangs and only earthwork undressed shall be paid to the contractor.

2. Wherever good silt berms exist and it is specified by the engineer-in-charge, earth for repairs shall be obtained from the berms. Only the available amount of silt should be removed, leaving a layer of silt at least six inches (15 cm.) thick next to the bank. Cross dowels at close intervals should be left on the berms to permit the borrow areas to silt up. Raising of driving banks shall not be with soil from the berms.

Earth for canal
bank repairs.

If no good silt berms exist, or the soil obtainable from the berms is not sufficient or it is specified by the engineer-in-charge, earth for repairs shall be obtained from the spoil banks, if such banks exist, or from outside excavation. No borrow-pits shall be dug on top of the spoil banks, and earth shall be obtained either from back of the spoil or by widening the drainage gaps in the spoil banks, where such gaps exist.

Where there are no spoil banks or good berms or it is specified by the engineer-in-charge, earth for repairs shall be obtained by levelling

SPECIFICATION NO. 6.8—Repairs of Earthwork

down any high lumps if there be any, or if there are no alternate sources available, from the borrow-pits. Borrow-pits shall conform to the specifications laid down in paragraph 9 of specification No. 6.2.

Sandy and silty clays or cohesive silts shall be preferred for repairs to earthwork. Where possible, the soil used for repairs shall be of the same type, and should have the same properties as the soil that was washed away. Where the filling consists of gravel or coarse sand for repairs to canal banks, unless near the toe of the bank, some sandy and silty soil should be mixed with the gravel to form a more impervious mass.

SPECIFICATION NO. 6-9--Turving of Slopes
(Rough Grassing)

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| <p>1. Turving should normally be done in the beginning of rainy season.</p> | Time. |
| <p>2. When old surfaces are to be turfed, they shall be picked up to a depth of about 1½ inches (4 cm.) to give a hold to the sods. New bank shall also be picked up similarly in case surface is not loose. Thoroughly decomposed manure shall be spread evenly after proper sieving. <i>Doob</i> Grass roots shall then be planted at 6 inch (15 cm.) intervals. When turving by sodding has been specified, the sods shall be about 6 inches (15 cm.) square and not less than 3 inches (75 cm.) thick. In laying the sods, their edges are to be brought into as close a contact as is possible by manipulation and then welded by being gently rammed, till they form a compact, unbroken and even surface. Watering by spray, being preferable to watering by flow, should be adopted where practicable.</p> | Method. |
| <p>3. The rate includes loosening of soil, supply and spreading of manure at 6 cft. per 100 sq. ft. (0.18 cu. metres per 10 sq. metres), supply and planting of '<i>doob</i>' grass roots 6 inches (15 cm.) apart or laying of sods 6 inches (15 cm.) square as detailed above, and the first watering.</p> | Rate. |
| <p>4. Turving shall be maintained for one year. When handed over at the end of the period of maintenance, the turving shall be smooth and green, free from bare patches, with the edges neatly trimmed. The contractor shall be responsible that the grass grows properly, and in the event of its not doing so, he shall re-turf, grass or regrass, such parts as have not grown. No area which does not show a good healthy growth shall be paid for. Rate of maintenance of turving of slopes includes dewatering, watering, cutting grass with hand blade and replanting where necessary.</p> | Maintenance. |

SPECIFICATION NO. 6.10—Making of Lawns

- General. 1. Making of lawns may be of two types:—
- (a) Rough grassing.
 - (b) Fine grassing.
2. In case of rough grassing, grass roots are planted at 6 inch (15 cm.) apart and in case of fine grassing, roots are at interval of 4 inch (10 cm.). In the latter type, seeds of the good "doob" grass may be used instead of roots when the contract for planting and maintenance of the lawn for one year is with one agency.
- Method 2. Proper ploughing should be done first of all, which should be followed by breaking of clods removal of rubbish, spreading and mixing of well-decayed manure, dragging with "swahga" and then levelling the entire lawn. The grassing shall be done by planting good "doob" grass at specified intervals or planting seed which shall be followed by watering.
- Rate. 3. Rate in addition to the above items includes the supply of doob grass.
- Maintenance. 4. Maintenance shall be for a period of one year. When handed over at the end of the period of maintenance, the lawn shall be free from bare patches, with the edges neatly trimmed. The contractor shall be responsible that the grass grows properly and in the event of its not doing so he shall grass or regrass, such parts, as have not grown. No area which does not show a good healthy growth shall be paid for.
- Rate of maintenance of lawns includes watering, deweeding, mowing, rolling at intervals, and replanting where necessary.

