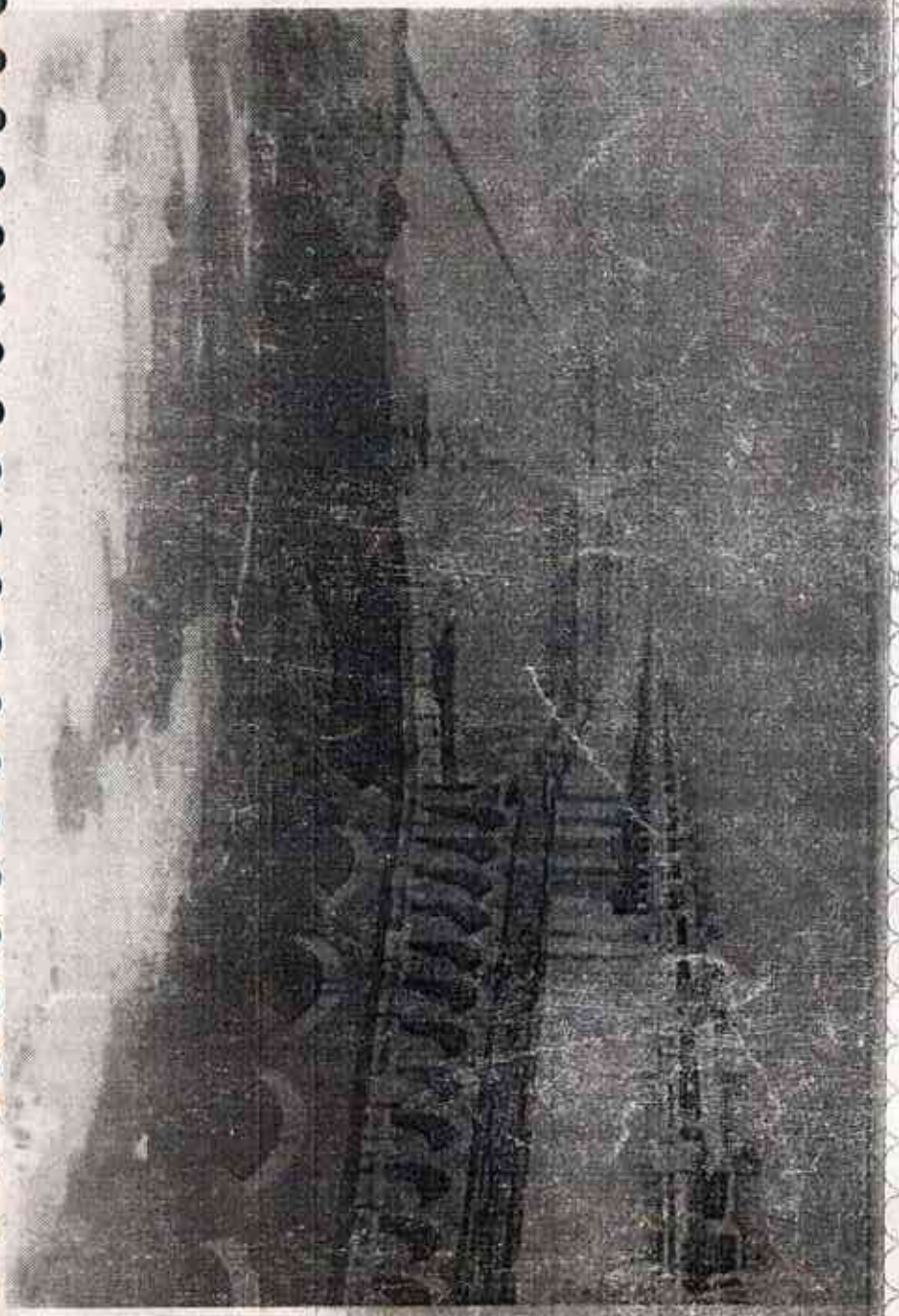
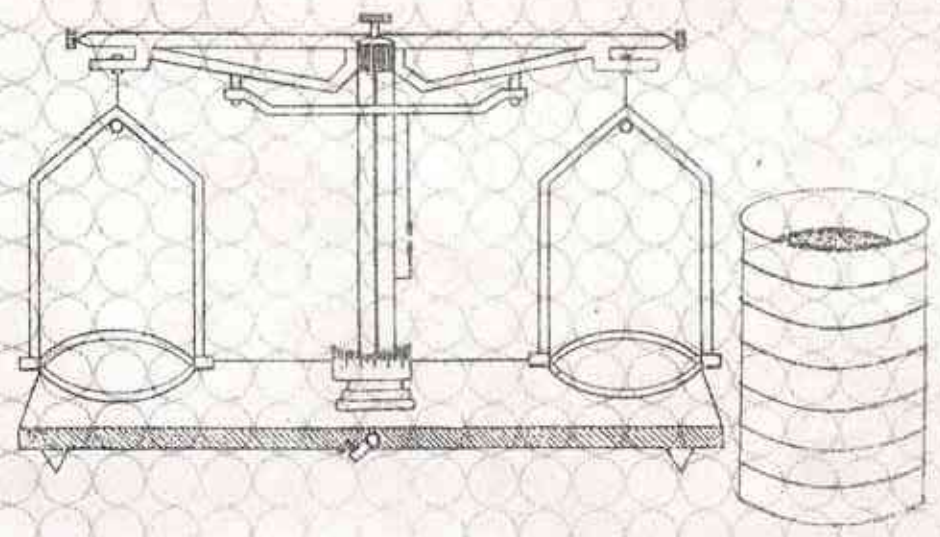
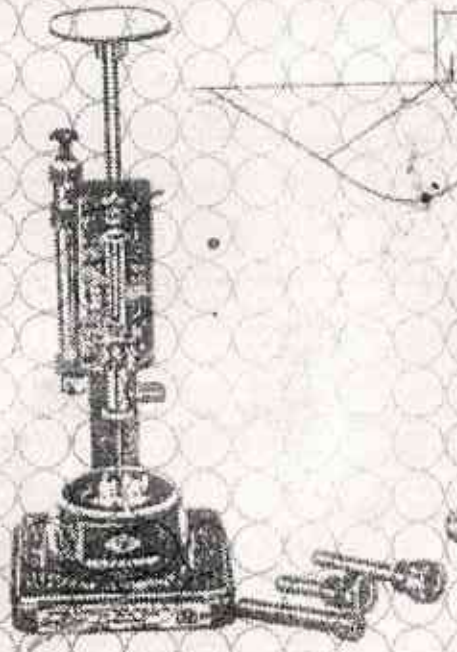
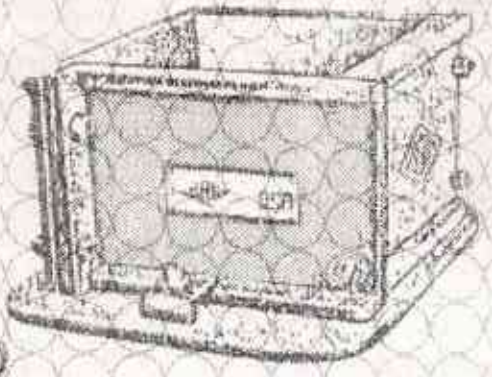




QUALITY CONTROL GUIDE
for Field Engineers





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(G. Hari Singh)
Superintending Engineer
Q.C. V & E Circle
Dowlaiswaram

QUALITY CONTROL GUIDE

FOR

FIELD ENGINEERS

QUALITY CONTROL GUIDE

FOR FIELD ENGINEERS

Not for Sale. For circulation among Irrigation Q.C. Field Engineers only

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PREFACE

This book is revised and enlarged to suit needs of Field Engineers. Some topics which are very useful were selected from "Quality Management Series" prepared under the able guidance of Hon'ble Sri **N.Subbaram Reddi,** Technical Advisor to Government of A.P. and added to this book. To create general awareness regarding quality control among construction staff it is decided to distribute these books to all construction circles of Nine Coastal districts right from Nellore to Srikakulam.

In this Second edition of this book items like 1. Introduction of o.k cards, 2. Some important Do's & Do'nts, 3. Test to be conducted on Graval base, and on Quarry rubbish etc. were introduced

The effort put forth by Er. Ch.Lakshmi Narayana,M.Tech., M.I.E Executive Engineer Vigilance in compiling the materials, processing totally in bringing out this book needs rich appreciation.

Special Thanks are due to Er. D.V. Bhavana Rao, M.Tech., M.IE Executive Engineer (R&B) for allowing topics from Quality Management Series to add in this Book.

The Services rended by Er. T.H Gandhi Prasad, B.E., Er. I.V.Chandra Shekaram, Er. T. Brahmaji Rao of this circle office staff are appreciable.

Any suggestions for improvement of this book for next edition are solicited

Er. G.HARI SINGH, B.E.,
Superintending Engineer
QC V & E Circle
DOWLAISWARAM

A WORD

There are good number of Hand Books or compilations available on civil engineering topics. It appears that no hand book is readily available on quality control aspects exclusively. Therefore the book is devised and planned to be a guide book for the use of Irrigation Q.C. Field Engineers.

Until fifties, control of quality in Public Works Projects was the sole responsibility of the executive staff. with the advent of international consultants and increased utilisation of mechanised construction techniques and later involvement of external financing agencies, separate streams for construction and quality control were established almost in all the States.

"Quality consciousness" is no longer a matter of choice. It is an Unavoidable necessity. It may be expressed as "Quality is the totality of features and characteristics of a product or service that bears on its ability to satisfy stated or implied needs."

The true function of an effective quality control organisation is to prevent deviations from the prescribed norms at the source rather than merely detect them after they occur.

A better quality of work is obtained only through systematic control of all operations right from selection or production of materials to acceptance of completed work.

An attempt has been made to prepare a guide on Q.C. aspects. The important test procedures, specifications, limits and criteria for suitability of materials as laid down in A.P.S.S , as well as I.S. Codes are compiled and made into a booklet form as a guide to the field staff for ready reference. For further details the respective codes and specifications may be referred. Suggestions for improvement are invited.

The book mainly contains the quality aspects of earth work excavation, embankment, testing of materials, procedures, field tests to be conducted with illustrative examples and testing equipment, C.C. and R.C.C. work, masonry, revetment, grouting, backfill etc..

The idea in bringing out a guide on field aspects of quality control originated during the course of conducting refresher courses conducted as directed by Er.K.V.Rao, the then S.E, Q.C.V and E (Now Retired) to field officers on quality control aspects by a Team of Engineers from Circle consisting of Sri P.Venkata Reddy, Deputy Executive Engineer, Sri Bh.S.K.Bhagavanulu, Assistant Executive Engineer, Sri I.V.Chandrasekharam, Assistant Engineer and Sri V.V.V.Satyanarayana, Assistant Executive Engineer. Emphasis is made to impress the field staff on the important field tests, test procedures, sampling procedures, testing materials and acceptance creteria etc., from the practical point of view.

The services contributed by Sri K.Ashok Kumar, M.Tech., Executive Engineer and Sri P.Suryanarayana Raju, B.E., Deputy Superintending Engineer (Rtd.) in close monitoring of the data at every stage and in bringing out the book are valuable.

The effort put by Sri Ch.Laxminarayana, M.Tech., M.I.E., Deputy Executive Engineer and by the Technical Staff of Circle office in compiling the materials, tables, codes, charts, getting it typed, printed, proof reading and in finishing the job can not be expressed in words.

The efforts made by Sri Bh.S.K.Bhagavanulu, B.Tech., Assistant Executive Engineer in compiling the data, processing and totally in bringing out the book needs rich commendation and appreciation.

The services rendered by Sri V.S.Achary, Senior Assistant and Sri P.Nooka Raju, Typist in typing the material are appreciable.

Er.K.V.RAO, M.Tech., F.I.E., C.Eng.,
Formerly Superintending Engineer

GENERAL INDEX

DETAILED INDEX

PART - C

TECHNICAL SPECIFICATIONS

PART - D

PART - E

PART-V

PART - A

1.0.0 SCOPE AND PROCEDURE

1.1.0 Quality Control and Scope

Quality control is the art of getting the work done to accomplish the best possible construction to specified standards of quality in a most economical way. It can be defined as the degree to which the construction meets the requirments of soundness and stability of structure. It should be understood that its scope does not limit itself to get the work done to a certain standard at site, but has to cover the entire process of construction starting from the selection of raw material required for the work, till completion including testing etc.,

The quality control techniques adopted should be suitable and consistent with the type of construction undertaken and should be practicable and innovative to get the work done in the best possible way to achieve the efficient results under the given conditions and circumstances.

However, it should not be used as a tool to stall the work on one pretext or the other, and hamper the progress. In its own way it can at best assume the status of technical auditing but in a constructive way.

As the construction industry is closely associated with developmental works, it involves through 'Quality Control Techniques' only. There may be no exaggeration to say that the stability and performance of a structure depends on the 'Quality Control' exercised during construction. Best quality materials used in a bad way would produce a bad 'End Product' with disastrous results. As we have the responsibility of putting to best use of the construction material available in a most economical way and execute the works efficiently and pass on the benefits to the society quickly

Quality control is analagous to Hygiene to human body. Construction work executed without adopting proper quality control techniques will be injurious to its structural stability similar to the food prepared under 'Unhygienic conditions despite using the best quality materials is injurious to Health. It is evident that 'Quality Control' assumes a wide range of scope and it starts right from planning stage itself, and ends with final quality

product. It is a multifaced technique and if it has to be successfully implemented, experienced, knowledgeable and trained personnel should be made incharge. They must comprehend what the designer exactly, expects to achieve at site, and what the specification stipulates. They should evaluate the site conditions thoroughly and rise to the occasion to see that the specifications are implemented in the best possible way and get the work executed efficiently.

STATE-OF THE ART OF QUALITY CONTROL TECHNIQUES

State-of-the art concerning quality control techniques can be briefly stated as follows :

1) Investigation of raw materials available locally and determination of their suitability or otherwise.
2) Evolving design mixes for the specified strength and performance requirements.
3) Batching and its field control.
4) Mixing the mortar to the required consistency.
5) Transportation to site of work.
6) Placement and construction.
7) Curing.
8) Tests and instrumentation.

QUALITY CONTROL TECHNIQUES

Some of the quality control techniques are discussed below. It is to be mentioned that the techniques discussed are mainly applicable to major structures such as dams, barrage etc., Every item discussed shall equally applied irrespective of the magnitude of the work. The techniques are common but the system facilities may vary from work to work.

1. INVESTIGATION OF RAW MATERIAL AVAILABLE LOCALLY AND DETERMINATION OF THEIR SUITABILITY

The principal ingredients required for stone masonry are stone, sand, and cement.

After having selected the quarry for manufacture of rubble stone, and sand after working out economics, samples of rubble and sand have to be produced at random and get them tested in a competent laboratory. Care should be taken to see that sufficient success or representative samples are collected and sent to laboratory.

1. **Rubble/Stone** The following tests have to be conducted on rubble/stone and results analysed to decide acceptability or otherwise :
    1. Specific gravity
    2. Absorption of water
    3. Crushing strength
        a. First crack
        b. Ultimate strength
    4. Acid test for chemical reaction

2. **Sand**
    1. Specific gravity
    2. Fineness modulus
    3. Organic impurities
    4. Colour and acid test
    5. Unit weight

3. **Cement**
    1. Chemical analysis
    2. Fineness modulus
    3. Blaineair permeability test
    4. Soundness test
    5. Setting time initial and final
    6. Normal consistency
    7. Compressive strength at 3 and 7 days
    8. Tensile strength at 3 and 7 days

In the case of large masonry works, replacement of cement with Surki or Flyash is recommended to reduce hydration and workability to improve

The following tests have to be done.

1. Mechanical analysis
2. Sieve analysis
3. Chemical analysis
4. Puzzolonic activity of surki or Fly ash
5. Fitness test
    a. Blaine air permeability test
    b. Sieve analysis

II : Evolving design mixes for the specified strength requirements.

Mix designs for the specified design strength of masonry required to be constructed should be done in competant laboratory. It is imperative that the mix proportions using the actual materials collected from selected quarries should be got done. In the case of big works such as dams etc. different mix designs will be evolved for different zones depending upon the strength requirements and in the case of small works a uniform mix design will be evolved. In case, usage of puzzolonic materials are contemplated to be used, design mixes have to be evolved separately and tested. Mix designs for both with and without Fly ash should be evolved and made available at site so as to facilitate adoption depending upon the circumstances.

A field laboratory is essential to carry out tests on the materials being used from time to time and check whether mix design needs any modification. Adopting the same mix designs without caring for the variation in temperatures and quality of ingredients may some times yield lower strengths.

Quality Control staff should be alert enough to notice the variation and arrange immediately to get the test done at short-notices. Cement is one such item which needs to be got tested at frequent intervals. A vigilant field officer should notice the variation if any in the setting time of the cement supplied, and take measures to rectify the same.

III BATCHING

Uniformity of mortar required for masonry necessitates the maintenance of the designed proportion of ingredients so as to achieve a good quality of masonry. In order to achieve uniformity

and consistency of a mix fairly accurate measuring equipment is required.

Two types of batching are resorted to

1. Volumetric batching
2. Weigh batching

VOLUMETRIC BATCHING

Volumetric batching is done with the help of measuring boxes and the required quantity is added judging the consistency of mortar. Volumetric batching despite the precautions, leads to inaccuracies due to variable bulking of sand and variation in surface moisture, and it is difficult to maintain uniformity in the consistency and strength of mortar.

In batching by volume, it is generally advisable to set quantities of sand interms of one full bag of cement.

WEIGH BATCHING

Weigh batching is preferable wherever facilities for weighing the ingredients could be provided.There are three types of weigh batching in vogue. They are,

1. Manual
2. Semi automatic
3. Automatic weighing

In manual weigh batching as the name suggests, the operations of weighing the different ingredients are done manually. This type is suitable for small job having low batching rate. In otherwords where placement is done manually and slow, manual weigh batching will be suitable. In this method, if any attempts are made to increase the rate of batching by manual weighing, there will be an excessive weighing inaccuracies in feeding the ingredients and the mortar manufactured will be inconsistent.

In semi automatic batching, sand bins for feeding into the mixer are manually operated and its shutters are automatically closed when the designated material is fed. In this method provision is made for visual inspection of the meter reading.

In automatic batching all the weighing scales are electrically activated by a switch. However, interlocks interrupt the batching cycle when present. Weighing tolerances are exceeded.

In the case of major works like construction of dams, barrages etc., where huge construction of masonry is involved a separate batching plant is installed in a central place which is attached with a control panel with large batches, dials at the top for continuous inspection, automatic recording tracer arms just below and under control push button. In this batching, it is possible to present the weights for a no. of mix designs, or batch sizes and feed them into the mixer to automatically.

In the case of automatic controls, the responsibility for a correct batch is generally delegated to the control system with inter-locking arrangement in order to notify if any thing is wrong.

MIXING OF MORTAR

In the process of manufacturing of mortar, mixing plays an important role. All the ingredients, should be mixed thoroughly to render the product a homogeneous blend. It is common practice to resort to hand mixing in most of the works. For small works located at remote places where facilities are not available, hand mixing is being done. But care has to be exercised to obtain a good mix of mortar. Spreading of sand and cement of uniform layers over a clean and non-porous surface, turning them dry thoroughly two to three times till the mix appears uniform and adding water gradually and turning again till it appears colour and consistency involves human effort and the possibility of variation from batch to batch can not be ruled out.

It is always desirable to resort to machine mixing, which gives mortar with better consistency. There are different types of mixers with different capacities, and their selection depends upon the rate of batching required.What is important is, the blend of the mortar that mixer can produce. The efficiencies of mixes can be judged by observing the variations in the mix while discharging on the platform, certain standards stipulate that the deviation in strength of samples taken at different points of unloading should not vary much. As per I.S. standards, the percentage of variation between quantities of cement and fine aggragate in **two halves** of a batch and the average of the **two halves** of the batch should not be more than the following.

Cement	8%
Sand	6%

MIXING TIME

For a given mixer, there exists a relation between the mixing time and uniformity of mix and the exact value of mixing time varies with the type of mixer and depends on its capacity. Satisfactory results can be obtained for a mixing time of 1 to $1\frac{1}{2}$ minutes. When admixtures are used, longer mixing time has to be allowed. After studying one or two batches the exact mixing time can be fixed.

FEEDING INTO THE MIXERS

As regards feeding of ingredients into the mixer, no general rule can be fixed. Normally a small quantity of water is to be added first followed by solids, and gradually water should also be fed simultaneously as far as possible along with the ingradients, to obtain best results.

There seem to be a general impression that more mixing time would produce better blend. It may be a wrong notion as mixing for longer periods would result in evaporation of water from the mix and also decrease the workability and strength. There is a likely hood of increasing the temperature due to friction. Further in the case where air entrainment is resorted to, prolonged mixing may reduce the air content.

TRANSPORTATION TO SITE

Transportation of mortar to site of work is equally important to get a good job done. In many cases, this item is not properly planned. In the case of small jobs, the mixers can be located very close to the work spot and the mortar can be transported and placed in position without much time getting lapsed. Depending upon the magnitude of work and rate of consumption of mortar, suitable arrangement has to be made, keeping inview of the time factor, as the mortar has to be placed in position before initial setting time starts.

There are different types of transportation of mortar.

1. By head loads.
2. Tippers and trucks.
3. Tipping trolleys on rails.
4. Through skips operated by mobile cranes.

5. Chutes and tremies.
6. Conveyor belts.
7. Cable-ways.

Whatever method is adopted, it should be ensured that segregation and blending does not take place and the workability is not reduced.

PLACEMENT & CONSTRUCTION

Mortar has to be placed in position as rapidly as possible before mortar becomes stiff and unworkable. Under any circumstances, water should not be added to the mortar before or after placement in position. It is to be ensured that the placement area is cleaned with water and sufficient quantity of mortar is applied and well spread and then the stones are properly bedded, and jerked to set the stones in position. Then mortar is filled in the interstices without leaving voids and then spauls are inserted and wedged in between the stones. Roding is also done for effective filling of mortar between stones.

Masonry is generally constructed at the rate of one layer per day and under emergencies, two layers can be built, however taking care to see that the bottom layer is not disturbed. Sometimes the first layer is built for same length first and the second layer is started over it before the initial layer starts setting. After setting the stones inposition and filling the gaps properly, the excess mortar that comes out must be removed.

CURING

Normally curing of the first layer has to be done after 16 hours profusely before the next layer is laid the next day.

CONCLUSION

We the Civil Engineers who are incharge of construction of masonry works have the responsibility to get the work done duly following the quality control techniques in a most economical way and get the best possible workdone.

1.2.0 PROCEDURE FOR QUALITY CONTROL CODE FOR QUALITY CONTROL OF EARTH FILL

The entire operations of construction of embankment may be briefly summerised under the following heads.

a. Borrow area control
b. Placement and control of compaction.
c. Testing and report.

BORROW AREA CONTROL

i) **Selection :** For selection and marking borrow areas, the samples from borrow area should be collected and the following tests should be carried out in the laboratory.

1. Sieve analysis.
2. Compaction.
3. Liquid limit & Plastic limit
4. Grain size analysis.
5. Permeability of soil.

ii) After carrying out the above tests, the soil classification and suitability of soil will be decided by refering to specification for earth fill appended vide Table, 5,6 & 7 of IS. 1498-70.

iii) After these tests are carried out, the borrow area should be suitably demarcated and divided into grids and numbered.

iv) At one time, one grid should be in operation for impervious and another for semipervious material.

v) Shifting of machines to other grid should be done only when the materials of present grid have been exhausted to the full depth (3M or more) or when properties of soil are visibly found to have changed.

vi) The part of the borrow area in operation must be properly stripped off from all types of vegetation, roots and out-crops.

vii) Stones, pebbles or rock fragments having dimensions more than 7.5 cm should be avoided.

viii) Shovel/dragline or other cutting machines (even manually) should take cutting depth of atleast 3M and excavate the composite soil.

ix) When semi-pervious and impervious soils exist one below the other excavation should be done by scrapers to avoid intermingling.

x) It should be ensured that carriers engaged transport only right type of soil.

xi) The right type of soil should be obtained from the quarry as per the test data and the zone, where the truck is to be unloaded, should be decided at quarry itself.

PLACEMENT AND CONTROL OF COMPACTION

i) Before placement, the surface must be cleaned from all vegetation and roots, ditches and bumps, scarified to 15 cm. of depth and proper bonding maintained.

ii) Fill material should be placed in layers of sufficiently large length and breadth to allow rollers to move freely and to avoid joints. Perpendicular joints to the axis should be avoided.

iii) Shall ensure uniform layer as specified by means of graduated rods.

iv) Right type of soil should be placed at right zone. Coarser semi-impervious material should be moved to the outer most side of embankment, while coarse impervious material must be placed in the key trench or inner part of the impervious zone. Root pickers should be engaged to collect roots and large size boulders and to dispose them.

v) While dumping is still on, the average M.C. of the dumped material must be ascertained from the collected borrow area or by actual determination.

vi) Experience alone is the guiding factor to judge the extent of watering to be done by jet spraying, although rough estimation may be made by calculation.

vii) Practically it can be checked by two methods. The earth be rolled in 3 mm dia. thread, if it is on the verge of breaking it shows that the moisture is nearer to OMC. or prepare a ball of 25 mm dia. and drop it down from 1.5 m height and if it does not change shape, it is near to the OMC if it cracks water is less and if it changes its shape, the water percentage is more.

viii) It is advantageous to compact impervious soil on the lower side, and semipervious soil on the higher side of OMC.

ix) To regulate the thickness of layer to 15 cm or as specified, the volume of layer(Lxbxt) should be divided by the volume of carrier

and the resultant number of trips should be received by one or all carriers. If carriers of different capacities are working, suitable adjustments should be made.

x) Shall ensure uniform watering of layers by spraying with the hose provided with spout of 10 cm width. Uniform watering of every 10 cm or 7.5 cm layer (half the thickness of layer) should be ensured.

xi) Rolling may be allowed if average OMC is in the range of + 1% to –1% for imperious soils and –1% to +2% for semi pervious .

xii) Rolling by sheep foot roller as per specifications having foot area between 25 to 60 sqm. and projection from the drum of atleast 18 cm may be allowed. It must exert pressure not less than 40 kg/cm^2. For creating this pressure, water filling in sheepfoot roller should be ensured. Where roller can not be moved, mechanical or pneumatic tampers may be used, and layer thickness so adjusted to give desired density.

xiii) At any cross section of the embankment construction, the imperious core should be 60 cm higher than the casing. The first layer of soil immediately after filter should not be rolled by sheep foot roller but rubber tyred roller or Dozer's chain may be used.

xiv) A study of number of passes required for achieving the desired compaction, must be made and results followed in future works.

xv) Shall frequently change the route of movement of scrapper/ trucks (in-coming and out-going) for every shift or whenever rolledfill shows sign of pulverization into dust.

xvi) If compaction is less, rerolling is advised.

xvii) After proper compaction is achieved, sample cores be tested in the field laboratory for final results.

TESTING AND REPORT

1. For testing and report of compacted earth fill and frequency of test, specifications given in relevant chapters may be referred.

2. The test results given may be maintained by the Deputy Executive Engineer in proforma given and reports submitted.

CODE FOR CONCRETE AND MASONRY WORKS

The quality control of concrete and masonry works can be grouped as :-

a. Testing and inspection of various materials selected for use.

b. Proper proportioning and adequate mixing of the materials.

c. The use of proper handling, placing and consolidation procedure.

d. Conducting field tests and preparation of samples for the tests in the central laboratory.

e. Proper curing.

f. Reporting.

TESTING AND INSPECTION OF VARIOUS MATERIALS SELECTED FOR USE

i) The quality control staff shall make, quite in advance, inspection of the stocks of various materials meant for use in the concrete, masonry and filter works, at crusher and batching plants. Quarry sites should also be inspected and familiarised with the mode of working.

ii) They shall send samples of material in requisite quantity from stocks, quarries and crushing plant to the Central laboratory for suitability tests. They will allow these materials to be used in works only after getting certificate of suitability from the central laboratory as per procedures laid down in ISI. Samples of all supply agencies and cement shall be tested in the Central Laboratory and test report will be sent to the field Engineers, with copy to the quality conrol staff for guidance.

PROPER PROPORTIONING AND MIXING OF THE MATERIALS

i) The mix proportion for various types of concrete and mortar in masonry works are to be furnished by the Central Laboratory asper the Specifications given with designs.

The Quality control staff shall see that the proportions fixed are maintained strictly. However, mix design will be carried out in the Central laboratory and the adjustment recommended due to change in grading etc. will be adopted by the quality control staff

in the mix and followed strictly. Minor adjustment in the quantity of water required for a mix on the basis of slump may be done by the quality control staff taking into account the moisture already present in sand.

ii) Cases of seggregation and bleeding should be reported to the Central laboratory for adjustment in mix and also collected on the spot.

iii) The quality control staff will also ensure that all the ingredients are properly mixed before placement.

iv) The Central and field laboratory staff will constantly inspect batching plant and mixer to regulate the batch as per mix design for a good mix.

v) The minimum mixing time after all the gradients are added may be adopted as given in relevant paras.

vi) The requirement of slump for various types of works has been shown in the specifications.

vii) The quality control staff should get the batching plant calibrated atleast as close as every fortnight.

viii) Allowance for bulking must be made in the quantity of sand.

USE OF PROPER HANDLING, PLACING AND CONSOLIDATION PROCEDURES :

i) The Engineer-in-Charge of construction is to make arrangements and specify the procedure for proper handling, placing and consolidation.

ii) The Quality control staff will assist the site Engineers in the above work.

iii) The surface taken up for work must be cleaned by wire brush and water jet. When work after a long duration is started, chiseling will be essential.

CONDUCTING FIELD TESTS AND PREPARATION OF SAMPLES FOR TESTS IN THE CENTRAL LABORATORY

i) The quality control staff will conduct the following pre mix tests in the field laboratory.

a. **Sand :** One sample daily in morning and one in the afternoon for all tests as outlined.

b. **Coarse aggregate** : One sample daily for all the tests as outlined.

c. **Stone samples** : When required.

During Preparation of Mix and After :

d. Proportion, W/C ratio and slump Twice per shift.

e. Preparation of concrete cubes, mortar cubes.

f. 12 cubes of concrete per shift.

g. 6 cubes of mortar per shift.

Samples should be prepared at the place of casting fairly distributed in respect of time, so as to be representative. They will be numbered as per direction of Deputy Executive Engineer/ Assistant Executive Engineer and sent to the Central Laboratory for strength testing at 7 days & 28 days. The specimens cast at sites may be sent to Central Laboratory atleast 2/3 days in advance of its due date of testing. The Central Laboratory will cure for balance days and test the same on the due date. Test reports will be sent by the Central Laboratory to the construction Engineer with copy to the quality control staff.

PROPER CURING

Ensuring proper curing will be the responsibility of construction Engineer and whenever required, the quality control staff will assist him by pointing out timely, any case of deliberate negligence. Curing should be done for atleast 7 days in foundation concrete and 28 days in surface concrete and masonry by sprinkling water atleast thrice in a day.

REPORTING

The test results may be maintained by the Deputy Executive Engineer in proformae given and report submitted to concerned officers.

CODE FOR OTHER ITEMS

Reinforcement :

The purpose of reinforcement in concrete is to increase its tensile strength and make it strong enough to withstand the harmful effect of any stress caused by bending moment. This is achieved by providing steel bars of requisite dimensions with proper spacings.

The quality control staff has to see that steel bars of required dimensions, as specified, with spacing as per drawings and designs are used in the reinforcement. Besides this, the following points are of importance.

Steel :

a. Steel for reinforcement shall be approved Indian manufacture as far as possible, and shall be "Tested Steel".

b. The steel reinforcement shall conform fully with the standard specification ISS 1786.

c. Steel shall be free from loose mill scale, rust, oil, grease, dirt, paint or other deleterious material.

d. Bending of rods should be done at ordinary temperatures but when heating becomes unavoidable, the cooling should be gradual, otherwise the strength will be affected.

No part of reinforcement should be left exposed to the atmosphere without concrete covering as per I.S. Specifications.

Acids, alkalies and some salts do affect the steel. It must, therefore, be ensured that they are not present in water, which may be in contact with the reinforcement.

When corrosion is feared, the exposed/reinforcement should be painted with asphalt, pith or other inert material or by any other method.

Dissimilar diameter rods should not be joined together.

Bending of rods and position of reinforcement should be strictly as per the drawings.

SHUTTERING OR FORM WORK

The concrete mix is a semi-fluid mass and becomes solid only after it fully sets, so to give a proper shape and finish, wooden or metalic frame of required dimensions is prepared, in which concrete paste is poured and compacted. The frame or shuttering should, therefore, be strong and sturdy enough to withstand the vibrations, so that the hardened concrete may achieve the designed shape. The wooden planks of shuttering should be placed closely together to make it leakproof against oozing out cement slurry or mortar. The inside of the frame is made smooth even by providing a lining of lime or cement slurry or jointed with oil to give

a smooth surface. The preparation of shuttering becomes difficult when curved surface is to be provided in the concrete. The defects in shuttering render the shape of the concrete defective, which is sometimes, removed by providing a plaster of mortar. This is not at all desirable.

After pouring the concrete in the frame, compaction should be done by proper vibration, so that concrete enters in all the cavities and angular points of the frame and no void remains. After removal of shuttering, honeycombing in the concrete can be seen when voids are not properly filled. If honeycombing is there it should be properly filled up by mortar. There should be a stand by vibrator always at site to make use of the same in times of breakdown.

The quality control staff should note the above points and carry them out in practice.

CONCRETE

Grades - The concrete shall be in grades designated as per Table 2.

The characteristic strength is defined as the strength of material below which not more than 5 per cent of the test results are expected to fall.

TABLE 2 GRADES OF CONCRETE

(Clauses 5.2.1 8.2.1 14.1.1 and 35.1) IS 456 - 1978

Grade designation	Specified characteristic compressive Strength at 28 days.
(1)	(2) N/mm²
M - 10	10
M - 15	15
M - 20	20
M - 30	30
M - 35	35
M - 40	40

Note 1 : In the designation of a concrete mix, letter M refers to the mix and the number to the specified characteristic compressive strength of 15 cm cube at 28 days expressed in N/mm2.

Note 2 : M5 and M 7.5 grades of concrete may be used for lean concrete bases and simple foundations for masonry walls. These mixes need not be desinged.

Note 3 : Grades of concrete lower than M. 15 shall not be used in reinforced concrete.

1.3.0 QUALITY CONTROL SPECIFICATIONS FOR CONSTRUCTION MATERIALS

A better quality in work is obtained only through systematic control of all operations from selection or production of materials to acceptance of completed work. Total economy in any activity results from optimisation of the system which in turn calls for compatability of quality among the elements involved. There are refined techniques of design, powerful methods of analysis and deeper insight into structural action. The maximum benefit can be obtained only when these techniques are used with quality materials.

Specifications should be a guide for construction. They should give details of project construction and set the standards of quality desired for the project. Specifications should be in logical sequence. They should be concise, and clearly underatood. Reference to standard specifications should be given for each item. Concrete specifications are often inadequate. Specifications must cover all details of construction including supervision, inspection standard procedures for complying and frequency of testing and acceptance criteria.

The standard specifications for some of the materials are given below.

CEMENT

The user has very limited control on the quality of cement received at the site. It must be tested before use by Q.C. Labs. The quality of cement varies from factory to factory or even from the same source. The following precautions are to be taken.

i) Ensure compliance with the minimum requirements of relevant standard specifications, for each consignment by independent tests.

ii) Where-ever it is possible, use cement from a single source or keep seperate storage for different sources.

iii) Store different consignments of cement in such a manner as to permit identification if required later in case of investigation of defective work.

iv) Avoid deterioration due to improper or prolonged storage and losses due to unnecessary repeated handling.

The following are various types of cements used in the construction :

1. I.S : 269 - 1976	Specification for 33 grade OPC
2. I.S : 8112 - 1978	Specification for 43 grade OPC
3. I.S : 12269-1986	Specification for 53 grade OPC
4. I.S : 1489 - 1976	Specification for portland pozzolana cement.
5. I.S : 455 - 1976	Specification for portland slag cement

SPECIAL CEMENTS

1. I.S : 8041 - 1978	Specification for rapid hardened cement
2. I.S : 6452 - 1972	Specification for High allumina cement
3. I.S : 6909 - 1973	Specification for sulphate resistance cement

TESTS ON CEMENT

1. I.s : 4031 - 1968	Physical tests.
2. I.S : 4032 - 1968	Chemical tests.

Sl. No.	Type of cement	fine-ness Sq. cm/g	Setting time		Comp. strs.			Sound-ness Max
			Initial (Min)	Final (Max)	3d	7d	28d	Lechal-lier Exp. mm
1	2	3	4	5	6	7	8	9
1.	OPC IS : 269-1976	2250	30	600	160	220	330	10
2.	OPC IS : 1489-1976	3000	30	600	–	220	330	10
3.	Rapid hardening cement IS : 8041-1978	3250	30	600	275	–	–	10
4.	Super sulphate cement IS : 6909-1973	4000	30	600	150	220	300	5

Increased fineness of cement increases strength, particularly at early ages. It decreases bleeding, expansion and improves cohesiveness of concrete. An increase in fineness by 1200 cm^2/gr can increase 1 day strength of concrete by 50-100% and 3 day strength by 30-60%.

Adultration in cement :

Sl. No.	Constituent	Require-ments as per IS : 269-1976	OPC %	ADULTRATION 30%	45%	65%	75%
1	2	3	4	5	6	7	8
1.	Loss on ingnition	Not more than 5%	2.80	4.70	5.55	6.36	9.20
2.	Silica	–	22.32	16.85	11.80	8.38	7.00
3.	Iron Oxide	–	5.98	3.59	2.20	2.0	0.96
4.	Calcium oxide	–	64.50	42.76	31.56	18.65	3.90
5.	Insoluble residue in 2N sodium cartenite	not more than 4%	3.15	29.29	43.08	65.55	74.50

APPENDIX - I

Factors contributing to variation in concrete strength

Sl. No.	Factors causing variation	App. total variation in concrete strength as a result of this factor
1	2	3
1.	Quality of cement	Upto 50% or more @ 28 days age
2.	Grading of aggregate	20%
3.	Bulking of fine aggregate	10% (allowing for average bulking) upto 25% (No allowance for bulking)
4.	Batching	
	a) By weight	8%
	b) By volume	
	i) Good	16%
	ii) Normal	70%
	iii) Bad	100%
5.	Handling, mixing and transporting	Unknown, but may be eliminated by attention to detail
6.	Poor compaction	Upto 50%
7.	Temperature	Unimportant after 28 days, provided temperature is above freezing.
8.	Other factors concerned with making and testing of test cubes	About 30%

1.4.0 QUALITY ASPECTS - CERTAIN GUIDELINES

1. It is the duty of the quality personnel to verify and go through the copies of sanctioned estimates, agreements and approved drawings so as to get themselves acquainted with the items of work to be carried out.

2. In no case the work should be allowed to be grounded without the approval of drawings and estimates. The Quality staff should bring such cases if any to the notice of the higher authorities.

3. The actions of the quality staff should always be within the frame work of codal provisions, specifications and stipulated procedures. Any deviations as and when noticed are to be recorded in field registers maintained by the construction staff.

4. The quality staff are expected to acquaint themselves with the relevant codes and testing equipment etc. and to conduct the required tests wherever necessary.

5. It is to be understood that the materials proposed to be used on any construction work are to be got tested inevitably before their use and results entered in the registers and suitability assessed and recorded in the material O.K.Register. The quality personnel are expected to appraise the construction staff the necessity and insist in this regard.

6. The quality staff are expected to inspect the quarries and borrow areas from which the materials are proposed to be brought and ascertain the availability of adequate material and its suitability for use.

7. Quality staff are to be present themselves at site as far as possible while collecting samples, involve themselves and cooperate in sending the samples of concrete, soils etc., to laboratory within the scheduled time.

3. The quality staff are expected to go through the test results, note them in a separate register and record their observations wherever necessary. They are to maintain record of the tests conducted and record of B.Ms. verified in a separate register.

). The quality staff shall maintain a clear cut record of the requisitions received from the construction staff and the tests conducted by them at Sub-Division level and division level and present it for verification of higher officers during inspection.

0. It is for the quality control staff incharge of quality control operations of the work to see that the observations made and defects pointed out during inspection by the officers are rectified fully before passing/certifying the work.

The field staff should bring any lapses to the notice of the igher authorities and always communicate the observations to he construction staff incharge of the work in time.

PART - B

2.0.0 **ANNEXURES**

2.1.0 **G.C.Register Proformae 1 to 15 Vide from page 207**

2.2.0 **CLASSIFICATION OF SOILS**

TABLE 4.3
BASIC SOIL COMPONENTS (IS CLASSIFICATION)
(IS : 1498-1970)

Soil	Soil Component	Symbol	Particle-size range and description
Coarse-grained components	Boulder	None	Rounded to angular, bulky, hard, rock particle, average diameter more than 30 cm.
	Cobble	None	Rounded to angular, bulky, hard, rock particle, average diameter smaller than 30 cm but retained on 80 mm sieve
	Gravel	G	Rounded to angular, bulky, hard rock particle, passing 80 mm sieve but retained on 4.76 mm sieve Coarse : 80 mm to 20 mm seive Fine : 20 mm to 4.75 mm sieve
	Sand	S	Rounded to angular, bulky, hard rock-particles, passing 4.75 mm sieve retained on 75 micron sieve Coarse : 4.75 mm to 2.0 mm sieve Medium : 2.0 mm to 425 micron sieve Fine : 425 micron to 75 micron siev
Fine grained components	Silt	M	Particles smaller than 75 micron sieve identified by behaviour : that is slightly plastic or non-plastic regardless of moisture and exhibit little or not strength when air dried
	Clay	C	Particles smaller that 75 micron sieve identified by behaviour, that is, it can be made to exhibit plastic properties within a certain range of moisture and exhibits considerable strength when air dried.
	Organic matter	O	Organic matter in various sizes and stages of decomposition

Table 2-1 Soil Classification (Including field Identification and description) (Clauses 3.3, 3.3.3 and 3.4) I.S. 1498-1970

Table 2-1

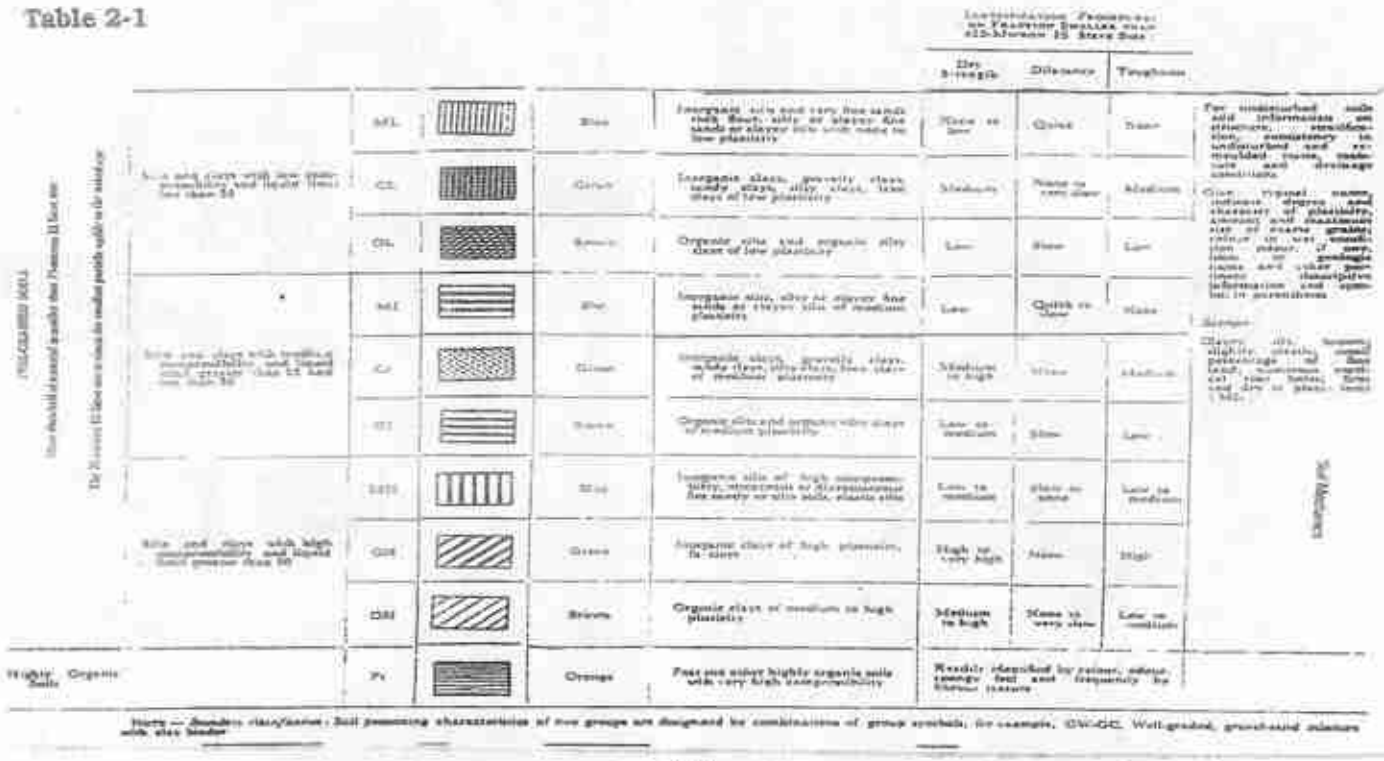


Table 2.2 Classification of Coarse - Grained Soils (Clause 3.5.1 of I.S. 1498-1970)

Group Symbols	Laboratory Classification Criteria		
GW	Cu Greater than 4 Cc Between 1 and 3		Determine percentages of gravel and sand from grain - size curve. Depending on percentage of fines (fraction smaller than 75 micron IS sieve) coarse - grained soils are classified as follows:
GP	Not meeting all gradation requirements for GW		
GM	Atterberg limits below 'A' line or Ip greater than 4	Limits plotting above 'A' line with Ip between 4 and 7 are border-line cases requiring use of dual symbol	Less than 5% GW, GP, SW, SP More than 12% GM, GC, SM, SC 5% to 12% Border-line cases requiring use of dual symbols
GC	Atterberg limits above 'A' line with Ip greater than 7		
SW	Cu greater than 6 Cc between 1 and 3		Uniformity coefficient, $Cu = D_{60} / D_{10}$
SP	Not meeting all gradation requirements for SW		Coefficient of curvature, $Cc = (D_{30})^2 / D_{10} \times D_{60}$
SM	Atterberg limits below 'A' line or Ip less than 4	Limits plotting above 'A' line with Ip between 4 and 7 are border-line cases requiring use of dual symbols	Where, D_{60} = 60 percent finer than size D_{30} = 30 percent finer than size D_{10} = 10 percent finer than size
SC	Atterberg limits above 'A' line with Ip greater than 7		
I_p = Plasticity Index			

2.3.0 DETAILS OF EARTHEN EMBANKMENT (BUND)

TABLE - 2.3 (F.P.S)

Details	Height of bund in feet (Measured from the cleared bed) upto 30'	& 60'
Top width of bund (inclusive of revetment thickness)	6'	8'
Front slope of the casing	2 : 1	$2\frac{1}{2}$: 1
Rear slope of the casing	$1\frac{1}{2}$: 1	2 : 1

Note : For bunds above 60' in height special designs have to be worked out.

