TENDER FOR CONSTRUCTION OF INTERNAL ROADS AND EARTHWORK FOR PROVIDING WATER BODIES WITHIN PROPOSED PERMANENT CAMPUS (as part of PHASE I) FOR

NALANDA UNIVERSITY, AT RAJGIR, BIHAR.

TECHNICAL SPECIFICATIONS

(ROAD WORK & EARTH WORK)

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TECHNICAL SPECIFICATIONS

SUB HEAD: 0.0

GENERAL

GENERAL

0.1 These Specifications shall apply to all such road and bridge works as are required to be executed under the Contract or otherwise directed by the Engineer-in-charge.

0.2 The work of CONSTRUCTION OF INTERNAL ROADS AND EARTHWORK FOR PROVIDING WATER BODIES WITHIN PROPOSED PERMANENT CAMPUS (as part of PHASE I) is the Detailed Items Specifications for Roads & Bridges Works Published by Indian Road Congress on behalf of Ministry of Road Transport and highways (MoRTH) with its latest revision.

0.3 The Items not covered under MoRTH specifications, will be executed as per relevant specifications of CPWD Civil Works Specifications Volume I & II (2009)

0.4 The specifications for NON Scheduled itmes not covered by MoRTH Specifications or CPWD Specifications for Civil works are given in this booklet.

0.5 In every case, the work shall be carried out to the satisfaction of the Engineer-in-Charge and conform to the location, lines, dimensions, grades and cross-sections shown on the drawings or as indicated by the Engineer-in-Charge. The quality of materials, processing of materials as may be needed at the site, salient features of the construction work and quality of finished work shall comply with the requirements set forth in succeeding sections. Where the drawings and Specifications describe a portion of the work in only general terms, and not in complete detail, it shall be understood that only the best general practice is to prevail, materials and workmanship of the best quality or to be employed and instructions of the Engineer-in-Charge are to be fully complied with.

0.6 Indian roads Congress Specifications and Recommended Codes of Practice have been used in the preparations of these specifications. The latest edition of all Specifications/Standards till 30 (thirty) days before the final date of submission of the tender, shall be adopted. Reference mentioned herein shall be applicable to all sections to the extent the context permits and are intended to supplement the provisions in the particular section. In case of any discrepancy/ deviation, the provisions in the particular section shall take precedence.

0.3 INTERPRETATIONS

0.3.1 The Tender authority through Engineer-in-Charge shall be the sole deciding authority as to the meaning, interpretation and implications for various provisions of the specifications. His decision in writing shall be final.

0.3.2 Wherever any reference is made to any Indian Standard, it shall be taken as reference to the latest edition with all amendments issued thereto. In the event of any variation between the detailed specifications and the Indian Standard, the former shall take precedence over the latter.

0.4 DEFINITIONS

The following terms and expressions in the specifications shall have the meaning or implication hereby assigned to them unless otherwise specified elsewhere.

0.4.1 ***Contractor:*** The Contractor shall mean the individual or firm or company whether incorporated or not, undertaking the works and shall include the legal personnel/ representatives of such individual or the persons composing such firm or company, or the successors of such individual or firm or company and the permitted assignees of such individual or firm of company.

0.4.2 ***Engineer-in-Charge:*** The 'Engineer-in-Charge' means and refer to the authorized Engineer Officer appointed by NU who shall supervise and be In-Charge of the work.

0.4.3 ***Site:*** The 'site' shall mean the land/ or other places on, in, into or through which the work is to be executed under the contract or any adjacent land, path or street through which the work is to be executed under the contract, or any adjacent land, path or street which may be allotted or used for the purpose of carrying out the contract.

0.4.4 ***Store:*** The 'store' shall mean the place of issue of materials.

0.4.5 ***IS:*** The standards, specification and code of practices issued by the Bureau of Indian Standards.

0.4.6 ***Best*****:** The word 'best' when used shall mean that in the opinion of the Tender Authority/ Engineer-in-Charge, there is no superior material/ article and workmanship obtainable in the market and trade respectively. As far as possible the standard required shall be specified in preference to the word 'best'.

0.5 LEVELS

0.5.1 Road Works

The work shall be carried out as per levels mentioned in detailed drawings and as per the Instructions of Engineer-in-Charge.

0.6 Sub Structure & Super structure

The work For Road works - all items up to subgrade, GSB, WBM etc. level shall be considered as Works in Sub Structure. The work of Paver Blocks, Krebs, Dense Bitumen Macadam, Dry lean concrete or Paver Quality Concrete for pavement topping shall be considered as work in super structure

0.5.1.3 For the calculation of Variation in Quantity as per GCC Clause 11 – Deviations/Variations and Pricing, these shall apply.

0.7 MEASUREMENTS

0.7.1 In booking dimensions, the order shall be consistent and in the sequence of length, width and height or depth or thickness.

0.7.2 Rounding off: Rounding off where required shall be done in accordance with IS: 2-1960. The number of significant places rounded in the rounded off value should be as specified.

0.7 MATERIALS

0.8.1 Samples of all materials to be used on the work shall be got approved by the contractor from the Engineer-in-Charge/Design consultant/Client well in time. The approved samples duly authenticated and sealed shall be kept in the custody of the Engineer-in-Charge till the completion of the work. All materials to be provided by the contractor shall be brand new and as per the samples approved by the Engineer-in-Charge.

0.8.2 Materials obtained by the contractor from the sources approved by the Client shall be subjected to the Mandatory tests. Where such materials do not conform to the relevant specifications, the matter shall be taken up by the Engineer-in-Charge for appropriate action against the defaulters. In all such cases, necessary documents in original and proof of payment relating to the procurement of materials shall be made available by the contractor to the Engineer-in-Charge.

0.8.3 Samples, whether submitted for approval to govern bulk supplies or required for testing before use and also the sample of materials bearing 'Standard mark,' if required for testing, shall be provided free of cost by the contractor. All other incidental expenditure to be incurred for testing of samples e.g. packaging, sealing transportation, loading, unloading etc. except testing charges shall be borne by the contractor.

0.8.4 The materials, supplied by the Client shall be deemed to be complying with the specifications.

0.8.5 Materials stored at site, depending upon the individual characteristics, shall be protected from atmospheric effects due to rain, sun, wind and moisture to avoid deterioration.

0.8.6 Materials like timber, paints etc. shall be stored in such a way that there may not be any possibility of fire hazards. Inflammable materials and explosives shall be stored in accordance with the relevant rules and regulations or as approved by Engineer-in-Charge in writing so as to ensure desired safety during storage.

0.8.7 The unit weight of materials unless otherwise specified shall be reckoned as given in IS: 1911-1967.

0.9 SAFETY IN CONSTRUCTION

0.9.1 The contractor shall employ only such methods of construction, tools and plant as are appropriate for the type of work or as approved by Engineer-in-Charge in writing.

