Andhra Pradesh Community Based Tank Management Project

OPERATIONAL MANUAL

Volume – VI of VI

Quality Control Manual

28th February, 2007

Irrigation & CAD Department
Government of Andhra Pradesh

OPERATIONAL MANUALS

VOLUME	**I**	**WUA OPERATIONAL MANUAL**
	II	**SUPPORT ORGANIZATION MANUAL**
	III	**FINANCIAL MANUAL**
	IV	**PROCUREMENT MANUAL**
	V	**TECHNICAL MANUAL**
	VI	**QUALITY CONTROL MANUAL**

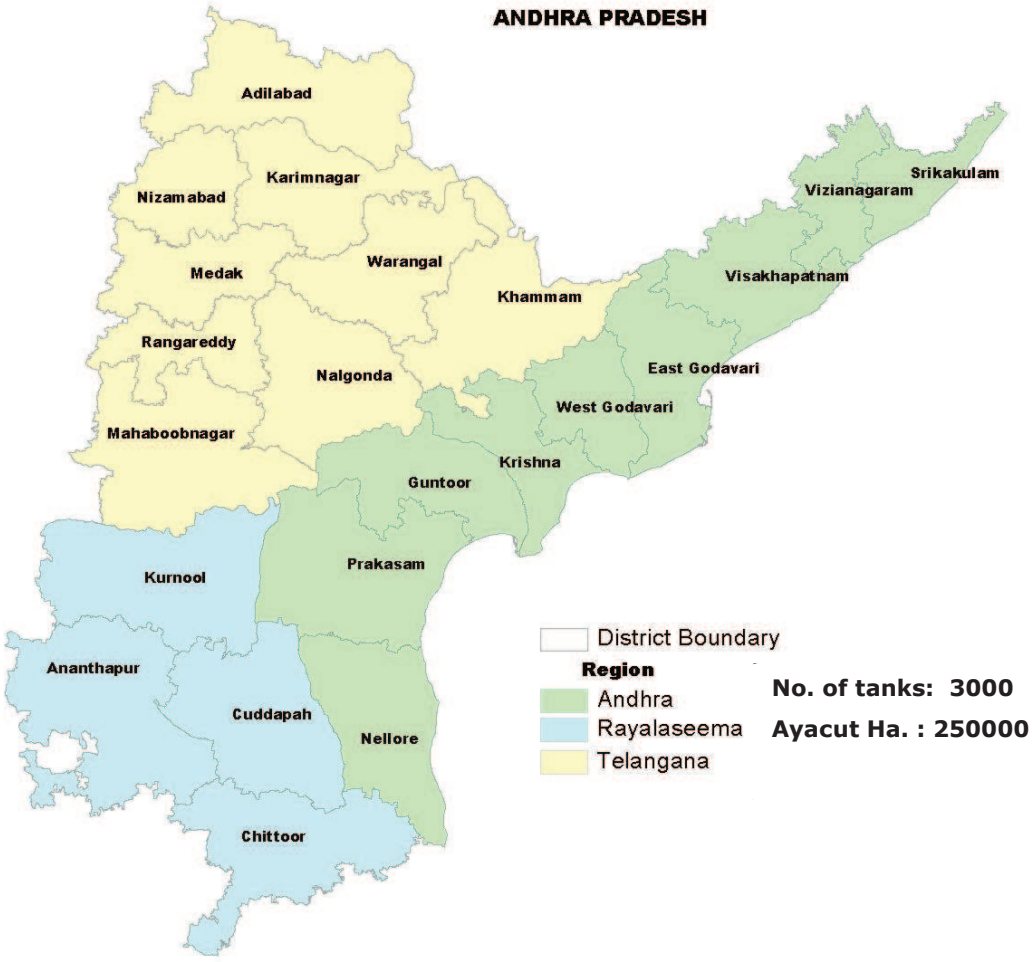
Foreword

The Government of Andhra Pradesh has initiated the process of providing substantive and enabling role to farmers benefiting from irrigation projects for management, operation and maintenance of the irrigation infrastructure by enacting the APFMIS Act, 1997. Following this, I&CAD Department has carried out minimum rehabilitation of the M.I tanks through Water User Associations. Performance evaluation of the WUAs highlighted the need for investment in institution building to enable WUAs to take up irrigation system management responsibilities. This has now been initiated in the I&CAD Department as part of the ongoing sector reforms process under the flagship of "Jalayagnam" programme of Government of Andhra Pradesh in tune with the Mid-Term Appraisal of the X Plan and observation of the Sub-Group on Agriculture and Irrigation of the National Development Council.

I&CAD Department is already implementing a project on "Repair, Renovation and Restoration of water bodies directly linked to Agriculture" with assistance from Government of India in the districts of Ananthapur and Mahaboobnagar. I&CAD Department has developed a step-by-step process guideline towards scaling up of the above programme to benefit 2.5 lakh ha under 3000 tanks at an estimated cost of Rs. 1000 crores with financial assistance from the World Bank and the Government of India under the **AP Community Based Tank Management Project.** This restoration work is proposed to be undertaken in three batches over a period of next five years.

The Project Implementation Plan has been prepared to act as a guiding document, describing the activities of the project on spatial and temporal scale. In addition, a set of six Operational Manuals on various components have also been prepared to steer the project stakeholders in effective implementation of the project. Present volume is one of the series of these six manuals. Though sufficient care is taken to avoid any contradiction with the existing provisions, however in cases of any ambiguity or contradiction, the existing statutes and government orders would prevail. We welcome any suggestions for further modifications and improvement.

Commissioner,
Irrigation & CAD Department
Government of Andhra Pradesh


ANDHRA PRADESH
Adilabad
Karimnagar
Nizamabad
Medak
Warangal
Khammam
Rangareddy
Nalgonda
Mahaboobnagar
Srikakulam
Vizianagaram
Visakhapatnam
East Godavari
West Godavari
Krishna
Guntoor
Prakasam
Kurnool
Ananthapur
Cuddapah
Nellore
Chittoor
District Boundary
Region
Andhra
Rayalaseema
Telangana
No. of tanks: 3000
Ayacut Ha. : 250000

PREFACE

In terms of the conditions laid down by World Bank, a manual of Quality Control for A.P. Community Based Tank Management Project is prepared in order to have uniform procedure and testing methods of Quality Control Management.

The manual is approved and released by the Chief Engineer, Minor Irrigation for systematic and strict implementation by all construction staff and Quality Control Staff of Minor Irrigation Department.

Chief Engineer
Minor Irrigation

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CHAPTER – I
Quality Assurance And Control

1.1 Objectives of Scope of Quality Control:

The objective of quality control management is to collect, process and then communicate the data related to the quality of inputs and outputs as well as finished item of work to those who are responsible for the quality. Any programme of quality control seeks to ensure adequacy and uniformity of quality through the following operations.

a) Inspection of storage, handling and processing facilities for all materials in conformity with accepted or specified practice.
b) Monitoring the variation in specification of the materials and quantities used in the operation of production and in the final product by suitable observation, measurements or tests.
c) Analysis of the observed variations by statistical or other techniques.
d) Feed-back of the results of analysis for exercise of control at each stage and to take corrective steps for maintaining the variations within specified limits.
e) Indicating expeditiously the possible remedial measures, if specifications are not likely to be met.
f) Rejecting, where warranted, the material or the product at any intermediate or final stage in case acceptance criteria is not satisfied.

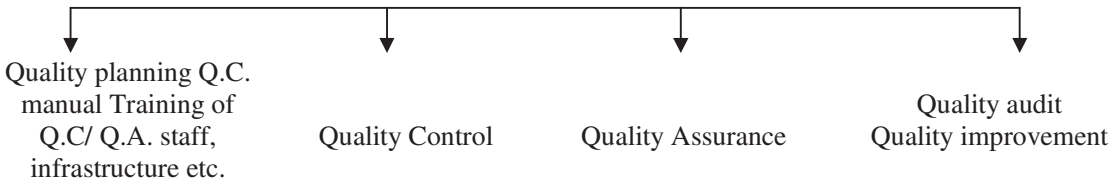
1.2 To maintain uniformity in setting up the standards, it becomes more imperative to have a Quality Control organization covering all the Engineering Departments of the State Viz., I & CAD., R & B and Public Health Department, it is also noticed that, not much emphasis is generally is laid on the Q.C. and Q.A. aspects in almost all the Engineering Departments of the State as compared with the construction activities.

To achieve the above objective, Engineers who are sincere, hard working, experienced and specially connected with quality control works with adequate knowledge of testing of construction materials have to be enlisted from all the departments. Special pay is to be given to attract best personnel.

The Quality Control is to be exercised at various stages of works, like.

a) Selection of material
b) Testing of material
c) Procuring material
d) Checking of pre and final levels.
e) General supervision of works.
f) Checking the properties of final products.

CONFIGURATION OF QUALITY MANAGEMENT SYSTEM



1.3 Quality Control (Q.C):
The operational techniques and activities that are used to fulfill the requirements for quality.

1.4 Quality Assurance (Q.A):
All the planned and systematic activities implemented within the quality system and demonstrated as needed to provide adequate confidence that an entity will fulfill requirements for quality and making sure that the quality of a product is what is should be.

Purpose of Quality Assurance is to prevent problems before they occur to identify and correct them swiftly if they occur, and to uncover root cause.

1.5 Quality Management:
All activities of the overall management function that determine the quality policy, objectives and responsibilities, and implement them by means such as Quality planning, Quality Control, Quality Assurance and Quality Improvement within the quality system.

1.6 Co-ordinations:

a) The construction staff and quality control staff must act in tandem as a single unit to achieve finished product of good quality and construction as per standard specifications.
b) Construction staff should make it a point to inform the quality control staff, the date of starting of any component of the work well in advance so as to enable the quality control staff to schedule their plan of inspection and attend that particular work on that particular date.
c) In turn, quality control staff should programme their itinerary so as to attend the work on the dates required by the construction staff and ensure that, the progress of work is not hampered.
d) The construction staff shall be responsible for exercising the various field checks with reference to drawing and specification laid down in respective I.S. codes and agreements etc., during the construction and carrying out all the tests required on materials used in construction, and on the finished work, and recording the data and results in the field registers.
e) The agency shall be made responsible to provide equipment for all the field tests to be conducted on the work. The equipment has to be made invariably available for all the testing of Q.C. and construction wings.
f) The quality control staff shall also posses the required equipment and conduct the field tests to check the quality of input materials and finished product and pass their remarks in the placement Registers. Defects, if any, noticed by the quality control staff during their course of inspection shall be brought to the notice of the construction staff then and there. It is the duty of the construction staff to attend to the rectification and maintain specifications as pointed out by their counter parts in the quality control organization.
g) As far as possible the defects are to be rectified in the presence of the quality control staff and the payment shall be effected only after the quality control staff has fully satisfied with the rectification and quality of work. Any rectification done subsequently without, any intimation and verification of quality control staff shall be at the sole responsibility of the construction staff.
h) The Quality control staff cannot supervise the placement of concrete or mortar on a mix to mix basis continuously. They can only conduct random check. It is the primary responsibility of the construction staff to ensure adequate supervision of mix to mix placement of concrete or mortar.
i) The operations of the Quality Control staff shall neither interfere in any way, with the executive powers vested nor diminish the responsibility of the officers in charge of execution. The field officers in charge of works are primary responsible for the quality of all works and to carryout the work as per the technical specifications.

j) In case of difference of opinion between quality control staff and construction staff, it should be sorted out by way of discussions in a friendly atmosphere with mutual trust as the following guidelines indicate.

k) Where the objection raised by the section officers of quality control is not acceptable to his counter part of the construction unit, Dy.Exe. Engineer of construction shall discuss with his counter part of quality control to see the objection. If they fail to arrive at a solution, the matter may be reported to the Executive Engineer, in charge for execution and Quality. In case Executive Engineer, Quality Control is unable to settle the issue or dispute he would refer to Superintending Engineer to settle the issue.

l) Disciplinary action shall be taken against the staff concerned, who frequently violate the above norms and appropriate measures taken, against the contractor to rectify unacceptable work at contractors cost.

CHAPTER – 2

ORGANIZATION SET UP

2.1 General:

a) Anyone connected with quality control work should possess adequate knowledge and experience of quality control works and be conversant with general testing of construction materials. The object of quality control should be clearly understood by them in letter and spirit so as to help in construction and achieve high order of quality as laid down in specifications for works by controlling various factors responsible for deterioration in quality investigating reasons therefore and suggesting ways and means for improvement and not to hinder the progress.

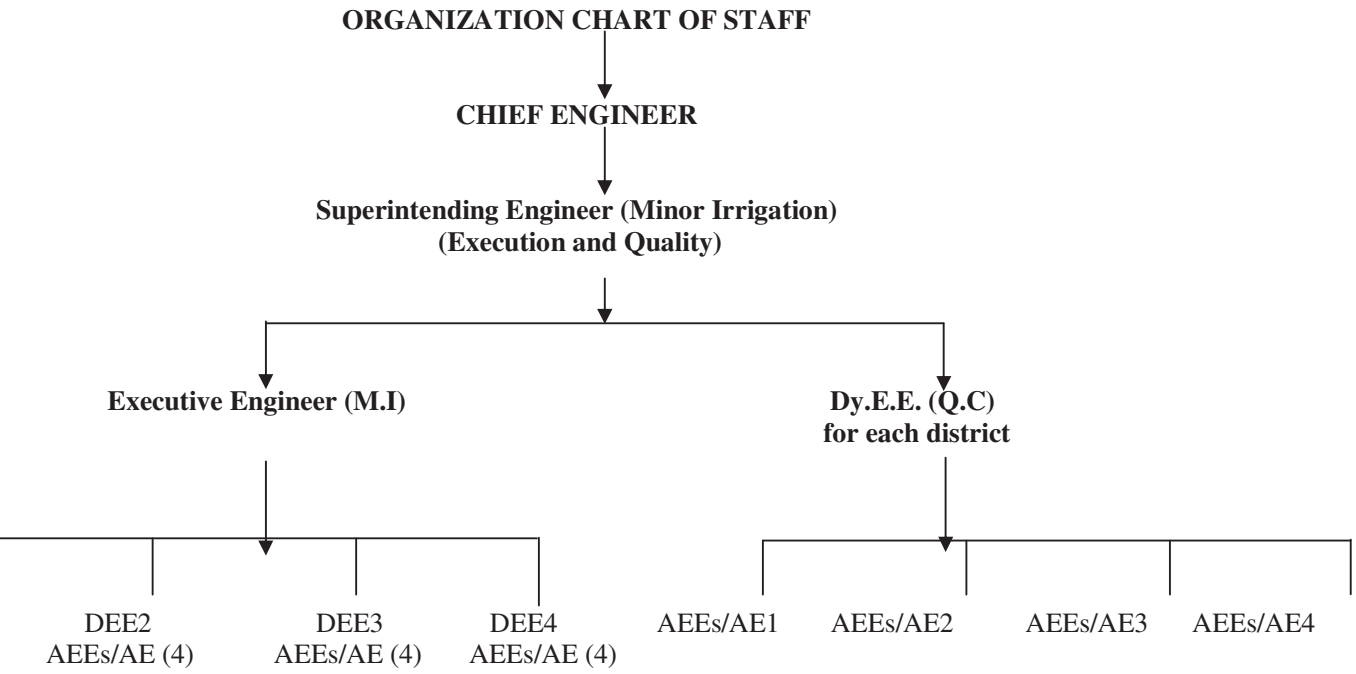
b) To have proper control quality control setup shall consist of one sub- div with 4 AE's/AEE's for each district under the Superintending Engineer in charge for execution and quality control and he will be vested with full powers in regard to quality assurance, quality control and quality audit. The Superintending Engineer will be under the control of Chief Engineer Minor Irrigation.

c) One exclusive Sub-Division will be put for each district under the Superintending Engineer who is in charge for quality control to have effective quality control.

d) Quality control Sub- Division headed by the Dy. Executive Engineer entrusted with quality control works will have four AE's/AEE's and shall be provided with necessary field testing equipment for conducting field tests as may be necessary.

e) There are number of level II Labs and field labs in the major Project areas available for conducting tests for soils, materials and steel. In addition to these Laboratories the A.P.E.R.L as a main Level-I Laboratory at Hyderabad can be utilized for the tests for the purpose. As on to day many Engineering colleges are available in every district, who can conduct the requisite test for the works to be executed, whenever required.

f) One filed level III lab preferably at district head quarters shall be formed utilizing any of the existing buildings with basic equipment essential for the tests involved in these works. This lab can be upgraded and utilized for all other works of the circle.


ORGANIZATION CHART OF STAFF
CHIEF ENGINEER
Superintending Engineer (Minor Irrigation)
(Execution and Quality)
Executive Engineer (M.I)
Dy.E.E. (Q.C)
for each district
DEE2
AEEs/AE (4)
DEE3
AEEs/AE (4)
DEE4
AEEs/AE (4)
AEEs/AE1
AEEs/AE2
AEEs/AE3
AEEs/AE4

CHAPTER – 3

3.1 Duties and Responsibilities of Section Officer (Quality Control):

1) To study thoroughly the specifications, drawings, estimates, agreements, etc. pertaining to every work under his jurisdiction.
2) To insist & ensure his construction counterpart to maintain the prescribed field registers and to see that entries are made regularly. Lapses to be brought to the notice of the D.E.E (Q.C) / E.E.
3) Shall check the mark outs of the areas and entries made in the respective register by his construction counterpart.
4) To check the pre-levels/final levels recorded by the construction staff to the extent of min.25% of his counterpart and to inform the Dy.E.E. (Q.C) immediately, together with variation if any.
5) Shall possess required field testing equipment.
6) To submit monthly return of the L.F. books' pages used along with details of field tests carried out to the Executive Engineer before 5th of every succeeding month.
7) The foundation levels of the structures have to be checked at every stage in addition to the verification of foundation soils and its suitability as per design.
8) The materials collected at the site of work should be tested in addition to the verification of the tests carried by the construction staff.
9) Shall check the adequacy of the construction equipment and operations of execution.
10) The suitability of the materials as well as areas shall invariably be entered in the relevant registers in red link.
11) Shall conduct all field tests like slumps, water cement ratios, mix quality etc., during the work and shall maintain record of field tests conducted.
12) Shall make random checks of feeding of input materials and mixing time.
13) Shall check and see that the preparation of the surface is properly done before proceeding further.
14) Shall check the adequacy of curing/watering and shall see that the final surfaces are finished neatly, to plumb to straight lines etc.
15) To ensure that, all items of works are carried out as per approved drawings and specifications. If any variation is noticed, the same should be noted in the placement register in red ink and shall bring the same to the notice of Dy.E.E (Q.C).
16) Defects, if any noticed during execution of work, are to be pointed out and recorded in the placement register. Shall insist his counterpart for rectifications and compliance before allowing further work. The fact of rectifications so carried out is to be certified and recorded in the field registers.
17) Shall submit extracts of the placement registers in case of major defects, pointed out along with the action taken to the Dy.E.E (Q.C) with copies to the E.E.

3.2 Duties and Responsibilities of DY.E.E. (Quality Control):

1) Shall ensure that the copies of the specifications, approved drawings, estimates, agreements etc., pertaining to the works under this jurisdiction are obtained.
2) To insist his counterpart to ensure maintenance of the prescribed field registers and to see that entries are made regularly and made available at the work site.
3) To check the pre-level/final levels recorded by the construction staff as well as AEE (QC) to the extent of at least 10% of the total area covered by the const., staff.
4) The monthly return of the LF Books' pages used by him should be submitted to the S.E. by 5th of the succeeding month.
5) He shall invariably check the foundations of all components of works and C.O.T. and make necessary entries in the concerned registers.
6) To test the materials collected at the site of work at random and record the same in the relevant field register.
7) All the test results as entered in the registers by the construction staff and the AEE (QC) shall be verified.
8) Shall conduct field tests like slump, percentage of gradation of fine and coarse aggregates at random and details of all such tests are to be submitted to the S.E.
9) Shall check the test reports of cement, date of manufacture etc., and satisfy himself before allowing the same for use.
10) Shall check at random, feeding of input materials, mixing, placing, vibration, rolling etc.,
11) Shall verify the entries made in the placement register in respect of area clearance by the A.E.E. (QC) and should affix his signature therein.
12) Should always record his remarks/observations in the placement registers, only in red ink and affix his dated signature.
13) Shall intimate the defects, if any, to his counterpart and submit copies of the same to EE (Const.,) as well as to S.E. (Q.C) and to ensure that further work is carried out only after the rectifications are done. The fact of carrying out rectifications by the construction staff should be verified and entries recorded in the field registers.
14) Shall verify the compliance reports furnished by the construction staff from time to time and submit verification report to the S.E. accordingly.
15) Shall bring to the notice of the E.E (Construction) any important deviation, defects and persistent non-compliance of rectifications invariably.

3.3 Duties and Responsibilities of Superintending Engineers:

1) Shall ensure that meetings/classes are conducted by the E.E. (Construction) and D.E.E. (Q.C) with all the field and Q.C. staff.
2) Shall monitor the Q.C. operations keeping the progress of works also in view and shall review every month the outturn and the overall work of the Q.C. sub-division which is directly under his control.
3) Shall ensure that all the necessary documents/records are made available by the construction staff at the site to the Q.C. staff, in case the same are not made available by the construction staff, in time.
4) Shall obtain the inspection reports from the E.Es and in case of major defects he shall inspect the site and take up necessary actions with rectifications.

5) On requisition from the construction staff, in case of variation in classification/quantities for more than 25%, he shall inspect the works.

6) Shall obtain monthly returns from the divisions by 5th of the succeeding month and fortnightly returns by 20th of the same month and 5th of succeeding month for the 1st and 2nd fortnight respectively.

7) Shall insist his construction engineers on furnishing the compliance reports on the remarks pointed out by the Q.C. staff.

8) Shall issue technical circulars whenever necessary to the Q.C. staff on quality aspects with a copy to C.E.

CHAPTER – 4

4.1) Duties and Responsibilities of Section Officers (Constn.):

1) To supply the copies of estimates, Agreements etc., to Q.C. if not already supplied by the E.E/S.E.
2) To study thoroughly the specifications, drawings, estimates, agreements etc., pertaining to every work under his jurisdiction.
3) To open the following registers immediately in the proforma on grounding the work.
   - Site order book
   - Mark out register
   - Placement registers for different items of work i.e. earth work, masonry, concrete, revetment, plastering etc.,
   - Bench mark register
   - Compaction registers in case of embankment
   - Material testing register
   - Reinforcement register
   - Load register in respect of concrete
   - Register of test report of compressive strength of concrete specimen.
   - L.F. Books
   - O.K. Cards
   - Note: The above registers can be maintained combinedly in one register by allotting required pages to each item of work depending upon the nature.
4) Shall see that the mark out of the area to be tackled is properly given and recorded in the register duly checked by D.E.E (Construction).
5) Shall see that the O.K. cards are kept ready at the site of work before starting the work and that they are used at different stages of work.
6) Pre-levels and final levels should be taken in respect of earthwork and got them checked by the Dy.E.E. (Constn.).
7) As soon as the cutoff trenches are excavated, the fact should be intimated to the Q.C. staff and get them passed, area wise, before filling the C.O.T.
8) Foundation levels in respect of structures may be recorded and got them checked by the Dy.E.E. (Constn.) immediately including verification of soils met with and the same should be intimated immediately, to the AEE and DEE of Q.C. to check the levels and soils, and get the areas passed by Q.C. before laying concrete.
9) The returns of L.F. Books' pages used, M.B. pages used, progress reports, log extracts of all machinery etc., should be submitted to the E.E. concerned before 20th of the current months for 1st fortnight and 5th of the succeeding month for the 2nd fortnight.
10) The construction materials required may be got collected at site and should be tested by them. Results must be furnished to Q.C. staff well in advance, so as to enable them to conduct necessary field tests required for passing of the materials.

11) The field tests required are to be conducted for the materials collected at site. The fact may be recorded in the material register.

12) The samples of materials proposed to be used on the work are to be collected and to be sent to the laboratory for testing them suitability and the results from the laboratory may be obtained before staring of the work for the samples which cannot be tested in the field.

13) Copies of the above test results shall be made available to the counterpart for study and verification.

14) The values of OMC and MDD may be obtained for the soils from the laboratory in advance.

15) All the materials proposed to be used and the areas for placing the embankment, earth/concrete may be got passed by the Q.C., staff before starting of the work.

16) To examine the foundations, to asses whether they are to the designed specifications, and to record the same in placement registers.

17) If the above soils are varying from the proposed, the revised drawings may have to be got approved from the competent authority and the same are to be furnished to the Q.C. staff.

18) The earth/structural work should be carried out strictly in accordance with the specification laid down in APSS and relevant IS Codes, as well as agreements. In case of any discrepancy, the same should be brought to the notice of the E.E. (Constn.).

19) Before starting the concrete work, he should ensure that the materials and requirement available for the work is adequate, at least 20% of the required materials shall be ensured for the purposes.

20) Shall supervise and ensure that the correct quantities of input materials including water as per the mix design communicated by the central laboratory are fed into the mixture/batching plants and shall ensure adequate mixing time.

21) Shuttering for concrete/R.C.C. is to be checked, not only for dimensions, but also for gaps between shutters, denting shutters, before allowing the concrete for getting correct shape and smooth faces.

22) The steel used for reinforcement is to be got tested for its tensile strength, diameter, unit weight etc., and to satisfy himself before use. Proper cover to be ensured for reinforcement.

23) The pre-measurements are to be recorded for the steel used for RFT in the RFT register and to be checked by the construction DEE and the Q.C. staff before laying the concrete.

24) Proper vibration should be insisted to avoid honey combing or segregation. Shall ensure that stand by vibrator is kept at site of work.

25) Shall ensure proper curing of concrete samples collected, till the stipulated time is over and to make arrangements to send the samples to the laboratory.

26) The concrete samples may be obtained during the laying of concrete and the same may be sent to the laboratory and got them tested for their strength for 7 days and 28 days respectively. The results obtained may be recorded in a separate register. Latest technology and equipment should be used for purpose to test at site.

27) Shall ensure green cutting of concrete with brushing, scrapping, chiseling etc., so as to prepare the surface for the next lift of work.

28) Shall ensure proper curing/watering and shall allow the removal of the centering only after the time limit prescribed in the specifications.

29) All the field registers are to be kept at site and should be made available to the inspecting officers and obtain their signatures without fail. If the same are not recorded, as and when, the work is inspected the concerned construction staff will be held personally responsible.