S.No.	Name of the components of the bund	Description
1.	Cut-off trenches	To be taken to $\frac{1}{2}$ F.S.D. or upto hard strata with bottom width 6' as minimum. Side slopes $\frac{1}{2}$: 1 for stiff clay - do - 1 : 1 for silty or sandy soil - do - $\frac{3}{4}$: 1 for very loose sand.
2.	Hearting	Top width of 6' is kept with its level one foo above M.W.L. and side slopes: 1 to depending upon the availability of materials.
3.	Berm	8' to 10' width with 3' thickness of murram is provided and this is proposed only when the higher of the dam is more than 30'.
4.	Drainage	Bed filter or bed drains with toe drain and rock toe is provided when F.T.L. from the cleared ground level is more than 10'

PART - C

3.0.0 TECHNICAL SPECIFICATIONS

3.1.0 EARTH WORK EXCAVATION

ALL SOILS

General Excavation of canal/channel/approach channel/ drain/cut off trench/key trench/ toe wall / toe drain/ foundations for structures/cut of wall/chute drains etc all soils HDR I & II/F & F Rock/Nandyal shales/HR/in both wet and dry conditions and disposal of spoil not useful for construction etc are to be carried out as per the drawings.

EXCAVATION

a) Where sub-soil water is expected, the excavation shall be started preferably from the nearest valley.

b) Suitable arrangements for drainage shall be provided to take surface water clear of excavation during the progress of work. Sump pits if found necessary shall be excavated at suitable places and the water thus collected shall be bailed out or let into a nearby valley at his cost.

c) No distinction shall be made as to whether the material being excavated is wet or dry or in water.

d) All washable materials and any soil which generally becomes unstable on saturation such as organic soil, loose soils and expansive soils shall be removed as directed by the Engineer-in-charge.

e) All suitable excavated material shall be used for construction of embankments.

f) Stones of more than 75mm. in size and indurated material shall be removed from material to be used for compacted embankments.

g) In soils the Contractor shall not excavate out side the slopes or below the established grades or loosen any material outside the limits of excavation. Any excess depth excavated below the specified levels it shall be made good at the cost of the contractor to standards as prescribed by the Engineer in charge.

h) The method of drilling and blasting to be resorted to the excavation in rock shall be in accordance with specification "Drilling and Blasting".

i) Above the lining, in case of lined canals and above the proposed water level in case of unlined canals, the rock may be allowed to stand at it's safe angle.

j) Except in areas of rock, all areas to be excavated shall be pre-wetted so that at the time of excavation moisture content, will be at about optimum.

k) During rock excavations, over-hangs or unsafe slopes shall not be permitted.

l) Final cutting for 300 MM. in rock shall be carried out, by controlled blasting or trimming or by chiseling, wedging, barring with the help of pneumatic paving breakers.

EXCAVATION FOR KEY TRENCHES AND CUT OFF TRENCHES

a) Immediately after preparation of the ground surface for embankment and prior to commencement of canal excavation key and cutoff trenches are to be excavated to dimensions, slopes, grades and levels as shown on the drawings.

b) All materials suitable for embankment construction as determined by the Engineer-in-charge based on laboratory test results shall be used in construction of the embankments. Any material unsuitable for embankments shall be disposed off as directed by the Engineer-in-charge on the spoil bank on the rear side of catch drain/toe drain.

SLIDES/SLIPS :

a) If slides occur in cuttings during the process of exacavation they shall be removed.

b) The classification of debris material shall confirm to its conditions at the time of removal.

For excavation in rock, tolerance of 75mm beyond the designed canal profile will however be permitted.

c) Sand and metal in (1:2) ratio using 40mm & 20mm size metal obtained from canal spoil in (4:1) ratio in bed.

d) M 7.5 mix using 40mm. MSA. H.B.Metal graded or approved quality obtainable from canal spoil for side lining.

In the lined canal where expansive type of soil such as C.H.type of soil is encountered and over which cement concrete lining directly be laid, the canal prism shall be over excavated to the extents as directed by the Engineer in charge and such over excavated section shall be filled with suitable cohesive non swelling (CNS) type soil and shall be placed in uniform horizontal layers and compacted as directed by the Engineer in charge.

DEWATERING

If water is met in the excavation due to sub-soil ground water, spring seepage, rain or other causes, it shall be removed by suitable diversion pumping or bailing out and the sub-soil water table shall be kept below the excavation so that the excavation kept dry whenever so required as directed by the Engineer-in-charge care shall be taken to discharge the drained water as not to cause damage to the works, crops or any other property. In case of lined canals, the sub soil water shall not be allowed to be accumulated in the bottom of the canal. The bed/sides shall be moistured to receive lining as directed by the Engineer in charge.

DISPOSAL OF EXCAVATED MATERIAL

a) Material removed in excavation including stripped top soil and expansive soils not required for embankments, back fill or other required earth work shall be deposited in waste, banks on right of way owned by or controlled by the department as directed, by the Engineer-in-charge. A gap of 3M. wide shall be left in spoil banks at 150M. Intervals or as directed by the Engineer-in-charge for disposal of drainage in accordance with cluse 8.20 of IS : 4701-1982.

b) Minimum gap of 1 metre or 1/2 the depth of canal excavation as per drawing (whichever is more) from the edge of the canal excavation canal at G.L. in cutting reaches and 1 m gap from the outer toe of the ebankment to the inner toe of the spoil bank or a greater distance as prescribed by the Engineer in charge shall be maintained.

c) In case of Reservior/Tank works, if the excavated material in stripping under embankment, foundations for sluices, surplus weir, toe wall, toe drain, cut offf trench, over burden removal on the U/S and D/S sluice of surplus weir, surplus course excavation, approach channels to the sluices excavated not suitable for construction of embankment, shall be deposited beyond the toe drain of embankment of reservior/tank, leaving a gap of 1.0 meter or 1/2 the depth of toe drain or more and on either sides of the surplus course on the rear side of the guide banks formed leaving a gap of 1.0 meter or 1/2 the depth of surplus course, or more, as per the drawings and as directed by the Engineer-in-charge. Excavated or foreign materials shall not be left in the foreshore area of the reservior/Tank.

d) Where the canal is aligned on sloping ground, excavation material not required for construction of adjacent embankments at any other place, shall be deposited on the lower side. Where canal is on level or nearly level ground, the material from excavation shall be deposited on embankments on both sides of the canal.

e) In case of deep cutting the spoil shall be so disposed off as not to result in unsighty heaps and shall be leveled and properly dressed. The top of both the finished banks shall slope away from the inner edge with a suitable gradient.

f) If there is excess of useful material from the excavation than needed for construction of embankments of canal/reservior/ tank, it shall be used to strengthen the embankment on either side of the canal/reservior/tank, deposited in low areas uphill of the canal to eliminate trapped drainage, or it should be deposited in stock piles as directed by the Engineer-in-charge. The disposal of excavated material shall be in accordance with clauses 0.1 of I.S. 4701-1982.

g) The useful rock obtained from the cutting shall not be mixed with other soils and shall be closely stacked to the gauge separately beyond spoil bank and all other stone not useful for construction purpose shall be deposited on the slopes of the canal spoil bank.

EXCAVATION FOR STRUCTURES

Description of work :

a) Excavation and depositing the soil on spoil bank or at any place specified by the Engineer-in-charge with all leads and lifts for structures shall consist of the removal of material for the construction of foundations for the Structures like Bridges, U.Ts, Aqueducts, Super-passages, retaining walls, canal side walls, in lets, out lets, head walls, cut off walls, pipe under-tunnels, cross regulators, off-take sluices and other similar structures, in accordance with the requirements of these specifications and the lines elevations and dimensions shown on the drawings or as indicated by the Engineer-in-charge.

b) The work shall include providing all the materials, tools and plants and labour required for presplitting and utilising controlled blasting technique over and above the normal blasting technique in hard rock and quartzes excavation, construction of the necessary coffer dams and cribs and their subsequent removal and necessary sheeting, shoring, strutting, benching, draining and pumping the removal of all logs, stumps, grubs and other deleterious matter and obstructions necessary for placing the foundations, trimming bottom of excavations, all leads and all lifts of excavated material back filling with selected approved material and clearing up the site and the disposal of all surplus materials, spoil and the stone not useful for construction purpose shall be deposited beyond the profile of the structure, canal, stream etc. leaving a minimum gap of 5 metres, and in accordance with clause 8.1 of IS 4701-1982

or at greater distance as directed by the Engineer-in-charge. The useful stone stacking and soils required for back filling shall be placed without foregoing the working space. The material removed in excavation for structures shall be used for backfilling and embankments.

EXCAVATION

a) Excavation shall be taken to the width of the lowest step of the footing and the sides shall be left to plumb where the nature of soil allows it.

b) The depth to which the excavation is to be carried out shall be as shown on the drawings, unless the type of material encountered is such as to require changes in which case the depth shall be as ordered by the Engineer-in-charge.

c) Excavation in rock shall be carried out by crow bars, pickaxes, chisels or pneumatic drills etc. Unless permitted by Engineer-in-charge blasting shall not be resorted to.

d) Where blasting is to be resorted to the same shall be carried out to the requirements of specification 3.3 and all precautions therein observed.

Blasting in a manner as to produce over breakage is excessive shall not be done. In order to minimise over breakage and loosening of material at the finished surface on bottom and side slopes over which foundation concrete is to be laid, final cutting for the last 300mm in hard rock shall be carried out by controlled blasting or chiseling or trimming with the help of pneumatic paying breakers. If excavation is required to be done within 30m. from the existing sructures the same should be carriedout by chiseling, without resorting to blasting.

DEWATERING AND PROTECTION

a) Where water is met with in excavation due to stream flow, seepage, rain or other reasons, adequate measures such as bailing, pumping, construction of diversion channels, drainage channels, bunds, cofferdams and other necessary works to keep the foundation trenches dry when so required and to protect the green concrete/masonry against damage by erosion or sudden rising of water level are to be taken up.

b) Precautions are to be taken in diverting the channels and discharging the drained water as not to cause damage to the works, crops or any other property.

c) Pumping from the interior of a foundation shall be done in such a manner as to preclude the possibility of the movement of water through any fresh concrete. Pumping shall not be permitted during the placing of concrete or for any period of atleast 24 hours thereafter, unless it is done from a suitable sump separated from the concrete works by water tight wall or other similar means.

PREPARATION OF FOUNDATION

a) The bottom of the foundation shall be levelled both longitudinally and transversely or stepped. Before foundation concrete is laid, the surface shall be slightly watered and rammed. In the event of excavation having been made deeper than that shown on the drawings the extra depth shall be made up with concrete or masonry of the foundation grade. Ordinarily earth filling shall not be used for the purpose to bring the foundation level. If hard strata is not met at foundation level shown in the drawings extra depth as directed by Engineer-in-charge shall be excavated to remove unsuitable material.

b) When rock or other hard strata is encountered, it shall be free from all soft and loose material, cleaned and cut to a firm surface either level, stepped or serrated as directed by the Engineer-in-charge. All seams shall be cleaned out and filled with cement mortar or grout to the satisfaction of the Engineer-in-charge.

OVER EXCAVATION

a) If at any point in common excavation, the foundation material is excavated beyond the lines required to receive the structure or the natural foundation material is disturbed or loosened during the excavation process, it shall be done as follows :

i) In excavation of soils, over excavation shall be filled back with suitable selected bedding material and compacted.

ii) The Soils loosened or disturbed shall be compacted by filling extra selected bedding material if found necessary and compacted.

iii) In respect of rock all excess excavation or over excavation for any purpose or reason except for additional excavation as may be prescribed the excess or over excavation shall be filled in by C.C. of grade directly coming over it or M.15

Slips and blows

If there are any slips or blows in the excavation, these shall be removed.

SIDE DRAINS

a) The location, grades and sections of the drains shall be as shown on the drawings and or as directed.

EMBANKMENT CONSTRUCTION

SCOPE

Site clearance, stripping and formation of embankment of homogeneous section/zonal section viz., casing zone/hearting zone with the useful excavated soils and balance soils of approved quality from the borrow area including the cost of soil, if any, sampling, testing and prewetting of soils at source of excavation and conveyance of Soil and extra soils required for shrinkage including swell factor with all leads, lifts, delifts, laying on bank, spreading, breaking clods, sectioning, extra watering and consolidation including benching of Old embankment Slopes, joining with the new embankment formation, trimming of side slopes, formation and removal of ramps, formation of Dowel banks etc., constitute this item.

GENERAL REQUIREMENTS

a) Embankment shall be built to the height, top width and side slopes and all the edges of the embankment shall be neatly aligned symmetrical to the central line. They shall be absolutely straight in all reaches except at bends. At bends they shall be smoothly curved.

b) The top of each embankment shall be levelled and finished so as to be suitable for road way and given a cross slope to drain away rain waters. The bank carrying road shall be given a suitable cross slope.

MATERIAL

a) The suitability of foundation of placing embankment materials thereon and all materials proposed for use in construction of embankment shall be determined well in advance on the basis of Laboratory Test results. Chemical and Physical tests of the material proposed for construction of embankment shall be carried out to ensure that the soil does not contain soluble lime content soluble limesalt content or cohesionless fines, in quantities harmful to the embankments.

b) Material for construction of embankment should be free from the organic material. Unless otherwise directed by the Superintending Engineer/Executive Engineer all materials shall be deposited in embankments so that cobbles, gravel and boulders are well distributed through other material and not vested in any position within or under are embankment as per clause 6.4 of Is. 4701-1982.

c) Suitable excavated material available from the cut off trenches, canal cutting extra cutting for seating to lining. Foundation excavation for structures approach and tail channels for structures, vagu diversions, removal of ramp obstruction removal on the upstream and downstream of surplus weirs and excavation in surplus course and any such excavations, shall be used for construction of adjacent embankments and also embankments of deficit reaches.

d) After completing the construction of embankments with the materials as indicated in (c) above, material required for the construction of balance embankment shall be obtained from the borrow areas.

e) The soils and moorum excavated and useful for construction of the embankment shall be classified by the Superintending Engineer/Executive Engineer as impervious and Semi-Pervious based on Laboratory Test results. They shall be utilised on the embankment work.

f) All portions of excavation made for test pits or other subsurface investigations, all holes, hollows and all other existing cavities found within the area to be covered and to the extent below the established lines of excavation for embankment seat shall be filled in earth of the corresponding zone of the embankment and suitably compacted. The pits of surface boulders shall be filled with suitable material and compacted.

g) Pools of water shall not be permitted in the foundation for embankment and such water shall be deemed and cleared prior to placing the first layer of embankment materials.

h) On sloping ground in case of existing banks, where embankment portions are to be modified, benching of slopes shall be done with a little slope towards the inside of benching so as to give a good grip to the embankment soil with the subgrade. Unless otherwise specified, the benches shall be 0.3 x 0.6m. on the front and rear slope of the embankment. Before benching,

the bank slopes shall be cleared of all roots and vegetables matter. The bank section shall be brought to design standards by filling the scours with suitable material and compacting to 98% proctor density by suitable measure of compaction.

i) **Soil foundation.**

The ground surface under embankment and area of bed filling wherever necessary (except rock surfaces) shall be loosened or scarified making open furrows by means of a plough, or ripper or any other methods to a depth of not less than 200 mm deep below the stripped surface at intervals of not more than 1m. to the satisfaction of the Engineer. Roots or other debris turned up during scarifying, shall be removed from the entire foundation area for the fill. The areas under the embankments shall be prewet by sprinkler before the construction of embankment begins. The moisture content shall be optimum.

j) **Rock Foundation**

The treatment of the rock surface under the embankment shall be done so as to ensure tight bond between embankment and the foundation. This shall be done by the following procedure.

i) The area of the rock surface which is to be in contact with the embankment shall be fully exposed by removing all the loose and disintegrated rock having the surface of rock rugged. Hard rock projects and overhangs shall be removed. If blasting is to be resorted to, care shall be taken to avoid objectional shocks to foundation rock. As far as possible the whole contact area shall be exposed at one time to enable examination of rock surface characteristics and planning the method of treatment.

ii) Exposed rock shall be benched.

COMPACTION

a) **General**

The earth compacting equipment specified in appendix-C of I.S. 4701-1982 shall be used for compacting the soils shown against them. The compacting equipment shall conform to the relevant I.S. Specification.

While the I.S. Specifications specify the compacting. It is contended that the use of improved compaction equipment for embankment construction shall be encouraged as may be most

suited to the site conditions and the programme of construction. The methods of compaction shall conform to clause 7.2.1, 7.2.2 and 7.2.3 of I.S. 4701 - 1982.

COHESIVE MATERIALS

a) When each layer of material has been prepared so as to have the proper moisture content uniformly distributed throughout the material, it shall be compacted by passing the roller. The layer shall be compacted in strips over lapping not less than 0.30 Meter. Rolling shall commence at edges and progress towards centre longitudinally. The rollers shall travel in a direction parallel to the axis of the bank. Turns shall be made carefully to ensure uniform compaction. Density tests shall be made after rolling and dry density attained shall be not less than 98% of the maximum dry density (standard proctor) as obtained in the laboratory for the type of material used. The density achieved shall not normally be less than the designed density. The dry density of soil in field shall be determined in accordance with I.S. 2720 (Part-XXVIII) - 1974 or I.S. 2720 (Part.XXIX) - 1975.

b) Standard proctor desnity test shall be carried out at regular intervals to account for variations in the borrow area materials as well as that in site excavated material. Not less than three tests shall be carried out to indicate variations in the Standard Proctor Density attained in laboratory.

c) In case embankment covers the barrels of cross drainage or any other structures, first 45 cm. of the embankment shall not be compacted with roller but it shall be compacted with pneumatic/hand tampers in thin layer. The compaction above this layer of total 45 cm shall be done by using suitable slight rollers to avoid damage to the structure, by adjusting the thickness of layers until sufficient height is achieved to permit compaction by heavy rollers. Density test shall be conducted from time to time on site to as certain, whether the compaction is attained as specified.

Separate tests shall be conducted for each zone of the embankment for every 1500 cubic metres of compacted earthwork, atleast one field density test shall be taken in each layer. Minimum two density tests shall be taken in each layer per day irrespective of the quantity of earthwork specified.

If) Separate tests shall be conducted for each zone of the embankment for every 1500 cubic metres of compacted earthwork, atleast one field density test shall be taken in each layer. Minimum two density tests shall be taken in each layer per day irrespective of the quantity of earthwork specified above. In case the test shows that the specified densities are not attained, suitable measure shall be taken either by moisture correction or by entire removal and relaying of layer or by additional rolling so as to obtain the specified density which shall be checked again by taking fresh tests at the same locations.

d) Compaction shall be achieved by the use of smooth rollers, pneumatic type rollers, sheep foot rollers, mechanical compactors like vibratory rollers, vibrating plates, programmers, power rammers, slope compacting equipment, pneumatic tamping equipment and such other equipment as shall be specified by the Engineer based on type of material and actual field tests.

e) The dimensions and weight of the rollers should be such as to exert a ground pressure of not less than 12 kg/cm² of tamping when it is empty and 25kg/cm² when ballasted. The number of passes required for each layer to obtain the specified density shall be determined by actual field tests.

COHESIONLESS MATERIALS

a) Where compaction of cohesionless free-draining material such as sand and gravel is required, the materials shall be deposited in horizontal layers and compacted to the relative density specified. The excavating and placing operations shall be such that the material, when compacted, shall be blended sufficiently to ensure the highest practicable degree of compaction and stability. Water shall be added to the materials if required to obtain the specified density depending on the method of compaction being used.

b) As per Clause 6.6.2.1 of I.S. 4701 - 1982, the thickness of embankment layer shall not exceed 25 cms. (Loose) before compaction and it should be spread over the full width of embankment and compaction shall be done by rollers or tampers to obtain specified density. The thickness of the horizontal layers after compaction shall not be more than 10 cm. If compaction is performed by tampers, not more than 15cms. if by 8 to 10 tonnes rollers and not more than 30 cm. If compaction is performed by vibratory or pneumatic rollers or

similar equipment. The relative density of the compacted materials shall not be less than 70 percent as determined by laboratory tests as per I.S. 2720 Part-XIV. If compaction is performed by internal vibrators, the thickness of layers shall not be more than the penetrating depth of the vibrator.

Embankment without controlled compaction.

a) Where the natural ground surface is above the maximum water but below the top of the embankment, the embankment shall be built in layers not exceeding 15 Cm, in thickness and to the full width of embankment. Each layer shall be commenced from the edge farthest from excavation. It shall be compacted with Two ton roller.

b) The excavating and hauling equipment shall travel over the embankment to evenly distribute the material and compacting effect over the whole surface.

EMBANKMENTS WITH CONTROLLED COMPACTION

a) Bushes, roots, sods or other perishable or unsuitable materials shall not be placed in the embankment.

b) i) Embankment materials shall be spread in successive horizontal layers generally not exceeding 25 cm, in thickness (loose layer) in the zones where these are required to be laid extending to the full width of the embankment including slopes at the level of the particular layer. Each layer shall be commenced from the edge farthest from excavation. In no case shall embankments be widened by material dumped from the top.

ii) Top of each layer shall be kept slightly depressed in the centre.

c) i) Extra width of 600 mm. in thickness as measured perpendicular to the slope shall be provided on either side so that when compacted, lines of the finished embankment slopes shall have not less than specified density.

ii) Later the extra width shall be neatly trimmed and the trimmed material shall be re-used in embankment at higher elevations.

d) Thickness of layers shall be adjusted with particular type of compactors used to give the required density by carrying out trial compaction and requisite tests and required number of passes should also be determined.

e) No fresh layer shall be laid until the previous layer is properly watered and compacted as per requirement. The work of spreading and compaction shall be so adjusted as not to interfere with each other and in such a way that neither of the operations is heldup because of non-completion of the rolling and watering. The surface of the banking shall at all times of construction be maintained true to required cross section. If the surface of any compacted layer of earth fill is too dry or too smooth it shall be moistened and scarified to provide a satisfactory bonding surface before the succeeding layer is placed. All the rollers used on any one layer of fill shall be the same type and same weight.

f) It should be ensured that only approved soils are used for construction of embankment.

g) For proper bond of the embankment done in the previous season with the new embankment, the work shall be carried out as detailed below :-

i) In case of the old bank to be extended horizontally. It shall be cut to a slope not steeper than 1 in 4 and the surface so prepared shall be scarified and made loose at least for a depth of 15 Cm. Necessary watering shall be done and the earth surface shall be thus prepared to receive the new embankments. The soils shall be laid in layers and compacted to the required degree of compaction to have a proper bond with the old one.

ii) If the old bank is to be raised vertically, vegetation shall be cleared followed by scarifying, watering and placing of the new earth layer as specified above.

iii) The surface which is damaged due to rain shall be made good by filling with proper soil duly compacted by tampers. A cross slope away from the centre of canal of about 1 in 80 shall be maintained thoughout the rainy season to ensure proper drainage in the event of occasional rainfall.

h) **Settlement allowance :**

i) The canal embankments shall be constructed to a higher elevation than that shown on drawings at the rate of 2.5 cm. per every one meter height of bank if power driven equipment is used and 25cm/ height if other than power driven equipment is used for compaction towards Shrinkage/Settlement.

I) i) Care shall be exercised that all large clods are broken and no clod bigger than say 8 Cm. rock, are buried in the banks.

ii) **Homogeneous Section.**

The homogeneous section or canal embankments shall be provided as specified on the drawings. The available coarser and more pervious materials shall be placed nearby outer slopes in order to have increasing permeability from inner to outer side. The compaction shall be carried out as per Clause. 6.6.2 of I.S. 4701-1982.

iii) **Zonal Embankments**

In zonal sections the selected and approved soils shall be spread to the required widths of respective zones. All the zones shall be tackled simultaneously and the difference in level between zone to zone shall not be more than 150 mm.

MOISTURE CONTENT

a) The initial moisture content of the material shall be determined at the source of supply (all excavations including from the borrow areas) in field laboratory test. Prior to and during compaction operations, the embankment shall have optimum moisture content required for the purpose of compaction and this moisture content shall be fairly uniform throughout the layer as per clause 6.6 of I.S. 4701 - 1982.

In so far as practicable the moistening of the material shall be performed at the site of excavation but such moistening shall be supplemented as required by sprinkling water at the site of compaction, if necessary. Flooding shall not be permitted under any circumstances. Sprinkling of water shall be done either through a proper sprinkler tanker or using proper spray nozzles. Sprinkling straight from the water hose shall not be allowed.

b) If the earth delivered to the embankment is too wet, it shall be dried by aeration, exposure to the sun, ploughing, disc handrowing or other methods till the moisture content is acceptable optimum for compaction. If due to wet weather, the moisture content cannot be reduced to the required optimum by the above procedure, work on compaction shall be suspended until such time the earth has dried to the optimum moisture content.

c) If the moisture content is not uniformly distributed thoughout the layer or less than the optimum rolling shall be stopped and shall be started again only when the above conditions are satisfied.

After adding the required amount of water, if found necessary, the soil shall be processed by means of harrows, rotary mixers or as otherwise approved until the layer is uniformly wet at optimum moisture content.

REFILLING OF KEY TRENCH AND CONSOLIDATION

a) Key trench shall be back filled with impervious material of the same specifications and in the same manner, as for the impervious hearting zone of the embankment of the canal. The impervious soils shall be placed in continuous and approximately horizontal layers not more than 25 Cm. (loose) and compacted by 8 to 10 Tonne Power roller under optimum moisture content.

b) Rolling shall be done along the key trench and the roller shall be taken close to the sides of the trench.

c) In cases where the compaction by rollers is not possible, compaction to the required density shall be achieved by such other means as specified by the Superintending Engineer/ Executive Engineer.

d) Each layer shall be compacted to achieve the required dry density of not less than 98% of the maximum dry density (Proctor's density) for the type of material at optimum moisture content.

e) During placing and compaction of impervious soils in the key trench where dewatering is involved, the sub soil water level at every point in the key trench shall be maintained below the bottom of the earth fill until the compacted fill in the key trench at that point has reached a height of 3 m after which water level shall be maintained at least 1.5 m below the top of compacted fill.

COMPACTING BY OTHER THAN POWER DRIVEN EQUIPMENT

a) This shall conform to that of embankments compacted by power driven equipment except that instead of using powerdriven rollers ordinary rollers driven by tillers shall be adopted for compaction if the work is at small magnitude. No manual compaction shall be allowed except through the use of pneumatic tampers laid only very occasionally hand tampers shall be used.

b) Thickness of layer shall not exceed 150 mm before compaction (loose).

c) Each layer shall be compacted to not less than 90% dry density (Proctor density) at optimum moisture unless otherwise specified.

d) Any loose soil shall be removed by trimming and bringin embankment and side slopes of canal to the sections shown o the drawings.

DOWEL BANKS

a) Dowel Banks shall be constructed to the dimensions, grade slopes as show on the drawings.

BORROW AREA CONSIDERATION

a) The only suitable soils are to be used for formation of embank ments, out of the soils excavated based on Laboratory te results, the borrow soils from the borrow area after te checking the suitability of the soils for the embankments fo particular embankment work.

BORROW PITS

1. The borrow pits shall not normally be more than 25 M in length and 10 M in width and 1 1/2M depth. A clear spacing of on metre between each pit shall be left out. Each pit shall be clear peg marked and number tags of the pits shall be maintained
2. In the case of earth dams unless otherwise specified the borro pits shall not be located within a distance of 10 times the heigh of the embankment on the upstream side and two times th height of the embankment on the down-stream side.
3. The depth of the pits shall be so regulated that their botto does not cut the hydraulic gradient line having a slope 4:1 fro the top edge of the embankment.
4. In no case the pits shall be located within 5m from the toe of th embankment. If there are old pits in the borrow area the ne pits shall be located one metre away from them.

STRIPPING OF BORROW AREAS

a) Borrow areas shall be stripped of top soil and any othe objectionable materials to the required depths. Materials fro Stripping shall be deposited off in exhausted borrow areas o in the approved adjacent areas. Particular care shall be take to exclude all organic matter from the barrow area. The cleare areas shall be maintained free of vegetable growth during th progress of work.

Classification of soils to be used, for homogeneous earth fill embankment and zonal embankments

a) For homogeneous embankments : (Used with soil only)

Sl. No.	Soil classification	Remarks
1.	GW, G.P., S.W, S.P.	Not suitable
2.	G.C, G.M, S.C, S.M.	Suitable
3.	C.L, M.L	Fair
4.	CH, M.H	Poor

b) For zonal sections embankments

Sl. No.	Soil classification		Remarks
	Casing	Hearting	
1.	G.W, S.W. S.P, S.C.	G.C, G.H, S.C, S.M. C.L, M.L	Suitable
2.	-	C.H, M.H.	To be used with caution

TOLERANCES :-

For hearting zone :- +1% moisture

For casing zone :- 1% to +2% moisture.

1. Statement showing the intervals for various heights of embankments for conducting the control tests :

As per Technical circular No. CE/Medium/Correspondence/ 96, dated 23-06-1996)

Sl. No.	Height of the Embankment	Distance between two consecutive test points. (For a quantity of 500 M3)
1.	0 to 5 M	200 M
2.	5 to 10 M	100 M
3.	10 to 15 M	50 M
4.	15 M and above	

Note :-

a) For the above cases, the height of each compacted lift, is take as 15 cm, when the roller of 8 to 10 T capacity is used, loo layer shall be 20 cm thick.

b) When sheep foot rollers are used the loose layer depth shall $1\frac{1}{4}$ times the length.

c) Test pits shall be staggered, both horizantally, and vertically f each layer.

2. **Shrinkage Allowance**

a) In firm compacted earth :- $1\frac{1}{2}$ inches per foot of length of n embankment.

(12.50 cm per meter height)

b) In ordinary loose earth :- 2 inches per foot of height of ne embankment

(16.67 cm per meter height)

c) In black cottons soils :- 3 inches per foot of height of ne embankment

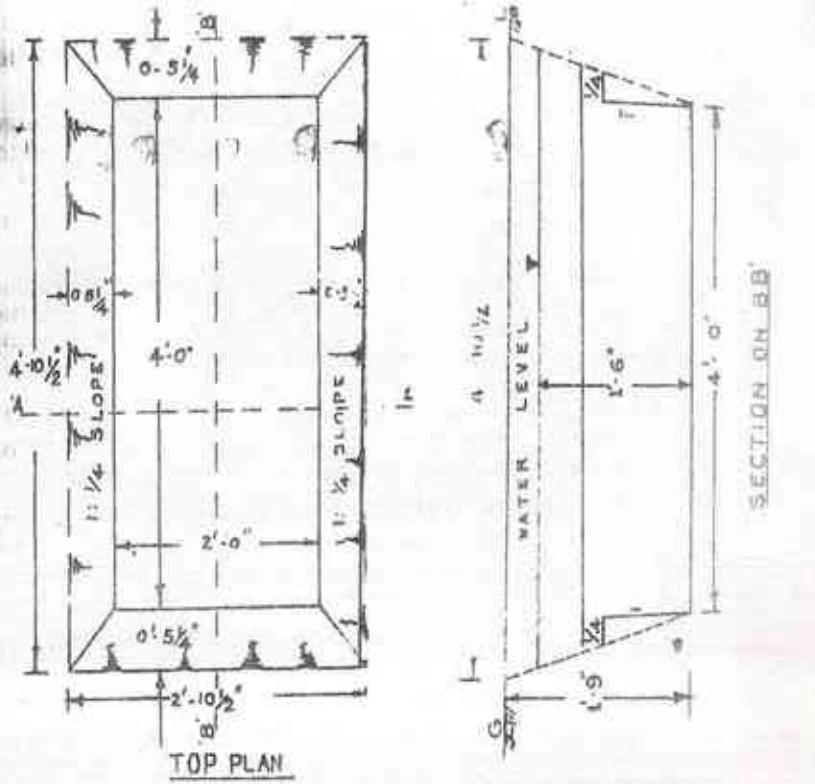
(25 cm per meter height)

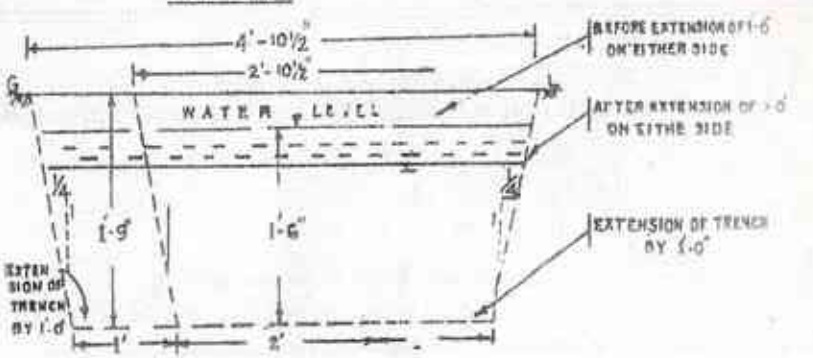
(As per para 4 of section 3 (earth work etc) of MDSS)

d) An allowance of about 10% for settlement is recommended fo embankment in which controlled compaction has not bee carriedout. (Para 6.2.2.1 of I.S 4701 - 1982)

e) For compacted banks with 2 cm per meter height 8 to 10 roller.

3.2.0 **PROCEDURE FOR THE DETERMINATION OF PERMEABIL ITY (INSITU) (JAPANESE METHOD)**





NOTE:-
SIDE SLOPES OF THE TRENCH DEPEND ON THE SOIL MET WITH BUT ARE TENTATIVELY PROVIDED AS ½:1. TRENCH MAY BE EXCAVATED WITH VERTICAL SIDES IF THE SOIL PERMITS.

Fig. 4.2 IN SITU PERMEABILITY TEST (TRENCH METHOD) (JAPANESE METHOD) SCALE 1"=1'-0"

1. Scrap all the top loose material at the desired areas for a extent of 6' x 6'.
2. Make a trench of bottom dimensions 4' x 2' and 1' deep wit side slopes of $1:1\frac{1}{4}$. The trench may be excavated with vertica sides if the soil permits.
3. Have a cane calibrated in 1/10 gallons from which water ca be fed in to the pond.
4. Fill up the trench with water to a depth of 3' from the top an go on feeding water in to the trench from the reservior so tha water level is maintained constant at a depth of 3' from the to surface.
5. Record the water intake every one hour.
6. The experiment should be continued till the intake reading are steady, say for a period of 4 hours (at least).
7. Extend the pit to the dimensions of 4' x 4' at the bottom b cutting an extra width of 1 ft. On either of the shorter side of the trench.
8. Feed the trench with water as in the previous case maintain ing the water level in the pit 3' from top.
9. Measure the intake every one hour for a period of 2 hours o more till the intake is constant.
10. Determine the extra amount of water required to maintain the level in the pit after it has been extended.

If the extra amount of water is 1/100 gallon per hour, the permeability is 1 ft/year.

If the extra amount of water is 1/10 gallon per hour the permeability is 10 ft/year.

If the extra amount of water is 1 gallon per hour the permeability is 100 ft/year.

Suppose Q = 1/100 G.P.H. then K-1 ft. per year.

= 1/100 G.P.H. to 1/10 G.P.H. is in the limits 1 - 10 . ft/year.

= 1/100 G.P.H to 1/10 G.P.H is in the limits of 10 - 100 ft/year

1 G.P.H = 100 ft/year

1 Gallon = 4.536 litres

1/10 = 453.6 C.C.

1/100 = 45.36 C.C.

Note :-

1. After excavating the pit, the bottom and sides may be scarified with an iron tool like trovel or spades and kept away from sun flame till water is fed in to the pit so that the natural compaction and soil moisture are not disturbed.
2. The bottom of the pit after dewatered and before excavating the width from 2' to 1' shall be covered by polythene cloth or tarpaulin or an impervious covering or gunny bags. Only one person should be allowed to work in the pit. (So that the humidity relations etc., remain constant through out the experiment).
3. While extending the width of bottom of trench remove the excavated material with minimum disturbance to the foundation soil in the trench.

3.3.0 CORE CUTTER APPARATUS FOR SOIL DENSITY - TESTING PROCEDURE (IS : 2720 (Part XXIX - 1975))

In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country. This has been met by basing the standard on the following publications :

BS 1377 : 1974 Methods of testing soils for civil engineering purposes.

British standards institution.

INDIA. MINISTRY OF IRRIGATION AND POWER, CBIP Publication No. 42 Standards for testing soils, 1963. Central Board of Irrigation and Power, Delhi.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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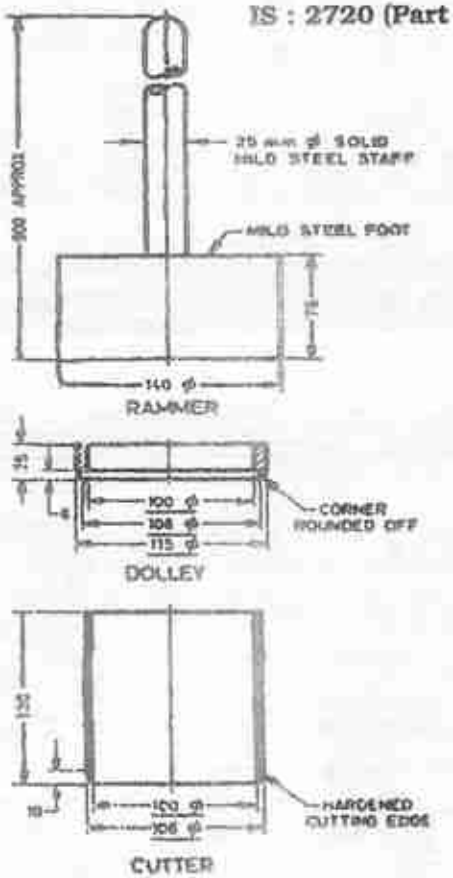
* Methods of test for soils : Part -II determination of water content (Second revision)

1. SCOPE

1.1 This standard (Part XXIX) covers the method for determination of the in-place density of fine-grai natural or compacted soils free from aggregates usin core-cutter.

1.1.1 For the purpose of the tests described in this stand a soil shall be termed as fine-grained soil if not less t 90 percent of it passes a 4.75 mm IS sieve.

2. APPARATUS



Note 1 — These designs have been found satisfactory, but alternative designs may be employed provided that the essential requirements are fulfilled.

Note 2 — Essential dimensions are underlined. (Tolerance on all essential dimensions shall be ±0.25 mm).

All dimensions in millimetres.

FIG. 1 CORE-CUTTER APPARATUS FOR SOIL DENSITY DETERMINAT

2.1 Cylindrical Core-Cutter - of seamless steel tube, 130 mm long (see Note 1) and 10 cm internal diameter, with a wall thickness of 3 mm, bevelled at one end, of the type illustrated in Fig. 1. The cutter shall be kept properly greased or oiled.

Note :- 1. Length of cutter - If the average density over a smaller depth is required than the appropriate length of cutter should be used.

2. Where situations permit, for quality control purposes smaller size cutters have also been used.

2.2 Steel Dolley - 2.5 cm high and 10 cm internal diameter with a wall thickness of 7.5 mm with a lip to enable it to be fitted on top of the core-cutter (See Fig. 1)

2.3 Steel Rammer - with solid mild steel foot 140 mm diameter and 75 mm height with a concentrically screwed 25 mm diameter solid mild steel staff. The overall length of the rammer including the foot as well as the staff should be approximately 9 Kg (See Fig. 1).

2.4 Balance - Accurate to 1 g.

2.5 Palette Knife - A convenient size is one having a blade approximately 20 cm long and 3 cm wide.

2.6 Steel Rule.

2.7 Grafting Tool or Spade or Pick Axe.

2.8 Straight Edge - A steel strip about 30 cm long, 2.5 cm wide and 3 to 5 mm thick, with one bevelled edge will be suitable.

2.9 Apparatus of extracting samples from the Cutter -Optional.

2.10 Apparatus for determination of Water content - In accordance with IS : 2720 (Part-II) - 1973.

3. PROCEDURE

3.1 The internal volume (Vc) of the core-cutter in cubi centimetres shall be calculated from its dimension which shall be measured to the nearest 0.25 mm.

3.2 The cutter shall be wieghed to the nearest gram (Wc).

3.3 A small area, approximately 30 cm square of the soil laye to be tested shall be exposed and levelled. The steel doll shall be placed on top of the cutter and the latter shall b rammed down vertically into the soil layer until onl about 15 mm of the dolly protrudes above the surfac care being taken not to rock the cutter (see Note). Th cutter shall then be dug out of the surrounding soil, car being taken to allow some soil to project from the lowe end of the cutter. The ends of the soil core shall then b trimmed flat to the ends of the cutter by means of th straight edge.

Note :- The cutting edge should be kept sharp. The cutter shou not be used in stoney soils.

3.4 The cutter containing the soil core shall be weighed to th nearest gram (Ws)

3.5 The soil core shall be removed from the cutter an representative sample shall be placed in an air-tig container and its water content (w) determined as in IS 2720 (Part-II) - 1973.

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Note :- It is necessary to make a number of repeat determin tions (at least three) and to average results, since the d density of the soil varies appreciably from point to poi The number of determinations should be such that additional one would not alter the average significant

4. CALCULATIONS

4.1 The bulk density Y; that is the weight of the wet soil per cubic centimetre shall be calculated from the following formula;

$$Y = \frac{W_s - W_c}{V_c} \text{ g/cm}^3$$

Where

W_s = Weight of soil and core-cutter in g,

W_c = Weight of core-cutter in g, and

V_c = Volume of core-cutter in cm3.

4.2 The dry density Y_d, that is, the weight of the dry soil per cubic centimetre shall be calculated from the following formula :

$$Y_d = \frac{100 Y_b}{100 + W} \text{ g/cm}^3$$

Where

Yb = bulk density (see 4.1), and

W = Water content of the soil (percent) to two significant figures

5 REPORTING OF RESULTS

5.1 The results of the test shall be recorded in suitable form. A recommended proforma for the record of the results of this test is given in Appendix- A.

5.2 The following values shall also be reported :

a. Dry density of the soil to second place of decimal in g/cm^3, and

b. Water content of the soil (percent) to two significant figures.

IS : 2720 (Part XXIX) - 1975

APPENDIX A

(Caluse 5.1)

DETERMINATION OF DRY DENSITY OF SOIL IN-PLACE (CORE-CUTTER METHOD)

A-1 The test results shall be tabulated as follows :

Project : Tested by :

Location : Date :

1.	Determination No.	1	2	3
2.	Weight of core-cutter + wet soil (W_s), in g			
3.	Weight of core-cutter (W_c), in g			
4.	Weight of wet soil ($W_s - W_c$), in g			
5.	Volume of core-cutter (V_c), in cm^3			
6.	Bulk density $Y=\frac{W_s-W_c}{V_c}$ g/cm^3			
7.	Water content container No.			
8.	Weight of container with lid (W_1) in g			
9.	Weight of container with lid and wet soil (W_2), in g			
10.	Weight of container with lid and dry soil (W_3) in g			
11.	Water content (W), in percent $W=\frac{W_2-W_3}{W_3-W_1} \times 100$			
12.	Dry density $Y=\frac{100\,Y}{100+w}$, in g/cm^2			

4.0 Consolidation with 2 Tonne roller - circular memos.

opy of :- Office of the Superintending Engineer, CERP QC Circle, Dowlaiswaram - 533 125.

