
EARTHWORK

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EARTHWORKS

PART 1- GENERAL

1.1 SCOPE OF WORKS

- A. This specification covers all necessary work required for the site preparation, removal of existing structures,
- B. Work included: Work to be done under this section includes, but is not limited to, the following items together with all labour, materials, equipment and services necessary and incidental for the proper execution of the works in accordance with the Drawings and Bills of Quantities and as directed by the Engineer and as specified herein.
1. Clearing, grubbing and site preparation as required.
 2. Excavating all types of materials to the limits indicated or required, including soil, rock, utilities, pavements, curbs and other materials and obstructions for new below-grade construction, and other site improvements indicated on the drawings.
 3. Pre-trenching, as required, to remove or to work around potential obstructions which might affect installation of excavation support systems.
 4. Handling and legally disposing of excavated materials as specified.
 5. Preparing base and sub-base to the limits indicated on the drawings and as specified.
 6. Providing specified materials from off-site sources as required.
 7. Backfilling and compaction operations associated with common fill, select common fill, crushed stone, structural fill, gravel base course, and rip rap placement; new utility construction, utility relocation work; sidewalk and other areas where backfill is required for project construction.
 8. Grading, shaping and compacting excavations, backfills and original ground upon which pavement, surfacing, base, sub-base or structures are to be placed as per grading plans.
 9. Restoring grade to original conditions beyond the site limits, where disturbed.
 10. Disposal of surplus and waste materials.

1.2 RELATED DOCUMENTS

Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.3 SOIL INFORMATION

The Contractor shall be deemed to have visited the Site of Works and satisfied himself as to the nature of the ground and made him conversant with the local conditions to be encountered during the execution of the Contract.

1.4 STANDARDS

Concerned Authority's Specifications for Backfilling & Earthworks (last Edition).

ASTM

- | | | |
|----------|---|-----------------------------------------------------------------------------------------------------------------------------|
| C 33-93 | : | Specification for Concrete Aggregates. |
| C 88-90 | : | Test Method for Soundness of Aggregates by use of Sodium or Magnesium Sulfate. |
| C 117-90 | : | Test Method for Material Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing. |
| C 131-89 | : | Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine. |
| D 421-80 | : | Dry Preparation of Soil Samples for Particle Size Analysis & |

Determination of Soil Constants.

D 1140-92	:	Amount of material in Soils Finer than 75 µ Sieve.
D 1006-90	:	Density of Soil in Place by the Sand-Cone Method.
D 1007-91	:	Compaction Characteristics of soil Using Modified Effort (2,250 kN-m/m ³).
D 1883-92	:	CBR of Laboratory Compacted Soils.
D 2992-91	:	Density of Soil and Soil-Aggregate in Place by Nuclear Methods. (Shallow Depth).
D 4318-93	:	Liquid & Plastic Limits & Plasticity Index of Soils.
BS		
BS 1377	:	Method of Test for Soils for Civil Engineering Purposes.
BS 812	:	Testing Aggregate.
RS 6031: 1981	:	Code of Practice for Earthworks.

1.5 SUBMITTALS

- A. General:** The Contractor shall submit following for approval:
1. Detailed sequence of work, description of construction methods, including erosion control measures. Formulated schedule and procedures to eliminate possibility of undermining or disturbing foundations of partially and completed structures, pipelines and existing structures and pipelines.
 2. Information on proposed compaction equipment at least two weeks prior to use. Compaction operations shall not be commenced until the equipment has been reviewed and approved by the Engineer / Project Manager.
 3. Details of dust control measures at least two weeks prior to start of any earth moving activities.
 4. Details of effective control measures against erosion and sedimentation, prior to start of earth moving activities.
 5. Locations of proposed borrow sources for screened gravel and selected borrow, at least two weeks prior to use of material.
 6. Laboratory test results every week or as required by the Engineer / Project Manager.
 7. Written verification of fill lift thickness and compaction weekly or as required by the Engineer/ Project Manager.
 8. Tamping tools adapted for the backfilling of retention system voids after its removal.
- B. Samples:** For but not limited to the following:
1. 1 kg samples sealed in airtight containers, of each proposed soil material from on-site or borrow sources.
 2. 300-by-300-mm sample of drainage fabric.
 3. 300-by-300-mm sample of separation fabric.
- C. Technical Data:** Submit for Engineer's review.
1. Catalogues of heavy equipment used for excavation and earth removal.
 2. Workshop drawings including plan of complete site showing any relocation of existing underground services.
- D. Excavation Supervisor:**
1. Allow for employing full time on site, an experienced and qualified excavation supervisor. Submit with the Tender, full resume details of the Supervisor.
 2. No excavation shall start until the Engineer has approved the nominated Supervisor.