30) Further work is to be done only after attending to the remarks of the Q.C. staff and after obtaining their signature, in token of their acceptance.

31) As field officer, he shall primarily be responsible for any defective material being used and for any flaws noticed in the execution.

32) For the same work, no two L.F. books/M. Books field registers should be operated simultaneously.

33) For embankment P.D. tests have to be conducted as per I.S. code 2720-1971 @ the rate of at least one test for every 500 cum of earth work and at least one test in each layer of the embankment.

4.2) <u>Duties and Responsibilities of DY.E.E. (Constn.):</u>

1) The date of handing over the site to the Contractor/grounding the work, is to be intimated in writing, well in advance to the E.E. and Dy.E.E., Q.C., along with copies of estimates/agreements, specifications etc. if not already supplied by E.E./S.E.

2) The pre-levels/foundation levels recorded by the S.O. (constn) should be checked and the fact of checking is to be intimated to the Dy.E.E. (Q.C) through a requisition in writing for facilitating the checks by Q.C. staff.

3) As soon as the cut-off trenches are excavated, the fact should be intimated to the Dy.EE (QC) and the area got passed by Q.C. staff before proceeding with further work.

4) Shall regularly inspect the work in progress and check the work of AE/AEE and conduct test check personally, during his visit.

5) He should ensure that the work is carried out in accordance with the approved drawings and specifications stipulated in I.S. Codes, APSS, agreements etc.,

6) He should ensure that the returns of L.F. books' pages used, M.B. pages used progress reports, log extracts of all machinery etc., should be submitted to the E.E., construction.

7) He should ensure that, all the registers are maintained properly and verified regularly every month at the site of work and see that they are made available to the inspecting officers.

8) He should ensure that the tests such as compaction test for earth work, slump test for concrete, bulking for sand and the sieve analysis for the coarse and fine aggregates are conducted and the results recorded in the respective registers and also furnish to the Q.C. staff.

9) The Dy.E.E., himself should also conduct the field tests whenever he inspects the site to the extent possible and satisfy himself with the results and then record personally in the registers.

10) Latest technology and instruments should be used for conducting the tests.

11) A statement showing the weekly reports of tests conducted by the construction staff at site may be submitted to the Dy.E.E. (Q.C) and E.E. construction.

12) He should ensure that, same soils are being used for embankment works, from which the samples are sent to the laboratory for OMC and MDD and satisfactory results obtained.

13) Shall check the feeding of input materials, mixing, placing, vibration, rolling etc., during his visits.

14) He should furnish the weekly progress report on the works to his Q.C. counterpart.

15) He should check the ongoing works at regular intervals and should ensure that at least 25% work is covered in the check measurement done.

16) Should personally look into the remarks/defects pointed out by Q.C. staff during inspections, carryout the rectifications, prepare compliance reports and submit to the E.E/Construction for onward transmission to Q.C., unit, for dropping the remarks. The remarks pointed out in placement register also are to be attended to immediately and rectifications carried out and got certified by the Q.C., staff in placement Register.

17) The D.E.E. construction shall also be responsible for any defective material being used and for any flaws noticed in the execution

18) The D.E.E should check the bench marks and issue a certificate authenticating the location and values of the BMs in the bench mark register.

19) The D.E.E. should check the pre-levels and final levels of every item of work and record the levels in a separate L.F. book.

4.3) Duties and Responsibilities of Executive Engineer (Constn.):

1) Shall ensure that the activities of the Q.C. aspects are incorporated in the agreement, so as not to allow any objections to be raised by the contractor at a later date.
2) Shall intimate the Executive Engineer/D.E.E., Quality Control immediately after concluding the agreement. He should also furnish the copies of sanctioned estimates, agreements/specifications, with approved drawings to the Executive Engineer/D.E.E. (Q.C) and superintending Engineer, Q.C.
3) Shall furnish a return regularly by 5th of every month, showing the list of ongoing works in the proforma communicated, directly to the Chief Engineer, Q.C. for the purpose of vigilance checks.
4) Shall ensure that all the field registers are numbered duly authenticating the same and to issue to field officers in advance of the commencement of works. All the registers should be verified and reviewed every three months and also to be verified while making payments for running bills.
5) Shall ensure that the latest equipment for carrying out the tests by the staff, are procured and made available.
6) Shall also ensure that all the machinery/equipment being used by the contractor are got periodically calibrated.
7) Shall see that OK cards are kept at the site of work for the use by the construction staff before starting of any work.
8) Shall conduct classes and should impart knowledge of important matters in the construction activity along with specifications to the staff under him periodically, preferably for two or three times, till the field staff are fully acquainted with the specifications.
9) Shall inspect the cement godowns of the contracting agencies periodically and ensure the cement is stacked and stored properly and also use in the order of “First come First served”. Consignment certificate from the manufacturers must be obtained for each supply and a copy of which should be furnished to the Q.C. staff along with a bag of cement of that consignment for testing in the laboratory for verification of their

results furnished by the manufacturer. The cement may be tested for fineness as per I.S. code 4032-1985.

10) C.O.T: This has to be checked by the Executive Engineer. The C.O.T, mainly in the gorge portion, should be invariably checked and ensured that the base is of impervious strata duly conducting permeability test at site by Japanese method or in Lab. As per I.S. 2720(Part-17) – 1986.
11) The foundations, reinforcement, shutters, centering etc., of all important works must be checked and certified by the Executive Engineer before starting of the works and area should be passed.
12) When ever serious lapses/irregularities/deviations are noticed he shall take appropriate steps to rectify the same in time and promptly.
13) Shall instruct the field staff that the remarks pointed out by the Q.C. staff should be attended to immediately and compliance reports are to be furnished in time for verification by the Q.C. staff. Belated submission of compliance reports does not give scope for verification of the rectifications.
14) He shall note and instruct his field staff that the non fulfillment of the Q.C. checks or non rectifications of the defects pointed out by the Q.C. staff may be considered as a disqualification for the acceptance of the work and the responsibility for the same lies with the construction staff only. This shall be ensured while payment of work done running bills.
15) He shall take appropriate action and guide his field staff in obtaining the design mixes in advance so as not to suffer the progress of work at a later date, in co-ordination with the Q.C. counter parts.
16) Whenever there is variation in the earth work quantities more than 5% and up to 25%, it should be got checked by the D.E.E. (Q.C) and if the variation 25% it should be got checked by the Superintending Engineer, (Q.C).
17) Whenever there is any difference in the specification between the codes, i.e. I.S. codes, A.P.D.S.S. etc., and the agreements, then the condition of the agreement will only prevail unless amended.

4.4) <u>Duties and Responsibilities of Superintending Engineer (Contn.):</u>

1) Shall closely monitor and review the progress of work periodically and ensure that the progress of work is in accordance with the stipulated programme and specifications.
2) Shall conduct meetings/classes with the staff down below so as to impart knowledge of important points in the execution of the works.
3) Shall ensure that all the documents reach different levels of the Q.C. set up by taking up the matter with the concerned Executive Engineers.
4) Shall ensure and arrange for the use of latest equipment at the site of works for the tests to be carried out.
5) Shall periodically inspect the sites of works to an extent of a minimum 2% of the works monthly and issue inspection reports with a copy to C.E.
6) Shall ensure personally that the major defects affecting the stability of the structure pointed out by the Q.C. staff are rectified immediately and only then, further work to be carried out.
7) Shall issue general circulars from time to time on all the matters relating to monthly returns, progress reports, compliance reports etc., at his level to all the divisions so as to maintain uniform procedure.

CHAPTER - 5

TESTS TO BE PERFORMED ON MATERIALS

MATERIAL	TEST	METHOD
Cement	a) Chemical	IS: 4032-1985
	i) Sio_2, Al_20_3, Fe_20_3, Cao MgO, SO_2, Insol, residue & Loss On ignition	At any level I or II labs
	ii) Alkalies & Chlorides	
	iii) Free Lime	
	b) Physical	
	i) Specific gravity	
	ii) Fineness	
	iii) Soundness	
	iv) Compressive strength	
	v) 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 V
	xi) Abrasion value	
	xii) Potential reactivity of aggregate	PART VIII
	xiii) Petrographic examination	
	xiv) Alkali Aggregate reactivity test	PART VII
Water	Chemical	IS: 3025-1968
	i) CL, SO4, Organic & Inorganic Solids, pH, Alkalinity/Acidity	IS: 516-1959 IS: 1199-1959
	ii) Setting time of mortar	
	iii) Relative strength of concrete	
Admixtures	i) Relative water content	IS: 9103-1959
	ii) Bleeding	IS:9103-1959
	iii) Relative strength	IS:516-1959
	iv) Setting time	IS:8142-1959
	v) Relative length change	IS:1199-1959

MATERIAL	TEST	METHOD
Concrete	a) Fresh Concrete	IS:516-1959
	i) Air content	
	ii) Vibration	
	iii)Yield	
	iv) Temperature measurement	
	v) Mix prop:	
	vi) Water cement ratio	
	b) Workability test	IS:516-1959
	i) Slump test	Usual procedure
	ii)Compaction Factor test	IS:CED2(CESS)
		ASTM C 597-83
	c) Hardened Concrete	BS 4408
	i) Compressive strength	PART 5:1974
	ii) MDT Tests	IS:CED2(3890)
	iii)Ultrasonic pulse velocity	ASTM C805-85
	iv) Rebound Hammer	BS 4408
		PART 1971
	d) Special Test	
	i) Microscopy	
	ii) Non-destructive	
	iii)Core Testing	
Embankment	i) Disturbed grain size analysis	IS 2720 Part (iv) 1965
	ii) Proctors compaction	IS 2720 Part(vii& viii)1965
	iii) Atterbergs Limits	IS 2720 Part (v) 1970
	iv) Permeability	IS 2720 Part (xvii) 1966
	v) Shear test	IS 2720 Part (xiii) 1972
	vi) Specific gravity	IS 2720 Part (iii) 1964

CHAPTER – 6

FREQUENCY OF TESTING

Sl. No.	Test	Frequency of Test	Purpose	Test Designation
1.	Gram size analysis For classification	One test per day for every 3000 m^3	To know the classifications of soil actually put in the embankment	As per IS-2720-IV-1975
2.	Atterberg Limit test	One test per day	-do-	IS-2770-V-1970
3.	Specific Gravity	One test per day	-do-	15-2720-111-1964
4.	Field Density and Moisture content & consolidation test	One Test for every 500 m^3 of earth work and at least one test in each layer laid on embankment.	To determine the placement density and moisture content	IS-2720-XXVIlI-1974 IS-2720-XXIX-1966 IS-2720-XXXIll-1971
5.	Consolidation Test	1 set of 3 samples in Every 6m height Of embankment or for 30,000 m3 or once in ten days	To know the Settlement Rate and its magnitude	IS-2720-XV-1965
6.	Standard Proctor Test	One test per day for individual borrow Area	To determine MDD and OMC of the soil and compare the results with Laboratory value	IS-2720.VII-1970
7.	Moisture content	One test in each Sample	To know the Moisture content of the sample	15-2720-11-1975
8.	Shrinkage Factor	One test in one week or 5 mtrs of embankment height.	To determine Shrinkage limit	IS-2720-PartVI-1972
	FI LTERS			
9.	Grain Size Analysis	One test for every 200 m^3 of filter (sand) One test for every 200 m^3 of filter (Aggregate)	To find % of the D10, D15, D30, D50, D60 and D85 grain sizes of materials	IS-2385-Part I
10.	Clay lumps and organic impurities	One test for every 200 m3 (sand) One test for every 200 m^3 (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 and variability of material placed and the rate of fill placement with the objective of ensuring best quality control and quality construction.

CHAPTER – 7

IMPORTANT SPECIFICATIONS FOR MINOR IRRIGATION

7.1.Jungle Clearance

a) **Clearing:** The portion of the site required for constructing the work under these specifications shall be cleared of all trees bushes, rubbish and other objectionable matter. Trees designated by the Engineer-in-Charge shall not be cut and shall be protected from injury. Such cleared material shall be disposed off as provided in sub-paragraph C. below or removed from the site of work before the date of completion of the contract as approved by the Engineer-In-Charge. The clearing operation shall be in accordance with clauses 4.1, 4.11, 4.2 and 4.3 of I.S.4701 – 1982 Indian Code of practice of earth work in canals, surface boulders either loose or partly embedded in the ground will have to be removed and stacked as directed.

b) **Grubbing:** The ground surface under all embankments of normal dimensions as shown on the drawings and under other embankments where directed by the Engineer-In-Charge and the surface of all excavation that is to be used for embankment shall be cleared of all stumps, roots and vegetable matter of every kind. The stumps shall be pulled or otherwise removed and roots shall be grubbed.

c) **Disposal of cleared and grubbed material:**
The disposal of cleared and grubbed material shall be in accordance with clause 4.1.1 of I.S.4701 code of practice for earth work in canals. All waste material to be burnt shall be piled neatly and when in suitable condition shall be burnt completely to ashes. Piling of waste material for burning shall be done at such a location and in such a manner as would not cause any fire risk. Necessary precautions shall be taken to prevent spreading of fire to areas beyond the limits of cleared areas. Suitable materials and equipment for prevention and suppression of fire shall be kept available at all times.

7.2.Raising Bund:

On sloping ground or 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 soils with the sub grade. 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 vegetative matter as per specifications 2.0 No separate payment will be made for either benching or refilling. The rate quoted for raising embankment is inclusive of above operations. The bank section shall be brought to design standards by filling the scours with suitable material and compacting to 95% to 98 % Proctor density by suitable method of compaction.

7.2..1. Compaction:

a) **General**
The earth compacting equipment specified in Appendix – C of I.S. 4701 – 1982 shall be used for compaction of the soils shown against them. The compacting equipment shall conform to the relevant I.S. specification.
While the I.S. specifications specify compacting it is contended that the use of improved compact equipment for embankment construction shall be encouraged as may be most suited to the site conditions and the program of construction. The methods of compaction shall conform to clause 7.2.2, 7.2.3, of I.S. 4701 – 1982.

7.2..2. 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 IS 2720 (Para XXIX) 1975.

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

c) Engineer might review the design if necessary on examination of density test results and the contractor shall have no claim arising out of such a review and consequent change. If any in the design.

d) **i)** 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 tempers in this layers. The compaction above this layer of total 45 Cm shall be done by using suitable light 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 ascertain whether the compaction is attained as specified above.

ii) Separated tests shall be conducted for each zone of the embankment for every 500 Cubic Meters of compacted earth work, at least one field density test shall be taken in each layer. Minimum two density tests shall be taken in each year per day irrespective of the quantity of earth work specified above. In case the test shows that the specified densities are not attained, suitable measure shall be taken by the Contractor either by moisture correction or by entire removal and relaying layer or by additional rolling so as to obtain specified density which shall be checked again by taking fresh tests at the same locations. Necessary unskilled labour required for carrying out such density tests shall be provided by the Contractor.

e) Compaction shall be achieved by the use of smooth rollers. Pneumatic type rollers, sheep foot rollers, mechanical compactors like vibratory roller, vibrating plates, 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.

f) 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 25 kg / CM2 when ballasted. The number of passes required for each layers to obtain the specified density shall be determined by actual field tests.

7.2.3. Cohesion less materials:

a) Where compaction of cohesion less free – draining material such as sand and gravel is required the materials shall be deposited in horizontal layers and completed to the relative density specified. The excavating and placing operations shall be such that the materials, when compacted shall be blended sufficiently to secure 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 compact on being used.

b) As per clauses 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 16.5 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.

7.2..4.Embankments with controlled compaction:

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

b) **i)** Unless otherwise specified, 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 execution. 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 materials shall be permitted for re-use in embankment at higher elevations.
iii) No payment shall be made for providing or removal of the extra section. Removal of extra section in the embankment shall be deemed to have been included in the item of compaction.

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 as directed by the engineer.

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 held up 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 as satisfactory bonding surface before the succeeding layer is placed. All the rollers used on any one layer of fill shall be of the same type and same weight.

f) The Contractor shall ensure that only approved soils are used for construction of embankment.

g) For proper bond of the embankment done in 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 due to be compacted by tampers. A cross slope away from the centre of canal of about 1 in 80 shall be maintained throughout the rainy season

to ensure proper drainage in the event of occasional rainfall. No extra or separate payment shall be made for these items of work.

h) **Settlement allowance:**

i) The canal embankments shall be constructed to a higher elevation than that shown on drawing at the rate of 2.5 Cm per every one meter height of bank, if power driven equipment is used and 2 Cm / 1 Mt. height if other than power driven equipment is used for compaction towards shrinkage settlement.

ii) No extra or separate payment shall be made for this work as this shall be deemed to have been included in the respective item of construction and consolidation of embankment.

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 for canal embankments shall be provided as specified in 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.

7.2..5. Moisture content:

a) The initial moisture content of the material shall be determined at the source of supply (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 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 hole shall not be allowed.

b) If the earth delivered to the embankments is too wet, it shall be dried by aeration, exposure to the sun, ploughing, disc harrowing 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. For such suspension of work no extra claim to the contractor shall be allowed.

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

d) 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 with optimum moisture content.

e) Moisture content of each layer of soils shall be checked in accordance with I.S. 2720 (Part II) 1973 and unless otherwise mentioned shall be adjusted making due allowance for evaporation loss that at any time of compaction: up to – 1 % to + 2 %

than the optimum moisture content in casing zone and up to +1 % to –1 % than the optimum moisture content in the hearting zones may be permissible. The optimum moisture content shall be determined in accordance with I.S. 2720 (Part VII) 1973. The above compaction tests will be conducted by the Engineer or his authorized representative and the contractor shall ensure compaction till it is satisfied that 98 % of the maximum dry density at OMC is obtained.

7.3. Revetment:

a) Resetting revetment:

The disturbed revetment shall be removed and the stones be stacked at a suitable place and pre-measurements taken and recorded. The base for the new revetment shall be formed and well compacted as per the approved slopes and profiles. The stacked stones shall be reused in addition to new ones.

b) Revetment (New):

c) preparation of bed and slopes:

i) Bed

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

No packing shall be on uncompacted made up soil.

ii)Side Slopes

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

7.3.1) Laying Apron (Bed Pitching) And Revetment (Pitching to Sides)

7.3.1.1) Apron (Bed Pitching)

a) Apron shall be provided to the dimensions and levels shown in 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 hand – packed.
c) The thickness 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 soft that they may meet all round their bases and with the top of the stone level with finished surface of packing. The stones shall be laid breaking joints 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 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 with the largest size chips or spalls practicable each chip or spalls being well driven home with a hammer so that

no chip or spall is possible of being pick up to ensure tight packing. The size spalls 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.

g) Round stones or very flat stones having small thickness shall be avoided. Density of stones should be 2000 to 2300 Kgs / Cum.

7.4 Repairs to sluices:

7.4.1. Masonry works:

Any damaged part of the masonry in the sluice shall be reconstructed in accordance with clauses 9.1 and 9.2 of I.S. 1597 (part 1) – 1992 as under.

(a) Random Masonry (Uncoursed and brought to Course)

i) Dressing:

Stones shall be hammer – dressed on the face, the sides and the beds to enable it to come in proximity with the neighbouring stone. The bushing on the face shall not be more than 40 mm on an exposed face.

ii) Insertion of Chips:

Chips and spalls of stones shall be used wherever necessary to avoid thick mortar beds or joints and it shall also be ensured that no hollow spaces are left anywhere in masonry. The chips shall not be used below hearting stones to bring these up to the level of face stones. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 20 percent of the quantity of a stone masonry.

iii) Hearting Stones:

The hearting or interior filling of a wall face shall consist of rubble stones not less than 150 mm in any direction, carefully laid, hammered down with a wooden mallet into position and solidly bedded in mortar. The hearting should be laid nearly level with facing and backing.

iv) Bond Stones:

Through bond stones shall be provided in walls up to 600 mm thickness, a set of two or more bond stones overlapping each other by at least 150 mm shall be provided in a line from face to back. In case of highly absorbent types of stones (porous lime stone and sand stone, etc) the bond stone shall extend about two-third into the wall, as through stones in such cases may give rise to damp penetration and, therefore, for all thickness of such walls a set of two or more bond stones overlapping each other by at least 150 mm shall be provided. Each bond stone or a set of two or more bond stones overlapping each other by at least 150 mm shall be provided. Each bond stone or a set of bond stones shall be provided for every 0.5 M2 of the wall surface and shall be provided at 1.5 m to 1.8 m apart clear in every course.

v) Quoin stone:

Quoin stone shall not be less than 0.03m3 in volume.

vi) Plum stone:

The Plum stone at about 900 mm interval shall be provided.

vii) Laying:

The masonry shall be laid with or without courses as the case may be as per general requirement. The quoins shall be laid header and stretcher alternatively. Every stone shall be carefully fitted to the adjacent stone so as to form neat and close joint. Face stone shall extend and bond well in the back. These shall be arranged to break joints, as much as possible, and to avoid long vertical lines of joints.

b) Squared Rubble – Coursed Rubble (First sort):

i. Dressing:

Face stone shall be hammer–dressed on all beds and joints so as to give them approximately rectangular shape. These shall be square and all joints shall be chisel drafted for at least 80mm back from the face and for the side joints at least 40 mm. No portion of the dressed surface shall show a depth of gap more than 6 mm from a straight edge placed on it. The remaining unexposed portion of the stone shall not project beyond the surface of bed and side joints. The requirements regarding bushing shall be the same as for random rubble masonry.

ii.Hearting Stones:

The hearting or the interior filling of the wall shall consist of flat bedded stone carefully laid on their proper beds in mortar. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 10 percent of the quantity of masonry. While using chips it shall be ensured that no hallow spaces are left anywhere in the masonry.

iii. Bond Stones:

The requirements regarding through or bond stone shall be same as for random rubble masonry but these shall be provided at 1.5 m to 1.8 m apart clear in every course.

iv. Quoin stone:

The quoin which shall be of the same height as the course in which these occur, shall not be less than 450 mm in any direction.

v. Face stone:

Face stone shall tail into the work for not less than their height and at least one thirds of the stones shall tail into the work for a length not less than twice their height. These should be laid headers and stretchers alternatively.

vi. Laying:

All courses shall be laid truly, horizontal and all vertical joints shall be truly vertical. The quoin stones shall be laid square on their beds, which shall be rough chisel dressed to a depth of at at least 100 mm.

vii. Square Rubble – Coursed Rubble (Second sort):

All requirements are the same as for coursed rubble masonry (first sort) except that no portion of dressed surface of joints shall show a depth of gap more than 10 mm from a straight edge placed on it and use of chips shall not exceed 15 percent of the quantity of the stone masonry.

c) Squared Rubble – Uncoursed Rubble

All requirements are the same as for coursed rubble masonry (first sort) except that stones (risers of jumpers and stretchers), which are of varying heights are laid uncoursed and in general, the risers shall not be more than 250 mm in height and stretchers shall not exceed two – thirds the height of the adjoining risers.

7.4.1.1. MASONRY

I.S. CODES 1597, 1812, 1200 383, 269, 2116

DO'S	DO NOTS
1. The Stone shall be of uniform colour, texture, strong, hard durable.	1. Do not use stones other than granite of crushing strength less than 1000 kgs/sq.cm.
2. Dress C.R.S. stone to a depth of 75 mm. on all four sides	2. Do not allow bushing more than 40 mm. on the face.
3. Wet the stones before placing in position clean and cover with fresh mortar	3. Do not allow stones of length more than 3 times the height

4. Place stones in layers to the line and plumb.	4. Do not allow stone of breadth less than height of ¾ of thickness of wall.
5. Provide weep holes at 2 mtrs interval staggered as per drawing.	5. Do not allow breaking of vertical joints less than 75 mm.
6. Chisel dress the corner stones.	6. Header shall not be projected less than 10 cm beyond stretcher.
7. Face stones shall be laid alternately in headers and stretchers.	7. Do not place stones in position without cleaning and wetting.
8. Provide bond stones at 2 mtrs. Interval in each layer and mark	8. Do not allow skin stones, weathered stones.
9. Place the hearting stones on its broadest face.	9. Do not place stone in position without wetting.
10. Ensure perfect hearting to make the masonry water tight	10. Smaller stones shall not be placed in lower coarse.
11. Mortar shall be used within 30 min. after discharge from mixer.	11. Joints thickness should not be more than 12 mm.
12. Sieve analysis for sand shall be done periodically which confirm to: I.S.Seive Designation — % of passing 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	12. Do not allow mixing less than 3 minutes for thorough mix.
13. For flush pointing the mortar shall be finished off flush and level with edges of the stones.	13. Do not add more water than required to have a consistency of 90 to 130 mm.
14. Joints shall be raked out to minimum depth of 12 mm. when the mortar is green.	14. Avoid spreading of mortar over the surface of the masonry.
15. Cure the masonry with water for 2 weeks.	15. No pointing to be commenced without washing and wetting the joints thoroughly.
16. Cure the plastered surface with water for 14 days.	
17. Cure the pointing surface with water for 7 days	

7.4.1.2. PLASTERING AND POINTING:

a) **General:**

The surface of Masonry shall be finished by "pointing" or by "plastering". For a surface which is to be subsequently pointed or plastered the joints shall be squarely raked out to depth not less than the width of the joints or as directed while the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and the surface shall be thoroughly washed and cleaned and wetted.

b) Scope:

Plastering of specified thickness with specified mortar proportion to the exposed faces of R.R. Masonry / brick masonry / concrete including cost and conveyance of cement and all other materials. Sampling, testing mixing of mortar, labour charges, all leads, lifts, delifts, seignorage charges, scaffolding, curing, all water

leads, and all other operations necessary to complete the finished item of work as per drawings and as directed by the Engineer-In-Charge.

c) Mortar:

Preparation of Mortar for Plastering, Pointing work:

i) Unless otherwise specified the same cement mortar used in Plastering, pointing work shall be of cement mortar mix MM7.5 grade, or any other specified grade using minimum 360 Kgs of cement per cubic metre of mortar. The cement and sand mortars are specified with mix proportions as follows for 1 cum of mortar(the weight of dry sand 1571 Kgs per cubic meter):

Sl.No.	Mortar	Cement	Sand
1	CM (1:3)	480 Kgs	1571.4 Kgs.
2	CM (1:4)	360 Kgs.	1571.4 Kgs.
3	CM (1:5)	288 Kgs.	1571.4 Kgs.
4	CM (1:6)	240 Kgs.	1571.4 Kgs.