Circular Memo. No. SE/CERP. QCC/OT-W/Gel-1/Vol-5/293 M, dt. 20-3-93.

Sub :- CERP WORKS - Conducting compaction tests for the standard banks compacted by other than power driven equipment - certain insructions issued.

Ref :- Arising.

❀❀❀

An instance has come to notice that some of the field staff are the opinion that compaction tests need not be conducted to now the proctor's density achieved inrespect of the standard anks formed by consolidating the banks with 2 Ton Rollers, attle treading or by other means i.e., other than power driven ollers. The assumption of Executive Engineers is not correct.

In this connection, the attention of the Executive Engineers s drawn to the relevant specifications laid down under specifica-on No.302 of APSS which are reproduced hereunder.

Specification No. 302.

Embankments compacted by other than power driven equip-ent. 302-4 :- Forming embankments :- This shall conform to lause 303.6 except that instead of using power driven rollers, rdinary rollers drawn either by bullocks or by manual labour and r including tamping with wooden or iron rammers, shall be dopted for compaction. Thickness of layers shall not exceed 150 m before compaction. Layer shall be compacted to atleast 90% roctor's density unless otherwise specified. Any loose soil shall e removed by ramming and bringing the embankment to the equired section.

02.5:- Tests :- This shall conform to clause 303.8 The relevant clause 303.8 is also reproduced hereunder

03.8Tests :- Quality control tests shall be regularly carried out to determine the suitability of the soils used for the embank-ment and to control the moisture content and to ensure that

the density as specified in the relevent clause has be attained. The number and frequency of such tests shall done in accordance with the relevant Indian Standards.

In veiw of the above all the Executive Engineers incharge CER Project works are requested to conduct core tests for eve layer of the embankment where there is provision for consolid tion with 2 T Roller or by any other means ie., other than pow driven equipment so as to ensure the required density as specifi in the relevant clauses is achieved. The tests so conducted may furnished to the concerned officers along with progress report

Further the Executive Engineers are requested that the s samples for which the soil is proposed to be utilised in t embankments should be tested to its corrrect MDD value adopting the same in conducting core tests of layers is achieve Any other tests of the soil samples that may be required to ver its suitability for embankment should also be conducted in vi of the safety of the embankments. The above instructions shou be followed during the execution of all the embankments by t construction staff and also should be checked by the qual control field staff.

The receipt of this memo may be acknowledged in th fi instance.

To
All the Executive Engineers
including (QC EEs) incharge
of CER Project works.

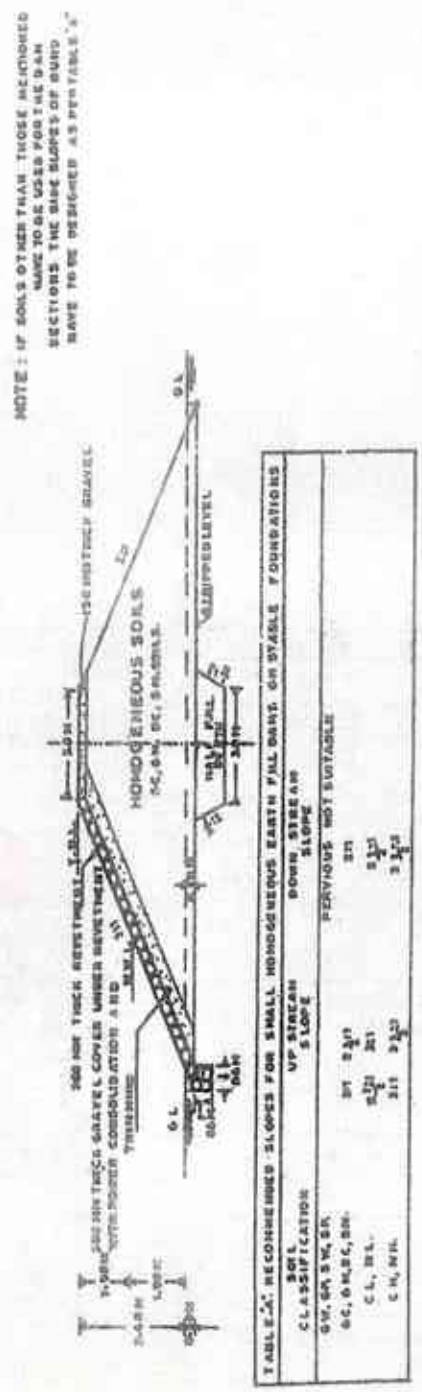
Sd/-
Superintending Engine
CERP QC Circle,
Dowlaiswaram.

Copy to all the Superintending Engineer's incharge of C Project works for information with a request to issue necessa instructions to their subordinate staff in this regard.

Copy submitted to the Chief Engineer, CER Proje Dowlaiswaram for favour of information and necessary acti

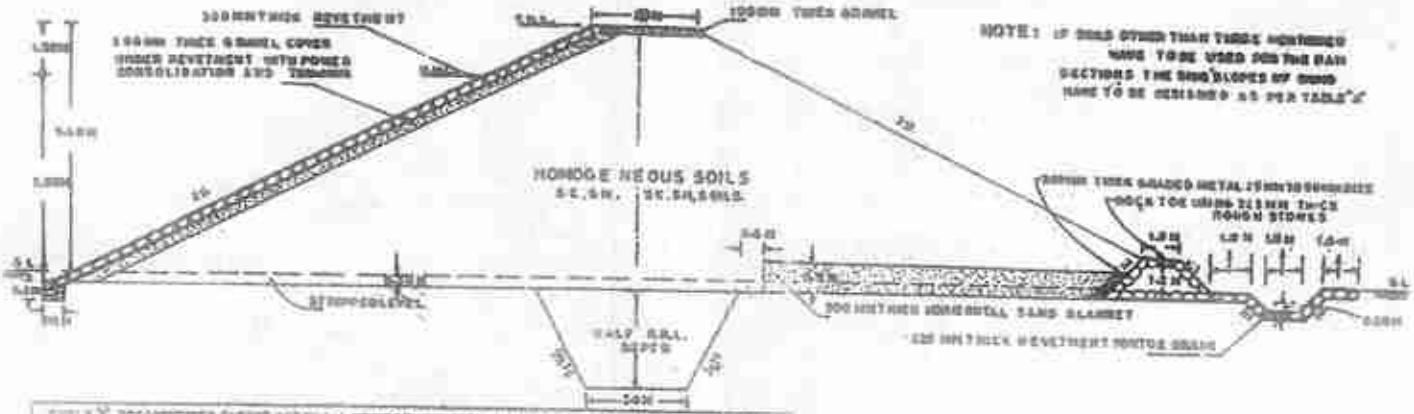
Sd/-
Superintending Engine
CERP QC Circle,
Dowlaiswaram.

3.5.0 ZONAL SECTIONS OF EARTH DAMS



EARTH DAM SECTION UPTO 34M HEIGHT

SCALE:

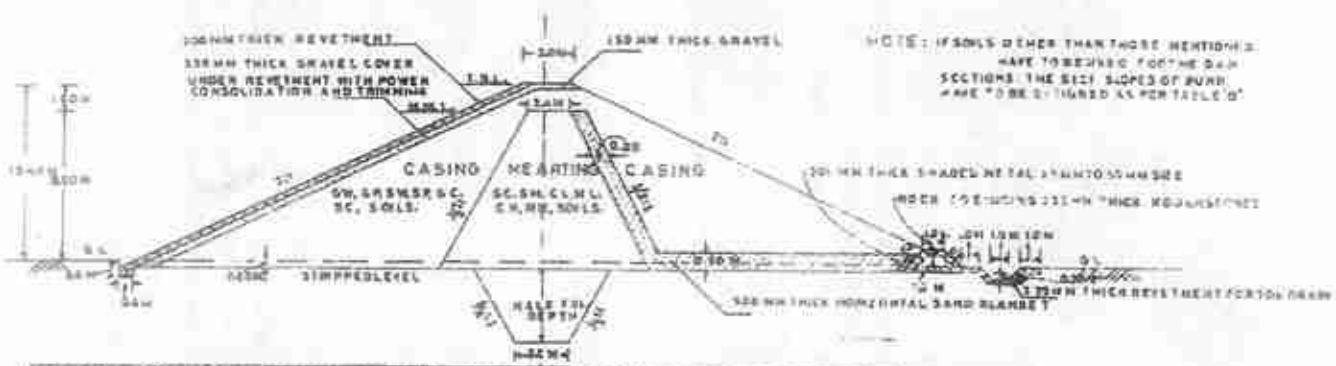


SOIL CLASSIFICATION	UPSTREAM SLOPE	DOWN STREAM SLOPE
GW, GP, SW, SP, GC, SC, SM, SC-SM		PERVIOUS NOT SUITABLE
CL, ML		
CH, MH		

EARTH DAM SECTION 3.5 M TO 7.4 M HEIGHT

SCALE :

T. HANUMANTHA RAO

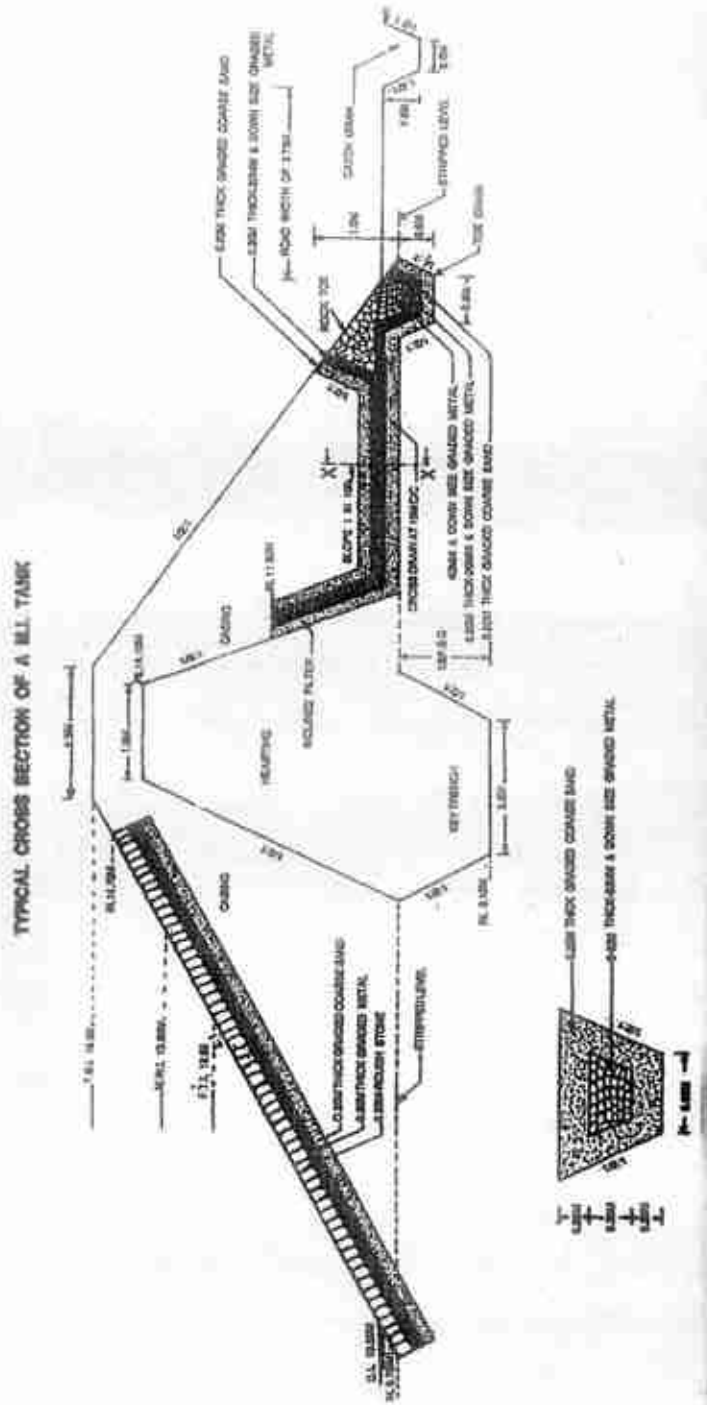


SL NO	CASE	CASING SOIL CLASSIFICATION	HEARTING SOIL CLASSIFICATION	UP STREAM SLOPE	DOWN STREAM SLOPE
1	ZONAL SECTION WITH 1(U) SLOPES FOR HEARTING SOILS	GW, GP, SW, GRAVELLY SP (GRAVELLY) GC, SC	SC, SM, CL, ML, CH, MH.		
2	ZONAL SECTION WITH (U) SLOPES FOR HEARTING SOILS	GW, GP, SW, GRAVELLY SP, GRAVELLY GC, SC.	CL, ML, CH, MH.		

EARTH DAM SECTION 7.5 TO 10.4 M

SCALE :

T. HANUMANTHA RAO
CHIEF ENGINEER



TYPICAL CROSS SECTION OF A M.I. TANK

3.6.0 BACK FILL

BACK FILL ABOUT STRUCTURES

GENERAL

a) The item for back fill about Structures including pipe portions of structures is to be carried out as per specifications.

b) **Materials**

The type of material used for back fill the amount thereof and the manner of depositing the material shall be subject to approval of Engineer-in-Charge. In so far as practicable back fill material shall be obtained from material moved in required excavations for structures. But when suifficient suitable material is not available from this source or from adjacent Drain excavation, additional material shall be obtained from approved borrow areas. The borrow pit excavation, shall be in accordance with clause 9.1 to 9.3 of I.S. 4701-1982.

Except as otherwise provided below, backfill material if to be compacted shall contain no stones larger than 80 millimetres in diameter and if not to be compacted shall contain no stones larger than 130 millimetres in diameter. If the excavation for the foundations of the structure is in swelling soils, a layer of cohesive non-swelling soil conforming to I.S 9451 - 1980 should be interposed between the swelling soil of the structure and compacted to atleast 95% standard proctor's density.

c) **Placing Back Fill**

Back fill shall be placed to the lines and grades shown on the drawings as prescribed in this paragraph or as directed by the Engineer-in-Charge. All backfill shall be placed carefully and spread in uniform layers so that all spaces about rocks and clods will be filled. Backfill shall be brought up as uniformly as practicable on both sides of walls and all sides of structure to prevent unequal loading. Backfill shall be placed to about the same elevation on both sides of the pipe positions of the structures to prevent unequal loading and displacement of pipe.

d) **Structures on Fill**

Where the original ground surface is below the base of a structure or below the bottom of pipe all fill required for the structure foundation and all fill upto the bottom of the pipe

shall be placed as compacted embankment. Th: embankme
over the natural ground upto pipe bottom and over the pi
shall be laid in accordance with clauses 9.2.4 : 9.2.5 and 9.2
of I.S. 783, Indian code of practice for laying of concrete pipe
Clauses 9.2.4.; 9.2.5 and 9.2.6. incorporated specify that th
compacted backfill shall be placed in horizontal layers n
exceeding 15 centimetres after compaction. Heavy stones sha
neither be dropped on top of the pipe nor shall be allowed to r
down the side of the embankment against the pipe.

Compacting Back Fill About Structures

a) **General** :

Unless otherwise shown on the drawings backfill about stru
tures shall be compacted as prescribed in 3.1.2. The compac
ing equipment shall be so selected as to give maximum safe
to the structure. The compaction of backfill under or over th
pipes shall be in accordance with clauses 9.2.4.; 9.2.5. an
9.2.6. of I.S. 783. In the case of very high embankments, th
embankments shall be built to an elevation above the top of th
pipe equal to the external diameter of the pipe after which
trench shall be excavated and the pipe laid. When the backf
is placed above the pipe, the vertical surfaces of the trenc
above the top of the pipe shall not be more than 20 centimetre
beyond the outside diameter of the pipe. After the pipe has bee
laid, suitable backfill material shall be placed around the pip
and carefully compacted in lyaers, not more than 15 centimetre
after compaction upto the top of the pipe. Thereafter, a loose f
of a depth equal to external diametre of the pipe shall be place
before further layers are added and compacted.

Compacted backfill shall be placed in horizontal layers n
exceeding 15 centimetres after compaction.

b) **Material And Compaction** :

The material used for backfill to be compacted shall be selecte
material containing no stones larger than 80 millimetres or a
approved by the Engineer-in-Charge and obtained from re
quired excavation or approved borrow pit. To prevent unequa
loading and displacement of a pipe, the backfill shall be place
and compacted in layers having essentially the same to
elevation on each side of the barrel.

EMBANKMENT

a) **Dowel Banks**

Dowel banks of size 500 mm x 500 mm with side slopes 1 : 1/2 :1 upto and beyond 5 m width of banks and of size 250 mm x 250 mm with side Slopes 1 1/2 :1 below 5m width of banks shall be provided.

3.7.0 EARTH WORK BY MACHINERY

INTRODUCTION

Heavy earth moving machinery is an automobile with special arrangements for self loading and unloading the earth. Movement of earth for short distances, is generally economically done by these specially designed machinery. The general heavy earth moving machines are (1) Dozers (2) Scrapers (3) Excavators and Cranes (4) Dumpers (5) Loaders etc.,

The Heavy earth moving machine basically consists of:

1. Engine (Generally diesel)
2. Clutch (Mechanical or fluid type)
3. Transmission (Direct drive or power shift)
4. Final drive (Tyre or track)
5. Steering unit (Mechanical or power)
6. Special attachment (Mechanism) for doing the work intended by the machine.

TRACTORS

Tractors have many uses in earth work construction. Tractors can be either (1) Wheel type or (2) Crawler type. The wheel type tractors are generally used as prime moves for (1) Scrapers (2) Dumpers (3) Trailors etc which will have very fast movement compared to crawler type.

The crawler type tractors are generally used as dozers, with special attachments. Crawler tractors which have more tractive force than the wheeled type tractor of the same H.P.

Selection of tractor is based on the facts.

1. Size of job

2. Type of job (ie. Bull dozing, pulling, ripping pushing and cleaning etc.
3. Type of footing ie., high tractive or low tractive.
4. Firmness, smoothness, slope, length of haul road.
5. Scope of further work after completion of the job.

The tractors can be either directive drive or powershift with Torque converter. Capacity of tractor generally specified with rated draw bar pull (ie., for continuous use) for crawler tractors and rated rim pull in case of wheeled tractors.

As the speed increases, the pulling speed capacity of tractor gets reduced.

Pull x Velocity = constant for a machine of given H.P.

(Work done)

Bull Dozer :

This is a crawler tractor with blade attachment. It is very versatile machine and very much useful in construction works. The main type of works that can be done with dozers are

1. **Moving the earth :-** Moving earth with dozer is also called dozing. Generally earth is moved with dozer for short distances ie., upto 300 ft. in the jobs such as excavating ponds, trench silos, high way cuts, stripping top soils, back filling trenches, spreading earth etc.,

   The output of a dozer is volume of earth moved.

   $$V=\frac{L \times H \times W}{2} \text{ Cu m. Per one Cycle (Trip)}$$

   $$V \text{ per hour} = \frac{L \times H \times W}{2} \times N, \text{ N=No. of trips per hour.}$$

2. **Land clearing**

   Land clearing operation involves

   1. Removal of trees, stumps including roots.
   2. Removal of surface vegetation.
   3. Disposal of vegetation by stacking and burning

The Bull dozer equipped with special V blade

2. rake, 3.clamp rake, 4.heavy chains, 5.root plough, 6.grapple shear cut are generally used.

Time required for clearing one acre land.

T = B+M1N1 + M2N2 + M3N3 + M4N4 + DF.

B = Basic time required for one acre.

M = Time required for tree in each dia range

N = No. of trees in each dia range

D = Some of diametres of left over heavy trunk trees

F = Time required for foot of diameter to make fall the trees larger than 6'dia

$$\text{Cost of clearing land} = \frac{\text{Total working cost of dozer}}{\text{Area cleared}}$$

3. **Ripping rocks :**

Ripping of rock which was not easy previously is now very easy and economical due to

1. More powerfull dozers
2. Improvement in sizes and performance of rippers.
3. Better instruments to find out the rippiability of rock.
4. Improve techniques in using instruments & equipment.

The cost of ripping and hauling with scrapers amounts to 50% of the cost of drilling, blasting, loading with shovels and hauling with trucks.

SCRAPERS

The scrapers are becoming more prominent in earth moving operations because the scraper is self loading and unloading machine and independent on other equipment performance operations, ie, loading and unloading are very quick compare to other equipment. The only disadvantage of scraper is that the earth will not be mixed like shovels excavation.

Types of scrapers :

1. Crawler tractor pulled.

2. Wheel tractor pulled.

a. Single engine, b. Twin engine, c. Two bowl Tandem, d. Elevati scraper.

Size of scraper : Size of scraper is expressed as struck heaped capacity of bowl expressed in cubic yards.

Operating scraper : Scraper bowl is lowered until the cutti edge enters into ground and the apron is opened to allow t soil cut is entered into bowl. While pushing the scraper forwa by scraper or even self operation continued till bowl is filled u with soil and apron is closed and bowl is raised above groun

The scraper after reaching to site the cutting edge is lower to the extent of thickness earth layer is required, apron raised an earth is forced out of bowl by the ejector (Tail gate).

Cycle time : It is the time required for a scraper to load, ha dump, and return to original position.

Cycle time in minutes.	1. Fixed time	a. loading	-	1.0
	+			
	2. Variable time	b. dumping	-	0.5
	Turning			
	c. Accelerating		-	0.4
	a. Haul time			0.4
	Distance			
	Speed/min			1.9
	b. Return time			
	- do -			1.0
				5.2
				minute

Operating efficiency : is the ratio of actual metres worked b scraper in an hour to the 60 mts. available. This will range fro 55 Mts for best operation to 40 Mtrs for poor operation.

SHOVELS (EXCAVATORS)

The types of excavators are:

(1) Power shovels (2) Back hoes. (3) drag lines, (4) Clamp shells cranes, (5) trenching machines, 6. Wheel mounted belt loaders.

Shovels are used to excavate earth and load in wagons or dumpers. They excavate all type of earth except solid rock. Without prior loosening.

Size of shovel : is generally indicated by the size of the dipper (bucket expressed) in Cu.yard. Life period of shovel generally depends upon the size of shovels. Bigger the size, greater the life period. Life period varies from 8 years or 15000 hours for 1/2 cu. yard bucket shovel to 16 years or 30,000 hours for 5 cu.yard bucket shovel.

Basic parts of shovel : 1) Mounting (2) Cab. (3) Boom. (4) Dipper stick. (5) dipper selection of shovel is based.

1. job quantum
2. Lifts
3. Material to be handled
4. Toughness of material
5. Time of completion
6. Size of hauling units
7. Limitations in trasportation

The ideal ratio of dumper capacity to shovel dipper capacity is 6:1.

Optimum depth of cut : is the depth of digging by dipper which produces maximum out turn. In this depth of cut the dipper comes with full load without undue crowing in spilling. The optimum depth of cut varies with (1) class of soil, (2) size of dipper.

Class of soil	Size of shovel	Optimum depth ft	Ideal output Cu. yards
Good common earth	1/2 cu. yards	5.7	95
	3/4	6.8	135
	1	7.8	175
	1 1/2	9.2	240
	2	10.2	300
	2 1/2	11.2	350

Output of shovels :

Actual output of shovel is affected by the numerous factors as following.

1. Class of material
2. Depth of cut
3. Angle of swing
4. Job conditions
5. Management conditions (Men, Material, Machine)
6. Size of hauling units
7. Skill of operator
8. Condition of shovel.

DRAG LINES :

Drag lines are excavators only but fitted with drag bucket instead of dipper. Drag lines are well suited for deep foundation because of greater working radius and higher lifts and depths.

Drag lines can be, crawler of wheel mounted. The capacity of drag line is limited by the lifting force. The combine force generated by the weight of bucket and load should not exceed 75% of lifting force required to till the dragline, smaller boom, bigger bucket vice versa.

TYPICAL WORKING RANGES OF CABLE DRAG LINE

1. Boom length 50 ft.
2. Capacity of bucket 1200 lbs.

WHEEL EXCAVATORS :- Basically consists a wheel with buckets, the milling action of wheels permits the excavator to get any material including weathered and broken rock depth of cut 13' or more assures blending of soils giving more facilities for compaction and placement.

TRUCKS AND WAGON :

Trucks or wagons are generally used to haul any type of materials. These trucks can be either on road or off the road trucks depending upon whether they are permitted on highways or not. Most of road trucks are made for specific purpose.

Capacity of trucks are generally mentioned either in Tonnes (Weight) or in cu.metres (Volume)

Trucks are (a) Rear dump (b) bottom dump (c) side dump

1. Effect of size of excavator on cost of excavating and Hauling.

Sample calcultion for 1 Cu. yard

Out put of shovel at 80% efficiency 0.80 x 175=140 Cu.yards per hour.

Truck capacity 15 Cu. yards, Truck time =8 Mts.

Time required to load truck $= \frac{15 \times 60}{140} = 6.4$ minutes

Round trip time per truck 6.4+8 = 14.4 minutes

(Cycle time)

No. of trucks needed $\frac{14.4}{6.4} = 2.25$

to decide whether to use 2 or 3 trucks

Output using 2 trucks $\frac{2.0}{2.25} \times 140 = 125$ cu.yards

Output using 2 trucks 2 x 500 = 1000

Cost per hour for 2 trucks 2 x 500 = 1000

Cost per hour for 3 trucks 3 x 500 = 1500

1. Cost per truck during loading $\frac{6.4}{60} \times 500 = 53.00$

2. Hauling cost per cu.yard using 2 trucks $= \frac{1000}{125} =$ Rs. 8.00

Hauling cost per cu.yard using 3 trucks $\frac{1500}{140} =$ Rs. 10.70

As the size of excavator increases the truck cost of loading decreases due to less loading time. Therefore overall excavation and hauling cost decreases as size of excavator increases with balanced truck unit.

COMPRESSED AIR (Uses in construction)

Compressor's air is used very extensively on construction projects for 1. drilling rock or, 2. other hard formations, 3.loosening earth, 4.operating air motors, hand tools, pile drivers, pump and mucking equipment, 5. cleaning.

Compressors are used to compress the air to the required degree of pressures, low, medium and high range pressures (ie. Kgs, 10 Kgs, 15 Kgs).

Compressors types

1. Reciprocating (2) rotary, (3) Screw, (4) centrifugal compressor

Basically the compressor consists of

1. Engine to drive compressor
2. Clutch unit (coupling)
3. Compressor Unit.
   a. L.P.Cylinder
   b. Inter cooler
   c. HP Cylinder
   d. After cooler
   e. Receiver of storage tank

DRILLING ROCK AND EARTH

Types of drilling

1. Rotary drilling or abrasion drilling
2. Percussion drilling
3. Rotary-cum-percussion

The basic components of any drilling machines are

1. Frame or stand
2. Rotation head with up & down sliding arrangement
3. driver shaft
4. hammer
5. bit

It is observed that the following machinery is essential for embankment for one poclain with borrow area situated 1/2 to 1 KM lead:

1)	Tippers/Lorries	5 Nos.
2)	Water tanker	1 No.
3)	Road Rollers	
	10 Tonne capacity	1 No.
4)	Dozer	1 No.

EXTRACT OF HIRE CHARGES OF MACHINERY APPROVED BY CHIEF ENGINEER, MACHANICAL FOR THE YEAR 1996-97

Sl. No.	Name of the Machine and its capacity	Updated cost	Life Hours/ Years	Depre-ciation	Total cost of POLs	Total crew charges	Hire charges with interest
1	2	3	4	5	6	7	8
1.	Pump set 5.1 to 8.0 HP Electrical	25,530	6000H / 8Y	1.80	14-70	20-00	45-00
2.	Pump set 5.1 to 8.0 HP Diesel	23,585	- do -	1-45	23-30	22-25	56-00
3.	Air Compressor upto 175 CFM 85HP	1,96,636	10000H / 8Y	8-60	155-40	80-00	275-00
4.	Air Compressor 401 to 580	5,89,909	30000H / 20Y	6-40	332-15	149-10	563-00
5.	Tipper/Lorry 5 to 7.5 Tonnes 80 HP.	3,93,273	200000H / 10 Y	0-65	4-70	4-80	18-00
6.	Tipper/Lorry 10 Tonne 120 HP Diesel	4,31,913	- do -	1-10	6-30	4-90	21-50
7.	Water Tanker Tailor upto 10 Tonne without PRIMEN.	1,17,638	-do -	0-25	-	4-00	8-50
8.	Water Tanker Lorry mounted with Engine upto 80 HP.	4,31,913	-do -	1-00	-	9-00	51-00

1	2	3	4	5	6	7	8
9.	Wheeled Tractor upto 50 HP.	1,87,420	12000H / 8Y	6-40	91-15	41-10	209-
10.	Dozer upto 100HP Wedges Russian FM 100 Diesel	11,79,247	12000H / 10 Y	19-25	182-85	73-60	577-
11.	Jack Hammer	31,256	4000H / 4 Y	3-20	5-05	2-65	22-
12.	Wagon Drill	3,14,275	8000H / 8 Y	16-00	129-80	61-00	297-
13.	Joy 7 core Drill	3,14,275	-do-	16-00	130-00	61-00	297-
14.	Grout Pump	3,14,275	-do-	16-00	112-95	61-00	254-
15.	Dozer 101 HP to 165 HP including BEML P.80.	17,68,870	12000H / 10Y	32-00	301-70	673-60	862-
16.	Dozer 166 to 190 HP including D-120 A12 BEML	23,59,639	-do-	85-60	347-55	73-601142-	
17.	Dozer 191 to 250 HP including BEML Dozer D-120 A 18 CAT 8	35,38,885	15000 / 12	107-00	457-15	680-001570-	
18.	Russain 250 HP Dozer P&H Drag line 21/2 Cyd Capacity.	25,94,343	12000H / 10Y	55-60	320-00	73-60	894-
19.	P&H Drag line 2 1/2 Cyd capacity 210HP	35,38,886	15000H / 12 Y	58-85	384-00	73-601011-	
20.	Hind Marino Drag line 265 HP	35,38,886	- do -	64-20	484-70	80-001140-	
21.	L&T Poclain Excavator for 80 CK 90 HP.	25,94,343	-do-	107-00	164-50	49-00	777-
22.	Poclain Excavator 90CK 103 HP	28,31,337	12000H / 10Y	117-70	188-35	49-00	870-
23.	JCB Excavator Mark-III 70 HP	11,79,819	-do-	32-00	129-00	49-00	480-
24.	JCB Excavator Mark IV 70 HP	12,02,145	-do-	64-20	126-00	49-00	523-
25.	Escort Front End Loader 40 HP.	3,53,774	-do-	10-70	73-15	49-00	228-

1	2	3	4	5	6	7	8
26.	CATER PILLOR FRONT END LOADER 96 CK 165HP	19,11,983	15000H / 10Y	53-40	301-70	64-00	840-00
27.	BEML HAULAK Dumper 310 H.P.	23,57,349	12000H / 10Y	89-20	567-00	89-501402-00	
28.	Scrapper Upto 290 - H.P.	23,59,410	10000H / 10Y	75-00	530-00	86-001859-00	
29.	C.P.T.Wagon Drill	1,25,881	8000H / 8Y	2-70	131-60	61-40	256-00
30.	ATLAS CAPCO over burden drill	4,71,698	10000H / 8Y	21-40	132-65	62-40	334-00

3.8.0 SLOPE PROTECTION

ROUGH STONE DRY PACKING

Rough Stone Dry Packing for Aprons and Revetments :

GENERAL :

The section covers the specifications for construction of 600 mm/450mm/ 300mm rough stone dry packing for aprons and revetments as specified in bill of quantities and its materials.

Quality of material for pitching :

The bed pitching material shall consist of the most durable rock fragments of approved quality selected for the purpose. The stone shall be sound, hard, dense, resistant to abrasion, durable and free from segregation, seams, cracks, shale partings, weathered portions, conglomarate, bands and other structural defects or imperfections tending to affect their soundness and strength. Stone shall generally be freshly quarried with sharp edges and clean faces. They shall be free from rounded, worn or weathered surfaces or skin or coating. Stone subject to marked deterioration by water or weather shall not be used. The shape of the individual stones shall be angular. Stones when immersed in water for 24 hours shall not absorb water by more than 5% of their weight when tested as per IS : 1125-1974 or its latest edition.

Size of stone

The size of the stone to be used for various thickness of revetments shall be as follows :

The size of stone shall be as large as possible. In no case any fragment shall weigh less than 40 kg. The specific gravity of stones shall be as high as possible and it shall not be less than 2.50. Unless otherwise specified, for revetments upto 450 mm thickness, the length of the stones shall be equal to the revetment thickness. For revetment over 450 mm thick atleast 50% of the stones shall be 450 mm long. No stone shall have any dimension less than 150 mm or less than 50% of the maximum dimension of the stone.

The minimum volume of the individual stones used for various thickness of revetments shall be as follows :

Thckness of revetment	Volume of stones
225 mm	0.015 cum
300 mm	0.015 cum
450 mm	0.030 cum
600 mm	0.045 cum

STACKING

Stacking shall be done as detailed below.

a) Stacks shall be formed to regular shape and uniform cross sections.

b) Materials shall be stacked on even ground. Stacking shall not be done in flood zones or in water logged areas.

c) Rough stone shall be stacked so closely as to give minimum quantity of voids possible without actual dressing of stone to fill interstices.

d) Templates shall be provided to the sizes and dimension of the stack.

PREPARATION OF BED AND SLOPES

a) **Bed :**

The surface on which the rough stone is to be laid shall be excavated to the required level and levelled and prepared for the length and width as shown on the drawings. The base shall be compacted suitably with hand rammers or other means to have an even bedding.

No packing shall be done on un-compacted made up soil.

b) **Side slopes :**

The sides of banks to receive rough stone revetment shall be trimmed to the required slope and profiles put up by means of line and pegs at intervals of 3 meters to ensure, regular, straight and an uniform slope throughout. Depressions shall be filled and thoroughly compacted.

Laying apron (Bed Pitching) and revetment (Pitching to sides) :

a) Apron shall be provided to the dimensions and levels shown on drawings.

b) To ensure regular and orderly disposition of the full intended quantity of stone in the apron, template or cross walls in dry masonry shall be built about a meter thick and to the full height of the specified thickness of apron at intervals of 10 metres or closer as directed by the Engineer, all along the length and width of the apron. In between the cross walls the stone shall be handpacked.

c) The thick-ness of the apron shall be made with one stone only. Total thickness shall not be made up in two or more layers.

d) The stones shall be laid closely in position of the prepared bed and firmly set with their broadest ends downwards so that they may meet all round their bases and with the top of the stone level with the finished surface of packing. The stones shall be laid breaking joint as far as possible in the direction of the flow of water. The stones shall be placed normal to the surface to be protected.

e) The interstices between adjacent stones shall be filled in with stones of the proper size, well driven in, with crow bars to ensure tight packing and complete filling of all interstices. Such filling shall be carried on simultaneously with the placing in position of the large stones and shall in no case be permitted to lag behind. The final wedging shall be done only after obtaining the orders of the Engineer. The final wedging shall be done with the largest size chips or spalls practicable, each chip or spall being well driven home with a hammer so that no chip or spall is possible of being picked up or removed by hand to ensure tight packing. The sizes of spalls shall be minimum 25 mm and shall be suitable to fill the voids in the pitching.

f) On completion, the surface presented by the apron revetment shall be even throughout, free from irregularities and the

required length, breadth and slope as specified or as shown on the plans.

ii) **Revetment (Pitching to sides) :**

a) Revetment shall be constructed to the required length, level, depth and slopes shown on the drawings.

b) Profiles or strings and pegs shall be put up to ensure that the pitching is done true, straight and to the proper slope thoughout.

c) Revetment shall in all cases be built up from the foot of the bund to be reveted and built up in courses upwards. Care is necessary that a strong toe wall or other protection is always given to the revetment.

d) Stones shall be placed to the required length by derrick or by hand. Stones shall be set normal to the slope and placed so that the largest dimension is perpendicular to the face of the slope unless such dimension is greater than the specified thickness of pitching. The largest stones shall be placed in the bottom courses and for use as headers for subsequent courses.

Moorum or Gravel backing to rough stone dry packing.

Preparation base.

The surface to receive the gravel backing shall be neatly trimmed to the required slopes dimensions and free from all roots and vegetation and profusely wetted before morum is laid on.

Gravel quality :

a) The gravel shall be composed of well graded, coarse siliceous grains, sharp and gritty touch and free from direct and other deleterious matter. It shall not contain lumps larger than 2 mm and the fines (passing through 75 microns IS sieve) shall not exceed 10%

b) The liquid limit shall be - 20.

c) Plasticity Index - Not more than 6.

d) Moorum stacking shall be as per standards.

Preparation and laying :

a) Gravel shall be mixed with water on the previous day. Next day morning it shall be well mixed and worked with mamoties till it can be formed into stiff plastic balls.

b) Gravel so mixed shall be carried in baskets to where it is to be laid and deposited in a single layer to give 150 mm thick of finished thickness and shall be well rammed in position with flat wooden rammers or any other method approved by the Engineer.

c) The finished surface of gravel shall be left untouched until it dries up and does not show signes of yielding.

d) If any thickness other than 150 mm is specified the work shall be executed to this specification, ramming in layers not exceeding 150 mm thickness.

C.C. GROUTING TO THE APRONS AND REVETMENT INCLUDING POINTING

i) The surface of the apron or revetment shall be thoroughly cleaned and joints raked out to 250 mm depth or to any other depth as specified by the Engineer. The whole surface shall be swept clean.

The joints shall then be filled in with cement concrete of specified mix and graded broken aggregate of maximum size 20 mm. If the interstices are large, a large size aggregate as specified by the Engineer may be used. The concrete shall be rammed with flat bars, trowels or flat ends of small thin crowbars to ensure effective consolidation.

The surface shall then be neatly flush pointed with cement mortar of specified mix covering the joints of the newly laid concrete while the concrete filling is still green.

The concrete and pointing shall be continuously kept wet for three weeks.

ROCK FILL FOR TOE OF EMBANKMENT (Rock Toe)

Rockfill shall consist of sound, durable and well graded broken rock obtained from excavation of work and/ or from approved quarries and shall be approved prior to being transported to the areas of deposition. The materials shall range in size from 75 mm. However, no load shall contain more than 15 percent by volume or rock fragments smaller than 75 mm in size. All brush roots, or other perishable material shall be removed from rockfill during the spreading.

3.9.0 ROCKFILL IN TOE OF EMBANKMENTS AND FILTERS

Scope :This specification covers filters to be laid for interna drains, sandy filter blankets, horizontal and inclined filte drains, longitudinal and transverse filters around rocktoe et

FILTERS

i) Sand as filter materials :

ii) **Scope :**

Formation of sand filters of specified thickness using the san of approved quality including cost and conveyance of san sampling, testing and laying with all leads, lifts, delifts an compaction to 70% relative density including hire and oper tional charges of power roller seigniorage charges and all oth incidental and operational charges necessary to complete th finished item of work for filter blanket, horizontal and incline filter drains, longitudinal and transverse filters around rock to etc., as directed.

BASE FILTER BLANKETS

a. Filter Blanket should be laid on the base, under the dow stream portion of the canal embankment. The number of layer in the filter blankets and the thickness of each layer shall b as specified in the drawings. Sand shall be placed and com pacted to an average relative density of 85% with a minimu relative density of 70%. The sand shall be placed and tampe into place in such a manner that mixing of sand with founda tion or backfill materials will not occur. The filter materia should satisfy the following criteria.

i) D_{15} of Filter material >4.<20

D_{15} base material

ii) D_{15} of Filter material < 5

D_{85} Base Material

iii) D_{50} of Filter material < 25

D_{50} Base material

iv) Co-efficient of Curvature

$$C_c=\frac{[D_{30}]^2}{D_{10}XD_{60}}$$ lies between 1 and 3

v) Coeficient of Uniformity :

$$C_U=\frac{D_{60}}{D_{10}} \quad >6 \text{ for SW}$$

and $$C_U=\frac{D_{60}}{D_{10}} \quad >4 \text{ for GW}$$

SW : Sand Well Graded and

GW : Aggregate well graded.

b) The base filter materials should be well graded so as to satisfy the above mentioned criteria. The grain size Curve should be approximately parallel to that of base materials, especially in the fine range. Filter materials should not contain more than5% of fines i.e., materials finer than 0.075 mm passing through sieve No.200 I.S. sieve 75 mircron and fines should be cohesion less to ensure that filter does not sustain a crack. The filter should not have particles larger than 75 mm. so as to minimise the segregation.

c) D.15 is the size at which 15% of the total soil particles are smaller, the percentage being by weight, is being propped to be determined by mechanical analysis. D.85 size is that at which 85% of the total soil particles are smaller. As more than one filter layer is required, similar criteria is followed in each case, viz., the finer filter is considered as base materials for the selection of the gradation at the coarser filter.

d) The requirement for grading of the filter shall be established by the tests conducted in the field laboratory on the basis of mechanical analysis of adjacent material; Mechanical analysis shall be performed of all samples, which have been compacted by the methods equivalent to compaction by roller, so that the individual particles are broken to their field condition in the embankment.

e) The filter materials shall be compacted to an average relative density of 85% with minimum relative density of 70% as determined by the standard U.S.Bureau of Reclamation (relative density test for cohesionless free draining soils).

$$Dd = \frac{e\ max. - e}{e\ max. - e\ min.}$$

Where "e" = In place void ratio

e max = void ratio in loose state.

e min = void ratio in most compacted state, and

$$\text{Void ratio} = \frac{\text{Volume of Voids}}{\text{Volume of solids}}$$

The relative density may also be computed using the maximu and min density as follows :-

Dd. = Yd max (Yd-Ymin). Yd (Yd max-Yd. min)

Where Yd Max=Maximum dry density of soil as obtained by t laboratory procedure.

Yd min= Minimum dry density of soil as obtained by the laborat procedure.

Yd= The dry density at which the soil is to be placed or the in pla dry density.

f) The thickness of each filter layer shall be less than 150 m

PLACING OF FILTER

a) Filters shall be laid to the lines and grades and dimensio shown on the drawings.

b) The foundation shall be cleared and stripped in accordan with specification 2.0 before laying the bottom layer of fil material.

c) Filter material shall be laid in layers of 150 mm adequat watered and compacted by required number of passes crawler type tractor to get dense and stable filter.

d) Care shall be taken to ensure that materials of different laye do not get mixed both at the time of placing and dur compaction. Extreme care shall be taken when placing ma rials to obtain a fill free lenses, layers and streaks of segrega materials.

e) In case of horizontal filters after being compacted earth material shall be laid over it in layers of 150mm and compact

Sheep foot roller or DRR shall not be used till earth has been laid and compacted to a thickness of 600 mm over the filter blanket. However, the construction of earthfill in the initial 600mm thickness shall be subjected to the same quality control regarding moisture content and dry density as for the rest of the embankment.

f) In case of inclined filter, the filter shall be raised along the adjoining embankment layers and shall be properly compacted by suitable means. In order to avoid contamination of filters with adjoining earthfill material, the top of filter be kept slightly higher than the adjacent embankment level and any contaminated portion shall be scrapped and removed before adding the new layer.

METAL FILTER

A) SCOPE

Formation of metal filters of specified thickness using approved quality of well graded metal of size 10mm to 75mm at the specified place including cost and conveyance of metal, sampling,, testing and laying with all leads, lifts, delifts, watering, compacting, seigniorage charges and all other incidental and operational charges necessary to complete the finished item of work as per drawings.

B) PLACING

i) The Coarse aggregate filter shall be laid to the lines and grades and dimensions shown on the drawings.

ii) Filter material shall be laid in layers of 150mm adequately watered and compacted to get a dense and stable filter, when placing materials to obtain a fill free from lenses, layers and streaks of segregated materials.

iii) In case of horizontal filters, after being compacted, earthfill material shall be laid over it in layers of 150 mm and compacted. Sheep foot roller or DRR shall not be used till earth has been laid and compacted to a thickness of 600 mm. over the filter blanket. However, the construction of earthfill in the initial 600mm. thickness shall be subject to the same quality regarding moisture content and dry density as for the rest of the embankment.

iv) In case of inclined filters, the filter shall be raised along t adjoining embankment layers and shall be properly compact by suitable means. In order to avoid contamination of filte with adjoining earth fill material, embankment level and a contaminated portion shall be scraped and removed bef adding the new layer.

ROCK FILL IN, TOE OF EMBANKMENT (ROCK TOE)

A) SCOPE

Formation of Rock toe using approved quality of well grad metal and stone of size 75mm to 450mm including cost a conveyance of metal, sampling, testing laying with all leads, lif delifts and at least 225mm thick rough stone dry packing to t external face.