0.9.2 The contractor shall take all precautions and measures to ensure safety of works and workman and shall be fully responsible for the same. Safety pertaining to construction works such as excavation, centering and shuttering, trenching, blasting, demolition, electric connections, scaffolds, ladders, working platforms, gangway, mixing of bituminous materials, electric and gas welding, use of hoisting and construction machinery shall be governed by relevant safety codes and the direction of Engineer-in-Charge

0.10 ABBREVIATIONS

The following abbreviations wherever they appear in the specifications, shall have the meaning or implication hereby assigned to them:

AASHTO		: American Association of State Highway and Transportation Officials
ASTM		: American Society for Testing and Material
BS		: British Standard published by the British Standards Institution
CBR	:	California Bearing Ratio
IRC	:	Indian Roads Congress
IS		: Indian Standard published by the Bureau of Indian Standards
Mm		Millimeter
Cm		Centimeter
M		Meter
Km		Kilometer
Mm^2/sqmm		Square
Millimeter Cm^2/sqcm		Square
centimeter Dm^2/sqdm		Square

decimeter M^2/sqm meter	Square
Cm^3/ cubic cm	Cubic centimeter
Dm^3/ cubic dm	Cubic decimeter
M^3/cum	Cubic meter
Ml	Milliliter
Kl	Kiloliter
Gm	Gram
Kg	Kilogram
Q	Quintal
T	Tonne
Fps system	Foot pound second system
°C	Degree Celsius temperature
Fig	Figure
Re/Rs	Rupee/ Rupees
No	Number
Dia	Diameter
AC	Asbestos cement
CI	Cast Iron
GC	Galvanized corrugated
GP	Galvanized plain
GI	Galvanized iron
PVC	Polyvinyl chloride
RCC	Reinforced cement concrete
SW	Stone ware
SWG	Standard wire Gauge

LIST OF BUREAU OF INDIAN STANDARD CODES

S. No.	***I. S. No.***	***Subject***
1	IS:2720	Method of test for Soils Parts (1 to 40).
2	IS:4988	Glossary of terms and classification of earth moving machinery(Parts 1, 2,
3	IS:10379	Code of Practice for Field Control of Soils.
4	IS:3764	Excavation Work – Code of Safety.
5	IS:8112	Grade 43 OPC
6	IS:12269	Grade 53 OPC
7	IS:383	Coarse and fine aggregates from natural sources for concrete
8	IS:456	Code of practice for plain and reinforced concrete
9	IS:516	Method of test for strength of concrete
10	IS:650	Standard sand for testing of cement
11	IS:1199	Method of sampling and analysis of concrete
12	IS:1834	Specification for hot applied sealing compound for joint in concrete
13	IS:1838	Specification for preformed fillers for expansion joints in concrete

14	IS-2386 (Part 1)	Methods of test for aggregates for concrete: Particle size and shape
15	IS-2386 (Part 2)	Methods of test for aggregates for concrete: Estimation of deleterious materials and organic impurities
16	IS-2386(Part 3)	Methods of test for aggregates for concrete: Specific gravity, Density, voids, absorption and bulking.
17	IS-2386(Part 4)	Methods of test for aggregates for concrete: Mechanical properties
18	IS-2386(Part 5)	Methods of test for aggregates for concrete: Soundness
19	IS-2386(Part 6)	Methods of test for aggregates for concrete: Measuring mortar
20	IS-2386(Part 7)	Methods of test for aggregates for concrete: Alkali aggregate
21	IS-2386(Part 8)	Methods of test for aggregates for concrete: Petrographic examination
22	IS 3025	Method of sampling and testing water
23	IS-3085	Method of test for permeability of cement mortar and concrete
24	IS-4082	Recommendation on staking and storage of construction materials at
25	IS-4926	Ready mixed concrete

CONSTRUCTION EQUIPMENT

In addition to the general conditions indicated in the contract Documents, the following conditions regarding use of equipment in works shall be satisfied.

(a) The Contractor shall be required to give a trial run of the equipment for establishing their capability to achieve the laid down Specifications and tolerance to the satisfaction of the Engineer-in-Charge before commencement of the work.

(b) All equipment provided shall be of proven efficiency and shall be operated and maintained at all times in a manner acceptable to the engineer-in-Charge.

(c) All the plant equipment to be deployed on the works shall be got approved from the Engineer-in-Charge for ensuring their fitness and efficiency before commencement of work.

(d) Any material or equipment not meeting the approval of the Engineer-in-Charge shall be removed from the site forthwith:

(e) No equipment will be removed from site without permission of the engineer-in-Charge;

(f) The Contractor shall also make available the equipment for site quality control work as directed by the Engineer-in-Charge.

Setting Out

1. The Contractor shall establish working Bench Marks tied with the Reference Bench Mark in the area soon after taking possession of the site. The Reference Bench Mark for the area shall be as indicated in the Contract Documents and the values of the same shall be obtained by the contractor from the Engineer-in-Charge. The working Bench Marks shall be at the rate of four per km and also at or near all drainage structures. Over-bridges and underpasses. The working Bench Marks/ levels should be got approved from the Engineer-in-Charge. Checks must be made on these Bench Marks once every month and adjustments, if any, got agreed with the Engineer-in-Charge and recorded. An up-to-date record of all Bench. Marks including approved

adjustments, if any, shall be maintained by the Contractor and also a copy supplied to the Engineer-in-Charge for his record.

2. The lines and levels of formation, side slopes, drainage works, carriageways and shoulders shall be carefully set out and frequently checked, care being taken to ensure that correct gradients and cross-sections are obtained everywhere.

3. In order to facilitate the setting out of the works, the centre lines of the carriageway or highway must accurately established by the Contractor and approved by the Engineer. It must then be accurately referenced in a manner satisfactory to the Engineer-in-Charge, every 50 m intervals in plain and rolling terrains and 20m intervals in hilly terrain and in all curve points as directed by the engineer-in-Charge, with marker pags and chainage boards set in or near the fence line, and a schedule of reference dimensions shall be prepared and supplied by the Contractor to the Engineer-in-Charge. The markers shall be maintained until the works reach finished formation level and are accepted by the Engineer-in-Charge.

4. On construction reaching the formation level stage, the centre line shall again in set out by the Contractor and when approved by the Engineer-in-Charge, shall be accurately referenced in a manner satisfactory to the Engineer-in-Charge by marker pegs set at the outer limits of the formation.

5. No reference peg or market shall be moved or withdrawn without the approval of the Engineer-in-Charge and no earthwork or structural work shall be commenced until the centre line has been referenced.

6. The contractor will be the sole responsible party for safe-guarding all survey monuments, bench marks, beacons, etc. The Engineer-in-Charge will provide the Contractor with the data necessary for setting out of the centre line. All dimensions and levels shown on the drawings or mentioned in documents forming part of or issued under the Contract shall be verified by the Contractor on the site and he shall immediately inform the Engineer-in-Charge of any apparent errors or discrepancies in such dimensions or levels. The Contractor shall, in connection with the staking out of the centre line, survey the terrain along the road and shall submit to the Engineer-in-Charge for his approval, a profile along the road centre line and cross-sections at intervals as required by the Engineer-in-Charge.

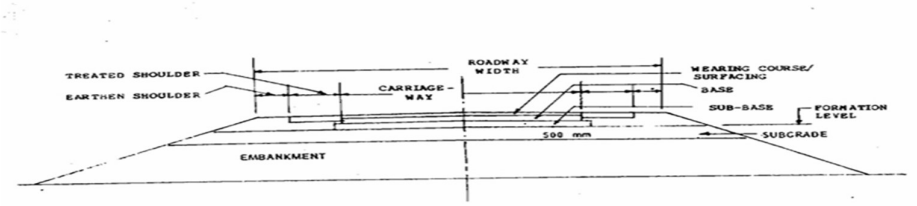
7. After obtaining approval of the Engineer-in-Charge, work on earthwork can commence and the profile and cross-sections shall form the basis for measurements and payment. The Contractor shall be responsible for ensuring that all the basis traverse points are in place at the commencements of the contract and if any are missing, or appear to have been disturbed, the Contractor shall make arrangements to re-establish these points. A "Survey File" containing the necessary data will be made available for this purpose. If in the opinion of the Engineer-in-Charge, design modifications of the centre line or grade are advisable, the Engineer-in-Charge will issue detailed instructions to the Contractor and the Contractor shall perform the modification in the field, as required, and modify the ground levels on the cross-sections accordingly as many times as required. There will be no separate payment for any survey work performed by the Contractor. The cost of these service shall be considered as being included in the cost of the items of work

in the Bill of Quantities.