SPECIFICATION NO. 6.11—Planting Hedges

- | | |
|---|---------------------|
| <p>1. Many dwarf growing shrubs and trees are used for making hedges. Those with small, ever-green leaves and compact growth and which are amenable to pruning make the best hedges. The hedging should normally be done in the month of July or middle of February.</p> | General. |
| <p>2. Trench should be dug and aeration of earth for one week should be done. Earth should then be mixed with well-decayed and sieved manure. Hedges shall be planted at 12 inches (30 cm.) apart. Surplus soil if any, should be disposed of within 100 feet (30 metres) lead as directed by the engineer-in-charge.</p> | Method of planting. |
| <p>3. Rate in addition to the operations as mentioned above includes the cost of hedge plants as well.</p> | Rate. |
| <p>4. Period of maintenance shall be for two years. The rate of maintenance of hedges includes watering, deweeding, loosening of soil and pruning of the hedge. The contractor shall be responsible that the hedges grow properly and in the event of their not doing so he shall replant such hedges as have not grown. No length which does not show a good healthy growth shall be paid for.</p> | Maintenance. |

SPECIFICATION NO. 6.12—Compaction of Earthwork

General.

1. Compaction is a process brought about with the help of moisture through which soil density is increased by expelling air from the voids in the soil and forcing the soil grains into more intimate contact. Water acts as a lubricant upto the optimum moisture content. The object of compaction is to improve the water-tightness and stability of earthfill structures to the desired extent depending on the nature of each work.

Compaction is measured by dry bulk density, which is the weight per cubic foot (cubic centimetre) of dry soil.

Optimum moisture content.

2. (a) Description :—The most important feature of soil compaction is the effect of moisture content of the soil on the density to which it may be compacted.

For every soil, there is a particular moisture percentage which enables it to be compacted to the desired dry bulk density with the minimum expenditure of mechanical effect. This is technically known as "optimum moisture." Optimum moisture is not, however, a property of the soil alone. It varies with weight of compacting equipment also. The greater the compacting force, the lower will be the optimum moisture for a given soil density.

(b) Determination of optimum moisture :—No general formula exists for determination of optimum moisture content in terms of percentages of the constituents. The optimum moisture content shall be determined by actual experiments.

Compaction criteria.

3. For every earthwork job, where compaction is involved, the following criteria shall be specified either with the designs or by the executive engineer-in-charge :—

- (a) Placement moisture content.
- (b) Maximum size of gravel permissible in the soil for compaction.
- (c) Maximum thickness of soil layers as placed.
- (d) Number of passes of a specified roller $\frac{E}{F}$.
- (e) Dry density of the soil desirable after compaction.

Dry density observed is the final and most important check on the efficiency of rolling or compaction operations. The frequency of field density tests and the desirable check on moisture content, shall be maintained according to paragraph II.

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4. The foundations of the total natural ground surface in contact with the embankment shall be cleared of all loose materials, roots, stumps and other debris, before placing the earth-fill. Prior to placing the first layer of embankment, the foundation whether earth or rock, shall be moistened if necessary, but no standing water shall be permitted on the foundations.

Preparation of foundation.

5. The distribution and gradation of the materials throughout the earthfills shall be as shown on the drawings or as directed by the Executive Engineer and shall be such that the earthfills will be free from lenses, pockets, streaks, or layers of materials differing materially in texture or gradation from the surrounding materials. No grass, shrubs or other jungle shall be allowed to be dumped in earthfill. The materials when compacted in the earthfills will be blended sufficiently to secure the best practicable degree of compaction, impermeability, and stability. Successive loads of materials shall be dumped on the earthfills so as to produce the most practicable distribution of the material, and for this purpose the engineer-in-charge may direct the points in the earthfills where individual loads shall be deposited. The earth shall be placed in continuous, approximately horizontal layers of nine inches (25 cm.) thickness. If in the opinion of the engineer-in-charge, the surface of the prepared foundation or the rolled surface of any layer of earth is too dry or smooth to bond properly, with the layer of materials to be placed thereon, it shall be moistened and/or scarified to the satisfaction of the engineer-in-charge before the succeeding layer of earth is placed.

Placing.

All masonry or concrete structures adjacent to an earthfill shall be suitably protected against displacement or other damage during the earthwork operations. The slopes of the earthfill shall be compacted thoroughly, and shall be reasonably true to line and grade.

