GOVERNMENT OF RAJASTHAN

DEPARTMENT OF WATER RESOURCES

Guidelines to Prepare Manual of Operation & Maintenance of Irrigation Structures

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PREFACE

Operation & Maintenance is an integral part of all irrigation structures. It is essential that all the water resources engineers and personnel responsible for managing the projects are conversant with the O&M needs and requirements of water resources structures. The O&M needs are project specific, as each water resources project is unique in character and has its own problems and constraints. A Manual of Operation and Maintenance of irrigation structures was issued by the department in year 2008. Based upon the feedback and suggestions received from field officers, the Manual has now been updated as Guidelines to Prepare Operation &Maintenance Manual and aspects relevant to the safety of structures and O&M requirements have been added. In the Guidelines, components of dams, canals and appurtenant structures which are to be maintained; preparation of canal and reservoir operation plan, equitable water distribution and procedure for different activities to be performed have also been included.

It is hoped that these Guidelines would provide necessary insight to the project officers for preparing O&M manuals for individual project under their jurisdiction.

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CHAPTER 1
INTRODUCTION

1.0 GENERAL

Operation and Maintenance (O & M) of Irrigation Structures is one of the main activities of Water Resources Department. Currently the O&M function of Water Resource Department, from head works to minors, is being carried out by the respective engineers in five Zones. Apart from Water Resources Department, O&M is carried out by IGNP, and CAD Chambal in their respective area of operations.

The operation system in Rajasthan is generally supply based. The distribution of water is done according to predetermined running schedules at varying carrying capacity and rotational operation. The distribution below outlets to individual farm holding is one prefixed sharing schedule of the water released.

In order to properly maintain and operate an Irrigation Structures, it is necessary to prepare a detailed O & M guideline for each Irrigation Structure and follow it. This manual is aimed at providing general guidelines for maintenance and operation of Irrigation Structures of the State and can be used to prepare individual O & M manuals for each dam and canal taking into account individual site conditions of the system.

1.1 DAMS

Dams play vital role in development activity of the State. Dams are constructed for exploitation of water potential of the rivers for irrigation, municipal and industrial use, hydro-power generation, flood control, fisheries and tourism development etc. Number of dams have been constructed in the state mainly for irrigation, drinking water and hydro-power generation by state Water Resources Department and erstwhile

princely States of Rajasthan. Operation and maintenance of these dams is responsibility of the Water Resources Department. In order to derive maximum benefits from the dams and to avoid mishaps, it is essential to properly maintain and operate them. It is rightly said that a stitch in time saves nine. Failure of a dam can cause heavy losses to life and property , as stored water in the reservoir is capable of causing floods of much higher magnitudes compared to natural floods of the river. Therefore, safety of the dams is the principal concern of State Water Resources Department.

1.2 LARGE DAM

Dams are classified as Large Dams, Intermediate Dams and Small Dams depending upon impounding water potential of the reservoir, danger potential on the d/s of the dam, height of the dam etc. Dams can be classified as per IS 11223-1985 as follows:

Classification	Gross Capacity	Hydraulic Head
Small	Between 0.5 and 10 million m^3	Between 7.5 and 12 m
Intermediate	Between 10 and 30 million m^3	Between 12 and 30 m
Large	Greater than 60 million m^3	Greater than 30 m

International Commission on Large Dam (ICOLD) has defined Large Dam as either-

- A dam above 15 m in height measured or a dam between from the lowest portion of the general foundation area to the crest, or a dam between 10 m and 15 m in height provided it complies with at least of the following conditions:
- the length of the crest of the dam to be not less than 500 m.
- The capacity of the reservoir formed by the dam to be not less than one million m^3.

- the maximum flood discharge dealt with by the dam to be less than 2000 cumecs
- the dam has specially difficult foundation problems or the dam is of unusual design.

  For dam safety purpose definition of large dams as given by ICOLD is used world wide.

1.3 INSPECTION OF DAMS

First and foremost important step for maintenance of a dam is its detailed inspection by the competent dam engineer/s. Detailed guidelines and formats of Periodical Inspection of Large Dams have been prescribed by Central Water Commission, New Delhi and shall be used for pre monsoon, post monsoon and special inspection of large dams by the respective inspection authorities as prescribed in the guidelines of CWC. The inspection shall be completed by the respective date and their report sent to appropriate higher authorities as contained in the guidelines. It shall be noted here that the above inspections are to be done in addition to routine inspection by the field engineer i.e. Junior Engineer, Assistant Engineer and Executive Engineer in charge of the dam.

1.4 MAINTENANCE OF IRRIGATION SYSTEMS

Most of the large dams constructed in the state are either concrete/masonry dams (gravity dams) or earthen embankments with gated overflow sections of concrete/masonry. In addition to Non-overflow and overflow sections of a dam, other structural components of a dam are wing walls, gates and their operating arrangements, energy dissipation arrangements below overflow section, bridge over overflow section. Approach and tail race channel / tunnel (if any) and other appurtenant works shall be maintained with the dam. Maintenance problems encountered in the large dams have been discussed in details for

concrete/masonry dams and earthen embankments. Their remedial measures have also been suggested.

Various type of instruments are provided in the large dams for continuous watch on the behaviour of dam in respect of time and various reservoir levels during the year.

It is necessary to properly maintain the various instruments where provided in the dam and properly record, documents and analyse their observations, to know any abnormalities in the behavior of the dam. It may be noted that for authenticity of the observations, they shall be recorded by properly trained staff and test checked by concerned Junior Engineer, Assistant Engineer and Executive Engineer. The analysis of the data shall be included in the pre-monsoon inspection reports.

1.5 FLOOD FORECASTING AND RESERVOIR OPERATION

The O&M of the dams is not being given its due weightage, at present by the field engineers . This state of affairs needs urgent change. Importance of flood forecasting at dam sites is increasing, as much higher values of design peak floods are being estimated at dam sites, compared to earlier adopted values at the time of construction of the dam. This is due to various reasons such as:

- more rational (hydrological) observations data are available now after construction of the dam.
- more hydro-meteorological observation data are available now after construction of the dam.
- there is change in characteristics of the catchments area.
- due to change in atmospheric conditions.

If flood-forecasting techniques are adopted, the anticipated floods can be moderated to greater extent, thereby reducing their danger and enhancing

the safety of the dam. Out of various techniques available for flood fore-casting a comparatively simple technique of empirical models have been discussed in detail, so that it can be easily adopted by field engineers having preliminary knowledge of hydrology. Other available techniques have been discussed in brief. Principles of Reservoir operation and Gate operation schedule have also been discussed in details.

1.6 OPERATIONS OF IRRIGATION SYSTEMS FOR ROTATIONAL WATER DELIVERY

The rotational water delivery system is being followed in the Gang Canal, Bhakra Canal and the Indira Gandhi Canal system. The discharge in these Canals at its head depends on the availability of water at the Harike barrage which in turn depends on the release from the Pong dam and other reservoir. The Technical sub-committee of Bhakra Beas Management Board meets every months to decide the release from the Pong and the Bhakra dam reservoirs during the month taking into consideration the water requirements of the partner states.

In Bhakra and the Indira Gandhi Canal systems, the rotational system adopted is more fixed in nature as compared to the Gang Canal system. In this system of regulation, the channels are divided into groups, each having almost equal discharge. Priorities are fixed for each group for one crop season and is run for 8 days. while regulating, it is ensured that all cultivators get equal quantity of water as far as possible. A regulation chart is prepared for each crop season in which the period and priorities of each group of channel is indicted and this rotational programm is made available to all Panchayat Samiti through Patwaris.

1.7 WATER DISTRIBUTION PLAN:

The water distribution plan is the basis for all canal operations. Based on the availability of water in the reservoir, expected rainfall, estimated

water collection in the reservoir cropping pattern in the command area and the estimated water demand the Water Distribution Committee (WDC) finalises the plan, which has to be followed by all O&M staff and the farmers.

1.8 WARABANDI:

To deliver equitable irrigation supplies to the farmers according to the available water, a rotational system called the 'Warabandi' is used. This rotational method of irrigation allows delivery of water to all farmers within an outlet in the command area according to their entitlement. The quantity of water that each cultivator gets is proportional to his land holding irrespective of the crop grown. The Warabandi is a weekly plan. Warabandi plan is prepared by Patwaris, checked by Ziledars and is approved by the EE concerned.

Water course (WC) alignment for the chak is finalized and department approves it. The water course is constructed by the cultivators. The department check the physical parameters of the WC as per the approved plan. While preparing the plan department ensure that each tail end cultivator gets share of water. The length of the WC to be maintained by the cultivators is proportional to their holdings.

The canals are run for 8 days so as take care of losses and ensure that all the tail end cultivators get their share of water. The fill time and travel time are taken into consideration while calculating the water share timing. Each cultivator gets water at fixed times. Usually Warabandi starts on Monday morning at 6 AM. The water level at the tail end is maintained at 1 ft. This is true when the canal is running full.

1.9 OPERATION OF CANAL SYSTEM:

Water is introduced into the main canal according to the schedules developed by the WDC. The water distribution plan indicates the time

and the quantity of water to be released to the canal system. The gates are opened in such a way so as to pass the required discharge for the downstream area. All canal head works are connected with adequate communication system and three hourly gauges and discharge of channels are maintained.

Water is released to each of the distributaries and minors directly off-taking from the canal, ensuring full capacity supply for a normal rotational period of 7 days in case of Gang, Bhakra and IGNP and 21 days in case of other projects, depending upon water availability plus the travelling time of water upto the tail end of the canal. This is done by operating the cross-regulators at the control points and raising the level of water in the supply channel. During the water distribution periods, the distributaries are run at full capacity for the outlets to draw their stipulated share of water. The water within the command area is distributed to the fields through outlets from the minors. Each cultivator gets water for a fixed period depending on his cultivable command area.

CHAPTER- II
DAMS AND APPURTENANT WORKS

2.1 GENERAL

Dams by their very nature create risks. Every artificial storage can be a potential hazard to downstream life and property. As national needs for water intensify and its value increases, more dams are being built. At the same time, many existing dams are reaching or passing their design life spans and, for various reasons, people continue to settle near dams in their down streams. As builders are forced to use poorer sites for dams, the job of protecting life and property becomes more difficult. Therefore, as dam construction continues and the population grows, exposure of the public to dam failure hazards increases and the overall safety problem becomes more difficult.

It is important to note that the probability of small dams failures are much higher than larger dams due to lack of resources resulting in poorer maintenance. Even a relatively small dam can have severe consequences in the event of a failure. Therefore, each structure must be provided safety with adequate precautions.

Although these risks can be minimized through sound technical engineering practices, but risks increase substantially without proper maintenance. At the same time, deficiencies in the design, poor construction practices/materials, and inadequate spillway capacity and poor foundation conditions cause the most common structural failures. Safety of the dams therefore, has to be tackled at all stages from the stage of investigation till the concept is translated to reality and subsequently during its life time. Many subtle signs which can be symptomatic of larger problems may be unnoticed for a variety of reasons. In times, these

problems become apparent even to untrained eyes. In due time problems progress to a point of potential risks and repairs become not only complex but very costly.

Therefore, it is not only necessary but essential to include quality control and sound technology before and during construction, regular preventive maintenance, routine visual inspections, and identification of problems in their early stages after their completion must be ensured for good operating conditions of dams.

A dam consists of a variety of different components, each having its unique potential problem area and inspection, operation & maintenance requirements. All storage dams are provided with spillways, the primary purpose of which is to reduce this artificial hazard to negligible or acceptable level. The decision on spillway capacity of a dam including the decision on its discharging capacity, free board etc. is an important hydrologic and engineering decision affecting the safety of the dams. Earlier, these decisions were being taken on the basis of "empirical" formulae based on regional experience and not adequately supported by systematical data and analysis. The Central Water Commission, New Delhi has formulated "Design flood criteria" for hydraulic structures and the major projects are designed accordingly.

One of the responsibilities of owning and operating a dam, regardless of its size, is the commitment to maintain it. When minor problems are identified during an inspection, they should be dealt with as quickly as possible. A program of regular preventative maintenance will stop many of these problems from developing in the first place. If a change or deterioration of the conditions of the dam is noted in its early stages, repairs to remedy the situation can be completed with minimal expense. If a dam is left to deteriorate, failure will eventually result.

For proper up keep of these structures some important facts which field officers must know, are briefly described below:.

- The different types of dams
- Essential components of a dam
- How the components function, and
- Important physical conditions likely to affect a dam.

2.2 EARTHEN DAM

Earthen dams require frequent repairs and maintenance as they easily get damaged by rainfall, water wave action, rat holes, traffic etc. Besides this it is difficult to precisely locate a leakage in an earthen dam in early stages. Therefore extra watch and ward is required for earthen dams.

2.2.1 General Repair & Maintenance

a. Leveling of Embankment Tops & Slopes

Existing embankments have to be repaired or reconditioned in advance, so that these can safely withstand pressure of the likely highest water level against them, in the ensuing monsoon. The most important point, therefore, is to bring the embankment to the proper grade or levels and section. To achieve this the required free-board for designed or higher flood level (in case there had been higher levels attained subsequent to the preparation of designs) should always be maintained. This factor of safety is necessary against any unexpected settlement, the rise in bed of the river, wave action or occurrence of flood higher than the designed. A careful study of the revised statement of high flood levels at the embankment will show at a glance whether the required free-bard is available. If not, the embankment has to be raised. In the case of loop embankments not exposed directly to river spill, the level at each Km. is to be taken the same, as the level at a point on the front embankment where the projection from it made normally to the course of river, cuts the

front embankment. If the free-board, thus found over the year's maximum or over the extrapolated high flood levels, is less than the free board over the previous maximum, the loop embankment requires to be raised. Having thus determined the available free-board available on site has to be found by actual leveling. All front and loop embankments must be carefully leveled annually after the year's maintenance raising has been completed the annual leveling of the embankment lines being done by JEn, subject to a minimum of 10 percent by the Assistant Engineer. The Assistant Engineer should submit a certificate annually that he has satisfied himself with regard to the correctness of the level of the top and of the side slope (including berm levels) of the front as well as the loop or retired embankments. True and accurate data should be kept of the annual leveling done, showing the name of the leveler and in case of check leveling, of the checking officer, together with the dates and all details. Such data should be readily available for the inspection in separate register, with cross reference to actual field books in which the original leveling record is entered and should form important records which should only be destroyed after the approval of the Superintending Engineer has been obtained. From this data, graph should be drawn to compare in each Km. the actual top level and ground level with the highest flood level of the previous year and of the other flood year's. This reveals to the eye, reaches of the embankment subject to large heads against them.

b. Item of Earthen and Annual Repairs

All hollows and depressions in the embankment section, where ever existing must be made-up with rammed earth after clearing the site of all loose and vegetable material. Where the top of embankment is dusty or sandy, 30 cm of soil containing 10 to 15 percent of clay should be put on and well rammed or rolled.

c. Opening up and Refilling Leaks

A register of leaks should be maintained showing the exact location and the action taken during the monsoon period (that is, whether it has been fully opened out and refilled with good soil duly watered and rammed, or just plugged at its upstream face). During the monsoon period deep nicks on the slope and sides are also left at the site of each leak as well as a peg indicating the number assigned in Leak Register so as to facilitate tracing their location on site.

It is important that leaks which could not be fully treated during the monsoon period should be attended to immediately afterwards as described under:

Such leakage sites should be opened out in the full width of the embankment, particular care being taken to trace to its upstream ends. It should then be refilled with good earth in 15 cm layers watered and rammed, the old earthwork being stepped or benched back at the sides and new earthwork properly bonded and interlocked into the old. Where good material is not available, pure sand should be used for refilling the opened-up portion. Whenever sand or sandy soil has been used, it should invariably be covered with at least 60 cm layer of good clayey earth. Rodents and other burrowing animals make holes, cavities and tunnel through and under an embankment. These are a source of danger as very often these cause leaks and excessive seepage and even serious breaches, during flood periods. Such holes should be carefully located and opened up and refilled with good earth and properly rammed.

Upon water touching the embankment, these site should be carefully watched in order to staunch them thoroughly in advance of the floods.

d. Repairs to Masonry Works

It is also important to inspect very carefully masonry works so that there is no danger of seepage of water along the plane of contact between the earth and masonry. The earth adjacent to the masonry work should be brought to designed sections laying in very thin layers and then consolidating by reamers.