1.6 QUALITY ASSURANCE

Testing Agency: Testing of all fill materials shall be carried out at the approved Laboratory, which is fully equipped to carry out the testing.

1.7 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Engineer and then only after arranging to provide temporary utility services according to requirements indicated:
1. Notify Engineer not less than two days in advance of proposed utility interruptions.
 2. Do not proceed with utility interruptions without Engineer's written permission.
 3. Contact utility-locator service for area where Project is located before excavating.
- B. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.
- C. Nature of Excavation:
1. Include for excavating in any type of ground encountered.
 2. Include for breaking up rock materials, materials so firmly cemented as to possess the characteristics of rock, concrete or masonry structures, or any other hard or compacted materials encountered in excavations, all at the Contractor's cost.

PART-2 PRODUCTS

2.1 MATERIAL

Backfill and imported fill material shall be any structurally sound material obtained either from excavations or other sources, approved by the Engineer. The material shall in general comprise non-plastic granular matter, well graded and free from organic or other perishable items and shall not contain an excess of fines.

In general and unless otherwise indicated or specified, material for backfill of structures, utilities, sidewalks, pavements,, trenches and excavations around structures, shall be crushed gravel, crushed stone, and natural , crushed sand, selected borrow or concrete and shall be used as directed by the Engineer / Project Manager.

The nature of the materials shall govern both their acceptability for backfill and methods best suited for their placement and compaction in backfill.

The contractor has to consider in his work the soil report issued by the soil laboratory, including all the studies and recommendations of the soil laboratory.

The following definitions of Earthwork materials shall apply:

- A. Suitable Material (non structural fill): shall comprise all material that is acceptable in accordance with the Contract for use in the Works. Suitable material for earthworks shall be approved soil obtained from excavations within the works or from borrow pits approved by the Engineer / Project Manager with the following characteristics:
1. Plasticity index shall not exceed 10% (BS 1377: Part 2, method 0).
 2. Liquid limit not exceed 40% (BS 1377: Part 2, method 0).
 3. shall not contain more than 0% of water soluble salts by weight of dry soil (BS 1377: Part 3, method 1).
 4. shall not contain fines more than 30% passing Nr 200 sieve (ASTM C 117) and more than 3% organic materials (BS 1377: Part 3).
 0. Maximum particle size shall not exceed 70 mm.
 6. shall not be susceptible to spontaneous combustion.
 7. shall not contain any other material which the Engineer may deem to be unsuitable for earthworks.

~~B. Engineered Fill (Structural Fill): Naturally or artificially graded mixture of natural or~~

crushed gravel, crushed stone, and natural or crushed sand; ASTM 2995, and shall be directed by the Engineer / Project Manager and shall be chosen from the following :

Grading similar to that shown below:

Sieve Size	Alternatives/ Percent Passing	
	A	B
0.075 mm (3/4 in.)	-	100
0.425 mm (16 in.)	100	70-100
0.850 mm (33 in.)	70-100	50-80
1.18 mm (46 in.)	60-90	50-80
1.75 mm (69 in.)	40-80	-
2.50 mm (98 in.)	40-70	40-70
4.75 mm (Nr 4)	30-70	30-70
7.5 mm (Nr 20)	20-40	20-50
14.75 mm (Nr 10)	8-20	10-30
30.0 mm (Nr 5)	0-10	0-10

Maximum particle size shall not exceed 75mm. Passing #20 sieve shall not exceed 20% and shall exhibit the following characteristics when tested as indicated.