Rockfill shall consist of sound, durable and well grade brok rock obtained from approved excavation of work and/or fro quarries and shall be approved prior to being transported to t areas of deposition. The materials shall range in size from 7 mm to 450 mm. However, no load shall contain more than, percent by volume of rock fragments smaller than 75 mm size. All brushroots, or other perishable material shall b removed from rockfill during the spreading.

B) PLACING

i) The rockfill shall be constructed, true to the lines and grad as shown in the drawings.

ii) The rockfill shall be placed and packed to obtain a suitable we graded and free draining fill.

iii) The smaller rock fragments shall be placed adjacent to the filt of embankment and large rock fragments near the outer ed of the fill.

iv) The rockfill shall be placed and roughly levelled in layers n greater than one meter in thickness.

v) The stones shall be properly hand packed and the interstic shall be well filled with spalls and chip and tightly wedged t ensure firm packing so as to have dense well graded fill with n larger voids and cavities.

vi) Contamination of rock toe with finer material from any othe zones shall be avoided.

vii) Suitable outfall for draining out the seepage water collected in the rock toe shall be provided depending upon the site conditions.

4.0.0 MATERIALS

4.1.0 Cement - Tests - Requirements

1.2 Reduction in strength of concrete due to storage of cement :

Sl. No.	Period of Storage of cement	Minimum expected reduction in strength at 28 days	Remarks
1.	Fresh	0%	These values are approximate.
2.	3 months	20%	As cement is likely to loose
3.	6 months	30%	its strength during storage.
4.	1 year	40%	It sould be sent to a laboratory
5.	2 years	50%	for test.

1.2 Field test for quality of cement :

a) When a sample of cement is burnt for about 20 minutes on a steel plate, an adulterated sample will change in colour. While the colour of an un-adulterated sample remains unchanged.

b) When hand is pushed into the Cement bag there should be least resistence and the cement dust (powder) should be sticked to the hand. Also a feeling of cold touch should be there to the hand for pure cement. This is only a tip to assess the purity/quality of cement.

4.2.0 FINE AGGREGATE

Granular material (passing 10 mm sieve and almost entirely passing 4.75 mm sieve and predominantly retained on 75 micron sieve), resulting from material disintegration and abrasion of rocks.

	4.75 mm	2 mm	0.425	0.075 mm
GRAVEL				
	Coarse Sand	Medium Sand	Fine Sand	Silt

Material with particles of size more than 4.75 mm is term as gravel while that below 0.075 mm as silt.

Quality of aggregate :- Fine aggregate shall be hard, stro dense, durable, clean, and free from veins and adherent coat and free from injurious amounts of disintegrated pieces of alk vegetable matter and other deleterious substances.

Specific gravity :- 2.6 to 2.65 (Generally 2,65)

Deleterious materials :- Aggregates shall not contain any harm materials such as pyrites, coal, lignite, mica, shale or simil laminated materials, clay, alkali, soft fragments, sea shells a organic impurities in such quantity as to effect the strength durability of the concrete. Aggregates to be used for reinforc concrete shall not contain any material that attack the st reinforcement.

Limits of deleterious materials :- The maximum quantity deleterious materials shall not exceed the limits specified belo However, the Engineer-in-charge at his discretion may relax so of the limits as a result of some further tests and evidence satisfactory quality of the aggregates.

SAMPLING

Sampling is the process of selecting a small representat quantity of given material for the purpose of testing. Since t quality of large quantities of materials are to be determined on t basis of sample selected, it is very essential that sample for testi must be truely representative.

Preparation of main sample :- To ensure the true representati the main sample should be made up from about 12 smal samples taken from different parts of the stack and thorough mixed.

Reduction of sample :- The main sample should be so reduc to suit for despatch to a testing lab or for carrying out te directly. The main sample is reduced by a method known "Quartering" as illustrated below :-

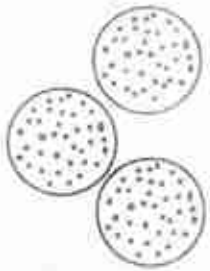
i) Pour the main sample in the shape of a heap as shown

ii) Spread the main sample to a layer of thickness about 7Cm thick.

iii) Devide this layer into four equal parts by means of a cross.

iv) Discard two diagonally opposite quarters and remix the reminder.

v) Repeat the process until the sample is reduced to the required quantity for testing.



NOTE :- Incase cross is not available the divisions may be made with showel or trowel.

2.1 TABLE I LIMITS OF DELETERIOUS MATERIALS

As per Clause 3.2.12d I.S. 383-1970

Sl. No.	Deleterious substance	Method of test	Fine aggregate percentage by weight, Max		Coarse aggregate percentage by weight Max	
			Uncru-shed	Crushed	Uncru-shed	Crshd
1	2	3	4	5	6	7
1.	Coal and lignite	IS : 2386 (Part-II) -1963	1.00	1.00	1.00	1.00
2.	Clay lumps	-do-	1.00	1.00	1.00	1.00
3.	Materials finer than 75-M IS sieve	IS : 2386 (Part-I)-1963	3.00	15.00	3.00	3.00
4.	Soft fragments	IS :2386 (Part-II)-1963	–	–	3.00	–
5.	Shale	-do-	1.00	–	–	–
6.	Total of percentages of all deleterious materials (except mica including Sl.No. (i) to (v) for Col.4,6 and 7 and Sl.No. (i) and (ii) for Col.5 only	–	5.00	2.00	5.00	5.00

NOTE :1. The presence of mica in the fine aggregate has be found to reduce considerably the durability and compressi strength of concrete and further investigations are underway determine the extent of the deleterious effect of mica. It advisable, therefore, to investigate the mica content of fi aggregate and make suitable allowances for the possible redu tion in the strength of concrete or mortar.

2. The aggregate shall not contain harmful organic impuritie (tested in accordance with IS:2386 (Part-II)-1963) in sufficie quantities to affect adversely the strength or durability concrete. A fine aggregate which fails in the test for organ impurities may be used, provided that, when tested for th effect of organic impurities on the strength of mortar, th relative strength at 7 and 28 days, reported in accordance wit 7 of IS : 2386 (Part-VI) -1963 is not less than 95 percent.

Size and grading of aggregate :- The grading of fine aggregat when determined as described in I.S.2386- Part-I - 1963, shall b within the limits given in the following table and shall be describe as fine aggregate, grading Zone-I, II,III & IV.

Where the grading falls outside the limits of any particula grading zone of sieves other than 600 micron I.S. sieve, by a tota amount not exceeding 5% it shall be regarded as falling with i that grading zone. This tolerance shall not be applied to percent age passing the 600 micron I.S.sieve or to percentage passing an other sieve size on the coarse limit of grading zone-I or the fine limit of grading Zone-IV.

Grading of fine aggregates suitable for concrete :

Table 4 Fine Aggregates (Clause 4.3)

I.S.Sieve designation		Percentage passing for			
		Grading Zone-I	Grading Zone-II	Grading Zone-III	Grading Zone-IV
10	mm	100	100	100	100
4.75	mm	90-100	90-100	90-100	95-100
2.36	mm	60-95	75-100	85-100	95-100
1.18	mm	30-70	55-90	75-100	90-100
600	micron	15-34	35-59	60-79	80-100
300	"	5-20	8-30	12-40	15-50
150	"	0-10	0-10	0-10	0-15

Note :- 1. For crushed stone sands, the permissible limit on 150-micron IS sieve is increased to 20 percent. This does not affect the 5 percent allowance permitted in 4.3 applying to other sieve sizes.

2. Fine aggregate complying with the requirements of any grading zone in this table is suitable for concrete but the quality of concrete produced will depend upon a number of factors including proportions.

3. Where concrete of high strength and good durability is required, fine aggregate conforming to any one of the four grading zones may be used, but the concrete mix should be properly designed. As the fine aggregate grading becomes progressively finer, that is, from Grading Zones I to IV, the ratio of fine aggregate to coarse aggregate should be progressively reduced. The most suitable fine to coarse ratio to be used for any particular mix will, however, depend upon the actual grading particle shape and surface texture of both fine and coarse aggregates.

4. It is recommended that fine aggregate conforming to Grading Zone-IV should not be used in reinforced concrete unless tests have been made to ascertain the suitability of proposed mix proportions.

Grading of fine aggregate suitable for masonry :-

The sand to be used in mortars shall be as per the following table. (Reference - I.S. 2116 - 1980).

Sl. No.	I.S. sieve designation		Percentage by weight passing I.S. sieve
1.	4.75	mm	100
2.	2.36	mm	90 - 100
3.	1.18	mm	70 - 100
4.	600	Micron	40 - 100
5.	300	Micron	5 - 70
6.	150	Micron	0 - 15

Grading of fine aggregate suitable for internal, external or ceilin plastering. (Reference - I.S. 1542 - 1992).

Sl. No.	I.S. sieve designation	Percentage by weight passing	Remarks
1.	10 mm	100	F.M. of sand shall not
2.	4.75 mm	95 - 100	be less than :
3.	2.36 mm	95 - 100	a. 1.40 in case of
4.	1.18 mm	90 - 100	crushed sand
5.	600 Micron	80 - 100	b. 1.50 in case of
6.	300 Micron	20 - 65	naturally occuring
7.	150 Micron	0 - 15	sand.

Sieve analysis :- Sieve analysis is a simple operation of dividin a sample of aggregate into fractions each consisting of particles o the same size. In practice each fraction, contains particles be tween definite limits. The sieves that are used for sieve analysis o aggregates are aso follows :-

i) 4.75 mm (ii) 2.36 mm (iii) 1.18 mm

iv) 600 Micron (v) 300 Micron (vi) 150 Micron

The materials retained on each sieve after shaking represent the fraction of aggregate coarser than the sieve in question bu finer than the sieve above.

Fineness modulus :-

Fineness modulus is a single factor computed from the siev analysis and is defined as the sum of cumulative percentag retained on the sieve of the standard sieves devided by 100. Th higher the values of the fineness modulus the coarser is th aggregate.

In order to ensure the presence of all the sizes of particles i is desirable to have the fineness modulus between 2.0 to 3.2.

SAND

(I.S : 2386 (Part-I)-1963) & (I.S : 383-70)

SIEVE ANALYSIS

1. **AIM :** Detrmination of particle size distribution of fine aggregates by sieving or screening.

2. **APPARATUS :** a) Sieves sizes :

10.0	mm	600 microns	
4.75	mm	300	"
2.36	mm	150	"
1.18	mm		

b) Balance : Take a balance of suitable capacity and accuracy of 0.1% of the weight of the sample.

SAMPLE : Take about 500 grams of the sample for testing.

1. **PROCEDURE :** Take an air-dried sample for weighing and sieving. This may be achieved either by drying at room temperature or by heating at a temperature of 100°C. Weigh the air dry sample and sieve it successively on the above sieves starting with the largest.

2 **(a) Hand Operation :** Shake each sieve separately over a clean tray until no material passes through the sieves, but in any case for a period of not less than two minutes. The shaking is to be done with a varied motion, backwards and forwards, left to right, circular clock wise and anticlock wise with frequent jarring, so that the material is kept moving over the sieve surface frequently changing directions. Materials are not to be forced through the sieve by hand pressure, Lumps of fine material, if present are to be broken by gentle pressure with fingers against the side of the sieve. Light brushing with soft brush on the under side of the sieve may be used to clear the sieve openings.

(b) Machine Operation : The set of sieves along with the co starting from the 10 mm sieve on top one below the other, a the container in the order shown above is fixed on the elec cally operated sieve shaker. Place the sample in the topm sieve i.e., of 10 mm size, and do the sieving for about 5 minut

4.3 Light brushing with a hair brush may be used on the micron I.S : sieve to prevent aggregation of powder blinding of apertures.

4.4 On completion of sieving, weigh the material retained each sieve together with any material cleaned from mesh.

5. **RESULTS :** Calculate the results and report them as follow

a. The cumulative percentage retained on each individ sieve, expressed as a percentage of the total sample.

b. The percentage of material passing each sieve, expressed a percentage of the total sample.

4.2.2 **Bulkage allowance :-** While measuring sand, due allowance shall be made for bulkage from moisture.

Determination of bulkage allowance of Sand (approximate method :- (Field method) :-

Sand stacked at the site may contain moisture, which will cause it, when loosely filled into a container to occupy a larger volume than it would occupy when dry. If sand is measured loose (Wet), it is necessary to add, more volume of sand (based on bulkage) in order that the, quantity of sand put may be exactly required.

Procedure :- Take a 250ml. measuring jar, pour the damp sand (consolidated by shaking) until it reaches the 200 ml mark.

Then fill the jar, with water and stir well (The water shall be sufficient to submerge the sand completely).

It will be seen that the sand surface is below its original level.

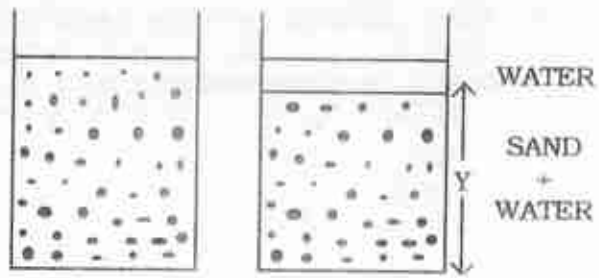
Suppose the surface is at the mark "Y" ml.

The percentage of bulking of the sand due to moisture shall be $\frac{200-Y}{Y} \times 100$

Note : i) The percentage of bulkage of sand shall be rounded off to the nearest whole number.

ii) Allowance for bulkage of sand is applicable only when the mixing is done by volume.

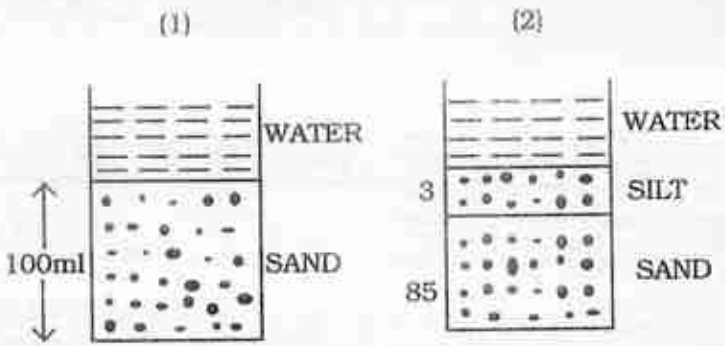
iii) In case of mix design the question of allowance for bulkage does not arise.



4.2.3 **Determination of silt content :** (Field Test) :

The percentage of silt content may be determined as given below :-

A sample of sand to be tested shall be placed without drying in 200 ml, measuring cylindrical jar. The size of the sample shall be such that it fills the cylinder upto 100 ml mark. Clear water shall be added to it upto 150 ml mark. The mixture shall then be shaken vigorously and the container allowed to settle for 3 hours. The height of silt visible on settled layer above the sand shall be expressed as percentage of the height of the sand below.



The percentage of silt content shall be $= \frac{3}{85} \times 100$

$= 3.52\%$

Note : Clay, fine silt, fine dust

in natural sand - shall not be more than 4%

Silt content can be approximately known to a certain extent sieve analysis itself. The material passing through 150 micro sieve indicates the approximate extent of silt content.

4.3.00 COARSE AGGREGATE

The term coarse aggregate designates clean well graded aggregate most of which retained on 4.75 mm I.S. sieve and containing only that much finer material as is permitted for various types as described below :-

Coarse aggregate for concrete shall consist of uncruhsed gravel or stone, crushed gravel or stone and partially crushed gravel or stone.

Quality :- The coarse aggregate shall consist of naturally occuring (Crushed or un-crushed) stones and shall be hard, strong, durabe, dense, clean and free from veins an adherent coatings and free from injurious amounts of disentegrated pieces, alkali, vegetable matter and other deleterious materials. As far as possible flaky, scoriaceous, and elongated pieces should be avoided.

Aggregate crushing strength :- Aggregate crushing value, when determined in accordance with I.S. 2386- Part-IV 1963 shall not exceed 45% for aggregate used for concrete other than wearing surfaces and 30% for wearing surfaces such as runways, roads and pavements.

Aggregate impact value :- The aggregate impact value may be determined in accordance wtih the method specified in I.S. 2386-Part-IV -1963 and it shall not exceed :

i) 45% by weight for aggregates used for concrete other than for wearing surfaces.

ii) 30% by weight for concrete for wearing surfaces such as runways, roads and pavements.

Aggregate abrasion value :- The abrasion value of aggregate, when tested in accordance with the method specified in I.S. 2386 - Par-IV - 1963, by using Los- Angeles machine, shall not exceed.

i) 30% - For aggregates to be used in concrete for wearing surfaces.

ii) 50% - For aggregates to be used in other concretes.

Soundness test :- The coarse aggregate to be used for all concrete works shall pass sodium or magnesium sulphate, accelerated soundness test specified in I.S.2386 - Part-V-1963 and the average loss of weight after 5 cycles shall not exceed the following:

i) 12% when tested with sodium sulphate (Na_2So_4)

OR

ii) 18% when tested with magnesium sulphate ($Mg\ So_4$)

Specific gravity :- 2.60 minimum.

Deleterious materials :- The limits of deleterious materials are given in. (Table 1 of I.S. 383 - 1970) vide item 4.2.1

Size and grading of aggregate :-

i) Single size coarse aggregate :- Coarse aggregate shall be supplied in the nominal sizes given below (Table-2) for any one of the nominal sizes, the proportion of other sizes, as determined by the method, described in I.S.2386 Part-I-1963, shall be in accordance with the following table - (Table 2-I.S.383 -1970)

ii) Graded aggregates :- Graded coarse aggregates are to be supplied in the nominal sizes as given below :-

I.S. 383 - 197

TABLE 2 COARSE AGGREGATES

(Clause 4.1 and 4.2)

I.S.Sieve Designation	Percentage passing for single-sized aggregate of nominal size						percentage passing for grade aggregate of nominal size			
	63 mm	40 mm	20 mm	16 mm	12.5 mm	10 mm	40 mm	20 mm	16 mm	12.5 mm
1	2	3	4	5	6	7	8	9	10	11
80mm	100	-	-	-	-	-	100	-	-	-
63mm	85 to 100	100	-	-	-	-	-	-	-	-
40mm	0to 30	85 to 100	100	-	-	-	95 to 100	100	-	-
20mm	0 to 5	0 to 20	85 to 100	100	-	-	30 to 70	95 to 100	100	100
16mm	-	-	-	85 to 100	100	-	-	-	90 to 100	-
12.5mm	-	-	-	-	85 to 100	100	-	-	-	90 to 100
10mm	0 to 5	0 to 5	0 to 20	0 to 30	0 to 45	85 to 100	10 to 35	25 to 55	30 to 70	40 to 85
4.75mm	-	-	0 to 5	0 to 5	0 to 10	0 to 20	0 to 5	0 to 10	0 to 10	0 to 10
2.36mm	-	-	-	-	-	0 to 5	-	-	-	-

Coarse aggregate for mass concrete :-

Coarse aggregate for mass concrete works shall be in the sizes specified below (Table -3 I.S. 383 - 1970)

TABLE 3 SIZES OF COARSE AGGREGATES FOR MASS CONCRETE (Clause 4.1.1)

Class and size	IS Sieve Designation	Percentage passing
Very large, 150 to 80 mm	160 mm	90 to 100
	80 mm	0 to 10
Large, 80 to 40 mm	80 mm	90 to 100
	40 mm	0 to 10
Medium, 40 to 20 mm	40 mm	90 to 100
	20 mm	0 to 10
Small, 20 to 4.75 mm	20 mm	90 to 100
	4.75 mm	0 to 10
	2.36 mm	0 to 2

* There being no IS sieve having an aperture larger than 100 mm a perforated plate complying with IS : 2405-1963 and having a square aperture of 160 mm may be used.

All in aggregates :- If combined aggregates are available, they need not be separated into fine and coarse, but necessary adjustment may be made in the grading, by addition of single sized aggregates. The grading of the all-in-aggregate when analyzed, as described in I.S. 2386 -Part-I-1963, shall be in accordance with the following Table-5, I.S.383 - 1970.

TABLE 5 ALL-IN-AGGREGATE GRADING

(Clause 4.4)

IS Sieve Designation	Percentage passing for All-in-aggregate of	
	40 mm Nominal size	20 mm nominal size
80 mm	100 - -	- - -
40 mm	95 to 100	100
20 mm	45 to 75	95 to 100
4.75 mm	25 to 45	30 to 50
600 micron	8 to 30	10 to 35
150 micron	0 to 6	0 to 6

Average test values for rocks of different groups :-

Sl. No.	Name of the Test	ROCK GROUP				
		Granite	Basalt	Lime stone	Qua-qtzite	Flint
1.	Core crushing strength	150-220 N/mm²	180-225 N/mm²	120-180 N/mm²	300-350 N/mm²	150-25 N/mm
2.	Aggregate crushing value	15to30	10to25	20to40	15to30	15to3
3.	Aggregate impact value	12to25	10to25	20to40	15to18	15to3
4.	Abrasion value I3	18	17	15	19	1
5.	Attrition Value Dry	2.9	3.3	4.3	2.5	3.
	Wet	3.2	5.5	7.8	3.0	2.
6.	Specific gravity	2.69	2.85	2.69	2.62	2.5

Sieve analysis :- The sieve analysis is conducted to determine th particle size distribution in a sample of aggregate, which is terme as gradation. The aggregate fractions from 80 mm to 4.75mm a termed as coarse aggregate, for assessing gradation by sie analysis, the quantity of materials to be taken on the sieve is follows :-

Minimum weight of the Sample for Sieve Analysis IS 2386 Part 1963

Maximum size present in substantial proportions	Minimum weight of sample to be taken for sieving
63 mm	50 Kg
50 mm	35 Kg
40 to 31.5 mm	15 Kg
25 mm	5 Kg
20 to 16 mm	2 Kg
12.5 mm	1 Kg
10 mm	0.50 Kg
6.3 mm	0.2 Kg
4.75 mm	0.2 Kg
2.36 mm	0.1 Kg

4.3.1 **SIEVE ANALYSIS (COARSE AGGREGATE)**

(I.S : 383 - 1970 and I.S : 2386 (Part-I) - 1963)

1. **AIM** : Determination of particle size disribution of coarse aggregate by sieving.

2. **APPARATUS** :

2.1 **Sieves** : Sieves of the sizes conforming to I.S : 460-1978 "Specification for test sieves" shall be used : 80mm, 63mm, 50mm, 40mm, 31.5mm, 25mm, 20mm, 16mm, 12.5mm, 10mm, 6.3mm, 4.75mm.

2.2 **Balance** : Take the balance such that it is readable and accurate to 0.1 percent of weight of the test sample.

2.3 **Sample** : The weight of the sample available is to be not less than the weight given in table-I. Prepare the sample for sieving from the larger sample either by quartering or by means of a sample divider.

TABLE - I

Minimum Weights for sampling

Max.size present in substantial proportions	Min.weight of sample required for testing
63 mm	100 Kgs
50 mm	100 Kgs
40 mm	50 Kgs
25 mm	25 Kgs
20 mm	25 Kgs
16 mm	12 Kgs
12.5 mm	6 Kgs
10.0 mm	3 Kgs

2.4 **Procedure** : Shake each sieve separately over a clean tray until not more than a trace passes, in any case, for a period of not less than two minutes. Do the shaking in a varied motion backwards, and forwards, left to right, circular clockwise and anticlock wise and with frequent jarring, so that the material is kept moving over the sieve surface in frequent changing directions. Material is not to be forced

through the sieve by hand pressure, but on sieves coarse than 20 mm placing of particles is permitted, break lumps of fine materials, if present by gentle pressure with finger against the side of the sieve.

2.4.1 In order to prevent blinding of the sieve apertures by overloading the amount of aggregate placed on each sieve shall be such that the weight of the aggregate retained on the sieve at completion of the operation is not greater than the value given for that sieve in table-II. Sample weights given in table III will thus normally require several operations on each sieve.

TABLE - II

Maximum weight to be retained at the completion of sieving

I.S.Sieve	Maximum weight for	
	45cm dia sieve kgs	30cm dia sieve kgs
50 mm	10	4.5
40 mm	8	3.5
31.5 mm or 25 mm	6	2.5
20 mm	4	2.0
16 mm or 12.5 mm	3	1.5
10 mm	2	1.0
6.3 mm	1.5	0.75
4.75 mm	1.0	0.50
3.35 mm	-	0.30

TABLE - III

Minimum weight of sample for sieve analysis

max.size present in substantial proportions	Min.weight of sample to be taken for sieving
63 mm	50 kgs
50 mm	35 kgs
40 or 31.5 mm	15 kgs
25 mm	5 kgs
20 or 16 mm	2 kgs
12.5 mm	1 kg
10.0 mm	0.5 kg
6.3 mm	0.2 kg
4.75 mm	0.2 kg
2.36 mm	0.1 kg

2.4.2 If the amount of the coarse aggregate obtained as above is substantially less than that required for testing in accordance with table-III, take another sample which is sufficiently large to produce an adequate sample. If the amount of the coarse aggregate thus obtained is substantially greater than that required for testing reduce it by quartering or by means of a sample divider.

2.5 Reporting of results : Calculate the results and report them as :

a) The cumulative percentage by weight of the total sample passing each of the sieves to the nearest whole number.

b) The percentage by weight of the total sample passing one sieve and retained on the next smaller sieve to the nearest 0.1 percent.

GRAVEL

4.4.0 Specification No. 138 of APSS :

The moorum shall be comprised of well graded coarse siliceous grains sharp and gritty to touch and free from dirt and other deleterious matter. It shall not contain lumps larger than 20 mm

and the fines passing through 75 microns I.S.Sieve shall no
exceed 10%

The liquid limit (L L) and plasticity index (P.I) of moorum fo
various uses shall be as follows :-

		LL	PI
a)	Filler material in WBM roads	-- 35	Not more than 4 to
b)	Filler material in surface treated WBM roads	-- 20	Not more than 6
c)	Sub-base for roads	-- 20	Not more than 6
d)	Backing for revetments	-- 20	Not more than 6

Stacking :- This shall conform to I.S.101

All linear measurements shall be in metres correct to 0.01 of
metre. Volumes shall be worked out in cubic metres. Correct
0.01 of a cubic metre.

4.5.0 STEEL

I.S.I.Codes applicable are

1. I.S. 226 - 1975	(Structural Steel)
2. I.S. 432 - 1966	(Part-I) Mild and medium tensile ste bars
3. I.S. 1139 - 1966	(Hot rolled M.S., Mts) deformed bars.
4. I.S. 1786 - 1979	(Cold worked steel high strength bars)
5. I.S. 1566 - 1967	(Hard drawn steel wire fabricated)

The modulus of elasticity of steel shall be 200 KN/mm²
1786-1979)

0.2% proof stress : The stress at which no proportional elon
tion equal to 0.2% of the original ga
length takes place.

Tensile strength : The maximum load reached in a tensile t
divided by the original cross sectional are
the gauge length portion of the test pie
Also termed as maximum stress or ultim
tensile stress.

Nominal mass : The mass of bar of nominal dia meter and of density 0.00785 Kg/mm² per metre run.

Reinforcement bars :

a) **General :**

Reinforcing Bars shall be placed in the concrete as shown in the drawings.

b) **Materials :**

The reinforcement to be used shall be of High Yield Strength Deformed (H.Y.S.D.) bars of grade F.I. 415 conforming to I.S. 1786 - 1979 (I.S. specifications) for High Yield Strength Deformed steel bars and wires for concrete reinforcement).

a) **Placing :**

Reinforcement shall be bent and fixed in accordance with the procedure specified in I.S. (code of practice for bending and fixing of bars for concrete reinforcement). All reinforcement shall be placed and maintained in the position shown in the drawings.

Splices shall be located where shown on the drawings provided that the location of the splices may be altered subject to the written approval of the Engineer-in-Charge.

In order to meet design and space limitation, on splicing, some bent bars may exceed usual clearance cutting and bending of such bars from stock lengths may be required at the site.

Unless otherwise prescribed, placement dimensions shall be to the centrelines of the bars. Reinforcement will be inspected for compliance with requirements as to size, shape, length, splicing, position, and amount after it has been placed but before being covered with concrete. Before reinforcement is embedded in concrete the surfaces of the bars and the surfaces of any supports shall be cleaned of heavy flaky rust, loose mill scale, dirt, grease or other foreign substances which are objectionable. Heavy flaky rust that can be removed by firm rubbing with burlaps, or equivalent treatment is considered objectionable.

As specified to clause 11.8 of I.S.456-1978 (unless otherwise specified by the Engineer-in-charge) reinforcement shall be placed with in the following tolerances.

a) For effective depth 200 mm or less = +/- 10 mm

b) for effective depth more than 200 mm = +/- 15 mm

The cover in no case be reduced by more than one third of specified over or 5 mm which ever is less.

(a) Reinforcement shall be securely held in position so that it will not be displaced during the placing of the concrete and special care shall be exercised to prevent any disturbance of the reinforcement in concrete that has already been placed. Welding bars shall be done as directed by the Engineer-in-Charge and in conformity with the requirements of clause 11.4 of I.S. 456-1978, chairs, hangers, spacers and other supports for reinforcement shall be of concrete, metal or other approved materials. Concrete cover shall be as shown on the drawings.

Dowels

The dowels shall be of same HYSD bars of grade F.I. 415 conforming to I.S. 1786-1985 as used for reinforcement.

Details for dowels shall be as shown on the drawings or as directed by the Engineer-in-Charge.

Dowels shall be placed in the concrete where shown on the drawings or where directed and will be inspected for compliance with requirements as to size, shape, length, position and amount after they have been placed but before being covered by concrete.

Before the dowels are embedded in concrete, the surfaces of dowels shall be cleaned of all dirt, grease or other foreign substance which in the opinion of the Engineer-in-Charge are objectionable.

The dowels shall be accurately placed and secured in position so that they will not be displaced during the placing of the concrete.

4.6.0 **MASONRY**

Materials

4.6.1 **Stone for masonry**

(a) **General**

The stones used for stone masonry shall conform to the relevant specification of clause 4.1 to I.S. code of practice for construction of stone masonry part-I rubble stone masonry.

The stone of the required quantity shall be obtained from the quarries specified in the lead chart. The common types of natural stones which are generall used are granite, trap and other igneous rocks, and shall be free from defects like decay, cavities, cracks, flaws, sand, holes, soft seats, veins, patches of soft or loose materials, or any other deleterious materials like iron oxide, organic impurities etc. They shall be free from rounded, worn or weathered surfaces or skin or coating which prevents the adherence of mortar. All stones used shall be clean of uniform colour and texure, strong, hard and durable.

The crushing strengths of the stones shall be determined in accordance with I.S. 1121-1974. The strength shall be as detailed below.

TABLE 4 (A)

Sl.No.	Type of stone	Minimum crushing strength
1.	Granite	1000 Kgs./Sq.cm
2.	Basalt	400 Kgs./Sq.cm
3.	Lime Stone	200 Kgs./Sq.cm

The percentage of water absorption shall not exceed 5% by weight as determined in accordance with I.S. 1124-1974.

Samples of the stones collected from the stone stacks are to be tested for the standards specified above and other relevant Indian Standards and stones stacks not conforming to the standards are to be rejected.

Sand for masonry

(a) **General**

Sand shall generally conform to specifications given in paragraph except that the sand for mortar shall conform to the grading of sand given in clause 4 of I.S. 2116 - 1980 as detailed below, in Table 4 (b)

All material shall be deposited in embankments so that cobbles, gravel and boulders are well distributed through other material and not nested in any position within or under the embankment as enunciated in clause 6.4 of I.S. 4701- 1982.

In areas where required excavation does not furnish suitable or adequate material for constructing embankments, material

shall be obtained from areas where material in excess of that required to construct the adjacent embankment is available.

Where the original ground surface is below the bed of the drain or where construction of a fill below the bottom of the drain is prescribed, such fill shall be placed as compacted embankment. Where the orginal ground surface is below the base of a structure, the fill required to form a suitable foundation for the structure shall be placed as compacted embankment.

(a) **Embankments not to be compacted :**

Embankments not to be compacted shall be formed conforming to clause 6.6.1 of I.S.4701-1982. The material for these embankments shall have optimum moisture content before earth moving equipment is routed over the embankment. The embankment shall be built in layers not exceeding 30 cms in thickness. Embankments shall be built in approximately horizontal layers carried across the entire width of the embankmnts to the required slopes. Embankments shall not be widened with loose material dumped from the top. Embankments may be built by excavating and hauling equipment or by excavating machinery depositing the materials directly from the excavation. Embankments built by excavating the hauling equipment shall be made in horizontal layers and shall be kept as close to level as practicable. The travel over the embankments during construction shall be routed so as to distribute the compacting effect of the equipment to the best practicable advantage.

Embankments built by excavating machinery depositing the material directly from the excavation shall be made in horizontal layers having a thickness of 30 centimetres. Finer portions of the material excavated shall be placed in that part of the embankment nearest the water and the coarser materials shall be placed in the outer part of the embankment.

TABLE 4 (B)

GRADING OF SAND FOR USE IN MASONRY MORTARS

I.S.Sieve designation	Percentage passing by mass
4.75 mm	100
2.36 mm	90 to 100
1.18 mm	70 to 100
600 Micron	40 to 100
300 Micron	5 to 70
150 Micron	0 to 15

A sand whose grading falls out-side the specified limits due to excess or deficiency of coarse or fine particles may be processed to comply with the standard by screening through a suitably sized sieve and/or blending with required quantities of suitable size sand particles.

Cement

Portland Pozzolana cement conforming to I.S. 1489-1976 shall be used for masonry work Ordinary Portland cement conforming to I.S.269-1976 may also be used for masonry work in the event of non-availability of Portland Pozzolana cement.

Water

The specifications and conditions specified shall be applicable.

Mortar

Preparation of mortar

Unless otherwise specified the cement Mortar used in masonry works shall be cement mortar mix MM 5 grade using minimum 288 Kgs. or cement per cubic metre of mortar where a particular mix is indicated in the specifications and drawings, it shall be used. Mixing shall be done thoroughly preferably in a mechanical mixer. In such case, the cement and sand in the specified proportions shall be mixed dry thoroughly in the mixer operated manually or by power.

Water shall be added gradually and wet mixing continued atleast for 3 minutes. Water should not be more than that required for bringing the mortar to the required working consistency of 90 to 130 millimetres as required in clause 9.1.1 of I.S. 2250-1981. The mix shall be clean and free from injurious kind of soil, acid, alkali, organic matter or deleterious substances.

Time of use of cement mortar

Cement mortar shall be used as soon as possible after mixing and before it has begun to set, with in 30 minutes after the water is added to the dry mixture.

Mortar unused for more than 30 minutes should not be used and shall be removed from the site of work. The use of re-tempered mortar will not be permitted to be used for the masonry.

Test of mortar

Mortar Test cubes shall be cast for the mortar used on the work and shall be tested in accordance with appendix - A of I.S. 2250-1965 code of practice for preparation and use of Masonry Mortars. Such cubes shall develop a compressive strength of atleast 50 Kgs. Per Square centimetre for M.M. 3 grade cement mortar mix, 75 kgs. per square centimetre for M.M. 7.5 grade mortar mix and 30 Kgs per square centimetre for M.M 5 grade mortar mix.

Stone masonry

General

Stone masonry in General shall conform to the requirements of I.S. 1597-1967 code of practice for construction of stone masonry (Part-I) rubble stone masonry. Ashlar Masonry I.S. 1129-1972 specification for dressing natural building stones.

Size of stone

The length of the stones shall not exceed three times the height nor shall the stones be less than the twice as long as height plus one joint. No stones shall be less in breadth than height and the breadth on the base shall not be greater than 3/4th thickness of the wall nor less than 15 centimetres.

Dressing of the stone for coursed rubble masonry

The stones to be used for the faces of the masonry shall be hammer dressed. A hammer dressed stone also known as hammer faced stone shall have no sharp and irregular corners and shall have comparatively even surface so as to fit well in the Masonry. Unless otherwise specified the bushing on the face shall not be more than 40 millimetres on the exposed face.

Other stone surfaces like rock faced stone surface, or punched stone surface, or closed pitched stone surface, are to be brought out in dressing as per the orders of the Engineer-in-Charge.

Laying of stones for coursed rubble masonry

The masonry shall be laid to lines, levels, curves, shapes shown in the drawings. Stones in the hearting shall be laid on their broadest face.

Stratified stones must be laid on their natural beds. All bed joints shall be normal to the line of pressure upon them.

In battered walls, the beds of the stones and the planes of course should be at right angles to the batter.

The courses of the Masonry shall ordinarily be predetermined. Where there is to be variation in the depth of course, larger stones shall be placed in the lower courses the thickness of course decreasing gradually towards the top of the wall.

The stones shall throughly be wetted before placing in position in the masonry and before covering with mortar. The bed which is to receive the stone shall be cleaned, wetted and covered with a layer of fresh mortar. All stones shall be bedded full in mortar and the vertical joints filled with mortar. The stones so covered with mortar should be settled carefully with a wodded mallet immediately on placement and solidly bedded in mortar before it has set. Clean chips and spalls shall be wedged into the mortar joints and beds wherever necessary. No dry or hollow space shall be left any where in the masonry and each stone shall have all the embedded faces completely covered with mortar.

Face work and hearting shall be brought up evenly but the top of each course shall not be levelled up by use of flat chips.

In case of any stone already set in mortar is disturbed, or the joints broken, the stone shall be taken out without disturbing the adjoining stones and joints, the mortar thoroughly cleaned from the joints and the stone reset in fresh mortar. Attempts shall never be made to shake one stone over another already laid.

Shaping and dressing shall be done before the stone is laid in the work. No dressing and hammering which will loosen the masonry will be permitted after it is once placed.

The face stones shall be squared on all joints with beds horizontal. They shall be set in regular courses of uniform thickness from bottom to top throughout. No face stone shall be less than 150 millimetres in width for 400 millimetre thick walls, 200 millimetres for 450 millimetre thick walls and 250 millimetres for 600 millimetre thick walls. More than half the quantity of stones shall each have a volume of more than 1/70 cubic metre, 1/50 cubic metre and 1/35 cubic metre being used in for walls of 400 millimetres, 450 millimetres and 600 millimetres respectively. The bed and vertical joints of the stone shall be hammer dressed square with the face for a width of not less than 75 millimetres and 40 millimetres onwards from the face respectively. Bushing shall not project more than 40 millimetres in faces.

The height of each course shall be the height of the stone used in the course. Stones of different depths should not be used. Height of each course shall not exceed breadth at face nor thickness inwards.

The face stone shall be laid alternately in headers and stretchers, so as to break joints by atleast 75 millimetres. Headers shall project atleast 100 millimetres beyond the stretchers. The joints should not exceed 12 millimetres in thickness.

In walls upto a width of 600 millimetres bond stones running through the wall shall be provided at intervals of 2 metres clear in every course. For walls thicker than600 mm a line of headers each header overlapping the other by 150 mm or more shall be provided front to back at 2 metres intervals in every course. Care shall be taken not to place the bond stones of successive courses over each other. The positions of bond stones shall be marked on both the faces for identification and verification.

All connected masonry in a structure shall be carried out neatly at one uniform level through out but when breaks are unavoidable, the masonry shall be raked in sufficiently long steps for facilitating joining of old and new work. The stepping of the raking shall not be more than 45 degrees with the horizontal.

For masonry hearting, all stones, chips, spall etc. shall be washed clean with water before use to ensure a good bond between the stone and the mortar. The interior of the masonry shall be filled in with good flat bedded stones set as close as possible and well covered with mortar. Chips and spalls of stone should be covered with mortar alround, should be wedged in the mortar joints wherever necessary, such that there are no hollow spaces, any where in the masonry joints nor the mortar joints are thicker than specified.

Dressing of stones for random rubble masonry

The facing stone shall be hammer dressed on the face, sides and the beds to enable it to come into close proximity with the neighbouring stone. The bushing in the face shall not project more than 40 millimetres on an exposed face and 12 millimetres on a face to be plastered. Stones with round surface shall not be used in construction.

Laying of stones for random rubble masonry

The laying of stone for Random Rubble Masonry is same as described above except that the stones to be used for face shall be dressed, as described above.

Curing

All masonry surfaces shall be treated as specified to prevent loss of moisture from mortar until the required curing period is elapsed or until placement of other masonry or concrete or backfill against surfaces.

All masonry built with cement Mortar shall be kept watered continuously for a minimum period of two weeks from the date of construction. Watering shall be done carefully so as not to washout the mortar, joints or disturb the masonry in any manner.

4.7.0 **BRICK MASONRY**

The bricks shall be well burnt and shall give a clear ringing sound when struck. They shall be clean, free from cracks, chips, stones etc.,

SIZE : 190 x 190 x 90 mm

PHYSICAL CHARACTERSTICS

1)	Compressive strength	Not less than 40 Kg/Cm^2
2)	Absorption after 24 hours immersion in cold water	Not more than 20% by weight

CONSTRUCTION

A layer of mortar shall be spread on full width for suitable length of the lower courses. Each brick shall be laid so as to project over the one below, and then pressed into the mortar and set by gentle tapping with the handle of a trowel. Its inside faces shall be buttered with mortar before the next brick is laid and pressed against it. On completion of a course, the vertical joints shall be fully filled from the top with mortar.

The thickness of the joint shall not be more than 12 mm.

The face joints shall be raked to a minimum depth of 15 mm during the progress of work when the mortar is still green so as to provide proper key for the plaster or pointing. The face of brick work shall be cleaned the very day on all mortar droppings.

Brick shall be laid on edge for window sills and roof level.

IMP : It is common practice to lay mortar horizontally over each layer without filling the vertical joints. This shall be avoided. Vertical joints shall invariably be filled with Mortar.

4.8.0 PLASTERING AND POINTING

Materials

Sand for mortar for plastering and pointing

(a) General

Sand shall generally conform to specification given in para graph except that the sand for preparation of mortar for plasterin and pointing shall conform to the following gradation, shown Table 5 (A)

TABLE 5 (A)

4.8.1 REQUIREMENTS OF GRADING FOR EXTERNAL PLASTERING AND POINTING

For the purpose of indicating the suitability for use, the san is classified as Class-A and Class-B in accordance with the limit of grading. Class-'A' sands shall be used generally for plasterin and pointing and when they are not available Class-B sands ma be used.

I.S.Sieve Designation	Percentage By weight passing I.S.Sieve	
	Class - A	Class - B
4.75 mm	100	100
2.36 mm	90 to 100	90 to 100
1.18 mm	70 to 100	70 to 100
600 Microns	40 to 85	40 to 95
300 Microns	5 to 50	10 to 65
150 Microns	60 to 10	0 to 15

The procurement of sand for mortar for plastering an pointing shall conform to the specifications given in paragraph

Cement

The specification and conditions specified for supply o cement in paragraph shall be applicable here also.

Protland Pozzolana cement conforming to I.S. 1489-197 shall be used for preparation of mortar for plastering and pointin work. Ordinary Portland cement confirming to I.S. 269-1976 ma

also be used for plastering and pointing work in the event of non-availability of Portland Pozzolana cement.

Water

The specification and condition specified for procurement of water shall be applicable here also.

Mortar

Preparation of mortar for plastering work

Unless otherwise specified the cement mortar used in plastering work shall be in cement mortar mix of MM-7.5. Grade using minimum 360 Kgs.of Cement per cubic metre of mortar. Where a particular mix is indicated in the specification and drawings, it shall be used. The other specifications and conditions enunciated in paragraph 4.2.1. shall apply for this mortar for plastering work also.

Preparation of mortar for pointing

The cement mortar used in pointing work shall be cement mortar mix of MM-7.5 grade, using 360 Kgs. of cement per cubic metre of mortar where a particular mix is indicated in the specification and drawings, it shall be used. The other specifications and conditions enunciated in Paragraph 4.2.1 shall apply for this mortar for pointing work also.

Plastering with cement mortar mix- mm -7.5 grade 20 mm thick

Preparation of surface

The roughening of the back-ground improves the bond of plaster. All joints shall be thoroughly raked. After roughening the surface, care shall be taken to moisten the surface sufficiently before plastering as otherwise freshly exposed surface may tend to absorb considerable amount of water from the plaster.The surface shall be wetted evenly before applying the plaster. Care shall be taken to see that the surface is nor too dry as this may cause lack of adhesion or excessive suction of water from the plaster. A fog spray may be used for this work. As far as possible, the plaster work shall be done under shade.

Laying of plastering with cement mortar mix mm-7.5 Grade, 20 mm thick

The mortar used for plastering shall be stiff enough to cling and hold when laid. To ensure even thickness and true surface,

plaster shall be applied in patches of 150 mm x 150 mm of the required 20 mm thickness at not more than 2 metres intervals horizontally and vertically over the entire surface to serve as guides. The surface of these guides shall be truly in the plane of the finished plaster surface and truly plumb. The mortar shall then be applied to the surface to be plastered between the guides with a trowel. Each trowel full of mortar shall overlap and sufficient pressure shall be used to force it thorough to contact with the surface. On relatively smooth surfaces, the mortar shall be dashed on with the trowel to ensure adequate bond. The mortar shall be applied to a thickness slightly more than that specified, using a string, stretched out between the guides. This shall then be brought to a true surface by working with a long wooden float with small swing motion. The surfaces shall be periodically checked with string stretched across it. Finally the surface shall be rendered smooth with a wooden float, over working shall be avoided. All corners and junctions shall be brought truly to a line with any necessary rounding or chamfering.