The return walls, where they are low must be raised to at least 30 cm above the highest flood level. The scour holes should be properly filled in and brought to design section. The pavement should be very carefully examined and all likely cavities opened reconstructed.

e. Plantation

The plantation of trees on embankments are not allowable because their roots tend to loosen the structure of the embankment when shaken by wind storms and these encourage cracks and the development of leaks, which are difficult to close. When trees are removed, it is necessary to remove the roots thoroughly because, if the root is left in, when the organic matter dies and decays and crumbles, it leaves dangerous hollows which cause settlement and lead to further trouble. On the other hand short grass growing on the embankments (tufts of sod) is good protection against erosion and wave wash. It is, therefore, specified that the removal of growth on embankment should be done as under:

The side-slopes of all embankments and land beyond the toes up to 6 m on the countryside and 3 m on the waterside should be kept clear of all trees and other growths except short grass and lai. Existing well established avenues within these limits need not be removed if the trees in them are safe. Such avenues should be maintained but the greatest care must be taken to uproot and remove all trees which are dead or which

show any tendency to fall of them. When clearing away trees, care must be taken to have the roots thoroughly removed and the embankment or ground properly made up.

f. Inspection of River Course and Programme of Work

The Executive Engineers in charge of embankments should inspect the river course in their charge immediately after the monsoon period and formulate program of works required to be done during the non-monsoon period for the safety of the embankment in the next flood season. In framing this program they should keep in view any changes which have taken place in the course of the river during the previous monsoon season. Reaches where the river is eroding bank and likely to cut through a loop, particularly upstream of the embankment, should be carefully inspected, as much higher levels may be expected below it in the event of a cut off. Any likely change of the river can be judged by a careful inspection. If thereby it is anticipated that the river may come against the embankment, a full report together with suitable proposals should be forwarded to the Superintending Engineer.

g. Filling Up of Borrow Pits on Land Side

Any borrow pits on the land side made in emergency during flood season near the rear toe may cause excessive seepage and form a surface of saturation along which the superincumbent material may slide or slip, endangering the stability the embankment. These should be properly filled up.

h. Miscellaneous Items of Pre-Monsoon Maintenance

The more important miscellaneous items of pre monsoon maintenance are as follows:

i. Broadcasting of lai and grass seeds as soon as flood water recedes to encourage growth for protection against wave-wash and erosion.

ii. Repairs of ghats, cross fences and longituding fences near village or road crossings.

iii. Upkeep of road on top of the embankment.

iv. Removal of all unwanted growth on slopes and top.

v. Attending to plantation beyond 6 m of the toe of the embankment to country side and 3 m on the river side.

i. Maintenance of Drain

Existing drains shall be kept in proper shape, grade, free from vegetation growth and shall be freely draining. Pitching of the drains shall be repaired from time to time if necessary, paving to the drains should be intact. Existing drainage arrangement, if found inadequate, shall be modified as per site condition and its defects rectified.

2.2.2 Specific Problems and Their Remedial Measures

a Seepage

Uncontrolled seepage through embankment dam and its foundation reduces the embankment stability by increasing the actuating forces and decreasing the resisting forces. The loss of strength of the embankment foundation materials and the flow-of the embankment foundation materials are due to seepage.

- Seepage appears as a wet area or as a flowing 'spring'. Area where the normal vegetation appears to be greener is another indicator of seepage.
- Junction of earth work with foundation abutments, masonry structures are especially prone to seepage problems, since a proper compaction is difficult to achieve in these junctions.
- The clarity of the seepage may be evaluated to check for the turbidity, which is an indication that the water passing through the embankment or foundation is carrying soil with it.

Remedial Measures

If Horizontal Piping is Detected

Pervious soil portions on U/s side shall be made impervious by clay pudding and rock grading from fine to coarse shall be recommended to be dumped into the downstream face of the dam, where the horizontal piping is observed.

For a permanent remedy, as soon as the reservoir is at its low level, the upstream face of the dam should be opened and pervious layers causing seepage should be traced out and sealed with impervious soil.

If Vertical Piping is Detected

Vertical piping causes boils on the surface of the grounds and a failure is expected only when the escape gradient exceed 1.50 except if the material is fine sand.

If a boil is noticed, the back pressure on the boils shall be increased with sand bags, for an area of ten times the diameter of the boil.

If number of small boils is noticed on a longer area, the entire area shall be loaded with 1.0 to 1.5 m thick filter blanket.

One way to have a permanent remedy is to provide relief wells on the downstream side and upstream blanket on the upstream side.

Another measure for a permanent remedy is to cover the area, in which the boils occurred, first with coarse sand and gravel and then with the coarser stone. The thickness of the fill is to over come any tendency toward movement even at maximum head.

b Cracking

Cracking is another serious deficiency and these appear in the crest or on the slopes of the dam.

Desiccation Cracks

Drying and inturn shrinking of certain types of embankment soil like plastic soils, causes cracks.

Remedial Measure

If the depth of the cracking extends below the reservoir level, the place shall be excavated in the form of trench up to the end of the crack and shall be filled with well compacted soil, of course, not with a plastic soil.

It is very important that excavation in the form of trench be done carefully under the skilled supervision.

Transverse Cracks

The indication of a differential settlement with in the embankment or underlying foundation appears in the form of TRANSVERSE CRACKING in a direction perpendicular to the length of the dam.

The cracking can be seen on the dam crest, near abutments, and in U-shaped or trapezoidal shaped valleys.

They are especially dangerous if it extends up to the core below the reservoir level.

Presence of compressible foundation material, irregular foundation surface, steep, abutment slopes develops transverse cracking.

Remedial Measures

The place shall be excavated in the form of a trench up to the end of the crack and filled with well compacted soil, if the cracks are up to 1.50 m and above the water level of the reservoir.

If the cracks are above 1.50 m and extends below the water level of the reservoir a trench of 1.50 to 2.0 m depth along the crack shall be cut. The remaining portion of the crack, i.e. from the excavated trench is to be filled with well compacted clayey soil, of course not plastic in nature.

Longitudinal Cracking

Uneven settlement between adjacent embankment zone of differing compressibility and the beginning of an unstable slope appears as a longitudinal cracking in a direction parallel to the length of the dam.

Remedial Measure

The material up to the depth of the crack shall be removed when the reservoir level is at low, the material shall be spread in thin layers and rolled after deciding on the designed density, the thickness of the layers, the amount of rolling and the weight of rollers.

It is very important that excavation in the form of trenches for treating all type of cracks be done carefully in parts under the skill supervision.

c. **Slides**

Overly steep slopes of the upstream and down stream, the horizontal or rotational movement of embankment material over-rolling, are shaped cracks, the swelling nature of the embankment material are some of causes for the shallow slides and deep seated slide.

Loss of strength of embankment material imbalances the force resisting movement with those forces tending to produce movement, resulting into slides.

If there is a slip, the reservoir shall immediately be lowered or drained to safe limit to prevent the possible breaching of dam.

d. Depressions

Gently sloping, bowlike side's depressions are due to localized settlement in the embankment or foundation embankment spreading in the upstream and down stream direction, erosion and improper final gadding following construction.

Depression on the crest and embankment slopes can be detected by sighting.

Remedial Measures

The place shall be excavated up to the depth of the depression and filled with well compacted soil.

e. Sink Holes

This is a serious type of depression and is formed when the removal of sub-surface embankment or foundation material has caused overlying material to collapse into the resulting voids. The embedded vegetative matter and animal burrow can also contribute to the formation of sink boles.

The presence of sink hole is an indication that piping process may be in progress.

Remedial Measure

The voids shall be filled by grouting with clay mix or clay cement

f. Swelling Pressure and Heave

Structure constructed in expansive soils undergoes damages, moderate to severe, sooner or later. When expansive soils are used in impervious zone, its properties are controlled by controlling the moisture movement and the external loading. Plastic clay of swelling type earthen foundation is usually the type of foundation which requires the greatest amount of study and investigation in order to obtain unquestionable safety.

Recommendations of remedial measures are possible only if a proper knowledge of soil properties in foundation and in embankment is available.

2.3 MASONRY DAMS

Proper repairs to the body of masonry/concrete dams shall be done where ever necessary either by replacing weathered or damaged portions of masonry/concrete or by repairing. Generally following problems are associated with masonry/concrete dams.

i. Excessive seepage & leaching from body and foundation of the dam.
ii. Increase in the uplift pressure in the foundation.
iii. Excessive deflection of the body of the dam beyond permissible limits, concentration of stress at critical points.

a Seepage and Leaching Action In Concrete/Masonry Dams

The leaching of cement from the set concrete and masonry as $Ca(OH)_2$ may cause serious problems in concrete/masonry dams. The nature of reservoir water stored by dam considerable bearing on such leaching.

Leaching in concrete is due to complex mechanism. This is caused by action of liquids (acquious solution). Which is capable of dissolving the ingredients from hardened cement, mortar.

Water having a low Ph value is acidic in nature. If such type of water having low Ph value (i.e. Ph values less than 7) enters into concrete structures, dissolution of the ingredient of hardened cement takes place. As hardened cement/mortar will always have a small percentage of free lime in it, the aggressive water hastens the reaction and lime is leached out.

Remedial Measures

Measures to be taken to prevent water from entering the body of dam and consequent corrective measures can be as follows:

i. Pointing the upstream masonry body with epoxy cement mortar to the lowest water level possible.
ii. Guiniting the up stream face with suitable material in one or two layers with wire mesh etc.
iii. For reducing the foundation seepage, grouting the foundation through the drainage gallery is the only remedy. Such fresh grouting will replace the cement grout already leached out from the foundation, in addition to strengthening of foundation.
iv. Grouting the body of dam from the top of the dam. This will ensure adequate bending inside the dam.

Both epoxy pointing and grouting the upstream face are effective in making the upstream face impermeable.

b Uplift Pressure

Due to passage of time pressure relief pipes provided in the foundation of masonry/concrete dams get choked thereby increase in uplift pressure on the dam. The increased uplift pressure tends to destabilize the dam.

Remedial Measures

If it is found that some of the pressure relief pipes are choked and uplift pressure is increasing, measures shall be taken either to reopen choked pipes by air water jetting or new pressure relief pipe shall be drilled from the galleries of dam.

c Excessive Deflection of The Body of The Dam and Concentration of Stresses at Critical Points

Due to weathering of concrete or masonry, the dam may become weak and increase in water level in the reservoir beyond certain levels may cause excessive bending of the dam and connect ration of stresses at critical point. If excessive bending is noticed, it shall be immediately reported to the higher authorities and dam safety organization. Till permanent solution to this problem is suggested, it may not be desirable to fill the reservoir beyond a critical level.

d Spillway and Energy Dissipation Arrangement

The spillway maintains the normal water level in the reservoir. Its function is to pass expected flood flows past the dam safely and without erosion. It may consist of a pipe through the dam or a system of gates that discharge water over the top into a concrete spillway. Either method uses the overflow principle. When the reservoir reaches a certain level, water flows into a standpipe or riser pipe or over a crest which may be gated or ungated. The crest of the spillway shall be cleared of all the boulders and other loose materials. Intake structures for spillways must have systems that prevent clogging by trash or debris. Following points should at least be checked during inspections of spillways:

- There is no leakage from the spillway.

- The surface of spillway is correct and true to their design sections and there is no cavity /cracks are visible.
- The spillway and its bucket is free from all vegetations and mud.
- The spillway section is in designed condition.

Energy dissipation Buckets.

- Wherever Energy dissipation bucket is in submerged position, after each heavy flood, it should be de-watered for inspection. In routine procedures, it should be de-watered every 5 years for inspection / maintenance.
- Required remedial measures be taken to repair defects if any found.

The spillway and energy dissipation arrangement shall be maintained properly to pass designed flood over them. Progressive erosion and retrogression in tail channel shall be inspected. Extent and location of such erosion shall be recorded for taking remedial measures.

Concrete surface of stilling basin (or bucket) and Apron including friction block, chute block and sill and slotted roller teeth shall be in good condition. Pitting, cracking spoiling or wearing of the concrete surface shall be repaired as per drawings. If abnormal cracking, pitting abrasion and cavitations is noticed it should be brought to the notice of higher authorities and dam safety organisation.

Gallery.

- The gallery should have proper lighting arrangements. Its drainage holes should be clear. The side intercepting holes and vent pipes should also be cleared. There shall be proper arrangements for disposal of water collected through drains in the gallery and measurement of discharge in each section.

- There should be V-notches etc. properly installed and fitted with gauges for measurement of discharges of each blocks in the dam. The AEN should analyze the data on day-to-day basis and excessive and less discharge in relation to water levels of previous years should be identified and immediate steps should be taken for its correction. A report of water measurement and conclusion summary should be prepared on monthly basis and forwarded to EE, SE and C.E.
- It should be ensured that cabling in gallery is properly installed and maintained. The inner surface of the gallery should be white washed with snowcem / white cement at least once in 5 years.
- The instrumentation provided in gallery should be kept in working order and wherever they are in-operative, case should be referred to experts for their opinion for taking corrective measures.

e Appurtenant Works

i. WALLS (Guide Walls/Divide Walls/Junction Walls/Return Walls/Spray Walls etc.)

Damage to the wall shall be repaired from time to time. Weep holes if provided shall be properly draining.

By suitable arrangement wall shall be protected by suitable arrangements if any erosion in their foundation is noticed. Unusual settlement lifting or development of cracks in walls if any shall be brought to the notice of higher authorities.

ii. BRIDGES (Spillway Bridge, Hoist Bridges/Trunnion Bridges)

Bridges shall not be loaded with higher loads then designed. Type and load of bridges shall be displayed at each bridge. Damaged parapets of the bridge, if any, shall be repaired for safety of the traffic. Slab and other structural parts of the traffic. Slap and other

structural parts of the bridges such as beams, piers, and abutments shall be properly maintained by repairing damaged masonry/concrete or joints if required)

2.4 GATES

2.4.1 Purpose of Gates

Mechanical system is commonly used in dams. Gates and valves are used to control or stop the flow of water in a water way. In general, gates consist of a leaf which is moved across the water way from an external position, valves on the other hand are fixed permanently within the water way and have a closure member that is either rotated or moved transversely or longitudinally in the water way, in order to control or stop the flow. Gates can be classified as control gates or maintenance gates.

i. Control gates and valves are designed to regulate water flows, and therefore can be used either fully opened or closed or in any setting in between.

ii. Maintenance of emergency gates and valves are used upstream of control devices, to act as stand by or reserve closure equipments, or to stop the flow of water so that a gate, valve or fluid way downstream can a serviced.

2.4.2 Hoists and Operators

Hoist and operators are the mechanisms used to adjust the position of gates and valves. Hoists are employed exclusively with gates, to move them into and out of waterways, while the term "operator" is used to refer to positioning systems for both gates and valves. Hoists and operators can be operated either manually, electrically, hydraulically, or air-powered.

The proper operation of a dam in an emergency depends on the proper operation of its outlet works. Improper operation of mechanical

equipment can cause dam failure resulting in huge losses of life and property, as well as the loss of the dam itself. Moreover these equipment are used very infrequently (often in an emergency situations only), regular inspection must be conducted to ensure that the equipment will function when needed. Since a large portion of this equipment is exposed to the elements, operating and structural problems can develop that may only be discovered through periodic inspection and testing.

2.4.3 Inspection of The Gate Leaf

The gate leaf must be checked for seal damage, cracks and damaged structural members. The primary consequence of seal damage is leakage past the gate leaf. The loss of water may in some cases be acceptable, while in others it may not. When leaking occurs past a seal on a gate leaf that is subjected to high hydraulic head, the velocity of the leaking water will be high. If there are any particles in the water, they will act as an abrasive on the downstream side of the gate leaf and the adjacent floodway, resulting in progressive erosion of the leaf and floodway.

2.4.4 Damaged Structural Members

Structural members are often damaged by overloading the leaf. This can occur if a piece of debris strucks under the gate leaf when the gate is being closed.

The gate operator will exert its full pressure, since there is no signal from the limit switch to stop the operator, and the stress will be absorbed by the structural members in the leaf.

Damage can also occur when debris strikes the structural members. The result of damage to the structural members is a reduction in the structural integrity of the gate leaf, possibly leading to failure of the leaf.

2.4.5 Inspecting The Gate Frame

Damage to a gate frame is often incurred when an attempt is made to close the gate while debris is lodged in the gate opening. This action can bend the gate guides and/or the seal.

Warp of Misalignment

Differential settlement in the structure that houses the gate can also damage the gate frame. Such settlement will result in warp or misalignment of the seat and/or guides, which are attached to the structure.

When inspecting a gate frame, look for leakage which is an indication that something is wrong (i.e. the sector guides are bent or wrapped).

2.4.6 Inspecting the Lifting Assembly

The operation of gate's lifting assembly can be impaired by corrosion and by a damaged stem or stem guides.

Corrosion

Corrosion damage at the hoisting connection can eventually break the attachment between the stem and gate. The stem and stem guides can also be damaged by corrosion, especially if the gate is infrequently operated and/or the assembly is improperly lubricated. When inspecting a lifting assembly, look for corrosion at the hoisting connection and on the stem and stem guides, and check the assembly for proper lubrication.

Bent Stem and Stem Guides

Debris, ice, or other large matter slamming into the hoisting assembly can bend the stem and/or bread deform, disalign or dislodge the stem guides. Forcing the gate into operation when debris is wedged in the gate opening or when the gate is "frozen" in the place can have the same, destructive

effect on the stem and stem guides. When inspecting lifting assembly, look for improper alignment of the stem and for misaligned, damaged or missing stem guides.

2.4.7 Specific Guidelines for Visual Inspection of Gates

Scintillates, beams and Girders	:	Look for corrosion or cavitation damaged area cracked welds, broken structural members and missing or broken rivets or bolts. Pay particular attention to the leaf.
Roller Assembly and Carriage	:	Roller assemblies shall be well lubricated and shall be well lubricated and shall be checked by actual raising and lowering the gates through full range of travel.
Tracks	:	Look for deformations, corrosion, damaged surfaces, and missing or damaged belts and clips.
Frame	:	Look for badly corroded parts, damaged or missing bolts and damage, especially down stream from slots and along the floor.
Seals	:	Check the seals for wear & tear and replace the damage seals.
Trunnion	:	Make sure that the trunnion is anchored securely.
Clearance	:	Check that there is a minimum clearance between the edge of the skinplate and side-seal plates and rollers where provided.
Limit Switches	:	Ensure that they are set for proper operation of the gates.
Hoisting Connections	:	Check that each connection (i.e. pin or clevis) is structurally sound and is not worn.