Test	Standard	Limit
-Los Angeles Abrasion	ASTM C 131	40% max.
-Soundness (Na ₂ S ₂ O ₈ Solution)	ASTM C 88	12% max.
-Liquid Limit	ASTM D 4318	20% max.
-Plasticity Index	ASTM D 4318	7% max.
-Compaction test (Modified Proctor)	ASTM D 1557 (Method D)	-
-C.B.R. at 100% of modified Proctor density (96 hr soaked) for road sub base only	(ASTM D 1883)	80% min.
-Field density	ASTM D 1556/ D2922	90 %min.
-Sulphate Content	BS 1377 (part 3)	0.5%max.
-Chloride Content	BS 112 (Part 117)	1% max

Moisture content of the compacted material shall not vary more than $\pm 2\%$ of the optimum moisture content (OMC) and shall possess satisfactory binding characteristics to enable it to be compacted to give a smooth well knit surface as judged by the Engineer.

2.2 REQUIREMENTS AND TESTING

The following requirements, tests and frequencies shall be followed:

Density and OMC for each fill material as defined by ASTM D1557 Method D and determined in an approved laboratory shall be referenced to the Engineer/ Project Manager. The percentage of compaction shall be determined by the percent of maximum dry density at OMC in accordance with ASTM D 1557 Method D.

If some of the materials are larger than 75 mm the maximum density shall be corrected by the following formula:

$$D = \frac{(P_f D_f) / 100 + (P_c x .90 D_t) / 100}{100}$$

Where D = Corrected maximum dry density.

Pc = Percent of material retained on the 75 mm sieve.

Pf = Percent of material passing the 19 mm sieve.

Df = Maximum density of material passing 75 mm sieve.

Dt = Bulk specific gravity of material retained on 75 mm sieve multiplied by 1000 kg/m³.

The area of excavation and the length of trench open at anyone time shall be controlled according to the site conditions and subject to limits as directed by Engineer/ Project Manager.

Excavation support system (wood or steel sheeting, soldier piles and wood lagging) and bracing shall be cut off or left in place at elevations/locations determined and as directed by the Engineer/ Project Manager.

During progress of work, earth moving operations shall be conducted in such a manner so as to minimize the creation and dispersion of dust.

Suitable and safe ramps or other covered crossings where required shall be provided access to construction personnel and other users during construction, and shall be removed on completion.

When testing agency reports that sub grades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required, re-compact and retest until specified compaction is obtained.

A. Excavated material / selected Borrow (non structural fill)

1. Non Compacted

- Gradation Analysis - one test per 3,000 m³ of excavated on-site soil stockpiled for use as compacted on-site fill material and whenever classification of material is in doubt and/or as directed by Engineer.
- Liquid Limit and Plastic Limit and Plasticity Index - One test per 3,000 m³ of excavated on-site soil stockpiled for use as compacted on-site fill material and whenever classification of material is in doubt.
- Liquid Limit - 40%, Plastic Limit - 11 %
- Moisture Density - One per 3,000 m³ of soil placed and/or whenever visual inspection indicates a significant change in material gradation.

2. Compacted

- In-Place Density - Areas greater than 100 m²; one per 1000 m³ placed, or one per alternate lift, whichever results in a greater frequency. Minimum percentage compaction.
- Areas 100 m² or less; one per every half (1/2) meter of compacted fill.

B. Engineered Fill (Structural Backfill)

- Contractor's soils testing laboratory to provide sufficient inspection to ensure compaction of fill material and compaction equipment in use
- Gradation Analysis -
 - One test for each 1000 m³ placed.
 - One test whenever there is a change of gradation or placement conditions.
- Other test mentioned in item 2.1/B above –one for each 1000 m³.

2.3 TOLERANCES

1. Finished surfaces shall be constructed to ± 20 mm of the elevations indicated.
2. Cut and fill areas shall be graded to within ± 10 mm of the grades indicated.
3. The Engineer shall be provided with adequate survey information to verify compliance with above tolerances.
4. Moisture content of fill material shall be maintained within ± 2 % of optimum moisture content (OMC) as specified in the case of structural backfill.