7.4.1.3. Plastering with cement mortar mm 7.5 grade or any other specified grade:

i) Preparation of surface:

The roughening of the back-ground improves the bond of plaster. All joints shall be thoroughly raked. After roughening the surface, a 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 surfaces shall be wetted evenly applying the plaster. A fog spray may be used for this work as far as possible, the plaster work shall be done under shade.

ii) Laying of plastering:

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 thickness at not more than 2 meters 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. Plastering shall be properly filled in advance of the plastering. 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 into through 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 the 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 upward and side ways motion 50 mm or 75 mm at a time. The surface shall be periodically checked with lasting stretched across it. Finally the surface shall be rendered smooth with a small wooden float; over working shall be avoided. All corner's 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.

a)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 mm from any corner or arises or parapets 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 hrs and there after kept moist and not permitted to dry until the final rendering is applied.

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

c) No portion of the surface shall be left out initially to the 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.

d) The average thickness of plaster shall not be less than the specified thickness but shall not be thicker than 25 mm. In any case, any cracks which appear on the surface and all portions which sound hollow when tapped or found to be soft or other-wise defective, shall be cut-out in rectangular shape and random as directed by the Engineer at no extra cost. Plastering shall be cured for 10 days.

7.4.1.4. Pointing to C.R. Masonry with cement mortar mm 7.5 grade:

a) Scope:

Flush pointing / with cement mortar of specified proportion to the exposed faces of CRS masonry including cost and conveyance of cement and all to the materials, sampling, testing, mixing of mortar, labour charges, all leads, lifts, delifts, seignorage 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.

b) 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 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.

c)Laying flush pointing:

Flush pointing shall be done with cement mortar mix MM 7.5 grade or any other specified grade. The mortar shall be pressed into the raked out joints. 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 to edges of the stone so as to give a smooth appearance. The edges shall be neatly trimmed with a trowel and straight edge.

d) The pointing shall be cured for seven days.

7.4.1.5. Reconstruction of sluice in masonry:

a) Existing damaged masonry and / or foundation shall be removed and foundation for the new sluice laid according to the approved plans, specifications and as directed by the Engineer-In-charge.

b) Masonry for the sluice shall be constructed with course rubble second sort.

7.4.1.6. REPAIRS TO SURPLUS WEIR

a) **In cement concrete:**

Damaged part shall be completely removed in a regular shape. Before laying fresh concrete of the same grade as the old one, the old exposed surface shall be thoroughly cleaned and cement slurry applied. Curing shall be done for the specified period.

b) **In masonry:**
Damaged part shall be completely removed in a regular shape. Relaying of new masonry shall be carried out with course rubble second sort as explained in clause D.d.b.VII above.

c) **Replacement of shutters:**
Replacement of shutters shall be carried out as per the approved drawings and as directed by the Engineer-In-Charge.

7.4.1.7. RESECTIONING OF FEEDER CHANNELS:

a) Accumulated silt shall be removed and the channel brought to the designed section to carry the designed discharge.

b) Earth work banking shall be taken up wherever necessary. Masonry guide walls in CM 1:5 and bed lining in CC 1:3:6 proposed at vulnerable reaches where the BC soils are met with.

CHAPTER – 8

IRRIGATION CHANNELS

8.1) EARTH WORK:

8.1.1. General: The canal sections are shown on the drawings. The Government reserves the right during the progress of work to vary the slopes of excavations or the slopes of the embankment and the dimensions dependent thereon. Any increase or decrease of quantity excavated as a result of such variations will be included in the estimates. If the Engineer-In-Charge determines that the contractor's costs of performing the work will be increased or decreased by reason of such variations, an equitable adjustment will be made to cover this increased or decreased costs and the payment will be done as per condition of bid document (i.e. Alterations, additions, and omissions). Stones and indurate material shall be removed from material excavated for the canal and not required for constructing canal embankments, shall be used to construct road ramps and bridge approach embankments. The excavation of canal both in soils and rock shall conform to clauses 5.1 to 5.3 of IS. 4701 – 1982.

8.1.2. Excavation in expansive B.C. soil:

Canals excavated in expansive soils such as B.C. clayey soils of high plasticity pose severe problems involving stability of slopes and shape of section. The contractor shall excavate and remove B.C. and clay soils so that the thickness of CNS soil proposed to be provided should be in conformity with IS 2720 (part 41)-1977 as outlined in the Table I & II on page 49 i.e. Thickness of CNS Layer.

8.1.3. Design of channels on Principles of Regime Flow

(a) Bed width to depth ratios

Cross sections which are stable and in regime appear to have certain relationship between bed width to depth of flow.

To avoid the necessity of making assumptions best fitted equation of regime channels based on data of stable channels for every region are important from practical considerations.

Bed width to depth ratios suggested by C.W.P.C. and generally adopted are presented in table -8.1.3.(a) below for design of channels until best fitted equations are developed for each region. The values may vary depending upon individual needs.

TABLE – 8.1.3.(a)

Bed width to depth ratios

In Q Litres / Second	b/d	Q in Cumecs	b/d
300	2.9	02	4
400	3.0	04	4.9
600	3.2	10	5.4
900	3.4	15	6.0
1000	3.5	30	7.4

(b) Inner side slopes for design.

Silt transporting channels have tendency to assume semi-elliptical sections. The finer the silt, more does the section approximate to semicircle. Therefore for purpose of design the practice is to assume 0.5 H to 1 V side slopes.

(c) Side slopes for construction

Side slopes to be adopted for construction depend upon the soil characteristics. The side slopes are to be designed to withstand following conditions.

i) Sudden draw down condition for inner slopes.

ii) Canal running full with banks saturated due to rainfall.

(d) Channels are usually excavated in 1 H to 1 V side slopes, it being assumed that after silting they will have side slopes, of approximately 0.5 H to 1 V. However in sandy soils the side slopes in cutting may be 1.5 H to 1 V or flatter.

Canals in filling in general are proposed with 1.5 H to 1 V but in loose sand they shall be 2 H to 1 V or flatter.

(e) Rugosity Coefficient *n*.

For normal alluvial soils, it is usual in India to assume following values of n depending the carrying capacity of canals.

for canals of carrying capacity more than 15 Cumecs $n = 0.02$
For canals of carrying capacity less than 15 Cumecs $n = 0.0225$
In some projects values of *n* adopted are as follows.
Canals in range of 1.5 to 100 Cumecs, $n = 0.0225$
Canals carrying less than 1.5 Cumecs, $n = 0.025$
Very small channels that is below
0.3 Cumecs capacity $n = 0.0275$

Basically the value of n depends upon the Physical roughness of the canal and standards of maintenance during its operation.

Assuming average standards of maintenances it is better that canals are designed with n = 0.025.

(f) Bed fall:

The average slope of the ground is to be determined from the longitudinal section of the ground. This would be the maximum slope which can be provided on the canal. Flatter slopes have to be adopted if the velocity generated is higher than permissible one due to adoption of average slopes of the ground.

(g) Flow formula: Manning's formula which is derived from Chezy's fundamental equation is being adopted in design of open channels.

$V = 1/n\ R^{2/3}\ S^{0.5}$
Where V = Mean velocity of flow in metres per second
n = Rugosity coefficient.
R = Hydraulic mean depth
(Area over perimeter, A/P)
S = Bed fall 1 in __m of length. i.e. fall per unit length.
Discharge Q = A X V in Cumecs.

8.1.4. Excavation Of Canals

DO'S	DO NOTS
1. Fix up the centre line and set the curves correctly	1. Do not avoid approval of the deviation statement
2. Take working levels, real variation in ground levels and classification of soils as per Govt. Memo No.1970-12/72-11, dated 4-7-1994	2. Avoid over break and loosening of canal. 3. Do not mix up useful soils with other soils of cutting
3. Get top soil vegetation etc. removed.	
4. Provide treatment with C.N.S. soils in B.C.reaches (Expansive soils)	
5. Form spoil bank as per drawing and away from side drain with suitable gaps for drainage into the valley	
6. Form Dowel Bank, as per drawing	
7. Form Inspection path to a uniform longitudinal gradient and with gentle transverse slope towards drains	
8. Compact over excavation/breakage portion with suitable soils, gravel, spalls	

8.1.5. Formation Of Embankments

DOS	DO NOTS
1. Get the top spoil, vegetation and sand patches removed to complete depth	1. Do not raise the bank in piecemeal.
2. Scarify the ground and wet properly	2. Do not allow new layer without scarification and wetting of old layer
3. Obtain P.D. OMC for the useful soils and borrow soils	3. Do not allow new layer unless required degree of compaction is achieved.
4. Provide C.O.Ts according to height of bank.	4. Don't leave any loose layer un-rolled at the end of the day in rainy season
5. Raise embankment to full width with uniform horizontal layer of 25 cm thickness.	5. Don't allow compacted layer to be more than 150 mm.
6. Break clods, remove roots, big boulders other materials etc., larger than 80mm from the soils used in embankment	6. No new layer to be laid unless the over moistened layer is either completely removed or allowed to dry
7. Supplement deficit moisture whenever required	7. Don't dump soils in heaps.
8. Provide extra offset on both sides of bank	8. Don't dump the soils in water and slush

9. Compaction with 8 to 10 tonnes power roller	9. No. of roller passes should not be less than 10.
10. Conduct field compaction tests and determine compaction efficiency	10. Do not forget to provide settlement allowance of 2 cm/mtr height of bank.
11. Check embankment profiles periodically	11. Don't use expansive soils in banking.
12. Ensure 8 minimum No. of passes	
13. Provide 10% allowance in setting profile of the embankment	

8.2. CM AND CD WORKS

8.2.1. Foundation

a) General: Excavation for the foundation of structure shall be to the elevation shown in the drawing or as directed by the Engineer-In-Charge. In so far as practicable, the material removed in excavation for structures shall be used for back fill embankments. Otherwise it shall be wasted.

b) Foundations for structures:

The contractor shall prepare the foundations at structures sites by methods which will provide firm foundation for the structure. The bottom and side slopes of common excavation upon or against which the structure is to be placed shall be finished to the prescribed dimensions and the surfaces so prepared shall be moistened and tamped with suitable tools to form firm foundation upon or against which to place the structure. The contractor shall prepare the foundations for the structures as shown on respective drawings. The natural foundation material beneath the required excavation shall be moistened if required and compacted in base.

If it is considered necessary by the Engineer-In-Charge to consolidate the foundation strata by grouting cement slurry, the drilling and grouting or any other foundation treatment as directed by the Engineer-in-Charge shall be done by the Contractor and the payment will be as per mutually agreed rates.

Densities of the compacted foundation materials and the testing thereof shall be in accordance with Paragraph 3.1.2 in page 47 i.e. Sub grade density and moisture control..

Separate payment will not be made to the Contractor for moistening and compacting the foundation of structures. The Contractor shall include cost thereof in the price bid per cubic meter of the item of the Bill of quantities for preparation of foundation.

Whenever unsuitable material is encountered in the foundation for a structure, the Engineer – In – Charge will direct additional excavation to remove the unsuitable material. The additional excavation shall be refilled as follows. In excavation in soils, the over excavation shall be filled in by selected bedding material and compacted. In excavation in rock, it shall be filled by M5 grade cement concrete. Measurement and payment for excavation back fill will be made as per clause 3.2.2 i.e. C.N.S.treatment on page 48.

c) Over Excavation: At any point in common excavation the foundation material is excavated beyond the lines required to receive the structure, or if at any point in common excavation the natural foundation material is disturbed or loosened during the excavation process, it shall be compacted in place or where directed, it shall be removed and replaced as follows. In excavation in soils, the over excavation shall be filled in by selected bedding material and compacted. In excavation in rock, it shall be filled by M5 grade cement concrete. Any and all excess excavation or over

excavation performed in the contractor for any purpose or reason except for additional excavation as may be prescribed by the Engineer-In-Charge and whether or not due to the fault of the contractor shall be at the expense of the contractor. Filling for such excess excavation or over excavation shall be at the expense of the contractor.

d) Excavation in expansive B.C. Soil: Canals excavated in expansive soils such as B.C. clayey soils of high plasticity possess problems involving stability of slopes and shape of section. The contractor shall excavate and remove B.C. and clayey soils up to depth of 1000 MM for a discharge of 1.50 Cumecs and above 600 mm for a discharge of below 1.50 Cumecs and fill it with C.N.S. soils and compact for balancing the swell pressures exerted by soils.

e) For Foundation:

DO'S	DO NOTS
1. Verify dimensions and foundation levels as per drawing.	1. Do not forget to compare bearing capacity of actual soils met with design strength.
2. Wet the foundation surface to a depth of 150 mm or to impermeable material	2. Don't lay the foundation concrete without wetting the surface. 3. Do not lay the concrete under water and over slush
3. Ensure the rock surface free from oil, objectionable coating unsound fragments.	4. The minimum mixing time should not be less than 2 min.
4. Check-up concrete batching of ingredients.	
5. Check the batch of cements and its make	5. Do not forget to keep stand by vibrator and needles.
6. Check-up water cement ratio and slump test.	6. Do not place concrete in raw in sufficiently heavy to wash mortar from concrete
7. Ensure uniform mixing.	7. Do not forget to cast the cubes.
8. Ensure proper compaction with vibrators and keep stand-by vibrator and needles.	8. Do not allow segregation of concrete.
9. Operate immersion type vibrators nearly in vertical position to vertical drain.	9. Do not use unsatisfactory mix.
10. Cure with water for 28 days.	10. Don't allow admixtures which will harm the strength of concrete.
11. Compact with suitable bedding materials in case of over excavations and with M-5 grade concrete in case of rock.	
12. Allow admixtures as per I.S. 9103 – 1979.	

f) Super Structure:

1. Check the form work	1. Avoid abrupt surface irregularities.
2. Apply cement slurry after cleaning the surface at vertical joints	2. Do not deviate from specified dimensions of cross section from -6 mm to + 12mm.
3. Clean and cover with a layer of 10 to 15 mm thick mortar of the same proportion of concrete mix for horizontal joints.	3. Do not allow concreting until all form work installation of items to be embedded and preparation of surface involved are approved.
4. Place the concrete at temperature between 15^{o}C to 30^{o}C.	
5. The concrete shall be discharged within half an hour after introduction of the mix water and cement	

g) Back Filling:

Back filling with selected material in foundation trenches, around structures and above lining key.

i) General:

a) The type of material used for backfill, and the manner of depositing the material, shall be subject to approval of the engineer. As far as practicable, backfill material shall be obtained from the excavation for structures or from adjacent canal excavation or from excavation of other ancillary works. Back filling shall be done with approved material after the concrete or masonry is fully set.

b) Backfill material shall not contain stone larger than 7.5cm size.

c) The pervious materials (sand) with profused watering used for backfilling around the cut off wall shall be placed as shown on drawings or as directed by the Engineer

d) Backfill shall not be placed against' retaining walls until the retaining wall is cured adequately and is strong enough to take lateral pressure of the back fill. Trimming of the sides of excavation against which the back fill is to be laid shall be delayed until immediately prior to backfilling and any excessive drying of the surface shall be conditioned properly and made adequately moist to avoid potential desiccation of the rock or partly compacted/consolidated materials.

e) The backfill material shall be placed carefully and spread in uniform layers. The backfill shall be brought up as uniformly as practicable on both sides of walls and all sides of structures to prevent unequal loading. The backfill material shall be placed at about the same elevation on both sides of the pipe portions of tile structures and culverts and difference in elevation shall not exceed 15 cm at any time. The contractor shall be responsible for providing adequate earth cover over pipe to prevent damage due to loads of construction equipment.

f) If a haul road is built over a pipe, all back fill around and over the pipe shall be placed to a uniform surface and no humps or depressions shall be permitted at the pipe crossing.

ii) Compaction of Backfill :

(a) When compacting the soil against the steep rock abutment walls of masonry or

concrete structures, the construction surface of embankment shall be sloped away from the rock or masonry or concrete structures leaving a minimum distance of 0.6 metre and at an inclination of 3:1. Rollers shall not be used close to structures as structural damage is very likely more particularly when structures have not been fully cured. The size and weight of equipment will depend on nature of material, the height and load assumed in design of structure. The backfill close to the structure up to the rolled layer shall be compacted in suitable uniform layers, using pneumatic tampers as appropriate to obtain dry density of at least 98% of Proctor density. The moisture content of the earth fill placed against rock or the structure shall be on higher side of OMC by about 2% or so to allow it to be compacted into all irregularities of the rock, profuse watering shall be done to pervious materials (sand) before compaction as per instruction of Engineer. Compaction at junction of each work and backfill around the structure shall be carried out with special care without claiming any extra cost.

(b) No payment shall be made for backfilling around the structures and consolidation as the cost of the same shall be deemed to have been included in the relevant item of concrete/masonry of bill of quantity. Full payment of the relevant item of concrete/masonry shall not be made till the contractor carries out the compaction of backfill as per the above specifications. Deployment of hand tampers be restricted to rare usage that too for very small jobs.

iii) Structures on Backfill:

Where the original ground surface is below the base of the structures or below the bottom of pipe, all fill required for the structures foundation and all fill up to the bottom of the pipe shall be placed as compacted embankment. The embankment over natural ground up to pipe bottom and over the pipe shall be laid in accordance with clause 9.2.4, 9.2.5 and 9.2.6 of I.S.783 of 1985. The compacted back fill shall be placed in horizontal layers not exceeding 15 Cm. after compaction. Heavy stones shall neither be dropped on top of pipes nor shall be allowed to roll down the side of the embankment against the pipes.

8.2.2. CEMENT CONCRETE:

8.2.2.1. General Concrete Requirements:

a) General: Concrete shall be composed of cement, sand, coarse aggregate, water and admixtures (if any) as specified all well mixed and brought to the proper consistency.

b) Nominal maximum size of aggregates –in coarse aggregate 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 and canal lining shall be as indicated in the relevant drawings appended to the contract documents. Smaller coarse aggregate than specified shall be used where in the opinion of the Engineer-In-Charge that proper placements of concrete is impracticable with the size of the aggregate specified in the drawings.

c) 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 determined by mass as per clause 9.2 of I.S. 456 – 2000. Water shall be either measured by volume in calibrated tanks or weight. Batching plant shall confer to I.S. 4925 – 1968 (Indian

Standard specifications for batching and mixing plant). All measuring equipment shall be maintained in a clean serviceable condition and their accuracy is 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 – 2000.

The mix design and average concrete strength shall be adjusted according to the cube strength test results conforming to clauses 14.2, 14.3, 14.4, 14.5, of I.S. 456 – 2000. The contractor shall not be entitled for any additional allowances above the prices bid in the schedule due to adjustment of the mix proportions.

The net water cement ration 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 or pozzolonas if ordered shall conform to the requirements specified I.S. 9103 – 1979 (Indian Standard Specifications for admixtures for concrete).

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

8.2.2.2. **Reinforced cement concrete:**

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

ii) For plain concrete work slump requirements mentioned in item-I above are applicable.

iii) Lining with slip from machine – 60 to 70 mm and 50 mm for concrete pave finisher.

If the specified slump is exceeded at the placements the concrete require lesser slump and concrete of such lesser 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 for concrete shall be adjusted to compensate for any variation in the moisture content or grading of the 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.

DOS	DO NOTS
1. Check the reinforcement as per drawing 2. Provide asphaltic pad and water stopper as per drawing.	1. do not pass without proper cover 2. Do not allow less lengths in over laps

8.2.2.3 Concrete quality control measures and concrete Quality Assurance Test Programme.

a) Concrete quality control measures: The Contractor shall be responsible for providing quality concrete to ensure compliance of the contract requirements.

b) Concrete Quality Assurance 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 IS 1199 – 1959.**

8.2.2.4. Tests: The Q.C/Construction unit will obtain samples, conduct tests in accordance with the methods of tests given below:

a) Sampling of fresh concrete: As specified in clause 14 of I.S. 456 – 2000 (Indian Standard Code of practice for plain and reinforced concrete) samples from fresh concrete will be taken as per I.S. 1199 – 1959 (Indian Standards methods of sampling and analysis of concrete) and cubes shall be made, cured and tested at 28 days age in accordance with I.S. 516 – 1959 (Indian Standard Methods of tests for strength of concrete).

b) Density : Unit weight and yield.

The unit weights and yield will be tested in accordance with I.S. 6441 (part – I).

c) Air Content: Clause 5.6.2 of I.S. 3873 – 1978.

d) Slump: I.S. 1199 – 1959.

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

f) Making and curing concrete test specimens in the field: I.S. 516 – 1959.

g) Capping Cylindrical concrete specimens: I.S. 516 – 1959.

h) Compressive strength of concrete specimen : IS 516 – 1959.

8.2.2.5. Test Facilities: The contractor shall furnish free of cost samples of all ingredients of concrete for testing and obtain approval as 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.

8.2.2.6. Cement:

a) General:

As per clause 4 of I.S. 456 – 2000 for the purpose of those specifications, cement used shall be any of the following with the prior approval of the Engineer-In-Charge.

Ordinary Portland cement of 43 and 53 grades conforming respectively to Indian Standard, I.S. 8112 and IS 12269 is to be used.

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.

The Contractor has to make his own arrangements for procurement of cement of required specification. The co-efficient of variation in the compressive strength of cement should invariably be not more than 8%. The certified reports from

manufacturer of cement should include the test results in respect of the following data in fulfillment of the requirement of I.S. 269 – 1976.

Alkali and Chloride Levels: Indian standard requirement is that total Alkalies should not exceed 0.6 % for O.P.C. and chloride not more than 0.05 %.

Heat of Hydration: Indian standard requirement is that the head of hydration should not exceed 75 Cal / 28 days.

The Cement plants (from which the contractors procure cement) should furnish the quality characteristics data on cement supplied by them.

Sampling and testing will be done by the relevant authorities. No cement procured by the Contractor shall be used in any work until notice has been given by the engineer that the test results are satisfactory.

The contractor shall create a suitable and adequate infrastructure for handling, storing and conveying bulk cement or bagged cement procured by themselves or by the employer, with advance planning of work to be done during next seven days, as approved by the Engineer. Cement shall be stored above the ground level in perfectly dry and water tight sheds and shall go stacked not more than eight bags height. Wherever bulk storage containers are used, their capacity should be sufficient to cater to the requirements at site and should be cleaned at least once in every 3 to 4 months. Cement more than 3 months old shall invariably be tested to ascertain that it satisfies, the acceptability requirements.

b) Cement options:

Cement shall be furnished in accordance with the following options.

1. 43 grade and 53 grade ordinary Portland cement conforming I.S. 8112 and IS 12269 shall be used for all R.C.C. works.
2. Portland pozzolana cement conforming I.S. 1489 – 1976 shall be used for all works other than R.C.C. works.

c) Materials:

1. Ordinary Portland cement of 43 grade and 53 grade of IS 8112 and IS 12269
2. Portland Pozzolana cement I.S. 1480 – 1976.

d) Acceptance of Cement:

- Tested cement will be accepted by the Department (Clause of IS 8112 and IS 12269

e) Acceptance of pozzolana:

- Pozzolona added to the concrete as an admixture will be sampled and tested as per I.S. 9103 – 1979.

f) Recovery of cost cement in wasted concrete etc.,

The cost of cement used in wasted concrete, in replacement of damaged or defective concrete, in extra concrete required as a result of careless execution, and in concrete placed by the contractor in execution intentionally performed to facilitate the contractor's operations will be deducted from the payments due to the contractor.

8.2.2.7. Water:

The water used in making and curing of concrete, mortar and grout shall be free from objectionable quantities of silt, organic matter, injurious amounts of oils, acids, salts and other impurities etc., as per I.S. specifications No. 456 – 2000.

The Engineer-In-Charge will determine whether or not such quantities or impurities are objectionable.

Such determination will usually be made by comparison of compressive strength, water requirement, time of set and other properties of 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 limit for solids

1. Organic	Maximum permissible limit 200mg/ ltrs
2. Inorganic	3000 mg / litre
3. Sulphates (as SO_4)	400 mg / litre
4. Chloride (as CL)	2000 mg / litre for plain concrete work and 500 mg/ litre for R.C.C. work.
5. Suspended matter	2000 mg / litre

The PH value of the water should not be less than 6 and the acceptable range of PH value is with in 6 to 9.

If any water to be used in concrete, mortar or grout is suspected by the Engineer-In-Charge of exceeding 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.

8.2.2.8. Sand: (Fine Aggregate)

a) GENERAL: The term sand is used to designate aggregate most of which passes 5.75 millimeters I.S. Sieve and contains only so much coarse material as permitted in clause 4.3 of I.S. 383 – 1970. Sand shall be predominantly natural sand which may be supplemented with crushed sand to make up deficiencies in the natural grindings.

All sand shall be furnished by the contractor from any approved source specified in the contract.

Sand delivered to the batching plant, shall have a uniform and stable moisture content. Determination of moisture content shall be made as frequently as possible, the frequency for a given job being determined by the Engineer-In-Charge according to weather conditions (I.S. 456 – 2000)

b) Quality: The sand shall consist of clean, dense, durable, uncoated rock fragments, as per I.S. 383 – 1970.

Sand may be rejected if it fails to meet any of the following quality requirements.

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 accelerate test is specified in I.S. 2386 (Part-V) for limiting loss of weight.

Specific Gravity: 2.6 minimum

Deleterious substances:
The amounts of deleterious substances in sand shall not exceed the maximum permissible limits prescribed in table 1 clause 3.2.1 of I.S. 383-1970 (Indian Standard Specification for coarse and fine aggregates from natural sources 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.

8.2.2.9. COARSE AGGREGATE:

a) General: For the purpose of these specifications, the term "Coarse Aggregate" designate clean well graded aggregate most of which is retained on 4.75 mm I.S. sieve containing only so such finer 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 for concrete shall be furnished by the contractor from the sources specified in the lead chart forming the contract documents.

Coarse aggregate as delivered to the batching plant shall generally have uniform and stable moisture content. In case of variations, clause 9.2.3 of I.S. 456 – 2000 shall govern during batching.

b) Quality: The coarse aggregate shall consist of naturally occurring (crushed or uncrushed) stones, and shall be hard, strong durable, clear and free from veins and adherent coating, and free from infurious 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-Angeles abrasion test: The abrasion value of aggregate when tested in accordance with the method specified in I.S. 2386 (part-IV) using Los-Angeles machine shall not exceed 30 % for aggregates to be used in concrete for wearing surface and 50 % for aggregate to be used in other concrete.
2. Aggregate crushing strength test: Aggregate crushing value where 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 aggregated impact value shall not exceed 45 % by weight for aggregate used for concrete for other than wearing surfaces and 30 % by weight for concrete for wearing surfaces such as runways, roads and pavements.