The gates must be painted annually with Anti Corrosive Black Paint after sand blasting if necessary.

Test Operation

The test the gate, operate it under balanced, no-flow conditions (if possible) and ensure that the leaf moves smoothly and without binding.

After ensuring that the downstream side of the leaf is adequately vented, operate the gate through full travel with full flow while subjected to maximum head (if possible). Ensure that the leaf moves smoothly and without binding.

2.4.8 Specific Guidelines for Inspection of Power Systems Test Operation

Electrical Parts & Motor.

All the bearings, ropes, fittings etc. should be properly cleaned and oiled/greased before monsoon. The motors shall be checked by lifting the gates. They should also be inspected weekly by the concerning JEN/AEN to ensure their perfect working during monsoon period also.

Cabling.

The cabling used for lifting arrangements of gates should be inspected at least once in 6 months i.e before monsoon and after monsoon and should be ensured that they are properly insulated and laid properly. Any weakness in insulation or otherwise should be identified and must be removed / replaced by proper jointing.

Panel boards and Switches.

Each panel board, switches etc. used in lifting arrangement systems and or illumination system or otherwise must be checked for their perfect conditions atleast once in every 6 months .

Generator and Control Panels.

Each Generator, Control Panels etc. used in lifting arrangement systems must be checked for their perfect conditions atleast once in every 6 months .

To test the motors and electrical system operate them under maximum loading conditions (if possible). Test operation of the electrical system should consist of the following steps:

i. Before the test operation, megger all electrical supply conductors and motor windings. The reasons for these tests are to check the insulation resistance of conductors and motor windings.

ii. Take voltage readings before operation and during operation, to check for an excessive voltage drop in the electrical system.

iii. Take current reading when the gate or valve is being opened and again when it is being closed. The reason for this is to check for overloading on the motor.

During the test operation, look for the following occurrence that could indicate problems within the electrical system.

i. Motor starter making noise or chatter.

ii. Circuit breaker tripping or fuses blowing.

iii. Motor bearing making noise (check by listening with the motor running)

2.4.9 Specific Guidelines for Visual Inspection of Hoists and Operators

Fixed Hoist

A fixed hoist is a hoist that has been permanently installed for use with a particular gate. The hoist consists of one or two rotating shafts and power unit. Wire rope or chain is wound onto the drum(s) to raise the gate and the gate is lowered by winding the rope of chain off of the drum(s). A fixed gate hoist typically is powered by an electrical motor, but in some

instances hydraulic, air or direct mechanical means such as a manually operated hand crank and used.

Surfaces and coatings	:	Make sure that all surface and coatings are free from cracks, corrosion and other damage.
Structural members	:	Check the structural members are not corroded, out of alignment, loose or damaged.
Base plate mounts	:	Ensure that mounting nuts and bolts are tight
Coupling	:	Check that nuts and bolts are tight and moving parts are lubricated.
Drums	:	Check for debris and corrosion.
Wire rope	:	Inspect for broken strands, splices, and proper lubrication. Make sure that the rope winds neatly onto the drums and that there are at least two full wraps on the drum when gate is in the lowered position.
Chain links	:	Spot check for cracked, deformed or severely corroded links.
Clear reducers	:	Open the drain and check for any accumulated condensation.
Oil sump	:	Check for condensation in the oil sump and drain any water that is found. This must be done before the hoist is operated or the water will be mixed with the oil. Record the amount of water and determine whether it is significant or merely reflects normal condensation.

Traveled Hoist Unit

A traveling hoist unit is a hoist, mounted on rails that can travel the length of the spillway deck to lifts gates one at a time.

When a gate must be lifted, the unit is spotted over the gate slot. The operating personnel attach the gate's lifting chains or ropes to the hoisting drums on each end of the hoist unit.

The hoist is operated to raise the gate to the desired height, at which point a dogging mechanism then reversed to unwind the tope on the drum, so that the hoist unit can move on the next gate.

Overall Unit	:	Check for corrosion or other surface deterioration. Made sure the motors and controls are in good condition. Check for loose or missing hardware. Look for oil leakage, especially at the oil seals. Inspect the following for proper lubrication and or excessive wear: – Chain drums – Bearings – Gears and Pinions – Brake linings
Trolley Wheels and Rails	:	Examine for wear and misalignment.
Oil Sumps	:	Check for condensation in the oil sumps, drain any water that found. This must be done before the unit is operated or the water will be mixed with the oil. Record the amount of water and determine whether it is significant or merely reflects normal condensation.
Dogging Mechanism	:	Check for lubrication and water.

2.5 Maintenance of Relief Wells

Relief wells require a certain amount of nominal maintenance to ensure their continued and proper functioning. For relief wells to function properly, it is essential that they be kept free of sand, silt, organic matter, of any other material that would retard free flow.

Relief wells should be inspected twice a year preferably immediately prior to normal high-water seasons, and more often during major high waters.

Each well should be sounded every two to three years and after each major high water to see that it is free of trash and any obstruction, and to determine the amount of sand. Silt, or other material that may have settled at the bottom of the well. Any trash, obstruction, of sediment to a depth greater than 45 cms in the well should be removed. All wells requiring removal of sediment should be pump tested after cleaning to see if any appreciable loss of efficiency has resulted form foreign material entering the well. In addition, all wells should be pump tested at least every 5 to 8 years, if the pumping test indicates that the specific yield (rate of flow in liters per minute per meter depth of draw dons) is less than the original specific yield by 20 per cent of more, the well should be surged in an effort to its original efficiency.

Individual wells known to have been subjected to inflow of muddy water should be pumped or cleaned before the next high water season.

Surging and jetting should normally restore the capacity of the well. However, each well in which excess sediment has been noticed should be pump tested to its specific yield. If the specific yield is found to be less than 80 percent of the original, rejecting will be necessary to restore the

specific yield. If the specific yield permanently drops down to appreciably below 80 percent a new relief well may be installed a few meters away.

Discharge observations on each relief shall be made by measuring the time required to fill a drum of container of known volume. The discharge measurements shall be made at least once a month at the time of high reservoir level and for every 2 meter fall in reservoir level.

A register of relief wells shall be maintained giving the as executed plan of the relief well indicating subsoil strata, details of slotted pipe and shrouding and observation made from time to time regarding performance of the relief well.

Piezometers

All Piezometers should be inspected annually for damage of any unusual condition that might affect their performance. The site of Piezometers should be kept clear of weeds and bushes and cared for in the same manner as described for the relief wells. Any damage to or maintenance performed on Piezometers should be reported and the Piezometers repaired. Effectiveness of the Piezometers should be checked.

2.6 D/S River Portion Retrogation.

The capacity of the down stream channel up to certain distance, say 300 m below spillway, shall be checked. Any damage in the channel shall be repaired. JEn must take cross section levels of river down stream at 30 meter interval at least up to 2 Km. and superimposed over previous year x-sections to identify retrogation or deposition in river bed after monsoon. The results of cross sections should be compared from design levels and if any trend detrimental to structures is identified, immediate remedial measures should be taken.

Non-Overflow Section.

Following items should be checked during inspection of Non-Overflow Section.

- The TBL of top width, down stream and upstream slopes are maintained as per design section. The dam is free from all vegetation growth and should clear.
- There is proper arrangement for disposal of rain water.
- The pointing in masonry / damages is properly taken care of.
- The railing etc. are properly cleaned and sluice well is functioning properly.
- The pitching and local settlement, rain cuts, turfing etc. are properly maintained.
- The down stream toe should be inspected and it should be free from any obstruction. The drainage arrangement is properly laid and maintained. The discharge measurement of seepage water should be taken regularly and analyzed. It should be compared from previous years/ as per design parameters.
- In case trees have grown over the dam then it should not be uprooted without making arrangement for filling up the voids so created through puddling/ ramming or otherwise. The number of such trees should be counted and be recorded and no-trees should be allowed to grow henceforth. However, trimming of trees / cutting stems should be taken so that due to wind action trees may not loosen embankment earth. No vegetation up to 20H of dam should be allowed on country side and 10 H towards filling side.
- The Embankments of upstream and downstream should be checked thoroughly for rat holes / burrow animals etc. The supervisor should check the embankments in pre monsoon / post

monsoon and during monsoon period daily and he should report in the register.

2.7 INSTRUMENTATION

2.7.1 Introduction

Every physical system deteriorates with passage of time. Dam structures cannot be exceptions. Continuous surveillance to see behavior of dam is necessary. Observations have to be annualized and documented for follow up action, for strengthening of dam. It is necessary to check whether the basic measurements and readings of the instruments installed for watching the behavior of dams are being taken at the specific intervals and are recorded properly in the proper manner. They would form the basic field level information, which shall be used for analyzing and scrutinizing of behavior of dam eg Piezometer, Stress Meter, strain Meter, Thermometer, Extensometer, Inclinometer, Joint-meter, Foundation Deformation Meter, "NO-Stress" Strain Meter, Optical Plummets etc.

2.7.2 Importance of Observations

Instrumentation, which is an essential tool, for monitoring of Dam Safety and its behavior under different conditions of loadings, observations of uplift pressure build up in the foundation of a masonry or concrete dam and the pore pressures in the body of earthen embankment across the dam section would give valuable information called for. Piezometers and pressure transducers of cells buried can transmit these readings truthfully.

The internal stress developed in various sections of the dam structure for different levels of reservoir are to be read to see whether they are within the designed values so that the factor of safety adopted is not encroached

upon in the normal functioning of the dam. Stresses can be obtained from strains measured with electrical strain gauges or can be directly measured with electro-acoustic strain meters.

Deflection in the masonry dam due to water pressure is also a parameter to be checked to see whether it is with in permissible limits. The old plumb bob measurement through a vertical shaft in the dam is now improved up on by measuring through accurate theodolite or laser beams.

2.7.3 Type of Measurements and Instruments

a. Masonry & Concrete Dams

The type of measurements normally required to be taken for a concrete dam are in respect of stress, strain, uplift, pore pressure, temperature, displacement, seepage and those pertaining to seismic activity. Most of the instruments work on strain meter technology and basically are of two types.

i. Resistance Type

These work on the principle that elastic resistance of a metallic wire changes proportionately to change in its length. The reading in this type of instruments is affected by length of lead cable and contact resistance of switches and plugs. Their use is not recommended when lead length exceeds 70 m.

ii. Vibrating Wire Type

These work on the principle that when plucked the frequency of a stretched wire depends on the tension in the sire and hence on the strain. The reading in such instruments is not affected by cable length or contact resistance of switches and plugs.

b. In Earthen Dam

Displacement, pore pressure and seepage observations are important for watching the structural safety of an earthen dam.

Seepage can cause internal erosion as well increase in pore pressure resulting in displacement or directly measured. Accurate measurements of stress in earth dams in complex and the design analysis is based on radial simplifications of the stress pattern and slope of the raptive planes. Interpretation of results of stress measurements therefore requires considerable judgment and experience.

i. Internal joint measurement is measured by joint meters. Surface joint meter on down stream face or in galleries is generally provided at three elevation at the centre of the blocks to measure their movements with respect to adjacent blocks.

ii. Foundation displacement is measured both in vertical and horizontal direction. Point bore hole extenso-meters are used to measure vertical displacements.

For measuring horizontal foundation displacement inverted plumb line is installed in deepest block.

The instruments for measurement displacement, pore pressure, strain and stress are provided into the section of dam which is critical from safety considerations.

A neat and tidy record of instrument observations is essential for easy accessibility and interpretation.

2.7.4 Importance of Various Measurements

Head Water and Tail Water Gauges

The existing record of the head water and tail water gauge should be examined to determine the relationship between other instrumentation

measurements such as stream flow, uplift pressure, alignment and drainage system discharge with the upper and lower surface elevations.

Horizontal and Vertical Alignment Instrumentation (Concrete Structure)

The existing records of alignment and elevation surveys and measurements from inclinometers, inverted plumb bobs, gauge points across cracks and joints, or other devices should be examined to determine any change from original position of structures.

Horizontal and Vertical Movement Consolidation Instrumentation (Embankment Structures)

The existing records of uplift measurement should be examined to determine if the uplift pressure for the maximum pool would impair the safety of the dam.

Uplift Instrumentation

The existing records of uplift measurements should be examined to determine if the uplift pressure for the maximum pool would impair the safety of the dam.

Drainage System Instrumentation

The existing records of measurements of drainage system flow should be examined to establish the normal relationship between pool elevations and discharge quantities and any change that have occurred in this relationship during the history of the project.

Seismic Instrumentation

The existing records of seismic instrumentation should be examined to determine the area and the response of the structures to past earth quakes.

Accelerometers are required to be installed near the bone and at top of dam to measure and record seismic activity at dam site.

Measurement of Temperatures

Measurement of temperature in the body of a concrete dam is of great importance and ample number of thermometers should be provided.

Measurement of Seepage

Sudden increase in quantity of seepage without its relevance to the increase in reservoir level or other immediate factors like incessant rain may indicate some cracking in the dam body. small weirs and notches are proposed to be installed to measure flow in the drains provided in galleries.

Measurement of Displacements

Measurement of displacements provides useful indication about the behavior of an earth dam. Vertical displacement indirectly indicate the stresses while horizontal displacements would reveal dangerous incipient sliding or shear fail in problems of long term stability of soils having time dependents strength properties measurements for measurements of internal displacements are obligatory when such problems arise. These instruments are also essential for test embankments to check the failure surface.

Measurement of Pore Pressure

Pressure depends on compressibility of soil, measurements of internal impression and settlements must supplement pore pressure measurements. Similarly measurement of seepage and corresponding levels of the reservoir and water is essential for interpretation of pore pressure observations. Measurements of pore pressure are also essential for

evaluating the performance of measures to control seepage through or under the dam. Failure of drainage provision and dangerous concentration of seepage can be revealed by pore pressure observations.

2.8 PERIODICAL INSPECTION OF DAMS

The Central Water Commission, New Delhi has issued detailed instructions regarding pre-monsoon/post monsoon inspection, of large dams. The format for inspection of large dams is enclosed as Annexure – 1 (a) and (b). The periodical inspections of all dams must be completed as per schedule given in Annexure –I(a) and (b).

Authority for Inspection Dams

In addition to periodical inspection of large dams by the concerned Assistant Engineer, Executive Engineer, the dam shall also be finally inspected as specified in Annexure - 1.

Check List

Central water commission has issued guidelines about what to check before and during monsoon for safety of dam. The guide lines are enclosed as Appendix – II (a) & (b). These guide lines shall be adhered to and proper measures taken for safety of the dam before every monsoon, and during monsoon.

Pre-Monsoon Certificate about Proper Maintenance of Irrigation Works

All the Executive Engineers are required to submit certificate to the following affects so as to reach Chief Engineer Irrigation by name latest by 15th June of every year.

i. That the necessary maintenance/repairs/restoration has been carried out on the tank is of the Division and that all the tanks are in a position to behave well during ensuing monsoon.

ii. That all the allied masonry works have been supervised and that there seems to be no danger to the various structures.

iii. That all the regulator gates on all the irrigation works of the Division have been checked and found to be in a satisfactory working order.

iv. That all the new works taken in hand during the year have been brought to a stage where no danger due to the floods is feared and that no damage is likely to be caused during the rainy season.

v. That all the outer borrow-pits made in emergency during the flood season which might cause excessive seepage have been properly filled-up and that filling reaches where heavy percolation is likely to occur have been properly strengthened.

vi. The general condition of all the irrigation works in the Division is satisfactory and no danger is foreseen to floods.

CHAPTER- III
CANAL OPERATION & MAINTENANCE

3.0 GENERAL PROBLEMS OF AN IRRIGATION CANAL NETWORK

The general problems that are found in an irrigation canal network include:

- limited amount of water available at the water source;
- high water consumption in fields close to the water source resulting in water shortages at the tail end of the scheme;
- illegal manipulation of canals, structures and encroachments;
- siltation;
- plant growth;
- water losses;
- frequent overtopping; and
- Low water levels due to canal erosion.
- Non use of night irrigation

Lack of maintenance of the canal network causes severe problems. Canals may also have problems relating to;

- Bad design or bad construction leading to sub-optimal functioning of a scheme. A canal may be too small to supply enough water to irrigate the area served by the canal, and if the discharge needed is supplied to such a canal, it will be excessive and water will overtop.
- The water level in a canal may have been wrongly determined, and if it is too low, water may not enter the fields by gravity. Check structures or even pumps will then be needed to supply water to the fields.

- If the minimum required free board levels are encroached, canals can easily overtop in emergencies.
- Canal slopes which are too steep may suffer erosion from high flow velocities. When construction materials are not well chosen, canals may collapse.

3.1 CANAL MAINTENANCE

A good maintenance programme can prolong the life of canals. Maintenance of an irrigation canal system is usually carried out in between two irrigation seasons, or at times of low water demand. It consists of cleaning, weeding, desilting, re-shaping, and executing minor repairs. Plant growth and sedimentation not only impede the flow in a canal, they also diminish the area of the cross-section. As a consequence, the canal capacity may diminish. A reduction in the capacity may result in overtopping and limit the water supply to the fields. The available water will also be reduced when there are leakages in a canal. To protect the system from these problems, the canals should be maintained on a regular basis. Even when a canal is well maintained, serious technical problems may arise. These problems need to be resolved by repair or improvement works. A repair should usually be done as soon as possible, depending on the severity of the problem. Improvements, such as the lining of a canal section, may be postponed until the end of an irrigation season, when canals are dry and farmers have more time available.