2.4 WORKMANSHIP

Materials for backfilling shall comply with and be laid in accordance with BS 6031: 1981 Code of practice for earthworks.

Approved suitable excavated material as specified under "materials" shall be used on the backfilling and filling of structures, utilities, sidewalks, pavements, trenches and excavations around structures, etc and shall be laid in layers not exceeding the thickness as specify herein and compacted with approved compaction equipment or mechanical tampers. When not possible to use such compaction equipment, compaction shall be carried out as approved by the Engineer / Project Manager. A relative compaction of at least 90% of the Laboratory maximum dry density shall be achieved at optimum moisture content determined in accordance with Test 13 of BS 1377.

Each layer of backfill shall be inspected, tested and approved by the Engineers, prior to commencement of the next layer.

Should the quantity of excavated material be not sufficient for the process of backfill and fill, the Contractor shall obtain the quantity required for such backfill and fill from approved borrow pits and transport the same to the work site at his own expense.

No backfill shall be executed until the footings, foundations, etc have been inspected, measured and approved by the Engineer / Project Manager.

Trenches shall not be backfilled until all required tests are performed and until the Engineer/Project Manager has verified that the pipes and cables have been installed in accordance with the Specifications and the Drawings.

Unless otherwise stated in the Specification, selected fine dry material free from stones, organic matter, lumps and deleterious materials shall be carefully hand packed and tamped around the lower half of the pipes and against the sides of the trench, and for the full width of the trench in order to avoid displacement of the pipes. Filling shall then be continued to a height of 100 mm above the pipes and levelled across the trench from side to side with selected fine material which shall be hand packed and consolidated with wooden or other approved rammers.

Each layer shall then be well rammed and consolidated before the next layer is placed, until the trench is completely filled to the required levels. Power ramming shall be permitted on layers which are 300 mm above the crown of the pipes provided that all the lower layers have been hand rammed to a satisfactory level of compaction and tested in accordance with the requirements of this specification.

2.5 WOOD

Timber sheeting and lagging shall conform to the following:

1. Allowable working stress of not less than 48 Kg/cm².
2. Nominal thickness not be less than 76 mm (3 inches).

2.6 WATER

Water shall be clean potable water as specified under Division 3 Concrete Work.

2.7 CONCRETE

Concrete used as fill for making up to correct levels for areas of over-excavation and the like, shall be of blinding concrete grade as specified on structural drawings to the approval of the Engineer. It shall conform to all the requirements of Division 3- Concrete Works.

PART-3 EXECUTION

3.1 SITE PREPARATION

A. Concrete Excavation Permits

The Contractor shall be responsible for obtaining all permits relating to excavation works and shall bear all costs involved. The Contractor shall abide by all conditions, etc. laid down in such permits.

B. Clearing And Grubbing

The Contractor shall perform the clearing and grubbing (if any) of top soil consisting mainly of loose soil, vegetable and organic matters, drift sand, unsuitable soil and rubbish by scarifying the areas to be excavated and side-walks to a required depths from the natural ground level as directed by the Engineer.

The Contractor shall remove stumps and roots larger than 75 mm in diameter to a minimum depth of 300 mm and roots larger than 100 mm in diameter to a depth of 100 mm from existing ground surface or proposed finished grade, whichever is lower.

Cavities left below sub grade elevation by the removal of stumps or roots shall be carefully backfilled and the backfill material compacted. Stumps, roots, foreign matter, topsoil, and unsuitable earth shall be stripped from ground surface. Material from clearing and grubbing shall be promptly disposed, off site and shall not be reused or stockpiled. In doing so, all applicable laws, ordinances, rules and regulations shall be observed.

C. Setting-Out

The Contractor shall stake-out the work as shown on the Drawings and secure the Engineer/ Project Manager's approval of his stake-out before proceeding with construction. If, in the opinion of the Engineer, modification of the line or grade is advisable before or after stake-out the Engineer will issue detailed instructions in writing to the Contractor for such modification and the Contractor shall revise the stake-out for further approval in accordance with the relevant Clause of the Conditions of Contract.