If it is necessary to suspend the work at the end of the day it shall be left in a clean horizontal or vertical line not nearer than 150 millimetres for any corner or arises or on parapet tops or on coping etc. When recommencing the work the edges of the old work shall be scraped clean and treated with cement slurry before the new plaster is laid adjacent to it. After the first coat is done it shall be kept undisturbed for the next 24 hours and thereafter kept moist and not permitted to dry until the final rendering is applied.

After the plaster has sufficiently hardened cement slurry with cream like consistency shall be applied thinly and evenly and rubbed to a fine condition.

The finished surface shall be cured with water for a period of 100 days.

Pointing the CR masonry with cement mortar mix mm 7.5 grade

Preparation of surface

The joints in the masonry shall be raked out to a depth not less than the width of the joint or as directed when the mortar is green. Joints are to be brushed clean of dust and loose particles with a stiff brush. The areas shall be washed and the joints thoroughly wetted before pointing is commenced.

Flush pointing with cement mortar mix MM 7.5 grade for masonry

The pointing to be done shall be flush pointing with cement mortar mix MM 7.5 grade. The mortar shall be pressed into the raked out joints according to the type of pointing required. The mortar shall not be spread over the corners, edges or surface of the masonry. The pointing shall then be finished as detailed below. The mortar shall be finished off flush and level with the edges of the stones, so as to give a smooth appearance. The edges shall be neatly trimmed with a trowel and a straight edge.

The pointing shall be cured for seven days.

4.9.0 CONCRETE

Concrete structures

Concrete in structures

a) Concrete in structures shall conform to the General concrete requirements.

Construction of structures

The structure to be constructed include the following

a) Road bridges including abutments and piers

b) Cross drainge works like under-tunnels, Acqueducts, super passages and inlets and outlets.

c) Regulators.

d) Off-take sluices.

e) Spillway regulator

f) Anicut and aprons.

The structures shall be built to the lines grades and dimensions shown on the drawings. The dimension of each structure as shown on the drawings will be subject to such modifications as may be found necessary by the Engineer-in-Charge to adopt the structure to the conditions disclosed by the excavation or to meet other condition. Where the thickness of any portion of a concrete structure is variable, it shall vary uniformly between the dimensions shown.

Model sections

Model section shall be constructed in C.C.M 10 grade concrete at 100 mts intervals in straight reaches and at 50 metre interval in curves. The length of the section in bed, shall be 5% of bed width at ends (minimum 500 mm, Maximum 2 mts. at each end and 15% of bed width at centre (minimum 1 metre, maximum 6 metres).

General concrete requirements :

Composition :

(a) **General**

Concrete shall be composed of cement, sand, coarse aggregate, water and admixtures (if any) as specified and all well mixed in concrete mixers by weight and brought to the proper consistency.

(b) **Nominal maximum size of aggregates**

Coarse aggregates to be used in concrete shall be as large as practicable, consistent with required strength, spacing of reinforcement and embedded items and placement thickness. The size of the coarse aggregate to be used will be determined by the Engineer-in-Charge and may vary incrementally according to the conditions encountered in each concrete placement. Nominal maximum size of aggregate for concrete in structures shall be as indicated in the relevant drawings appended to the contract documents. Smaller coarse aggregate than specified shall be used where in opinion of the Engineer-in-Charge proper placement of concrete is impracticable with the size of the aggregate specified in the drawings.

(a) **Mix proportions :**

The proportions of various ingredients to be used in the concrete for different parts of the work will be established by proper mix design by the Engineer-in-charge during the progress of the work. In proportioning concrete, the quantity of both cement and aggregate should be determind by mass as per clause 9.2 of I.S. 456-1978. Water shall be either measured by volume in calibrated tanks or weighed. All measuring equipment shall be maintained in a clean serviceable condition and their accuracy periodically checked. Adjustments shall be made as directed to

obtain concrete having suitable workability, impermeability, density, strength and durability without the use of excessive cement. The acceptance or rejection of concrete shall be as per the acceptance criteria laid down in clause 15 of I.S. 456-1978.

The mix design and average concrete strength shall be adjusted according to the cube strength test results conforming to clause 14.2, 14.3, 14.4, 14.5 of I.S. 456-1978.

The net water cement ratio exclusive of water absorbed by the aggregate shall be sufficiently low to provide adequate durability in concrete. The water cement ratio for various grades of concrete shall be as determined and ordered by the Engineer-in-Charge.

Admixtures of pozzolana if ordered shall conform to the requirements specified in I.S.9103-1979 (Indian Standard Specification for admixtures for concrete).

(b) **Consistencies**

The slump of concrete at the placement shall be as follows :

I. Reinforced cement concrete :

Sl.No.	Placing condition	Degree of Workability	Value of workability
1.	Concreting of lightly reinforced sections without vibration or heavily reinforced sections with vibration.	Medium	25 mm to 75 mm slump for 20 mm aggregate
2.	Concreting of heavily reinforced sections without vibration	High	75 mm to 125 mm slump for 20 mm aggregate

I. For plain concrete work, slump requirements mentioned in Item-I above are applicable. If the specified slump is exceeded at the placement, the concrete is unacceptable. The Engineer-in-Charge reserves the right to require lesser slump whenever concrete of such less slump can be consolidated readily into place by means of vibration specified by the Engineer-in-Charge. The use of any equipment which will not readily handle and place concrete of the specified slump will not be permitted.

To maintain concrete at proper consistency, the amount of water and sand batched shall be adjusted to compensate for any vibration in the moisture content or grading of aggregates as they enter the mixer. Addition of water to compensate for stiffening of the concrete after mixing but before placing will not be permitted. Uniformity in concrete consistency from batch to batch will be required. However for general guidance the slump requirements for various situations may be considered.

Slump Requirement for Various Situations

1.	Concrete for Road Work	:	20 to 30 mm
2.	Concrete for Beams & Slabs	:	50 to 100 mm
3.	Concrete for walls		
	thin vertical members columns	:	75 to 150 mm
4.	Vibrated concrete	:	15 to 25 mm
5.	Mass Concrete	:	25 to 50 mm

4.9.1 **Quality control measures and concrete**

Quality assurance test programme

The concrete samples will be taken by the departmental engineers and its quality will be tested in the Departmental Laboratory as per the relevant Indian Standard Specifications I.S. No.516-1959 and I.S. No.1199-1959.

1. **Tests :**

(a) **Sampling of fresh concrete :**

As specified in clause 14 of I.S.456-1978 (Indian Standard Code of Practice for plain and reinforced concrete) samples from fresh concrete will be taken as per I.S. 1199-1959 (Indian Standard Methods of sampling and analysis of concrete) and cubes shall be made, cured and tested at 28 days age in accordance with I.S. 5176-1959 (Indian Standard method of test for strength of concrete).

(b) **Density : (Unit Weight) and Yield**

The unit weight and yield will be tested in accordance with I.S. 6441 (Part-I)

b) **Slump** : I.S. 1199-1959

c) **Temperature** : Temperature will be determined by placing a thermometer in the concrete immediately after sampling at the site of placement

d) Making and curing concrete test specimens in the field I.S. 516-1959

e) Capping cylindrical concrete specimens : I.S.516-1959

f) Compressive strength of concrete specimens : I.S.516-1959.

Test facilities :

The contractor shall furnish free of cost samples of all ingredients of concrete for testing and obtain approval from the Engineer-in-Charge. He should also supply free of cost, the samples of all the ingredients of concrete for conducting the required tests.

Cement :

a) General

As per clause 4 of I.S.456-1978 for the purpose of those specifications, cement used shall be any of the following with the prior approval of the Engineer-in-Charge.

a) Ordinary or low heat portland cement conforming to I.S.269-1978 (I.S.Specifications for ordinary and low heat portland cement third revision) and (2) Portland Pozzolana Cement conforming to I.S.1489-1976 (I.S.Specification for Portland and pozzolana cement second revision)

The provisions of this paragraph apply to cement for use in cast in place concrete required under these specifications. Portland cement required, for items such as concrete pipes, precast concrete structural members and other precast concrete products, for grout and mortar and for other items is provided for in the applicable paragraphs of these specifications covering the items for which such portland cement is required.

All cement should be procured by the contractor himself from the reputed cement factories. Tansport from the place of supply to the site shall be in weather tight rail cars, trucks, conveyors and other means which will protect the cement completely from exposure to moisture. Immediately upon receipt at the job site, cement shall be stored in dry, weather tight, properly ventilated

godowns until the cement is batched. Storage of materials shall be as described in I.S.4082-1977 (I.S.Recommendations on stacking and storage of construction materials at site). To prevent undue aging of bagged cement after delivery, the contractor shall use bags of cement in the chronological order in which they were delivered to the job site. All storage facilities shall be suject to approval by the Engineer-in-Charge and shall be constructed to permit easy access for inspection and identification.

a) **Cement options** : Cement shall be furnished in accordance with one of the following options.

b) Ordinary portland cement conforming I.S.269-1976 shall be used for all R.C.C.works.

c) Portland Pozzolana cement conforming I.S. 1489-1976 shall be used for all other than R.C.C.works. Ordinary portland cement may also be used in the event of non-availability of pozzolana cement.

a) **Materials** :

i. Ordinary Portland Cement I.S.269-1976.

ii. Portland pozzolana cement I.S.1489-1976.

iii. Acceptance of Cement : Tested cement will be used by the contractor (Clause 10.1 of I.S.269-1976)

iv. Acceptance of Pozzolana : Pozzolana added to the concrete as an admixture will be sampled and tested as per I.S. 9103-1979.

Admixtures :

Admixture shall be uniform consistency and quality and shall be maintained at the job site at uniform strength of solution. Admixtures shall be batched separately in liquid form of containers capable of measuring at one time the full quantity of each admixture required for each batch. Chemical admixtures which harm the quality and strength of concrete shall not be used in the concrete.

Admixture to be used in concrete shall conform to I.S.9103-1979 Indian Standard Specifications for admixtures for concrete.

Water :

The water used in making and curing of concrete mortar and grout shall be free from objectionable quantities of silt, organic matter, injurious amouts of oils, acids, salts and other impurities etc., as per I.S. Specifications No.456-1978.

The Engineer-in-Charge will determine whether or not such quantities of water impurities are objectionable.

Such determination will usually be made by comparison of compressive strength, water required, time of set and other properties concrete made with distilled or very clean water and concrete made with the water proposed for use. Permissible limits for solids when tested in accordance with I.S.3025-1964 shall be as tabulated below :

		Permissible Limits For Solids
1.	Organic	Maximum permissible limit 200 mg/litre
2.	Inorganic	3000 mg/litre
3.	Sulphate (as SO_4)	500 mg/litre
4.	Chlorides (as Cl)	2000mg/litre for plain concrete work and 1000 mg/litre for RCC work
5.	Suspended matter	2000 mg/litre.

If any water to be used in concrete, mortar or grout is suspected by the Engineer-in-Charge of exceeeding the permissible limits for solids, samples of water will be obtained and tested by the Engineer-in-Charge in accordance with I.S.3025-1964.

Sand : (Fine aggregate)

a) **General :**

The term sand is used to designate aggregate most of which passes 4.75 millimetres I.S. Sieve and contains only so much coarser material as permitted in clause 4.3 of I.S.383-1970. Sand shall be predominently natural sand which may be supplemented with crushed sand to make up deficiencies in the natural sand gradings.

Sand shall have a uniform stable moisture content. Determination of moisture content shall be made as frequently as possible, frequency for a given job being determined by the Engineer-in-Charge according to weather conditions (I.S.456-1978).

b) **Quality**

The sand shall consist of clean, desnse, durable uncoated rock fragments, as per I.S.383-1970.

Organic impurities in Sand : Colour no darker than the specified standard in clause 6.2.2. of I.S.2386 (Part-II) 1963 (Indian Standard method of test for aggregates for concrete Part-II estimation of deleterious materials and organic impurities).

Sodium Sulphate Test for Soundness : The sand to be used shall pass a Sodium or Magnesium Sulphate accelerated test as specified in I.S.2386 (Part-V) 1963 for limiting loss for weight.

Specific gravity : 2.6. Minimum

Deleterious Substance : The amounts of deleterious substance in sand shall not exceed the maximum permissible limits prescribed in table I Clause 3.2. I of I.S.383-1970 (Indian standard specification for coarse and fine aggregates from natural source for concrete) when tested in accordance with I.S.2386-1963.

c) **Grading**

The sand as batched shall be well graded and when tested by means of standard sieves shall conform to the limits given in Table-4 of I.S.383-1970 and shall be described as Fine Aggregates, grading Zones-I, II, III and IV. Sand complying with the requirements of any of the four grading zones is suitable for concrete. But, sand conforming to the requirements of grading zone-IV shall not be used for reinforced cement concrete work.

Coarse aggregate :

a) **General**

For the purposes of these specifications, the term 'Coarse Aggregate designate clean well grades aggregate most of which is retained on 4.75 mm. I.S.Sieve and containing only so such fine material as permitted for various types described under Clause 2.2 of I.S.383-1970. Coarse Aggregate for concrete shall consist of uncrushed gravel or stone, crushed gravel or stone and partially crushed gravel or stone.

Coarse Aggregate shall generally have uniform and stable moisture content. In case of variation, clause 9.2.3 of I.S.456-1978 shall govern during batching.

b) **Quality**

The coarse aggregate shall consist of naturally occuring (crushed or uncrushed) stones, and shall be hard, strong, durable, clean and free from veins and adherent coating and free from injurious amount of disintegrated pieces, alkali, vegetable matter and other deleterious materials. Coarse aggregate will be rejected if it fails to meet any of the following requirements.

1. **Los-angles abrasion test :**

The abrasion value of Aggregates when tested in accordance with the method specified in I.S. 2386 (Part-IV) using Los-Angles machine shall not exceed 30% for aggregates to be used in concrete for wearing surface and 50% for aggregates to be used in other concrete.

2. **Aggregate crushing strength test :**

Aggregate crushing value, when determined in accordance with I.S.2386 (Part-IV) 1963 shall not exceed 45% for aggregate used for concrete other than wearing surface and 30% for wearing surfaces. As an alternative to the crushing strength test aggregate impact value will be determined with the method specified in I.S.2386 (Part-IV) 1963. The aggregate impact value shall not exceed 45% by weight for aggregates used for concrete for other than wearing surfaces and 30% by weight for concrete for wearing surface such as runways, roads and pavement.

3. **Soundness test :**

The coarse aggregate to be used for all concrete works shall pass a sodium or magnesium sulphate accelerated soundness test specified in I.S.2386 (Part-V) 1963, and the average loss of weight after 5 cycles shall not exceed the limits specified in clause 3.6.67 of I.S.383-1970.

4. **Specific gravity :** 2.60 minimum.

5. **Deleterious materials :**

The maximum quantity of deleterious materials in coarse Aggregate shall not exceeed the limits specified in Table-I of I.S.383-1970 when tested in accordance with I.S.2386- 1963, 6.3.8.

Production of sand and coarse aggregate :

a) **General**

Sand and coarse aggregate for concrete and sand for mortar and grout is to be obtained from the sources approved in the relevant lead charts.

Tests performed on samples of sand and coarse Aggregate obtained from the sources mentioned in the descriptive lead charts, indicated that they are generally suitable. Well in advance of their usage on the works, the contractor shall have his own testing of materials and satisfy himself that they conform to the specification mentioned herein for use on the works.

If sand and coarse aggregate are to be obtained from a deposit not previously tested and approved representative samples for preconstruction test and approval shall be taken not less than 60 days before the sand and coarse aggregates are required for use. Each sample shall approximately consist of 100 kg. Of material. In addition to pre-construction tests, and approval of deposits, theEngineer-in-Charge may test the aggregates for their suitability during their processing. The contractor shall provide such facilities as may be necessary for procuring representative samples at the aggregate processing plant. Final acceptance of aggregates will be based on the samples taken from the stocks at work site.

Batching :

a) **General :**

The grading of aggregates will be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions, the different sizes being stocked in separate stock piles. The materials shall be stock piled a day before use. The grading of coarse and fine aggregates will be checked as frequently as directed by the Engineer-in-Charge.Water shall be added by weight or measured by volume in calibrated tanks. The amount of added water shall be adjusted to compensate for any observed variations in the moisture contents. Determination of moisture content in the aggregate shall be in accordance with I.S.2386 (Part-III) 1963 (Indian Standard method of test for aggregate for concrete Part-III specific gravity, density, voids, absorption, and bulking). In the absence of tests, the amount of surface water carried by aggregates will be estimated in accordance with Table-4 of I.S.456-1978.

Mixing

General :

The concrete ingredients shall be thoroughly mixed in mechanical mixers designed to ensure uniform distribution of all the component materials through out the concrete at the end of the mixing period. Mixing shall be done as per clause 9.3. of I.S.456-1978. The mixer should comply with I.S.1791-1968 I.S.Specifications for batch type concrete mixers).

The concrete as discharged from the mixer, shall be uniform in composition and consistency from batch to batch. Workability shall be checked at frequent intervals as per I.S.1199-1959. Mixers are to be examined regularly for changes in condition due to accumulation of hardened concrete or mortar or to wear of blade. The mixing shall be continued until there is a uniform distribution of the materials so that the mass is uniform in colour and consistency. If there is segregation after unloading the concrete should be remixed.

Any mixer that at any time produces unsatisfactory mix, shall not be used until repaired. If repair attempts are unsuccessful, a defective mixer shall be replaced. Batch size shall be atleast 10% but not in excess of the rated capacity of the mixer.

b). **Central mixers**

Water shall be admitted prior to and during charging of the mixer with all other concrete ingradients. After all materials are in the mixer, each batch shall be mixed for not less than the time specified. The minimum mixing time shall be 2 minutes. The minimum mixing time specified is based on average mixer performance. Excessive over mixing which require addition of water to maintain the required concrete consistency should not be permitted.

4. **Truck mixers :**

Each truck mixer shall be equipped with accurate water meter located between the supply tank and mixer and having a dial or digital indicator and a reliable revolution counter, located near the water meter, which can be readily reset to zero for indicating the total number of revolutions of the drum from each batch. Each mixer shall have affixed there to a metal plate on

which the drum operations in terms of volume for both mixing and agitating and maximum and minimum speeds of rotation of the drum are plainly marked.

Mixing shall be continued for the minimum period specified, and may be increased and No. of revolutions, speed of the drum may be such that the mix as delivered from the mixer has a uniform distribution of materials and the mass is uniform in colour and consistency. In no case, shall be the design water content be exceeded. Concrete shall be discharged within half an hour after the introduction of water and cement into the mixer. Each batch of concrete, when delivered at the job site from commercial ready mix plants, shall be accompanied by a written certificate of batch weights and time of batching.

Temperature of concrete

Fresh structural concrete shall be placed at temperature of between 15 to 32 degree Centigrade. During Hot or cold weather the concreting should be done as per the procedure set out on I.S. 7861 (Part-I) – 1975 or I.S.7861 (Part-II)

The temperature will be determined by placing a thermometer in the concrete immediately after sampling at the site of placement. The temperature of concrete at the batch plant shall be adjusted to assure that the specified concrete temperature is attained at the placement. In case of concrete in hot weather condition, effective means shall be employed such as precooling of aggregates and mixing water and placing at nights as necessary to maintain the temperature of the concrete as it is placed at the specified limit. The methods of pre-cooling shall be subject to approval.

4.9.2 Forms :

a) General

Forms shall be used wherever necessary to confine the concrete and shape it to the required lines. The concrete forms shall be maintained so as to ensure completed work is within the applicable tolerance limits prescribed in clause 10 of I.S.456-1978. If a type of form does not consistently perform in an acceptable manner the type of form shall be changed and method of erection shall be modified.

Plumbing and string lines shall be installed before, and maintained during concrete placement.

Forms shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete and shall be maintained rigidly in position. Where vibrators are to be used, forms shall be sufficiently rigid to effictively transmit energy from the vibrators to the concrete, while not damaging or altering the positions of forms. Forms shall be sufficiently tight to prevent loss of mortor from the concrete chamfer strips shall be placed in the corners of the forms and at the top of the wall placements to produce beveled edges on permanently exposed concrete surfaces. Interior angle of intersecting concrete surface and edges, of construction joints shall not be beveled except where indicated on the drawings.

Suitable struts or stiffners or ties shall be used for the form work wherever necessary. All supports shall be braced and cross braced in two directions. All slices and braces shall be secured by bolting unless specially intended otherwise. All struts shall be firmly supported against settlement and slipping, by suitable means as directed. All supports shall be cut square at both ends and firmly supported against settlement and slipping. When the form work is supported on soils, planks, sleepers etc., shall be used to properly disperse the loads. In case the supports rest on already completed beam or slab suitable props shall be provided under the matter.

b) The form work shall be of well seasoned timber or steel. When timber forms are used, they shall be lined with MS.sheet or other suitable smooth faced non-absorbent material as specified. Supports may be of timber or steel. Suitable wedges in pairs to facilitate adjustment and subsequent releasing of forms shall be provided preferably at the upper end of the suports. The details of the proposed form work and supports shall be got approved before erection.

c) In case of columns, retaining walls or deep vertical component, the height of the column shall facilitate any placement and compaction of concrete and suitable arrangement may be made for securing the form to the already poured concrete for placing the subsequent lifts. No steel ties or wires used for securing this form work shall be left exposed on the face of the finished work.

d) Suitable inserts for blockouts for electrical and other servic fixtures where necessary shall be provided in the required loca tions as specified.

e) Cleaning and Oiling of Forms : At the time of concrete placed in forms, the surfaces of the forms shall be free from encrustations of mortar, grout or other foreign material. Before concrete is placed, the surface of the forms shall be oiled with commercial forms of oil.

f) Removal of Forms : The stripping of form work shall conform to clause 10.3 of I.S. 456-1978. Forms on upper sloping faces of concrete such as forms on the water sides of warped transitions shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Any needed repairs or treatment required on such sloping surfaces shall be performed at once and be followed immediately by the specified curing. To avoid excessive stresses in concrete that might result from swelling of forms, wood forms for wall openings shall be loosened as sooon as the loosening can be accomplished without damage to the concrete. Forms for the openings shall be constructed so as to facilitate such loosening. Forms shall be removed with care so as to avoid injury to the concrete, and any concrete so damaged shall be repaired.

4.9.3 Tolerances for concrete construction; placing and curing

a) **General :**

Tolerances are defined as allowable variations from specified lines, grades and dimensions and as the allowable magnitude of the surface irregularities. Allowable variations from specified lines, grades and dimensions are listed in table given under Sub-Paragraph below :

Concrete shall be within all stated tolerances even-though more than one tolerance may be specified for a particular concrete structure, provided that, the specified variation for one element of a structure shall not apply when it will permit another element of structure to exceed its allowable variation. Where tolerances are not sepcified for a particular structure, tolerances shall be those specified for similar work. As an exception to clause 2 of the general provisions, specific tolerances shown here in connection with any dimension shall govern. Concrete work that exceeds the tolerance limits specified shall be remedied.

b) **Variations from specified lines, grades and dimensions :**

Variation is defined as the distance between the actual position of the structure or any element of the structure and the specified position in plan for the structure or the particular element. Plus or minus variations shown as (+/-) indicate a permitted actual position up or down and in or out from the specified position in plan. Variation not designated as plus or minus indicate the maximum deviation permitted between designated successive points on the completed element of construction.

Specified position in plan is defined as the lines, grades and dimensions described in those specifications or shown on the drawings or as otherwise prescribed by the Engineer-in-Charge. Table variations from specified lines, grades and dimensions.

B. Tolerances for structures

1. Deviations from specified dimensions of cross section of columns, beams, piers and slabs from those specified - 6 mm to +12 mm deviation from dimensions of footing.

a)	Dimension in plan	=	-12 mm to + 50 mm
b)	Eccentricity	=	0.2 times the width of footing in the direction of deviation but not more than 50 mm
c)	Thickness	=	+/- 0.05 times the specified thickness.

NOTE : (Tolerances apply to concrete dimensions only, but not for positioning of vertical reinforcing bars or dowels).

a) Concrete surface irregularities :

1. **General** : Bulges, depressions and offsets are defined as concrete surface irregularities. Concrete surface irregularities are classified as "Abrupt" or "Gradual" and are measured relative to the actual concrete surface.

2. **Abrupt Surface Irregularities** : Abrupt Surface irregularities are defined herein as offsets such as those caused by misplaced or loose forms, loose knots in form Lumber, or other similar

forming fault. Abrupt surface irregularities are measured using a straight edge held firmly against the concrete surface over the irregualrities and the magnitude of the offset is determined by direct measurement.

3. **Gradual Surface Irregularities :** Gradual surface irregularities are defined herein as bulges and depressions resulting in gradual changes on the concrete surface. Gradual surface irregularities are measured using a suitable template conforming to the design profile of the concrete surface being examined. The magnitude of the gradual surface irregularities is defined herein as a measure of the rate of change in slopes of the concrete surface. The surface irregularities shall not exceed6 mm. for bottom slab and 12 mm. for side slopes when tested with a straight edge of 1.5 metre in length.

4. The magnitude of gradual surface irregularities on concrete shall be checked to ensure that the surfaces are within the specified tolerances.

a) **Repair of hardened concrete not within specified tolerances :**

Hardened concrete which is not within specified tolerances shall be repaired to bring it within those tolerances. Concrete repair to bring concrete within the tolerances shall be done only after consultation with a representative of Engineer-in-Charge regarding the method of repair.

Preparation for placing :

a) **General :**

No concrete shall be placed until all form work installation of items to be embedded, and preparation of surface involved in the placement have been approved.

b) **Foundation surfaces :**

All surfaces upon or against which concrete is to be placed shall be free from frost, ice, water, mud and debris.

1. Rock surface shall be free from oil, objectionable coatings and close, semi-detached and unsound fragments. Immediately prior to placement of concrete, surfaces of rock shall be washed

with air water jet and shall be brought to a uniform surface dry condition.

2. Earth foundation surfaces shall be wet to a depth of 15 cm., or to impermeable material whichever is less before concrete is placed.

a) **Construction joint :**

Construction joints are defined as concrete surfaces upon or against which conrete is to be placed and to which new concrete is to adhere but which have become so rigid that the new concrete can not be incorporated integrally with that previously placed. The provision of constructions joints shall conform to clauses 12.4 and 12.4.2 of I.S.456-1978.

When the work has to be resumed on a surface which has hardened, such surface shall be roughned. It shall then be swept clean and thoroughly wetted. For vertical joints neat cement slurry shall be applied on the surface before it is dry. For horizontal joints the surface shall be covered with a layer of mortar about 10 to 15 mm thick composed of cement and sand in the same ratio as the cement and sand in concrete mix. This layer of cement slurry or mortar shall be freshly mixed and applied immediately before placing of the concrete. Where the concrete has not fully hardened all substance shall be removed by scrubbing the wet surfaces with wire or bristle brush care being taken to avoid dislodgement of particles of aggregate. The surface shall be throughly wetted and all free water removed. The surface shall then be coated with neat cement slurry. On this surface, a layer of concrete not exceeding 150 mm. in thickness shall first be placed and shall be well rammed against old work. Particular attention being paid to conrners and close spots, and work thereafter shall proceed in the normal way.

b) **Contraction joints :**

Contraction joints serve to provide for volumetric shrinkage of monolithic concrete and for movement between monolithic units at established joints thus preventing formation of objectionable shrinkage cracks elsewhere in concrete prior to application base curing compound to contraction joints, the surfaces of all joints shall be cleaned throroughly of accretion of concrete or other foreign material by scraping, chipping or other means

approved by the Engineer-in-Charge. Water stops, reinforcing bars and other embedded items shall be free of curing compound when adjoining concrete is placed.

Placing :

a) General

All surfaces upon or against which concrete is to be placed shall be prepared in accordance with specifications.

Retampering of concrete will not be permitted. Any concrete which has become so stiff that proper placing can not be assured shall be wasted.

Concretes shall not be placed in standing water except with written permission of the Engineer-in-Charge and the method of placing shall be subject to approval. Concrete shall not be placed in running water and shall not be subjected to running water until after the concrete has hardened.

Concrete shall not be deposited as nearly as practicable in its final position and shall not be allowed to flow in such a manner that the lateral movement will cause segregation of the coarse aggregate from the concrete mass.

All concrete except drain lining shall be placed in approximately horizontal layers. The depth of layers shall not exceed 15 cm. All construction joints which intersect exposed concrete surface shall be made straight and level to plumb except as shown otherwise on the drawings.

The placing of concrete shall be in accordance with clause 12.2 of 456-1978. If concrete is placed monolithical around openings having vertical dimensions greater than 60 cm. Or if concrete in decks, floor slabs or other similar parts of structures is placed monolithically with supporting concrete, the following requirements shall be strictly observed.

1. Concrete shall be placed up to the top of the formed openings at which point further placement will be delayed to accommdate settlement of fresh concrete. If levels are specified beneath nearly horizontal structual members such as decks, floor slabs beams and girders such levels being between the nearly horizontal members and the vertical supporting concrete be-

low, concrete shall be placed to the bottom of the bevels before delay of placement.

2. The last 60 mm. Or more of concrete placed below horizontal members on bevels shall be placed with a 50 mm or less slump and shall be thoroughly considered. In placing concrete on uniformed slope so steep as to make internal vibrations of the concrete in practical, without forming the concrete shall be placed ahead of non-vibrating slip from screed extending approximately 0.75 metres back from its leading edge. Concrete ahead of the slip form screed shall be consolidated by internal vibrators so as to ensure complete filling under the slip form.

A cold joint is an unplanned joint resulting when a concrete surface hardens before the next batch is placed against it. Cold joints will be allowed only in the event of equipment breakdown or other unavoidable prolonged interruption of continuous placing. If such unavoidable delays in placing occur which make it appear that unconsolidated concrete may harden to the extent that later vibration will not fully consolidate it, the immediately consolidated such concrete to a stable and uniform slope. If delay of placement is then short enough to permit penetration of the underlying concrete placement shall resume with particular care being taken to thoroughly penetrate and re-vibrate the concrete surface placed before the delay. If concrete cannot be penetrated with vibrator, the cold joint shall be then treated as a construction joint.

Care shall be taken to prevent cold joints when placing concrete in any part of the work. The concrete placing rate shall ensure concrete is placed while the previously placed adjacent concete is plastic so that the concrete can be made monolithic by normal use of vibrators. Concrete shall not be placed in rain sufficiently heavy or prolonged to wash mortar from concrete. A cold joint may necessarily result from prolonged heavy rainfall.

a) Transportation :

The transportation of concrete shall conform to clause 12.1 I.S. 456-1978. The methods and equipment used for transporting concrete to its final position in the placement and for time that elapses during transportation shall not cause measurable segregation of coarse aggregate or slump loss during transportation exceeding 5 centimetres.

Concrete shall be deposited as near as practical to its final position. The use of Aluminium pipe or Aluminium chute for delivery of concrete will not be permitted.

If used to transport concrete the truck mixtures shall meet the applicable requirements.

Protection

All fresh concrete surfaces shall be protected from contamination and from foot traffic until be protected against damage from foot traffic and other construction activity by covering with protective mats, plywood, or by other effective means. Methods of protection shall be subjected to approval.

Concrete curing membranes shall be kept intact, and other curing materials and processes shall be maintained as necessary to assure continuous curing for a minimum specified curing time. Protection of curing membranes and other curing methods shall be as per specifications.

Curing

a) **General :**

The curing of concrete shall conform to clause 12.5 of I.S. 456-1978 and clause 5.8 I.S.3873-1978.

Concrete shall be cured by water curing.

The unformed top surfaces of bridges decks shall be cured for 28 days with a damp sand cover on curing mat cover.The sand or curing mats shall not be kept so wet so as to allow water to drain from them and strain other concrete. The sand or curing mats shall be removed after the expiry of the curing period.

All concrete surfaces shall be treated as specified to prevent loss of moisture from the concrete until the required curing period elapses or until immediately prior to placement of other concrete or back fill against those surfaces. Only sufficient time to prepare construction joint surfaces and to bring them to a surface dry condition shall be allowed between discontinuance of curing and placement of adjacent concrete.

Forms should be removed within 24 hours after the concrete has hardened sufficiently conforming to clause 10.3 of I.S. 456-

1978 to prevent structural collapse or other damage by careful form removal. The required repair of all minor surface imperfections shall be made immediately after form removal and prior to curing. Minor surface repair shall be completed within 2 hours after form removal and shall be immediately followed by the initiation of curing by the applicable method specified herein. Concrete surfaces shall be kept continuously moist after form removal until initiation of curing.

Materials :

Concrete cured with water shall be kept wet atleast 28 days from the time the concrete has attained sufficient set to prevent detrimental affects to the concrete surface. The concrete surfaces to be cured shall be kept wet by covering them with water-saturated material by using a system of perforated pipes, mechanical sprinklers or porous hose, or by the other methods which will keep all surfaces continuously (Non periodically) wet.

4.9.4 Repair of concrete

a) General :

Concrete shall be repaired in accordance with clause 5.7 of I.S. 3873-1978. Imperfection and irregularities on concrete surface shall be corrected. In accordance with clause 5.7 of I.S.1873 -1978.

b) Types of repair

All repairs shall be made with concrete. Repairs to concrete surfaces and addition where required shall be made by cutting regular openings into the concrete and placing fresh concrete to the required lines. The chipped openings shall be sharp and shall not be less than 70 mm in depth. The fresh concrete shall be reinforced and chipped and troweled to the surface of the openings. The mortar shall be placed in layers not more than 20 mm in thickness after being compacted and each layer shall be compacted thoroughly. All exposed concrete surfaces shall be cleaned off impurities, lumps of mortar or grout and unsightly stains.

4.9.5 **ACCEPTANCE CRITERIA AT A GLANCE**

EarthWork or Borrow Materials 50 Kg. I.S. 2720 (All Parts)

S.No.	Test	Frequency	Equipment	Acceptance criteria	Purpose of testing
1	2	3	4	5	6
1.	Grain size analysis IS : 2720-IV, 1975	1/1000m³	Coarse sieve (80mm, 63, 37.5, 25.0, 20.0, 10.0, 6.3, 4.75 mm) Fine sieves (21mm, 600 micron, 425, 212, 75 micron), balances oven, stirrer, hydrometer with jars.	As per design	For classification of soil and there by getting indication of properties
2.	Plasticity index, IS : 2720-V-1970	1/1000 m³	Liqid limit device grooving tool and sieves, oven, Uppal's cone penetrometer.	Workable range for hearting LL PL PI 35 20 15 to to to 50 30 30	Indicates properties of soils. Test not possible for non-plastic soils which are used for casing.
3.	Standard compaction IS : 2720-VII-1974	1/100 m³	Standard compaction mould with base, collar, and rammer, soil extractor, balance 20 kg oven.	As per design	For determining the max. density which can be attined on field at optimum moisture content, with standard energy.

1	2	3	4	5	6
4.	Relative density IS : 2720-XIV-1968	1/1000 m³	Relative density apparatus, vibrator, balance 50 kg oven.	As per design	Similar as above but for coarse grained soils.
5.	Field density and moisture IS : 2720-XXVII-1974 XXXX 1975 XXXIII 1971	1/300 m³ minimum one in each zone per layor	Core cutter, sand replacement kit and water replacement kit.	Minimum 95 per cent of MDD of 65 per cent of RD Moisture OMC+2 per cent	To determine the placement density and monitor compaction effort. It also indicates adequacy of moisture content
	Rock fill	1/5000 m³		Above 65 per cent RD.	
6.	Permeability IS : 2720-XVII-1966	1/1000 m³	Permeability apparatus soil extractor, oven.	Workable range for hearting, less than 10^{-6} cm/sec. Casing more than 10^{-4} cm/sec.	To decide drainage conditions under which the soil will behave in field, anticipate probable seepage and design drains.
7.	Field permeability IS : 5529-I-1969.	1/3 m depth	Field permeability apparatus like water storage drum, shovels, augers etc.	do	To determine the drainage condition of soil in situ.

1	2	3	4	5	6
8.	Direct shear IS-2720-XIII 1972	1/1000 m^3	Direct shear apparatus, soil extractor, balance 5 kg.	As per design	To determine shear strength of soil in foundation or in an embankment.
9.	Consolidation IS : 2720-XV 1965	1 set of 3 samples per season per zone at end of season	Consolidation test apparatus, oven, balance	As per design	To determine settlement rate magnitude and to assess when soil is normally consolidated preconsolidated.
10.	Moisture Content IS : 2720-I-1973	IS : 300 m^3	Balance, oven or rapid moisture meter.	As per design	To determine degree of saturation, consistancy rate of a natural soil or a compacted fill

Portland Cement 15 Kg IS : 269-1976 and 4031-1968
Sampling :- Collect (15kg) one sample from 2 percent of bags in a consignment of 50 tonnes : 2 upto 100 tonnes, 3-200t, 4-300t, 5-500t 6-800t, 7-1300t and 8 for larger consignments.

S.No.	Test	Frequency	Equipment	Acceptance criteria	Purpose of testing
1	2	3	4	5	6
1.	Consistency	Each sample	Vicat needle apparatus, beam balance.	About 30 per cent	Determines mixing after requirement for subsequent tests and the minimum water requirement for hydration of cement.

1	2	3	4	5	6
2.	Setting time	Do	Do	Initial-Not less than 30 minutes Final-Not more than 600 minutes	Placement compaction is to be completed within initial limit. Final limit indicates hardening and gain in strength.
3.	Compressive strength	Do	7.07 cm cube Moulds, mortar vibrating machine, Curing tank, 25. tonne loading frame.	160 kg/cm2 at 3 days for ordinary portland cement (OPC). 220 kg/cm2 at 7 days for oridnary portland cement and pozzolana cement (PC) at 28 days 310kg/cm2 pozzzolana cement (PPC)	Higher strength indicates acceptability.
4.	Finoness by sieving	1 in 5 samples	IS sieve 90 micron	Residue less than 10 percent	High residue indicates cement having undergone moisture attack or indicates inadequate grinding.

1	2	3	4	5	6
5.	Fineness by specific surface	Do	Blain's Air permeability with accessories	2250cm2/g and above for OPC for for PPC 3000 cm2/g	Do
6.	Soundness	Do	Le-Chatelier apparatus	Le Chatelier expansion less than 10 mm	More expansion indicates excessive and harmful chemical reaction.
			Autoclave lenths comparator, 2.5x2.5x25 cm mould	Autoclave expansion less than 0.8 per cent.	
7.	Chemical Analysis IS : 4032-1968	Do	Muffle furnace, oven, platinum crucible, chemical balance	Mgo less than 6 per cent; SO_3 less than 2.75 per cent. Loss on ignition upto 5 per cent.	Higher MgO idnicates harmful expansion at a late age. Higher SO_3 indicates lesser durability.

Sand, 10 Kg. IS : 2386 (Part III, VII, VIII) 1963, 383-1970

S.No.	Test	Frequency	Equipment	Acceptance criteria	Purpose of testing
1	2	3	4	5	6
1.	Specific gravity and water absorption	2 season	Two pan balance, oven, pycnometer	As per design	Lower specific gravity and higher water absorption decrease durability and density and increase shrinkage.

1	2	3	4	5	6
2.	Alkali reactivity (Chemical method)	Do	Reactivity containers, water, bath, Chemical balance.	As per Sc/Rc curve	Amorphous silica, glass, mica etc., in aggregate lead to disintegration due to chemical reation.
3.	Petrographic examination (4.75 to 2.36 mm, 2.36 mm to 300 micron)	Do	Microscope, balance	Deleterious constituents plus silt not more than 5 percent.	Deleterious material beyond 5 percent affects durability.
4.	Silt content	1/150m3	75 micron sieve	Upto 3 percent	Higher silt content reduces strength increases water requirement and inhibits bond.
5.	Gradation : Fineness modulus	1/150 m3	Fine sieve set 4.75, 2.36 1.18 mm, and 600, 300, 150, 75 micron.	As per standard design zonal limits Concrete .. IS : 383-1970 Masonry .. IS: 2116-1965 Mortar Plaster : IS :1542-1960	Poor gradition and lower FM give low strength demand more water for mixing.

Metal, gravel, 100 kg : IS : 2386 (Part I to VIII) 1963

S.No.	Test	Frequency	Equipment	Acceptance criteria	Purpose of testing
1	2	3	4	5	6
1.	Gradation IAC : SP-11-1973	IRC Concrete WBM	I/150 m3 coarse sieve 1/100 m3 80, 63, 40, 20, 16	per design Concrete IS:383-1970	Gradien governs the bulk density and void content.
		Concrete pavement Bituminous surface course.	1/15 m3 12.5, 10, 4.75 1/25 m3 2.36 mm		
		Bituminous Macadam	Two tests per day per plat both on the individual constituents and mixed aggregates from the dryer.		
		Asphalt concrete	One set of tests on individual constituents and mixed aggregates from the dryer for each 100 tonnes of mix subject to a minimum of two tests per plant per day at regular close interval.		

1	2	3	4	5	6
2.	Specific gravity, gravity absorption	2/Season	Two pan balance, wire basket	Work: Water absorption; Specific gravity Bituminous road: 1 per cent; 2.5 to 3.0 generally	Hiher the specific gravity higher the density and greater the durability
3.	Flakiness index	WBM	1/200 m³ Thickness guage	Work: Maximum (%) WBM 15; Bituminous road 25; Others As per design.	IS : 6579-1972 IRC: SP.11-1973. Flaky materials neds more sand, water and cement for same strength.
		Bituminous penetration macadam.	1/200 m³		
		Bituminous macadams	1/50-100 m³		
		Bituminous surface course	1/50 m²		
		Asphalt concrete	1/50 m2		

1	2	3		4	5			6
4.	Impact value	Concrete WBM	2/Season 1/200 m^3	Impact testing apparatus. Triple beam balante. sieves	Use	Wearing surface percentage	Over laid percentage	Lower impact value gives better perfo-rmance in facing successive moving loads.
		Bituminous penetration macadam.	do					
		Bituminous macadam	1/50-100 m^3		Conc-crete	30	45 IS : 383-1970	
		Bituminous surface course	1/50 m^3		WBM	30	35 IS : 6579-1972	
					Bitu-minours	30	IRC-1973	
		Asphalt concrete	1/50-100 m^3		road			
		Concrete pavement	2/Season		WBM	40	50-IRC 1973	
5.	Abrasion value	Same as impact value test	Losangeles abrasion machine		Wearing surface percentage		Overlaid surface percentage	High abrasion value indicates more wear and tear and higher cost of repairs and maintenance.
					Concrete	30	50	IS :383-1970
					WBM	40	50	IS:6579-1973
					Bitumin-ous road	35	..	IRC-1973
					WBM	50 (for base)	60 (for sub-base)	IRC-1973
					Surface course WBM	40	..	IRC-19

1	2	3	4	5		6
6.	Soundness (5/cycles) (For) Saurashtra aggregates only vide Government circular No.SSR-1074 C, dated 7th November, 1974)	2/Season	Sieves 31.5, 16, 8.4 mm	Loss with Na_2SO_4	Loss with $MgSO_4$	Higher loss indicates less ability of the stones to with stand effect of freezing and thawing.
				Concr-ete	12 18	18:383-1970
				WBM	20 30	IS:6579-1972
7.	Alkali reactivity (Chemical method)	2/Season	Reactivity container	As per Sc/Rc curve Is:2386-1963, Part VII		Deletrious aggregates cause distintegration of concrete
8.	Petrographic examination 80 mm - 10 mm 10 mm - 2.36 mm	2/Season	Hammer, acid bottle			Deleterious constitu-ents plus silt shall not exceed 5 per cent.

Note : For road work either impact or abration test shall be carried out.

Water (concrete, mortar), 1 liter, IS : 456-1964 (Amendment 5, 1972)

S.No.	Test	Frequency	Equipment	Acceptance criteria		Purpose of testing
1	2	3	4	5		6
1.	Chemical analysis	Once for approval of source and subsequently only in case of doubt.	Muffle furnace, Water bath. Chemical balance. Oven. Ec. meter, pH meter, Flame photometer	TDS (mg/l)	3000	
				Sulphate (mg/l)	500	Excess sulphate atacks calcium carbonate to form calcium alumino-sulphate which is weak. expands and distintegrates concrete.
				pH	6 to 8	pH lower than 6 is acidic leads to corrosion. loosens bond. pH more than 8 causes excessive leaching.
				Chlorides (mg/l)	2000 PCC 1000 for RCC	Higher chlorides cause corrosion.
				Organic matter (mg/l)	200	Organic matter causes. disintegration.

1	2	3	4	5		6
				Inorganic matter (mg/l)	3000	
				Neutralization of alkalinity and acidity.	10ml. with 0.1 N HCl. 2ml. with 0.1 N NaoH	
				if water does not pass any of the above recrred test then it should be tested as per clauses 4.3.1.2 and 4.3.1.3 of above IS.		