Some general maintenance requirements needing frequent attention:

- Bushes or trees on canal embankments should be removed. They may obstruct the water flow and their roots will open the soil in the banks and cause the development of leakages.

- Plants, silt and debris in the canal should be removed. While cleaning the canal bed, care must be taken that the original shape

of the cross-section is kept. For this, a wooden frame, or template, with the exact dimensions of the designed cross-section of the canal being cleaned, can be of great help.

- Breaches and rat holes in the embankments should be filled with compacted soil, inside as well as outside of the embankment. For compacting, the soil should be wetted.

- Weak sections and sections of canal embankments where people or animals cross the canal should be strengthened with compacted soil or with bricks.

- Eroded sections of a canal should be rebuilt to the original shape. For maintenance operations it is important to organize farmers (WUA) and to involve them in the activities.

3.2 UNLINED CANALS.

The main requirements of canal section are as follows:

a) A clean regular bed,
b) Straight clean slopes,
c) Uniform berm widths, and
d) Uniform regular top width and other anti inner faces of both banks.

Closure of main canal and branches shall be notified sufficiently in advance. Whenever a canal is closed it should be inspected as soon as possible. All pipes and openings in the crest of falls shall be opened so as to drain off the water upstream of the fall. The canal shall be cleaned before it is run again. All masonry work shall be periodically cleared of rubbish, stones, brickbats, etc. as the opportunity offers, especially the siphons and the stilling basins.

3.2.1 Bed and Berm

Bed and berm shall be scraped, where necessary and especially in tail reaches. Berm and bed lines shall be correctly aligned beforc scraping. Berm shall not be scraped if it has not silted properly.

Before starting work on either the bed or berms, they shall be aligned by flags and string. The former are necessary for the alignment in general and the latter to correct small irregularities in that. Every opportunity shall be taken to straighten file canal and to get rid of kinks and irregularities in the alignment and also to ease of-Fall curves where scouring or sitting takes place.

Clearing operation shall be started from down stream to upstream slanting either loom the fail or a fall.

Bed

All grass shall he scraped and weeds removed from the silted bed wherever they are found to exist since their presence induces silt deposit. All local accumulations or continuous deposits or mounds of silt shall be removed to correct bed level.

Beds shall be leveled and their gradients regularized by tile removal of sill mounds and all mounds higher than correct bed level. Bed levels shall be fixed correctly at close intervals by means oh boning rods. In case of main canals. branches, and distributaries, sill at the junction of bed and slopes should not be removed if- the section of waterway is not unduly affected. Small minors and all tail reaches shall, however, are cleared to the correct trapezoidal section. The practice of cutting the silt deposited at the junction of side slope and bed and throwing it on the bed to level it shall not be permitted.

Note: It will be desirable to prepare a longitudinal section of main canal and branches during closure once a year Cross-sections should be taken in reaches where the Section is over-wide or too much scoured. The behaviour of canal should be studied and longitudinal section readjusted, if required. Closure register should be maintained in which brief inspection report 1m each work long with details of repairs if any carried out shall be entered by the Assistant/Executive Engineer.

Irrigation canals that carry silt-free water from reservoirs generally get infected will) aquatic weed growth which reduces their capacity and thereby impairs their proper functioning For maintaining these canals at designed efficiency it is essential to keep them clear of aquatic weeds. In case of new constructed canals regular inspections should be undertaken to locale any spots where tile weed growth has set in. Weeds from such spots should be removed completely so that infestation does not spread. In the ease of old canals where aquatic weed growth is profuse suitable mechanical or chemical methods may be employed at as early stage as possible. Care should be taken that the chemical is used within reasonable limits so that it is not harmful for living beings and the crops. Biological methods such as list) culture of the type of grass-carp could also be tired.

Inlets and Escapes

Inlets normally cause harm to the canal bed and side slopes and the drainage therefore should be siphoned under the canals wherever economically feasible. If storm water is admitted to the canal at any place, the canal immediately, above and below the inlet, should be inspected after storms and any silt or sand that may have been brought down should be cleared away to maintain proper section. When inlets are provided with loose stone bunds or inlet walls or traps they shall be cleared of silt from time to time.

Escapes shall be kept clear of sill and jungle growth. These shall be run occasionally to test their discharging capacity and to maintain right of escaping excess water into natural drains in which such escapes join and to avoid tendency of cultivators to sow in low lying lands in the bed and along the sides of such natural drains.

Berm

Berm cutting shall not be started until samples profiles have been cut and the lines carefully laid. Where earth is required for repair of banks, berm pockets may be made in the manner specified in 2.5.3.

Wherever berms are fully formed up all grass and brushwood shall be removed from them since their presence induces abnormal and irregular growth resulting in construction of canal section.

Irregular protruding and overhanging berms shall be cut back to proper alignment and slope. If his is neglected berms fall in or protrude abnormally and the canal tends to adopt an irregular section or winding course. Wherever berms have grown excessively thereby tightening the waterway they shall be cut to proper section.

Berms shall be kept straight by trimming projections after aligning them correctly. Heavy berms cutting may be voided by regular trimming and scraping as the situation call for every year.

3.2.2 Silt Clearance

If canal is in regime and taking its full supply, it is not necessary to clear silt to the theoretical cross section. If the canal is not functioning properly, it may be sufficient merely to clear a portion of silt to get it into efficient working order or it may be necessary to clear to full theoretical cross-section. Om run of the river canals and specially those which are

also run for paddy up when clear water runs in the channel after monsoon. Longitudinal sections of silted bed of such channels should be taken during closure immediately after monsoon and the gradient at which silt shall be removed should be approved by the Executive Engineer. Silt should not be cleared below falls but if outlets in such places are overdrawing water due to rise water surface, they should be raised. Boning rods should be used to see whether silt has been properly cleared. As soon as canal closed for a fairly long period the bed shall be uncovered and the depth of sit them recorded.

3.2.3 Silt Disposal

a) **Coarse Silt-** found in head reaches of distributaries. It contains a large percentage of sand which does not stabilize and is useless for any repairs. This should be disposed of in filling old borrow pts first and then on long outer slopes of banks; care being taken that the top of the heap is never allowed come above the bank level. Silt thrown along outer slopes of banks shall be disposed of in a regular and uniform manner and not in irregular heaps;

b) **Medium Silt -** found in middle reaches of distributaries. It stabilizes after one monsoon passes over it if taken out taken out before or during the monsoon. It may be utilized in : (1) closing leaks, (2) securing outward slopes, and (3) widening bank only as supplement to the berm earth if it proves insufficient; and

c) **Fine Silt –** found in tail reaches of canals. Contains a good proportion of clay and settles down to a very smooth surface and allows grass to grow freely on it. It is valuable for all repairs and should be sued like berm earth.

Silt shall not be heaped above bank level. It shall not be used in raising and narrowing already high and narrow banks. It shall never be thrown on the berm of inner slope of banks. Coarse and medium silt shall not be spread on canal service road. If this has to be done for any reasons, the surface should be covered by a 15 cm thick layer of good loamy soil or fine silt.

Material obtained from bed and berm cutting should be utilized in repaired the banks to make them up to the design section.

Bed silt should generally be thrown on outer slope of the weaker bank to strengthen it; if both banks are equally weak it should be thrown equally on each side.

Miscellaneous

Where a canal is running brushwood that collects at bridges, siphons and falls, it shall be removed to some distance away from the banks, dried and burnt. When trees fall into a canal they shall be removed at once. When general clearance it being done it should be particularly seen that silt and rubbish are cleared from under the bridges.

Instances of excessive scouring at any point should be noted and adequate measures, such as driving in stakes along with brush wood and construction of revetment shall be taken to stop them.

Discharge observations on main canal and branches shall be carried out at least once a month during non-monsoons. During monsoons discharges should be observed more frequently for diversion canals. Percentage to normal discharge should be revised from time to time for purposes of regulation and distribution of water. In case of high seepage losses in the main canal, discharge observations should be carried out at several points

along the canal to locate the reaches where the seepage loss is high and suitable remedial measures should be taken to reduce it. Frequent observation of discharges on distributaries and minors is necessary to see that they draw the authorized discharge at FSL. Currents meters should be used for observation of discharges. Where such facility is not available or where depth of water in the channel is insufficient, floats may be used, discharge sites should be fixed at suitable points and may preferably be in the form of flumes, falls or straight runs of lined section. All discharges observations should conform to relevant Indian Standards.

Gauges at the head and tail of all the channels and at important points in between on long channels should be observed and recorded daily.

3.3 LINED CANALS

3.3.1 Canal Lining

A lined canal shall be maintained so that it continues to function efficiently and serves the purpose, for which it has been constructed, throughout its effective span of life. In addition to maintaining its imperviousness, the lining shall be maintained so that it also continues to have the same discharge capacity for which it has been designed and which it had when it started operating soon after the construction was over. The reduction in discharge may generally be due to accumulation of silt; cracking of lining; failure of the drainage; growth of weeds, alae and moss; etc.

Normally no silt deposition shall be permitted to take place in a lined canal. Sometimes the canal may have to be run at less than the designed full supply discharge on account of fluctuating water demands, over the base periods of the crops to be irrigated. Also, even for a single crop discharge requirements vary from month to month. Such low discharge condition induce deposition of silt over the canal bed owing to low

velocities of flow. Consequently, the discharge carrying capacity of the lined canal is adversely affected. Silt deposition in lined canals can be minimized by judicious operation of gates of cross regulators. These gates of cross regulators. These gates should be lowered for ponding on the upstream side only under the following conditions:

a) To limit the rate of draw down in the lined canal to a maximum of 0.5 meter per day either during fluctuations of discharge or when the canal is being closed.

b) To enable channels taking off upstream of the regulator to be fed properly or to divert flow through escapes.

All other times, the canal should be run with gates fully open.

Special design features like under-drainage arrangements, humps or regulators in canal bed silt ejectors, surface drainage; etc should continue to function efficiently so that the safety of the lining is not endangered.

3.3.2 Canal Closure

Suitable rules shall be framed and observed for each canal system to ensure that the closure does not create a rate of drawdown which is more than what is provided for in the design.

3.3.3 Inspection of Lining

Whenever canal is closed for periodical inspection and repairs, the lining, its auxiliaries and special design features shall be carefully inspected. The following points shall be notes while carrying out the inspection;

a) Whether any cavities or pockets have been formed behind the lining. Note: At places where considered necessary these may be checked by sounding the lining tiles by means of a suitable light hammer.

b) Development of any cracks or displacement or damage to lining;

c) Whether the filler material in the joints of the lining is sound, intact and leakproof and any weed growth in the joints has been taken place;

d) Whether pressure release arrangements and humps or regulators (if any) function effectively;

e) Whether pipes and openings provided in the crest of falls are choked; and

f) Silt deposits and weed growth.

3.3.4 Maintenance of Lining

There can be distress to the lining ranging from small settlement cracks to excessive heaving displacement and sinking of the lining in the following situations:

a) Cuts in soft fine grained soils, specially when the lining was laid directly on the soil without any special preparation of the sub grade;

b) High water table situated considerably above the canal bed, especially in fine grained soils, where weep holes or other simple drainage devices are not very effective.

c) Freshly laid embankments, specially if composed of clayey soils;

d) High continuous spoil banks, left too near the canal excavation without sufficiently wide berms and adequate arrangements for draining the rain water away from the canal and similar situations permitting surface drainage to enter behind the lining; and

e) Cavities behind lining caused due to sucking out action on sub grade material by oscillating waves or fluctuating supplies of water of the canal through cracks, open joints and holes in lining. Such action as may be necessary to avoid recurrence of any failure in the lining shall be taken by investigating the causes of the failure and remedying them. The defects or damaged parts of the lining, joint

filler, etc, shall be immediately attended to and repaired so as to ensure a sound, stable and water-tight lining.

Any cavities or pockets portions of lining shall be removed and replaced by fresh lining of quality comparable to the original lining. The sub-grade shall be thoroughly compacted and prepared in accordance with IS:3873-1978* before laying the fresh lining. The cracks (other than hair cracks) shall be filled with bitumen or other suitable filler so as to ensure water tightness of the lining. A more effective sealing of cracks may be obtained by cutting a V-groove along the face of the crack before filling with sealing compound. Minor cracks on the lining may be sealed by dumping powered clay upstream of the cracks.

The damaged or displaced portions of the joint filler shall be carefully removed. The joint shall be cleaned of dirt, weeds, etc, before filling in fresh filler material.

The choked pressure release pipes shall be cleaned by intermittent application of air and water or by rodding. Defective flap valves or other parts shall be repaired or replaced. The humps or regulators shall be well maintained and repaired, if necessary.

All drainage and pressure release pipes and opening and openings shall be cleaned of any dirt, debris, etc, and water accumulating upstream of the fall, if any, shall be drained off.

In previous linings, such as boulder lining, any portion in which excessive settlement has taken place, shall be repaired by dismantling making up the sub grade and relaying the lining.

The lining should be protected from ingress of rain water behind the lining. The free edge of the lining should be well tucked into the canal

bank and a berm with a catch water drain provided at this level as an added protection. Turfing of the slope above the lining level would greatly help in preventing scours and gully formation.

3.3.5 Reaches With High Subsoil Water Level

The subsoil water level shall be observed in such reaches carefully and regulatory during and after the rainy season besides routine observations from time to time. In case of rise, the adequacy of the pressure release system or other remedial measures like humps, regulators, etc, provided for the safety of the lining, shall be reviewed and further measures adopted, if necessary.

3.3.6 Seepage Through Embankments

Seepage through embankments, if any, should be observed at reasonable intervals of time. Where necessary, particularly in high embankment reaches, observations of seepage flow shall be made and any abnormal increase in the seepage rate shall be viewed with caution, its possible causes investigated and remedial measures taken.

3.3.7 Silt Clearance

If any silt deposition is detected during inspection, steps shall be taken to investigate causes thereof and to take remedial measures for the same. Only in exceptional circumstances it may be necessary to excavate the silt and remove it. If any silting tendency is noticed in the form of reduction of discharge carrying capacity, cross-sections of the lined canal should be taken at frequent intervals to determine the extent of silting and to see if the silt deposited during monsoons can be flushed out during non-monsoon period when the water is silt free. Where silt clearance in unavoidable, it should be done carefully by manual labour to prevent damage to lining.

3.3.8 Weed Removal

Aquatic weed growth, if observed below the supply level should be removed. Land weed growing over the free board should also be controlled.

Performance of Canal

An accurate and systematic record of the performance of a canal should be maintained by periodic observations of Manning's roughness coefficient evaporation and seepage losses, life and behaviour of the lining adopted, surge wave heights, and performance of any special design features like pressure release system. Provision of humps or regulators etc.

Miscellaneous

Brushwood that collects at bridges, siphons and falls shall be removed. When trees fall into a canal they shall be removed at once.

3.4 CANAL BANKS

Banks shall be brought up and maintained to full section. The minimum width and free board of the bank shall be in accordance with the relevant Indian Standard.

Before continuous bank repairs are started, profiles shall be made at about 100 m apart. These shall be at the correct height and width of the bank repaired and shall be checked before work is started.

All holes and rain cuts shall be fully opened up to the bottom by digging steps not more than 0.5 m deep in the sides and removing all the fallen of loose lumps of earth, bushes, grass roots, etc. Filling and repairing shall be done by placing level layers of earth (nor more than 15 cm deep) obtained from source specified in. The earth in each layer should be free

from clods, roots, grass, brickbats and other debris and it shall compacted at adequate moisture content.

Leaks should be stopped from the upstream side cutting off the penetrating water. If practicable, cracks should have good earth worked into them by chisel pointed poles, but it the present of water against the bank prevents this, the leakage should be stopped by a cover of good earth thrown over its. Subsequently, in dry season the defective part should be opened up and properly remade.

Top of bank shall be smooth and free from clods and silt mounds. They shall be given a slight outward cross slope of about 1 in 80 in order to take the rain water away from the canal.

Both edges of banks especially the inner ones shall be neatly aligned paralled to the canal. They shall be absolutely straight reaches and regular on curves.

Both inner and outer slopes and toes of banks shall be free irregularities. Only projections shall be cut down and earth thus obtained should be utilized in filling hollows.

The banks slopes shall not be scraped or cut back as a general rule.

Loose earth shall not be left lying on top of a bank. Wherever filling is necessary, it shall be well compacted.

Grass or turfing shall not be scraped. It should only be cut as far as necessary to show the surface of the bank and to avoid the holes being hidden under long grass.

Scraping the top edges of banks for appearance shall not be permitted.

Earth from any surface for bank repairs shall be placed where required and in such quantities only as needed, otherwise banks will become irregular by developing unwanted bulges and hollows.

The top of both banks shall always be kept smooth and free from holes. One bank, at least, should be maintained as an inspection bank.

Banks that are too low should be raised to the proper design levels as early as possible.

Banks should generally be at least 30 cm above the country level to prevent drainage getting in the canal.

Breaches and hollows shall be repaired as specified in 5.10.

When banks show signs of slashing owing to saturation they may be protected with an appropriately designated filter and/or drain.

In case of banks where there is trouble due to burrowing of animals a sand core may be provided.

In previous reaches where seepage is excessive puddle clay core, in place of sand core, may be provided.

Where water logging is observed seepage drains shall be provided on either bank.