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-IV) – 1963 and the average loss of weight after 5 cycles shall not exceed the limits specified in clauses 3.667 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 exceed the limits specified in Table-I of I.S. 383 – 1970 when tested in accordance with I.S. 2386 – 1963.

c) **Separation:** The coarse aggregate shall be separated into nominal sizes during production of the aggregate. Just prior to batching, the coarse aggregate shall be rewashed by pressure spray and finish screened on multi-deck vibrating screen capable of simultaneously removing undersized and over-sized aggregate from each of the nominal aggregate size. If variations in the water content of the aggregates entering the batches occur during intermittent batching then a dewatering screen will be required after the finish screens to remove the excess free moisture. Finish screens shall be mounted over the batching plant or on the ground adjacent to the batching plant. Finish screens shall be so mounted that the vibration of the screens will not be transmitted to the batching bins or scales and will not affect the accuracy of the weighing equipment in any other manner.

The method and rate of feed for finish screening shall be such that the screens will not be over loaded and will result in a finish product which meets the grading requirements of these specifications. Coarse aggregate shall be fed to the finish screens in a combination of alternations of nominal sizes which will not cause noticeable accumulation of poorly graded coarse aggregate in any bin. The finish screened aggregate shall pass directly to the individual batching bin in such a manner as to minimize breakage. Minus 2.36 mm material passing through the finish screens shall be wasted unless it is routed back through a sand classifier in a manner which causes uniform blending with the natural sand being processed. Water from finish screening shall be drained in such a manner as to prevent aggregate wash water from entering the batching bins and weighing hoppers. Washing and finish screening requirements shall be subject to approval by the Engineer – In- Charge.

Coarse aggregate for concrete shall be separated into various nominal maximum sizes specified in the relevant drawings. Separation of the coarse aggregate into the specified sizes after finish screening shall conform to the grading requirements specified in Table-2 of I.S. 383 – 1970 when tested in accordance with I.S. 2386 – (Part-I) 1963 (Method of test for aggregate for concrete Part – I particle size and shape).

Coarse aggregate for mass concrete may be separated as previously herein specified. Separation of the coarse aggregate into the various sizes shall be such that when tested in accordance with I.S. 2386 (part – I) 1963 shall conform to the requirements specified in Table-3 of I.S. 383 – 1970.

Sieves used in grading tests will be standard mesh sieves conforming to I.S. 460 (Part – I) – 1978 (Specification for test sieves Part – I wire cloth test sieves).

8.2.2.10. MIXING:

a) **General:** The concrete ingredients shall be thoroughly mixed in mechanical mixers designed to positively on sure uniform distribution of all the component materials throughout the concrete at the end of the mixing period. Mixing shall

be done as per clause 9.3 of I.S. 456 – 2000. 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 will be examined regularly by the Engineer-In-Charge for changes in conditions due to accumulation of hardened concrete or mortar or to wear of baldes. The mixing shall be continued until there is uniform distribution of the materials so that the mass is uniform in colour and consistency and to the satisfaction of the Engineer-In-Charge. If there is segregation after unloading the concrete should be remixed.

Any mixer, that at anytime produces unsatisfactory mix, shall not be used until repaired. If repair attempts are unsuccessful, a defective mixer shall be replaced. Botch size shall be at least 10 % of, but not in excess of the rated capacity of the mixer unless other wise authorized by the Engineer-In-Charge.

8.3. PREPARATION OF SUB-GRADE FOR C.C. LINING (I.S. CODES: 2720.4701. 3873)

8.3.1 Preparation Of Sub grade

Preparation of sub-grade is a factor on which depends much of the successfully performance of lining. Failure or cracking of lining in many cases can be attributed in some measure to poor preparation of sub-grade. Due stress is therefore to be laid on control and proper preparation of sub grade for lining. Sub-grade indifferent soil reaches shall be prepared based on IS : 3873-1966.

8.3.1.1 Preparation of Sub-grade consisting of Earth:

The sub-grade should be prepared dressed and rolled true to level according to the required cross-section of the canal to form a firm compacted bed for the lining. Sample profiles true to the cross section of the canal should be made at suitable intervals to ensure correct formation of the sub grade. If at any point material of sub-grade has been excavated beyond the neat lines required to receive lining. The excess excavation should be filled with material compatible with sub-grade material and thoroughly compacted.

The consolidation of the bed in predominantly sandy reaches should be done by over saturating the bed by flooding it with water before lining is laid. The consolidation of sides in such reaches should be done by over cutting the sub-grade by 15 cm and re-filling it with sand concrete with adequate quantities of cement or by vibro-compactors. The relative density of the compacted sub-grade shall be at-least 70%..

All compaction in other than predominantly sandy reaches should be done at optimum moisture content in layers not more than 15 cm thick to obtain a dry bulk density of not less than 95 percent of the density at optimum moisture content compaction of sub-grade, depending upon the position of sub-soil water level shall be carried out in accordance with I.S: 3873-1966 and by employing Nuclear gauges. (In-situ cement concrete lining in canals)

8.3.1.2 Sub-grade Density and Moisture Control:

A sound dense earth foundation, carefully trimmed and pre-moistened before lining placement are critical steps, prerequisite to a good lining construction. Required foundation density of embankment and preparation coupled with moisture control are the key requirement. At the time, concrete is placed the sub-grade is required to be thoroughly moist (but not muddy) for a depth of about 12 to 15 cms and 20 to 22 cm in case of sand as else the concrete would extract moisture from the sub-grade. Compliance of these requirements must be recorded by the QC staff in the OK card. Photographic record showing the actual use of very fine spray nozzles instead of hose (for moistening the compacted sub-grade) should also be kept.

8.3.1.3 Preparation of Sub-grade consisting of Rock:

The Sub-grade should be prepared and dressed true to level and according to the required cross-section of the canal. All excavation including over breakage below lines of under side of lining should be filled completely up to the lines of the under side of lining with suitable material. viz. spalls. lean concrete or sand compacted to density equivalent to sub-grade. Care should be exercised in selecting refill material for use over fractured rock of rubbles because of the danger of washing of fines into the sub-grade voids and thus loosing support.

8.3.1.4 Preparation of sub grade consisting of Expansive Soils (IS: 9451-1994)

(a) Field and laboratory experiments shall be carried out to determine the physical,

textural, Engineering and Chemical properties of the black cotton soils/expansive soils and evaluate the swelling pressures of soils in various reaches to establish the thickness of CNS layer required so that the resulting deformation is within the permissible limit.

In respect of the provision of CNS layer in the bed. it shall be as worked out from the consideration of swelling pressure. However the thickness of CNS layer to be provided on slopes shall in addition, be governed by the construction considerations viz., from rollable width consideration for achieving effective compaction.

(b) Thickness of C.N.S Layer:

The samples of in-situ expansive soils in bed and side of canals are to be collected. Necessary tests are to be conducted for swell pressure in addition to differential free-swell index, by R.K. Katti's method and thickness of CNS layer has to be decided depending upon the carrying capacity of canal for balancing the swell pressure as per the values furnished in the table given below as per I.S. 9451-1994.

IS 9451 – 1994 specifies thickness of CNS soils to be placed depending upon the swelling pressures of B.C. soil and carrying capacity of canal as has been listed in the tables I & II (on Page 49)i.e. Thickness of CNS layer. Also the CNS material shall be laid and compacted to 0.45m beyond the finished profile (wherever directed by the Engineer). This will provide a horizontal width of about 2.25m corresponding to the canal slope of 1.5:1 which is the optimum width required for compaction by power driven 8 T to 1O T rollers. The extra width so laid shall be trimmed to the required profile. Sketch B and Annexure II is enclosed in Page 54 and 55

8.3.1.5. Specification of CNS Soil

(i) Gradation of C.N.S. Soil

1. Clay (less than 2 microns) - 15 to 20%
2. Silt (0.06 mm - 0.002 mm) - 30 to 40%
3. Sand (2mm - 0.06 mm) - 30 to 40%
4. Gravel (Greater than 2 mm) - 0 to 10%

(ii) The CNS material shall be non-swelling. with a maximum swelling pressure of 10 KN/m^2 when tested in accordance with IS 2720 (Part-41) - 1977 at field moisture content over dry condition and minimum cohesion.

(iii) Index Properties:

1. Liquid Limit less than 50% but greater than 30%.
2. Plasticity Index less than 30% but greater than 15%

8.3.1.6 CNS Treatment:

- Identifying parts of canals where expansive soils are met with through laboratory tests to decide if CNS treatment is required.
- To identify quarries where CNS soils are available and confirm suitability through laboratory tests on samples taken from various parts of the quarry to satisfy the representative ness.
- To go though all the Q.C. operations narrated in banking part above.

8.3.1.7 Specification of CNS Soils:

(i) Index properties

< 50% but > 30%

P.I. < 30% but > 15%

(ii) Gradation: Clay 15% to 20%
(less than 2 microns)

Silt 30% to 40%

(0.06 mm – 0.002mm)

Sand 30% to 40%

(2 mm – 0.06 mm)
Gravel 0% to 10%
(2 mm)

(iii) The CNS material shall be non-swelling, with a maximum swelling pressure of 10 KN/m^2 when tested in accordance with I.S: 2720 (Part 41) – 1977 at field moisture content over dry condition and minimum cohesion.

Table – I Thickness of CNS Layer, Carrying Capacity less than 2 cumecs

Discharge is cumecs	Thickness of CNS layer in cm	
	Swell pressure 50-150 KN/m^2	Pressure more than 150 KN/m^2
1.40 – 2.00	60	75
0.70 – 1.40	50	60
0.30 – 0.70	40	50
0.03 – 0.30	30	40

Table – II Thickness of CNS Layer, Carrying Capacity of 2 cumecs and more

Swelling pressure of soil KN/m^2	**Thickness of CNS Materials Cm (min)**
50 to 150	75
50 to 300	85
300 to 500	100

Note: However, optimum thickness of CNS materials needs to be determined for different swelling pressures by actual experiments in both in field and laboratory if required.

Sub grade preparation – tolerances: Tolerances in the preparation of sub-grade should be limited to the following values.

a) 6.25 mm for sub-grade in bed
b) 12.50mm for sub-grade in the side slopes.

8.3.1.8. CNS Soils:

DO'S	DO NOTS
1. Check the model section to the canal profile i.e.. bottom or lining.	1. Do not allow concrete lining on loose sub-grade.
2. Check the canal profile with reference to model sections.	2. Do not allow any root or stumps to be on sub-grade.
3. Remove roots and stumps completely from the sub-grade.	3. Do not allow lining in expansive soils without treatment with C.N.S. soils.
4. Compact over-excavation in soils with gravel duly wetted.	4. Do not place the porous plug below the surface of the lining.
5. Compact over excavation in rocky area with gravel spalls and aggregate spalls and aggregate duly wetted.	5. Do not allow lining without wetting the sub-grade suitably.
6. Provide treatment with C.N.S. soils in expansive soils i.e., 0.6 mtrs., thick for discharge up to 50 cusecs.	
7. Provide porous plugs of size 375 mm long x 100 mm dia in each panel with local filters of graded metal and sand size 600 x 600 x 750 mm.	
8. Provide longitudinal and transverse drain of size 600 x 750 mm filled up with graded metal and sand as per drawing.	
9. Check whether porous plugs are freely draining or not.	
10. Note down December water table for providing longitudinal drains and other relief measures (as per drawing)	

8.3.1.9 Placing Concrete for Lining:

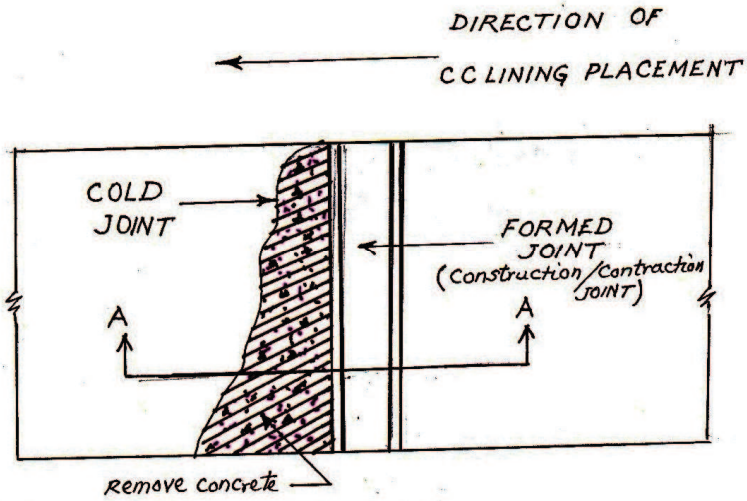
Canal lining in concrete shall be constructed in the canal prism as shown in the drawings. The contractor shall not place concrete for canal lining during rains.

Before placing the concrete for lining canals, the earth work shall be completed to sub-grade and the foundation shall be trimmed as explained under preparation of sub-grade. Concrete in canal lining shall conform to clause 9.6.2 in this chapter. The mixing and laying of concrete for lining shall be in accordance with clauses 5.4, 5.5, 5.6, 5.7, 5.8, 5.9 of IS 3873-1978.

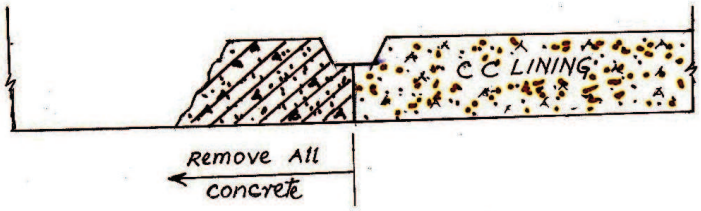
When placing of concrete for lining is stopped for the day, interrupted because of break down or delayed by other causes or where the contractor elects to construct a joint such as would result from constructing one half of the lining in one pass, the edge of the fresh concrete lining shall be bulk headed to a surface normal to the lining along transverse or longitudinal lines. Before placing operations are resumed, the surface of the hardened concrete shall be prepared as construction joint.

The fresh concrete shall then be placed against the existing concrete with the full groove for required contraction joint formed in between them. The completed groove shall be sealed with sealing compounds as per clause 6.3 of IS 3878-1978. Where concrete lining joints a structure, sponge rubber filler and sealing compound shall be placed as shown on the drawings. Refer sketch “C” for illustration and guidance

SKETCH C



PLAN



SECTION A-A

ELIMINATION OF COLD JOINTS IN LINING DURING CONCRETING

8.3.1.10. Contracting joints for concrete lining:

General: Joint shall be constructed in concrete lining as shown in the drawing and shall conform to clause 6.2, 6.2.1, 6.2.2, 6.3, 6.3.1 and of IS 3873-1978. The joint shall be made along straight lines to the detailed dimensions shown in the drawings and shall be maintained to the required shape and dimensions during any subsequent finishing operation until the concrete has hardened.

Joints shall be continuous across and along the canal section. Transverse contraction joints shall be terminated at the top of the side slopes and a 20mm minimum depth grooved shall be tooled across the concrete curb from the end of each transverse joints. No filler or scalar will be required for these tooled grooves.

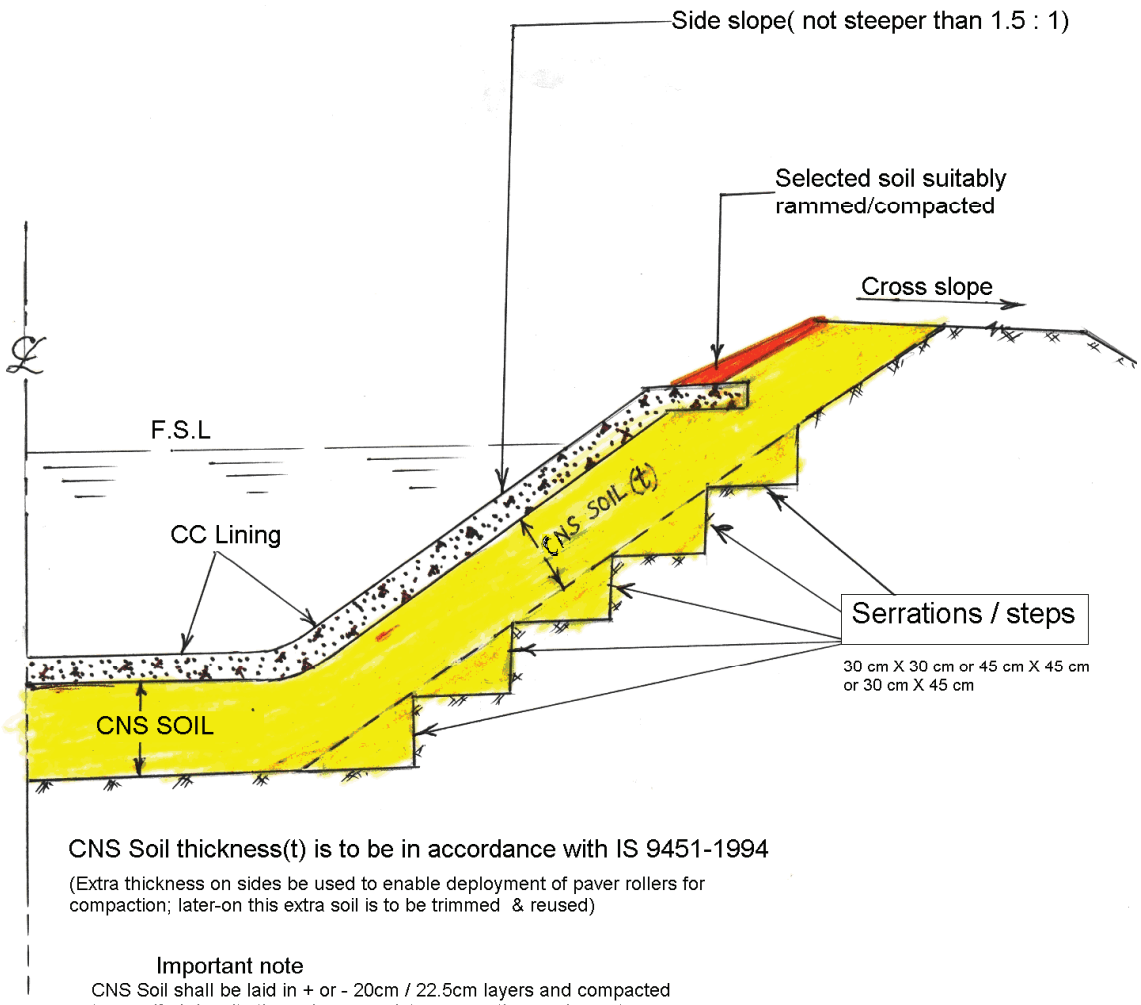
To facilitate special condition at structures and where concrete lining placing operations are stopped for the day, interrupted because of break down or delayed by other causes, transverse contraction joints may be placed at spacing shown on the drawings. The spacing shall not be less than one half of the spacing shown on the drawings.

8.3.1.11 C.C. Lining:

DO's	DO NOTS
1. Check the canal prism and verify the bed levels.	1. Do not allow the concrete Over loose sub grade.
2. Check the gradation analysis of fine and coarse aggregate to the requirement of mix at batching plant.	2. Do not allow lining without wetting sub. grade.
3. Allow the ingredients of fine and coarse aggregate as per required mix by weigh batching.	3. Do not allow C.C. lining manually without vibration.
4. Check the calibration of weighing machine at batching plant.	4. Do not allow segregation of concrete while laying through discharge conveyor.
5. Check the water meter and its discharge.	5. Do not allow concrete directly on sub grade from transit mixer.
6. Check the batch of cement, its make and test results.	6. Do not form contraction joints over longitudinal drains.
7. Check the water cement ratio and record the slump.	7. Do not fill up contraction joints with sealing compound without cleaning with air water jet or sand blast.
8. Check whether any retarders and air entraining agents are added.	8. Do not allow any projections or contraction joint over the surface of the lining.
9. Maintain load register.	9. Do not allow the C.C. lining without applying suitable primer to sides.
10. Record the No. of CC cubes cast and its compressive strength.	10. Do not remove the channels immediately before setting of C.C.
11. Cure CC Lining with water for 28 days	11. Do not use untested cement.
12. Ensure smooth surface with paver roller passes	12. Do not allow to sink the porous plugs in the drains.
13. Form the contraction and construction joints as per approved drawing.	13. Do not allow lining without making proper arrangements for curing with water.
14. Check the thickness of C.C.Lining for each panels.	14. The Co-efficient of variation in the compressive strength of cement should not be more than 8 %.
15. Checking placing of mastic pad at structures of construction joints.	

16. Allow concrete lining at temperature between 15°C and 32°C.	
17. Check periodically the coefficient of variation in the compressive strength of cement.	
18. The batching plant to be used shall confirmed to the required of IS 4925-1968.	

SKETCH- B



CNS Soil thickness(t) is to be in accordance with IS 9451-1994

(Extra thickness on sides be used to enable deployment of paver rollers for compaction; later-on this extra soil is to be trimmed & reused)

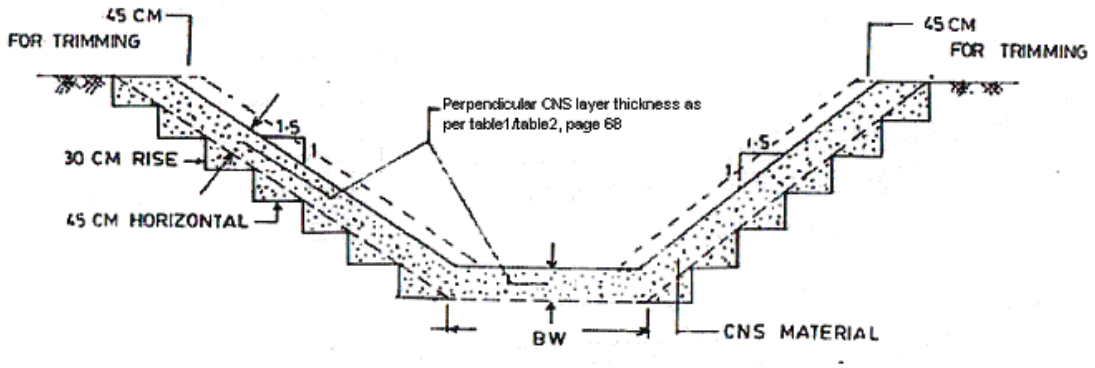
Important note

CNS Soil shall be laid in + or - 20cm / 22.5cm layers and compacted to specifed density through appropriate compaction equipment

CNS Treatment to sub-grade in swelling BC soils for Placement of CC Lining

ANNEXURE - II

TREATMENT OF CANAL PRISM IN EXPANSIVE SOILS WITH CNS MATERIALS



30 to 75 cm thick for less than 2 cumecs canal discharges (Based on swell pressure as per Table –I page 68).
75 to 100mm thick for more than 2 cumecs canal discharge (based on the swell pressures as per Table – II page 68).
CNS material shall be laid in layers and each layer shall be compacted to the specified density.

8.4. CONCRETE (IS CODES 383.269.2116.2386.456.516. 1199.3878.9103)

CONSTRUCTION JOINTS & TECHNIQUE OF GREEN CUTTING

8.4.1. Construction Joints:

Concrete shall be placed in massive structures in lifts which are generally 1.5 m high. To develop proper bond between the lifts the concrete surface shall be free of all laitance, coating stains, defective concrete and all foreign material and the surface shall be roughened. This can be achieved by green-cutting.

8.4.1.1 Green Cutting:

The surface of the joint shall be thoroughly green-cut with an air-water jet. Green cutting is usually done 8 to 12 hours after the top surface of a concrete lift has been completed and sufficiently hardened. The actual time for taking up the green cutting operation shall depend upon the following factors:

a) Concrete placement temperature
b) Atmospheric temperature
c) Concrete mix: and
d) Slump

The air-water jet will remove the thin surface film of laitance and grout to expose clean surface.

8.4.1.2 Green Cutting If Done At The Proper Time, Shall Yield Very Good Results :

When started too early, it shall result in over-cutting and removing too much mortar. It is also liable to loose the aggregate particle and leaving too poor a surface to bind the fresh concrete. On the other hand. if green-cutting is delayed too long, the cutting action of the air and water jet would be ineffective for proper removal of laitance. It therefore requires much greater care and judgment for proper use at the proper time.

8.4.1.3 Skill Of Jet Operator

Besides determining the proper time for initiating green-cutting the process will require constant attention on the part of the air-water jet operator. By correct manipulation of the high velocity air-water jet a trained operator can ensure the removal of the thin surface film of laitance and grout effectively and at the same time leaving the aggregate stones already embedded in the mortar, undisturbed.

8.4.1.4 Proper Air-Water Gun

In addition to the skill of the jet operator a proper air-water gun is also a vital requirement for effective green-cutting. The issuing nozzle must be about 460 mm (18 inches) long to ensure the requisite cutting force close to the concrete surface. A dimensioned sketch of an air-water gun is enclosed as Annexure - III.

8.4.1.5 Quantum Of Compressed Air And Water:

For effective green-cutting, it is essential that the air pressure should be around 6.33 to 7.03 kg/cm2 (90 to 100 lbs. Per square inch.) It should not be allowed to fall below 90 lbs per square inch. The water pressure, of course, should be sufficient to bring the water into effective influence of the air pressure. As an approximate estimate the quantity of compressed air required by the green cutting gun is 2 cubic meters per minute (70 dm) and the ,quantity of water 60 gallons (273 liters) per minute.

8.4.1.6 Sand Blasting:

Sand blasting is the process of roughening and cleaning the surface of old and set

concrete by means of coarse sand and air applied under pressure of 90 to 100 pounds per square inch (6.33 to *7.03* kilograms per square centimeter) through a nozzle so as to erode the laitance and grout from the old and fresh concretes monolithic. Sand blasting of rock is also done so that concrete may be placed on or against a clean surface as required according to specifications.

There are two types of sand blasting. namely "wet sand blasting" and "dry sand blasting". In wet sand blasting water is also used along with sand and air under pressure. while in the latter. only sand and air under pressure are used. Normally the concrete and rock surface etc.. are wet sand blasted to keep down the dust.

The percentages of different sizes of sand particles for efficient Sand blasting shall be as follows :

Size	Percentage
8 mesh per inch (25.40 millimeters)....	26
16 mesh per inch (25.40 millimeters).....	30
30 mesh per inch (25.40 millimeters)...	23
50 mesh per inch (25.40 millimeters)....	21

for effective sand blasting it is essential that pressure of air should be between 90 to 100 pounds per square inch (6.33 to 7.03 kilograms per square centimeter). If pressure falls below 90 pounds per square inch (6.33 kilograms per square centimeter). sand blasting becomes ineffective. If sand having large percentage of fines is used, it will not provide the requisite cutting power and the whole effort goes waste. A good quality well graded "sand-blast sand" is needed for achieving the objective of sand blasting.