3.2 EXCAVATION

A. General

The Contractor shall perform all excavations true to lines, widths and depths shown on the Drawings or to such further lines, depths or dimensions as may be directed by the Engineer to reach a suitable bearing strata.

B. Excavation In Rock

Rock shall be defined as boulders, exceeding 0.20 m³ in volume or any kind of stone or rock formation which in the opinion of the Engineer requires for its removal drilling and blasting, wedging, sledging or barring, or breaking up with a power-operated hand tool. The definition shall exclude any soft or disintegrated rock which can be removed with a hand pick or mechanical excavator or shovel, or loose, shaken or previously blasted rock or broken stone in rock fillings or elsewhere. Blasting by explosive not permitted.

C. Planking And Strutting / Shoring System

The terms "Planking and Strutting" will be deemed to cover underpinning, or any other method the Contractor elects to adopt for shoring the sides of excavation and also planking and strutting the excavation against the sides of adjoining buildings, public roadways, etc.,. The Contractor will be held responsible for shoring the sides of all excavations, adjoining and the like and no claim for additional excavation, concrete or other material and workmanship will be considered in this respect. The shoring system shall be carried out by competent specialist having a minimum 10 years experience.

In the event of any collapse occurring during the excavations, the Contractor shall re-excavate and re-instate such excavations at his own expense. No additional excavations

will be paid for should the Contractor batter the sides of the excavations.

D. Storing Of Suitable Excavated Material

During excavation, materials suitable for backfill and fill shall be stockpiled on the Site at sufficient distance from the sides of the excavation to avoid over-loading and prevent any cave-in or mixing with the concrete during the construction of foundations.

E. Disposal Of Unsuitable And Surplus Excavated Material

Upon the order of the Engineer / Project Manager, all unsuitable and surplus excavated materials shall be immediately removed, loaded and transported off Site area by the Contractor to dumps located by and approved by the local authorities concerned.

F. Excavation For Structures

Excavate to indicated elevations and dimensions within a tolerance of plus or minus 5 mm. Extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
2. Excavation for Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1/2 inch (12 mm). Do not disturb bottom of excavations intended for bearing surface.

G. Excavation For Foundations And Sub-Structures

The levels to which the Contractor shall excavate are shown on the Drawings. Should it be found necessary to reach more suitable strata, the Contractor shall perform all additional excavation as directed by the Engineer.

During excavation for foundations, the bottom layer of excavation of minimum 50 mm in thickness, shall be left undisturbed and subsequently removed manually only when the concrete blinding is about to be placed in order to avoid softening or deterioration of the surfaces of the excavation. Bottom of all excavations shall be formed to correct levels as shown on the Drawings or as directed in writing by the Engineer / Project Manager and shall be trimmed, levelled and well cleaned before pouring any concrete.

In the event of the Contractor excavating deeper than the levels shown on the Drawings he shall make up the difference between levels with blinding concrete of Grade indicated on Structural drawings, at his own expense. Should loose soil, bad ground or cavities be encountered within any part of the excavations the Contractor shall remove such matter and fill to the appropriate levels with hard-core or other approved fill material levelled and compacted to the Engineer / Project Manager's satisfaction.

After each excavation is complete, the Contractor shall notify the Engineer to that effect, and no concrete shall be placed until the Engineer / Project Manager has approved the excavation and the character of the foundation material.

H. Excavation For Walks And Pavements

Excavate surfaces under walks and pavements to indicated cross sections, elevations, and grades.

I. Excavation For Trenches

The Contractor shall excavate trenches and provide all planking and strutting necessary to install all drainage, sewer, water supply, electrical and telephone cables to the lines and grades complete in strict conformity with these specifications, applicable Drawings and/or as directed by the Engineer.

The bottom of the trenches shall be accurately graded to provide uniform bearing and support for each section of the pipe on undisturbed soil at every point along its length, except for the portions of the pipe where it is necessary to excavate for bell-holes and for proper sealing of joints. Bell-holes and depression for joints shall be dug after the trench

bottom has been graded.