3.5 SOURCES OF EARTH FOR CANAL REPAIR

Suitable earth for repairs may be obtained from the following sources:

a. From Internal Clearness – Material obtained from internal clearness shall be utilized.

b. By Removal of Irregularities – High banks can be lowered and bumps or projections on top or sides cut down to fill in the hollows.

c. By making Pockets in Berms – By making 1.5 m long pockets in the berm with a minimum distance of 1.0 m left in between them. Depth should be usually kept 30 cm. The silt shall be removed leaving a layer of silt at least 15 cm thick next to the bank.

d. From Spoil Bank

e. From Prominent Mounds in the Fields near the site.

f. From Beds of Drains near the site

g. From Borrow Pits in the Bed of Distributaries, and minors – These are usually not recommended but shall not be used in any case at the tails of distributaries and minors which do not get silt. This is particularly important for canal fed from reservoirs.

h. From outside borrow pits – Earth from outside borrow pits shall be only obtained if it is not possible to produce earth from any of the other sources specified above.

The following precautions shall be observed in taking earth from out –

a. No borrow pits shall be dug within 6 m from the toe of banks or driving road or ramps of bridges.

b. Borrow pits shall normally be not more than 30 cm deep; and

c. Earth shall not be taken from the toe of banks, as the natural rounding of the corner should not be disturbed as shown in Fig. 1.

3.6 CANAL ROADS AND RAMPS

Roads and ramps shall be kept smooth and shall have a regular longitudinal grade. At outlet and bridge crossings the road should be specially attended to, for it is here that one generally gets very bad jolts while motoring due to bumps and hollows existing there. These defects

shall be removed by stretching a string across the top and shaving off the bumps and filling in the hollows till the string touches the surface all through.

Ramps and approaches to bridges should be maintained smooth and to the designated gradient.

Where there are spoil banks on the side of the roadway and higher than it, there shall always be a continuous drain along the outer edge of the road as well as cross drains through the spoil banks, the latter being at right angles to the former and leading with a gentle slope to the boundary ditch. Cross drains shall not be allowed to get higher than side drains. Where there are no spoil banks outside the roadway no drain is required. Where the service road has a longitudinal gradient such as near bridges, side drain along dowel (earth in parapet) should be provided.

The roadway shall be never allowed to remain blocked by fallen trees or in a dangerous condition by holes and hollows.

Spare construction material, if any, shall be properly stacked along the outer edge of the road.

Kilometer stones shall be adjusted to the correct positions, whitewashed and lettering recoloured, when necessary. Guard stones and bumping stones should be adjusted and whitewashed.

While undertaking any repair work on service road suitable diversion shall be provided to allow uninterrupted traffic during repairs.

All gaps, foundation pits etc, shall be fenced with spout railings, their position being marked at night be lanterns or watch fires under the charge of a watchman.

A dowel shall be made to the size and shape specified in the relevant Indian Standard. The bottom edge of the dowel shall not be cut for repairing the banks.

If a position of the dowel falls into the canal another dowel shall be made a short distance behind and parallel to the old one. The new and old dowels shall be joined with reverse curve. This should be considered only as a temporary measure pending further appropriate action for protecting the edge of the road.

Ordinary repairs to canal roadway should be taken in hand after first heavy rain falls and should never be postponed till the end of the monsoon.

The canal roadway should be inspected after heavy rain and holes where seen shall be filled. Silt from canal berm may be used for closing these holes where there are no spoil banks. Holes generally result from defective drainage which should be looked into and remedied otherwise the holes will quickly re-open.

If the top of road over an outlet is higher than elsewhere a horizontal stretch of 15 m shall be provided over the outlet with ramps having 1 in 30 slope.

3.7 CANAL STRUCTURES

This part of manual covers, maintenances of canal structures, drains, outlets, jungle clearance, plantation and regulation of canals.

All masonry works should be inspected and soundings taken in vicinity and repairs carried out during the closure period. A register of masonry works for main canals should be maintained and updated from time to time when improvements are effected. It is proposed that in addition to

the register the drawings of all the masonry structures are maintained on tracing-cloth and remodeling or repairs, etc, carried out from time to time, are marked in different colours.

All masonry structures should be maintained through proper repairs in a sound condition. Any damage noticed in these works should be speedily rectified. Care should be taken to ensure proper curing of repair work.

No grass should be allowed to grow near the parapets or wings of canal structure which should be kept scrupulously neat and tidy.

Metalling over bridges and earthwork in both cart road and driving road ramps should be complete and wall consolidated everywhere.

Ramps for the bridges over canal should be maintained in proper condition so as to ensure that the canal bank is not encroached upon.

All drainage and crossing, downstream of canal structures where significant erosion persists due to turbulence of wave action, dumped rip ram consisting of brick bats or boulders should be provided. Protection by launching apron should be provided only in a length so as to cover maximum scour in a slope of 2:1, Dumping of boulders/ brickbats should not be above bed level. Embankments should be protecting by pitching on the side slope with bricks/ stones. Bricks/stones left out protruding in a staggered fashion will be helpful in dissipation of energy. However, if this provision does not improve the situation, the cause should be investigated and suitable energy dissipating device provided downstream of the canal structures. Scour charts showing the depth and extent of scour should be maintained for all major canal structures where this tendency persists. The charts should be re-plotted and revised at least once a year after the annual closure.

3.7.1 Outlets

All outlets should be regularly checked and set right, if found defective, in accordance which the detailed instructions issued by the department.

Outlet pipes should not be left lying about the canal. They should be carried to the nearest inspection house as soon as change in outlets have taken place and pipes are found surplus. They should be stacked neatly.

Water courses should have culverts/siphons wherever needed and should be properly maintained to avoid wastage water.

Register should be maintained and head of water (H) of each outlet i.e. the difference between the water level in the canal and the center line of the outlet at its exist end, when the canal is running at full supply level should be measured every month.

It will be of great help for ensuring that the outlets draw their authorized share of canal water. The outlets should be so fixed that this draws their proportionate share of supplies/silt when compared to the supply in the parent channel. The working of the outlets can be evaluated from the register and these can be adjusted suitably during the month of April & October.

3.7.2 Gates and Planks/Karries/Needles

Mechanical gates should be oiled, greased and kept in perfect working order. Exposed surfaces should be kept properly painted to prevent rusting and date of painting marked on them. Exposed surfaces which have been recently painted should be periodically examined and my patches of rust found should be removed and surface painted.

The lifting gear should be properly lubricated to keep it in an easy operating condition and to prevent rusting and all lifting gears should be properly lubricated once a month.

The gates and their embedded parts should be inspected during closure. They should be repaired, painted and lubricated, wherever necessary.

Gates, etc. should be periodically operated to the extent possible to see that these are in proper upkeep.

Planks/Karries/Needles at regular heads should be kept in good condition. These should be painted/ coal tarred once a year to keep them in good condition.

Planks/ Karries/ Needles should always be kept near the works for which they are needed. They should be stacked on edge of masonry walls built in shade if possible, and occasionally turned upside down to prevent their getting warped or destroyed by white ants.

3.8 DRAINS

The inspection bank should be maintained in good condition.

Silt cleared from the bed of a drain should be used to fill up holes and ruts on the inspection bank. This silt should not be thrown up in heaps in such a way as to interfere with the ingress of drainage. The silt should also not be disposed off on the inner slopes of the drain to safeguard against its re-entrance into the drains during rains.

Toe drain provided to intercept seepage water should be cleared of weeds before the showing of the crop in that region, to keep down the spring level.

Trees should not be allowed to grow on the inner slopes of drains. The dead branches and rubbish that may have accumulated in the drains should be cleared before the monsoon breaks.

Discharge of drains in high floods should be observed each year at suitable points and recorded in a register.

Any slipped pitching etc. of the drain cross section should be made good particularly before monsoon.

3.9 JUNGLE CLEARANCE

All vegetative growth on canal banks should be cleared from 1.5M beyond the outer edge of the road on the inspection bank and 3 M beyond the shade line on the other bank. Where the full supply level of the canal is more than one meter above the ground level jungle clearance should be done from toe to toe of the outer slopes of the banks.

All vegetative growth on distributaries and minors should be cleared from toe to toe of the outer slops of the banks. Shrubs, large grass such as Kans, Jhunds and small tress, especially Dhak should be dug out by the roots. Stumps of trees that have been standing should be cut down to at least below the ground. Ant hills shall be dug out and leveled off.

All vegetative growth on escapes and drains should be cleared from the outer edge of the riding bank to the inner edge of the opposite bank.

The surroundings of change stones should be kept clear of jungle, grass or any other rubbish to enable them to be seen from a distance.

Grass and jungle should never be allowed to grow on masonry works; it should be dug out by the roots and the masonry then pointed or plastered. Grass growing against masonry work should not be scrapped off, as the

masonry may get damaged in the process. No trees, tall grass nor jungle of any kind should be allowed within 10 M of a masonry work. No big trees such as Pipal. Gular, Pinkhan, and Bargad should be allowed to grow within 25 M of an important masonry work, as the roots of these tress may extend up to the joints and damage the masonry.

Slime and moss, which often coat masonry should be carefully scrapped off, care being taken not to injure the mortar or plaster in doing so.

When a tree is to be felled, a hollow should be dug round the base, and the trunk cut through as low down as possible, the hollow should be then filled up to cover the root.

Shade line trees should not be felled with out special sanction.

Pruning of tress if done at all should not be carried out with axes. The branch should first be sawn about half through from the top, so that the bank may not be torn off. It should be done preferably in February just before the sap begins to rise.

3.10 PLANTATION

Acquired land width of canal should be demarcated by planting suitable species of tress at suitable intervals.

Sowing seed or plantation should commence in June and be finished by the middle of the month, so as to get the full benefit of the rains.

In low ground liable to flooding, seeds should be sown on ridges.

The roots of seedling should not be cut nor broken when transplanting. They should be dug out with a good ball of earth adhering and so carried to the new site. If grown in pots like eucalyptus, the roots are sure to be

pot-bound. In such cases the pot should be carried to the new site and the seedling roots bare of the earth and straightened down in to the holes dug for them. This greatly facilitates their subsequent growth.

The parasitic plants such as AMARBEL and BANDA should be removed carried to an open space and burnt. If the tree is completely covered by the parasite, it is recommended to cut it down and burn the parasitic plant at once.

Branches and twigs overhanging a bank or roadway should be sawn or looped off sufficiently to give a clear bead way of 4 M above the road or bank.

Young plants should not be put out in the shade line until they have attained a height of at least 1.25 M. It is better to lose a few plants by their being rather too large for transplanting than to undertake the nursing of small seeding in the shade line.

All large roots found in the plantation should be taken out during the rains and burnt into charcoal when dry.

The old tree guards should be repaired properly where necessary and all grass, jungle and large grass such as KANS weeded out.

Small trees should be all erect and not reclining sideways. Where necessary a prop should be used for the purpose.

Newly planted trees should be watered regularly but not in excess and the top soil loosened soon after watering. Established plants which have only been less than two years on the shade line require to be given similar treatment though not so often.

Large trees are well able to look after their own nourishment. A good heavy watering of 5 or 6 bucketfuls about once a month only in the very hot weather is about all that is necessary for trees of medium growth; and even so the very big and established trees do not even need this attention. Watering of trees should be given in ring trenches made away from the trunk. As the tree grows the trench should be taken further away from the tree, so as to lie over the root development.

All trees should, however be carefully watched and any bad effect noticed should be immediately attended to.

3.11 CANAL REGULATION OPERATION & EQUITABLE WATER DISTRIBUTION

Basically canal operation is the process of releasing, conveying and dividing water in the canal system to ensure predetermined flows at prescribed times for specified durations at demarcated points of delivery. Operations aim is to introduce an irrigation service which is reliable, predictable and, equitable. In each irrigation project, operation plans are to be developed at two different stages.

The first stage is the period of formulating the project, during which the plan known as the Design Operation Plan (DOP) is prepared. The DOP is the reference plan and is entirely based on the historical data on dependable river inflows into the reservoir and on rainfall over the command. With the DOP as the reference and taking into consideration the real availability of resources (both water and rainfall) for use just before the commencement of the season, a Seasonal Operation Plan (SOP) is to be prepared. The SOP must be approved by the water distribution committee consisting of officials & water user association members, representative farmers of the area before it can be implemented. An essential feature of operation is an agreed plan according to which

operation is carried out every season. The plan is also called the seasonal operation plan. The seasonal operation plan is aimed to:

- assist in effective day-to-day operation,
- provide a basis for monitoring of the water delivery,
- provide a basis for longer-term review and evaluation of policy and operational practices in the light of the operational experiences.

The efficient operation of an irrigation system depends upon many variables comprising of technical and social parameters. The basic objective should be to optimize per unit use of water to achieve the optimum production level. Each operator of canal system must have thorough knowledge of the system and good understanding with WUAs. The operator must understand;

- The basic concept of operation system
- The basic concept & principles of water regulation
- The equitable water distribution method 'Warabandi'

In operation of irrigation system, water regulation is an important function, to enable proper allocation of irrigation supplies to each segment of the operational area of the farmers' organization.

Most of the minor irrigation projects in state have been designed either only for Rabi irrigation or some protective irrigation in Kharief in case rains are either delayed or insufficient. Due to insufficient availability of water in comparison to the culturable command area (CCA) available canal system has been designed under extensive irrigation policy by keeping the intensity of irrigation less than 100% that too with assumed cropping pattern suggested by agronomist at the time of preparation of project report. In most of the MIW projects in the state the intensity of irrigation is around 70-75%. This means that if all farmers in command

follows assumed cropping pattern than also water is available at full reservoir level is just sufficient to irrigate 70-75 % of CCA in place of full command with required delta of each crop.

This seldom happens. Farmers cultivate their entire lands. The losses in canals are more than what were assumed in project report. Farmers do not adopt efficient irrigation methods as well do not maintain water courses resulting in more water losses than assumed. The reservoir do not fill up to FTL each year. It is difficult to restrain cultivators of adjoining un-command area to steal water through direct pumping or by diverting in drains and lifting thereafter.

Under less supply it is also equally important that the irrigation water should be made available at the minor and outlet level and are distributed among all the landholdings in a chak proportional to the size of the landholding. Hence, under more demand and less water supply situations some rationing in water distribution has to be adopted like Warabandi. Therefore, water regulation in the system has to be followed by a rotational water supply among farmers.

The canal regulation officers should ensure the following:

No leakage should be permitted through the heads of canals that have been closed, A little water dribbling down a canal promotes the growth of grass and weeds in the bed.

When a canal is first opened after clearance a low supply should be run, for a few hours and then the gauge be gradually raised according to requirements.

The gates at the cross regulators should be lowered only after the parent channel has been run for sometime. The lowering of gates should be to the extent necessary to create the designed pond level. The downstream of the parent channel should not be kept dry with full pond level upstream of the regulator unless conditions require the same and the structure is design for it.

For regulating supplies into distributaries the discharge through each bay should be more or less equal when the number of bays is more than one. Suitable silt control measure should be introduced where excessive silt is likely to be drawn by a distributary.

Standing regulation orders for all important main canals and branches and critical works should be framed and observed to ensure safety of works and proper utilization of water. These regulation orders should be action oriented specifying the duties of various categories of staff connected with the regulation work and should be in possession of all the concerned staff looking after the maintenance.

No regulator should be planked up higher than is necessary for regulation, or kept planked up after the necessity no longer, exists.

The staff-in-charge of a canal regulator or distributary head should always have written instructions about minimum permissible being clearly stated therein.

A line marking the full supply level should be painted on the upstream face of every structure. If there is no structure in a considerably long reach, the full supply level should be marked on profile walls specially constructed for this purpose such that it is conveniently visible from the inspection bank.

3.12 EMERGENCY WORKS

Emergency works require immediate and joint action by irrigation staff and farmers, to prevent or reduce the effects of unexpected events such as:

- breach or overtopping of canal embankment or river dike, causing flooding;
- critical failure of pumps or head works, causing interruption of irrigation water supply;
- natural disasters such as floods, earthquakes etc.

Operational staff must be trained so that they know what to do as soon as they arrive on the scene, such as cutting off the power to a overheated pump, and closing the head works in case of a canal breach. A good communication system can do much to reduce the damage.

CHAPTER IV

MAINTENANCE DURING MONSOON

4.1 MAINTENANCE OF EMBANKMENTS DURING MONSOON

Very careful visit and proper maintenance of dams is necessary during monsoon also apart from the pre-monsoon maintenance done already. It is quite possible that deficiencies and damages are more likely to surface during monsoon, because of various reasons (mainly heavy inflows). A stitch in time saves nine, timely warning and timely action with efficient and unremitting patrolling will save a dangerous situation, while complacency born of false sense of security due to flow at lower levels in the river may lead to disaster. Continuous vigilance in patrolling everywhere is therefore, enjoined on all the staff particularly during night and in the early hours of the morning when breaches most frequently occur with the slackening of the supervision.

4.1.1 Special Situations That May Arise During Flood Season

During the flood season special situation may arise resulting in breaches of the embankments. These may be due to any of the following reasons,

i. Erosion of main and loop bunds by the rivers.
ii. Failure of bund sluices resulting from the under cutting of sluice foundation etc.
iii. Development of leaks into breaches due to rat holes and other reasons.