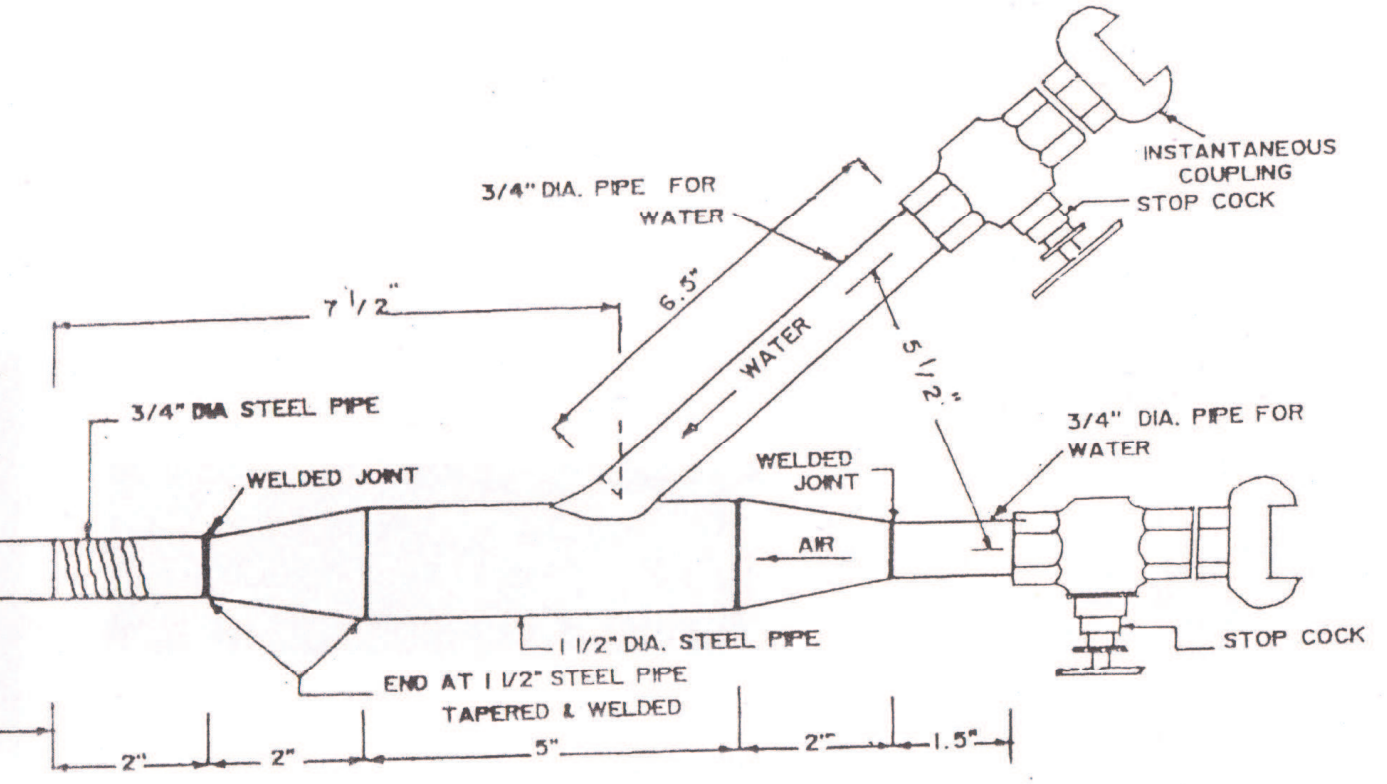
8.4.1.7. Admixtures :

In Gorakallu Bypass Syphon Structure. with heavy congested reinforcement and poor accessibility pumping of concrete becomes inevitable and takes longer time without the process of pumping. The concrete mix for the above is to be designed with high workability. The slump of 60 mm specified in the agreement is not at all sufficient. Further at high cement air entrained concrete becomes sticky and difficult to flush. But as per A C I report concrete with a slump greater than 190 mm that remains cohesive without excessive bleeding and segregation or abnormal retardation is known as flowing concrete. Flowing concrete is useful for pumping because it reduces pumping pressure and increases both the rate and distance that the concrete can be pumped.

For pipe about 150 Cum of concrete per day is to be laid at difficult placement conditions. To produce flowing self compacting concrete without losing the required strength and with reduction in usage of free water content. Super-plasticizers available in market are used with a slump of 150 mm.

With the usage of Super-plasticizers in the pipe concrete the workability of concrete is considerably increased and the period of time that the concrete is to be placed and compacted is well sufficient. The surface finish of the concrete is very smooth without honey-combing. The concrete produced with the usage of Super-plasticizers is dense and impermeable.

Annexure - III



AIR - WATER GUN

8.5) SHOT - CRETING

Specifications & Procedure of Application.

8.5.1. Materials for Shot creting :

Cement, sand, coarse aggregate, water and admixtures are used in the shot – crete mix. Ordinary Portland Cement, 43 Grade or 53 Grade will be used.

8.5.1.1 Sand: Well graded sand as per either of the following grading can be used.

SAND

Sieve Designation	Percentage by mass passing for	
	Grading – I	Grading - II
10 mm	100	100
4.75 mm	90 – 100	90 – 100
2.36 mm	75 – 100	85 – 100
1.18 mm	55 – 90	75 – 100
600 micron	35 – 59	60 – 79
300 micron	8 – 30	12 – 40
150 micron	0 - 10	0 - 10

Sand should be free from deleterious substances and organic impurities.

8.5.1.2. Coarse Aggregate:

The maximum size of coarse aggregate should be restricted to 10 mm. It should be free from impurities, clay / shale particles, and conform to the requirements of impact, abrasion, and crushing criteria (viz less than 45 %) and the soundness acceptance criteria (less than 12 % with sodium sulphate method). It should have a specific gravity of not less than 2.6. The aggregate should be well graded and should broadly conform to the following grading.

Sieve Designation	Percentage by mass passing for aggregate of 10 mm maxim. Size.
12.5 mm	100
10 mm	85 – 100
4.75 mm	10 – 30
2.36 mm	0 – 10
1.18 mm	0 – 5

8.5.1.3. Water: Ordinary potable water with pH value not less than 6 and not more than 8.5 will be used.

8.5.1.4. Chemical Additives:

The following additives be used in the concrete mix in the 'Dry Mix Process' of shot creting.

- Sodium Carbonate = ½ Kg per 50 Kg bag of cement
- Sodium Aluminate = ½ Kg per 50 Kg bag of cement
- Calcium Carbonate = 1 Kg per 50 Kg bag of cement

Total	=	2 Kg per 50 Kg bag of cement Viz 4 % by weight of Cement

Alternatively, following additives can be used:

- Super plasticizer @ 1 % by weight of cement viz 4.5 Kg of super plasticizer for 450 Kg cement to be used in the mix.
- Accelerator (say sodium Silicate) @ 5 % by weight of cement Viz. 22.5 Kg for 450 Kg cement to be used in the mix.

8.5.1.5. Air Supply:

Properly operating air compressor is essential for a satisfactory shot creating operation. The compressor should be fitted with a moisture extractor to deliver clean and dry air. For hose length of up to 30 m, air pressure at the nozzle should be 0.3 N / mm^2 or more.

8.5.1.6 Water supply:

The water pressure at the discharge nozzle should be sufficiently greater than the operating air pressure to ensure that the water is intimately mixed with the other material.

Properly applied Shot Crete is a structurally adequate and durable material capable of excellent bond with concrete as well as masonry.

8.5.1.7. Shot –Crete Mix:

The water – cement ratio should be maintained within the range of 0.40 to 0.50 by mass. The mix should have a 28 day characteristic compressive strength of not less than 200 Kg / cm2 though strength of 250 kg / cm2 would be preferable. Normally the following mix proportions would be adequate.

Cement	=	450 kg / m^3
Sand	=	1100 kg / m^3 (0.70 m^3)
Coarse aggregate (5 mm – 10 mm size)	=	500 Kg/M^3 (0.30 M^3)
Proportioning of mix	=	1:2.44:1.11

8.5.1.8 Application of Shot Crete: Following guidelines and sequence will be followed:

1. All unsound and deteriorated concrete be removed and chipping done, wherever necessary, or sand blasting done.
2. Exposed reinforcement bars be cleaned free of rust / scales. Additional reinforcement be provided if and as warranted.
3. Ensure sufficient clearance around the reinforcement to permit complete encasement with sound shot crete. A clearance of at least 50 mm should be provided.
4. Air – water jet be applied for final clean – up of the surface. Spray pneumatically the first layer of shot crete of about 38 mm thickness (hollow pockets) will consume more shot crete).
5. Next "Welded wire mesh of size 100 mm x 100 mm x 5 mm" be nailed, butting with shot crete. Binding wire of 20 gauge or 24 gauge be used for binding of wire mesh panels.
6. The second and final layer of shot crete of thickness ± 38 mm be than pneumatically sprayed over the first layer. The finished shot crete surface should be kept continuously wet (viz. cured) for at least 7 days. Alternately, 'membrane –forming chemical curing compound' be used for curing. A re-bound of 25 % to 30 % would occur and the re-bounded material is not to be re-used in the shot crete mix.

8.5.1.9. Quality Control of Shot - Creting

The shot creting operation should be continuously inspected by the engineers who should check the materials, concrete mix, shot creting equipment, application of shot crete, and

curing. The finished surface should be sounded with a hammer for detection of any hollow pockets due to lack of bond. Such hollow pockets or other defects are required to be carefully cut out and replaced with the new shot crete layer. The first layer is also to be sounded with a hammer and remedial action taken for any hollow pockets before commencing the application of the final layer.

8.6 - GUNITING ON THE UPSTREAM FACE OF MASONRY DAM
(50mm thick gunite in 1:3 cement sand mortar)

8.6.1. Scope
These specifications cover, in general, all the materials, and the methods and workmanship for providing a 50mm. thick guniting on the upstream face of masonry dam including preparation, providing and fixing reinforcement fabric, placing gunite finishing and curing.

8.6.2 Materials
The cement shall be ordinary portland cement conforming to I.S 8112: 1989 or I.S. 12269 : 1987, for use in massive structures.

The sand shall consist of natural sand and shall be strong, hard, coarse, sharp, chemically inert, clean and free from any coatings, organic or any other impurities that may impair the strength or durability of the gunite mortar and shall conform to I.S. 1542. It shall be well graded and particles shall range in size within the limits as specified in the latest relevant I.S. specifications. The fineness modules shall be between 2.4 to 2.8. The sand shall be screened and thoroughly washed so as to remove all earthy impurities and shall be dry before being used for the mix.

The steel reinforcement where used, shall be of hard drawn steel wire fabric of mesh size 150 mm x 150mm formed of 3.15 mm. dia. steel wires, conforming to I.S. 1566. The mild steel rod to be used as dowels or nails for anchoring the I.R.C. fabric shall conform to I.S. 432. The steel shall be free from loose mild scale, rust, oil, grease and other deleterious matter, before being placing in-situ.

The water proofing compound shall be of approved quality conforming to I.S. 2645.

The water for mixing the grout shall be clean and free from earth, organic matter, acids and alkaline substances in solution or in suspension, with the turbidity within permissible limits.

8.6.3. Preparation Of Surface For Guniting
The masonry surface where guniting is required to be done shall be made rough by chipping and raking out mortar joint deep or as directed by the Engineer-in-Charge. Chipping shall be done by using pneumatic chippers or manually by using chisels and hammers. After roughening the surface and raking of joints, the face shall be cleaned and washed by air and water jets under pressure. It shall be ascertained that no loose material, dirt, etc., is left on the face.

8.6.4. Fixing Reinforcement
10mm dia. M.S. rods are to be securely fixed in masonry or concrete at 1m intervals both horizontally and vertically to a minimum depth of 225mm. either by drilling holes or any other approved method. After the rods are fixed, the hard drawn steel wire fabric reinforcement is to be securely tied to these rods by using binding wire of approved quality. The minimum space of 20 mm, is to be maintained between the surface of the Dam and the fabric reinforcement. The adjacent sheets of wire fabric both horizontally and vertically shall be lapped at least 150mm. and firmly tied together with the binding wire of approved gauge. There should be at least 20mm. cover for the anchor rods.

Suitable additional anchor bars shall be provided at proper intervals, if necessary, for taking the thickness of guniting work to be done.

8.6.5. Composition And Mixing Of Gunite

The average thickness of guniting shall be 50mm. Gunite shall consist of an intimate mixture of ordinary portland cement, dry sand fly ash (Where used) and approved water proofing agent, by weight, 1½ Kgs. of water proofing compound is to be added for 50 Kgs. of cement. All the ingredients shall be thoroughly mixed by machine mixing before feeding into the guniting machine. Hand mixing will not be generally permitted unless special approval is accorded.

The mixing operation shall continue for not less than 1 ½ minutes after all the ingredients have been placed in the mixer. Hand mixing, if permitted, shall be thorough and should be done on a clean and water tight floor. The water content shall be regulated so that the mix is elastic enough to give good compaction and a low percentage of rebound and stiff enough not to sag.

8.6.6. Placing Of Gunite

The equipment used for guniting shall be capable of discharging the sand-cement mixture into the delivery hose under close control and it should deliver a continuous smooth stream of uniformly mixed materials at the proper velocity to the nozzle. The discharge nozzle shall be equipped with a manually operated water injection system for directing an even distribution of water through the sand-cement mixture. The water valve shall be capable of ready adjustment to vary the quantity of water and shall be located convenient to the nozzle operator. A nozzle velocity of about 150 m/sec is preferable.

The required layer of gunite is to be built up by making several passes of the nozzle over the working area. The gunite shall emerge from the nozzle in a steady stream. If the flow becomes intermittent, the nozzle shall be directed away from the face. The nozzle shall be held at a distance of about one metre and shall be perpendicular to the application surface, except when guniting through reinforcing bars, the nozzle shall be held close and at a slight angle to permit better encasement and facilitate removal of rebound. Special care shall be taken to ensure that no loose material is left behind the reinforcement bars. Corners, re-entrant surfaces and pockets shall be filled first. The gunite shall be applied in thick layers normally 12mm (½") thickness or as directed by the Engineer-in-Charge under a pressure of 5 to 7 Kg/cm2.

When the work is to be suspended at the end of the day or otherwise, the gunite shall be tapered, where practicable, to a thin edge over a width of 30cm. Before work is resumed, the surface of the gunite upon or against which fresh gunite is to be placed shall be thoroughly cleaned, and roughened and shall be wetted to ensure adequate bond between old and new gunites. The contractor shall take such preventive measures as the Engineer may consider to prevent injury to or the formation of objectionable coatings on completed gunite surfaces by particles, dust or rebound from subsequent guniting operation.

Materials which rebound and drop down, shall in no case be re-used and must be immediately removed and disposed off. The guniting shall be done in such a manner that waste of cement due to rebound is minimum. In any case, the consumption of cement shall not normally exceed 50Kgs. per sq.m. of gunited surface.

The natural gun finish is preferable but when greater smoothness is desired, a fresh coat containing fine sand shall be applied.

During the period immediately followed by the placing of the gunite, the gunite shall be protected against injury from any cause which in the opinion of the Executive Engineer might result in weakening the bond between gunite and the surface to which it is applied or in

otherwise injuring the gunite. As soon as the gunite is set, it shall be properly cured and protected.

After completing the guniting and after the mix is set, the surface should be thoroughly sounded by a hammer for drumming areas resulting from rebound pockets or lack of bond, etc., which should be cut out and replaced to the entire satisfaction of the Engineer. Any guniting which is damaged or found to be defective any time before completion or acceptance of the work shall be replaced.

8.7) GROUTING

8.7.1. Foundation Grouting/Curtain Grouting

Pressure Grouting of rock foundations shall broadly follow the procedures outlined in Indian Standard Specifications: 1.5. 6066 : 1994 (Second Revision) and Indian Standard Specifications 1.5. 11293 (Part 2) 1994.

8.7.2. Drilling:

a) The actual locations spacing direction and depth of grout holes however will depend on the nature of the rock the results of water pressure of other test core drilling and results of the actual grouting shall be as directed by the Engineer. The order in which the holes are drilled and the manner in which each hole is drilled and grouted the proportions of cement and water used in grout, the type and quantity of admixtures used, the time of grouting the pressure used in grouting, the depth at which packers are to be fixed and all other details of the grouting operations shall be recorded. Each grout hole shall be water tested and grouted in sections or stages located between depths in the hole best suited to treat the geological defects of the foundations as determined are to be recorded. For curtain grouting below the earth dam the grout holes may be drilled using either diamond or percussion drilling at the convenience at site. When percussion drills are used the holes shall be cleared carefully. However for areas like fault zones etc.. the method of drilling shall be as per specifications. The minimum diameter of each grout hole shall not be less than that produced by the appropriate commercial standard drill bit.

b) Holes shall be drilled vertically or at an inclination to the vertical or as required by site conditions. Exploratory holes shall not deviate from the required direction by more than 1 percent of the length of the hole as measured at the point of maximum penetration.

c) On completion of drilling. the holes shall be immediately capped or plugged with wooden plug or steel caps and shall be protected from entry of dirt,. muck. grout water or any kind of waste drilled holes or portion of holes shall not be left ungrouted for a long time.

d) All holes remaining open on completion of work shall be back-filled with grout.

8.7.3. Core Drilling

All core drilling shall be performed with rotary type hydraulic feed core drilling equipment using bottom discharge diamond bits and triple tube, swivel inner tube type core barrels and shall include washing of holes with air and water under required pressures, taking permeability tests at specified pressures. The log should include the following data.

1. Location
2. Bore Hole
3. Type and diameter of holes
4. Ground Level
5. Immediate, intermediate and equilibrium water levels with times and dates, note on colour and losses.
6. Description and state of weathering of rock and the levels of its boundaries.
7. Percentage core recovery.
8. Rock quality designation percentage.

9. Type of core barrels used.
10. A record on progress of drilling, rate of penetration, type of bit etc.
11. Water pressure test results.
12. Special observations, If any.
13. Date of starting and completion. Strong 1.05m long teak wood core boxes as per IS : 40781980 should be used for preservation of core recovered.

Cleaning Of holes

Before grouting and when a suitable small group of holes have been drilled, all but three holes (consecutive or as otherwise considered suitable for the purpose of cleaning and more or less than three holes as may be required) shall be closed temporarily at the surface. Water and air shall be pumped under pressure as per standards into two holes and allowed to escape from the third until all possible loose materials and mud etc., has been washed out of communicating seems or other passage ways, if any. Combination of three holes at a time shall thus be cleaned before applying any grout into the holes. Suitable valves shall be used to permit alternate or continuous injection of air and water and for quickly switching the flow from one hole to the other so as to produce the turbulent action necessary to dislodge the softer material, if any. Water will be connected to one hole and air to the other which shall be an adjoining hole. The water and air connections shall be interchanged at frequent intervals to cause water to flow in every possible direction. The operation should be continued till reasonably clear water emerges out of the holes.

Pressure Testing holes

When during drilling, abnormal gain or loss of drill water is observed or caving of the hole occurs or the bit and drill rod falls through an open-crack of cavity or when unusually low recovery is obtained drilling shall be discontinued and the hole shall be water tested. Water testing in about 20 percent of consolidation grouting holes shall be required to be done for entire test holes.

A record of the time, pressures and quantities of water used for testing a section of a hole shall be maintained. The pressure testing apparatus shall be calibrated before use and shall be periodically tested for accuracy and satisfactory operation.

The existing water level in the hole to be tested shall be established and recorded before commencement of pressure testing. The pressure test shall be performed in one continuous operation using the following steps of pressures and times.

Step No.		Pressure (P)	Elapsed time minutes.
1 P1	=	1/3 R3	5
2 P2	=	2/3 P3	5
3 P3	=	Prescribed Grouting	10
4 P4	=	2/3 P3	5
5 P5	=	1/3 P3	5

The pressure for step number three shall be equal to the grouting pressure for the stage.

Pressure Grouting

Drilling and grouting holes for curtain grouting shall be done using the split spacing method. Stage and packer grouting shall be used and drilling and grouting shall be performed in successive operations. In stage grouting, the hole will be drilled to a limited depth, pressure tested and then grouted at that depth. After the hole has refused grouting (to the extent specified herein after) it shall be flushed out before the grout in the hole has set sufficiently to require re-drilling. After the

grout surrounding the grouting hole has set, the hole shall be water pressure tested and may be regrouted, if considered necessary. Thereafter successively deeper stages shall be drilled. grouted and tested at increasing water pressure, until the required depth of the hole is completely drilled and grouted. Each stage shall during these operations be isolated from the previous stage by a packer provided at the bottom of the previous stage.

The curtain grouting will be done to achieve permeability values of 5.0 lugeon or less in the foundation rock. The function of curtain grouting is to provide extremely effective barrier to seepage and in this context the post grouting permeability value should not be more than 5.0 lugeon. The lugeon co-efficient of 1 is approximately equivalent to a permeability of 10 cm/sec. (Water loss is expressed in lugeon and 1 lugeon denotes a water loss of 1 liter per metre depth of hole per minute at a pressure of 10 kg/cm in accordance with IS : 6066.1971). Additional holes at closer spacing shall be drilled and grouted wherever so warranted till the test holes drilled midway between the grouted secondary territory holes indicate through permeability test a value of 5 lugeons.

Grout mixes usability shall range between 10:1 and 0.5:1 by volume. No grout hole or grout connection shall be grouted unless otherwise specified until all *concrete* required within a radius of 60 metres has been placed set and properly cured.

Back Fill Grouting Of Over Concrete In Tunnel And Test Grouting:
Back fill grouting between the rock and over concrete lining is essentially required to fill any voids/gaps/cavities left after the placement of final concrete lining and gaps due to shrinkage of concrete. The concrete lining is to be carried out through pump crete. The portion below springing level gets filled up through gravity but there are chances of gaps being left in the portion above the springing level, especially near the crown. The grouting of the crown above the springing level has to be done to ensure complete interaction between the concrete lining and the rock. The contact grouting is also expected to make it more competent to carry external loads.

Grouting Procedure:
(1) This includes embedment of 75 mm dia grout holes prior to concrete placement in the overt (ii) fixing the pattern and drilling of grout holes (iii) Preparation of grout mix (iv) Fixation of sequence of grouting operations.

The entire grouting procedure is to confirm 1.5.: 587H-1972 (Part VII) and to be arrived in consultation with the Geologist. Subject to the Geologist the following may be adopted.

Particulars	Normal Reaches	Poor/High over Break Reaches
Depth of holes in rock	0.9 M	1.5 M
Slicing	3.0 M	3.0 M
Grout pressure	2.1 kg/M2	3.5 Kg/M2

Test Grouting:
Test grouting of at least 10% of the holes already grouted shall be carried out to ensure that no gap/void/cavity remains unfilled. The holes with high consumption of grout during initial grouting and those with high water intake but less consumption of grout shall be specially included for test grouting along with other holes.

Daily Records Of Grouting Operations:
Daily Records of grouting operations along with the approval of Engineer in charge shall be maintained as specified in I.S. Codes.

REGISTERS TO BE MAINTAINED:

1. Load Register
2. Cement Day Book
3. Sieve analysis for sand and metal
4. slump for consistency
5. compressive strength of concrete

Tests to be conducted:

1. Sieve analysis for the aggregate (field test)
2. Sieve analysis for coarse aggregate (Field test)
3. Slump test (Field test)
4. Compressive strength of concrete (Lab test).

CHAPTER – 9

FIELD TESTS

DETERMINATION OF DRY DENSITY OF SOILS IN-PLACE BY TOP CORE-CUTTER METHOD

As per I.S. 2780 (part XXIX) 1975

SCOPE:

1. This standard (Part XXIX) covers the method for the determination of the in-place density of fine-grained material and compacted soils free from aggregates using a core-cutter.

2. For the purpose of the test described in this standard, a soil shall be termed as fine-grained soil if not less than 90% of it passes a 1.75mm I.S. sieve.

APPARATUS :

1. Cylindrical core-cutter of seamless steel tube, 130mm long (see Note 1) and 10 cm internal diameter, with a wall thickness of 3mm, beveled at one end. The cutter shall be kept properly greased or oiled.

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

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

2. Steel Dolley:- 2.5 cm high and 10cm internal diameter with a wall thickness of 7.5mm with a lip to enable it to be fitted on top of the core-cutter.

3. Steel Rammer:- With solid mild steel foot 110 mm diameter and 75mm height with a concentrically screwed 25mm diameter solid mild steel staff. The over all length of the rammer including the foot wall should be approximately 900mm. The rammer (foot and staff together) should weigh approximately 9 kg. (See Fig.1)

4. Balance:- Accurate to 1 g.

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

6. Steel Rule

7. Graffing Tool or spade or pick axe.

8. Straight Edge: Steel strip about 30 cm long 2.5 cm wide and 3 to 5mm thick, with one beveled edge will be suitable.

9. Apparatus for extracting samples from the cutter:-optional.

10. Apparatus for determination of water content:- In accordance with IS:2720 (Part II) – 1973.

PROCEDURE:

1. The internal volume (Vc) of the core-cutter in cubic centimeters shall be calculated from its dimensions which shall be measured to the nearest 0.25mm.

2. The cutter shall be weighed to nearest gram (Wc).
3. A small area approximately 30cm square of the soil layer to be tested shall be exposed and leveled. The steel dolly shall be placed on top of the cutter and the patter shall rammed down vertically into the soil layer until only about 15mm of the dolly protrudes above the surface, care being taken not to rock the cutter (See Note). The cutter shall then be dug out of the low surrounding soil, care being taken to allow some soil to project from the lower end of the cutter. The ends of the soil core shall then be trimmed flat to the ends of the cutter by means of the straight edge.
   Note:- The cutting edge should be kept sharp. The cutter should not be used in stony soils.
4. The cutter containing the soil core shall be weighed to the nearest gram (Ws).
5. The soil core shall be removed from the cutter and a representative sample shall be placed in an air-tight container and its water content (w) determined as in IS:2720 (Part II) – 1973.

   Note:- It is necessary to made a number or repeat determinations (At least three) and to average results, since the dry density of the soil varies appreciably from point to point. The number of determinations should be such that an additional one would not alter the average significantly..