Building stones, 25 Kg IS : 1597 (I) 1967, 1123 - 1975

S.No.	Test	Frequency	Equipment	Acceptance criteria	Purpose of testing
1	2	3	4	5	6
1.	Compressive strength. IS : 1121 (Part-I) 1974	Builings Bridges : 2 sets of tests per working season. Dams : 1 set of per month.	Rock cutting machine 200 tonne compression testing machine.	Workable range : Granite 1000 Kg/cm² Basalt 400 Kg/cm² Sandstone 300 Kg/cm² For permissible load with different proportions of mortar refer IS : 1905-1969	Indicates load carryling capacity and integrity

1	2	3	4	5	6
2.	Transverse strength for flooring, IS:3622-1966, IS:1121 (Part-II) 1974	1/800 Nos.	5 tonne loading frame Transverse tool.	Sandstone 70 Kg/cm²	Ensures least breakage.
3.	Shear strength IS:1121 (PartIV) 1974.	As per test	Shear tool	Workable range : Granite 140-500 Kg/cm² Basalt 200-600 Kg/cm² Sandstone 80-40 Kg/cm²	Ensures integrity against vertical sustained load.
4.	Specific Gravity (true) IS:1122-1974	1/week	Mortar and pestle, sieves 150 micron, Specific gravity bottle (50 ml) Chemical balance.	As per specification	Higher the specific gravity more is the durability and economy.
5.	Specific gravity (apparante) water absorption, IS :1124-1974	1/week	Mortar and pestle, Sieves 150 micron, Specific gravity bottle (50ml), chemical balance, Balance cylinders.	Absorpetion Less than 5 per cent for rubble masonry. Absorption less than than 2.5 percent for sandstone flooring.	Lesser the water absorption higher the durability lesser the weathering. For dams higher porosity causes more leakage.

1	2	3	4	5	6
6.	Porosity IS:1124-1974.	1/week	As per tests 4 and 5	As per specification	
7.	Weathering IS: 1125-1974	As per test 1	Balance, Gypsum powder.	As per design.	Measure of durability and strength.

Masonry mortar

S.No.	Test	Frequency	Equipment	Acceptance criteria	Purpose of testing
1	2	3	4	5	6
1.	Mixer efficiency	At start of job and occasionally for each mixer	Concrete mixer, 0.03m³container, weighing balance (50kg)	Maximum unit weight variation within batch 0.8 per cent from average. Maximum average viriability percentage 0.6 for 3.0.5 for 6, 0.4 for 9 and 0.3 for 90 batch tests.	Ensures intimate homogeneous mixing and unifom dispersal of cement paste.
2.	Workability	1/50m3	Slump cone	+ 12 mm from design	Ensures proper placement and minimum voids.
3.	Air content	Do	Air entrainment meter	+ 1 per cent from design	Higher air content causes reduced strength.

1	2	3	4	5	6
4.	Yield and unit weight	Do	0.03 m3 container	+2 per cent from design cement level unit volume of morter.	Useful for determining and controlling cement level.
5.	Compressive strength	3 cubes/ 150 m3 or/ day which ever is more for each age.	Compression testing machine	1 in 5 samples may fall below specified strength upto 80 per cent.	Governs strength durability.
6.	Permeability	1/Week	Permeability apparatus	As per design	Ensures tightness
7.	Insitu permeability	As per specification	Drilling machine, institu permeability apparatus with pressure guage and packers.	As per design	Ensures tightness

List of standards of I.R.C. I.S. 55

S.No.	Short Title	No.	S.No.	Short Title	No.
1	2	3	1	2	3
I. **Soil :**			15.	Specification of aggregate for WBM	IS : 6579-1972
1.	Gradation	IS : 2720 Part IV	16.	Specification of road and bridges	IRC : 1976
2.	Atterberg limit	IS : 2720 Part V	17.	Flakiness index	IS : 2386 Part I-1963
3.	Standard proctor	IS : 2720 Part VII	18.	Crushing, Impact, Abrasion	IS : 2386 Part IV -1963
4.	C.B.R.	IS : 2720 Part XVI	19.	Soundness	IS : 2386 Parts IV -1963
5.	Natural moisture content	IS : 2720 Part II	20.	Specific gravity and water absorption	IS : 2386 Part VII-1963
6.	field dry density	IS : 2720 Part XXVIII	21.	Petrographic examination	IS : 2386 (VII) - 1963
7.	Hand book of quality control	IRC Special Publication No.11, 1978	22.	Stripping test	IRC : 1978 (Appendix IS-6241)
8.	Specifications for Road and Bridge works (MOT)	IRC Sp. 1978	**III. Bitumen :**		
9.	C.A.C. techniques (Cyclostyled booklet of GERI)	IRC	23.	Sampling	IS : 12011-1958
10.	Construction of earth embankment	IRC : 36	24.	Specific gravity	IS : 1202-1958
11.	Design of flexible pavement	IWC : 37	25.	Penetration	IS : 1203 - 1958
12.	Design of soil lime mixes	IRC : 51	26.	Softening point	Is : 1205 - 1958
II.	**Aggregate :**		IV.	**Bituminous mix :**	
13.	Stripping	IS : 383, 515-2386 Part I to VII	27	Stripping value	IRC-SP
14.	Specification for coarse and fine aggregates	IS : 383	28.	Stability of mix	IRC-SP
			29.	Centrifuge extraction	IRC-SP II-[illegible]
			30.	Thickness and density of compacted layers	IRC-SP 11

ACEEPTANCE CRITERIA

ROAD MAKING MATERIALS

1. **Hardness or Abrasion Test :**

C	14	for	Road making materials
C	14 to 17		Medium Hardness
C	17		Satisfactory Hardness

2. **Impact Test M = Toughness index of stone :**

M	13	not tough
M	13 to 19	moderete toughness
M	19	toughness in high

3. **Abration Test : Rate of wear due to grinding :**

Wear	2%	good
	3%	tolerable

4. **Cement value**

M_{10}	poor
$M_{10 \text{ to } 25}$	Fair
$M_{25 \text{ to } 75}$	good
M_{75}	very good

5. **Absorption Test :** 0.6%

6. **Crushing strength**

1. 1050 Kg/Cm²
2. 1750 Medium
3. 2800 good

Recommended values of slump :- (As per Table 402-C of \PPSC)

Sl. No.	Type of work	When Vibrations used	Without Vibration
1	2	3	4
a)	**Plain Concrete :**		
	i) Mass concrete, in foundations retaining walls, pavements, footings etc.,	10 mm to 25 mm	50 mm to 75 mm

1	2	3	4
	ii) sections less than 75 mm thick	25 mm to 40 mm	75 mm to 100 mm
b)	**Reinforced concrete :**		
	i) Mass concrete	10 mm to 25 mm	75 mm to 100 mm
	ii) Beams, slabs etc., with normal steel	25 mm to 40 mm	100 mm to 125 mm
	iii) Thin sections with congested steel	40 mm to 50 mm	125 mm to 150 mm

Also indicate workability values as per IS code 456-1978

Sampling of concrete specimens :- (Cube moulds)

Test specimens cubical in shape, shall be 15 cm x 15 cm x 15 cm.The moulds shall be metal preferably steel or cast iron. The tamping bar shall be a steel bar 16 mm in dia, 0.60 m long and bullet pointed at the lower end.

4.9.6 CONCRETE :-

i) **Slump Test** :- This test is made for measuring the workability of fresh concrete on the field as well as in the Lab.

Apparatus :- The mould for the test specimen shall be in the form of frustum of cone having the following dimensions;

Bottom dia	200 mm
Top dia	100 mm
Height	300 mm

The tamping rod shall be of steel or other suitable materials, 16 mm in dia, 600 mm long and rounded at one end, graduated.

Sampling :- If the test is carriedout in the field, the sample of freshly mixed concrete shall be used. In case of concrete containing aggregate of maximum size more than 40 mm, the concrete shall be wet sieved through 40 mm screens, to exclude particles bigger than 40 mm.

Procedure :- The mould shall be filled in 4 layers, each

1. approximately one quarter of the height ie. 8 cm of the mould.

2. Each layer shall be tamped with 25 strokes of the rounded end of the tamping rod. The strokes shall be distributed in a uniform manner over the cross section of the mould and second and subsequent layers, shall penetrate into the under lying layer.

The test specimens shall be made as soon as practicable after mixing, and in such a way as to produce full compaction after the concrete with neither segregation nor otherwise.

The concrete shall be filled into the moulds, in layers approximately 5 cms deep. Each layer shall be compacted either by hand or by vibration. For cubical specimens, the concrete be subjected to not less than 35 strokes per layer for 15 cm cubes (IS 516-16 1959). The strokes shall be penetrated into the under lying layer and the bottom layer shall be rodded throughout its depth.

Recording of sample :- (As per para 3.5 of IS 1199 - 1959)

The following information regarding the sample shall be recorded.

i) Date and time of sample.

ii) Method of sampling.

iii) Mix proportion (Proportion of ingredients, including water, admixtures etc.,)

iv) Mixture from which delivered (if more than one is used)

v) The location of the sample, batch after placing (Reference to location from fixed end, elevation)

vi) Temperature and weather condition.

Frequency of sampling :- (Para 14.2 of IS 456 - 1978)

The sampling should be spread over the entire period of concrete and cover all mixing units.

The minimum frequency of sampling of concrete of each grade shall be in accordance with the following :

Quality of concrete in the work in M^3	Number of samples
1 - 5	1
6 - 15	2

16 - 30	3
31 - 50	4
51 and above	4 +one addl. sample for each additional $50M^3$ or part thereof.

NOTE :- i) Atleast one sample shall be taken from each shift.

ii) Sample means three cubes.

Mixing of concrete :- Mixing of concrete is almost invariably to be carriedout by machine. To get better efficiency, the sequence of charging the loading into skip is as follows :-

i) Firstly, about half the quantity of coarse aggregate is placed into the skip (Hopper) then fine aggregate, on that full quantity of cement (ie., one bag) is poured over which the remaining portion of coarse aggregate is put on the top.

ii) Before the loaded skip (Hopper) is discharged into the drum about 5 to 10% of the total quantity of water required for mixing is poured into the mixer drum to set the drum and to prevent any sticking of cement on the blades or at the bottom of the drum. Immediately, on discharging the dry material into the drum, the remaining quantity of water is added to the drum. It is desirable that the remaining 90 to 95% of water is admitted simultaneously along with the other materials. The time is counted from the moment all the material, particularly, when complete quantity of water is fed into the drum.

Mixing time :- For proper mixing, about 25 to 30 revolutions are required in a well designed mixer.

TIME OF MIXING TABLE 1 OF I.S. 457 - 1957

Sl. No.	Capacity of Mixer	Minimum time of mixing	
		Natural aggregates	Manufactured aggregate
a.	3 cum or more	2 Minutes	2 1/2 Minutes
b.	2 cum	1 1/2 Minutes	2 Minutes
c.	1 cum or less	1 1/4 Minutes	1 1/2 Minutes

NOTE :- The mixing period shall be timed after all materials including water are in the drum.

5.0.0 MISCELLANEOUS

5.1.0 DRILLING AND BLASTING OPERATIONS

General :

Blasting where required will be permitted only when proper precautions have been taken for the protection of persons and properly in accordance with I.S. 4081-1967. (Indian Standards Specification for safety code for blasting and related drilling operations. While carrying out excavation, adequate precautions in accordance with I.S. 3764-1966 (Indian Standard Specifications for safety code for excavation work) shall be taken.

Personnel :

Excavation by blasting will be permitted only under the personal supervision of competent and licenced persons and trained workmen employed by the contractor at his cost. All supervisors and workmen in charge of make up, handling storage and balsting work shall be adequately insured by the contractor.

The storage shall be incharge of a very reliable person approved by theEngineer-in-charge, who may, if necessary cause police enquiry being made as to his reliability antecedents etc., The contractor shall have to produce security for the person incharge of the explosives, if and as required by the Engineer-in-Charge or the civil authorities of the District.

Charging of Holes :

The work of charging of holes shall not commence before all the drilling work at the site is completed and contractor's supervisor be satisfied himself to that effect by actual inspection. While charging, open lamps shall be kept away. For charging with powered explosives, a nacked flame shall not be allowed. Only wooden tamping rods, without any kind of metal on the rod shall be allowed used. The tamping rods shall have cylindrical ust be of such size that the catridges can easily they shall not however be too big.

tridge shall be inserted at a time and gently ole with the tamping rods. The sand, clay or erials used for filling the holes completely shall hard.

Storage of Explosives :

The explosives should be stored only in magazines, specially built. The site of Magazine, its capacity and design shall be subject to approval by the Engineer and inspector of explosives. Before the construction is taken up. As a rule, the explosives should be stored in a clean, dry, well ventilated, bullet proof and Fire proof building, on an isolated site.

Armed guard security of required number shall be provided of explosives magazine, or while transporting to worksite, as per rules in force at his cost.

The explosives, detonators, and fuse coils shall each be separately stored.

The magazine shall at all times be kept scrupulously clean.

No unauthorized person should at any time be admitted inside the magazine. A notice shall be hung near the storage prohibiting entrance of unauthorised persons.

The magazine on no account be opened during or on the approach of a thunder storm and no person shall remain in the vicinity of the magazine during such periods.

Magazine shoes without nails shall at all times be kept in the magazine and a wooden tub or cement trough about 300 millimeter high and 450 millimeter in diameter filled with water shall be fixed near the door of the magazine.

Persons entering the magazine, must put on the magazine shoes which shall be provided by the Contractor for the purpose and be careful :

i) not to put their feet on the clear floor unless they have the magazine shoes on :

ii) not to allow the magazine shoes to touch ground outside the clean floor :

iii) not to allow any dirt or grit to fall on the clean floor.

Persons with bare foot shall, before entering the magazine, dip their feet in water and then step direct from tub over the barrier (if there be one) on the clean floor.

A brush or broom shall be kept in the lobby of the magazine, for clearing the magazine on each occasion it is opened for the

receipt, delivery or inspection of explosives. No matches or inflammable material shall be allowed in the magazine. Light shall be obtained from the electric storage battery lantern.

No person having articles of steel or iron with him shall be allowed to enter the magazine.

Oily cotton, rags, waste and articles liable to spontaneous ignition, shall not be allowed inside the magazine.

Workmen shall all be examined before they enter the magazine to see that they have none of the prohibited articles with them.

No tools or implements other than those made of copper, brass gun metal or wood shall be allowed inside the magazine. All tools shall be used with extreme gentleness and care.

Boxes of explosives shall not be thrown down or dragged along the floor, and shall be stacked on wooden trestles.

Where there are white ants,the legs of the trestless should rest in shallow copper, lead or brass bowls containing water. Open boxes of dynamite shall never be exposed to the direct rays of the sun. Empty boxes or loose packing materials shall not be kept inside the magazine. Magazines shall be inspected at least twice a year by an officer representing the Engineer.

He shall see that all the rules are strictly complied with. The magazine shall have lightning conductor which should be got tested at least once a year. The Contractor shall, comply with all the recommendations made by the officer testing the lightning conductor and also rectify the defects notified by him within 15 days, failing which the Engineer shall be entitled to comply with the same at the contractor's expenses which shall not be open to question. The Engineer may take any action that he may consider fit at the cost of the Contractor.

The following shall be hung in the lobby of the magazine.

a. A copy of notes both in English and in the languages which the workers concerned are familiar

b. A statement showing the stock in the magazine on that day;

c. A certificate showing the last date of testing of the lightning conductor

d. A notice that "Smoking is strictly prohibited."

BLASTING :

Blasting shall be carried out during fixed hours of the day which shall have approval of the Engineer-in-Charge. The hours once fixed shall not be altered without prior, written approval of the Engineeer-in-Charge.

The site of blasting operations shall be prominently demarcated by red danger flags. The order to fire shall be given only by the Contractor's supervisor incharge of the work and his order shall be given only after giving the warning signal three times, so as to enable all the labour, watchment etc., to reach safe shelters.

A whistle/bigle with distinctive note shall be used to give the warning signals. The bigle shall not be used for any other purposes. All the labour shall be made acquainted with the sound of the bigles and shall be strictly warned to leave their work immediately at the first warning signal and to move for safe shelters. They are not to leave the shelters until the all clear signal has been given.

All the roads and foot paths leading to the blasting area shall be watched.

In special cases, suitable extra precautions shall be taken. The Engineer-in-Charge may however permit blasting for underground excavation, without restriction of fixed time, provided that he is satisfied that proper precautions are taken to give sufficient warning to all concerned and that the work of other agencies on the site is not hampered. for lighting the fuse, a lamp with a strong flame such as a carbide lamp shall be used.

The contractor's supervisor shall watch the required time for the firing of the fuses and shall see that all the workmen are under safe shelters in good time.

PRECAUTIONS AFTER BLASTING :

After the blast, the contractor's supervisor must carefully inspect the work and satisfy himself that all the charges have exploded. After the blast is taken place in under ground works, workmen shall not be allowed to go to the place till the toxic gases are evacuated from the face.

MISFIRES :

If it is suspected that part of the blast has failed to fire or is delayed. Sufficient time shall be allowed to elapse before entering

the danger zone. When fuse and blasting caps are used, a safe time should be allowed and then the contractor's supervisor alone shall leave the shelter to see that misfire.

None of the drillers are to work near this hole until one of the two following operations have been carried out by the supervisor.

BLASTING :

Blasting operation is performed to loosen rock so as to excavate it or remove it from the existing position. This is a detonation of explosive placed in drill hole resulting fracture of rock.

1. BLASTING AGENT : It is the explosive compound placed in blast hole.
2. BLASTING CAP : A metal cap which is filled with high explosive and detonated within or adjacent to blasting agent.
3. BLASTING MACHINE: A machine used to generate electric current to detonate electric blasting cap.
4. BOOSTER : This is a high explosive that is placed in a hole at desired spacing to assure that the explosive detonates through out the hole.
5. DYNAMITE : This is a very high explosive whose primary content is nitro glycerene.
6. PRIMER : This is a position of consisting cap sensitive explosive, loaded with fixing device which initiates explosion.
7. GELETENE : Jelly like explosive made by desolving nitro cotton in nitro glycerene.
8. STEMMING : Adding an inert material such as rock powder, drill cuttings in blast hole on top of explosive to confirm the energy of explosive.

METHODS OF LOADING EXPLOSIVES :

1. Primer - Charge - Stemming (with leading wires)
2. Primer - Charge - Stemming repetition (do)

3. Charge - Stemming (Prime card)
4. Charge - Stemming repetition (Prime card)

FIRING CHARGES (1) Parallel (2) Series (3) Combination

SAFETY FUSE — This device is a continuous core of black powder enclosed in a covering of suitable materials. When core is ignited it conveys flame to other end where the explosive attached.

ELECTRIC BLASTING CAPS — These caps are ignited by electrical machine.

DELAY CAPS — When the rows are more it is desirable to blast the first row (nearest to face) first and subsequent rows later one after other. This requires delay caps which will delay the ignition cumulatively for 2nd, 3rd and 4th rows. Thus the delay caps are named as delay 1,2,3,4 respectively.

The delay period for each row is 0.2 second for L.P.series and 25 milli seconds for M.S. series generally.

SLANTED DRILLING — Slanted drilling increases the blasting efficiency in addition to

1. More uniform burden permits uniform loading of explosive.
2. Grate spacing.
3. Less Sub drilling.
4. Smooth faces, and pit bottoms.
5. Bitter Fragmentation of rock.

PROPER SPACING OF BLAST HOLES :

Critical radius of outer circle fracture R.

$$R = \frac{K}{12}\frac{P}{S}$$

K = coefficient = 0.8 most rocks

P=Maximum explosion pressure (PS)

S=Ultimate strength of rock (PSI)

the holes are to be drilled in staggered in alternate rows

to give more effective : Unstaggered rows.

and fragmented blasting : Staggered row.

REPRESENTATIVE SPACING OF BLAST HOLES :-

Type of rock	Spacing of blast holes per inch of hole diameter
1. An hydric strong	1.97
2. -do- Weak	2.45
3. Granite Strong	1.92
4. Granite average	2.32
5. Granite Weak	3.37
6. Grey weak	2.62
7. Green stone	3.55
8. Lime stone strong	2.30
9. Lime stone Average	3.15
10. Lime stone Weak	4.12
11. Marble	2.37
12. Marble weak	3.15
13. Sand stone strong	2.85
14. Sand stone Average	3.40
15. Sand stone Weak	4.12

MONITORING SEISMIC EFFECT OF BLASTING :

Since the blasting damages buildings and structures, the Siesmic recording instruments are to be placed within the vicinity of blasting to monitor the magnitudes of effect of blasting. Blasting hole, depth and quantum of explosive is to be decreased to lessen the effect on buildings and structures.

5.1.1 DRILLING AND GROUTING

General :

The specifications provide for drilling of "A" and "B" holes and grouting of "A" and "B" holes with cement slurry for foundation treatment

A LIST OF IS CODES APPLICABLE IS FURNISHED BELOW :

01 IS 6066 - 1984 Recommendations of pressure grouting of ROCK FOUNDATIONS in river valley projects.

02 IS 5441 - 1986 Potable pneumatic drilling machine

03 IS 2529 - 1973 Code of practice for in-situ permeability tests

a. Drilling and grouting shall include drilling holes washing of holes, washing of seams, fixing of grout pipes of packers for stage-wise grouting, grouting with cement grout and back filling of holes.

b. The purpose of grouting is to consolidate the foundations and to reduce seepage through the foundations and uplift pressures under the structure. The programme of grouting prescribed herein, consists first of a low pressure shallow grouting for consolidating and improving the stability of the upper portion of foundation rock followed by a high pressure curtain grouting to create a tight curtain which will cut off any paths of percolation shall then be brought to a true surface by working with a long wooden float with upward and side ways motion 50 mm or 75 mm at a time. The surface shall be periodically checked with a string stretched across it. Finally the surface shall be rendered smooth with a small wooden float. over working shall be avoided. All corners, arises, and junctions shall be neatly finished. Metal floats shall not be used I.S. 1661 -Code of practice for application of cement and cement lime plaster finishes shall be applicable for this section.

c. If it is necessary to suspend the work at the end of the day, it shall be left in a clean horizontal or vertical line not nearer than 150 millimeters from any corner on arises or tops or copings etc. When recommencing the work, the edges of the old work shall be scraped clean and wetted and treated with cement slurry before the new plaster is laid adjacent it. After the first coat is done it shall be kept undisturbed for the next 24 hours and thereafter kept moist and not permitted to dry until the final rendering is applied.

d. After the plaster has sufficiently hardened, cement slurry with cream like consistency shall be applied evenly and rubbed to a fine condition.

e. No portion of the surface shall be left out initially to be plastered up later on. The plaster shall be finished to a true and plumb

surface and to proper degree of smoothness as required by the Engineer.

f. The average thickness of plaster shall not be less than the specified thickness but not be thicker than 25mm in any case. Any cracks which appear on the surface and all portions which sound hollow when tapped or found to be sort or other-wise defective, shall be cut in rectangular shape and redone as directed by the Engineer at no extra cost. Plastering shall be cured for 10 days.

SCOPE :

Flush pointing with cement mortar of specified proportion to the exposed faces of CRS masonry including cost and conveyance of cement and all other materials, sampling, testing, mixing of mortar, labour charges, all leads, lifts, delifts, seigniorage charges, scaffolding, curing all other operations necessary to complete the finished item of work as per drawings and as directed by the Engineer-in-charge.

PREPARATION OF SURFACE :

a. The joints in the masonry shall be raked out to a depth not less than the width of the joint or as directed when the mortar is green. Joints are to be brushed to clean the dust and loose particles with a stiff brush. The area shall then be washed and the joints, thoroughly wetted before pointing is commenced.

b. Drilling and grouting of foundations is inclusive of washing and testing of permeability. The curtain grout holes for foundations treatment will be drilled to a depth and spacing of holes as shown on the drawings or as directed by geologist of Geological Survey of India and holes shall be drilled and grouted after the completion of excavation and prior to placing masonry or concrete.

EQUIPMENT :

a. Drilling Equipment : Grout holes are to be drilled with standard core drilling equipment. Plug or non coring bit may also be used. Where consolidation or blanket grouting is to be done from the foundation surface, in rock which does not produce mud slurries, percussion, drilling in lieu of rotary drilling may be used for shallow holes.

1. Creations pneumatic or electrical driven diamond drill machine and its equipment.
2. Deep hole jack hammer with 80'-0" drill capacity and its eqipment.
3. 1000 cft Air compressor or 500 cft Air compressor.

b. Grouting Equipment : All equipment for mixing and injecting grout, shall have adequate capacity and shall be maintained in first class operating condition. The minimum equipment required will be,

1. Four specially equipped, air driven duplex, double action slush pumps, capable of operating at a maximum discharge pressure of about 500 P.S.I./35.00 Kgs/Sq. Cm.
2. Four mechanical grout meters.
3. Four mechanically agitated sumps.
4. Two high head water pumps for auxiliary water supply to be used in pressure testing flushing and pressure washing operations.
5. The suitable water meters suitably graduated.
6. Sluice valves, pressure gauges, pressure hose, supply lines, packers and small tools may be necessary to provide a continuous circulating supply of grout and accurate pressure control.

c. Hand operated grout pumps shall not be used to grout low or high pressure holes, only pumps which are capacble of injecting grout into holes at sustained highest allowable safe pressure are suited for this type of grouting.

d. The grout mixing and conveying system, consisting of the above equipment, shall be laid out to provide sufficient capacity for a heavy flow of grout. In general, an uninterrupted flow of grout shall be maintained and the grout conveyed from the pump to the hole through a hose or pipe of not less than 40 mm in diameter and return line not less than 40 mm in a diameter. Wherever practicable the grout plant shall be placed as near the hole as possible and along pipe lines avoided especially during hot weather. The flow of grout into the holes at a constant speed of the pump shall be controlled by the return

valve on the header, by passing and returning to the agitator all grout, not accepted by the hole at the desired pressure. As the grout hole approaches refusal, or when the valves on the holes are closed for any reason, the pump shall continue in full operation, circulation of the grout through the line to prevent setting or clogging. Both the pump and the pipe line shall be flushed periodically with clear water during grouting operations, especially when using thick grout. Deposits of grout in the pump mixer and agitator not removed by flushing shall be cleaned out, once a week, by scraping and chipping. Upon the completion of any continuous operation or at such time as found necessary, the pump grout lines header, cap and mechanical expander shall be dismantled, thoroughly cleaned with water and blown out with air.

e. The mixer shall be provided with an accurate meter, for controlling and measuring the amount of mixing water in the grout. Specially equipped pressure gauges shall be provided with diaphragms or by filling a short gauge tube in the form a "pigtail" with semifluid water proof grease and oil or other devices to prevent the entrance of grout in the gauge. The combined ranges of the high pressure gauge shall be 0.035 Kg/Sq. Cm/0.500 PSI and for low pressure gauges shall be 0.0175 Kg/Sq. CM/0.250 PSI. One of the pressure gauges shall be mounted so that it will measure directly the pressure on the hole and shall preferably be mounted directly on the vertical pipe of the head connected to the grout cap or expanding packer and the other gauge shall be mounted on the supply line at the pump.

DRILLING GROUT HOLES AT FOUNDATIONS OF SPILL WAY, BODY WALL

(a) LOW PRESSURE GROUTING :

The procedure for grouting of the foundation will be subject to modification as determined in the field, but in general, will consist of.

1. Drilling the holes of diameter 75 MM to 50 MM to the required depth at a time except in the cases where shattered rock on crushed zone is met with in such cases descending stage of drilling and grouting to be done. After completion of drilling, the hole is to be protected by capping till the grouting is completed.

2. Plain washing of holes is to be done using G.I. pipes or drill rods, with air and water lowering the pipes or rods to full depth.

3. Washing of seams is to be done by fixing grout pipes or mechanical expanding packers, in stages starting from bottom zone.

4. The holes are to be washed after seam washing of each zone is to be completed, and then seam washing of next higher zone is to be taken up.

5. After completion of washing of seams, the holes are to be flushed with air and water and grouting to be started for bottom zones first by using expanding packers. First grouting of all bottom zones in a region are to be completed before taking up grouting of next higher zones.

6. During grouting of any hole, if inter-connection is found in neighbouring holes, the same are to be plugged till the grouting of the hole in operation is completed and then the inter-connected holes are to be drilled again and washed to full depth or required depth with water.

7. Grouting is to be continued till the zone of the hole refuses to take grout which can be found by measuring at the grout agitator or sump.

8. Once grouting of holes in a region is completed the holes are to be kept plugged for 48 hours and then blown with air and then back filled to the top with some kind of mortar that is being used in that region for construction of masonry.

(b) HIGH PRESSURE GROUTING :

The holes for the high pressure grouting the foundation of the structure shall and be drilled from the foundation to a depth and spacing of holes as shown on the drawings are approximate and subject to revisions at the time of drilling, testing, and grouting. The diameter of any grout hole shall not be less than 50 MM core recovery will not be required. Grout holes shall be drilled to varying depths and a carrying inclination, not to exceed 30 degrees from that vertical. The exact depth direction and interval between holes will be determined in the field from the conditions encountered, and as directed by the geologist of Geological Survey of India, drilling of any grout hole to a total depth greater than 60 mm is not anticipated: however holes to greater depths

to be drilled if found necessary during execution whenever, the drill water is lost on artesian flow encountered, the drilling operations or not to be stopped, but continued taking precautionary steps. Upon completion of drilling of a hole, it shall be temporarily capped or otherwise protected from entry of foreign material until grouting operations required it to be opened.

PIPES FOR FOUNDATION GROUTING

a. Low pressure grout holes : 65mm or 75mm diameter steel pipe of length 0.6m into masonry in the drilled holes to a depth 0.3 m into masonry or concrete from surface by reaming the hole with 80mm or 100mm bit to facilitate the easy washing of holes and prevent the drillings from reentry into the holes; the cost of these pipes and fixing them should be included in the unit rates for drilling and grouting and no separate payment will be made.

b. High pressure grout holes; Standard 65 mm steel pipe shall be used wherever embedded pipe specified for grout holes and also in foundation work over springs, crevices, seams, and other spots disclosing foundation defects and elsewhere if required. Pipes and fittings that are embedded in masonry or concrete shall be thoroughly cleaned and shall be held firmly in position and protected from damage while masonry or concrete is being laid around them. The pipes for the high pessure grout holes shall be over 0.9 mts long from the foundation level so that where drilling is done later on, difficulties inclination may be avoided. The above pipe shall be procured by the contractor at his own cost. The contractor has to embed these pipes without extra cost to the department.

WASHING AND PRESSURE TESTING :

Before taking up grouting of drilled holes plain washing and seam washing of holes is to be done as follows.

a. A set of holes in 4 rows in a block are to be drilled and flushed to full depth using air and water.

b. Then washing of seams intersected by holes is to be carried out by fixing expanding packers in pressure, Zone-wise until clear water comes out from inter connected holes. The work of seam washing is to be done carefully and as directed by field officers regarding changing of connections, procedure etc., (i.e) bottom

zones are to be taken up first for seam washing by fixing packing appropriate depths. Once the seam washing of bottom zones is completed the expanding packers are to be removed and the holes are to be flushed with air and water to bring out clay or much collected in the holes. Then seam washing of next higher zones is to be taken up. This procedure is to be continued till the full depth of hole, is completed. In no case washing pressures should exceed the maximum grouting pressures, which shall be decided by Executive Engineer.

c. When the seam washing is completed the holes are to be flushed with air and water to full depth and pressure testing of holes to be taken up by fixing expandig packers for zone required and water to be pumped under pressure through water meter to record water consumption. This consumption of water will decide the consistency of cement grout. After pressure testing, the zone will be taken up for grouting.

PRESSURE TESTING OF HOLES

a. During the drilling of the holes, or after drilling completed or during or after grouting, holes as required shall be water pressure tested. In all grout holes when abnormal gain or loss of drill water is observed or caving number of the holes or binding of the bit occur during drilling or the drilling rods fall suddently as through on open crack or cavity it may be required that drilling be discontinued and the hole pressure tested.

b. The procedure for water pressure testing shall be as specified herein, if hole drilled and tested shall be isolated by sealing off with double packers attached to a perforated steel pipe and lowered into the hole. If stage drilling method is used, a single packer shall be used to isolate the section to be tested. Water shall then be pumped into the test section under pressure and for period specified herein. The time, pressure and quantities of water used for testing section of hole shall be recorded. The length of test section shall be measured parallel to the direction of hole. Hole shall be tested in 2 to 5 meters sections. The pressure testing apparatus shall be subject to periodic tests for accuracy and satisfactory operations.

c. The pressure test shall be performed in one continuous operations using the following stages of pressure times.

Step No.	Pressure (p)	P.S.I.	Elapsed time Minute
1.	1/3	P	5
2.	2/3	P	5
3.	—	P	10
4.	2/3	P	5
5.	1/3	P	5

The Pressure "P" shall be determined, depending on geological conditions and on the depth of upper packers however, this pressure need not exceed a maximum of 10 Kg/Sq. Cm at the gauge. After steps No. 4 & 5, time the value shall be closed and pressure drop observed and recorded for a minimum period of 3 minutes in each instance.

d. A desirable degree of impermeability if considered to exit when the leakage obtained by applying water test to section of a hole drilled is less than two lugeons (L) i.e., two (2) Litres/metre/minute of hole tested when pressure of 10 Kg/Sq. Cm at the guage point is applied for a period of 10 minutes.

GROUT :

a. Materials : i) Grout shall consist of cement and water in proportions determined in the field. Cement water shall conform to the requirements specified under schedule 'D'.

ii) Admixtures to be followed :- There are number of admixtures when added in small quantities will give the following desirable characteristics.

Retarded for delaying the setting time

Accelerators for hastening the setting time.

b. The water cement ratio by volume will be varied to meet the characteristics of each hole as revealed by the grouting operation and will range between 10:1 to 2:1 the greater part of the grout probably being placed at ratio of about 10:1. In general, if pressure tests indicate a tight role, grouting shall be started with a thin mix. If an open hole condition exists, as determined by loss of drill water or inability to built up pressure during water testing operations, then grouting shall be started with a thick mix and with grout pump operating as nearly as practicable at constant speed at all times, the ratio will decrease if

necessary until the required pressure has been reached. When the pressure tends to rise too high, the water cement ratio shall be increased. If necessary, to relieve premature stoppage, periodic applications of water under pressure shall be made. Under no conditions the pressure or rate of pumping be increased suddenly as either operation may produce a water hammer effect which may promote, stops otherwise the grouting of any hole shall be continued until the hole refuses to take grout practically. For pressure above (14.00 Kg/Sq. Cm)/200 PSI, the grouting pressure shall be maintained for such reasonable time to assure that the foundation has been sastisfactorily grouted. Grout leaks if any develop, such leaks shall be caulked promptly if due to size and continuity of fractures, it is found impossible to reach the required pressure after pumping a reasonable volume of grout at the minimum workable water cement ratio, the speed of pumping shall be reduced. Following such reduction in pumping speed if the desired result is not obtained in, grouting the hole. In such an event, the hole shall be cleaned, the grout allowed to set, and additional drilling and grouting shall be done in the hole or in the adjacent area as determined in the field until the desired resistance is built up. All pressure grouting operations shall be performed in the presence of responsible Engineer-in-charge of grouting. After the grouting of any stage of a hole is finished the pressure shall be maintained by means of a stop cock or other suitable devices until the grout has set to the extent that it will be retained in the hole. The arrangements of the grouting equipment shall be such as to provide a continuous circulation of grout through out the system and to permit accurate pressure control at the hole by operation of a valve on the grout return line, regardless of how small the grout intake may be. The equipment and lines shall be presented becoming fouled by the constant circulation of grout and the periodic flushing out of the system with water flushing shall be done with the grout in take valve closed, the water supply valve open and the pump running at full speed.

GROUT PRESSURE :

The pressure should be as high as practicable but controlled to avoid distrubance of rock structure.

a. Under no conditions of water under pressure rate of pumping be increased suddenly. An injection should be continued

(unless prevented by leakage in any hole or there is negligible grout consumption). A useful rule is to stop pumping when the grout consumption is lessthan 1.5 lugeon at pressure upto 3.5 Kg/Sq.Cm/50 PSI and 2 lugeon at pressure between 3.50 Kg/Sq. Cm/50 PSI and 10.50 Kg/Sq. Cm/150 PSI. If due to size and continuous fractures, it is found impossible to reach the required pressure after pumping reasonable volume of grout the minimum workable water cement ratio shall be used and the speed of pumping shall be reduced. Following such reduction pumping speed, if the desired result is not obtained, grouting the hole will be discontinued. In such case the hole shall be cleaned the grout allowed to set, and additional drilling and grouting shall then be done in this hole or in the adjacent are so as determined in the field until the desired resistance is built up. All pressure grouting operations shall be performed in the presence of a responsible Engineer incharge of grouting. After the grouting of any stage of hole is finished the pressure shall be maintained in the hole.

b. Grouting pressure must be properly and carefully varied to suit the depth of the holes, and character of rock with reference to open the joints, seams etc., the highest possible pressure consistent, with safety, speedy work and the largest possible coverage as determined by pressure testing during grouting should be used. In some cases, where deemed necessary, the upper seams shall be grouted in advance of the regular programme to avoid disturbance to rock structure. It is expected that in general grout pressure may go upto 7.00 Kg/Sq. Cm/100 PSI for consolidation grouting. Grouting pressure must be properly and carefully varied to suit the depth of the holes, distance from exposed rock surface and character of rock with reference to open joints, seams etc., The highest possible pressure consistent with safety speed work and the largest possible coverage, as determined by pressure testing and check levelling during grouting should be used. Where deemed necessary the upper seams shall be grouted in advance of the regular programme in order to permit the use of increased pressure on the lower seams.

METHODS OF APPLYING GROUT :

a. In general, stage grouting shall be adopted. It may be necessary or desirable with reference to the field conditions to use

different sections of the grout holes, especially those of the high pressure grout holes. When such grouting of a hole is necessary, the grouting shall be performed by attaching a packer to end of a grout to the top of the bottom section i.e required to be grouted at a different pressure, grouting at the required pressure and allowing the packer to reduce in place until there is in back pressures; with drawing the grout supply pipe to the top of the next higher section i.e required to be grouted at a different pressure and thus successively grouting the hole in section at the specified pressure until the entire hole is completely grouted, except that the grouting of the section shall be performed without the use of a packer. The packers shall preferably consist of elastic rings of rubber, leather or other suitable material attached to the end of the grout supply pipes. The packers shall be designed so that they can be expanded, to seal the drill holes at the specified elevation and when expanded, shall be capable of withstanding without leakage, for water pressure and the maximum grout pressure to be used.

b. For doing the high pressure grouting, the first holes shall be spaced widely and shall be grouted before intermediate holes are drilled and in this manner the drilling and grouting of the holes shall be completed with such final spacing and depth of holes so as to obtain continuous grout curtain.

TEST OF GROUTED WORK :

a. To test the efficiency and penetration of grout in the grout curtain, core drill holes shall be drilled in the place of the grout curtain after deep grouting operations are completed, core drilling shall be preferably done with Nx size bits and double tube core barrels and they shall produce core 22mm in diameter. The NX holes will be required to drill to be maximum depth of 30m/100 feet. All core drilling shall be performed in a workman like manner, by competent and experienced workmen, and special care shall be exercised to obtain cores in as good condition as possible from all holes. The drill bit shall be pulled and the core removed as often as necessary to secure the maximum possible layout of core. Wood on core boxes, securely nailed, shall be used for placing the core in the correct sequence and they will be aggregated accurately by the labeled wooden blocks accounting to the measure distances in the hole. No box shall contain core from more than one hole.

b. The core drill holes shall be tested under a water pressure equal to or a little less than the pressure for high pressure grouting and the accounting and the account and limit of leakage in each hole measured. If any hole should seem excessive leakages it shall be grouted under pressure and no test hole shall be driven and tested under pressure in the same manner. The foundation will be considered to the consolidation satisfactory if the cement consumption less than 0.5 bag (25 Kgs) per 0.3 m of grout hole. If the cement consumption is more, secondary and or tertiary and shall be drilled and grouted. The test efficiency and generation of the low pressure grouting more drill test holes shall be drilled at the rate of one for either 90 mm grouted area.

5.2.0 BUILDING WORKS

Before starting the earth work :

1. Approved copy of Plan & Estimate shall be possessed.
2. Site shall be cleared.
3. Centerline shall be marked.
4. Centerline pillars shall be constructed.

Excavation of Foundation :

1. The width of foundation shall be marked symmetrically on both sides.
2. The width of the foundation shall be maintained not only top but also at the bottom.
3. Excavated earth shall be deposited 6'-0" away from the outer edge of excavation.

For laying Concrete :

1. Required width & depth of foundation shall be maintained.
2. Platform of size atleast 20' X 20 shall be provided.
3. Sand filling if provided in foundation, filling shall be done to the correct depth, well watered and rammed.
4. If any termite treatment is in 6" layers is prescribed.
5. Broken metal (Coarse Aggregate) shall be correctly to 40 mm size, it shall be free from dust.
6. Sand shall be tested for silt content and silt shall not exceed 6 percent.

7. Sand shall be tested for bulkage and extra quantity if any required shall be added for the concrete mix.
8. The coarse aggregate shall be stacked to the uniform height of 1'-0" (30 CMs)
9. Concrete shall be mixed in quantities which can be utilised within 30 minutes after adding water.
10. Concrete shall be laid in layers of 6" and properly rammed, it shall be watered thoroughly for one week.

FOUNDATION

The width of foundation of every building shall be designed and constructed to distribute the load within the safe bearing capacity of soils.

Minimum size : 4'-0" for Buildings and

3'-0" for Toilets and Compound Wall etc.

On sloping site, spread foundations shall be on horizontal bearing and stepped. At all changes of levels, they shall be lapped at the steps for a distance of atleast equal to the thickness of foundation or twice the height of the step whichever is greater.

CHECK LIST FOR LAYING R.C.C. ROOF SLAB

1. Centring shall be checked, whether properly done. Vertical posts shall not be rested on bricks. They shall be rested on flat surfaced rough stones.
2. Wall tops in slab bearings shall be plastered smooth and craft paper laid.
3. Reinforcement provided as per design. Spacer blocks shall be provided to maintain the correct cover.
4. Fan hooks shall be provided (16 mm M.S.Rods).
5. Sand shall be screened.
6. Silt test made or not (Silt shall not exceed 6% maximum).
7. Bulkage test for sand to be conducted in advance.
8. Granite chips shall be screened, to make them free from dust and dirt.
9. Concrete mixer shall be in good condition.

10. Measuring device for water shall be kept at site.
11. Following testing equipment shall be kept ready.

    (i) Slump test (ii) Cube test

12. Platform for pouring concrete from the mixer shall be in good condition.
13. Vibrator should be in good condition.
14. Accoproof powder packets at the rate of 1 Kg/1 bag of cement shall be kept ready at the site.
15. Storage facility for keeping sufficient water before the start of the work shall be made.

PRECAUTIONS WHILE LAYING CONCRETE :

1. Concrete should not be thrown from a height but shall be placed gently.
2. It should be laid to a uniform thickness of 6" layers and well rammed.
3. No ramming shall be done after concrete has started setting.
4. The old surface should be made rough cleaned and cement grouted before placing new concrete. Not less than 2 Men shall be arranged over the width of concrete with a lateral space of not more than 1/2 meter per man, shall do the ramming.
5. The placing of concrete should start width wise in R.C.C. slabs from one end.

HOW TO USE VIBRATOR :

1. It should be penetrated vertically.
2. Should be taken out of concrete carefully and slowly.
3. Slump should not exceed 5 Cm when at the rate of 5 Cm/Sec. compacted by Vibration.
4. Vibrations should be controlled carefully by immersing, the internal vibrator for 5 to 15 seconds at points 45 Cm apart.

5.3.0 PAINTING

All painting works are to be carried out with best quality of paint of approved brand and conforming to the specifications as laid down in A.P.S.S. vide specification Nos. 1201 to 1210 and 1212 to 1220.

The chemical composition should also conform to relevant I.S. codes I.S.1477-Part-II-1971 and I.S. 14177 - 1994.

Varnishing work should be carried out as per I.S. 337-1975

338 - 1982

339

342

347 - 1975, 524 - 1968 and 525 - 1968.

Representative samples are to be procured from each consignment and got tested in any National testing laboratory and results obtained before their use.

The particulars such as Batch No, Date of Manufacture, expiry, etc., for each lot are to be obtained from the manufactures and recorded in the relevant field registers.

The dry film thickness in microns of the paint applied to the surface is to be measured with the help of ELCOMETER in the presence of the Quality Control Staff.

1. Chemical Composition conforming to

   I.S. 1477 - Part- II - 1971 &

   I.S. 14177 - 1994.

2. Test weight per 10 T of paint thoroughly mixed
3. Drying time.
4. Flexibility of Adhesive.
5. Consistency &
6. Dry thickness & rate of composition.

are to be carried out wherever necessary.