In order to avoid the formation of raincuts in the inner compacted profile of channels which are to be lined, it is necessary to keep the slope of the soil layer spread for compaction towards the spoil. By doing so the rain water is drained outwards into the loose part of the embankment and helps somewhat in its consolidation and in addition it saves formation of ravines on the surface which is to be lined. The inner edge of compaction zone should be kept at least 6 inch (15 cm.) higher than the outer. The above practice will also ensure proper compaction on the inner edge, because if the inside edge is level or sloping the tractor driver or the bullock as the case may be will have a tendency to keep more to the centre and avoid the edge. In case of road embankments, earth shall be laid in slightly concave layers.

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Moisture control.

6. Prior to and during the rolling operations, the material in each layer of the earthfills shall have the optimum practicable moisture content required for compaction purpose, as determined and directed by the Executive Engineer. In so far as practicable the application of water to materials for this purpose shall be done at the site of excavation, and shall be supplemented as required by sprinkling on the earthfills, if necessary.

In case the moisture content of the natural soil is already greater than the optimum moisture, it shall be allowed to aerate till it comes to the desired moisture content before it is subjected to compaction. It is, however, advisable that under field conditions, the moisture content is kept on higher side by about 2% than the optimum moisture found in the laboratory. The moisture content shall again be checked before the compacting process is started.

With a little experience one can judge moisture content quite closely by compressing the soil in hand. If it forms a strong cast and no superfluous water is visible, it can be considered to contain the required quantity of water (Optimum).

It is important that materials under rolling shall have the optimum moisture content uniformly spread throughout the layer. Harrowing or other working may be done, if necessary, to produce the required uniformity of water content.

Rolling.

7. There is a practical limit to the compaction that can be obtained with a given roller, because added compaction obtained with repeated loads soon becomes very small. Repetition of load is particularly effective in increasing the density of fine graded soils but has less effect on coarse-grained materials. At the same time, very heavy rollers are not always more effective, as fine-grained soils become plastic and troublesome when remoulded by heavy rollers. They can, however, be satisfactorily compacted in thin layers with lighter equipment. Actually the choice of the type of roller depends upon the nature of the soil as below:—

(i) Cohesive soils:—For this type of soil to be compacted in thin layers, sheep foot roller shall be used.

(ii) Coarse-grained soils:—Sheepfoot roller is not suitable for coarse-grained soils, as the feet tend to tear and displace the material rather than compact it. For this type of soils, pneumatic tyre rollers or chain tractors are more suitable. The number of rollings required to produce the dry bulk density shall also be determined by practical tests and shall be specified by the Executive Engineer. Each layer of

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9 inches (25 cm.) shall be rolled and compacted to the requisite dry bulk density before the succeeding layer is added.

It is very important that the work be carried on in a systematic manner. When the required number of trips have been made, the supervising officer should check the completeness of compaction. If the compaction is not up to the standard specified, more trips of the rollers should be required. The field staff should be particularly alert to discover any lack of over-lapping in the travels of rollers.

8. Where mechanical arrangements for pulling standard sheep-foot rollers are not available, lighter bullock-pulled tamping rollers may be got manufactured by the department. Generally the soil shall be considered satisfactorily consolidated after 16 to 20 passes of the roller, or when the impression made by the feet is not more than $1\frac{1}{2}$ inch (4cm.) deep. However a more precise check in the form of field density or Proctor's needle penetration test may be specified by the Chief Engineer for compaction by light rollers.

Bullock-pulled
light rollers.

9. Portions of earthfill between rock projections near cut-off walls, piers and other masonry or concrete structures, and elsewhere, which in the opinion of the engineer-in-charge cannot be compacted properly by the use of rolling equipment, shall be compacted thoroughly by the use of mechanical or pneumatic tampers, or shall be puddled. The degree of compaction for such portions of the earthfill shall be equivalent to that obtained by moistening and rolling as specified for other portions of the earth fill. Where puddling is required, it shall be placed and compacted according to specification no. 6.4.

Tamping.

10. (1) Scope:—These specifications shall apply to standard sheepfoot rollers used for construction of rolled-fill embankments and for compacting earthwork in comparatively thin layers. For ordinary works and wherever ordered by the Chief Engineer, earthfill compaction may be carried out employing small sheepfoot rollers drawn by bullocks, and these specifications shall not apply to such small rollers or to other kinds of special rollers such as grid rollers, pneumatic compactors, etc.