CALCULATIONS:

1) The bulk density Y_b; that is, the weight of the wet soil per cubic centimeter shall be calculated from the following formula:

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

Where

W_s = Weight of soil and core-cutter in g.
W_c = Weight of core-cutting in g, and
V_c = Volume of core-cutter in cm^3

2) The dry density Yd, that is, the weight of the dry soil per cubic centimeter shall be calculated from the following formula:

$$Yd = \frac{100\ Yb}{100+W} \ g/cm^3$$

Where

Yb = Bulk density (sec.4.1),
W = Water content of the soil (percent) to two significant figures

REPORTING OF RESULTS:

a) The results of the test shall be recorded in a suitable form, A recommended proforma for the record of the results of this test is given in Appendix A.
b) The following volume 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.

APPENDIX – A
(Clause 5.1)

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

The test results shall be calculated as follows:

Project: Tested By:

Location: Date:

Sl.No.	Determination No.	1	2	3
1	Weight of core-cutter wet soil (Ws), in g.			
2	Weight of core-cutter (Ws), in g.			
3	Weight of core-cutter (Wc), in g			
4	Weight of wet soil (Ws-Wc), in g			
5	Volume of core-cutter (Vc), in cm^3			
6	Bulk density Yb= (Ws-Wc)/Vc, in g/cm^3			
7	Water content container No.			
8	Weight of container with lid (W1) 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 $W = \frac{W2-W3}{W3-W1} \times 100$			
12	Dry density $Yd = \frac{100\ Yb}{100 + w}$, in g/cm^3			

SAND

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

SIEVE ANALYSIS

1) AIM : Determination 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 microns
2.36 mm	150 microns
1.18 mm	

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

3) SAMPLE : Take 500 grams of the sample for testing.

4) 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 to 110 ° C. Weigh the air dry sample and sieve it successively on the above sieves starting with the largest.

(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 Operations:** The set of sieve along with the cover starting from the 10mm sieve on top, one below the other and the container in the order shown above is fixed on the electrically operated sieve shaker. Place the sample in the topmost sieve i.e., of 10mm size, and do the sieving for about 5 minutes.

Light brushing with a hair brush may be used on the 150 micron I.S. sieve to prevent aggregation of powder and blinding of apertures.

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

RESULTS : Calculate the results and report them as follows:

(a) The cumulative percentage retained on each individual sieve, expressed as a percentage of the total sample.
(b) The percentage of material passing each sieve, expressed as a percentage of the total sample.

Fineness Modules: An empirical factor obtained by adding total percentage of a sample of the aggregates retained on each of the following series of sieves divided by 100.

The sieves used are 150, 800, 600 microns 1.18, 2.36, 4.75,10, 20, 40 mm and larger increasing in the ratio 2:1.

Fineness modules (F.M) to the fine aggregate:

I.S. sieve size	Mass retained (grams)	Cumulative mass retained (grams)	Cumulative percentage of mass retained (grams)
4.75	0	0	0
2.36	100	100	10
1.18	220	320	32
600	250	570	57
300	230	800	80
150	190	990	99
150	10		
Total	1000		278

Fineness Modulus – F.M = 278/100 = 2.78

Grading of sand

F.M. from 2.2 to 2.6 - Fine Sand
From 2.6 to 2.9 - Medium Sand
From 2.9 to 3.2 - Coarse Sand

Fine Aggregate Grading I.S. Codes 383 – 1970.

I.S. Sieve Designation	Percentage of passing			
	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	90-100
2.36 mm	65-95	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 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

SIEVE ANALYSIS (COARSE AGGREGATE)
(I.S.383-1970 AND I.S 2386 (PART-I) – 1963)

AIM : Determination of particle size distribution of coarse aggregate by sieving.

APPARATUS :

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

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. wt. of sample required for testing
63 mm	100 kgs.
50 mm	100 kgs
40 mm	50 kgs.
25 mm	25 kgs.
20 mm	12 kgs
16 mm	6 kgs.
12.5 mm	6 kgs.
10.0 mm	3 kgs.

4) Procedure: 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. Do the shaking in a varied motion 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 be forced through the sieve by hand pressure, but on sieve coarser than 20 mm, placing of particles is permitted; break lumps of fine materials, if present by gentle pressure with fingers against the side of the sieve.

4.1) In order to prevent blinding of the sieve apertures by over loading 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	
	45 cm 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. wt. 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.

4.2) If the amount of the coarse aggregate is obtained as above is substantially less than the 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.

4.3) Reporting of results: Calculate the results and report them as:

a) The cumulative percentage by the weight of the total sample passing each of the sieve 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.

TEST FOR WORKABILITY OF CONCRETE BY SLUMP TEST
(As per I.S.1199-1959)

AIM : This method of test specifies the procedure to be adopted either in the laboratory or during the progress of work in the field, for determining, by the slump test, the consistency of concrete where the nominal maximum size of aggregate does not exceed 38mm.

APPARATUS : Slump mould (in the form of the frustum of a cone, having bottom dia 20cm., top dia 10cms. And height 30cms) (as shown in I.S.1199-1959) Tamping rod (16mm. dia, 60cms. Long and rounded at one end).

SAMPLING : If this test is being carried out in the field, the sample of freshly mixed concrete shall be obtained, in the case of concrete containing aggregate of max. size more than 38mm the concrete shall be wet. Sieved through (1 ½ inch) 38mm screen to exclude particles bigger than 38mm.

PROCEDURE : The internal surface of the mould shall be thoroughly cleaned and freed from superfluous moisture and any set concrete before commencing the test. The mould shall be placed on a smooth, horizontal, rigid and non-absorbent surface, such as a carefully leveled metal plate, the mould being firmly held in place while it is being filled. The mould shall be filled in four layers, each approximately one quarter of the height of the mould. Each layer shall be tamped with twenty five 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 for the second and subsequent layers shall penetrate in the underlying layer. The bottom layer shall be tamped throughout its depth. After the top layer has been rodded, the concrete shall be struck off level with a trowel or the tamping rod, so that the mould is exactly filled. Any mortar which may have leaked out between the mould and the base plat shall be cleared and lift the mould slowly in vertical direction. Record the slump, in terms of millimeters of subsidence, measured as a difference between the top level of the mould and the top of the concrete specimen.

Any slump specimen which collapses or shears off laterally gives incorrect result and if this occurs the test shall be repeated with another sample. If the repeat test also, the specimen should shear, the slump shall be measured and the fact that the specimen sheared, shall be recorded.

TEST FOR COMPRESSIVE STRENGTH OF CONCRETE SPECIMENS
(I.S: 516 – 1956)

AIM : Determination of the compressive strength of concrete specimen.

APPARATUS : Testing machine two steel bearing plattens with hardened faces (as per I.S.:516-1959).

THEORY : Test shall be made at recognized ages of the test specimens, the most usual being 7 and 28 days, ages of 13 weeks and one year are recommended if tests at greater ages are required. Where it may be necessary to obtain the early strengths, tests may be made at the ages of the early strengths, tests may be made at the age of 24 hours $\pm$ ½ hour and 72 hours $\pm$ 2 hours. The ages shall be calculated from the time of the addition of water to the dry ingredients.

NUMBER OF SPECIMENS: At least three specimens, preferably from different batches, shall be made for testing at each selected age.

PROCEDURE : Specimens stored in water shall be tested immediately on removal from water and while they are still in the wet condition. Surface water and grit shall be wiped off the specimens and any projecting fines removed. Specimens when received dry shall be kept in water for 24 hours before they are taken for testing. The dimensions of the specimens to the nearest 0.2mm and their weight shall be noted before testing.

Placing the specimen in the testing machine: - The bearing surfaces of the testing machine shall be wiped clean and any loose sand or other material removed from the surfaces of the specimen which are to be in contact with the compression plattens. In the case of the cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. The axis of the specimen shall be carefully aligned with the centre of thrust of the spherically seated platten. No packing shall be used between the faces of the test specimen and the steel platten of the testing machine. As the spherically seated block is brought to bear on the specimen, the movable portion shall be rotated gently by hand so that uniform seating may be obtained. The load shall be applied without shock and increased continuously at a rate of approximately 140 kg/sq.cm. min., Until the resistance of the specimen to the increasing load breaks down and no greater load can be substained. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted.

CALCULATION: The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross sectional area, calculated from the mean dimensions of the section and shall be expressed to the nearest kg/sq.cm. Average of three values shall be taken as the representative of the batch provided the individual variation is not more than $\pm$ 15% of the average. Otherwise, repeat test shall be made.

In case of cylinders, a correction factor according to the height to diameter ratio of specimen after capping shall be obtained from the curve shown in fig.1 of I.S. 516-1959. The product of this correction factor and the measured compressive strength shall be known as the corrected compressive strength, this being the equivalent strength of a cylinder having a height/diameter ratio of two. The equivalent cube strength of the concrete shall be determined by multiplying the corrected cylinder strength by 5/4.

REPORT : The following information shall be included in the report on each test specimen:-

a) Identification mark
b) Date of test
c) Age of specimen
d) Curing conditions including date of manufacture of specimen in the field
e) Weight of specimen
f) Dimensions of specimen
g) Compressive strength
h) Maximum load and
i) Appearance of fractured faces of concrete and type of fractures if these are unusual.

SAMPLING OF C.C. WORK
CASTING OF C.C. CUBES OF THE REPRESENTATIVE CONCRETE

DESCRIPTION

Cube mould consists of four plates bolted together. The faces of the plates are precisely machined. The assembled mould can be clamped to the plate. The mould can be dismantled into two parts by unscrewing the bolts holding the plates. The mould can be clamped with 'L' bracket to the base plate which is accurately machined flat.

Frequency of sampling as per I.S. 456-1978

Quantity of concrete placed m^3	Number of samples
Up to 5 m^3	1
Over 5 but under 15 m^3	2
Over 15 but under 30 m^3	3
Over 30 but under 50 m^3	4
Over 50 m^3	4 plus 1 per additional 50 m^3 or part thereof

OPERATION:

For hand compaction method, use a standard tamping rod of 16mm dia. 60cm long and rounded at one end. (Tamping Rod with ISI certification mark IS: 10086) compact each layer of concrete with tamping rod in such a manner that the strokes of the rod are uniformly distributed over the cross-section of the cube-mould, for example, for 100 mm mould not less than 25 strokes shall be used, for 150 mm mould 35 strokes and for large size moulds still higher number of strokes shall be used. The strokes shall penetrate into the underlying layer and the bottom layer shall be rodded throughout its depth. Where voids are left by the tamping bar, then side of the mould shall be tamped to close the voids.

When vibration method is used for compaction, each layer shall be vibrated by means of electric or pneumatic hammer or needle vibrator or by means of a suitable vibrating table until specific condition is attained. The mode and quantum of vibration of the laboratory specimen shall be as nearly the same as those adopted in actual concreting operations.

After completion of the compaction of the top layer finish the concrete surface level with top of the mould using a trowel (supplied at an extra cost)

Cover the casted cube mould suitably and store in a place free from vibration, in moist atmosphere of at least 90 percent relative humidity and at a temperature of 27 ± 2^{o}c (in field the temperature of the place of storage from 22^{o} C to 32^{o} C is permissible) for 24 hours $\pm$ ½ hour from the time of addition of water to the dry ingredients.

After this period, mark the specimen and remove it from the mould by dismantling the mould into two parts and submerge it in clean, fresh water or saturated with lime solution at a temperature of 27 ± 2^{o}c and keep it till the time of testing for compressive strength.

PRECAUTIONS:

1) Representative sample of the lot of the concrete mix should be taken.

2) Before moulds are assembled, there should not be any dirt or hardened mortar on the faces of the flanges as this would prevent the sections from fitting together closely. The faces of the flanges, inside surfaces of the mould and top of the base plate must be thinly coated with mould oil to prevent leakage and sticking of concrete (mould oil is not provided).

3) When it is found that the mould is too much full of concrete the top should never be scraped off because in this way the **fat'** is taken off which leaves the concrete short of cement than it should be. A corner of the trowel should be used to dig out a fair sample of concrete as a whole.

4) If the mix is wet, after the specimens have stood a little time, water will tend to come up to the surface and then slides to sink below the top of the mould. To allow for this, a wet mix just a little proud of the top of the mould should always be left.

5) Once a specimen has been compacted, it should not be left on the same bench as another specimen that is being compacted; because of which some vibration would be passed on to the first specimen and it would be more compacted than the other.

6) For removing moulds, the bolt should be loosened to take out the specimen by taking the mould apart completely. Concrete should not be allowed to dry or harden on the faces of mould. Dirt should not be allowed to collect between the faces of the flanges, as this would lead to leakages in moulds due to improper fitting.

7) The reference number and date should be inscribed on the specimen directly after moulding or these details should be put on the specimen after removing it from the mould the next day, and a record of which concrete went into which mould at the time of casting should be maintained.

MAINTENANCE:
The mould should be kept clean from any sticking material. The faces of the mould and base should be oiled adequately.

Note: Another range of 7.06 cm cube moulds are to be used for cement mortar compressive strength testing.

DETERMINATION OF FIELD DENSITY BY SAND REPLACEMENT METHOD

SCOPE:
The object of the test is to determine the dry density of natural or compacted soil, in place, by the sand replacement method.

EQUIPMENT AND MATERIALS:

1) Sand pouring cylinder of about 3 litre capacity, mounted above a pouring cone and separated by a shutter cover plate and shutter.
2) Cylindrical calibrating container, 100mm internal diameter 150mm internal depth fitted with flange approximately 50mm wide and about 5mm thick.
3) Glass plate, about 450mm square and 10 mm thick.
4) Metal tray with a central circular hole of diameter equal to the diameter of pouring cone.
5) Tools for excavating hole.
6) Balance accurate to 0.01 g.
7) Container for water content determination.
8) Clean closely graded natural sand passing the 600-micron IS sieve and retained on the 300 micron IS sieve.

TEST PROCEDURE:

Determination of weight of Sand filling the cone
Fill clean closely graded sand in the sand pouring cylinder (SPC) up to a height of 1cm below the top. Find the initial weight of cylinder plus sand (W1). This weight is to be maintained constant through out. Place the SPC on a flat surface and open the shutter. When no movement of sand is observed close the shutter and find the weight of SPC. The difference between these two gives weight of the sand in conical portion.

Determination of bulk density of sand
Determine the volume of the calibrating container. Pour sand into the calibrating can along with the conical portion. The difference in weights between w1 and weight of SPC after filling the calibrating can gives the weight of sand in the calibrating can. This weight of sand divided by volume of sand gives density of sand.

Determination of dry density of soil in-place
Clean the area of about 45 cm^2 and place the metal tray over the area. Excavate the soil equal to a depth of about the depth of the calibrating container and put it in the tray and find the weight of the excavated soil. Fill the excavated hole with sand from the SPC along with the conical portion. The difference in weights between WI and this weight gives the weight of sand in the cone. The volume of soil is found by dividing the weight of sand in the excavated hole by the density of sand. The weight of excavated soil divided by the volume of soil gives the density of soil. The dry density is found from this wet density. Keep a representative soil for water content determination.

DETERMINATION OF LIQUID LIMIT OF SOIL

DOCUMENTS USED:

INDIAN STANDARD SPECIFICATION

IS 2720 **(Part 5) 1985-** ***Determination of Liquid Limit of Soil second revision; reaffirmed*** **1995**

SCOPE:

The object *of* the test is to determine the liquid limit of the soil sample using Casagrande type mechanical liquid limit apparatus.

MATERIAL EQUIPMENT:

1. Mechanical liquid limit device:

i) Casagrande type (BS tool)	:	Grooving tool 'a' (top = 11mm wide) (Bottom=2mm wide) (Height = 8mm)
	:	Grooving tool 'b' (top =13.6mm wide) (bottom=2mm wide) (height = 10mm)
ii) Porcelain evaporating dish	:	12 cm diameter
iii) Flexible spatula	:	8 cm long, 2 cm wide
v) IS Sieve	:	425 micron
vi) Wash bottle with distilled water	:	
vii) Desiccators		
viii) Balance	:	accurate to 0.01g

CONDITIONS TO BE MAINTAINED DURING TEST:

Thermostatically controlled oven	:	105°C - 110°C

TEST PROCEDURE:

By means of the gauge on the handle of the grooving tool and the adjustment plate, adjust the height through which the cup is lifted and dropped so that point on the cup which comes in contact with the base falls through exactly one centimeter when the handle is rotated by one revolution.

Take about 120 g of the specimen, passing through the 425-micron sieve, and mix it thoroughly with distilled water in the evaporating dish or on the marble plate so that uniform paste is formed.

Take a portion of the paste with the spatula and place it in the center of the cup so that it is almost half filled. Level off the top of the wet soil symmetrically with the spatula, so that the maximum depth of the soil is 1 cm.

With the help of grooving tool' a' the paste in the cup is divided along the cup diameter (through the center line of the cam follower), by holding the tool normal to the surface of the cup and drawing it firmly across, however, in the case of sandy soils tool 'a' does not form a neat groove and hence tool 'b; is used.

Turn the handle of the apparatus at the rate of two revolutions per second, until the two parts of the soil come in contact with the bottom of the groove along a distance of 10 mm and record the number of blows.

Collect representative sample of soil at right angles to the groove, including the portion of the groove in which the soil flowed together for water content determination.

Change the consistency of the mix by either adding more water or leaving the soil paste to dry, as the case may be, and repeat the above steps and note the number of revolution to close the groove.

DETERMINATION OF INDEX PROPERTIES:

The soil paste in these operations should be of such consistency that the number of revolution or drops to close the groove is 25 + 10.

TABULATION OF OBSERVATION:

The observations are tabulated as illustrated in table

Data and Observation Sheet for Liquid Limit Determination

Soil No. C

Determination No.	1	2	3	4
Number of blows				
Container number				
Mass of container + wet soil (g)				
Mass of container + dry soil (g)				
Mass of water (g)				
Mass of container (g)				
Mass of oven-dry soil (g)				
Water content (%)				

CALCULATION AND RESULTS:

Plot the flow curve with water content as the ordinate and log of number of blows as abscissa. The water content Corresponding to 25 blows is taken as the liquid limit of the soil.

NOTE:

- The test should be repeated if the soil tends to slide instead of flowing. The test is not applicable if repeated slipping occurs.
- The soil should not be oven dried before the commencement of the test.
- Distilled water should be used.
- If possible the test should be performed in a humid room.

DETERMINATION OF PLASTIC LIMIT OF SOIL

DOCUMENT USED:

INDIAN STANDARD SPECIFICATIONS

i) IS 2720 (Part* 5) 1985 - *Determination of Plastic Limit of Soil
second revision; reaffirmed 1995

SCOPE:
The object of the test is to determine the plastic limit of soil sample and then to calculate Plasticity index, Toughness index, Liquidity index and Consistency index of the soil.

MATERIALS AND EQUIPMENT
The materials and equipment of liquid limit plus a rod of 3 mm diameter.

CONDITIONS TO BE MAINTAINED DURING TEST:
Thermostatically controlled oven 105°C - 110°C

TEST PROCEDURE:
Take about 20g of air-dried soil from the thoroughly mixed portion of the material passing 425 micron IS sieve. Mix it on the marble plate with sufficient distilled water to make it plastic enough to be shaped into a ball.

Take about 8g of the plastic soil; make a ball of it, and roll it on the marble (or glass) plate with the hand with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length. When the diameter of the thread has decreased to 3 mm the specimen is kneaded together and rolled out again. Continue the process until the thread just crumbles at 3 mm diameter.

Collect the crumbled soil threads in the airtight container and keep it for water content determination.

Determine the natural water content of the soil sample obtained from the field.

TABULATION OF OBSERVATION:

Data and Observation Sheet for Plastic Limit Determination,

Soil No. C-

Determination Number	1	2	3
Container Number			
Mass of container + Wet Soil (g)			
Mass of Container + Over-dry Soil (g)			
Mass of Water (g)			
Mass of Container (g)			
Mass of Dry Soil (g)			
Water Content %			
Plastic Limit =			

Natural water content of field soil

CALCULATION:

1. Plastic limit =

2. Plasticity index = Liquid limit – Plastic limit

3. Liquidity index $I_L = \dfrac{W - W_p}{I_p} =$

4. Consistency index $I_c = \dfrac{W_L - W}{I_p} =$

5. Flow index $I_f = (W_1 - W_2) / (\log_{10} n_2/n_1)$; where

n1, n2 = no of blows
W1, W2 = Water content corresponding to no of blows
I_f = slope of the curve, known as the flow index

6. Toughness index $IT = \dfrac{I_p}{I_f}$

Liquid Limit W1	Flow Index I_f	Plastic Limit W_p	Plasticity Index I_p	Liquidity Index I_L	Consistency Index I_c	Toughness Index I_T

NOTE:

- Oblique rolling should not be done. The rate of rolling should be between 80 and 90 strokes per minute.
- In the case of sandy soils plastic limit should be determined first. When the plastic limit cannot be determined, the plasticity index should be reported as NP (non-plastic)
- When the plastic limit is equal to or greater than the liquid limit, the plasticity index should be reported as zero.

DETERMINATION OF ORGANIC IMPURITIES

DOCUMENTS USED:

IS: 2386 (Part - II) - 1990

IS: 383 - 1990

SCOPE:

Determination of organic impurities

PROCEDURE FOR ESTIMATION OF ORGANIC IMPURITIES:

SCOPE:

This method of test covers an appropriate method of estimating whether organic compounds are present in natural sand in sufficient quantities to be harmful and hence intended to show whether further tests are necessary or desirable (Harmless organic materials may cause colouration and certain naturally occurring organic compounds do not cause colouration.

Apparatus:
i) A 350 ml graduated clear glass medicine bottles - 2 Nos.

Chemicals:
i) Sodium hydroxide (3% solution)

ii) 2% solution of Tannic acid

iii) 10 percent alcohol

Sheet:
i) Coloured acetate sheets for comparison

The sand shall be tested as delivered and without drying. A 350ml graduated clear glass medicine bottle is filled up to the 75ml mark with 3% solution of sodium hydroxide in water. The sand is added gradually until the volume measured by the sand layer is 125ml. The volume shall then be made up to 200 ml by adding more solution. The bottle is stoppered and shaken vigorously and allowed to stand for 24 hours.

Other tests are made if the colour of the liquid above the sand is darker than a standard solution freshly prepared as follows:

2.5ml of 2% solution of tannic acid in 10% alcohol is added to 97.5 ml of a 3% sodium hydroxide solution and is placed in a 350-ml bottle closed with stopper, shaken vigorously and allowed to stand for 24 hours before comparison with the solution above the sand. Alternatively, an instrument or coloured acetate sheets for making the comparison is obtained but it is desirable that these be verified on receipt by comparison with the standard solution.

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 200ml. measuring cylinder. The size of the sample shall be such that it fills the cylinder up to 100ml. mark (h). Clean water shall be added over it up to 150ml. mark. The mixture shall then be shaken vigorously and the contents allowed to settle for 3 hours. The height of silt visible (h1) as settled layer above the sand shall be expressed as percentage of the height of the sand below(h2).

Ht.of sand including silt h	Ht.of silt settled h1	Ht.of sand below the silt h2	Silt content % $\frac{h1}{h2} \times 100$

DETERMINATION OF BULKAGE ALLOWANCE OF SAND (FIELD METHOD)

Object: This test covers the procedure of determining in the field, the amount of surface moisture or bulkage in fine aggregates by displacement in water.

General: Sand brought on to the site may contain an amount of 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 amount of sand put into the concrete may be the amount intended for the proposed nominal mix.

Procedure: The procedure adopted depends on the fact that the volume of inundated sand is the same when dry.

In a 250ml. measuring cylinder pour the damp sand, volume V_i, (consolidating by shaking) until it reaches the h mark. Then fill the cylinder with water and stir the sand well. (The water shall be sufficient to submerge the sand completely). It will be seen that the sand surface is now below its original level. Suppose the surface is at the mark V_f ml. The percentage of bulking of the sand due to moisture shall be calculated from the formula.

Percentage bulking: $100\ \frac{(V_i - V_f)}{V_f}$

The percentage of bulkage of sand shall be rounded off to the nearest whole number.

BULKAGE OF FINE AGGREGATE

Sl. No	Sample No. Location	Date & Time of test	Initial reading in CC vi	Final reading in cc v_f	Bulkage % $\frac{vi-vf}{Vf} \times 100$
1					
2					
3					

Limitations:

Fine Sand	0 to 38%	Water content 0 to 27%
Medium sand	0 to 29%	Water content 0 to 20%
Course sand	0 to 18%	Water content 0 to 17%

DETERMINATION OF SURFACE MOISTURE IN FINE AGGREGATES (FIELD METHOD)

DOCUMENT USED

IS: 2386 (Part III) -1963. Methods of test for aggregates for concrete

SCOPE:

This method of test covers the procedure for determining in the field, the amount of surface moisture in fine aggregates by displacement in water. The accuracy of this method depends upon the specific gravity of the material in saturated surface in dry condition.

APPARATUS:

The apparatus shall consist of the following.

a) Balance:

A balance having a capacity of 2 kgs or more and sensitive to 0.5 gms or less.

b) Flask:

A suitable container or flask preferably made of glass or non-corrosive metal. The container may be a Pycnometer, a volumetric flask, a graduated volumetric flask or other suitable measuring device. The volume of the container shall be from 2 to 3 times the loose volume of the sample. The container shall be so designed that it can be filled up to the mark, or the volume of its contents read, with in 0.5 ml. or less.

PROCEDURE:

The surface water content may be determined either by weight or by volume. In each case the test shall be made at a temperature of 22° C. to 32° C.

DETERMINATION BY WEIGHT:

The container shall be filled up to the mark with water and the weight in grams is determined. The container shall be emptied. Enough water shall be placed in the container to cover the sample, after which the sample of fine aggregate shall be introduced into the container and the entrained air is removed. The container shall then be filled to the original mark, and the weight in grams is determined. The amount of water displaced by the sample shall be calculated as follows.

Vs = Mc+Ms-M

Where Vs = Wt in grams of water displaced by the sample.

Mc = Wt in grams of container filled up the mark with water.

Ms = Wt in grams of sample.

M = Wt in grams of sample + container filled to the mark with the water.

DETERMINATION BY VOLUME:

A volume of water sufficient to cover the sample shall measure in ml and placed in the container. The weighted sample of fine aggregate shall then be admitted into the container and the entrapped air is removed. The combined volume of the sampled and the water shall be determined by direct reading when a graduated flask is used. Where a Pycnometer or volumetric flask of known volume is used, the combined volume of the sample and the water shall be determined by filling up to the mark with a measured volume of water and subtracting this volume from the volume of the container. The amount of water displaced by the sample shall be calculated as follows:
Vs=V2-V1.