8. The work of setting out shall be deemed to be a part of general works, preparatory to the execution of work and no separate payment shall be made for the same.

9. Precision automatic levels, having a standard deviation of ±2 mm per km, and fitted with micrometre attachment shall be used for all double run levelling work. Setting out of the road alignment and measurement of angles shall be done by using theodolite with traversing target, having an accuracy of one second. Measurement of distances shall be done preferably using precision instruments like Distomat.

Typical raod section for flexible pavement



Terms used in the specifications to describe road cross-section elements with a flexible pavement.

PRECAUTIONS FOR SAFEGUARDING THE ENVIRONMENT

1. General

The Contractor shall take all precautions for safeguarding the environment during the course of the construction of the works. He shall abide by all laws, rules and regulations in force governing pollution and environmental protection that are applicable in the area where the works are situated.

2. Borrow pits for Embankment Construction

Borrow pits shall not be dug in the right -of-way of the road. The stipulations in Clause 305.2.2. shall govern.

3. Quarry Operations

The Contractor shall obtain materials from quarries only after the consent of the Forest Department or other concerned authorities is obtained. The quarry operations shall be undertaken within the purview of the rules and regulations in force.

4. Control of Soil Erosion, Sedimentation and Water Pollution

The Contractor shall carry out the works in such a manner that soil erosion is fully controlled, and sedimentation and pollution of natural water courses, ponds, tanks and reservoirs is avoided. The stipulations in Clause 306 shall govern,

5. Pollution from Hot-Mix Plants and Batching Plants

Bituminous hot-mix plants and concrete batching plants shall be located sufficiently away from habitation, agricultural operations or industrial establishments. The Contractor shall take every precaution to reduce the levels of noise, vibration, dust and emissions from his plant and shall be fully responsible for any claims for damages caused to the owners of property, fields and residences in the vicinity.

6. Substances Hazardous to Health

The Contractor shall not use or generate any materials in the works which are hazardous to the health of persons, animals or vegetation. Where it is necessary to use some substances which can cause injury to the health of workers, the Contractor shall provide protective clothing or appliances to his workers.

7. Use of Nuclear Gauges

Nuclear gauges shail be used only where permitted by the Engineer-in-Charge. The Contractor shall provide the Engineer-in-Charge with a copy of the regulations governing the safe use of nuclear gauges he intends to employ and shall abide by such regulations.

8. The Contractor must take all reasonable steps to minimise dust nuisance during the construction of the works.

9. All existing highways and roads used by vehicle of the Contractor or any of his sub-contractors or suppliers of materials or plant, and similarly any new road* which are part of 'the works and which are being used by traffic, shall be kept clean and clear of all dust/mud or other extraneous materials dropped by the said vehicles or their tyres. Similarly, all dust/mud or other extraneous materials from the works spreading on these highways shall be immediately cleared by the Contractor.

10. Clearance shall be effected immediately by manual sweeping and removal of debris, or, if so directed by the Engineer-in-Charge, by mechanical sweeping and clearing equipment, and all dust, mud and other debris shall be removed entirely from the road surface. Additionally, if so directed by the Engineer-in-Charge, the road surface shall be hosed or watered using suitable equipment.

11. Any structural damage caused to the existing roads by the Contractor's construction equipment shall be made good without any extra cost.

12. Compliance with the foregoing will not relieve the Contractor of any responsibility for complying with the requirements of any Highway Authority in respect of the roads

used by him.

GENERAL RULES FOR THE MEASUREMENT OF WORKS FOR PAYMENT

1. General

All measurements shall be made in the metric system. Different items of work shall be measured in accordance with the procedures set forthin the relevant sections read in conjunction with the General Conditionsof Contract. The same shall not, however, apply in the case of lumpsum contracts.

All measurements and computations, unless otherwise indicated, shall be carried nearest to the following limits:

(i)	length and breadth	10 mm
(it)	height, depth or thickness of earthwork, sub grade, sub -bases, bases, surfacing and structural members	5 mm
(iii)	areas	0.01 sq. m.
(iv)	cubic contents	0.01 cu. m.

In recording dimensions of work, the sequence of length, width and height or depth or thickness shall be followed.

2. Measurement of Lead for Materials

Where lead is specified in the Contract for construction materials, the same shall be measured as described hereunder:

Lead shall be measured over the shortest practicable route and not the one actually taken and the decision of the Engineer-in-Charge in this regard shall be taken as final. Distances up to and including 100 m shall be measured in units of 50 m, exceeding 100 m but not exceeding km in units of 100 m and exceeding 1 km in units of 500 m, the half and greater than half of the unit shall be reckoned as one and less than half of the unit ignored. In this regard, the source of the material shall be divided into suitable blocks and for each block, the distance from the centre of the block to the centre of placing pertaining to that block shall be taken as the lead distance.

3. Measurement of Pavement Thickness for Payment on Volume Basis

The finished thickness of sub-base, base and bituminous courses to be paid on volume basis shall be computed in the following manner: Levels shall be taken before and after construction, at grid of points 10 m centre to centre longitudinally in straight reaches but 5 m at curves. Normally, on two -lane roads, the levels shall be taken at four positions transversely, at 0.75 and 2.75 m from either edge of the carriageway; and on single lane roads, these shall be taken at two positions transversely, being at 1.25 m from either edge of the carriageway. For multi-lane roads, levels shall be taken at two positions transversely for each lone at locations specified by the Engineer-in-Charge.

Suitable references for the transverse grid lines should be left in the form of embedded bricks on either ends or by other means so that it is possible to locate the grid points for level measurements after each successive course is laid.

For pavement courses laid only over widening portions, at least one line of levels shall be taken on each strip of widening, or more depending on the width of widening as decided by the Engineer-in-Charge,

Notwithstanding the above, the measurements may be taken at closer intervals also, if so desired by the Engineer-in-Charge, the need for which may arise particularly in the case of estimation of the volume of the material for profile corrective course (levelling course). The average thickness of the pavement course in any area shall be the arithmetic mean of the difference of levels before and after construction at all the grid points falling in that area, provided that the thickness of finished work shall be limited to those shown on the drawings or approved by the Engineer-in-Charge in writing.

As supplement to level measurements, the Engineer-in-Charge shall have the option to take cores/make holes to check the depth of construction. The holes made and the portions cut for taking cores shall be made good by the Contractor by laying fresh mix/material including compacting as required at no extra cost immediately after the measurements are recorded.

4. Checking of Pavement Thickness for Payment on Area Basis

Where payment for any bituminous course in Section 500 is allowed to be made on area basis, the Engineer-in-Charge may have its thickness checked with the help of a suitable penetration gauge at regular intervals or other means as he may decide.

5. Measurement of Bituminous Courses for Payment on Weight Basis

Plant-mixed bituminous materials for pavement courses where designated to be paid on weight basis shall be weighed on accurate scales approved by the Engineer-in-Charge. Approved scales shall mean scales that are of size, capacity, kind and type suitable for the weighing to be done, and these shall be properly and adequately installed and maintained. Prior to the use of the scales and as frequently thereafter as the Engineer-in-Charge may deem necessary to ensure accuracy, the scales shall be checked and approved by the Engineer-in-Charge, or the Engineer-in-Charge may direct the Contractor to have the scales checked by other competent agency at the cost of the Contractor.

Location of the scales shall be as designated by the .Engineer-in-Charge, Trucks used for hauling the material to be weighed shall be weighed empty daily at such times as the Engineer-in-Charge directs, and each truck shall bear a plainly legible identification mark.