5.4.0 FIELD TEST EXPERIMENTS

(CertainTips)

FIELD TEST OF CEMENT : When cement has been received from a doubtful source and when where it is not possible to conduct the laboratory test immediately and where the cement is to be used immediately, its purity and quality can be judged by applying the following field tests :-

The lab test shall be conducted at the next immediate possible time

1. The colour of cement should be uniform and greenish grey.
2. When hand is thrusted into a bag of cement, it should feel cool touch.
3. Any lump found in the cement bag, should be powdered when pressed between the thumb and fore finger, if it does not turn into powder form, the cement is considered spoiled by air setting.
4. It should feel smooth when rubbed in between fingers. It should neither feel rough not gritty. Roughness or gritness shows some sort of adulteration i.e. sand etc.,
5. A handful of cement, thrown into a bucket of water, should float in case the cement is of good quality and if it sinks, it contains some impurities.

EXPERIMENTS :

Object : To perform field tests for Cement.

Apparatus : Stove, Steel Plate, enamelled trays, test tube, tumbler glass, measuring steel rule etc.

Material : Three samples of the given cement.

Theory : Although cement is manufactured at the factory under controlled conditions, yet there are always possibilities that the cement may deteriorate or be adulterated during storage or transportation. Whenever, cement is received from a doubtful source and where it is not immediately possible to conduct the laboratory tests on account of using the cement urgently, its purity and quality can be judged by performing the following three tests in the field subject to subsequent lab test :-

(a) Setting and hardening action.

(b) Detection of adulteration

(c) Ascertaining soundness of cement.

After performing these field tests, the approximate quality of the cement can be verified.

Procedure :

a) For setting and hardening action :-

i) Prepare three small parts, each 75mm x 75mm x 25mm in size from the given sample of cement by adding 28 percent of water by weight as shown in the figure.

ii) Prepare similar number of pats with good quality cement.

iii) Cover the pats with wet cloth for 24 hours.

iv) Try to make nail impression on all the pats. Good cement will resist this impression.

v) If the cement does not resist thumb nail impression, then continue curing upto 48 hours.

vi) Try to break the pats with pressure of thumb, if the cement is not of good quality, the pats will break under the thumb pressure and therefore, should be tested in the laboratory.

vii) After 48 hours, if the pats show improvement in hardening but does not attain hardness as compared with pats of good quality cement, then make third trial after 72 hours of curing.

viii) Setting quality in the cement, the pats will become as strong as the pats of good quality cement after this period and thus requires no further testing :

b) For detection of Adulteration in Cement :-

i) Take a small sample (about 100 gms) of cement on a steel plate and heat it thoroughly for about 20 minutes on a stove.

ii) If there is change in colour of cement, it is adulterated and therefore, should be tested in the laboratory.

iii) To detect adulteration with local ash, take a small quantity of cement in a test tube or a tumbeler glass.

iv) Add water till the container (Test tube or a tumbler glass) is half full.

v) Shake the container thoroughly and allow it to settle for few minutes.

vi) Check the cement lying in the container. If there is adulteration with coal ash the cement partciles will settle down and the ash-particles will either be found floating on the water surface or held in suspension.

c) **For ascertaining soundness of cement :-**

i) Prepare a pat of cement, 75 mm in diameter and 12mm thick as shown in the figure.

ii) Cure the pat with moist cloth for 24 hours.

iii) Then boil the pat in water for a period of 2 hour.

iv) Observe the conditions of surface of the pat.

v) In case the cement is sound, surface of the pat will not develop a pattern of crack.

EXPERIEMTN NO.1 :

Object : To perform field test for determining silt in the fine aggregate i.e. natural sand.

Appparatus : Measuring cylinder of 250 Ml capacity.

Material : Three samples of natural sand, 1% Solution of common salt in water etc.

Theory : The harmful substances normally present in natural sand are organic matters in the form of humus, coatings etc., the coatings usually comprise of clay and silt. Clay is the material of particle size below 0.002 mm and the silt having particle size varying between 0.002 to 0.06 mm.

Clay and silt, if present, in the fine aggregate (i.e. sand) in the form of coatings or loose form, prevent the development of good bond between the cement paste and aggregate. Moreover, on account of their fineness and if present in large quantity, more quantity of water is required in preparing a concrete mixture of desired workability which reduces the strength of concrete. Therefore, tests should be performed to determine the presence of clay and silt before using the natural sand for preparing the concrete mix.

There is a field test of determining volumetrically the percentage of silt in the natural sand. This test is recommended when the percentage of silt is upto 6% by volume. In case the percentage of silt exceeds 6% accurate tests as Per I.S : 2386 Part-II-1963 should be conducted. In such a case, the sand should be washed before adding the same in the concrete mix.

Procedure :-

i) Fill the measuring cylinder to 50ML with approximately 1% solution of common salt in water

ii) Add sand to be tested till the level of common salt in the cylinder reaches 100ML mark.

iii) Add more solution of common salt in the cylinder tillthe level reaches 150 ML mark.

iv) Cover the cylinder tightly with palm and shake the mixture of sand and solution of common salt by repeatedly turning upside and down;

v) Allow the mixture to stand for 3 hours in the cylinder. The silt, being a finer material, will take more time to settle and form a layer above the sand.

vi) Measure the thickness of silt layer formed in the cylinder and calculate the percentage of silt as follows :

PERCENTAGE OF SILT BY VOLUME :

$$= \frac{\text{Volume of silt after three hours}}{\text{Volume of sample}} \times 100$$

or silt %/Cu.M = V2/V1 x 100

vii) Repeat experiement thrice to get the average value.

OBSERVATIONS :

S.No.	Description of Date	Samples Ml.		
		I	II	III
1.	Total volume of sample (V1) Ml.			
2.	Volume of silt after three hours (V2) Ml.			
3.	Percentage of silt Volume = V2/V1 x 100			

Result : Average value of Silt content = $\frac{I + II + III}{3}$ %

Conclusion : Since the percentage of silt exceeds/does not exceed 6% the fine aggregate is required/not required to be washed.

PRECAUTIONS :

i) The sampling of the fine aggregate should be properly done.

ii) The solution of common salt should be prepared by dissolving 10gm. of common salt in 1 litre of water.

iii) The mixture of common salt and sand should be shaken vigorously.

PRACTICAL UTILITY :

The experiment is performed to decide whether the natural sand is required to be washed or not, before using the same for preparing mortar or concrete :

EXPERIMENT NO. 2 :-

Object : To determine necessary adjustment for bulking of fine aggregate i.e. sand (IS : 2386-Part-III-1963)

Apparatus : A container, steel rule, steel rod 6 mm diameter, 250 Ml measuring cylinder etc.,

Material : Three samples of sand.

Theory : Bulking is defined as the increase in the volume of a given volume of sand due to presence of surface water. It is caused by film of surface water covering each particle of sand and pushing them apart due to surface tension.

Fine sands bulk much more than the coarse sands. It has been observed that with the moisture content of 5 to 6 percent, the sand may increase from 20 to 40 percent in volume, according to the zone of sand.

When batching of aggregate is done by volume, bulking results, in less weight of the sand added in the mix. The concrete mix thus becomes deficient in sand and the concrete subject to segregation and its yield is also reduced. Therefore, while adding fine aggregate i.e. sand-to the concrete mix by volume, the bulkage of the fine aggregate (Sand) should be checked before adding the same in a concrete mix. The required volume of sand should be proportionately increased, according to the bulk of sand.

PROCEDURES :

i) Put sufficient quantity of sand loosely into a container until it is about 2/3rd full.

ii) Smooth and level the top surface of sand and measure its height by pushing a steel rule vertically down through sand at middle to bottom, say this is (h)

iii) Transfer the sand into another container.

iv) Fill the container with water to one-forth of volume occupied by the sand.

v) Put back about half the sand and compact it with a steel rod so that its volume reduces to minimum.

vi) Smooth and level the top surface of the compacted sand and measure its depth at middle with steel rule as above, say it is (h').

vii) Add the remaining sand and compact it again as above.

viii) Then calculate the bulkage of sand from the following relation :-

$$\text{BULKAGE OF SAND} : \frac{h - h^{1}}{h^{1}} \times 100$$

ix) Repeat this experiment thrice by taking samples of the same sand three times and then find the average value as the result.

x) After this, find the actual proportioning of the sand for a given concrete mix as conclusions.

OBSERVATIONS :

S.No.	Description of Date	SAMPLES		
		I	II	III
1.	HEIGHT of loose sand (h) mm			
2.	Height of saturated sand (h') mm			
3.	Percentage bulking= $\frac{h - h^{1}}{h^{1}} \times 100$			

CONCLUSIONS :

For a given concrete mix of _____ by volume, the actual proportioning of the sand under test should be _____

RESULT :

$$\text{AVERAGE PERCENTAGE OF SAND} = \frac{\text{I}+\text{II}+\text{III}}{3}$$

PRECAUTIONS :

i) The top surface of sand should be properly levelled smooth at the time of measuring the height.

ii) The height of sand should be accurately measured before and after rodding the sand.

iii) No sand should be lost in transferring it from one container to the other.

PRACTICAL UTILITY :

This experiment is performed to know the bulkage of sand when batching is done by volume so that the rquired volume of sand can be proportionately increased.

EXPERIMENT NO. 3 :

Object : To perform slump test for workability of concrete and to verify the effect of variations of water cement ratio, fine aggregate coarse aggregate-cement ratio on slump.

Apparatus : Mould in the form of frustum of a cone, tamping rod 16 mm diameter and 0.6 m long, trowel, metal plate, steel scale, trays etc.

Material : Samples of concrete mix to be tested and its ingredients.

Theory : The workability of a concrete mix is defined as the case with which it can be mixed transported, placed and compacted in position. The workability or slump depends upon the water content and proportion of fine aggregate to coarse aggregate and aggregate to cement ratio. For proper compaction, the concrete mix must have some mobility without loosing the

cohesiveness of aggregate. Only then the concrete mix can be compacted to get dense concrete.

Slump test is a field test used to check consistency of concrete. Requisite amount of slump is rquired for different types of concrete construction. Once the slump for a particular work is decided, it is desired to use the concrete of that workability. Thus the slump test is very useful on the site as a check on the day to day and hour to hour variations in the ingredients being used for preparing the concrete mix. Increase in slump means that either the moisture content in aggregate has unexpectedly increased or there is change in the grading of aggregate. Too high or too low slump gives immediate warning and thus enables the mixer operator to remedy the variation in the concrete mix.

PROCEDURE :

a. For slump Test :-

i) Clean the internal surface of the mould thoroughly by removing the superfluous moisture and set concrete, if any.

ii) Place the mould on a smooth, horizontal, rigid and non-absorbent surface which may be in the form of a carefully levelled metal plate.

iii) Fill the concrete mix under test in the mould in four equal layers, by tamping each layer with 25 strokes with the tamping rod.

iv) After tamping the top layer, struck of extra concrete level with the top of mould by means of a trowel or tamping rods so that the mould is exactly filled.

v) Remove the mould by leaving the compacted concrete in position on removing the mould, the concrete will subside.

vi) Measure the height of the subsided concrete heap of the specimen by means of steel scale immediately after removing the mould.

vii) Find out the slump by determining the difference between the height of mould and that of the highest point of the subsided concrete heap as shown in figs. 4.1.

viii) Repeat this experiment thrice and take the average value of three slumps as the result for conclusion.

RECOMMENDED SLUMPS FOR VARIOUS CONCRETE WORKS

S.No.	Type of construction	Recommended in slump in mm	
		Minimum	Maximum
1.	Pavements	25	50
2.	Mass concrete structures	25	50
3.	Unreinforced footings etc.	25	75
4.	Cassions & Bridge Deck :	25	75
5.	Reinforced foundation, footing and walls.	50	100
6.	Reinforced slabs and beams.	30	125
7.	Columns	75	125

WATER CEMENT RATIO :

The Ratio of volume or weight of water to that of cement in concrete mix is called **"Water Cement Ratio"**

CEMENT RATIO :

It is expressed in liters of water required per bag (50 Kgs) of cement.

A rich mix of concrete gives higher strength than a lean mix not only because of using more cement, but also because of using less water cement Ratio.

While adding the water the moisture in the metal and sand shall also be taken into account.

In case water cement ratio is considerably less, it produces weak concrete, and if it is much more the water in excess occupies the space more than that needed during setting of cement. When the water evaporates, this additional space which is occupied by excess water will form into voids and weakens the strength, durability and water tightness of cement.

CANAL LINING :

Clearing site, preparation of subgrade in soils and rock providing under drainage, pressure relief arrangements, anti salt treatment, placing model sections, laying plain cement concrete with machine crushed hard broken graded granite metal of 40 mm/20 mm maximum nominal size and using cement level of not less than 250 Kgs per cubic meter of concrete to yield a 28 days characteristic compressive strength specified for bed and sides using conventional placement of concrete lining constitute the main items of lining.

The codes applicable are :

1. I.S. 456 - 1978 Code of practice for plain and RCC
2. I.S. 3873 - 1978 Code of practice for laying in-situ-cement concrete lining of canals.
3. I.S. 2505 - 1980 General requirements for concrete vibrators (immersion type)
4. I.S. 2506 - 1986 General requirements for screed board concrete vibrators
5. I.S. 3366 - 1965 Specification for pan vibrators
6. I.S.3558 - 1983 Code of practice for use of immersion vibrators for consolidating concrete
7. I.S. 4558 - 1983 Code of practice for under drainage of lined canals
8. I.S. 5236 - 1968 Code of practice for sealing joints in concrete lining on canals
9. I.S. 3085 - 1965 Methods of test for permeability of cement mortor and concrete
10. I.S. 1199 - 1959 Method of sampling and analysis of concrete
11. I.S. 516 - 1959 Method of test for strength of concrete
12. I.S. 5529 Part 1&2 - 1985 Code of practice for in-situ permeability test.

13. I.S. 9103 - 1979 Specifications for admixitures for concrete

14. I.S. 9451 - 1985 Guide lines for placing lining for canals.

Types of lining

1. Puddle clay lining
2. R.R. Lining
3. Brick lining
4. C.C. lining
   a) Precast
   b) Cast in Situ.
5. Cement-soil Lining

The finishing in lining shall be in accordance with clause 5.7 of I.S. 3873 - 1978. The finished surface shall be equivalent in evenness, smoothness and free from rock pockets and surface voids to that obtainable by effective use of a long handled steel trowel. Light surface pitting and light trowel marks will not be considered objectionable. Where the surface produced by a lining machine meets the specified requirements no further finishing operations will be required. The top portions of the side slopes of the canal lining extending 1.50 meter vertically below the top of the lining shall receive a non skid, longitudenal brush finish.

The surface of concrete finished against forms shall be even, smooth and shall be free from projections, pockets honey combing and other objectionable defects.

Use of any finishing tool in areas where water has accumulated shall be prohibited and all finishing operations shall be laid until the water has been absorbed evaporated or removed by drawing, mopping or such other means.

Tolerances :-

The permissible tolerances for the canal lining shall be as under in accordance with section 5.3 of I.S. 3873 - 1989.

Departure from established alignment	+ 20 mm on straight reaches
Departure from established grade	+ 50 mm on partial curves or tangents
	+ 20 mm on small canals
Variation in thickness of lining	+ 10% provided average thickness is not less than specified thickness

Curing :-

The bed lining shall be water cured for 28 days through provision of earth bunds of small height so that a column of water is available above the lining.

The joints of plain cement concrete slabs lining on side slopes shall be water cured through sprinking of water at regular intervals at least for 21 days.

Weep holes :-

To prevent water pressure behind the wall drainage should be provided by the use of large material against the back of the wall and by weep holes, walls retaining soils through which water freely passes, such as clean gravel and sand, should have a drain of loosely packed rubble running along the back footings from which good sized weep holes from 1.8 to 3 m apart should lead through the base. With more retentive soils a drain atleast 250 to 300 mm wide should run nearly the whole way up the back of the wall. The mouths of the weep holes should always be carefully protected by loose packing. In some cases extra weep holes at higher levels may be advisable which may be 50 to 75 mm square or 75 mm pipes may be used at about 2 m intervals (in staggered positions) vertically and horizontally, the lowest being 30 cm from the ground level. Weep holes should be given a fall of 1 in 8 from the back of the masonry to the face. Weep holes should be provided in all abutments and wing walls. Weep holes should be provided above low water level 15 cm drain pipes can serve the purpose.

5.5.0 DERIVED S.I. UNITS

Table A-1 lists the basic SI Units

Table A-1 Baisc SI Units

Physical Quantity	Unit	Symbol
Length	Metre	M
Mass	Kilogram	Kg
Time	Second	S
Electric Current	Ampere	A
Themodynamic temperature	Kelvin	K
Luminous intensity	Candela	Cd

Table A-2 lists the derived SI units used in soil engineering.

Table A-2 Derived SI Units Used in Soil Engineering

Physical Quantity	Unit	Symbol	Formula
Acceleration	meter per second squared	m/s^2	
Angular Velocity	radian per second	rad/s	
Angular acceleration	radian per second squared	rad/s^2	
Area	square metred	m^2	
Area	hectare	ha	$hm^2=104m^2$
Density	kilogram per cubic metre	kg/m^3	
Dynamic viscosity	Newton second per square metre	Ns/m^2	kg.m/s.m2
Electric charge	Coulomb	C	C=A.s
Electric resistance	Ohm	Ω	Ω=V/A
Force	Newton	N	kg.m/s2
Frequency	Hertz	Hz	1/s
Kinematic viscosity	square metre per second	m^2/s	$kg.m^2/s^2$
Moment or torque	Newton metre	N.m	$kg.m^2/s^2$
Power	watt	W	j/s
Pressure	Pascal	Pa	N/m^2
Stress	Pascal	Pa	N/m^2
Unit weight	Newton per cubic metre	N/m^3	$kg/s^2.m^2$
Velocity	metre per second	m/s	
Voltage	volt	V	W/A
Volume	cubic metre	m^3	
Volume	litre	l	$dm^3=10^{-3}m^3$
Work/Energy	joule	J	N.m

Conversion Factors

To Convert from	To	Multiply by
in	mm	25.4
ft	mm	304.8
in^2	mm^2	645.16
ft^2	mm^2	92903
in^3	mm^3	16387
ft^3	m^3	0.028317
lb	kg	0.4536
ton (2240 lb) - long	kg	1016.05
ton (2000 lb) - short	kg	907.18
kg	lb	2.2046
kip	lb	1000
kip	kg	453.59
lb	N	4.4482
kg	N	9.8067
N	lb	0.22481
N	kg	0.1019
kip	kN	4.4482
Tonne-long	kN	9.8964
Ton-short	kN	8.8964
Tonne-long	MN	0.00981
MN	Tonne	101.64
kN	Tonne	0.1016
kip ft	kN m	1.3558
kg m	N m	9.8067
Tonne m	kN m	9.8067
	MN m	0.00981
kN m	Tonne-m	0.1016
lb/ft	kg/m	1.4882
kip/ft	kN/m	14.5939
Tonne/m	kN/m	9.8067
lb/in^2	kN/m^2(kPa)	6.8948
lb/in^3	kN/m^3	271.446
kip/ft^2	kN/m^2	47.88
kip/ft^3	kN/m^3	157.087
$Tonne/m^2$	kN/m^2	9.8067
$Tonne/m^3$	kN/m^3	9.8067
kg/cm^2	$Tonne/m^2$	10.00
	kN/m^2 (kPa)	98.0665
	MN/m^2 (MPa)	0.0980
kg/m^2	N/m^2 (Pascal)	9.8067
g/cm^3	kN/m^3	9.8067
kg/m^3	N/m^3	9.8067
Imperial gallon	Litr	4.546
U.S.Liquid gallon	Litre	3.785

5.6.0 LIST OF EQUIPMENT FOR CEMENT AND CONCRETE TESTING

TEST	EQUIPMENT
ACEMENT	Flame Photometer Spectrophotometer
a) Chemical	Potentiometer, Silver Electrode
i) Alkalines	Calmet Reterance Electorde Salt bridge
ii) Minor major sides by Caloremeter	Water Distillation still, oven Hot plate, Balance (Ace 0.0002 g) Mufle Fumace (upto 1200c)
iii) Chloride	Platinam Calcobes, conductilty
iv) General	Badge, Ph Meter, Sample Divider for powers, physical balance (Cap 150g)
b) PHYSICAL	Blaines Apparatus, stop watch.
i) Emeness	I-c-Chatelier Moulds hot water
ii) Soundness Le Chatelier	bath Autoclave, length comparator moulds 25 x 25 x 250 mm.
iii) Consistency and setting time (Initial & Final)	Vicat Aparatus, moulds setting time needless and plunger com;
iv) Compressive strength	pression testing machine (50 tonnes) vibratig machine
v) Heat of Hydration	moulds 50 sq. cm. Area
vi) Drying shrinkage	catorimeter backmann ther-
viii) General	mometer length comparator. flowtable stop watch timer tem-
B. AGGREGATES & CONCRETE	perature controlled oven, humidity chamber incubator,
a) General	physical balance (ACC 0.001 g)
i) Crushing value	balance (cap 5 kg ACC g) control room (Temp controlled cur-
ii) Impact value	ing tanks) set of standard
iii) Abrasion value	sieeves and receiver
iv) Alkali Aggregate Reactivity	Electric Drier, hot plates set of
v) Flakiness & longation Indices	standard sieves lid and receiver balance 10 Kg ACC Kg) 100 Kg (ACC 100Kg) 200 Kg (ACC 0.5 Kg) seep. Enamel trays balance showel compression testing machine (200 tonnes) crusher and ball mill proviling rings 2,25,50, 10 tonne.
	Crushing apparatus
	Aggregate impact test machine loss
	Angles machine
	Reaction containers
	Apparatus for measuring falkiness and clongation indicies

TEST	EQUIPMENT
vi) Unit Weight containers	Minimum Capacity of Measurnes
vii) Sampling (Sand)	Max CA / Size of mm / Capacity of Measure dm3
viii) Specific Gravity and Absorption	2.50 — 6 37.50 — 11 50.00 — 14 75.00 — 28 114.00 — 71 152.00 — 99
C.CONCRETE	Refiler sample Divider
a) Fresh Concrete	Pyenometer
i) Air content	Air meter
ii) Vibration	Internal Vibrator, table vibrator
iii) Temperature measurement	Metallic Themometer
iv) Mix proportions	Equipment as in IS : 1199 for Determination of constituents
b) Workability Tests	Slum cone Apparatus Compaction
i) Slump test	Factor apparaturs Universal.
ii) Compaction factor test	Testing Machines with Acccessorics (Cap. 100 tonnes)
c) Hardened concrete	Concrete workability meter
i) Compression, Flexural, tension bending & Brined hardness tests.	Capping moulds
ii) Capping of cylinders	Laboratory concrete mixer
iii) Mixing of concrete	Reflectance meter
iv) Testing of curing compounds.	Optical microscope, grainding and polishing equipment ultrasonic pulse velocity, rebound hammer core drilling machine, RCC cutting machine, thermal conductivity apparatus permeability apparatus.
d) Special Tests	
i) Microscopy	
ii) Non-Destmetive	
iii) Core Testing	

MATERIAL		TEST	METHOD
Concrete	a)	Fresh Concrete	IS:516-1959
	i)	Air content	
	ii)	Vibration	
	iii)	Yield	
	iv)	Temperature measurement	
	v)	Mix proportions	
	vi)	Water cement ratio	
	b)	Workability test	IS:516-1959
	i)	Slump test	Usual procedure
	ii)	Compaction Factor test	IS:CED 2 (CESS) ASTM C 597-83
	c)	Hardened Concrete	BS 4408
	i)	Compressive strength	PART 5:1974
	ii)	MDT Tests	IS:CED 2 (3890)
	iii)	Ulrasonic pulse vecolity	ASTM C805-85
	iv)	Rebound Hammer	BS 4408 PART 4:1971
	d)	Special Tests	
	i)	Microscopy	
	ii)	Non-destructive	
	iii)	Core Testing	
Embankment	i)	Disturbed grain size analysis	IS 2720 Part (iv) 1965
	ii)	Proctors Compactiuon	IS 2720 Part (VII & VIII) 1965
	iii)	Alterbergs Limits	IS 2720 Part (V) 1970
	iv)	Permeability	IS 2720 Part (XVII) 1956
	v)	Shear test	IS 2720 Part (XIII) 1972
	vi)	Specific gravity	IS 2720 Part (III) 1964

5.7.0 TESTS TO BE PERFORMED ON MATERIALS

MATERIAL		TEST	METHOD
Cement	a)	Chemical	IS:4032-1985
	b)	Sio2, A 1203, Fe203, Cao Mgo, So2, busol, tesidue & Loss On ignition	
	II)	Alkalies & Chlorides	
	III)	Free Lime	
	b)	Physical	
	I)	Specific gravity	
	II)	Fineness	
	IV)	Soundness	
	V)	Compressive strength	
	VI)	Drying shrinkage	
Coarse Aggregates	I)	Sieve Analysis	IS : 2386-1963
	II)	Flakiness index	
	III)	Elongation index	PART I
	IV)	Deleterious materials	
	V)	Specific gravity	PART II
	VI)	Bulk Density	
	VII)	Moisture content	PART III
	VIII)	Absorption value	
		Mechanical tests	PART IV
	ix)	Aggregate crushing value	
	x)	Impact value	PART VIII
	xi)	Abrasion value	
	xii)	Potential reactivity of aggregate	
	xiii)	Petrographic examination	
	xiv)	Alkali Aggregate reactivity test	
Water		Chemical	IS :3025-1968
	i)	CL,SO4, Organic & Inorganic Solids, PH, Alkalinity/Acidity	
	ii)	Setting time of mortar	IS : 516-1959
	iii)	Relative strength of concrete	IS:199-1959
Admixtures	I)	Relative water content	IS:9103-1959
	ii)	Bleeding	IS:9103-1959
	iii)	Relative strength	IS:516-1959
	iv)	Relative fletural strength	IS:8142-1952
	v)	Setting time	IS:1199-1959
	vi)	Relative length change	

5.8.0 FREQUENCY OF TESTING

Sl. No.	Test	Frequency of Test	Purpose	Test Designation
1	2	3	4	5
1.	Grain size analysis classification	One test per day/ for ever 3000 in	To know classifications of soil actually put in the embankment	As per IS-2720-IV
2.	Atterberg Limited	One test per day	- do -	IS-2770-V-1070
3.	Specific Gravity	One test per day	- do -	IS-2720-III-1964
4.	Field Density and Moisture content	One test for every 1500 m3 of earth work and atleast one test in each layer laid on embankment.	To determine the placement density and moisture content.	IS-2770-XXVIII-1974 IS-2720-XXIX-1966 IS-2720-XXXIII-1971
5.	In-situ permeability Test	One test in one meet or every 3m of embankment height or for 20,000 m³	To determine permeability characteristics of the fill material	IS-2720-XVII-1966
6.	Tri-axial Shear Test	One test in one week or every 3m of embankment or for 20,000 m³	To know the show characteristics of fill material (in-situ)	IS-2720-XII-1975
7.	Consolidation Test	1 set of 3 samples in every 6m height of embankment or or for 30,000 m³ or once in ten days.	To know the settlement rate and its manitude	IS-2720-XV-1965
8.	Standard Proctor Test	One test per day for individual Borrow Area	To determine MDD and OMC of the solid and compare the results with laboratory value	IS-2720-VII-1970

1	2	3	4	5
9.	Moisture content	one test in each sample	To know the moisture content of the sample	IS-2720-II-1975
10.	Shrinkage Factor	One test in one week or 5m of	To determine shrinkage limined	IS-2720-PartII-1972
B.	FILTERS			
11.	Grain Size Analysis	One test for every 200 m³ of of filter (sand) One test for every 200 m3 filter (Aggregate)	To find % of the D50, D125, D30 D50, D60 and D85 grain sizes of materials	IS-2385-Part I
12.	Clay lumps and and organic impurities	One test for every 200 m³ (sand) One test for every 200 m³ (Aggregate)	To find out clay lumps & Organic impurities level	IS-2386-Part II

The actual frequencies shall be determined by the Engineer-in-charge to suit the nature andmaturity of

6.0.0 REFERENCE INDIAN STANDARDS : LIST OF I.S. CODES

6.1.0 CIVIL

6.1.1 EARTH WORK EMBANKMENTS :

The following Indian Standard Books are suggested to be made available with every quality unit dealing with the embankment works.

IS :	12169	- 1987	Criteria for design of small embankment dams.
IS :	8026	- 1978	Guidelines for design of large earth and rockfill dam.
IS :	7894	- 1975	Code of practice for stability analysis of earth dams.
IS :	8237	- 1985	Code of practice for protection of slope for Reservoir embankments.
IS :	9429	- 1980	Code of practice for drainage system for earth and rock fill dams.
IS :	8414	- 1977	Guidelines for design of under seepage control measures for earth and rock fill dams.
IS :	4999	- 1968	Recommendations for grouting of pervious soils.
IS :	5050	- 1968	Code of practice for design, construction and maintenance of relief wells.
IS :	6066	- 1971	Recommendations for pressure grouting of rock foundations in River Valley Project.
IS :	2720	- 1966	Methods of tests for soils.
Pt-I		-1966/72	Preparation of dry soils and samples for variation tests.
Pt-II		-1969/72	Moisture content.
Pt-III		- 1964	Determination of specific gravity.
Pt-IV		- 1975	Grain size analysis.
Pt-V		- 1970	Liquid and plastic limits.
Pt-VI		- 1972	Shrinkage factors.
Pt-VII		- 1974	Water content - Dry density relative cases.
Pt-VIII		- 1974	Heavy compaction.

Pt-IX	- 1971	CDC - MC by constant weight of soil method.
Pt-X	- 1973	Unconfined compressive strength.
Pt-XI	- 1970	Shear strength factors triaxial compression without core manual.
Pt-XII	- 1975	With core pressure.
Pt-XIII	- 1972	Direct shear test.
Pt-XIV	- 1978	Density index.
Pt-XV	- 1965	Consolidation properties.
Pt-XVI2720	- 1965	Laboratory determination of CBR.
Pt-XVII	- 1965	Permeability.
Pt-XXI	- 1965	Total soluble solids.
Pt-XXVIII	- 1974	Dry density of soils in place by sand replacement method.
Pt-XXIX	- 1975	Core cutter method.
Pt-XXX	- 1968	Vane shear test.
Pt-XXXI	- 1969	Field CBR.
Pt-XXXII	- 1970	North Dakota core test.
Pt-XXXVI	- 1975	Permiability of granular soils (constant head)
1498	- 1970	Classification & Identification of soils.
1888	- 1971	Method of load test on soils.
1892	- 1962	Code of practice for site investigation.
2131	- 1963	Standard penetration test for soils.
4332	- Pt-I to X	Methods of test for stabilised soils.
67 to 69		
4968	- Pt-I to III/76	Method for subsurface sounding for soils.
Pt-III	Static core penetration test.	
2809	- 72	Glossary of time & symbols relating soil sample.

6.1.2 Other items

I. S : Indian Standard of the Bureau of Indian Standards

Sl.No.	I.S. Number	Short Title
01	IS : 4701-1982	Code of practice for Earth work on canal.
02	IS : 7293-1974	Safety code for working with Construction machinery.
03	IS : 3764-1966	Safety code for excavation work.
04	IS : 1948-1970	Classification and identification of soils for general Engineering purposes.
05	IS : 2720-1970 (Part-2)	Method of test for soils part-2 determination of water content.
06	IS : 2720-1980 (Part-7)	Method of test for soils part-7 determination of water content dry density relation using light compaction.
07	IS : 2720	Method of test for soils part-28 determination of dry density of soils (Part-28) -1974 in place by sand replacement method.
08	IS : 2720-1976 (Part-29)	Method of test for soils part-29 determination of dry density of soils inplace by core cutter method.
09	IS : 1888-1982	Method of load test on soils.
10	IS :2131-1981	Method of standard penetration test for soils.
11	IS : 4332-1967 (Part-I)	Methods of test for stabilized soils methods of sampling and preparation of stabilized soils for testing.
12	IS : 2720-1983 (Part-4)	Method of test for soils - Grain Size - Analysis.

13	IS : 2720-1983 (Part-4)	Method of test for soils Determination of liquid and plastic limits .
14	IS : 2720-1971 (Part-9)	Determination of dry density moisture content-relation by constant weight of soil method.
15	IS : 2720-1991 (Part-10)	Determination of unconfined compressive strength
16	IS :2720-1986 (Part-13)	Method of test for soils part-13 direct shear test.
17	IS : 2720-1986 (Part-15)	Method of test for soils : Part-15 determination of consolidation properties.
18	IS:2720-1983 (Part-14)	Index (relative density) of cohesion less soils.
19	IS : 2720-1987 (Part-16)	Method of test for soils. Laboratory determination of C.B.R.
20	IS : 2720-1964 (Part-18)	Method of test for soils. Determination of field moisture equivalent.
21	IS :2720-1977 (Part-40)	Method of test for soils determination of free swell of soils.
22	IS : 2720-1977 (Part-41)	Method of test for soils. Determination of swelling pressure of soils.
23	IS :8237-1985	Code of practice for protection of slope for reservoir embankment.
24	IS:8414-1977	Guidelines for design of under seepage control measures for earth and rockfill dams.
25	IS :4081-1986	Safety code blasting and related drilling operations.
26	IS : 4668-1985	Ammonium nitrate for explosives.

27	IS : 6609-19	Method of test for commercial blasting explosives (Part 1 to 5) and accessories.
28	IS :7632-1975	Detonators.
29	IS :5454-1986	Portable pneumatic drilling machine.
30	IS :3764-1986	Safety code for explosives work.
31 (a)	456-1978	Code of practice for plain and reinforced concrete.
(b)	457-1977	Code of practice for plain and reinforced concrete for dams and mass concrete.
32	2386-1977	Methods of test for aggregates for concrete. (Part-1 to 8)
33	516-1959	Methods of test for strength of concrete.
34	4925-1968	Specification for concrete batching and mixing plant.
35	1791-1985	Specification batch type concrete mixers.
36	650-1991	Specification for standard sand for testing cement.
37	2330-1986	Methods for sampling of aggregate for concrete.
38	2722-1964	Specification for portable swing weigh batchers for concrete (single and double bucket type).
39	4634-1991	Batch type concrete mixers-methods test performance.
40	5515-1983	Specification for compacting factor apparatus.
41	5640-1970	Method of test for determining aggregates impact value of soft course aggregates.
42	5816-1970	Method of test for uplifting tensile strength of concrete cylinder.

43	5889-1970	Specification for vibratory plate compactor.
44	5892-1970	Specifications for concrete transit mixers and agitators.
45	6461-1972 & 1973	Glossary of terms relating to cement concrete aggregates, materials etc., (Part 1.12)
46	6925-1973	Method of test for determination of water soluble chlorides in concrete admixtures.
47	1838	Specification for performed fillers for expansion joints in concrete pavements and structures.
48	7320-1974	Specification for concrete slump test Apparatus.
49	7861-1975 & 1981	Code of practice for extreme weather concreting.
50	8142-1976	Method of test for determing setting time of concrete by penetration resistance.
51	9013-1978	Method of making curing and determining compressive strength of accelerated cured concrete test specimen.
52	9284-1979	Method of test for abrasion resistance of concrete.
53	1200-1974 (Part-2)	Method of measurement of building & engineering works concrete works.
54	5751-1984	Specifications for precast concrete coping blocks.
55	3085-1965	Method of test for permeability of cement mortar and concrete.
56	3878-1978	Code of practice for lining insitu cement concrete lining of canals.

57	2506-1985	General requirement for concrete vibrators screed board type.
58	3363-1965	Specification for pan vibrators.
59	1199-1959	Methods of sampling and analysis of concrete.
60	3370-1965 & 1967 (Pat-1 to 4)	Code of practice for concrete structures for the storage of liquids.
61	2505-1980	General requirement for concrete vibrators, immersion type.
62	3558-1983	Code of practice for use of immersion vibrators for consolidating concrete.
63	4656-1968	Specifications for form vibrators for concrete.
64	8989-1978	Safety code for erection of concrete framed structures.
65	4990-1981	Specifications for plywood for concrete shuttering works.
66	6505-1985	Code of practice for installation of joints in concrete pavements.
67	3696-1991	Safety code of scaffolds and ladders.
68	IS:456-1991	Code of practice for plain and reinforced concrete.
69	IS:1786-1985	Specification for High Strength deformed steel bars and wires for concrete reinforcement.
70	IS:432-1982 (Part-I)	Specifications for mild steel and medium tensile steel bars for concrete reinforcement.
71	IS:818-1968	Code of practice for safety and healthy requirement and gas welding and cutting operations.

72	IS:3016-1986	Code of practice for fire precautions in welding and cutting operations.
73	IS:280-1978	Mild Steel wire for general Engineering purpose.
74	IS:2502-1963	Code of practice for bending and fixing of bars for concrete reinforcement.
75	IS:9417-1989	Recommendations for welding cold worked bars for reinforced concrete construction
76	IS:2751-1979	Welding of mild steel plain and deformed bars for reinforced construction.
77	IS :814-1991	Covered electrodes for manual metal arc welding of carbon manganese steel.
78	IS:1278-1972	Filler rods and wires for gas welding.
79	IS:456-1989	Code of practice for plain and reinforced concrete (Second Revision) (Amendment No. 1)
80	IS:3873-1978	Code of practice for laying in-situ cement concrete lining of canals. (First Revision).
81	IS:2505-1980	General requirements for concrete vibrators immersion type.
82	IS:2506-1985	General requirements for screed board concrete vibrators.
83	IS:3366-1965	Specification for Pan vibrators.
84	IS:3558-1983	Code of practice for use of immersion vibrators for consolidating concrete.
85	IS:4558-1983	Code of practice for under drainage of lined canals (First Revision)
86	IS:5256-1968	Code of practice for sealing joints in concrete lining on canals.
87	IS:3085-1965	Methods of test for permeability of cement mortar and concrete.

88	IS:1199-1959	Method of sampling and analysis of concrete.
89	IS:516-1959	Method of tests for strength of concrete (Amendment No. 1)
90	IS:5529-1985 (Part-1 &2)	Code of practice for in-situ permeability test.
91	IS:9103-1979	Specifications for admixtures for concrete.
92	IS:2720-1980 (Part-7)	Methods of test for soils determination of water content-dry density relation using light compaction (Second Revision)
93	IS:1121-1974 (Part-1 to 4)	Methods of test for determination of strength properties of natural building stones.
94	IS:1122-1974	Method of test for determination of true specific gravity of natural building stones.
95	IS:1123-1975	Method of identification of natural building stones.
96	IS:1124-1974	Method of test for determination of water absorption apparent specific gravity and porosity of natural building stones.
97	IS:1125-1974	Method of test for determination of weathering of natural building stones.
98	IS:1126-1974	Method of test for determination of durability of natural building stones.
99	IS:1127-1970	Recommendation for dimensions and workmanship of natural building stones for masonry work.

100	IS:1129-1972	Recommendation of dressing of natural building stone.
101	IS:1542-1977	Specification for sand for plaster.
102	IS:1597-1967 (Part-I & II)	Code of practice for construction of stone masonry. Part-I - Rubble stone masonry Part-II - Ashlar Masonry.
103	IS:1706-1972	Method for determination of resistance to wear by abrasion of natural building stones.
104	IS:2116-1980	Specification for sand for masonry mortars.
105	IS:2250-1981	Code of practice for preparation and use of masonry mortars.
106	IS:4101-1967 (Patrt-I)	Code of practice for external facing and veneers stone masonry.
107	IS:4101-1967	Method of test for determination of water transmission rate by capillary action through natural building stones.
108	IS:4122-1967	Method of test for surface softening of natural building stones by exposure to acidic atmosphere.
109	IS:4348-1973	Method of test for determination of permeability of natural building stones.
110	IS:5218-1969	Method of test for toughness of natural building stones.

111	IS:8381-1977	Recommended practice for quarrying stones for construction purposes.
112	IS:1200-1976 (Part-IV)	Measurement of building and civil engineering works stone masonry.
113	IS:11216-1985	Code of practice for permeability test for masonry (during and after construction)
114	IS:3696-1978 (Part-I)	Safety code of scaffolds and ladders.
115	IS:3696-1991	Safety code of scaffolds and ladders.
116	IS:458-1988	Specifications for concrete pipes with and without reinforcement (Third revision)
117	IS:783-1985	Code of practice for laying of concrete pipes (First Revision).
118	IS:9766-1981	Flexible PVC compounds.
119	IS:6066-1984	Recommendations for pressure grouting of rock foundations in river valley projects (First revision)
120	IS:1838-1983	Specification for preformed fillers for expansion joints in concrete pavements and structures (non-extruding and resilient type) Part-I bitumen impregnated fibre (First Revision).
121	IS:3597-1985	Methods of test for concrete pipes (First revision).
122	IS:5382-1985	Rubber sealing rings for gas mains water mains and sewers (First revision)
123	IS:5751-1969	Pracast coping blocks.

6.2.0. Mechanical

CODE OF PRACTICE FOR MANUFACTURE AND ERECTION OF CREST GATES, STOPLOGS, HOIST GATES, GANTRY CRANES ETC.,

Sl.No.	I.S. Number	Short Title
01	IS : 4622-1967	Fixed wheel gates.
02	IS:875-1964	Code of practice for design manufacutre, erection and testing of Cranes & hoists.
03	IS:3177-1965	Code of practice for design of overhead travelling cranes and grantry cranes.
04	IS:961-1962	Structural steel high tensile.
05	IS:2062-1969	Structural steel (Fusion welding quality).
06	IS:800-1962	Structural steel (Standard quality)
07	IS:1365-1968 (64,67-1967)	Bolts and Washers.
08	IS:2004-1970	Forged steel.
09	IS:210-1970	Cast Iron
10	IS:3016-1965	Fire precautions in welding and cutting operations code of practice.
11	818-1968	Safety and health requirements in electric and gas welding and cutting operations code of practice for.
12	822-1970	Inspection of welds code of procedure for.
13	823-1964	Manual of metal are welding of mild steel -code of practice for.
14	1323-1965	Oxy acetelene welding for structural steel work in mild steel code of practice for.
15	816-1969	Use of metal and welding for construction in mild steel.

16	IS:226-1969	Structural steel
	IS:2069-1969	Guide shoes.
17	IS:1030-1962	Cast steel.
18	IS:1570-1961	Corrosive resistance steel.

PROPERTIES OF ELASTOMER :

	Property	Unit	Test Method, IS specification reference	Value of the charactaristic specified
	1	2	3	4
1.	Physical properties			
1.1	Hardness	IRHD	IS:3400 (Part-II)	60 + 5
1.2	Minimum Tensile Strength	MPa	IS:3400 (Part-I)	17
1.3	Minimum Elongation at break	Percent	IS:3400 (Part-I)	400
2.	Maximum compression set	Percent	IS:3400 (Part-X) duration(H)	Temperature
	Or		+0 to 24.2	(deg c) 100+135
3.	Accelerated Ageing		IS:3400 (Part-X) duration(H)	Temperature
	Or		+70	(deg C) 100+1
3.1	Max Change in Hardness	IRHD		+ 15
3.2	Max change in Tensile Strength	Percent		- 15
3.3	Max change in Elongation	Percent		- 40

6.3.0 QUALITY CONTROL REGISTERS PROFORMAE

FORM NO. 1

REGISTER OF BENCH MARKS

NAME OF WORK :-

Location	Description	Value	Verified by AE/AEE (C) on Date	checked by DEE (C) on Date	Reference to L.F.Book	Remarks	Signature of AE/AEE/DEE (Construction)	Signature of Q C Staff
1	2	3	4	5	6	7	8	9

FORM NO. 2

MARK OUT REGISTER

NAME OF WORK :-

Date	Description of Structure	L.S.	Elevation	Location	Signature of AE/AEE (Constn)	Signature of DEE (Constn)	Signature of EE (Constn)	Signature of Q.C. Staff	Remarks
1	2	3	4	5	6	7	8	9	10

FORM NO. 3

MATERIAL O.K. REGISTER

NAME OF WORK :-

Date	Description of Material	Approximate Quantity	Location	Whether the material is as per specification with result of the analysis with reference to sample in Lab Test Register	Remarks of QC Staff if any when the material is not as per specifications	Compliance of Construction Staff	Signature of AE/AEE DEE (Constn)
1	2	3	4	5	6	7	8

Signature of AE/AEE/DEE (QC Staff)	Remarks
9	10

FORM NO. 4

REGISTER OF FOUNDATIONS

NAME OF WORK :-

Date	Details of area where foundation are proposed				Nature of soilmet with at foundation level	Details of clay layers if any	Details of foundation treatment if any	Details of measuring instruments installed
	L.S.	C.S.		Foundation level				
		U/S	D/S					
1	2	3	4	5	6	7	8	9

Deviations from approved drawings (OR) Specifications if any with authority	SIGNATURES				REMARKS
	AE/AEE DEE (C)	EE (C)	AE/AEE/ DEE (C) EE/QC	SE (C& QC)	
10	11	12	13	14	15

FORM NO. 5

REGISTER OF PLACEMENT FOR CONCRETE

NAME OF WORK :-

Date	Description of C.C.Mix	LOCATION			Foundation level		REFERENCE TO		Whether Final level are as per approved drawings
		L.S.	C.S.		From	To	Approved drawings	Foundation register	
			U.S.	D/S					
1	2	3	4	5	6	7	8	9	10

Whether foundation concrete Surface/ C.S., is cleared and kept ready as per specifications for receiving	Deviations from approved drawings (OR) specification etc, if any with authority	REFERENCE TO		REMARKS OF	
		Reinforcement Register	Item No.1 in material stack file O.K.Register	AE/AEE/DEE OC	EE (Constn)
11	12	13	14	15	16

Compliance reported by AE/AEE/DEE (Constn)	Remarks of S.E. (Q C)	REMARKS OF
17	18	19

FORM NO. 6

REGISTER OF PLACEMENT FOR MASONRY

NAME OF WORK :-

Date	Location of Masonry Work	Elevation		Reference to material stock file O.K.Register	SIGNATURES OF		Remarks of Q C Staff	Compliance report of Construction Staff	Remarks of SE Construction/ Se QC	REMARKS
		From	To		AE/DEE (C)	EE (C)				
1	2	3	4	5	6	7	8	9	10	11

FORM NO. 7

REGISTER OF PLACEMENT FOR REINFORCEMENT

NAME OF WORK :-

SL. No.	Description	Details of RCC Work 1 2 3	Signatures of Construction Staff	REMARKS
1	2	3	4	5
I:	MAIN REINFORCEMENT			
a)	Bar No.			
b)	Dia of Bar			
c)	No. of Bars with spacing.			
d)	No. of welded joints.			
e)	Whether qualified welders have been employed and quality welding work test checked.			
II.	DISTRIBUTION REINFORCEMENT			
a)	Bar No.			
b)	Dia of Bar.			
c)	No. of Bars with spacing			
III.	Whether overlaps are as per specifications.			
iv.	Whether cover is as per specifications.			