Where Vs = volume in ml of water displaced by the sample, V2 = combined volume in ml of the sample and the water, and V1 = volume in ml of water required to cover the sample.

CALCULATION: The percentage of surface moisture in terms of the saturated surface dry fine aggregate and in terms of the weight of wet fine aggregates shall be calculated as follows:
P1 = (Vs -Vd)/ (Ms - Vs) X 100.
P2 = (Vs-Vd)/ (Ms - Vd) X 100. Where

P1 = Percentage Surface Moisture in terms of saturated surface dry fine aggregates.
Vs = weight in grams of water displaced.
Vd = weight of the sample divided by the specific gravity on saturated and
surface dry basis determined as prescribed.
Ms = weight in grams of sample.
P2 = Percentage surface moisture in terms of the weight of wet fine aggregate.

CHAPTER – X

Formats of Test Results (Registers)

IRRIGATION AND CAD DEPARTMENT

TEST REPORT

DETERMINATION OF FREE SWELL INDEX OF SOIL

Name of Work

Sample No. & Location Date

Tested by

Weight of Sample : 10 Grams

Vd = Volume of soil specimen read from the graduated cylinder containing distilled water

Vk = Volume of Soil specimen read from the graduated cylinder containing kerosene

Free Swell index, percent = ((Vd-Vk) / Vk) X 100

Limitation = Swell potential should be less than 25%

FINENESS MODULUS OF FINE AGGREGATE

TEST REPORT

Name of Work: **Sample No.:**

Location :

Weight of Sample: **Date of Testing:**

Sl. No.	I.S. Sieve Designation	Weight Retained in Gms	% Weight Retained	Cumulative & Weight Retained	Percentage passing	Remarks
1	10mm					
2	4.75mm					
3	2.36mm					
4	1.18mm					
5	600 micron					
6	300 micron					
7	150 micron					
TOTAL:						

$$\text{Fineness Modules} = \frac{\text{Sum of Cumulative \% Weight retained}}{10}$$

Fine Sand : 2.21 to 26

Medium sand : 2.6 to 2.9

Coarse Sand : 2.9 to 3.6

GRADING LIMIT FOR FINE AGGREGATE (I.S. 383 – 1970)

Sl. No.	I.S. Sieve Designation	Results of sample	Percent Passing				Remarks
			Grading Zone – I	Grading Zone II	Grading Zone III	Grading Zone IV	
1	10mm		100	100	100	100	
2	4.75mm		90-100	90-100	90-100	90-100	
3	2.36mm		60-95	75-100	85-100	95-100	
4	1.18mm		30-70	55-90	75-100	90-100	
5	600 micron		15-34	35-59	60-79	80-100	
6	300 micron		5-20	8-30	12-40	15-50	
7	150 micron		0-10	0-10	0-10	0-15	

Results: **1. Fineness Modules**

FINENESS MODULUS OF FINE AGGREGATE

TEST REPORT

Name of Work: **LOCATION :**

Date of Testing:

Weight of Sample:

Particular size distribution and fineness modulus Weight of sample:

I.S. Sieve Designation	**Weight retained**	**% Weight Retained**	**% Weight Passing**	**Cumulative % weight retained**	**Remarks**
80mm					
63mm					
40mm					
20mm					
16mm					
12.5mm					
10 mm					
4.75 mm					
2.36mm					

TOTAL:

Fineness Module = Sum of Cumulative % Weight Retained

100

Grading limits for coarse aggregates (I.S. 883-1970)											
I.S. Sieve Designation	Results of sample	Percentage passage for single size aggregate of nominal size							Percentage passing for graded aggregate of nominal size		
		63mm	40mm	20mm	16mm	12.5mm	10mm	40mm	20mm	16mm	12.5mm
80mm		100	-	-	-	-	-	100	-	-	-
63mm		85-100	100	-	-	-	-	-	-	-	-
40mm		0.30	85.100	100	-	-	-	95-100	100	-	-
20mm		0-5	0.20	85.100	100	-	-	30-70	95-100	100	100
16mm		-	-	-	85-100	100	-	-	-	90-100	-
12.5mm		-	-	-	-	85-100	100	-	-	-	90-100
10mm		0-5	0-5	0-20	0-30	0-45	85-100	0-35	25-55	30-70	40-85
4.75mm		-	-	0-5	0-5	0-10	0-20	0-5	0-10	0-10	0-10
2.36mm		-	-	-	-	-	0-5	-	-	-	-

IRRIGATION AND CAD DEPARTMENT

TEST REPORT

In-Situ Permeability Test (Japanese Method)

Name of Work:

Location : Date:
Tested by:

Sl. No	Date Elapsed Time in Hours	In take of water per hour	Remarks
	A HALF TRENCH 4'x2'x1.5' 1ST One Hour 2nd " 3rd " 4th " 5th " 6th "		Continue till regime intake is achieved
	B. Full Trench 4'X4'X1.5' 1ST One Hour 2nd " 3rd " 4th " 5th " 6th "		Continue till regime intake is achieved

Limitation:

Q. Intake of Water in Gallon =

1). 1/100 GPH. Then K is 1 foot per year or 9.63 X 10^{-7} Cms/Sec
2). 1/100 G.P.H. to 1/10 G.P.H. K is in the limits of 1'-10'/per year
3). 1/10 to 1 GPH K is in the limits of 10'-100'/year
4) 1 GPH = 100'/year or 9.63 X 10^{-7} Cms/Sec

IRRIGATION AND CAD DEPARTMENT
TEST REPORT
CUBE STRENGTH OF CONCRETE

15, M20 **Water Cement Ratio:**

	Mix proportion	Date of casting	Date of testing	Age in day	Unit weight	Ultimate load in tones/KN	Average	Compressive strength in Kgs/Cm^2	Remarks

days strength **28 days strength**

Kgs/Cm^2 100 Kgs/Cm^2
5Kgs/Cm^2 150 Kgs/Cm^2
0 Kgs/Cm^2 200 Kgs/Cm^2

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

TEST REPORT

Name of Work:

Location:
Sample No.:
Date of Testing:

		1	2	3
1	Determination No.			
2	Weight of core-cutter wet soil (Ws) in g			
3	Weight of core-cutter (Wc) in g			
4	Weight of wet soil ($Ws-W_c$) in g			
5	Volume of core-cutter (Vc) in cm^3			
6	Bulk density (Yb (Ws – Wc) / Vc) in g/cm^3			
7	Water content container No.			
8	Weight of container with lid (W1) in g			
9	Weight of container with lid and wet soil (W2) in g			
10	Weight of container with lid and dry soil (W3) in g			
11	Water content (w) in percent $W = \frac{W2 - W3}{W3 - W1} \times 100$			

ENCY DETERMINATION

ion nple	Field classification	Earth full zone	Wet Density.	Embankment dry density	Data M.C. %	Laboratory % OMC	Data MDD gm/cm^3	Compaction %	Remarks

IRRIGATION AND CAD DEPARTMENT

TEST REPORT

CONCRETE SLUMP TEST

Name of Work:

Tested By

Sl. No.	Date & Time	Mix proportion	Water Cement Ratio	Slump in (mm)
1				
2				
3				
4				
5				
6				

Limitation:

1. Concreting of lightly reinforced sections without vibration or heavily reinforced sections with vibration including plain concrete. — 25mm to 75mm slump for 20mm aggregate

2. concreting of heavily reinforced sections without vibration — 75mm to 125mm slump for 20mm aggregate.

IRRIGATION AND CAD DEPARTMENT

TEST REPORT

FINENESS OF CEMENT

Name of Work:

Sl. No.	Sample No.	Weight of Sample in gms W1	Weight of Residue in gms W2	Fineness = W2/W1 X 100
1	1 No.	100 gms		
2	2 No.	100 gms		
3	3 No.	100 gms		

Average Value _____

Limitations: Fineness should be less than 10%

IRRIGATION AND CAD DEPARTMENT

TEST REPORT

Laboratory determination of permeability
Filling head method IS 2720 (Part-17) 1986

Name of Work:

Sample NO. And location | Date : | Tested by

Diameter of specimen (D) Cm | Length Specimen (L)…… Cm

Area of specimen A……. Cm^2 | Volume of Specimen (V) = AV Cm^3

Area of stand pipe (a)…….. Cm^2 | C = 2.303 aL/A

Sl. No.	Initial time Ti Sec	Final time Tf Sec.	Initial Head 'h' cm	Final head h2 cm	H cm h_1-h_2	Log_{10} h1/ h2	K (c log_{10}h1/h2)/(t-h)	Remarks
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Limitations:

K in centimeter per second	Degree of permeability
Over 10^{-1}	High
10^{-1} to 10^{-3}	Medium
10^{-3} to 10^{-6}	Low
10^{-6} to 10^{-7}	Very low
Less than 10^{-7}	Practically impermeable

CHAPTER- XI

MONITORING THROUGH CONTROL CHARTS

Monitoring of quality control and assessment of the trend of quality control being exercised by the Project Management is best done through control charts. Indian standards I.S.:397 (Parts I to II) cover control charts for general and special application. These charges are based on compressive strengths of cement and concrete tests specimens. Control charts for cement strengths are for different test ages (i.e.3.7 and 28 days) and both for strengths of individual test and moving average of five tests over periods of time control charts for concrete strengths are also constructed in more or less the same manner as per cement. In addition to the test data the control charts also incorporate certain reference line constituting a frame work within which the degree of control actually achieved is assessed and remedial measures initiated where called for. The reference lines are termed the "Warning" and "Action Limits". The warning and action lines provide feed-back for timely remedial measures.

The illustration of preparation of control charts of cement and concrete are appended in **Annexure IV.**

Preparation of quality control reports and control charts is considered to be a vital step towards the process of achieving good construction quality. The Central charts should be used as a dynamic tool and accordingly these should be prepared as a concurrent exercise as the work proceeds. These should be constantly scanned to identify indication of any significant deviation in quality and initiate the remedial action promptly.

STANDARD DEVIATION (I.S. 10262 – 1982)

The estimated standard deviation of given grade of concrete can be calculated from the result of individual tests of concrete, using the formula:

$$S = \sqrt{\frac{\Sigma \Delta^2}{n-1}}$$

Where Δ = The deviation of the individual test strength from the Average strength of 'n' samples and

n = number of sample test results

If at least 30 test results for a particular grade of concrete at site with the same materials and equipment are not available, the standard deviation, S for the corresponding degree of control may be assumed from the following tabulation given IS: 10262 – 1982.

Degree of Control

Grade of Concrete	Assumed standard deviations S N/mm^2 DL's		
	Very Good	Good	Fair
M 10	2.0	2.3	3.3
M 15	2.5	3.5	4.5
M 20	3.6	4.6	5.6
M 25	4.3	5.3	6.3
M 30	5.0	6.0	7.0
M 35	6.3	6.3	7.3
M 40	5.6	6.6	7.6

Degree of Field Control (as per I.S. 10262 – 1982)

Degree of Control	Condition of production
Very Good	Fresh cement from single source and regular tests weigh-batching of all materials; control of aggregate grading and moisture content, control of water added; frequent supervision: regular workability and strength tests and good field laboratory facilities.
Good	Carefully stored cement and periodic tests: weigh – batching of all materials: controlled water: graded aggregate: occasional grading and moisture tests: periodic check of workability and strength: intermittent supervision, and experienced workers.
Fair	Proper storage of cement: volume batching of all aggregates, allowing for bulking of sand; weigh-batching of cement; water content controlled by inspection of mix, and occasional supervision and tests.

Acceptance Criteria for concrete: As per IS: 10262-1982

The concrete shall be deemed to comply with strength requirement if:

a) The strength of one or more samples though less than the characteristic value, is in each case not less than the greater of;

1) The characteristic strength minus 1.35 times the standard deviation; and

2) 0.80 times the characteristic strength: and the average strength of all the samples is not less than the characteristic strength plus

$$\left| 1.65 - \frac{1.65}{\sqrt{\text{Number of samples}}} \right| \text{ times the standard deviation.}$$

The concrete shall be deemed not to comply with the strength requirements if:

a) The strength of any samples is less than the greater of:

1) The characteristic strength minus 1.35 times the standard deviation; and

2) 0.80 times the characteristic strength: or

b) The average strength of all the samples is less than the characteristic strength plus

$$\left| 1.65 - \frac{1.65}{\sqrt{\text{Number of samples}}} \right| \text{ times the standard deviation.}$$

Concrete which does not meet the strength requirements as specified in (1) but has a strength greater than that required by (2) may, at the discretion of the designer, be accepted as being structurally adequate without further testing.

If the concrete is deemed not to comply pursuant to the structural adequacy, the parts so affected shall be investigated and any consequential action as needed shall be taken.

Concrete of each grade shall be assessed separately.

Concrete shall be assessed daily for compliance.

Concrete is liable to be rejected if it is porous or honey-combed: its placing has been interrupted without providing a proper construction joint: the reinforcement has been displaced beyond the tolerances specified: or construction tolerance have not been met. However, the hardened concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the engineer-in-charge.

Coefficient of variation:

The Co-efficient of variation (COV) and Standard Deviation are the two statistical tools which are utilized to indicate the level of quality control. A high COV indicates poor control and a low C O V indicates good control. The following table gives the ratings that are commonly assigned to various COVs for deciding the level of control of concrete strengths. These standards represent the average of 28 days compressive strength tests:-

Coefficient of variation (COV) for different control standards (%)

	Excellent	**Good**	**Fair**	**Poor**
General Construction	Below 10	10 to 15	15 to 20	Above 20
Lab Control	Below 5	5 to 7	7 to 10	Above 10

Standard Deviation and Co-efficient of Variation (COV) will be worked out for different grades of concrete in addition to the 28 days compressive strengths. This will be done on a continuing basis and updated regularly and documented in the following format:-

Sl. No	Grade of Concrete	Period	No. of samples	Average 28 day compressive strength	Standard deviation	Co-efficient of variation (COV)	Degree of field control	Remarks

The COV ratings of concrete for different control standards are indicated in the table.

CO-EFFICIENT OF VARIATION RATINGS FOR CONCRETE FOR DIFFERENT CONTROL STANDARDS

Graham and Martin's suggested values for the co-efficient of variation for various types of control, and can be adopted for guidance. The co-efficient of Variation of 15% can be treated as good control.

The following table is an extract from the "properties of concrete" by A.M. Neville.

GRAHAM AND MARTIN'S SUGGESTED VALUES FOR THE CO-EFFICIENT OF VARIATIONS FOR VARIOUS TYPES OF CONTROL

Coefficient of variation per cent	Specified Minimum Strength		Controls			
	MN/m2	lb/in2	Materials	Water	Batching	Supervision
9 to 10	28 to 35	4,000 to 5.000	Three sizes of coarse aggregate plus fine aggregate. all with strict grading tolerances	Controlled Water/ cement ratio	Weigh-batching	Rigid
10 to 12	28 to 35	4,000 to 5.000	Ditto	Ditto	Accurate volumetric batching with cement	Ditto
	28 to 35	4,000 to 5,000	Two sizes of coarse plus fine aggregate, all with strict grading tolerances	Ditto	Weigh-batching	Ditto
12 to 13	21 to 28	3000 to 4000	Ditto. With less strict Grading tolerances	Ditto	Ditto	Very good
13 to 14	21 to 28	3000 to 4000	Ditto	Ditto	Accurate volumetric batching with cement	Ditto
14 to 16	21 to 28	3.000 to 4.000	Coarse aggregate with fine aggregate	Ditto	Weigh-batching	Good
16 to 18	14 to 21	2.000 to 3.000	Ditto	Ditto	Accurate volumetric hatching with cement weighed	Fair

INSPECTION AND TESTING OF STRUCTURES

Inspection - Immediately alter stripping the formwork. all concrete shall be carefully inspected and any defective work or small defects either removed or made good before concrete has thoroughly hardened.

In case of doubt regarding the grade of concrete used, either due to poor workmanship or based on results of cube strength tests. compressive strength tests of concrete on the basis of and/or load test may be carried out.

CORE TEST

The point from which cores are to be taken and the number of cores required shall be at the discretion of the engineer-in-charge and shall be representative of the whole of concrete concerned. In no case, however. shall fewer than three *cores* be tested.

Core shall be prepared and tested described in IS : 516-1959 :

Concrete in the member represented by a core test shall be considered acceptable if the average equivalent cube strength of the cores is equal at least 85 percent of the cube strength of the grade of concrete specified for the corresponding age and no individual core has a strength less than 75 percent.

In case the core test results do not satisfy the requirements of or where such tests have not been done, load test may be resorted to

Ex: In a concrete work, M15 (FCK".15 N/MM^2) is to be used. The assumed standard deviation for this grade of concrete from table is 3.5 N/MM^2 In the course of testing cubes, the following results are obtained from a week's production (average strength of 3 specimens) tested at 28 days in N/MM^2.

22.6, 21.7, 20.7, 20.6, 19.7, 13.2. 11.8, N/MM^2

Discuss the acceptance of the result;

Sol:

a) First five results are accepted as being greater than the characteristic strength

b) Sixth and Seventh samples are less than characteristic strength, these can be acceptable if their values are not less than the greater of :

1) Fck-1.35s = 15-1.35x3.5 = 10.275 N/mm^2

2) 0.8 x Fck = 0.8 x 15 = 12 N/MM^2

$$\text{The average strength} = \frac{22.6+21.7+20.7+20.6+19.7+13.2+11.8}{7} \ldots\ldots = 18.61$$

The average strength should not be less than

$$Fck + \left| \frac{1.65}{\sqrt{n}} \right| X\ S$$

$$= \quad 15 + \left| 1.65 - \frac{1.65}{\sqrt{n}} \right| \times 3.5 = 18.59 \text{ N/mm}^2 \text{ O.K.}$$

The Sixth sample is acceptable the seventh sample is not acceptable according to code but the decision may be left to the engineer- in-charge.

ANNEXURE – IV

ILLUSTRATION OF PREPARATION OF CONTROL CHARTS FOR CEMENT AND CONCRETE

A. CONTROL CHARTS FOR CONCRETE STRENGTHS

1) An illustrative set of compressive strength data (hypothetical data) and its further analysis for incorporation in a typical set of control charts is shown in the enclosed Table A. It is assumed that 3 companion specimen samples are made from each homogeneous batch and constitute a "test". Thirty such tests are covered in this Table.

Master Chart

The-axis indicates the chronological order of tests (col. 1 of the Table). Strengths of the individual companion specimens constituting a given "test" (Cols. 2 to 4), are plotted one above the other along the ordinate and their mean values (col. 5) representing each "test" are joined to generate the Chart. Refer Plate IA.

Moving - average strength Chart

Each test is averaged with 4 number of previous tests making a total of 5 and this "moving average", viz average of 5 consecutive tests (col. 6) is plotted. Refer Plate 2A.

Range Chart

The range between the maximum 5 consecutive tests as shown in Cot. 7 is also plotted. This chart monitors the overall batch to batch variation of production. Refer Plate 2 A.

2) The target average strength and control limits can be estimated depending on the percentage of test values permitted to fall below the specified or "characteristic" strength Fsp in terms of the standard deviation 5 (or coefficient of variation Cv) corresponding to the degree of control aimed at. The target average strength (TAV) is worked out as.

Fsp + 0.84 δ for mass concrete and Fsp + 1.65 for structural concrete conforming 10 IS : 456
The standard deviation is what is assumed for mix design. For mass concrete. Coefficient of variation Cv is assumed as 15% and the target average strength is 160 + 0.840 δ.

Then $\frac{\delta}{160 + 0.84\,\delta}$ = Cv = 15%

Solving δ
So. target av. Strength = 27.5 kg/cm2
= 150 + 0.84.8
= 160 + 0.84 x 27.5
= 182 Kg/cm2

Upper Warming limit (UWL) = 183 + 0.84. δ (TAV + 0.84. δ)
= 206 kg / cm2
Lower warming limit (LWL) = 160 kg / cm2 (viz Fsp)

Upper action limit (UAL) = 183 + 3 x27.5
= 265 kg /27.5
Lower action limit (LAL) = 183 – 3. δ
= 101 kg / cm2

Lower warming limit = 183 + 0.84 x (27.5/√5)

The control charts, incorporating these limits are exhibited in plates 11 A and 2A.

The lower action limit (LAL) shall, in no case be lower than the absolute minimum strength wherever specified. IS: 456 - 1978 specifies on over riding absolute minimum of 0.8 times the characteristic concrete strength.

3) Target average range = d x 6 = 2.326 x 27.5 = 64
(Refer Para B.5 below)
This is depicted in Control Chart 3A

B. CONTROL CHARTS FOR CEMENT STRENGTHS

An illustrative set of strength data and its analysis for incorporation in a typical set of control charts is shown in the enclosed Table B. Thirty one "tests" (each consisting of 3 companion specimens) are covered in the Table. The Master Chart, Moving Average Strength Chart and the Range Chart (range between the maximum and minimum 5 consecutive tests) are depicted in Plate IB. Plate 2B and Plate 3B respectively.

Target Av. Strength	=45 kg/cm2
Coefficient of variation (Cv)	= 8%
So, standard deviation (δ)	= 450 x 8% = 36 kg / cm2
The upper and lower warming limits are set as	= 450 $\pm$ 1.65 x δ
Upper warning limit (UWL)	= 450 + 1.65 x 36
	= 509 Kg/cm2
Lower warning limit (LWL)	= 450 - 1.65 x 36
	391 Kg/cm2
The upper and lower limits are set as	= 450 + 3 x 6
	= 450-3 x 6
Upper action limit (UAL)	= 450 $\pm$ 3 x 36
Lower action limit (LAL)	= 450.3 x 36
	342 Kg/cm2

The lower action limit (LAL) should in no case to lower than the minimum specified strength in IS specifications IS : 269 or IS : 1469 (330 kg / cm2 at 28 days).

The control charts incorporating these limits are exhibited in plates 1 B and 2B.

5) Target average range = d x δ

d = coefficient depending upon the no. of tests considered for obtaining the range: and for 5 consecutive tests d = 2.236

So, target average range = 2,326 x 36 = 84 kg/cm2

The control chart of cement test result ranges (between maximum and minimum of 5 consecutive tests), depicting the mean sample range (84 kg/cm2) as well, is shown in Plate 3B.

TABLE – A

ILLUSTRATIVE DATA AND ITS ANALYSIS FOR SETTING UP CONTROL CHARTS OF CONCRETE STRENGTHS (MASS CONCRETE)

Location on x-axis of chart Sr.No. / Date of sample	Strength of individual companion specimens a b C Comp. strength at 28 days (Kg/cm2)			Test value "T" (Mean of a, b & c (X) (Kg/cm2)	Moving avg. of "T" (Five consecutive tests)	Range bet. max. and min. 5 consecutive tests	$(X-x)^2$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	191	193	195	193	--	--	1.96
2	181	185	186	184	--	--	57.76
3	183	188	187	186	--	--	31.36
4	198	195	192	195	--	--	11.56
5	166	173	171	170	185.6	25	466.56
6	177	176	172	175	182.0	25	275.56
7	150	146	1 '18	148	174.8	47	1900.96
8	187	191	192	190	175.6	47	2.56
9	214	211	211	212	179.0	64	416.16
10	212	217	216	215	188.0	67	547.56
11	232	231	227	230	199.0	82	1474.56
12	218	218	224	220	213.4	40	806.56
13	192	t94	190	192	213.8	38	1.60
14	181	182	177	180	207.4	50	134.56
15	190	192	194	192	202.8	50	1.60
16	198	199	194	1')7	196.2	40	29.16
17	197	197	200	198	191.8	18	4096
18	180	183	183	182	189.8	18	92.16
19	190	191	195	192	192.2	16	1.60
20	197	198	190	195	192.8	16	1156
21	187	189	194	190	191.4	16	2.56
22	197	188	191	192	190.2	13	1.60
23	240	244	236	240	201.8	50	2342.56
24	208	208	214	210	205.4	50	338.56
25	155	150	151	152	196.8	88	1568.16
26	152	147	145	148	188.4	92	1900.96
27	168	166	161	165	183.0	92	707.56
28	193	198	200	197	174.4	62	29.16
29	222	214	215	217	175.8	69	237.16
30	187	188	195	190	183.4	69	2.56

STATISTICAL ANALYSIS

N (No. of sample) = 30

X (Av. Strength = 191.6 (Avg.of column 5 viz 5747 / 30)

Sd (δ) = 21.52 kg/cm^2 Total of column 8 = 13437.16

COV (Cv) = 11.23% $(X-X)^2$

Percentage of samples = 90% Sd (δ) = √13437.16 / N-1

Passing (viz. comp. strength more than Fsp of 160 x kg/cm^2)

Note: The data listed are hypothetical and in arbitrary units and are meant only to illustrate their analysis for incorporation in control charts.