Necessary remedial measures to counteract the above are dealt with in the following paragraphs:

a. River Erosion

The under mining of the embankment by a river due to erosion can be tackled by any of the river training methods such as construction of spurs and revetment. In case any of the methods are not successful then the only way is to retire the embankment.

b. Failure of Bund Sluices

It is often possible to avert the catastrophe till the flood season is over by closing the sluice with a ring bund constructed on the upstream of the sluice. If the pavement is weak and there is danger of uplift, the gate should be raised and the sluice opened to the maximum extent considered safe with regard to other consequences. If there is a deep scour hole below the sluices which is developing, this should be filled with brick bats, stones, sand bags, etc. A cage filled with brick bats/stones placed above the filling and kept in position by tying steel wire ropes will sufficiently delay the under cutting to tide over the season.

If the wing walls, abutments, pitching etc. are not high enough and the sluice is being overtopped raising should be done at once. If earth settles at the sides of the pitching it should be remade to the required level.

c. Inadequate Free Board

Inadequate free board may be due to undue settlement of banks or an unprecedented rise of water level following in unexpected change in the river course on shortening of the course of the river somewhere upstream. With rigid insistence on annual leveling and keeping the designed free board above an assumed flood level higher than the highest flood level which have actually occurred, risks due to inadequate free board are largely minimised.

The inadequate free board may affect in two ways :

i. By overtopping and washing out of the bund; and

ii. By wave wash gradually weaving away the top and exposing it to overtopping.

The raising of bunds by emergent measures to avoid overtopping should be carried out as far as possible. But it is to be pointed out that this can be done only to a limited extent of say 1 to 1.2 m, and the bund held for time, provided earth and labour are available or can be arranged at once.

d. Overtopping

Where there is sufficient labour at hand and dry earth is also available near the land side in sufficient quantities and at a short distance; an attempt can be made to raise the bund by dumping earth over existing section.

Where dry earth is not available near the inner toe or when time left is short, raising of the embankment can be done by gunny bags filled with earth removed from inner berm of the embankment or by earth brought by boats. The gunny bags should be filled preferably with clay or loam to make water tight facing. They should be filled only about 3/4th full, so that bags will fit closely to each other. They should be laid in alternate layers of headers and stretches and kept moist.

e. Wave Wash

The danger due to wave wash can be minimised by encouraging the growth of short root trees in a belt of 30 to 45 m wide on the riverside, 1.5 to 3 beyond the toe of the bund on the land side depending on the height and width of area to which the jungle will grow. Trees with heavy roots

should not be placed near the bund so that their roots may not open up passage for seepage or leaks.

Where severe wave wash is anticipated, either flat front slopes, or pitching or permanent revetment should be used.

The wave wash may however occur where it is not expected and therefore emergent measures to tackle the same will be required. These emergent measures can be:

i. using of gunny bags full of sand or earth on slopes;
ii. provision of special wave wash mate; and
iii. construction of longitudinal groyness on the slopes with their tops 0.6 m above the anticipated high flood level.

f. Failure Due to Inadequate Cover

Inadequate cover over the saturation level with consequent heavy percolation may cause a bund to fail by sliding or sloughing of the material on the land side slope. Also the fine particles are carried away during percolation causing earth to settle.

Inadequate cover may be due to :

i. Inadequate bund section.
ii. Flatter saturation gradient then designed.
iii. Designed H.F.L. having been appreciably exceeded.

The resulting slips however do not occur without warning and with proper vigilance can often be prevented. Seepage outcrops frequently occur without serious danger to the stability of the section. The first indications of a likely slip are soft wet sports on the surface of the rear slope followed by excessive seepage carrying particles of earth with it. The longitudinal cracks from at the top or the upper part of the slopes and finally the earth settles and slides increasing in extent until large portions

of the rear slope disappear fast, slowly resulting in a situation which may be impossible to control.

There are several ways known to prevent or delay the occurrence of slips, the method to be adopted depends upon the site conditions.

The most satisfactory method known is to add earth to the rear slope, giving the required cover over the saturation line. The necessary cover may be provided by flattening the rear slope or by constructing a rear berm or raising the existing berm.

For small slips, a small ring bund around the slip may be raised to a sufficient height to prevent further flow of water. The ring bund should be placed away from the slip to prevent slips taking place under the ring bund itself.

Suitable drainage material may also be placed on the land side toe. Such material consists of Coors gravel or brick bats crushed to chips suitably graded down from coarse to fine.

If the above methods are not successful and dangerous slips commence, earth may be dumped on the river side slope.

g. Unequal Settlement

Advance soaking of the bund is the only satisfactory method against unequal settlement. If however, settlement has taken place and cracks have developed, they should be carefully opened up in small reaches and sections at a time and refilled with sand or fine earth, thoroughly rammed and thoroughly soaked with water. The bund should be made up to the original section by adding new earth taking care to properly bond the old and new earth.

h. Leaks

Leaks are caused by :

i. treacherous character of the soil used in the body of the bund.
ii. Cracks in the bund or ground and cavities on account of excessive drying or lack of wetting and compaction.
iii. Faulty construction of bund like use of clods and lack of proper consolidation of earth.
iv. the presence of rat, rodent or snake holes in the section.
v. failure to remove roots of big or small trees under the seat of embankment during construction.
vi. The seepage from bund not having been properly and fully controlled in time.

On discovering a leak, the beldar should at once call his partner and attempt to close it as indicated below and at the same time inform the and work mistry. Other beldars in the vicinity should also be called, but not the one on patrol. If it is not possible to close the leak immediately, arrangements should be made to requisition a reserve gang of labourers for closing the leak.

If the leak is discovered immediately on its occurrence, it can usually be closed by stamping down upon it and filling it with earth at the inlet. If this is not successful, a small loop bund should be made round the inlet with pointed stakes, mats and earth. Where the leak has been closed by stamping, it is liable to reopen and therefore a loop bund may be made round the inlet shortly afterwards.

For detecting leaks, swirls and leakage must be carefully watched for.

Immediately a leak is observed, the beldar should search with his feet for the entrance in the water just below water level and if he finds the leak, he should at once stamp the earth down into the hole or plug it with earth so

that leak will be temporarily closed. As soon as this is done, the bund should be opened above water level and refilled with puddled earth. If the inlet mouth is not traceable in water, a trench above water level should be excavated in the slope to find out whether the leak is crossing the bund and if the position of the leak is found, the excavation should be carried out to about 0.6 m below leak bed. The trench may then be filled up with earth. At the same time, the earth slope should be observed to see whether the flow of water had ceased or not. If it has the leak, it should be opened further along the line of leakage and filled with puddled earth. An earth bund should be raised temporarily, round the closed leak to hold water for keeping the leak site wet. Constant vigilance is necessary on the leak site.

i. Underground Leaks or Blow Outs

Even with properly designed and constructed bunds and careful patrolling, water may leak through a sand stratum in the bund and break-through the ground surface downstream of the bund in the form of bubbling spring. When such underground leaks occur, the stream of water gushes through the ground like a fountain. carrying with it a quantity of sand which is mainly deposited around the edge of the hole. These blowouts may be as large as 1 or 1.2 m in diameter and may occur at a considerable distance away from the downstream toe of the bund. The danger of such underground leaks is maximum where there is an underlying layer of sand below the seat of the embankment which outcrops to the surface downstream of the bund. Underground leaks may also occur where deep borrow pits are too near the embankment particularly when such pits exist on its land side or on both sides.

If the water flowing from underground leak is clean, there is no danger of the bund failing immediately. But when the water is muddy, it indicates that the bund is being undermined. The nearer the downstream face of the

blowout to the toe of the bund. the greater the danger of an early collapse of the bund.

As underground leaks are caused by the fact that the soil particles cannot offer the necessary resistance to the pressure due to the head of the water against the bund, the method of stopping. that is to build an earthen bund of earth tilled gunny bags around them and allow the water to pond up. The subsequent treatment is similar to that which has already been described under Section(h) above.

As soon as the river level subsides, if such spots are few isolated ones. longitudinal trenches have to be constructed to trace the course of the leak. After doing so, trenches have to be constructed right across the embankment with bed lower than the bottom of the leak filled up with selected sand or earth duly watered and rammed.

If the reaches where blow outs are occurring are fairly long and spread out then special treatment comprising one of the following or a combination of these would have to be adopted.

i. providing a long blow out of suitable depth and length on river berm side of the embankment and in the upstream slope of the embankment.
ii. providing cut off clay trenches below the embankment.
iii. providing relief valves at suitable intervals on. the lard side at a short distance from the toe of the embankment.
iv. flattering the land side slope of the embankment or providing puttees to the embankment.
v. providing plantation shrubs etc. on the river side berm' of the embankments for arresting silt.

For deciding the appropriate measure, necessary investigation and study of the nature of the soil, below the embankment and of the embankment

itself and other site conditions would have to be made.

4.1.2 Breaches and Action Necessary in The Event Of Breach

The possible causes for breaches have been dealt with in the earlier paras. The most frequent cause of the breach is however the development of a leak. If the establishment is sufficient and vigilant and resourceful in :

i. detection of leaks,
ii. location or direction of leak, and
iii. taking prompt measure closing or leaks.

If a breach occurs or is threatened, the Mistry or the Overseer should immediately send special messenger to the Assistant Engineer intimating the position of the embankment and later send a report covering the following:

i. Name of embankment.
ii. Reduced distance or side of breach.
iii. Time or occurrence.
iv. Time at which report of the same reached the Mistry or Overseer.
v. Time at which the Mistry or Overseer reached the spot.
iv. Cause or breach.
iv. Width or breach at time of report.
viii. Depth of water at site of breach.
ix. Nature of soil.
x. Strength of labour and materials at site.

The Mistry or the JEn should also warn the village or villages which are likely to be affected by the breach. If additional labour is required, the village headman should be asked to supply the labour immediately. It is necessary to make as accurate an estimate as possible of the labour and other assistance required.

On receipt of the message, the Executive Engineer should immediately

inform the Superintending Engineer, also the Chief Engineer; the Collector, other Executive Engineers nearby and the Divisional Forest Officer.

The Assistant Engineer and Executive Engineer should rush to the spot immediately and attempt to get the breach closed in their presence. The assistance of the Army should be sought for only when the situation is beyond the control of Authorities.

Immediately after a breach occurs, the first step to be taken is to prevent the widening of the breach. Very often the velocity at the ends of the breach will be very high and in such cases attempt should be made to divert the side current away from the bund. In some cases a cross groyne of a short length and at right angles to the bund line can be constructed as near the breached end of the embankment as possible and be successful.

The following preliminary investigations arc essential to the successful closing of the large breach:

i. An estimate of the labour required.
ii. A detailed survey of the sites to determine the best location for the ring bund.
iii. A true appraisal of the river course upstream and downstream of the breach and a fairly accurate forecasting of the river conditions in respect of gauge and discharge.
iv. An estimate of the material required and the arrangements necessary to get them.
v. An estimate or the different kinds or labour. required and the steps necessary to obtain the required strength in due time
vi. An appreciation of the improvements in communication necessary for transport of materials, labour etc.

The first step is to improve the communications to enable speedy transport of materials and carriage of labour from the nearest railway or road station. Arrangements have also to the made for housing, food, and sanitation for the labour. The amount of dry earth and sand that will be required should be carefully estimate and then the place from where the most suitable earth can be obtained easily and economically should be decided.

The final details of the plans for closing of the breach would have to be drawn on the results of the preliminary investigation mentioned above. A definite plan should be drawn up quickly and followed rigidly.

4.1.3 Materials Required for Maintenance during Monsoon

Materials during monsoon period should be stocked in adequate quantity as experience shows them to be necessary. Particular care should be taken that the required materials are distributed with careful fore-thought so as to be readily available everywhere, particularly at dangerous sites. The quantity of materials required depends on importance or dangerousness of the embankment and the distances of the embankment from the nearest stations at which these can be purchased. The following scale of materials prescribed in one circle, is an indication of the relative quantities of the different kinds of materials usually required during monsoon period.

1. Patrolling

i.	Lamps Hurricane	1 for every 2 Beldars
		1 for every Mate
		1 for every Mistry
		1 for every Overseer
		and 20 percent of the total as spare.
ii.	Wicks	12 cm per lamp
iii.	Globes	1 spare for each 1 lamp

iv.	Burner and caps	Spares for 3/4 No. of lamps
v.	Torches	1 for Executive Engineer 1 for Assistant Engineer 1 for Overseer and 2 spare.
vi.	Cells	1 fill and 2 spare sets.
vii.	Petromax lamps	At dangerous places as necessary, each lamp with 2 spare globes, 2 nozzles, 2 washers, 2 wire gauges, 2 needles and 6 mantles 3/4th of the number should be 300 C.P. and ¼th 200 C.P.
viii.	Fuel for lighting	To be collected by beldar establishment fire
ix.	Kerosene oil	1 tin per hurricane lanterns (excluding spare) and 2 tins petromax lamp per season
x.	Match boxes	1 dozen match boxes per season.
xi.	Spirit	1 bottle per petromax lamp per season
xii.	Funnels	½ dozen per mistry
xiii.	Oil extractors	¼ dozen per mistry
xiv	Spirit cans	1 per petromax

2. Wave Wash

i. Lai fascines or any other mattress made up of split bamboos or pilchi or any other locally available material. Material for providing light longitudinal groynes sewed with compactly woven pilchi or split bamboos etc.

ii. Munj rope of lengths to be provided with fascines, ½ kg per km.

3. Leaks

i.	Gunny bags	a.	Where high flood depth is less than 2 m and the embankment is generally safe 60 bags per km.
		b.	Where high flood depth is greater than 2 m or the embankment is known to give trouble of leaks 120 bags per km.
ii.	Stakes	60 to 120 stakes per km.	
iii.	Baskets	1 Basket of toot per beldar or a basket of lai per beldar and one spare.	
iv.	Sutli	0.5 kg per 100 bgas	
v.	Needles	½ dozen with each work mistry	
vi.	Sand	Collection of 2 to 4 m^3 every km. for dangerous lengths.	

4. Breaches

Provision for materials required should be made for one or more small breach length each 75 m long depending upon the embankment.

Material for protecting ends of one breach and constructing one 75 m long, four row, are approximately as under :

i.	Big stakes or sal ballies spare.	Every 1.5 m apart with 100 percent
ii.	Split sal ballies or bamboos	For horizontal bracing of vertical ballies-3 m long each (for entire length)
iii.	Split sal ballies or bamboos	For cross bracing of vertical ballies-3 m long one for each vertical balli.
iv.	Matresess of split bamboos bamboos or pilchi or other locally available.	For sufficient length

v.	Brushwood or local	For sufficient length
vi.	Stakes	0.5m centre long each row of frame.
vii.	Munj Rope	Enough quantity
viii.	Coir Ropes	Enough quantity
ix.	Gunny Bags	2,500 per Asst. Engineer
x.	Sutli	½ kg. per 100 bags
xi	Needles	1 No. per 100 bags
xii.	Baskets	500 Nos. per ordinary Sub-Division, 1000 Nos, for Sub-Division, with dangerous embankment.

4.1.4 Strength of Annual and Monsoon Period Establishment

The matter of engaging the annual and monsoon establishment is left to the Executive Engineer, but where the Superintending Engineer or the Circle Incharge, considers a maximum scale should be laid down for the guidance of his Executive Engineer, he may do so. The staff should be engaged on the safe side and not on a flat rate. Attempts at undue economy in the staff should not be encouraged. The following scale of establishment is considered necessary for normal conditions.

1. Annual Establishment for Normal Maintenance

i. Mistry- one for 10 to 30 km of embankment line depending on local conditions.

ii. Mates - each mate will have 5 to 10 km of embankment like in his charge, according to the embankment in the monsoon.

iii. Beldars - one for every mile for clearing jungle and closing rain cuts etc.

2. Monsoon Establishment

This will be supplementary to the annual establishment and will consist of work mistries, beldars, telephone operators and emergency gangs of beldars.

i. Work Mistry - Each work mistry should have 10 to 15 km of embankment line depending upon the relative importance of the reach.

ii. Work Sarkar - Each work sarkar should have 5 to 7 km of embankment line depending on the relative importance of the beat.

iii. Mates - The number of mates be doubled or even trebled from the previous strength depending upon the nature of the earth.

iv. Beldar - Beldars will be engaged at the rate of 4 men under each mate, but in dangerous sections they may be increased as and when required to as many as 10 men or more per km. if found necessary. Where the Assistant Engineer can not obtain extra beldars must be engaged from the beginning of the season and kept busy on other jobs.

v. Telephone Operator - One or more telephone operator or messengers may be engaged according to the necessity of each station with due regard to having service by night as well as by day.

vi. Emergency Gangs - At important or dangerous sites emergency gangs in strength upto twenty beldars with one or two mates may be maintained from the time river rises above a prescribed gauge till it finally drops below that gauge. This gang should be carefully employed on the embankment and shifted to portions where leaks slips or wave wash are giving trouble or emergent action is necessary.

vii. Labourers - It is useful to maintain a batch of Labourers on strengthening of embankment who should be shifted where earth work is required.

The establishment should have good time scale and opportunities for promotion so as to attract men to stay on the embankments.

4.1.5 Miscellaneous Items of Maintenance During The Monsoon

Establishment engaged on patrolling, soaking or other special items upon which the safety of the embankment depends should not be diverted from their primary duty but at times of low water or with a falling river, with any other surplus establishment the following items of work can be attended to with advantage.

i. Repair of rain cuts.
ii. Cutting and stacking long grass etc.
iii. Distributing and storing monsoon period material at suitable central points.
iv. Clearing of all brush from dangerous crossings of old channels and keeping a proper watch on them and constructing cross and longitudinal groynes as necessary.
v. Opening out and refilling rat holes wherever possible.
vi. Putting the top of embankment in order.
vii. Taking regular soundings below embankment sluices and closely watching development of scour holes.
viii. Taking regular erosion ordinate measurement.