For materials specified to be measured by weight, the Engineer-in-Charge will have the option to make measurements of the finished work by volume in accordance with Clause 3 (above)and such volumes shall be converted into weight for payment

purposes. The factor for conversion from volume measurement to weight measurement shall be computed from the representative density of the compacted material at site determined at locations approved by the Engineer-in-Charge,

FIELD LABORATORY

1. Scope

The work covers the provision and maintenance of an adequately equipped field laboratory as required for site control on the quality of materials and the works.

2. Description

The Contractor shall arrange to provide fully furnished and adequately equipped field laboratory constructed as shown in drawings. The field laboratory shall preferably be located adjacent to the site office of the Engineer-in-Charge and provided with amenities like water supply, electric supply etc. The Laboratory shall be provided with all equipment required for testing of materials as may be necessary as per the detailed specifications.

SUPPLY OF COLOUR RECORD PHOTOGRAPHS AND ALBUMS

1. Scope

The work covers the supply of photographs, negatives and albums to serve as a permanent record of various stages/facets of the work needed for an authentic documentation as approved by the Engineer-in-Charge.

125.2. Description

The Contractor shall arrange at his cost, to take colour photographs at various stages/facets of the work including interesting and novel features of the work as desired by the Engineer-in-Charge. The photographs shall be of acceptable quality and they shall be taken by a professionally competent photographer with camera having the facility to record the date of photographs taken in the prints and negative. The Contractor shall supply two colour prints of each of the photographs taken to the standard cabinet size mounted in albums of acceptable quality. Also the soft copy in digital form shall be supplied for each photograph. Each photograph in the album shall be suitably captioned.

CARRIAGE OF MATERIALS

As per CPWD Specifications for Civil works

01 CARRIAGE OF MATERIALS

01.0 GENERAL

The carriage and stacking of materials shall be done as directed by the Engineer-in-Charge. Any tools and plants, required for the work shall be arranged by the Contractor. The carriage of materials includes loading anywhere within site or within a lead of 50 meters outside the site, unloading and stacking anywhere within site and within a lead of 50 meters outside the site.

01.1 RESPONSIBILITY FOR LOSS OR DAMAGE

Loading, carriage, unloading and stacking shall be done carefully to avoid loss or damage to the materials. In case of any loss or damage, recovery shall be affected from the Contractor at twice the Client issue rates of the materials. If the Client issue rates of the materials are not available then the recovery shall be affected at twice the prevailing market rates as determined by the Engineer-in-Charge.

01.2 MODE OF CARRIAGE

Depending upon the feasibility and economy, the Engineer-in-Charge shall determine the mode of carriage viz. whether by mechanical or animal transport or manual labor.

01.3 LEAD

01.3.1 All distances shall be measured over the shortest practical route and not necessarily the route actually taken. *Route other than shortest practical route may be considered in cases of unavoidable circumstances and as approved by Engineer-in-Charge along with reasons in writing.*

01.3.2 Carriage by manual labor shall be reckoned in units of 50 meters or part thereof.

01.3.3 Carriage by animal and mechanical transport shall be reckoned in one km unit. Distances of 0.5 km or more shall be taken as 1 km and distance of less than 0.5 km shall be ignored. However, when the total lead is less than 0.5 km, it will not be ignored but paid for separately in successive stages of 50 meters subject to the condition that the rate worked on this basis does not exceed the rate for initial lead of 1 km by mechanical/ animal transport.

01.4 GENERAL CONSIDERATION FOR STACKING AND STORAGE

01.4.1 Planning of Storage Layout

For any site, there should be proper planning of the layout for stacking and storage of different materials, components and equipment's with proper access and proper maneuverability of the vehicles carrying the material. While planning the layout, the requirements of various materials, components and equipment's at different stages of construction shall be considered. The storage & stacking check list is given in Table. For further details refer IS- 4082.

01.4.2 Material shall be stored in such a manner as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work.

01.5 PROTECTION AGAINST ATMOSPHERIC AGENCIES

Materials stored at site, depending upon the individual characteristics, shall be protected from atmospheric actions, such as rain, sun, winds and moisture to avoid deterioration.

01.6 PROTECTION AGAINST FIRE AND OTHER HAZARDS

01.6.1 Materials like timber, coal, paints, etc. shall be stored in such a way that there may not be any possibility of fire hazards. Inflammable materials like kerosene and petrol shall be stored in accordance with the relevant rules and regulations so as to ensure the desired safety during storage. Stacks shall not be piled so high as to make them unstable under fire fighting conditions and in general they shall not be more than 4.5 m in height. The provisions given in IS 13416 (part 5) shall be followed.

EARTH WORK

LIST OF BUREAU OF INDIAN STANDARD CODES

S. No.	*I.S. No.*	*Subject*
1	IS 632	Gamma – BHC (Lindane) emulsifiable concentrates
2	IS 1200 (Pt 1)	Method of measurement of earth work
3	IS 1200 (Pt-27)	Method of measurement of earth work (by Mechanical Appliances)
4	IS 4988 (Part IV)	Excavators
5	IS 12138	Earth moving Equipment's

201. CLEARING AND GRABBING – As per MoRTH

GENERAL SPECIFICATIONS OF EARTHWORK

301. EXCAVATION FOR ROADWAY AND DRAINS - As per MoRTH

305. EMBANKMENT CONSTRUCTION As per MoRTH

311. WORKS TO BE KEPT FREE OF WATER

311.1. The Contractor shall arrange for the rapid dispersal of water collected/accumulated on the earthwork or completed formation during construction or on the existing roadway or which enters the earthwork or any other item of work from any source, and where practicable, the water shall be discharged into the permanent outfall of the drainage system. The arrangements shall be made in respect of all earthwork including excavation for pipe trenches, foundations or cuttings.

311.2. The Contractor shall provide, where - necessary, temporary water courses, ditches, drains, pumping or other means for maintaining the earthwork free from water. Such provisions shall include carrying out the work of forming the cut sections and embankments in such manner that their surfaces have at all times a sufficient minimum
crossfall and, where practicable, a sufficient longitudinal gradient to enable them to shed water and prevent ponding.

The works involved in keeping the earthwork or any other item of works free of water shall be deemed as incidental to the respective item of work and as such no separate payment shall be made for the same.

Item no. 2.08: Sand filling in foundation trenches, in embankment, under floor as per drawing and technical Specification

SAND FILLING IN PLINTH As per CPWD Specifications

1.0 Sand

Sand from Local River shall be clean and free from dust organic and foreign matter and its grading shall be within the limits of grading zone IV or V**.**

2.0 Filling

Sand filling shall be done in a manner similar to earth filling in plinth specified above except that consolidation shall be done by flooding with water. The surface of the consolidated sand filling shall be dressed to the required level or slope and shall not be covered till the Engineer-in-Charge has inspected and approved the sand filling.

3.0 Measurements

The length, breadth and depth of consolidated sand shall be measured with steel tape correct to the nearest cm and cubical contents worked out in cubic meters correct to two places of decimal.

4.0 Rates

The rates include the cost of material and labour involved in all the operations described above in general specifications of earthwork.

As per CPWD Specifications - Item no. 2.09 : Cutting of Trees, including Cutting of Trunks, Branches and Removal (Cutting of trees, including cutting of trunks, branches and removal of stumps, roots, stacking of serviceable material with all lifts and up to a lead of 1000 mtrs and earth filling in the depression/pit.)

(a) : Beyond 30 cm girth upto and including 60 cm girth

Item No. 2.10: (b) : Beyond 60 cm girth up to and including 90 cm girth

Item No. 2.11: (c) : Beyond 90 cm girth up to and including 180 cm girth

Item No. 2.12 :(d) : Above 180 cm girth

1 Felling of trees

While clearing jungle, growth trees above 30 cm girth (measured at a height of one meter above ground level) to be cut, shall be approved by the Engineer-in-Charge and then marked at site. Felling trees shall include taking out roots up to 60 cm below ground level or 30 cm below formation level or 15 cm below sub-grade level, whichever is lower.