- Conc. Grade.A150 S160
- Cement level 170 Kg/m^3
- Specified strength 160 Kg/cm^2(Fsp)

TABLE – B

ILLUSTRATIVE DATA AND ITS ANALYSIS FOR SETTING UP CONTROL CHARTS OF CEMENT STRENGTHS

Minimum 28 days strength as per IS 269 = 330 Kg/cm^2

Location on x-axis of chart Sr.No./Date of sample	Comp. strength @ 28 days three individual specimens			Average of 4, 5 and 6	Moving avg. of 5 consecutive test results	Range bet. Max. & min. of 5 consecutive test results
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	500	490	495	495	--	--
2	450	430	425	435	--	--
3	500	480	490	490	--	--
4	550	555	545	550	--	--
5	415	430	415	420	478	130
6	430	430	430	430	465	130
7	400	390	395	395	457	155
8	405	425	4'15	425	444	155
9	440	445	450	445	423	50
10	465	435	435	445	428	50
11	445	435	440	440	430	50
12	450	410	430	430	437	20
13	505	495	500	500	452	70
14	500	495	490	490	462	70
15	465	450	450	455	464	70
16	445	465	455	455	467	70
17	465	490	485	480	477	45
18	430	445	445	440	465	55
19	445	455	465	455	457	40
20	410	430	420	420	450	60
21	490	510	485	495	458	75
22	450	450	465	455	453	75
23	450	435	450	445	454	75
24	470	460	465	465	456	75
25	475	470	465	470	466	50
26	450	465	465	460	459	25
27	460	450	440	450	458	25
28	450	450	450	450	459	20
29	470	470	470	470	460	20
30	490	490	.490	490	464	40
31	470	475	480	475	467	40

STATISTICAL ANALYSIS

N = 31

X = 459

Sd (δ) = 30.49

Cov (Cv) = 6.65%

Target average range: 84 kg/cm^2

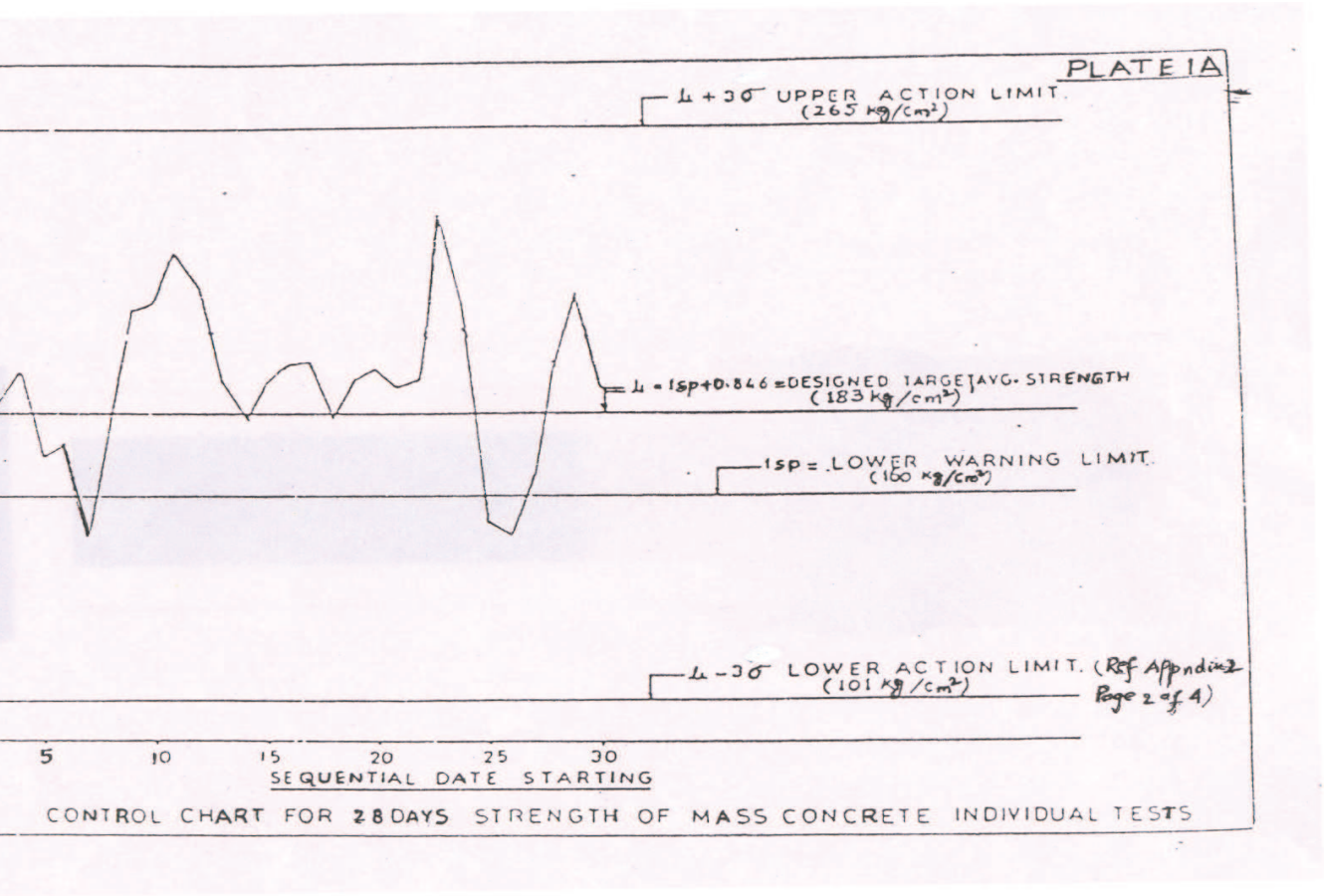
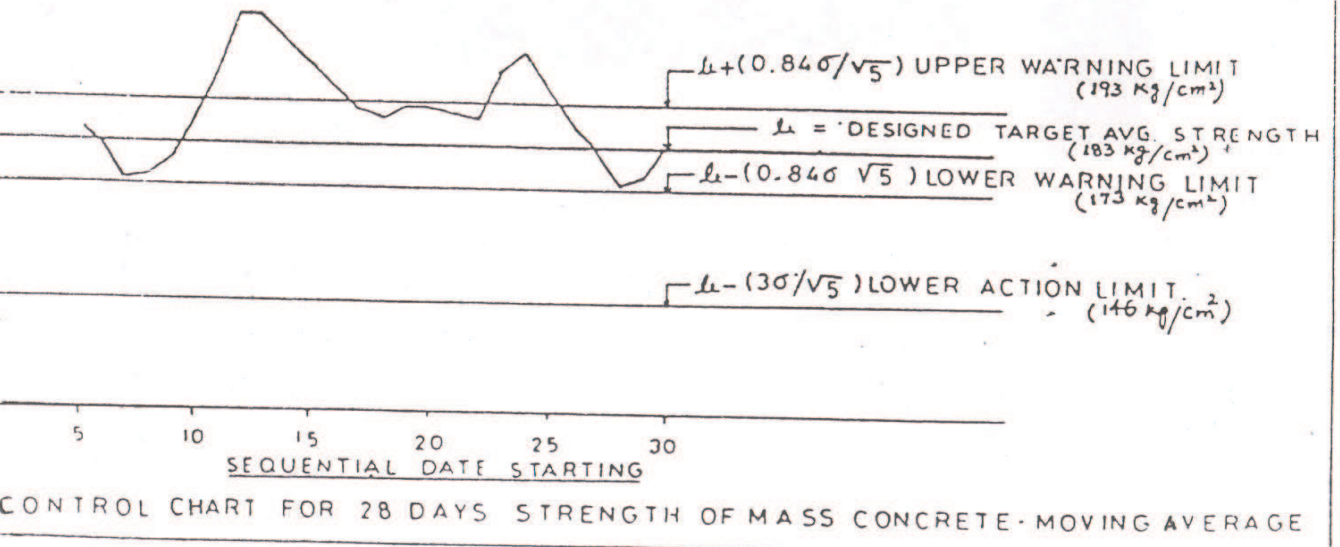


PLATE 1A
μ + 3σ UPPER ACTION LIMIT
(265 kg/cm²)
μ = Isp + 0.846 = DESIGNED TARGET AVG. STRENGTH
(183 kg/cm²)
Isp = LOWER WARNING LIMIT
(160 kg/cm²)
μ - 3σ LOWER ACTION LIMIT. (Ref Appndix 2 Page 2 of 4)
(101 kg/cm²)
5
10
15
20
25
30
SEQUENTIAL DATE STARTING
CONTROL CHART FOR 28 DAYS STRENGTH OF MASS CONCRETE INDIVIDUAL TESTS

APPENDIX 2

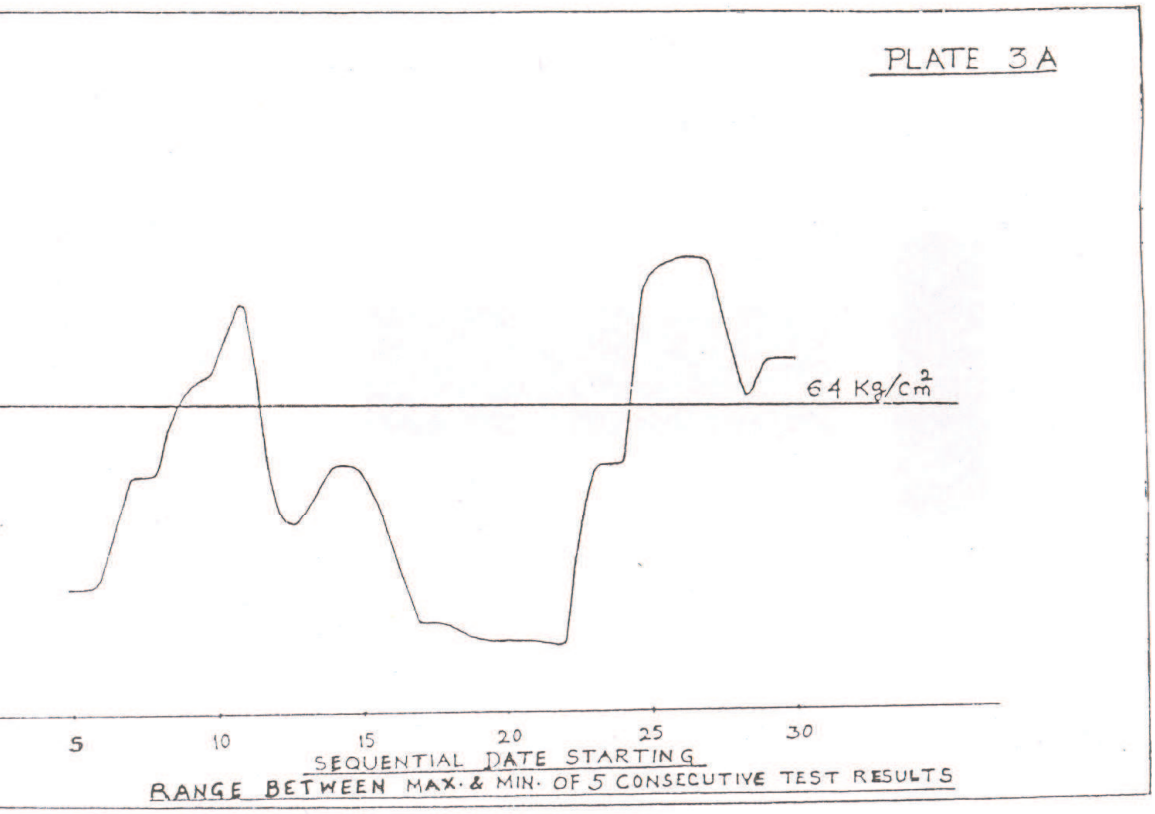
PLATE 2 A



CONTROL CHART FOR 28 DAYS STRENGTH OF MASS CONCRETE - MOVING AVERAGE

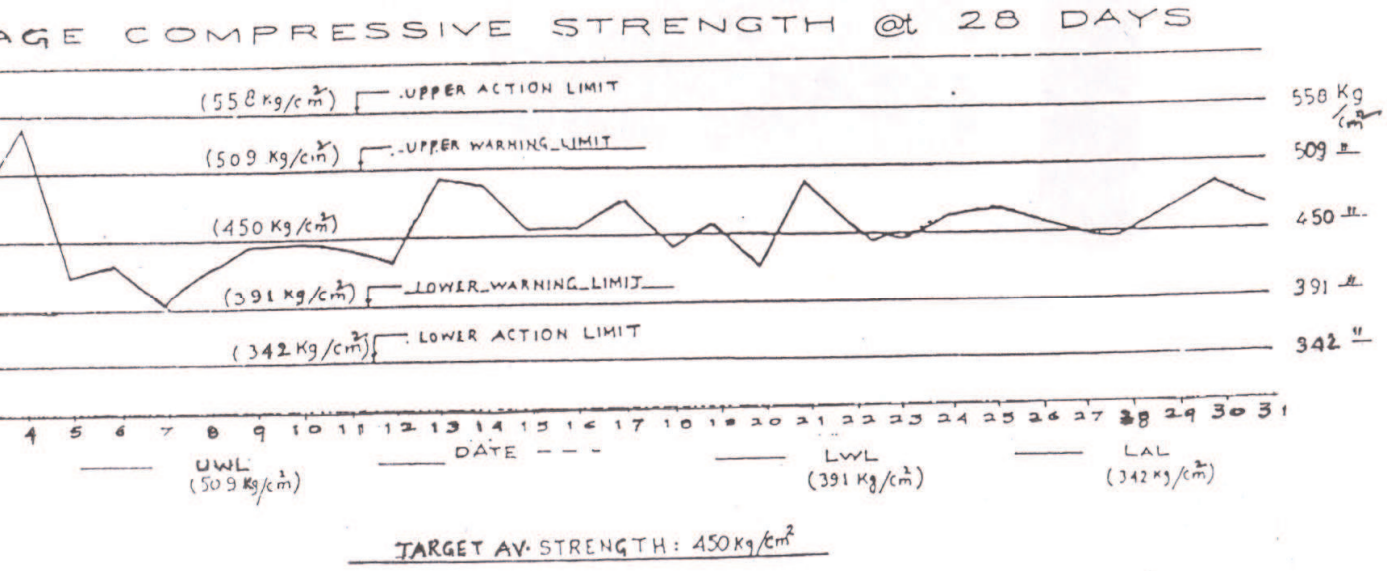
APPENDIX 2

PLATE 3A



APPENDIX 2

PLATE 1B

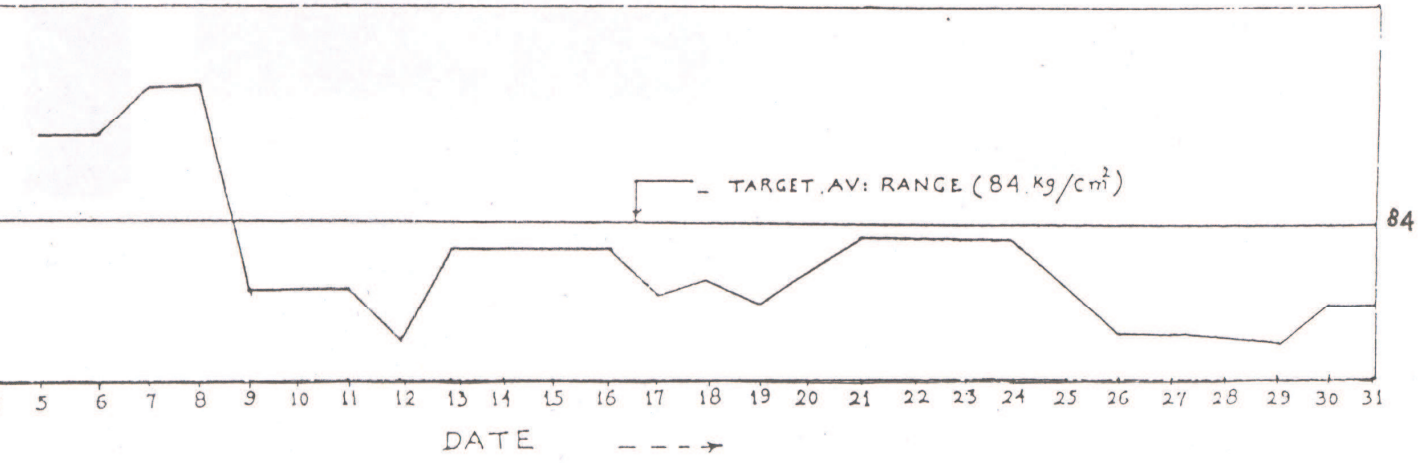


TARGET AV. STRENGTH: 450 Kg/cm²

APPENDIX 2

PLATE 3B

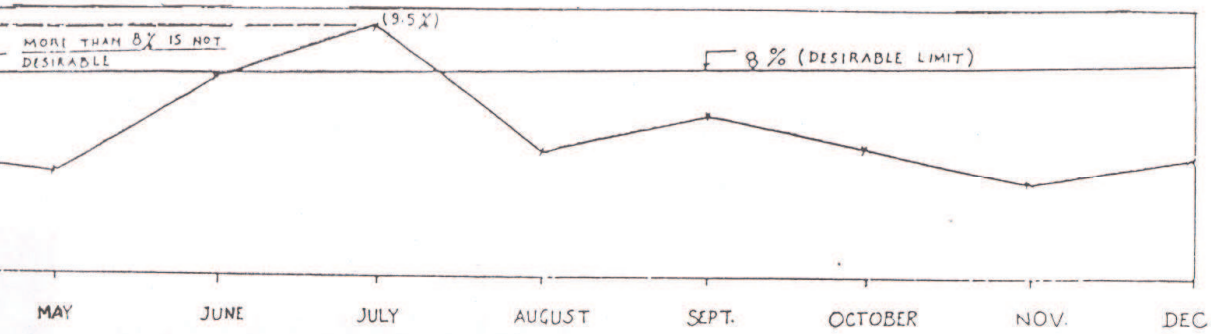
RANGE BETWEEN MAXM. & MINM. OF 5 CONSECUTIVE TEST RESULTS



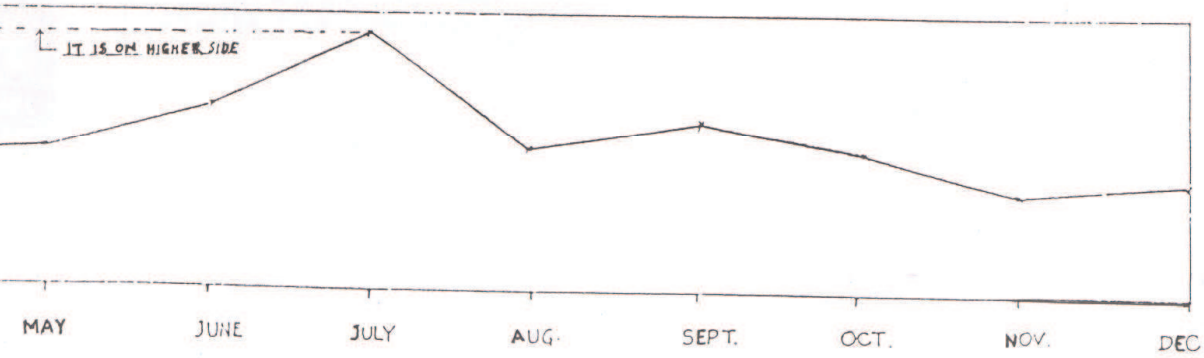
APPENDIX 3

CEMENT

CO-EFFICIENT OF VARIATION (Cv %)



STANDARD DEVIATION (6 - Kg/cm^2)



GRAPHICAL REPRESENTATION OF Cv & 6 (FOR ILLUSTRATION)

PROFORMA

Rest Results of Cement Samples

Name of Factory

Tested at_____ Laboratory

Sl. No.	Particulars	Values for the months of					Remarks
		Jan	Feb	Mar	Apr	May	
1 2 3 4	No. of test results (n) A v. Compressive strength at 3 days (Kg/cm2) Standard deviation (Sd) Co-efficient of variation (Cv)%						
5 6 7	A v. Compressive strength at 7 days (Kg/cm2) Standard deviation (Sd) Co-efficient of variation (Cv)%						
8 9 10	A v. Compressive strength at 28 days (Kg/cm2) Standard deviation (Sd) Co-efficient of variation (Cv)%						

CHAPTER – XII

O.K. CARDS

CHAPTER -XII

O.K. CARDS

GENERAL:

Since O.K. Cards contain important entries/information on execution of works at all stages and are liable to be referred/perused at a later stage also particularly during the Internal Quality Audit of works, the O.K. Cards shall be maintained in duplicate in two colours. The green coloured card shall form a part of the record of Q.C'/Q.A. Wing and the red coloured card remains in the custody of construction Wing. The O.K. Cards. relating to any particular work. shall be put in a round shaped tin box and placed right at the construction site. The exterior of the tin box shall be painted red. After the particular work has been completed (say. concrete placement has been completed in a particular lift: likewise say. fill placement has been completed in a particular layer.. etc.), the two O.K. Cards shall be removed from the tin box and filed in the permanent record files of the construction and Q.C./Q.A. divisions respectively. Senior officers shall also check the O.K. Cards during their field inspections to ensure that those are being maintained and properly/genuinely filled.

An O.K. Card is a condensed form of specifications and essential requirements for achieving specified workmanship and quality level of output. Each work is sub-divided into various construction activities in proper sequence/order of construction. Such activities are listed in chronological order on the O.K. Cards.

For various stages of construction activities where laboratory tests or checks with reference to drawing and specification are required from quality control unit. O.K. Card System shall be followed. The O.K. Cards should be made available on the site in a regular manner.

The O.K. Card consists of 3 columns. Besides the location and type of work, the first column is to be filled by the construction agency (contractor) by preparing each feature and making it ready for inspection by the project Construction Engineer, who Okays through his signature and then puts up to the Q.C./Q.A. Engineer for his final O.K.

The Assistant Executive Engineer (Construction) will prepare two copies of O.K. Cards by filling in the first set of columns meant for the construction staff and hand over to the Assistant Executive Engineer (Quality Control) in charge of the Quality Control Unit. The quality control staff at actual work site shall check the requirement or shall perform necessary tests under the guidance of Assistant Exe. Engineer. Quality Control. The Assistant Executive Engineer. Quality Control will scrutinize the O.K. Card and finally Okay the work if anything other wise is not observed. Should anything otherwise be found, the O.K. Card shall not be signed by him and ask the Assistant Exe. Engineer (Construction) for necessary rectification.

Subsequently. O.K. Card should refer to the defects removed. if pointed out previously in O.K. Cards and counter reference to the previous Check should be signed if Okayed.

It must be borne in mind that work cannot be held up unduly for disposal of O.K card. The Executive Engineer/Deputy Executive Engineer (Quality Control) will be the okaying authority for concentrated work like dam, spillway and barrage and important structures and the Assistant Engineer/Assistant Executive Engineer Quality Control will be the okaying authority for scattered works like canals and small structure. Random checks by superior officers should be recorded on O.K. Cards at site.

After processing through various levels and entering observations one copy of the O.K. Card (Red Colour Card) shall be retained with the Assistant Executive Engineer (Construction) for record and reference and the other copy shall be forwarded to the Dy.Executive Engineer Quality Control for record.

Specimen of O.K. Cards for various works such as embankment, concrete masonry shot creting, guniting, preparation of sub grade for lining and etc.. are appended.

O.K CARD FOR EARTH WORK EMBANKMENT

Amount of Contract:

Description of Item	Contractor	Remarks of Construction staff	Remarks of Quality control Staff
k from Km to Km			
on, whether as per specifications			
ed			
t Km.			
sed layer			
ontent			
size			
ompaction of layer			
in rolled fill			
and MDD			
iency			
in			
addition of moisture (Whether through spray nker)			
ion, if any			
ks			

Signature of the Contractor Signature of Construction Staff Signature of Q.C. Staff

CTURAL CONCRETE WORKS

Description of Item	Contractor	Remarks of Construction staff	Remarks of Quality control Staff
k			
om EL to EL			
from EL to EL			
e from EL to EL			
preparation of surface			
water blasting			
ate under size/over size graded analysis			
ulus of sand			
and date			
tails of shuttering should be checked with dimensions			
oncrete as specified in Technical specification (15^{o}c to 32^{o}c)			
oncrete as placed			

(25mm to 75 mm)			
g & mixing plant			
lacement			
g			
action			
io			
d joints			
wood float/steel trowel)			
rete laid			
cast			
forcement			
ents			
ks			

Asst. Engineer
Asst. Executive Engineer

Deputy Executive Engineer

Executive Engineer

Asst. Engineer
Asst. Executive Engineer

Deputy Executive Engineer

Executive Engineer

O.K. CARD FOR CAST-IN-SITU CONCRETE LINING

FEATURE _____

_____ Location_____

Bed/Slope_____ from_____to_____

ns_____ Grade_____

tem	Dated Signature of		
	Contractor	**Construction**	**Quality control**
m to Km Bed/Side Slope L/R			
ix			
gate under/over size			
20mm, 10mm			
e F.M. of sand			
date of Mfr.			
ke/Date of Mfr and % used.			
ete mix			
Vol/Weight			
t by Vol/Weight			
er			
oncrete as specified in technical			
oncrete as placed,			

g plant			
lacement			
tio			
lidation slip form/ mechanical vibrator			
ion / construction joints are provided drawings.			
d joint/joints			
uring/curing compound			
rete laid			
es caste			
ks			
ce concrete			

AE/AEE **AE/AEE**

Dy.EE **Dy.EE**

E.E.

O.K. CARD FOR ROUGH STONE DRY PACKING FOR APRONS / REVETMENT

_ Chainage :_____

_____

Description	Dated Signature of		
	Contractor	Construction	Quality control
ork			
of work			
Bed / Slopes			
g / Sub grade (filter) preparation			
f sub grade			
ry rubble revetment			
ble as per specifications:			
Volume of revetment			
5 cum			
cum			
0cum			
cum			
gh stone dry packing revetment			
arks :			

Sign of Contractor with date

Sign of GOAP (CS) with date

Sign of GOAP (QCS) with date

O.K. CARD SHOTCRETE

_ Description & Chainage of Structures:_____

_____

Description	Dated Signature of		
	Contractor	**Construction**	**Quality control**
ork			
of work			
of work			
ther available as per specifications			
ke / Date of manufacturer			
gate – F.M. of sand			
regate (5mm – 10mm size)			
ncrete mix			
ht			
ratio (0.40 to 0.50)			
x			
quipment			
deteriorated concrete and exposed bars free of rust & scales.			
einforcement provided			
f shot Crete			
of first layer of shot crete			

f welded wire mesh butting			
ing wire used for binding of wire mesh			
ys of curing			

of

Contractor GOAP-CS (GOAP-QCS)
AE AEE AE AEE
D.E.E. D.E.E.
E.E. E.E.

O.K. CARD FOR SUB GRADE PREPARATION FOR C.C. LINING

_ Description & Chainage: _____

_____

	Dated Signature of		
Description	**Contractor**	**Construction**	**Quality control**
b-grade is prepared as per specification in case of			
(Over excavation)			
soils (Treatment with CNS soils)			
avation in soils			
e profile of canal section is prepared to model section			
rous plugs cast as per specification			
e work of laying the filter media is carried out as per awing in case of			
ugs			
inal and transverse drawing			
b-grade is wetted to 150mm depth as per n			
of sub-grade			
y of compaction			
y of moistening, wetting of sub-grade.			
emarks			

Sign of Contractor with date

Sign of Constn. with date

Sign of Q.C. with date

O.K. CARD FOR GUNITING

_ Description & Chainage of Structure: _____
_____

	Dated Signature of		
	Contractor	**Construction**	**Quality control**
rk			
ork			
available as per specification			
Date of manufacturer			
– F.M. of sand – Moisture content			
te			
compound			
c of mesh size 150mm X 150mm formed of 3.15mm dia steel			
on			
o – 0.45 to 0.50			
orated concrete and exposed reinforcement labs free of rust and			
ndary) reinforcement provided			
niting			
nm to 50 mm in each passage			
f guniting			
n requirement			