4.2 MASONRY/CONCRETE DAMS

Following observations in masonry/concrete dam during monsoon are of great importance.

i. Measurement of uplift pressure.
ii. Seepage through

iii. Deflection in the body of the dam.

iv. Settlement

v. Stresses at critical points in the dam.

During monsoon when fresh flood water start arriving in the reservoir and there is rise in water level of reservoir, it is important to observe and analyse above data to know if there is any change in behavior of the dam. If any abnormal deviation with respect to reservoir level compared to previous years is noticed, its cause shall be analysed measures for safety of the dam shall be taken. All abnormal variations shall be brought to the notice of State Dam Safety Organisation. All observation shall be recorded properly and their test checks shall be done by Junior Engineer, Assistant Engineer and Executive Engineer incharge of the dam.

Gates of the spillway and other outlets shall be operated as per Reservoir Operation Schedule. It is the duty of field Engineer to check that levels of the reservoir me maintained us per schedule.

It is necessary to observe the behavior of spillway and energy dissipation arrangement during release of flood waters. Spillway profile may need modification if negative or possible pressures are recorded on its surface. If any damage to energy dissipation arrangements is noticed its cause shall be analysed and proper measures for its proper working shall have to be taken.

It is necessary to observe behavior of flood waters on the downstream site of the dam with respect to erosion of dams of river. If erosion at certain points is noticed, measures to check the erosion by way of river training works or other works, have to be taken.

Access to vital points and adequate facilities shall be arranged.

Drainage in pumping system in the gallery of dam shall work efficiently. Alternative source of power supply for uninterrupted pumping shall be arranged.

4.3 FLOOD WARNING AND COMMUNICATION FACILITIES

From what has been stated in the earlier sections, it will be evident that patrolling of the embankments and emergent works to be done can be carried out efficiently and economically if advance information of the gauge and discharge of the river can be forecast. Flood warning arrangement is therefore important in the maintenance of embankments during the monsoon season. The forecasting points depend upon the length and characteristics of the river embanked and have to be determined by detailed study.

Reliable forecasts of gauge and flood warning are possible only when adequate data of rainfall, river gauges and discharges are available. The location of rain gauges and gauge and discharge sites is to be decided after making a detailed office study and field inspection. Along the embankments gauges to record floods should be fixed at intervals varying from 10 to 15 km. They should also be fixed at the junction of various rivers, rivulets and local drainage's joining the river on which the embankments have been constructed. The gauge reading should be taken be by the permanent staff who are on the annual maintenance establishment. Where the gauges are at remote places and are important, there should be automatic recordings fitted with transmitting arrangements. The gauge reading should be taken regularly, the intervals being determined taking into account the size and characteristics of the river. The danger level at the gauges should be prominently marked so that the staff can be extra vigilant when the river level reaches the danger point.

A record of the rainfall and the gauges and discharge observations made at specific station should be maintained in a register. These data form the basis for flood forecasting studies, raising and strengthening of embankments and for design of work on the rivers.

The period of flood warning can be longer if there are arrangements for weather forecasts of the area by the Meteorological Department. The exact procedure of sending and receiving data and flood warnings along the embankments should be planned in advance and all concerned should be acquainted with the same.

The cell from which the Hood forecasts and warnings issue, can function usefully and efficiently only if there are adequate communication facilities for receiving data and despatching forecasts and warnings. There should be good arrangements for receiving data by telephone, telegram and wireless. Wireless transmitting arrangements should be invariable provided for getting data from remote areas and where telephone and telegraphic facilities are not available and if available are likely to be disrupted.

There should be good arrangements along the length of the embankments for receipt of the flood warning so that the patrolling arrangements can be organised as necessary. As far as possible telephone facilities should be provided at intervals of 15 to 20 km. These will also help in sending reports of any emergent situations to the Assistant Engineer, Executive Engineer etc.

A plan for providing the requisite communication facilities should be drawn up by the Executive Engineer in charge of the dams. In the long run, the cost involved for such a facility will not weigh the advantages obtained.

In addition to the telecommunications and wireless transmission 'it is necessary to have proper road communication to reach the embankments particularly during the flood season. The top of the embankments should be maintained in good shape and the approaches from the land side to the embankments at salient points should be maintained such that they are above the normal flood level in the area. This will ensure speedy approach to be embankments most of the time.

CHAPTER-V

FLOOD FORECASTING

5.1 INTRODUCTION

Flood forecasting in river valley projects means forecasting of floods at various sites of interest. The flood forecast may be of several hours, or day, which may be used for following purpose.

i. Proper operation of the reservoir for safety of the dams & moderation of floods.

ii. Warning the people likely to be affected by the imminent floods.

iii. Taking necessary safety step in advance & keeping vigil on engineering works along the river course.

Flood at any site along the river course is related to precipitation in the catchment. Accurate methods for making quantitative forecasts of precipitation over the catchment are not yet available but precipitation in the catchments at various stations can be correctly measured also corresponding to various quantities of rainfall in the catchment discharge & stages at various sites of river can be measured. With long term reliable data sufficiently accurate rainfall-runoff correlation can be established at various sites along river course.

Flood Forecasting makes use of such relation ships between :

a. Discharge & stage measurements at an upstream site known as site & at the forecasting sites.

b. Measurement of rainfall in the catchments & the discharge & stages at the forecasting sites.

The influence of various characteristics of the drainage basin can also be incorporated in the relationship.

5.2 PARAMETERS INFLUENCING FLOOD FORECASTING

Basic parameters used in flood forecasting methods are -

i. Rainfall distribution in the upper catchments in space and time i.e. area distribution & intensity in relation to time.
ii. Stage and discharge of the upstream base stations.
iii. Stage & discharge of forecasting stations.
iv. Change in stage and discharge of the base station.
v. Travel time at various stages.

Following parameters also can be taken into account for developing more accurate relationships.

i. The rainfall amount, intensity and duration in the intervening catchment.
ii. Topography, nature of vegetation, type of soil, land use density of population and urban development, depth of ground water table & soil moisture deficiency of intercepted catchment.
iii. The atmosphere and climatic conditions.
iv. Stage discharge of all important tributaries between the base station and the forecasting station.
v. Contributions from the various upstream controlling points such as reservoir barrages and free catchment below such controlling points.

5.3 FORECASTING TECHNIQUES

Following models can be used for flood forecasting -

i. Empirical models.
ii. Semi empirical models or mathematical models.
iii. Conceptual models.
iv. Computer simulation.

5.4 OPERATION OF A FLOOD FORECASTING SYSTEM

The following steps are involved in this system.

i. Observation & Collection of Operational Data

Basically gauge discharge & rainfall data are collected for past periods. Other hydrometeorological data such as evaporation, temperature, sunshine records, wind speed, wind direction & moisture deficiency data can also be collected and used for more realistic flood forecasting.

a. Stream gauge network -

For the flood forecasting gauge sites on the main river and its various tributaries shall be decided in such a way that most of the flow that will effect the discharge & the gauge at the forecasting station is measured in advance & suitably accounted for flood forecasting. The distance between the forecasting station & last data collecting station or the gauge site should be adequate so that sufficient warning time is available for receiving anticipated floods. While selecting the gauge sites following precautions shall be taken.

- River banks and bed should be stable.
- The gauge reached should be fairly straight on upstream & downstream sides upto a distance of at least four times the width of the river or eight hundred meters whichever is less, and should have a uniform cross section in general.
- The site should be free from interference from any hydraulic structure (its back water effect). The site should be easily accessible and should have communication facilities.
- Raingauges Network.

  The catchment area shall have adequate number of raingauge station so that fairly realistic weighted rainfall can be computed by Thiesson Polygon. Is 4987 (Recommendation for establishing

network of Raingauge Stations) recommends that following general criteria for distribution of raingauge station may be adopted.

In plains	One rainguage upto 520 Sq.km.
In elevated region above 1000 m above MSL with moderate precipitation.	One rainguage in260to399 sq.km.
In hilly area with heavy precipitation.	One rainguage in 130 sq.km.

ii. Transmission of The Data of The Control Flood Forecasting Station.

The rainfall & runoff data from the key network shall be transmitted to the forecasting station through the quickest possible channel.

Following types of communication system generally used for data transmission.

Telephone or telegraphs.

HF & VHF wireless sets.

Telemetry system including satellite meteoburst technology.

iii. Formulation of Forecasts

Formulation of flood forecasts is for at the control flood forecasting station of the system. The station is generally located at a prominent place near as the dam where regulation of floods has to be made or near the flood prone area which needs to be alerted and protected against floods or at a suitable site well connected with the reporting a warning stations. The flood forecasting stations should itself be out of the flood zone.

iv. Dissemination of Forecasts

The flood forecasts that are framed should be quickly disseminated to the various flood fighting stations. They should also be kept informed of the

progress of flood wave and any charges in anticipated situations of the forecast.

v. Up Dating Procedures

The data that is being continuously received shall be used to up-date the forecast. As the flood advances its progress in relation to warning time and any change in its form or situation shall be continuously ascertained. The changing pattern of the incoming flood shall be continuously disseminated to the flood fighting stations. An over estimate of the flood is likely to cause unnecessary panic & an under estimate may involve heavy avoidable changes and risk.

It is necessary the modern adopted for flood forecasting may be reviewed from time to time on the basis of previous forecast.

CHAPTER-VI

RESERVOIR OPERATION

6.1 INTRODUCTION

Most of the dams in the state have been constructed to store water for irrigation, water supply and/or power generation. The aspect of flood control has generally not been considered directly. The dams must serve the purpose of storing water without involving any risk of man-made floods to the area on down stream. Infact the reservoir constructed up stream of the dam shall also be used to moderate the anticipated floods from the catchment area. This objective can be achieved by a proper reservoir operation through carefully prepared reservoir regulation schedules, release procedure and gate operation schedules aided by an accurate and reliable flood forecasting and warning system.

Normally for irrigation, water supply and hydro-electric projects it is desirable to fill the reservoir as early as possible during the filling period. While doing so, it should also be seen that the reservoir level is not brought near F.R.L. too early in monsoon, if the run-off statistics shows that even by prescribing limiting reservoir filling levels the reservoir can be filed up after following such restriction.

6.1.1 Ungated Reservoirs

In case of ungated reservoirs, the aspect of moderation of floods is in built within the functioning of waste weir and flood lift normally provided for such reservoirs. Thus there is no scope to evolve separate reservoir operation schedule, only factor that needs to be carefully decided is the design flood or the adequacy of the spillway and the freeboard.

6.1.2 Gated Reservoirs

In such reservoir a part of the conservation storage space often forms a part of the flood control storage space. Therefore a semi-rigid or flexible reservoir operation can be evolved keeping both the requirement in view. The schedule shall be such that the anticipated flood can be moderated in the reservoir and at the same time reservoir shall fill upto desired levels during and upto end of monsoon or rainy seasons. Any error in operation of gates may endanger the safety of the dam or may cause artificial floods and wasteful spills and the reservoir may not fill-up as required inspite of adequate rains.

The flood control requirement will govern the reservoir operation during such period of the monsoon, when the floods are more severe. Since the reservoir has to fill at the end of the monsoon, the conservation requirements should also be kept in view while handling the flood situation. The reservoir operation should therefore involve a careful co-ordination between the flood disposal and the building up of the conservation storage. This is achieved by preparing guide curves and gate regulation schedules and an efficient system of flood forecasting.

6.2 GUIDE CURVE OR RULE CURVE

The guide curve of a gated reservoir shows the limits to which the reservoir levels should be normally raised at the end of specified periods for achieving the normal planned storage of the reservoir while availing of the flood absorption capacity to the greater possible extent during the specified periods. Guide curves should be prepared separately for the filling period and for the depletion period. The guide curves for the filling period can be developed from a study of the run-off or yield records from the catchment over a long time. While preparing the guide curves for the filling period the constraints of safe moderation of peak floods likely to

occur during the various subsequent periods have to be taken into account.

The guide curves are generally made up of an upper guide curve and the lower guide curve. The upper guide curve in a conservation schedule is the upper limit of the level up to which the reservoir can be built up or maintained on the respective dates. During the period of severe floods, the reservoir may be allowed to rise temporarily above the upper guide curve (but below the M.W.L.) at the description of the officer not below the rank of Executive Engineer. The storage space between the upper guide curve and the allowable Maximum Water Level in the reservoir indicates the minimum flood storage that can be available for flood absorption on the various dates.

The lower guide curve in a conservation schedule indicates the minimum levels upto which the reservoir filling must be achieved on various dates during the monsoon from the point of filling of the reservoir. The storage space available between the lower guide and M.W.L. indicates the maximum flood storage space that can be available for flood absorption on the various dates.

The procedure for disposal of floods and surplus inflows beyond the upper limit of stage of guide curve as well as surplus inflows after the reservoir attains the F.R.L. should be decided and specified in the filling schedule. The upper limits of flood discharge to be released during the various period related to the peak rate of anticipated inflows during the various intervals should also be clearly specified in the filling schedule.

Regulation schedules for reservoir operated as part of a valley system should be prepared separately for each reservoir but based on integrated plan of operation and consideration (e.g. Reservoir of Chambal Valley).

Flood forecasting and routing would have to be carried out for estimating flows from various parts of the basin before releases from different reservoir can be actually effected.

6.2.1 Preparation of Guide Curves

The following procedure may be adopted for preparation of the guide curves:

i. The available daily inflow data at the dam site for several years may be compiled into ten-day wise (or week wise) inflow figures for all the years. The entire period from 15th June to 31st October may be considered for this purpose.

ii. From the above ten-daily runoff for various years, a runoff series for each ten-daily period may be prepared and the 90% dependable and 75% dependable yields for various ten-daily periods may be worked out.

iii. The requirements or withdrawals for the various contemplated uses for each ten daily period are worked out.

iv. The surplus flows available for storage or deficits, during the various ten daily periods may be worked out at 90% and 75% dependability's. In vase of cascade reservoirs on the same stream or river in series, the net inflows after deducting upstream use may be considered.

v. The date of attainment of monsoon storage level or the F.R.L. may be decided by working backwards from the end of monsoon or the last ten-daily period and arriving inflow as worked out under step (iv) above at 90% dependability.

vi. While deciding the monsoon storage level as at step (v), it may appear that, the 90% dependable inflows for all the three ten-daily periods for the month of October may be less than the respective ten-daily requirements and the surplus yield for ten-daily period

may occur same where in September or August i.e. the reservoir must reach the full reservoir level at the end of that particular ten daily period.

vii. After deciding the date of monsoon storage level the date of all the historical floods occurring after that date is examined to ascertain that all such critical flood events can be safely routed within the available flood storage space or the flood lift and without exceeding the permissible limits of flood for the downstream river channel. If these limits are found inadequate then appropriate procedure for routing the severe most historical flood for the period after monsoon storage level is reached is evolved and incorporated in the standing operating procedure and the reservoir regulation schedule.

viii. The storage or guide curve levels for the 75% and 90% dependability's at the end of each preceding ten-daily period is then worked out by successively deducting the 75% and 90% dependable surplus yields from the respective lake full contents for each ten-daily period starting from the last surplus ten-daily period at 90% dependability. In some cases it may be necessary to build up or maintain the minimum operational requirements at the earliest possible time which may also be considered.

ix. The guide curves for the 90% and 75% dependable storage levels for the various ten-daily periods are plotted as 'A-Curve' and 'B-Curve' respectively. The guide curve for the 90% dependable storage levels is the conservation method while the guide curve for 75% dependable storage levels gives more space for flood storage.

x. After deciding the guide curves as above the analysis for routing of the historical flood events for the various ten-daily periods is carried out to ascertain that all such floods can be safely routed

with the reservoir standing at the guide curve elevations for the respectively ten-daily periods corresponding to 'A' or 'B' curve.

xi. With the above analysis, the appropriate procedure for flood regulation in all the cases is decided and specified in the standing operating procedures and the reservoir regulation schedules.

xii. Major floods occur in most of the rivers during July and August and some part of the conservation space during this period may have to be utilised for flood moderation. However, it should be seen that it is possible to fillup the same for conservation purpose towards the later part of the monsoon.

xiii. In case of lean years if the filling guide curves falls below the curve 'B' then efforts should be made to conserve the storage by curtailing the withdrawals suitable and the procedure to be adopted for the same should be incorporated in the standing operating procedures.

xiv. Separate guide curves for depletion period should be prepared taking into account the ten-daily withdrawals

xv. In case of lean years the withdrawals will have to be restricted further during the depletion period. The procedure for the same should be incorporated in the standing operating procedures.

xvi. Where adequate hydrological data is not available for developing the guide curves as above, the initial guide curves may be based on empirical methods or correlation's based on similar data of other projects in the vicinity or experience data and thumb rules. However, as the reservoir starts functioning, the hydrological data based on actual observations should be continuously collected and built-up to form the basic data for preparing and updating the guide curves for future reservoir operation.

xvii. Inspite of the preparation of the guide curves, it is necessary for the dam Engineers to keep a close watch on the developing rainfall

pattern in a particular year to decide variations, if any, needed to be adopted in the guide curves from the points of creating desired storage while avoiding the risk due to heavy floods reasonably.

xviii. The reservoir data should be continuously built up and the guide curves should be periodically reviewed and up-dated.