All excavation below general ground level arising out of the removal of trees, stumps etc. shall be filled with suitable material in 20 cm layers and compacted thoroughly so that the surfaces at these points conform to the surrounding area.

The trunks and branches of trees shall be cleared of limbs and tops and cut into suitable pieces as directed by the Engineer-in-Charge.

2 Stacking and Disposal: Wood, branches, twigs of trees and other useful material shall be the property of the Government. The serviceable materials shall be stacked in the manner as directed by the Engineer-in-Charge up to any distance. All unserviceable material, which in the opinion of Engineer-in-Charge cannot be used or auctioned shall be removed from the area and disposed of as per the directions of the Engineer-in-Charge. Care shall be taken to see that unsuitable waste materials are disposed of in such a manner that there is no likelihood of these getting mixed up with the materials meant for construction.

3 Measurements

Cutting of trees above 30 cm in girth (measured at a height of one meter above level) shall be measured in numbers according to the sizes given below:

(a) Beyond 30 cm girth, up to and including 60cm girth.
(b) Beyond 60 cm girth, up to and including 90 cm girth.
(c) Beyond 90 cm girth, up to and including 180 cm girth.
(d) Above 180 cm girth.

1000. Specifications of Materials (AS per MoRTH)

1500. Formwork (As per MoRTH)

1700. Specifications for Concrete Works (As per MoRTH)

ROAD WORKS

Item No. 5.02: Providing and laying Pitching on slopes laid over prepared filter media including boulder apron laid dry in front of toe of embankment complete as per drawing and Technical specifications.

2504. PITCHING / REVETMENT ON SLOPES As per MoRTH

2504.2.2. Filter media As per MoRTH

Item No. 4.03. Granular Sub-base with Close Graded Material (Table: - 400-1)Plant Mix Method (Construction of granular sub-base by providing close graded Material, mixing in a mechanical mix plant at OMC, carriage of mixed Material to work site, spreading in uniform layers with motor

grader on prepared surface and compacting with vibratory power roller to achieve the desired density, complete as per clause 401)

401. GRANULAR SUB-BASE As per MoRTH

Item No. 5.04: Wet Mix Macadam : Providing laying, spreading and compacting graded stone aggregate to wet mix macadam specifications including premixing the materials with water at OMC, in mechanical mix plant carriage of mix material by tipper to site, laying in uniform layer with paver in sub base/base course on well prepared surface and compacting with vibratory roller to achieve desired density as per relevant MoRTH clause 406

406. WET MIX MACADAM SUB -BASE/BASE As per MoRTH

Item No. 4.04: Prime coat (Providing and applying primer coat with bitumen emulsion on prepared surface of granular Base including clearing of road surface and spraying primer at the rate of 0.60 kg/sqm using mechanical means.)work as approved by the Engineer-in-Charge,

502. PRIME COAT OVER GRANULAR BASE As per MoRTH

501. GENERAL REQUIREMENTS FOR BITUMINOUS PAVEMENT LAYERS As per MoRTH

503. TACK COAT As per MoRTH

. **Item No. 5.07: Dense Graded Bituminous Macadam (Providing and laying dense graded bituminous macadam with 100-120 TPH batch type HMP / DMP 60-90 TPH capacity / 80 - 100 TPH Capacity using crushed aggregates of specified grading, premixed with bituminous binder @ 4.0 to 4.5 per cent by weight of total mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MoRTH specification clause No. 507 complete in all respects.)**

507. DENSE GRADED BITUMINOUS MACADAM (As per MoRTH)

2706. WEEP HOLE (as per MoRTH)

Specifications for Market Rate Items

MR Item No. 1.01 602.5. Separation Membrane – As per MoRTH
A separation membrane shall be used between the concrete slab and the subbase. Separation membrane shall be impermeable plastic/ Ploethelen sheeting 125 microns thick laid flat without creases. Before placing the separation membrane, the sub-base shall be swept clean of all the extraneous materials using air compressor. Wherever overlap of plastic sheets is necessary, the same shall be at least 300 mm and any damaged sheeting shall be replaced at the Contractor's expense. The separation membrane may be nailed to the lower layer with concrete nails As per CPWD Specifications of Civil works.

MR Item No. 1.03: Steel reinforcement for R.C.C. work including straightening, cutting, bending, placing in position and binding all complete up to plinth level. Thermo-Mechanically Treated bars TMT 500 D

1 General Requirements
The general requirements of Item No. 5.22 should be as mentioned above in 5.3.1 of general specifications of Reinforced Cement Concrete Works.

2 Welding of Bars
The Welding of bars should be as mentioned above in 5.3.2 of general specifications of Reinforced Cement Concrete Works.

3 Placing in Position
The Positioning of steel should be as mentioned above in 5.3.3 of general specifications of Reinforced Cement Concrete Works.

4 Measurement
The measurements should be as mentioned above in 5.3.4 of general specifications of Reinforced Cement Concrete Works.

5 Rate
The rates should be as mentioned above in 5.3.5 of general specifications of Reinforced Cement Concrete Works.

As per CPWD Specifications of Civil works.

MR Item No. 1.04: Steel reinforcement for R.C.C. work including straightening, cutting, bending, placing in position and binding all complete above plinth level. Thermo-Mechanically Treated bars TMT 500 D

The relevant specifications should be as per mentioned in above Item except that the rate shall be paid separately for work above plinth level.

As per CPWD Specifications for Civil Works

MR Item Sr. No. 1.05: Providing and laying Non Pressure NP-2 class (Light duty) R.C.C. pipes including collars/spigot jointed with stiff mixture of cement mortar in the proportion of 1:2 (1 cement : 2 fine sand) including testing of joints etc. complete

(a) 250 mm dia Hume Pipe

MR Item Sr. No. 1.06: Providing and laying Non Pressure NP-2 class (Light duty) R.C.C. pipes including collars/spigot jointed with stiff mixture of cement mortar in the proportion of 1:2 (1 cement : 2 fine sand) including testing of joints etc. complete

(a) 300 mm dia RCC Hume Pipe

Applicable specification for this item:

This item shall be executed as per CPWD Specification (Vol.2) Section 19 Clause 19.6.3 & 19.6.4 and shall be measured and paid in Rmt.

19.6 Cement Concrete Pipes (with and without Reinforcement) (Light Duty, Non-Pressure)

The pipes shall be with or without reinforcement as required and shall be of class not lesser than NP2. These shall conform to IS 458 and shall be capable of withstanding a test pressure of 0.07 MPa (7 m head). The reinforced cement concrete pipes shall be manufactured by centrifugal (or spun) process while un-reinforced cement concrete pipes by spun or pressure process. All pipes shall be true to shape, straight, perfectly sound and free from cracks and flaws. The external and internal surface of

the pipes shall be smooth and hard. The pipes shall be free from defects resulting from imperfect grading of the aggregate mixing or molding.

Concrete used for the manufacture of un-reinforced and reinforced concrete pipes and collars shall not be leaner than 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate). The maximum size of aggregate should not exceed one third of the thickness of the pipe or 20 mm whichever is smaller for pipes above 250 mm internal diameter. But for pipes of internal diameter 80 to 250 mm, the maximum size of aggregate should be 10mm. The reinforcement in the reinforced concrete pipes shall extend throughout the length of the pipe. The circumferential and longitudinal reinforcements shall be adequate to withstand the specified hydrostatic pressure and further bending stresses due to the weight of water when running full across a span equal to the length of pipe plus three times its own weight.

19.2.2.1 *Laying and Jointing Cement Concrete Pipes and Specials*

(i) ***Trenches:*** Trenches shall be as described in 18.4.4. Where the pipes are to be bedded directly on soil, the bed shall be suitably rounded to fit the lower part of the pipe, the cost for this operation being included in the rate for laying the pipe itself.