FORM NO. 8

REGISTER OF TEST REPORT OF COMPRESSIVE STRENGTH OF CONCRETE SPECIMENS

NAME OF WORK :-

PARTICULARS OF SPECIMEN		Mix Proportion	W.C. Ratio	Slump	Date of casting	Date of testing	Age in Days	COMPRESSIVE STRENGTH Kg/CM²		Required 29 days strength Kg/CM2	REMARKS
Id. NO.	BATCH NO.							Indi-vidual	Average		
1	2	3	4	5	6	7	8	9	10	11	12

FORM NO. 9

NAME OF WORK :- **PLACEMENT REGISTER FOR EMBANKMENT**

Date	ELEVATION		Casing OR Hearting	Location U/S OR D/S	Whether the previous layer is Passed OR not	Reference to embankment test results	OMC FMC	% of Clearance	Whether this layer is passed OR not
	From	To							
1	2	3	4	5	6	7	8	9	10

SIGNATURES OF		REMARKS
Consruction Staff	QC Staff	
11	12	13

FORM NO. 10

GENERAL PLACEMENT REGISTER FOR OTHER ITEMS

NAME OF WORK :-

Date	Chainage		Description of Work	Signatures of Construction Staff.			Signatures of Quality Control staff		Remarks
	From	To		A.E/AEE	Dy.EE	E.E.	A.E/AEE	D.EE	

FORM NO. 11

NAME OF WORK :- **ROLLER PASSES CONTROL REGISTER**

Date	Chainage		Total length to be rolled	Width	No. of passes required with D R R	Roller No.	TIME		SIGNATURE OF		REMARKS
	From	To					From	To	Consruction Staff	QC Staff	
1	2	3	4	5	6	7	8	9	10	11	12

FORM NO. 12

MOISTURE CONTROL REGISTER

NAME OF WORK :-

Date	Chainage		Total length	Quantity of loose earth	In place moisture	O M C	Moisture to be supplemented	% of moisture content before rolling	SIGNATURE OF		REMARKS
	From	To							Construction Staff	Q C Staff	
1	2	3	4	5	6	7	8	9	10	11	12

FORM NO. 13

EMBANKMENT TEST RESULTS REGISTER

NAME OF WORK :-

Date	LOCATION OF TEST PIT			LAB RESULTS			Core cutter No. and weight	Weight of sample with cutter	Netweight of sample
	Chainage	Elevation	Coordinates	OMC	MDD	Lab references			
1	2	3	4	5	6	7	8	9	10

Volume of Core cutter	Wet density	Weight of sampletaken for drying	Weight of dry sample	Weight of water content	% of moisture content	Field dry density	% of compaction
11	12	13	14	15	16	17	18

Type of Roller	No. of Passes	SIGNATURE OF		REMARKS	
		AE/AEE (C)	DEE (C)		
19	20	21	22	23	

FORM NO. 14

SITE ORDER BOOK

NAME OF WORK :-

Date	INSTRUCTIONS OF THE INSPECTING OFFICER
1	2

FORM NO. 15

CEMENT DAY BOOK

NAME OF WORK :-

Sl.No.	Date	Opening Balance	Receipts	Total Receipt	Issues Consumption	Balance	Remarks
1	2	3	4	5	6	7	8

O.K.CARD FOR CAST - INSITU CONCRETE LINING

S. No.	Description	Signatures of Contractor	Signatures of GOAP	Signatures of GOAP	Remarks
1.	DATE :				
2.	LOCATION FROM KM. ______ TO KM. ______ BED SIDE SLOPE LEFT/RIGHT				
3.	PROPORTIONS OF THE MIX				
4.	MATERIALS : (A) COARSE AGGREGATE UNDER/ OVER SIZE, 40M, 20MM, AND 10 MM. (B) FINE AGGREGATE F.M OF SAND (C) CEMENT MAKE/DATE OF Manufacture AND PERCENTAGE USED.				
5.	METHOD OF CONCRETE MIX : (A) MIX-VOL/WEIGHT. (B) BATCHING PLANT BY VOL. WEIGHT.				
6.	TRANSPORT : (A) BY TRANSIT MIXER (B) TEMPERATURE OF CONCRETE SPECIFIED (C) TEMPERATURE OF CONCRETE PLACED				
7.	SLUMPS :- (A) DESIGNING SLUMP (B) AT THE BATCHING PLANT (C) AT THE SITE OF PLACEMENT				
8.	WATER CEMENT RATIO				
9.	METHOD OF CONSOLIDATION SLIP/MECHANICAL VIBRATOR/ SCREENED VIBRATOR.				
10.	WHETHER CONTRCTION/CONSTRUCTION JOINTS ARE PROVIDED AS PER APPROVED DESIGN				
11.	Treatment OF COLD JOINT/JOINTS.				
12.	CURINGS :- WATER CURING/CURING COMPUTE				
13.	QUALITY OF CONCRETE LAID				
14.	NO. OF C.C. CUBES CASTED.				
15.	ANY OTHER REMARKS				

Sign. of Contractor   Sign. of GOAP (CS)   Sign. of GOAP (QCS)

O.K.CARD FOR EARTH WORK EMBANKMENT

S. No.	Description	Signatures of Contractor	G.O.A.P. (C.S)	G.O.A.P. (Q.C.S)	Remarks
1.	DATE				
2.	LOCATION OF WORK FROM KM. _____ TO KM. _____				
3.	ELEVATION (R.L)				
4.	SURFACE PREPARATION, WHETHER AS PER SPECIFICATION.				
5.	TYPE OF ROLLER USED.				
6.	LOCATION OF TEST AT KM. _____				
7.	THICKNESS OF LOOSE LAYER				
8.	INITIAL MOISTURE CONTENT.				
9.	REMOVAL OF OVER SIZE.				
10.	TOP LEVEL AFTER COMPACTION OF LAYER.				
11.	WET DENSITY				
12.	MOISTURE CONTENT IN ROLLED FILL				
13.	DRY DENSITY.				
14.	LABORATORY O.M.C. AND M.D.D.				
15.	COMPACTION EFFICIENCY.				
16.	EMBANKMENT OF INSTRUMENTS DEVICES (IN CASE OF EARCH DAM).				
17.	METHODOLOGY OF ADDITION OF MOISTURE (WHETER THROUGH SPRAY FROM SPRINKLER TANKER)				
18.	MANUAL COMPACTION IF ANY.				
19.	LAYER PASSED.				
20.	ANY OTHER REMARKS				

Sign. of Contractor | Sign. of GOAP (CS) | Sign. of GOAP (QCS)

O.K. CARD FOR GROUTING

Contract No. _____ Chainage of Stucture : _____

Name of contractor : _____

S. No.	Description	Dated Signatures of Contractor	GOAP(C.S)	GOAP (QCS)	Remarks

GENERAL :

1. R.L. AND AREA OF SURFACE TO BE GROUTED.
2. CLASSIFICATION OF THE ROCK STRATA.
3. SALIENT FEATURES OF THE STRATA SUCH AS A FAULT ZONE, CAVITIES, FISSURES ETC.
4. PERMEABILITY VALUE OF THE STRATA BEFORE GROUT.

GROUP :

5. PATTERN OF GROUT ADOPTED
6. DEPTH AND DIAMETER OF THE HOLE
7. PRESSURE ADOPTED FOR GROUT.
8. PROPORTION OF GROUTING MIX.
9. INTAKE OF SLURRY MORTOR PER UNIT AREA PER UNIT TIME
10. TOTAL QUANTITY OF INTAKE
11. FINAL PERMEABILITY VALUE OF THE STRATA, AFTER GROUT.
12. WHETHER THE GROUT STRATA IS O.K.

Sign. of Contractor | Sign. of GOAP (CS) DEE/EE | Sign. of GOAP (QCS) AE/AEE DEE / EE

O.K.CARD FOR STRUCTURAL CONCRETE WORK

S. No.	Description	Signatures of Contractor	G.O.A.P. (CS)	G.O.A.P. (QCS)	Remarks
1.	DATE				
2.	GRADE OF MIX				
3.	LOCATION OF WORK : (A) FOUNDATION (WITH ELEVATION) (B) SUPER STRUCTURE (WITH ELEVATION).				
4.	METHODOLOGY OF PREPARATION OF SURFACE : (A) GREEN CUTTING. (B) SAND BLASTING. (C) HIGH PRESSURE WATER BLASTING.				
5.	MATERIALS : (A) COARSE AGGREGATE UNDER SIZE/OVER SIZE GRADED ANALYSIS. (B) F.M. OF SAND. (C) CEMENT MAKE/DATE. (D) WATER.				
6.	TOOLS AND PLANTS : (A) FORM WORK DETAILS OF SHUTTERING SHOULD BE CHECKED WITH DIMENSION. (B) MIXER (C) VIBRATOR.				
7.	BATCHING				
8.	TEMP. OF CONCRETE SPECIFIED IN TECHNICAL SPECIFICATION.				
9.	TEMP. OF CONCRETE AS PLACED.				
10.	SLUMP : (A) DESIGN SLUMP (B) AT THE BATCHING & MIXING PLANT				
11.	METHOD OF PLACING				
12.	METHOD OF CONSOLIDATION				
13.	WATER CEMENT RATIO				
14.	TREATMENT OF CONSTRUCTION JOINTS.				
15.	EMBEDMENTS				
16.	WATER STOPPER				
17.	CONCRETE FINISH (WOOD FLOAT/STEEL TROWEL)				
18.	QUANTITY OF CONCRETE LAYED.				
19.	NO. OF C.C CUBES CASTED				
20.	CHECKING OF REINFORCEMENT.				
21.	CURING ARRANGEMENTS				
22.	ANY OTHER REMARKS				

Sign. of Contractor | Sign. of GOAP (CS) | Sign. of GOAP (QCS)

EARTH WORK

1) ***Specification Nos provided in the agreement :***

Standard Specifications

APSS

301 - Excavation & Forming uncompacted banks
302 - Embankment compacted by other than power driven Equipment
303 - Embankment compacted by power driven Equipment

MOST (IIIrd Revision)

301 - Excavation for road way and drain
302 - Blasting operations
303 - Presplitting Rock excavation slopes
304 - Excavation for structures
305 - Embankment constructions

308 - Excavations of foundations

2) ***Requirements of soils to be used :***

Name of test	Lab results	Field results	Allowable limits
1	2	3	4
(a) Liquid Limit			Less than 70%
(b) Plasticity Index			Less than 45%
(c) Optimum moisture content			
(d) Max Dry density			

Modified as 35% and 15% in APSHP & APERP Works

3) ***Density requirements :*** (305.2.1.5 of MOST)

a) MDD for Embankment upto 3.0 m height — Not less than 1.52 gr/cc
b) MDD for Embankment more than 3.0 m height — Not less than 1.60 gr/cc
c) MDD for sub grade, earthen shoulders and back fill — Not less than 1.75 gr/cc

4) ***Relative compaction :*** (305.2.2.2 of MOST) Field MDD & moisture content are not be arrived by conducting density test by sand replacement method or core cutter method . The results are to be compared with the Lab Results to satisfy the following requirements.

a) Field MDD not less than 95% of lab MDD for embankment construction
b) Field MDD not less than 97% of lab MDD for embankment construction
c) Moisture content : + 1% to - 2% of OMC (305.3.5.2 of MOST) at the time of compaction

5) **Layer thickness** : Not greater than 200mm thick compacted (305.3.5. of MOST)

6) ***Other points to be verified :***

(a) Measurements: Width and slope length with reference to C.S. Sheets
(b) Size of stones (Coarse material) not greater than 75mm in embankment (305.2.1.4)
(c) Size of stones (Coarse material) not greater than 50mm in sub grade Engineer may permit 2/3 of compacted thickness
(d) Cokls are to be broken to a max size of 75mm(305.3.5.2of MOST)
(e) Whether extra width of 0.6 m on either side for 2,1 Slopes is provided for each layer for trimming (305.3.1)

7) ***Quality Control Equipment :*** (a) Q.C. Equipment available at site office.
(b) Q.C. Equipment available with field officers

8) ***QC Tests to be done :***

1) Sieve Analysis 2) Atterberg's limits 3) Proctor's test to find out OMC and MDD
4) Lab CBR on 4 days soaked samples 5) Field density test to find relative compaction

GRANULAR SUB-BASE/GRAVEL BASE

1) ***Specification Nos provided in the agreement*** .....

Standard Specifications

APSS 138 & 1503 — MOST 401

2) ***Physical Requirements*** : The materials to be used for the work should be natural sand, moorum, gravel, crushed stone or combination there of to satisfy the following requirements

a) The mix should be from the six gradings given in table 400-1 & 400-2of MOST In some special cases modified grading may be used as adopted in some APSHP Works

TABLE 400-1, GRADING FOR CLOSE-GRADED GRANGULAR SUB-BASE MATERIALS

IS Sieve	Per cent by weight passing the IS sieve		
Designation	Grading I	Grading II	Grading III
75.0 mm	100	–	–
53.0 mm	80-100	70-100	–
26.5 mm	55-90	50-80	100
9.50 mm	35-65	40-65	65-95
4.75 mm	25-55	30-50	50-80
2.36 mm	20-40	15-25	30-35
0.425 mm	10-25	15-25	20-35
0.075 mm	3-10	3-10	3-10
CBR Value (Minimum)	30	25	20

TABLE 400-2, GRADING FOR COARSE-GRADED GRANGULAR SUB-BASE MATERIALS

IS Sieve	Per cent by weight passing the IS sieve		
Designation	Grading I	Grading II	Grading III
75.0 mm	100	–	–
53.0 mm		100	
26.5 mm	55-75	50-80	100
9.50 mm			
4.75 mm	10-30	15-35	25-45
2.36 mm			
0.425 mm			
0.075 mm	< 10	< 10	< 10
CBR Value (Minimum)	30	25	20

(b) The materials passing 425microns in the mix should have LL & PI not more than 25% and 6% respectively (APSS 138 specifies even stiffer limits of 20% and 6% respectively)

(c) The mix should produce the required laboratory CBR values on 4 days soaked samples

Requirements of materials be used

Name of test	Lab results	Field results	Allowable limits
1	2	3	4
(a) Liquid Limit			Less than 25
(b) Plasticity Index			Less than 6
(c) Optimum moisture content			
(d) Max Dry density			

Note : None of these requirements are being followed in many cases resulting in premature failure of works. Awareness is to be created in the field officers regarding these requirements. During last 10 to 15 years tests were conducted on many samples received from all over Andhra Pradesh and not one of them satisfied even one of the above 3 requirements. It proves that gravel in its original state is not suitable for use in sub base construction. It is to be mixed with other materials to satisfy the requirements.

3) Some recommended mixes are given below.

a) For CBR of 15%: 70% gravel + 10% of 6mm + 20% stone dust or sand
b) For CBR of 20%: 65% gravel + 5% of 12mm + 10% of 6mm + 20% of stone dust or sand
c) For CBR of 30%: 55% gravel + 15% of 40mm + 10% of 12mm + 20% of stone dust or sand

4) Compacted layer thickness : a) 100mm maximum if smooth wheeled roller is used
b) 225mm maximum if vibratory roller is used

5) Relative compaction :

(a) Field MDD should not be less than 98% of lab MDD determined as per Standard Proctor's compaction test for granular sub base if ordinary roller is used.

(b) Field MDD should not be less than 98% of labd MDD as per modified Proctor's compaction test if vibratory roller is used

6) Moisture content : + 1% to - 2% of OMC at the time of compaction

7) Quality control Equipment : a) Q.C. Equipment available at site office.
b) Q.C. Equipment available with field officers.

8) Q.C. Tests to be done: 1) Sieve Analysis, 2) Atterberg's limits, 3) Proctor's test to find out OMC and MDD, 4) Lab CBR on 4 days soaked samples, 5) Field density test to find relative compaction

9) Items to be verified : 1) Measurements: Width and compacted thickness, 2) Field MDD and moisture content to find relative compaction, 3) Camber and longitudinal undulations (max : 8mm).

WATER BOUND MACADAM SUB-BASE/BASE

1) ***Specification Nos provided in the agreement :***

Standard Specifications

APSS
138, 1501 & 1506 : for single size metal & for graded metal

MOST
404 - for graded metal

2) ***Physical Requirement of coarse aggregates :***

Name of test	Lab results	Field results	Allowable limits
Aggregate Impact Value			30% max for HBG/HBT metal
-do-			40% max for HOG/OTG metal
Flakiness Index			15% maximum
Combined Flakiness and Elongation Index for crushed metal			30% maximum

3) Size of **coarse aggregates (APSS 1501 A)** :

(i) Single of coarse aggregates: 40mm, 65mm & 75mm size

Size of metal	Wholly passing the sieve of size	Wholly retained on the sieve of size
40MM	50MM	25MM
65MM	80MM	50MM
75MM	100MM	63MM

(ii) Grade-I,II,III Coarse aggregates as per MOST Table 400-7

Grading No.	Size Range.	IS Sieve Designation	Percent by Weight passing
1	90 mm to 45 mm	125 mm	100
		90 mm	90-100
		63 mm	25-60
		45 mm	0-15
		22.4 mm	0-5
2	63 mm to 45 mm	90 mm	100
		63 mm	90-100
		53 mm	25-75
		45 mm	0-15
		22.4 mm	0-5
3	53 mm to 22.4 mm	63 mm	100
		53 mm	95-100
		45 mm	65-90
		22.4 mm	0-10
		11.2 mm	0-5

(a) Grading I should be restricted to sub base course only with 100mm compacted thick.
(b) Grading II & III should be 75mm thick compacted layers only.

4) Items to be verified :

a) Measurements : Width and compacted thickness
b) Camber and longitudinal undulations (mzx., 8mm)
c) Weight of metal by digging 0.5m x 0.5m test pit
d) Sieve analysis of the metal to verify the grading
e) Verify whether proper lateral support is provided

MIX SEAL SURFACING

1) ***Specification Number** provided in the agreement :*
***Standard Specifications** MOST: 510*

2) ***Aggregate Gradation.*** The coarse and fine aggregates should be as per Table 500-19

IS Sieve Designation	Per cent by weight passing the IS sieve	
	Type 'A' MSS	Type 'B' MSS
13.2 mm	--	100
11.2 mm	100	88-100
5.6 mm	52-88	31-52
2.8 mm	14-38	5-25
90 mm	0-5	0-5

3) ***Tack Coat with Bituminous emulsion or cutback (Table 500.3 of CLAUSE 503 MOST) :***

On Normal bituminous surfaces 2.0 to 2.5 Kgs/10sq.m
On Dry & hungry surfaces 2.5 to 3.0 Kgs/10sq.m

4) ***Proportioning of materials :***

(a) Total quantity of aggregates used for type A or type B MSS should be 0.27 cum/10Sqm.

(b) The quantity of binder used for premixing should be 22.0 Kgs for type 'A' MSS and 19 Kgs for Type 'B' Mss

OPEN GRADED PREMIX CARPET
500 OF MOST

Aggregates : 0.18 cum of 13.2mm size passing 22.4mm sieve and retained on 11.2mm sieve
0.09 cum of 11.2mm size passing 12.2mm sieve and retained on 5.6mm sieve

Binder : 14.6 kgs of bitumen per 10sqm

5) ***Items to be verified during construction :***
a) Temperature of premix 100° C to 160° C
b) Temperature of bitumen 150° C to 163° C
c) Collection of mix sample for bitumen extraction and sieve analysis
d) Verify whether camber board, thickness planks and straight edge are used

6) ***Items to be verified after construction :***
a) Measurements width and compacted thickness
b) Camber and longitudinal undulations (max : 6mm)
c) Collection of BT sample 15 cm x 15 cm in size for bitumen extraction and sieve analysis

B.T. SURFACE DRESSING/BT. RENEWAL COAT

1) ***Specification Number provided in the agreement :***

Standard Specifications

APSS MOST

15-10 Bituminous surface dressing 20mm with premixed aggregates over WBM or worn out bituminous surfaces.

2) ***Requirements of materials :***

Name of Test	Lab Results	Field Results	Allowable Limits
Sieve analysis			Under Size NILL
Aggregate Impact Value			30% maximum
Flakiness Index			25% maximum

Stone aggregates - 12.5 mm size - 0.27 cum/10sq.m (wholly passing 20mm sieve and wholly

3) ***Binder Content :*** For tack coat - 9.0 kgs over WBM surface
- 6.0 kgs over BT surface

For premixing : 14 kgs of bitumen should be premixed with 0.27 cum (.42 kgs per cu.m. of stone aggregate)

14.6 kgs. Of bitumen as per APSS 1510

4) ***Items to be verified during construction :***
a) Temperature of premix 100° C to 160°C
b) Temperature of bitumen 150° C to 163° C
c) sieve analysis on 12.5mm chips
d) Verify whether camber board, thickness planks and straight edge are used

5) ***Items to be verified after construction :***
a) Measurements width and compacted thickness
b) Camber and longitudinal undulations (max : 6mm)
c) Collection of BT sample 15 cm x 15 cm in size for bitumen extraction and sieve analysis

SEAL COAT WITH PREMIX AGGREGATE

Specification Number APSS 1512
Size of stone aggregates:6.3mm (wholly passing 10mm sieve and wholly retained on 2.36mm sieve)
Quantity of stone aggregates: 0.09 cum/10sqm
Quantity of bitumen: 9.8 kgs/10sqm

Important DOS and DON'Ts in Civil Engineering Works

Cement 1) Cement is to be verified for its grade, week of manufacture and authenticated test certificate before use

Important DOS and DON'Ts in Civil Engineering Works

Cement 1) Cement is to be verified for its grade, week of manufacture and authenticated test certificate before use

2) The grade number (33,43 or 53) is the compressive strength in Mpa (IMPa = 10.21Kg/Sq Cm) of the cement when tested on 70.6mm cubes made of (1:3) cement mortar using fine sand (Enniore type)
3) The same type of materials and cement that are going to be used for controlled concrete work are to be sent for mix design

Water water used for mixing and curing shall be clean and free injurious amounts of oils, acids, alkalis, salts, sugar, organic materials and other substances that may be deleterious to concrete or steel Potable water is generally considered satisfactory for mixing and curing with seawater shall not be permitted

Coarse aggregates All the coarse aggregates shall contim to IS:383 The maximum value of Flakiness index shall not exceed 35%

Sand Sand shall consist of clean, hard, strong particles and shall not contain dust, lumps, soft or flaky materials, mica or other deleterious materials Silt content shall not be more than 4%(APSS) or specified

Fineness modulus shall neither be less than 2.0 nor greater than 3.5(MOST)

Brick work 1) Mortar joint thickness shall not exceed 10 mm in 1st class bricks and 12 mm in 2nd class bricks 2) Bricks shall be tested for size, shape, crushing strength (shall not be less than 35 Kgs/Sqcm for ordinary bricks) and water absorption(shall be less than 20%) 3) Bricks shall be soaked at least for 1 hour before use

Stone masonry 1) Bond : A stone in any course shall over lap the stone in the course below, ie Joints parallel to the pressure in two adjoining courses shall not lie too closely in the same vertical line
2) Bond stones shall be built in the wall at intervals of 2M in length and 0.6M in height and shall run through the wall if the wall is not more than 600 mm in thickness. If the wall is more than 600 mm thick a line of headers shall be laid from face to back, each header overlapping the other buy at least 150 MM The bond stones shall be clearly marked on both the faces.

BUILDINGS

1) Check the orientation of the building as per site plan.

2) Check the S.B.C. of soils as assumed actually existiong Excavate upto the depth where desired S.B.C. of the soils are met with Check for other types of soil strata, which may be met with for a part of the building.

3) Check the R.C.C. Designs well in advance. Note the correct orientation of columns and direction of reinforcement before casting footings. Consult the design office if necessary.

4) Detailing of reinforcement is very essential. Check for correct anchorages, laps, continution of reinforcement of the other spans.

5) To maintain uniform cover,cast briquetters well in advance so that they gain strength and do not get crushed under reinforcement while concreting.

6) Becareful about the positioning of reinforcement in cantilevers and chezzas. Check for sufficient anchorage. Do not remove shuttering until sufficient counter balancing load is available. Reinforcement is to be kept at top in cantilever portions

7) In long continuous chezzas and cantilever,it is better to give expansion joints of 20 to 25 mm at a spacing of about 6 meters. So also at corners.

8) Plan for expansion joints well in advance. Similarly chalk out concreting schedule, with understanding where to stop and where to give a construction joint

9) Rise the brickwork, uniformly, check whether jambs can take the load or C.C. jambs are required

10) Give bearing plaster and kraft paper underneath the slabs giving them freedom to slide. Otherwise they may pull the top layers of brick, thus giving rise to cracks.

11) If under-reamed piles are cast in expansive soils, check for proper under reams. Test sample piles for their strength by a load test.

12) Provide air gap under plinth/grid beams in all expansive soils. No provision of air gap may result in cracks at a later date.

13) Provision of dripmould at the free ends of chezzas and canopies arrest creepage of water along the bottom of such projections. Do not forget this functional requirement.

14) Provision of dripmould at the free ends of chezzas and canopies arrest creepage of water along the bottom of such projections. Do not forget this functional requirement.

15) Maintaining verticality of columns, walls, Door frames, window frames etc., require meticulous attention.

16) The joints in brick work or stone masonry are to be raked up to give the required grip to plastering. This can best be done when the mortar is still green.

17) The plastering and finishing are to be done to get a plane vertical surface, true to plumb line.

18) Have a concept of the structural and functional requirement of various elements in a building. Go through the specifications thoroughly. There is no alternative for good quality work to enhance the useful life and serviceability of the building. Think how the various elements of the building constructed will behave and function after use, say for 10 years.

19) The most neglected part for a masonry, plastering ect. is curing. It is not the R.C.C. work alone that needs curing. Masonry and plasterings etc. Also need effective and continuous curing for the required period.

20. Make sure that the slabs laid are leak proof Agreements stipulate ponding of water for 15 Cms depth over roof slabs for 7 days and observe for leakages.

21. Another point requiring attention is refilling in basement. This requires thorough watering and ramming, worth going for Mechanical consolidation equipment such as frog rammers or pan type compactors Give proper slopes for wash/rain water to flow Do not give slopes from lavatories to bedrooms, verandahs to rooms.

22. It is better to provide grooves at the junctions of two dissimilar materials having different expansion properties, such as at junction of R.C.C. columns and brick work to localize cracks if any. A small gap between the beam bottom and panel brick wall may be preferable, for non load bearing walls.

BRIDGES

1. General considerations :-

1. The alignment of piers and abutments shall as far as possible be parallel to the mean direction of flow in the stream for all types of bridges, ie normal, skew and curved bridges.

2. For a bridge on a horizontal curve the road way width shall be increased by an amount not less than that required by the relevant road standards.

3. The superelevation of the road surface on a horizontal curve shall be provided in accordance with the IRC Standards.

4. Railings for submergible bridges shall be either collapsible or removable.

5. For culverts the parapets shall be with a minimum height of 300mm above the road surface.

6. It is preferable to provide Guide posts for vented causeways.

II **Plain and Reinforced** cement concrete for structures :

a) **Admixures** : No materials other than the essential ingredients, ie., cement, aggregates and water, ordinarily be used in the manufacture of concrete or mortar. But the Engineer - in - Charge may permit the use of approved admixtures for imparting special characteristics to the concrete, on satisfactory evidence that its use does not in any way adversely affect the properties of concrete particularly its strength, volume changes, durability and has no deleterious effect on the reinforcement.

b) **Controlled concrete** :

i) In proportioning concrete, the quantity of both cement and aggregate shall be determined by weight.

It is most important to keep the water cement ratio constant and at its correct value.

ii) Minimum quantity of cement to be used in controlled concrete shall not be less than 210 Kg. per cubic metre in plain concrete and not less than 300 kg per cubic meter in reinforced concrete structural members.

c) **Ordinary** concrete :

i) The ordinary concrete mix shall generally be specified by volume.

ii) While measuring aggregate by volume, shaking, ramming or hammering shall not be done proportioning of sand shall be as per its dry volume and in case it is damp, allowance for 'bulking' shall be made as per IS 2386 (Part III)

d) **Quantity of of water** : The quantity of water shall just be sufficent to produce a dense concrete of required workability for the job. An accurate and strict control shall be kept on the quantity of mixing water.

e) **Mixing concrete** : Mixing shall be done at least for 2 minutes after all ingredients have been put into the mixer.

f) **Placing and compaction** of concrete

i) Except where agreed to by the Engineer-In-Charge concrete shall be deposited in horizontal layers to a compacted depth of not more than 0.45 metre where internal vibrators are used, and not exceeding 0.3 metre in all other cases.

ii) Concrete shall not be dropped into place from a height exceeding 1.50 meters.

iii) Concrete shall be compacted in its final position within 30 minutes of its discharge from the mixer when transit mixers are not used.

g) **Curing of concrete** :

Concrete shall be kept continuously wet for a period of not less than 14 days.

III STEEL REINFORCEMENT FOR STRUCTURES :

a) All stel shall be procured from original produce, none-rolled steel shall be used.

b) Bars shall be bent cold to the specified shape and dimensions.

c) Bars shall not be bent or straightened in a manner that will injure the material.

d) All reinforcing bars shall be accurately placed in exact position shown on the drawings, and shall be securely held in position during placing of concrete by annealed binding wire not less than 1 mm in size and conforming to IS : 280.

e) As far as possible bars of full length shall be used, In case this is not possible, overlapping of bars shall be done as directed by the Engineer-in-Charge. When practicable, overlapping bars shall not touch each other, but be kept a part by 25 mm or 1 1/4 times the maximum size of the coarse aggregate whichever is greater for concreting between them. Where not feasible, overlapping bars shall be bound with annealed steel wire, not less than 1 mm thick twisted tight.

The overlaps shall be staggered for different bars and located at points, along the span where neither shear nor bending moment is maximum.

f) Joints of reinforcement bars shall not be welded when standard drawings are adopted for the decking.

FORM WORK

workmanship The form work shall be robust and strong and joints be leakproof Close watch shall be maintained to check for settlement of form work during concreting. Any settlement of form work during concreting shall be promptly rectified

Reuse of form work When form work is dismantled and before reuse all components shall be cleaned of deposits of soil, concrete or other unwanted materials. All bent steel props shall be straightened before reuse and the maximum deviation from straightness is 1/600 of the length.

finishing immediately after the removal of forms, exposed bars or bolts, if any, shall be cut inside the concrete member to a depth of at least 50 mm below the surface of the concrete and the resulting holes filled with cement mortar.

All other holes and depressions, honeycomb spots, broken edges or corners and other defects, shall be thoroughly cleaned, saturated with water, and carefully pointed and rendered true with mortar of cement and fine aggregate mixed in the proportions used in the grade of concrete.

ROADS.

Earth work Normally embankment formation, sub grade and shoulder construction are to be done with reduced borrow earth to suit the requirements shown in the sketch. In many cases the requirements of MDD, relative compaction and maximum layer thickness etc. are not being followed.

Following are some important tips to be followed.

1. Selection of borrow source is very important. Borrow pits along the roadside destabilizes road formation. The borrow soil shall satisfy the requirements shown in the sketch.
2. The maximum layer thickness of each layer shall not exceed 200 mm (Compacted)
3. Each layer is to be sectioned to have required cross fall after the clods are broken, stones larger than 75 MM are removed and watered to maintain water content around O.M.C (+1% or - 2% of OMC) before taking up rolling with appropriate machinery.
4. Subsequent layer shall be allowed only after the desired relative compaction is achieved.
5. In case of widening the formation, benching is to be resorted to for joining the old formation with the new portions.
6. Sufficient extra width is to provided in each layer to have proper compaction in the edges also.

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MINUTES OF THE STATE LEVEL COMMITTEE

1. Govt. in G.O.Ms.No.274 dt. 23-3-1999 accorded administrative approval for Rs.33.00 Crores for restoration of Krishna River flood banks in both krishna and Guntur Dists.

2. Technical clearance was accorded by the committee for Rs.17.36 Crores under priority I leaving a balance of Rs.15.64 Cross for formation of roads of Krishna river flood banks.

3. The State Level Committee in the minutes of the meeting held on 8-1-2000 agreed for formation of WBM road with B.T. with the specifications of sealing coat (6 mm) black topping (20 mm), 100 mm thick 40 mm metal consolidated to 75 mm, 100 mm thick 65 mm metal consolidated to 75 mm and 225 mm thick gravel consolidated to 150 mm.

4. The S.L.C. in the meeting held on 7-9-2000 has cleared the road works by providing inspection inspection path with quarry rubbish on DLF and DRF banks. The works were also approved by world Bank.

5. The estimates on DLF & DRF bank by providing inspection path with quarry rubbish were sanctioned by the Superintending Engineer, Irrigation Circle, Vijayawada and are nearing completion.

6. The Chief Engineer, CDO in Endt. No.Admn./2301/DC/2001 dt.26-5-2001 communicated his inspection notes dt. 26.26-5-2001 on the works of Krishna river flood banks.

The Chief Engineer, CDO. in his report, reported that the Divisoft flood bank works are inspected and the quarry rubbish being used as proposed over the existing bank. A core test by sand replacement method was conducted at Km.6.050 at a point located 0.30 m away from centre towards right and the proctor's density in found to be 91.65%.

Further the quarry rubbish partly spread and stacked at km.9.100 was verified and it is pointed out that the quarry rubbish consists of stone matrix and the size of the stones is found as large as 0.3 m x 0.03 x 0.3 as against the compacted layer thickness from 200 mm to 150 mm using compaction by 8 to 10 T rikker. The layer that was compacted, consists stones of even upto a depth of 150 mm. It is necessary that the specification of quarry rubbish be drawn as it is leading to dumping of larger size of stones, it is quite likely that upon the onset of monsoon, the road is likely to be damaged leading only the spells and it is necessary to spcify/the grain size distribution for the material to be used and suggested to refer the matter to the committee.

7. In this connection the Superintending Engineer has been instructed vide this office Memo. dt.1-6-2001 to rectify the defects as pointed by Chief Engineer, C.D.O. and payments to be released only after rectification.

8. It necessary to specify the specifications to quarry rubbish as pointed out by Chief Engineer, C.D.O.

As per specification No.1506 as per APDSS for WBM roads the grading requirements of coarse aggregate is given as below.

(Contd...2)

size Range	Sieve designation	Percent by weight passing the sieve
63 mm to 40 mm	90 mm	100
	63 mm	90-100
	50 mm	35-70
	40 mm	0-15
	20 mm	0-5

and for filling material, to the voids, the single size agreegate shall be used to fill the voids.

As per Indian practical Civil Engineer's hand Book the typical grading limits for Soil - Agreegate Mixtures is shown below.

Typical Grading Limits for Sil-aggregate Mixtures

Sieve designation	80 mm	Normal 40 mm	Maximum 20 mm	Size of Material 10 mm	5 mm
			Percent by weight Passing the sieve		
80 mm	100	-	-		
40 mm	80-100	100	-		
20 mm	60-80	80-100	-		
10 mm	45-65	55-80	80-100	100	-
4.75 mm	30-50	40-60	5-75	80-100	100
2.36 mm	-	30-50	35-60	50-80	80-100
1.18 mm	-	-	-	40-65	50-80
800 micron	10-30	15-30	15-35	-	30-60
300 micron	-	-	29-40	20-45	
75 micron	5-15	5-15	5-15	10-25	10-25
IRC : 63-1976	Suitable for Base Courses			Suitable both for Base and Surfacing	

Not less than 10% should be retained between each pair of successive sieves specified for use except for the larger pair.

Application of binding material may not be necessary where the screening consists of crushable type materials like moorum, laterite or soft gravel.

If the above proportions are adopted to quarry rubbish then the following can be specified.

Formation of road on the flood banks using quarry rubbish having 70% to 50% of coarse fraction of size Passing 65 mm and retained in on 4.75 mm IS sieve' and 30% to 50% fine rubbish passing 4.75 mm and retained on 75 micron (0.075) mm) to form quarry rubbish road of loose 200 mm compacted to 150 mm. with 8 to 10 tonne power roller.

A rough test for finding, if the consolidation has been fully done is: A Piece of about 25 mm stone is put on the consolidated surface and roller passed over it. It will be driven in if the consolidation is incomplete. Or, a fully loaded bullock cart (not of the heaviest type with iron - tyred wheels) going over it makes no impression.

FIELD / TEST

Based on the specific gravity of coarser and final fraction of the quarry rubbish, the yield per cum. of the finished road surfact may be computed and checked in the field for its conformation.

The comments of Chief Engineer, Central Designs Organisation are incorporated.

1. The maximum size of the stone/spalls in the quarry rubbish may be limited to 100 mm only, the quarry rubbish may be spread in position and the stone/spalls above 100 mm size may be pickedup and removed from the quarry rubbish and compacted to required thickness.

2. The quarry rubbish path should be protected suitably on shoulders against flow of quarry rubbish, besides the field test done.

sd/-
P.Sitapathi Rao
Chairman

Sd/-
B.P.Venkateswarlu
Member & Convener

sd/-
Routhu Satyanarayana
CO-opted Member

sd/-
Routh. Satyanarayana
Chief Engineer : CDO

for Chief Engineer : Major Irrigation & FC

Office of the Engineer-in-Chief (R&B) Roads,
Errum Manzil, A.P., Hyderabad - 500 082.

Circular Memo no. 7440/TEC/TA.15/AE.4?96-97. Date : 24-01-2000

Sub :- Quantitave Analysis of Road metal used for WBM layers - Reg.

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The main base course in construction of roads is Water Bound macadam in the State and the Country in general. The main materials in W.B.M. is road metal and the use of correct quantities of Road Metal per the specifications, has to be ensured. To achieve this A.P.D.S.S. specified pre-measurements of road metal by stancking the metal collected at road site. M.O.S.T. and World Bank, specifications specify recording initial and final levels of each W.B.M. layer to ensure that the correct quantum of road metal has gone into the work.

Not withstanding this standard procedures prescribed, the Advisor, Quality Control to the Hon'ble Chief Minister has started quantifying the road metal used by evaluating the weight of metal in a standard size pit dug into the W.B.M. layer. There is no such test specified into the Quality Control manuals or guidelines issued either in the State or by the Ministry of Surface Transport.

There are a number of variable to be considered to correctly assess the quantum of road metal obtained form a specified area of the W.B.M. layer. It is highly difficult to accurately standardize this quantum.

1. The Bulk density of road metal used varies from quarry to quarry and from Grade to Grade and even within the same grades. State-wide observations from a number of quarries of M.B.G road metal for Gr. II and Gr. III. indicate the Bulk density varying from 1250 Kg. To 1450 Kgs. per Cu.M.

2. The angular edges of road metal get crushed during compation with power roller and these chipings, depend on the impact value of the road metal used. These chippings cannot be recovered while recovering the Road Metal from the excavated pit.

3. The spreading of metal and gravel is done manually and hence there is a likely hood of some variation in the thickness layer obtained.

4. The pit cannot be excavated to the correct dimensions as each stone is interlocked with the adjecent stones.

Keeping all these factors in view and after observing number of tests conducted by various Quality Control Divisions and other field Executive Engineers. The following general guideline, are issued.

i. The bulk density of the particular Gradeof metal used on the road for W.B.M. layer has to be measured and recorded in the M.Book.

ii. Due to crushing of edges and corries while rolling approximately 10% loss in weight is allowed.

iii. Due to variation in the dimensions of the pit excavated on a conservative side+5% is allowed.

Summing up the weight of Road Metal that has to be used in a standard layer of 100 m/75 mm Grade.II W.B.M. layer has to be worked out taking bulk density of the metal used. As an example.

let the Bulk density be = 1350 kgs/cum.

Then the quantity of Gr.II metal=0.25x0.10

Actual used in a standard W.B.M.

Layer of area 0.25 sqm. = 0.025 Cu.M.

Weight of this quantity of metal=1350x0.025=33.75 Kgs.

let us call this "W"

Considering the losses as enumerated from (i) to (iii) above the weight of metal that can be recovered from the standard pit of 0.25 sq.m.is

$$W - \frac{10\ W}{100} + \frac{5\ W}{100}$$

= 0.85 W to 0.95 W.

As explained above, all the Superintending Engineers and Executive (R&B) are requested to ensure that the correct quantity of Road Metal is used in W.B.M. consolidation and the recovery of Road Metal from the Standard pit of 0.5 X 0.5 size to be in the range of 0.85 W to 0.95 W.

GOVERNMENT OF ANDHRA PRADESH

Office of the Chief Engineer (W&ES) P.R.Hyderabad

Cir. Memo No. W&ES iii/P12/QC&V/ATP/473/20co Dt. 27-03-200.

Sub: Panchayati Raj Engineering Department - Quantitative analysis of road metal used for WBM layers - Instructions issued - Regarding

Ref : 1. S.E., P.R., Anantapur Lr.No.Ar.2/Roads/9 Dt.10-02-2000 2. Govt. Memo No. 42243/Estt. (i) 99-02-2000

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In Panchayati Raj Engineering Department most of the roads are brought to WBM Standards to make them all wedather roads. Seven Instructions were issued in the past to construct WDM roads to the standards laid down in the APDSS. Howeve it is observed, of late, that there is over size in the material collected and short collection of the metal. To prevent this the following instructions are issued.

1. The tests specified in the APDSS to determine the suitability of the road metal should be conducted at regular intervals and a register shall be maintained at site duly incorporating the test results. The material which is found substandard shall be rejected.

2. The Superintending Engineers/Executive Engineers should frequently inspect the work as per the circular instructions given in the Govt. Memo in the reference 2 nd cited.

3. The Superintending Engineers Executive Engineers should checkmeasure and supercheckmeasure the work as per circular instructions given in the Govt. Memo in the refese 2nd cited.

4. Further to ensure the corrct quantity of of metal has gone into the compacted layer an area of 0.50MX0.50M of full depth of road shall be cut open and the weight of the metal shall be determined accurately and it shall not be less than the following.

   a. For 133 mm loose compacted to 100 mm thick.

   i) Volume of loose metal = 0.50X0.50X0.133=0.03325 Cum

   ii) Average unit weight of granite = 1400 Kg/ Cum

   (as per IRC paper no. 6)

   iii) Weight of metal = 46.55 Kgs

iv) tolarence allowable towards crushing of metal edges during power roller compaction and in accerate excavation of pit and collection of metal = 10%

v) Weight of the metal collected shall be = 90% of the Weight of loose metal = 0.90X46.55 Kgs= 41.895 Kgs or say 41.90 Kgs.

b. For 100 mm loose compacted to 75 mm thick.

i) Volume of loose metal = 0.50X0.50X0.100=0.025 Cum

ii) Average unit weight of granite = 1400 /Cum

(as per IRC paper no. 6)

iii) Weight of metal = 35.00 Kgs.

iv) Tolarence allowable towards crushing of metal edges during power roller compation and in accurate excavation of pit and collection of metal = 10%

v) Weight of the metal collection shall be = 90% of the Weight of loose metal = 0.90x35.00Kgs=1.50 Kgs.

A copy of the Government memo in the reference 2nd cited above is here with communicated to all the Superintending Engineer's Panchayati Raj in the state with instructions to follow the same with cut any deviation.

Encl : As above.

Sd/-PRama Krishnaiah
Chief Engineer (W&ES)
Panchayati Raj, Hyderabad.

To
All the Superintending Engineers, Panchayat Raj in the state
Copy to the Engineer-in-Chief, Panchayati Raj, Hyderabad for favour of information.