Care shall be taken not to excavate below the depths indicated. Where rock is encountered, the rock shall be excavated to the required depth. Uneven surfaces of the bottom of trench shall be excavated 100 mm deeper. Such depth, if in rock, shall be backfilled with blinding concrete of grade specified under "concrete work" and when in earth, shall be backfilled with approved sand at the Contractor's own expense.

Whenever unstable soil, which in the opinion of the Engineer / Project Manager, is incapable of properly supporting the pipe or duct is encountered in the bottom of the trench, such soil shall be removed to the depth required and the trench backfilled to the proper grade with sand, fine gravel or other suitable material approved by the Engineer / Project Manager.

The width of the trench for Drainage at and below the top of the pipe shall be such that the clear space between the barrel of the pipe and the trench wall shall be 200 mm on each side of the pipe. The width of the trench above that level may be as wide as necessary for sheeting and bracing and the proper performance of the work.

Trenches for Water Supply System shall be of a depth to provide minimum cover to the top of the pipe of 900 mm and avoid interference of water lines with other utilities. Width of trench shall be a maximum of 200 mm on each side of the pipe.

The width of trench for electrical and telephone cables shall be as specified in their relative Section. Banks may be sloped or widened to facilitate placement of cables, but not to an extent that will cause interference with other utilities.

Excavation for manholes, septic tank, percolating pits and similar structures shall be sufficient to allow a minimum of 100 mm of clear space between their outer surfaces and shoring timbers which may be used to protect the banks.

J. Settlement

The Contractor shall be responsible for making good all settlement in the works that may occur up to the end of the maintenance period of the Contract, unless stated otherwise in the Specification.

K. Approval Of Sub-grade

1. Notify Engineer when excavations have reached required level.
2. If Engineer determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
3. Proof roll with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof roll wet or saturated soil.
4. Reconstruct soils damaged by, rain, accumulated water, or construction activities, as directed by Engineer.

3.3 BACKFILL

A. General

1. Place and compact backfill in excavations promptly, but not before completing the following:
 - a. Construction below finish grade including, where applicable, damp proofing, waterproofing, and perimeter insulation.
 - b. Surveying locations of underground utilities for record documents.
 - c. Inspecting and testing underground utilities.
 - d. Removing concrete formwork.
 - e. Removing trash and debris.
 - f. Removing temporary shoring and bracing, and sheeting.
 - g. Installing permanent or temporary horizontal bracing on horizontally supported walls.
2. Place backfill in layers not exceeding 200 mm.

B. Utility Trench Backfill

1. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
2. Backfill trenches excavated under footings and within 400 mm of bottom of footings; fill with concrete to elevation of bottom of footings.
3. Provide 100-mm thick, concrete-base slab support for piping or conduit less than 30 inches (762 mm) below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 100 mm of concrete before backfilling or placing roadway sub-base.
4. Place and compact initial backfill of sub-base material, free of particles larger than 75 mm, to a height of 12" (300 mm) over the utility pipe or conduit. Carefully compact material under pipe haunches and bring backfill evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.
5. The trench for pipes to a depth of 30 cm above the top of the pipe shall be backfilled by hand or by approved mechanical methods. Use special care in placing this portion of the backfill so as to avoid injuring or moving the pipe. The backfill material shall be placed in 10 cm layers and compacted by tamping.
6. From 30 cm above the pipe to the finished level the backfill shall consist of approved excavated material. Backfill under permanent pavement shall be placed in 10 cm layers and compacted by tamping. Power tampers of an effective type approved by the Engineer shall be used.
7. Coordinate backfilling with utilities testing.
8. Fill voids with approved backfill materials while shoring and bracing, and as sheeting is removed.
9. Place and compact final backfill of satisfactory soil material to final.
10. Install warning tape directly above utilities, 12" (300 mm) below finished grade, except 6" (150 mm) below under pavements and slabs or as directed by the Engineer.