(ii) Loading, transporting and unloading of concrete pipes shall be done with care. Handling shall be such as to avoid impact. Gradual unloading by inclined plane or by chain pulley block is recommended. All pipe sections and connections shall be inspected carefully before being laid. Broken or defective pipes or connections shall not be used. Pipes shall be lowered into the trenches carefully. Mechanical appliances may be used. Pipes shall be laid true to line and grade as specified. Laying of pipes shall proceed upgrade of a slope.

(iii) If the pipes have spigot and socket joints, the socket ends shall face upstream. In the case of pipes with joints to be made with loose collars, the collars shall be slipped on before the next pipe is laid. Adequate and proper expansion joints shall be provided where directed.

(iv) In case where foundation conditions are unusual such as in the proximity of trees or holes, under existing or proposed tracks manholes etc. the pipe shall be encased all-around in 15 cm thick cement concrete 1:5:10 (1 cement : 5 fine sand : 10 graded stone aggregate 40 mm nominal size) or compacted sand or gravel.

(v) In cases where the natural foundation is inadequate the pipes shall be laid either in concrete cradle supported on proper foundations or on any other suitably designed

structure. If a concrete cradle bedding is used the depth of concrete below the bottom of the pipe shall be at least 1/4th of the internal dia of the pipe subject to the min. of 10 cm and a maximum of 30 cm. The concrete shall extend up the sides of the pipe at least to a distance of 1/4th of the outside diameter of pipes 300 mm and over in dia. The pipe shall be laid in this concrete bedding before the concrete has set. Pipes laid in trenches in earth shall be bedded evenly and firmly and as far up the haunches of the pipe as to safely transmit the load expected from the backfill through the pipe to the bed. This shall be done either by excavating the bottom of the trench to fit the curve of the pipe or by compacting the earth under around the curve of the pipe to form an even bed. Necessary provision shall be made for joints wherever required.

(vi) When the pipe is laid in a trench in rock hard clay, shale or other hard material the space below the pipe shall be excavated and replaced with an equalizing bed of concrete, sand or compacted earth. In no place shall pipe be laid directly on such hard material.

(viii) When the pipes are laid completely above the ground the foundations shall be made even and sufficiently compacted to support the pipe line without any material settlement. Alternatively the pipe line shall be supported on rigid foundations at intervals. Suitable arrangements shall be made to retain the pipe line in the proper alignment, such as by shaping the top of the supports to fit the lower part of the pipe. The distance between the supports shall in no case exceed the length of the pipe. The pipe shall be supported as far as possible close to the joints. In no case shall the joints come in the center of the span. Care shall be taken to see that super imposed loads greater than the total load equivalent to the weight of the pipe when running full shall not be permitted. Suitably designed anchor blocks at change of direction and grades for pressure lines shall be provided where required.

(ix) ***Jointing:*** Joints are generally of rigid type. Where specified flexible type joints may also be provided.

(a) *Rigid Spigot and Socket Joint:* The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. The opening of the joint shall be filled with stiff mixture of cement mortar in the proportion of 1:2 (1 cement: 2 fine sand) which shall be rammed with caulking tool. After a day's work any extraneous material shall be removed from the inside of the pipe and the newly made joint shall be cured.

(b) *Rigid Collar Joint:* The two adjoining pipes shall be butted against each other and adjusted in correct position. The collar shall then be slipped over the joint, covering equally both the pipes. The annular space shall be filled with stiff mixture of cement mortar 1:2 (1 cement: 2 fine sand) which shall be rammed with caulking fool. After a day's work any extraneous materials shall be removed from the inside of the pipe and the newly made joint shall be cured.

(c) *Semi Flexible Spigot and Socket Joint:* The joint is composed of specially shaped spigot and socket ends on the concrete pipes. A rubber ring shall be placed on the spigot which shall be forced into the socket of the pipe previously laid. This compresses the rubber ring as it rolls into the annular space formed between the two surfaces of the spigot and the socket, stiff mixture of cement mortar 1:2 (1 cement: 2 fine sand) shall then be filled into the remaining annular space and rammed with a caulking tool. After day's work any extraneous materials shall be removed from the inside of the pipe and the newly made joint shall be cured.

(d) *Semi Flexible Collar Joint:* This is made up of a loose collar which covers two specially shaped pipe ends. Each end shall be fitted with a rubber ring which when compressed between the spigot and the collar, seal the joint. Stiff mixture of cement mortar 1:2 (1 cement: 2 fine sand), shall then be filled into the remaining annular space and rammed with a caulking tool. After day's work, any extraneous material shall be removed from the inside of the pipe and the newly made joint shall be cured.

(e) *Internal Flush Joint:* This joint is generally used for culvert pipe of 60 cm dia and over. The ends of the pipe are specially shaped to form a self-centering joint with an internal jointing space 1.3 cm wide the finished joint is flush with both inside and outside with the pipe wall. The jointing space is filled with cement mortar 1:2 (1 cement: 2 fine sand) mixed sufficiently dry to remain in position when forced with a trowel or rammer. After day's work, any extraneous material shall be removed from the inside of the pipe and the newly made joint shall be cured.

(f) *External Flush Joint:* This joint is suitable for pipes which are too small for jointing from inside. This joint is composed of specially shaped pipe ends. Each end shall be butted against each other and adjusted in correct position. The jointing space shall then be filled with cement mortar 1:2 (1 cement: 2 fine sand) sufficiently dry and finished off flush. Great care shall be taken to ensure that the projecting ends are not damaged as no repairs can be readily affected from inside the pipe.

(x) In all pressure pipe lines the recess at the end of the pipe line shall be filled with jute braiding dipped in hot bitumen or other suitable approved compound. Pipes shall be so jointed that the bitumen ring of one pipe shall set into the recess of the next pipe. The ring shall be thoroughly compressed by jacking or by any other suitable method.

The number of pipes that shall be jacked together at a time shall depend on the diameter of the pipes and the bearing capacity of the soil, for small pipes up to 25 cm diameter, six pipes can be jacked together at a time.

The quantity of jute and bitumen in the ring shall be just sufficient to fill the recess in the pipe when pressed hard by jacking or by any other suitable method. Before and during jacking care shall be taken to see that there is no offset at the joint.

(xi) *Testing:* For pressure pipes, the completed pipeline shall be tested for pressure (Known as site test pressure) which shall not be less than the maximum pipeline operating pressure plus the calculated surge pressure, but in no case shall it exceed the hydrostatic test pressure. For non-pressure pipes the joints shall be tested as per procedure laid down under Para 19.2.1.2 (iv) of CPWD Specifications.

(xii) *Refilling of Trenches:* The specification described in 19.2.1.2 (v) of CPWD shall apply. In case where pipes are not bedded on concrete special care shall be taken in refilling, trenches to prevent the displacement and subsequent settlement at the surface resulting in uneven street surfaces and dangers to foundations etc. The backfilling materials shall be packed by hand under and around the pipe and rammed with a shovel and light tamper. This method of filling will be continued up to the top of pipe. The refilling shall rise evenly on both sides of the pipe and continued up to 60 cm above the top of pipe so as not to disturb the pipe. No tamping shall be done within 15 cm of the top of pipe. The tamping shall become progressively heavier as the depth of the backfill increases.

(xiii) *Measurements :* The lengths of pipes shall be measured in running meters nearest to a cm as laid or fixed, from inside of one manhole to the inside of the other manhole. The length shall be taken along the center line of the pipes over all fittings such as bends, collars, junctions, etc. which shall not be measured separately. Excavation, refilling, shoring and timbering in trenches, and cement concreting wherever required shall be measured separately under relevant items of work.