Standard
sheepfoot roller.

(2) Standard sheepfoot rollers shall be used wherever specified and these shall meet the following requirements:—

- (a) The roller drums shall have an outer diameter of not less than five feet (1.5 m.). The length of the roller drums shall be neither less than four feet (1.2 metres) nor more than six feet (1.8 metres).

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- (b) There shall be at least one tamping foot for every hundred square inches (645 sq. cm.) of surface area of the drums.
- (c) The distance, measured along the surface of the drums, between the centres of any two adjacent tamping feet shall be not less than nine inches (23 cm.).
- (d) The cross-sectional area of each tamping foot, measured in a plane normal to the axis of the shank shall be neither less than seven square inches (45 sq. cm.) one inch (25 mm.) from the outer end of the tamping foot, nor more than ten square inches (65 sq. cm.) within three inches (7.5 cm.) from the outer end of the tamping foot.
- (e) The weight of the drum, when fully loaded with ballast, shall be not less than 4,000 pounds per foot (6,000 kgs. per metre) of length of the drum.
- (f) The distance between any two adjacent drums shall not exceed 15 inches (38 cm.).
- (g) Each drum should be free to pivot about an axis parallel to the direction of travel, and the rotation possible between any two adjacent drums shall not be less than 45 degrees.
- (h) Each drum shall be provided with a suitable relief valve.

(3) Operation of standard sheepfoot rollers:—The loading and operation of rollers shall be subject to the approval of the Executive Engineer. Water, sand, or sand-and-gravel ballast shall be used in the roller drums as required to obtain the desired compaction and the tractors shall have sufficient capacity to move the roller satisfactorily when fully loaded. During rolling operations, the spaces between the tamping feet, should be cleared of accumulations of materials as such accumulations are detrimental to proper compaction to the desired dry density.

(4) Details and modification of sheepfoot rollers:—The details of sheepfoot rollers to be built by or for the Public Works Department shall be approved by the Chief Engineer.

(5) Roller data:—Data about all tamping rollers used on each earthwork job shall be maintained in the form shown below:—

- (a) Make of rollers.
- (b) Number of drums.

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- (c) Length of drums.
- (d) Diameter of drums (outside).
- (e) Knobs (k) Sheeps of foot (S.F.) or square (sq.).
- (f) No. horizontal rows of feet.
- (g) No. ft. per row per drum.
- (h) Total no. feet per drum (f) × (g).
- (i) Length of feet.
- (j) Dimensions of bottom of feet.
- (k) Area of bottom of feet.
- (l) Weight of roller (empty).
- (m) Ballast capacity (all drums).
- (n) Weight of roller as used.
- (o) Ballast used (material).
- (p) Weight of roller ÷ total area all feet.
- (q) Clearers (yes or no).
- (r) Type of frame (rigid or oscillating).

11. Construction control shall be exercised on one, more or all of the compaction criteria laid down in paragraph 3 in order to see that construction is being carried out according to the design stipulations. The following tests shall be carried out in connection with the proper control of compaction. These tests may be replaced by other standard tests under the orders of the Executive Engineer.

Construction
control.

(i) **Dry density:**—The dry density in lbs. per cu. ft. (gms. per cu. cm.) to which the materials are to be compacted shall be pre-determined in the laboratory. This value of dry density and the proper moisture density relations shall be established by carrying out the 'Standard Compaction Test' described in appendix X.

(ii) **Field density test** shall be made on rolled embankments during construction in order to compare the density to be obtained by construction methods with the desired standard of compaction determined in the laboratory. In case of compacted embankments, field density tests shall be made at three points along the width of compaction. One each at a point 1 ft. (30 cm.) from either edge and the third in the centre.

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These field densities shall be taken at 250 ft. (100 metres) apart or at intervals as specified by the engineer-in-charge along the compacted reach and shall be recorded directly on the compaction register. Dry bulk density of the compaction in the bank shall not be less than 90 per cent of the maximum dry bulk density at any place, as determined in the laboratory.

The field density test and the allied penetration resistance needle test shall be carried out as described in appendices X and XI respectively.

(iii) Moisture control:—After the materials are placed in the correct location, it is of extreme importance that the test be carried out to check that they contain the proper amount of moisture prior to compaction. Needle moisture test shall be carried out as detailed in appendix XI. Number of such tests shall be specified by the Executive Engineer. Moisture content shall be corrected before compaction if necessary as laid down in paragraph 6.