C. Moisture Control

Uniformly moisten or aerate and each subsequent fill or backfill layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill material on surfaces that are muddy.
2. Remove and replace, or scarify and air-dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

D. Compaction of Backfills and Fills

1. Place backfill and fill materials in layers not more than 8 inches (200 mm) in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.
2. Place backfill and fill materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
3. Unless mentioned otherwise, compact soil to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:
 - a. Under structures, building Foundations, steps, and pavements, scarify and re-compact top 12 inches (300 mm) of existing and each layer of backfill or fill material at 90 percent.
 - b. Under all planting areas, scarify and re-compact top 6 inches (150 mm) below and compact each layer of backfill or fill material at 90 percent.

E. Grading

1. General: Uniformly grade areas to a smooth surface, free from irregular surface

changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated as per drawings.

- a. Provide a smooth transition between adjacent existing grades and new grades.
 - b. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
۲. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish s to required elevations within the following tolerances:
- a. Planting areas: Plus or minus ۲۰ mm.
 - b. Pavements: Plus or minus ۱۳ mm.

F. Base Courses

۱. Install separation fabric on prepared sub-grade according to manufacturer's written instructions, overlapping sides and ends.
۲. Under pavements and walks, place sub-base course on separation fabric according to fabric manufacturer's written instructions and as follows:
۳. Under pavements & walks, place sub-base course on prepared sub-grade as follows:
 - a. Place base course material over sub-base.
 - b. Compact sub-base and base courses at optimum moisture content to required grades, lines, cross sections, and thickness to not less than ۹۰ percent of maximum dry unit weight according to ASTM D ۱۵۰۷.
 - c. Shape sub-base & base to required crown elevations and cross-slope grades.
 - d. When thickness of compacted sub-base or base course is ۶ inches (۱۵۰ mm) or less, place materials in a single layer.
 - e. When thickness of compacted sub-base or base course exceeds ۶ inches (۱۵۰ mm), place materials in equal layers, with no layer more than ۶ inches (۱۵۰ mm) thick or less than ۳ inches (۷۵ mm) thick when compacted.
۴. Pavement Shoulders: Place shoulders along edges of sub-base and base course to prevent lateral movement. Construct shoulders, at least ۱۲ inches (۳۰۰ mm) wide, of satisfactory soil materials and compact simultaneously with each sub-base and base layer to not less than ۹۰ percent of max dry unit weight according to ASTM ۰ ۱۵۰۷.

G. Drainage Course

Under foundations, place drainage course on prepared sub-grade and as follows:

۱. Compact drainage course to required cross sections and thickness to not less than ۹۰ percent of maximum dry unit weight according to ASTM ۰ ۶۹۸.
۲. When compacted thickness of drainage course is ۶ inches (۱۵۰ mm) or less, place materials in a single layer.
۳. When compacted thickness of drainage course exceeds ۶ inches (۱۵۰ mm), place materials in equal layers, with no layer more than ۶ inches (۱۵۰ mm) thick or less than ۳ inches (۷۵ mm) thick when compacted.

۳.۴ TESTING FOR EARTHWORK

A. Inspection and Control of Material and Work

For verification of material, moisture content, compaction, thickness, etc. the Engineer/Project Manager shall at all times have access to all portions of the work, borrow pits, etc. All sampling and testing of material and work shall be carried out by the Contractor at his own responsibility and expense under the control and direction of the Engineer/Project Manager.

B. Sampling and Testing of Materials

Sampling shall be in accordance with the Standard Method of Sampling Soils for AASHTO Designation T^{۸۶}. Gradatop analysis shall be by Standard Method Test for Amount of Material Finer than No^{۲۰۰} sieve in aggregate, AASHTO Designation T^{۱۱} (ASTM Designation C^{۱۱۷}).

Liquid and plastic limits and plasticity index shall be ascertained by the Standard Method of Test, AASHTO Designation T⁹⁹ and ⁹⁰, (ASTM Designation ^{ε23} and ^{ε24}). Test for defining soil shrinkage shall be by Standard Method, AASHTO Designation T⁹³, and (ASTM Designation ^{1006-64T}). Specific gravity of soils shall be tested by Standard Method of Test AASHTO Designation T¹⁰⁰, (ASTM Designation ⁸⁰⁴).

Testing shall be by the Standard Method of Testing by Sand Replacement, AASHTO Designation T⁹⁹, (ASTM Designation ¹⁰⁰⁶) or by Rubber Balloon Method, ASTM Designation ²¹⁷⁷ as approved by the Engineer/ Project Manager.