(xiv) *Rate:* The rate shall include the cost of materials and labour involved in all the

operations described above.

Item Sr. No. 1.07: Supplying and Filling the approved good quality earth brought from outside the premises in layers not exceeding 20 cm in depth, breaking clods, watering, rolling No layer with 1/2 tonne roller, or wooden or steel rammers, and rolling every 3rd and top-most layer with power roller of minimum 8 tonnes and dressing up including all lead and lift. Consolidation of Earth to be achieved up to 95% proctor Density of Earth. The mode of measurement will be made on the consolidated volume.

1 This shall comprise Supplying and Filling approved earth brought from outside in trenches, plinth, sides of foundations etc. in layers not exceeding 20cm in depth, consolidating each deposited layer by ramming and watering,

2 Filling shall be done as specified in item no 4 of general specifications of earthwork.

3 Measurements shall be done as specified in item no 4 of general specifications of earthwork.

4 Rates shall be as specified in specifications of filling under earthwork head except the rate of supplying of approved earth shall be included.

Item No. 1.08: Transporting surplus excavated unusable stuff/earth from the site of work including loading, unloading, etc. outside campus premises for all lead and lift.

Workmanship

The surplus excavated unusable stuff/earth shall be disposed of as and when directed by the Engineer-in-Charge-in-charge or the Architect, outside the campus premises. The site to which the excavated earth should be disposed off shall be specified by the Engineer-in-charge. The disposal of the stuff includes loading the earth in vehicle, conveyance to the specified site, unloading and spreading the same. The Contractor should contact the Engineer-in-charge before disposing the material, i.e. when the trucks are being loaded for disposal. Every time the truck is loaded, the Engineer-in-charge shall check whether it is loaded properly to the predefined level and then note its number in the register used to keep the record of the trips made by the same truck.

Measurements

The work shall be measured as 75% of the quantity, in cum, loaded in a single truck. The total no of trucks shall be taken from the register and the quantity shall thus be calculated. The total measurement shall be in cum.

Rate

The rate includes for spreading, dressing etc. complete, at the specified site and shall be for an unit of one cum.

The relevant specification for ploughing the ground shall be followed as per the item of earth work in surface excavation mentioned above and depth is to be kept from 15 cm to 25 cm.

Item Sr. No. 1.09 Removing from one location, a tree of girth not more than 60 Cms. Including the roots by excavating earth around the root, lifting the tree along with earth around the roots by suitable equipment, transporting the tree from old location to the new location, making a pit of required diameter and depth in earth at new location, and replanting the tree in to the pit, back filling the soil around the roots of the tree, including necessary manure, watering the tree for required time till the roots gets hold in the earth at new location complete as directed by Engineer In charge.

Tree transplantation is a complex process, and depends on numerous factors. The entire process of tree transplantation can be divided into the following stages:

I.Identification of tree species suitable for transplantation

II.Identification of factors affecting tree transplantation

III.Pre-transplantation process

IV.Manufacturing EM solution

V.Transplantation equipment list

VI. Transplantation process on existing host site

VII.Transplantation process on new host site

VIII.Post-transplantation care

Stage I: Identification of tree species suitable for transplantation

Different tree species have different suitability to adapt to transplantation. The following hierarchy may be followed for identifying trees suitable for transplantation:

1. Trees having aerial roots are best adapted to transplantation, as they can grow new roots easily after the old ones are cut-off. Trees of Ficus family fall under this category.

2. Palms and palm like trees, having collar root system, are next best suited for transplantation. One reason for this is that most palms brought from the nursery are in fact large sized plants that are transplanted from nursery to the site initially.

3. Trees having a hard bark have the 3rd order of preference for transplantation. A hard bark prevents drying up of the moisture retained in the trunk. In addition, the veins of trees having hard bark are located towards the center of the trunk, as compared to trees with softer barks, whose veins are located towards the outer part of the bark. Trees like Neem, Peepul, Cassias, Peltophorum, etc fall under this category.

4. The last preference for transplantation is given to trees having soft barks. Trees with soft barks have veins in the trunk towards the outer side & hence are prone to drying up easily during & after transplantation. Trees like Kapok fall in this category.

In addition to this, one must also look at the sizes of the trees that may be transplanted. A normal crane (up to 10 tonnes) can move a tree having trunk up to 45 cm in diameter. For larger trees, one needs to have either a heavy duty crane or two cranes, and the entire process becomes more complex. Further, the cost of transplanting larger trees is very high, and it may be found economical to cut the tree's branches and re-plant each branch individually, thus obtaining more trees from one tree.

Stage II: Identification of factors affecting tree transplantation

Trees are immobile living organisms and hence form very specific relationships with their surrounding ecosystem (climate, animate & inanimate objects). The growth habit of each tree is dependent on factors such as climate, surrounding objects & trees, general activity in the area, orientation to the sun, wind directions on site, insolation period on site, etc. A brief description of major factors affecting the tree growth & sustenance are discussed below:

1. Insolation: The foliage of each tree is adapted to the daily & seasonal insolation on the site. Hence, if the site is surrounded by large buildings or trees, and the tree receives sunlight only during noon, it will have more leaves towards the top of the canopy. Similarly, if the tree receives sunlight only during afternoon, it will have more density of leaves toward the west & south-west. This information is stored in the tree, and it reproduces leaves and grows keep the above factor in mind.

2. Wind: As the trees grow taller, they have to resist increasing force of wind. If the region generally receives strong winds from the south-west, the tree will have a root system developed in order to support it specifically from that direction. In addition the tree may also have a slight tilt in the direction opposite to the wind direction, due to continued force of wind over years. Further, local wind pattern is affected by surrounding buildings or trees, and the trees are adapted to the same.

3. Soil: Trees older than 3 years absorb not just water, but also humidity from the soil. While water may be available at greater depths, the top roots of the tree are adapted to absorb moisture from the soil. Similarly, roots in different parts are adapted to absorb moisture, water, and nutrients as available on the site. Thus, the entire root system development is very specific to the site, and the tree's growth is dependent on the nutrients usually available to it.

4. Culture: Micro-organisms in the soil provide necessary nutrients to the tree directly or indirectly. This culture is very important for tree growth and dictates the growth strategy of the tree.

Selecting the right season for transplantation

In addition to the above process it is very necessary to choose the right season for transplantation. In tropical India, December to February is the best season for transplantation as there is no precipitation, low soil moisture (so that soil is light & easy to transplant), dry weather and most trees are in dormant state during winter, which reduces their interaction with the surroundings. It is also easier to dig soil & retain it during transportation during this season.

However, if site conditions require transplantation during other seasons, one should try to induce dormancy in the tree in order to reduce its relation with the surroundings before transplantation. This can be achieved by:

-Removing fruits & flowers by applying chemicals

-Digging a moat around the tree & filling it with water+urea or water+cactus milk solution forcing the tree to shed fruits and flowers and go into dormancy

After a few weeks the tree will become dormant & it will be able to bear the effect of transplantation easily

Stage III: Pre-transplantation process

Each tree selected for transplantation needs to be conditioned before the actual transplantation process. The conditioning process lasts between 17-19 days, depending on the equipment & material availability. Keeping the factors shortlisted in stage-II in mind, the following actions are taken:

1. The first step is to modify the soil pH. Soil pH is critical for tree growth. If the pH is acidic, the root development is accelerated. A slightly acidic pH (between 6.5 & 7.2) is favorable for the transplantation process. This is achieved by using SO2 (sulphur dioxide), distilled water or cactus milk, which are poured or sprinkled around the tree in definite quantities (which are decided by the horticultural expert based on tree species, age and size). The site is left untouched for 2 days to allow the pH to change gradually.

2. The next step is to change the bacterial culture of the soil. One can prepare an EM (effective micro-organisms) solution or buy the same in powder or liquid form from the market. This solution is poured around the tree and sprayed on its leaves & trunk. The solution is re-applied after a period of 7 days. After 15 days of first application of the EM solution, the tree is generally ready for the transplantation process.

3. Simultaneously, on advice of horticultural expert, one may start chopping off few branches every 3-4 days to allow the tree to recuperate from the loss of branches gradually. The aim is to chop off most of the larger branches of the tree before transplantation.

Stage IV: Manufacture of EM solution

While processed EM solution is available in market in powder & liquid form, it is always best to prepare a fresh solution from the native regions of the tree species. The following are the steps of production:

-Identify a natural habitat of the tree species to be replanted, and look out for healthy trees of the same species in that region, in locations that are not frequented by humans. Collect about one kg of soil, mulch, leaf and other natural matter from near the trees. If such an area cannot be identified, the soil & mulch around the Rayan (Manilkara hexandra) tree can be used, as it is excellent culture raw-material.

-Procure an industrial mixing drum (about 50-100lts) and put the soil & mulch mixture in it. Buy some desi jiggery (dark brown to black coloured – non processed) – essentially glucose, and put it in with the mixture. Pour water and stir the mixture for some time. Add cow-dung (from wandering cows, not from those in cowsheds) and dal (protein) and stir the mixture again.

-The culture has to be left for 15 days with occasional stirring. After 15 days, the culture is ready for use.

-The culture should be used in 1:10 proportion of culture: water, applied and sprayed around and on the tree.

Stage V: Transplantation equipment list

The following equipment and materials need to be procured before the start of the transplantation process:

-EM solution required before transplantation

-SO2, distilled water or cactus milk required before transplantation

-CuS solution as fungicide

-Heavy Crane for lifting the tree, based on tree height & weight (with operator experienced in tree transplantation process)

-Truck for transporting the tree

-10-15 labourers

-JCB lifting machine

-Diamond tipped road-breaker if tree is on an existing road

-Jet spray pump with 15'-20' throw range

-1 process engineer or horticultural expert

-Tractor for balancing tree by providing push-pull force

-Steel or MS pipe or angle section for support at new host site

-1" thick rope and link-chain to hold tree onto the crane

-Cotton waste for buffer between tree and link chain

-Gunny bags or cotton / plastic tarpaulin for holding the tree's bulb

-Axe and ladder for chopping off the branches

-Fungicide Diythen M-45

Stage VI: Transplantation process

Tree transplantation is a very sensitive process for the tree, and one needs to perform it patiently. Hurried transplantation may lead to death of the tree subsequently. The process is performed in two steps. The first step takes place on the existing host site, and the second step takes place on the new host site.

Part-I: existing host site

1. North direction is marked on the tree with marker or chalk, and the bent of tree to the ground along with direction of bent is noted

2. A sketch of surroundings is made, so that similar conditions may be reproduced on the new host site.

3. The original foliage of the tree is marked on the ground with chalk powder, and approximately half of that is marked for digging. If the tree is large (>4-5m), a square of 2mx2m is marked with the tree in center, for digging.

4. If there is road, it needs to be cut with diamond cutter, and then the marked area has to be dug manually up to 1m depth.

5. The process engineer or horticultural expert will observe the collar rooting of the tree at this depth and decide on the total depth of digging. The depth of the collar is about 2'-3' below the first root. However, if the site has been filled after the tree has been planted; the collar may be much lower, at the original level of the site. The bulb of the tree is preserved within this collar.

6. The branches of the tree are now trimmed to half their size with an axe, and sand, soil and fungicide (CuS) is applied on the tip of the cut branch and up to 2' from tip on the entire branch surface. Clay-dung mixture may also be applied in place of fungicide.

7. Step 6 may be performed over a period of 3-5 days for best results, starting a week before the transplantation day.

8. After identifying the depth of digging, the rest of digging is carried out with JCB.

9. After the JCB has cut roots from below desired depth, the trunk is buffered with cotton waste and the crane lifts the tree up in the same place.

10. At this time, the labourers cover the bulb and soil with gunny bag or tarpaulin, and it is tied to the trunk.

11. The tree may be balanced using a tractor if required, and it is set onto the truck.

12. The truck has a soil slope created on it in advance, sloping downwards from the driver cabin.

13. The tree is laid on this soil at 45 degrees to vertical and transported to new host site.

Step II: New host site

-Before the tree is brought on the new host site, a pit equal to the size of the tree's bulb is dug on-site and kept ready to receive the tree.

-It is very important NOT to apply urea or any nitrogen based fertilizer to the pit at this stage.

-When the tree is brought on site, a crane lifts the tree from the truck and holds it over the pit, aligned with the north in the same manner as that on its original site.

-The labourers remove the tarpaulin or gunny bags and spray fungicide on the bulb. If gunny bags are used, they may be left on the tree bulb, as they disintegrate naturally.

-The tree is then lowered into the pit and surrounding pit is backfilled with soil taken out during digging.

-Light spraying of water should be done, but away from the bulb of original soil. The original bulb needs to be preserved for a few days with same levels of soil moisture & soil air without allowing soil to settle. If the soil bulb settles during this process, it must be filled with fine soil from original soil and some water should be sprinkled. Care should be taken that over-sprinkling should not destroy the soil bulb.

-Apply a coat of CuS wherever wear & tear has happened on the tree during the transplantation process, and cover these areas with cloth to avoid excess transpiration.

-Install the steel or MS pipe / angle support to align tree with vertical as it was on original site.

Stage VII: Post-transplantation care

-First watering should be done after 3 days of transplantation.

-Next watering should be done after 10 days of transplantation, and mulch should be added on the surface to maintain soil moisture.

-When possible one should try to recreate surrounding conditions similar to that of original host site around the new host site. Hence, if the tree was surrounded by tall buildings, it should be transplanted in a similar location or one should erect scaffolding with high shuttering for few weeks around the tree to simulate such conditions.

-Such simulations may be removed gradually over a few weeks to allow the tree to adapt to changing surroundings.

Measurement shall be per tree transplanted, irrespective of size. The rate includes the cost of all materials, equipment, labour, carting, loading & unloading, removal of debris to local specified within the site, involved in all the operations described above.

Item No. 1.10 Providing and laying non-pressure NP2 class (light duty) R.C.C. pipes vertically in tree-pits complete as directed by EIC including supply of all material, labour and equipment up to any lead and lift 900 mm dia R.C.C. pipe

Cement concrete pipes shall be installed in tree-pits along roads and near structures as shown in contract drawings to prevent tree roots from damaging constructed areas.

Precast cement concrete pipes of diameter as specified in contract drawings shall be supplied conforming to IS 458.

Contractor shall unload the pipes on location of laying only just before laying is about to begin, and trench is prepared. Contractor shall unload the pipes with great care. Any crack and chipping shall not be accepted, and Contractor shall replace the pipe at his own cost.

Contractor shall lay the pipe using pulley mechanism such that the pipe is absolutely vertical, checked with plumb line. Contractor shall level the pipe such that its finished level matches that shown in contract drawings.

Contractor shall refill the outside portion of the trench manually with excavated soil with great care not to disturb the laid pipe. Filling shall be done in layers 100 mm thick, and light tamping shall be done such that the pipe is not disturbed. Contractor shall keep checking the level and alignment of the pipe periodically with plumb line and correct any errors found.

Precast cement concrete pipes shall be measured in length just before laying, accurate to the nearest centimeter. This work shall include transport, loading, installation and soil filling around the pipe. The rate includes the cost of all materials, equipment, labour, carting, loading & unloading, removal of debris to local specified within the site, involved in all the operations described above.