The density and thickness of any compacted layer shall be ascertained by obtaining specimen from the soil after completing compaction in accordance with the AASHTO Specifications, at the rate as directed by the Engineer/ Project Manager. In case this specimen does not conform to the density & thickness, two other specimens will be tested. If any one of these specimens does not conform, the Contractor shall scarify, add new earth at his own expense, all in accordance with Specifications until the required result is obtained.

The Contractor shall also take all possible steps to ensure that such failure will not recur in future.

The Contractor shall allow in his daily work programmed enough time to permit the performance and checking of the above test, before he proceeds into any subsequent operations, all in accordance with the instructions of the Engineer/ Project Manager.

C. Testing Evenness of Surface

The Engineer/Project Manager shall test the evenness of the level and of other finished surfaces to ascertain their conformity to the Drawings and Specifications in respect to levels, cross falls, and evenness of surface.

- D. Requirements for evenness of surface:** The tolerances allowed for the finished sub-grade shall be between +0.00 cm and -0.00 cm from the levels shown on the drawings. These tests shall be made at any point requested by the Engineer/ Project Manager. In the event of any failure, correction of the surface shall be carried out to the satisfaction of the Engineer/ Project Manager.

3.5 SOIL COMPACTION WORK

A. General

The Contractor shall carry out the soil compaction specified for any external areas and under the foundations, after grading and levelling the surface to be compacted.

In areas to be filled, compaction shall include scarifying and the original surface, pulverizing, adding necessary soil, water, etc., and compacting the surface; all as Specifications and in accordance with the procedure outlined hereinafter.

B. Defining Optimum Moisture Content

The Contractor shall carry out necessary testing under the direction of the Engineer/ Project Manager to define the optimum moisture content for all types of soils, which he is required to compact, and he shall not be allowed to commence compaction except after determining and acquainting himself with such contents. These tests shall be in accordance with the Standard Method of Testing AASHTO Designation T¹⁸⁰⁻⁶¹ (ASTM Designation ^{1007-64T}).

Before compacting, soil samples will be taken and tested in order to establish the natural moisture content and if it is more than the optimum moisture content, the area of represented by this sample shall be specified, aerated until the moisture is less than 4% above the Optimum Content. Procedure of compaction shall thereafter continue.

C. Procedure for Compaction

The procedure outlined below shall not relieve the Contractor of his duties to determine the most suitable procedure all subject to the approval of the Engineer/ Project Manager.

After carrying out the grading, levelling, etc., of the soil layer to be compacted as per Specifications, the Contractor shall add the necessary amount of water in lots by means of vehicles equipped with special mechanical sprinklers, as indicated in the Specifications for the Main Machinery Utilized, to ensure control of water distribution so that water will spout out evenly and under adequate pressure to permeate the pulverized soil in the quantity required, all in accordance with instructions of the Engineer/ Project Manager.

The solid shall then be thoroughly turned over after adding each lot of water so as to achieve homogenous moisture content in the whole thickness of the layer.

When optimum moisture content is reached in pulverized soil according to laboratory testing, (field testing using "Speedy Moisture Device" or similar instrument giving direct readings for the field moisture content may be used for guidance only) or is not in excess of the optimum moisture content by more than 2.0%, the solid shall be primarily levelled by means of motor grades in order to commence earth compaction.

After primary levelling referred to above compaction shall be commenced by means of approved compactor depending on the type of soil being compacted in order to obtain the required density. The Contractor shall present to the Engineer/ Project Manager for approval a detailed constructional procedure outlining the method proposed by him for use prior to commencement of the Work. The Contractor's attention is drawn to the necessity of providing all machinery, equipment and attachments required for the effective and efficient shaping and compaction.

3.6 PROTECTION

- A.** Protecting Graded Areas: Protect newly graded areas from traffic and erosion. Keep free of trash and debris.
- B.** Repair and re-establish grades to specify tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace soil material to depth as directed by Engineer; reshape and re-compact.
- C.** Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to the greatest extent possible.