6.3 GATE OPERATION SCHEDULE

The gate operation schedule must be prepared based on the site conditions, the result of model studies and the regulation schedule of the complete sequence and stages of operation of various gates corresponding to various lake levels and the flood situations. The following general guidelines may be born in mind in preparing the gate operation schedule.

i. The regulation of gates should be based on model studies where such studies have been carried out or are felt necessary, otherwise the regulation can be based on past experience of the gates operation schedule of the reservoir. The aim will be to ensure safety of the dam structure including the gate parts, hoists, energy dissipation arrangement and spillway tail channel while letting out the desired discharge.

ii. The end gates normally be opened first to prevent cross-flows striking against the walls and junctions.

iii. At any time during the operation of different gates, the difference in gate opening of any two consecutive should not exceed 0.5 meters.

iv. After opening the end gates, the gates at the centre should be opened and the other gates should be opened in symmetrical manner starting from the centre towards the end through gradual increase in the openings.

v. While closing the gates, the gate that was opened last should be closed first. The procedure to be followed for closing the gates

should be generally reverse of the procedure followed for opening the gates. Complete closure of the gates should be accomplished by gradual lowering of the gates by 0.2 to 0.3 m in the proper sequence.

ANNEXURE I (a)

PERIODICAL INSPECTION OF LARGE DAMS

Serial No.	Type of Dam	Height from general level of deepest Foundation in M	Impounded gross storage capacity upto FRL in Mcum	Spillway Capacity	Type of Spillway	Inspection Authority	Inspection Report to be sent to	Test Inspection
1.	Large Dams (Category-1)	Above 30m	Above 60 Mcum	Above 3000 Cumecs	Gated Spillway	Superintending Engineer/ Administrator	(1) Chief Engineer (2) Superintending Engineer, Dam Director	Test Inspection by the Regional Chief Engineer / Chief Administrator for the dams having height more than 1000M cum or spillway capacity 10000 Cumecs or more.
2.	Large Dams (Category-II)	15m to 30m	15M cum upto 60 Mcum	2000 to 3000 Cumecs	Ungated Spillway	Executive Engineer	(1) Superintending Engineer / Administrator (2) Superintending Engineer, Dam Director	
3.	Large Dams (Category-III)	10m to 15m	1M cum upto 16 Mcum	2000 to 3000 Cumecs	Ungated Spillway	Sub Division Engineer / Sub Division Officer	(1) Superintending Engineer / Administrator	

Notes-

(1) All dams more than 15 meters in height will be classified under "Large Dams: irrespective of other parameters.

(2) All dams less than 10 meters in height will be classified as "Small Dams" irrespective of other parameters.

(3) In order to determine the exact category of "Large Dams" following procedure shall be followed. The category of Dam as per the (i) H, (ii) Storage Capacity, and (iii) Spillway Capacity shall be worked out individually. The highest of the category shall be appropriate category of the dams.

(4) Apart from above following additional parameters shall be considered for deciding the Category of Dams between 10 to 15m in height.

a) Dams having length of crest more than 2000 meters. OR

b) Dams having specially difficult foundation problems. OR

c) Dams with unusual design shall be classified under "Large Dams (Category-II)

d) Dams having length of crest more than 500 meters but less than 2000 meters shall be classified as "Large Dams (Category-III).

ANNEXURE-I (b)

PROFORMA FOR PERIODICAL INSPECTION OF LARGE DAMS

Date of Inspection:

A. General

S. No.	Item		Remarks
1	Name of Project	:	
2	Purpose of project : Water Supply/Power/ Multipurpose/irrigation	:	
3	Name of Dam	:	
4	Year of Completion	:	
5	First filling (years / level)	:	
6	Benefit accrued:		
	a. Irrigation	:	
	b. Water Supply	:	
	c. Power	:	
	d. Other benefit	:	
7	Important controlling level:		
	a. Top of dam	:	
	b. Maximum water level	:	
	c. Full reservoir level	:	
	d. Sill level of irrigation sluices	:	
	e. Sill level of scouring sluices	:	
	f. Spillway crest level	:	
	g. Minimum drawdown level	:	
	h. Lowest river bed level	:	
	i. Deepest foundation level	:	

S. No.	Item		Remarks
8	Important Salient features:		
	a. Dead storage capacity	:	
	b. Area of foreshore of F.R.L.	:	
	c. Design flood adopted (PMF/SPF/Any other) give relevant magnitude.	:	
	d. Design spillway discharge capacity and type of spillway.	:	
	e. Type, Number and size of spillway gates.	:	
	f. Location, sill level & capacity of low level outlets and scanning sluices.	:	
	g. Height of the dam in meters:		
	i. Above deepest foundation	:	
	ii. Above lowest river bed	:	
	h. Gross storage capacity in million cubic metres:		
	i. At F.R.L.	:	
	ii. At M.W.L.	:	
	iii. Length of the dam (at crest) in meters.	:	
9	Name and designation of the inspecting officers.	:	
10	Date of the inspection and the corresponding reservoir water level	:	
11	Maximum and minimum water levels reached during the last season with dates.	:	

S. No.	Item		Remarks
12	Maximum overflow during proceeding monsoon with dates	:	
13	History of past distress, if any and brief details of remedial measures carried out	:	
14	Does the officer-in-charge of the operation and maintenance of dam possess all the records as given in the Appendix-A.	:	
15	When and by whom was the dam inspected immediately preceeding this inspection	:	
16	Are the items pointed out during the last inspection properly attended to 7 (if not state deficiencies yet to be corrected)	:	

PROFORMA FOR PERIODICAL INSPECTION OF DAMS
INSPECTION OF DAMS AND ANCILLIARY WORKS

B. EARTH DAM:

S. No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4

1 Downstream drainage:

(a) Are there any signs of water logging, slushy conditions for growth of aquatic weeds on the downstream of the dam? **:**

(b) Are there any standing pools of water in the downstream area of dam? If so, give their locations of extent. **:**

(c) Are there any boils observed in the vicinity of the downstream toe of the dam? **:**

(d) Is the downstream area sufficiently clear and free draining? **:**

(e) What is the depth of ground water table on the downstream as evident from the existing wells in the vicinity of the dam? **:**

(f) Are all the exposed drains working satisfactorily? **:**

(g) Toe drains and cross drains:

S. No.	Item of Inspection		Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2		3	4
	(i)	Are the portions of longitudinal toe drain and exposed cross drains beyond the downstream toe of the dam in regular section and freely draining. :		
	(ii)	Is the pitching to those drains intact? :		
	(iii)	Is there any weeds growth in their drains? :		
	(iv)	Indicate other defects noticed in these drains, if any. :		
	(h)	Outfall drain:		
	(i)	Is the outfall drain in proper shape and grade and freely draining? :		
	(ii)	Is the outfall drain properly cleaned and maintained? :		
	(iii)	Does the outfall drain show any Stagnent pools of water or weeds growth? :		
2		Surfaced drainage of downstream slope:		
	(a)	Is the condition of the downstream slope drainage arrangements satisfactory? :		

S. No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	(b) Is the paving to these drains intact? :		
	(c) Are all the drain properly maintained and freed of vegetation growth and debris? :		
	(d) Does the slope have a tendency to develop severe rain cuts at any location? :		
	(e) Enumerate any other defects noticed in the surface drainage of down-stream slope. :		
3	Seepage Measurements:		
	(a) Is the quality of seepage being daily or periodically measured with respect to water level in reservoir and recorded? Please check registers and records observations. :		
	(b) Does it show any abnormal falls? If so, does it have any relation to a certain reservoir level elevation? :		
	(c) Does the seepage flow show a turbid colour at any stage? Was such photograph observed at any stage at any location in the past. :		
	(d) What is the measured rate of seepage flow with date and reservoir level. :		
	(i) On the day of :		

S. No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	present inspection.		
	(ii) Maximum since last June :		
	(iii) Minimum since last June :		
	(e) Is the portion upstream and downstream of measuring points of seepage easily accessible with proper steps and path and free vegetatic growth. :		
	(f) Are the measuring points properly located, constructed and maintained, so as to give accurate and reliable measurements of seepage. :		
	(g) Is the method of taking seepage measurements satisfactory? :		
	(h) What is design seepage discharge? State your observation on comparison. :		
4	Earth dam section crest:		
	(a) Is the crest profile at proper elevation? :		
	(b) Does it show any signs of excessive and / or uneven settlement? If so, indicate such locations and extent of settlement surface and settlement points much be installed for observing this aspect. :		

S. No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	(c) Is the surface of the crest free from undulations and local undulations and local depressions of heaving? :		
	(d) Does it develop any visible cracks in transverse or longitudinal directions? If so, attach a map showing their locations and extent. Depth and width of crack must be ascertained by taking open trenches extending below the bottom cracks. :		
	(e) What is the condition of the edges of crest? Is ramp provided any road crossing provided? Have they got eroded and cut up resulting in reduced effective width? :		
	(f) Is the crest free from local slips through out its length on either sides? :		
	(g) Do the headers, guard stones and parapet wall provided at the edges of the crest appear in proper profile and plumb? :		
5	Earth Dam Section - Upstream and Downstream slopes. Indicate the general conditions of upstream pitching, downstream pitching/turting and rock toe:		
	(a) Do the upstream and downstream slopes, indicate the general :		

S. No.	Item of Inspection		Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2		3	4
	conditions of upstream pitching, down-stream pitching/turfing and rock toe.			
	(b) Do the section of the dam and both the slopes appear structurally sound and stable?	:		
	(c) Are any longitudinal or transverse cracks noticed in any part of the slopes?	:		
	(d) Were any signs of distress to stability of slopes noticed at any time in any part of the dam? If so, give brief details of the incidents and locations, and method of treatment adopted and its effectiveness? Indicate the general conditions of upstream pitching, down-stream pitching/turfing and rock toe.	:		
	(e) Is there any profuse growth of bushes or weeds over any portion of the dam? If so, indicate the locations.	:		
	(f) Do the upstream of downstream slopes show existence of crab holes made by rodents or burrowing animals or anthills. If so, indicate the locations.	:		

S. No.	Item of Inspection		Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2		3	4
	(g) Are there any wet or slushy patches and concentrated leaks springs or trickles observed on the downstream slopes or the toe? Please look out for patches of extensive vegetation growth and examine them carefully and record your findings.	:		
	(h) Are all the rain cuts and erosion channels properly created and made good? Please indicate location of recurring damages, if any.	:		
6	Junction Earth with Masonry / concrete dam sections and outlets:	:		
	(a) Is there any existence of leaks springs or west spole in the earth work in the vicinity of the junctions between earth work and masonry work? If so, what is the approximate rate and colour of the leakage? Does it turn, turbid at any time? Please ascertain from enquiries and record the findings.	:		
	(b) Is there any tendency for separations cracking, settlement or upheavals of the earth work in the vicinity of masonry or concrete? If so, indicate the locations and the exact nature of deficiency.	:		

S. No.	Item of Inspection		Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2		3	4
	(c) Is there any tendency for surface erosion at the junctions?	:		
	(d) If the outlet conduit is located in the earth dam section, is the entire length of the conduit perfect order and profile and free from off sets, open joints, cracks and leakage. Examine the conduit carefully from the downstream of from inside if possible and indicate the deficiencies observed, if any?	:		
	(e) Checks the conditions of the crest and slopes specially in the zones adjacent concrete structures. Detect the deformations settlements, cracks or other distress conditions caused by external erosion due to wind, rain etc. Set up permanent observation system for the same at the places of course concurrence. Seepage at junctions between, earth dam and masonry concrete retaining wall or corch type junctions with concrete dams is possible source of trouble and should be carefully watched.	:		
7	Relief Wells :			

S. No.	Item of Inspection		Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2		3	4
	(a) Are the relief wells in good working conditions and functioning well?	:		
	(b) Are the relief wells properly cleaned periodically?	:		
	(c) Please indicate the dates of last cleaning and the next cleaning due.	:		
	(d) Are the necessary plant and equipments for cleaning the relief wells, available with the office.			
8	Breaching section (If provided):			
	(a) Is the breaching section easily accessible?			
	(b) Is the note of instructions as to when and how to operate the breaching section available on the record.			
	(c) Is the conditions of the breaching section satisfactory?			
	(d) For reconstruction after the breach, are the following items decided in advance?			
	(i) Quarry for embankment material.	:		
	(ii) Suitable routes of access.	:		

S. No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	(iii) Agency, Plant and Machinery for its reconstruction. :		
	(e) Is the maintenance staff fully aware of the instructions at (c) and (d) above. :		
	(f) Ascertains and indicate the latest event of operation of breaching section and its performance. :		
	(g) Is the surplus course from the breaching section acquired up to natural valley? :		
	(h) Is the course formed? :		
	(i) If so, what steps are taken. :		

Note:- For items pertaining to spillway, Gates, Sluices outlets etc. Please points 4,5,6,7,8,9,10, 11,12,13,14 under masonry / concrete dams.

C. MASONRY / CONCRETE DAM:

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
1	(a) Examine the monolith and construction joints for such defects as cracks open joints spalling seepage teaching etc. and indicate the findings.		
	(b) Is the upstream face of the dam is good conditions? If not, indicate the nature and extend of deficiency.		
	(c) Is any spalling or cracking observed on the downstream face especially near the zone of concentration of stresses like the or location of abrupt change in geometry, or at the openings? If so, indicate the details of observations.		
	(d) (i) Is there excessive seepage / sweating at any location on the downstream face of dam.		
	(ii) Whether the observations are analyzed and compared with the theoretical assumptions made in the design?		
	(iii) Remedial measured in case of large variations.		
	(e) Examine the roadway / top of the dam for offsets, opening of the construction joints, conditions of parapet wall : drainage, lighting etc.		
2	Drainage Gallery:		
	(a) General		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	(i) Is the drainage gallery easily accessible and does it have adequate lighting facilities with sufficient stand by units of lighting? If not, indicate the deficiencies.		
	(ii) Are proper arrangements made for the measurement of seepage into the gallery? Is the seepage from: a) Porous pipes b) Foundation Drains c) Monolithic joints d) Other seepage loations measures separately.		
	(iii) Are the above arrangements satisfactory? Seepage from Foundation: i) Is there has been a substantial reduction in the seepage through the foundations, is it due to chocking of the drain holes? ii) Are the all foundations holes periodically cleaned? Indicate the last date of such cleaning and extent of variation observed in the seepage discharge before and after the cleaning.		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	iii) Are measurements of uplift pressures taken regularly? What was the uplift like at highest reservoir level during last season? Is observed uplift within design limits?		
	iv) Are the seepage water and the deposit, if any from the seepage being regularly examined for the chemical composition if so, indicate the results and the probable source dissoluted seat, if any.		
	v) Are any seepage water springs observed in the downstream area any where? If so, indicate the locations and state the physical nature of this seepage. Look out for such seepage spots particularly near the dykes fault zone etc. ascertain if chemical tests are made of water samples from such springs for dissolved salts.		
	c) Seepage from body wall (Dam & Spillway)		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	i) What is the total seepage into gallery from the Porous pipes in the dam at lake full conditions. How does it compare with the seepage (for the corresponding water level) when the reservoir was first filled?		
	ii) If there has been a substantial reduction in this seepage ascertain and indicate the probable reasons therefore.		
	iii) It is statement showing the surface area of the dam (Water side) calculated blockwise for each meter of rise of water level available?		
	iv) What was the total seepage per square meter of upstream face submerged during inspection?		
	v) Is there any excessive seepage from any, body drain or any other location in the gallery.		
	vi) What steps are being taken for regular periodical cleaning of the porous pipes.		
	vii) Has there been attendency for gradual reduction of drainage through pipes and progressive appearance of sweating on the downstream face of the dam?		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	viii) Has there been considerable leaching from the seepage water and deposition of lime near the seepage exist sports.		
	ix) Are the samples of the seepage water and the reservoir water being regularly tested for reactive and corrosive properties?		
	x) Has the total leaching been estimated?		
	xi) Is the seepage on the downstream face on the dam measured. What was the seepage on the date of inspection? What was the maximum seepage during the past one year.		
3	Structural Performance:		
	(a) Are there any signs of structural distress noticed in the dam, spillway and foundation in the form of :		
	i) Excessive deflection.		
	ii) Tendency of general sliding.		
	iii) Cracking and upheal of settlement in any part of the body wall of foundation.		
	iv) Excessive uplift		
	v) Excessive seepage and leaching through the body or the dam and the foundation.		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	vi) Conspicuous weathering of materials or components in any portion of the body walls or the foundation.		
4	Spillway Gates: Spillways gates and other gates wherever applicable.		
	(a) Are the following documents available as at site?		
	i) A complete set of detailed designs calculation together with the drawings of gates, gate grooves embedded parts, hoisting mechanism and controls etc.		
	ii) Designers operating criteria and / or detailed operating instructions for the various types of gates installed in the dam.		
	iii) Maintenance schedules specifying each operation its frequency and for due and done dates.		
	iv) Operating instrumentation with "Dos and Don'ts" for all operational units.		
	(b) Is the condition of the steel surfaces and the surface paint deteriorated?		
	(c) Are any connecting bolls of rubber seals loosened or damaged? If so, indicate the details of defects. What is the general condition of rubber seals?		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	(d) Do any of the rubber seal show signs of weathering, hardening cracking or leaking and damaged.		
	(e) Are the rubber seals of side and bottom touching uniformly all along the selling surface?		
	(f) Do the rollers (wherever applicable) touch the tract plates uniformly?		
	(g) Are the electrical meters, gear systems, limit switches, brakes, bush bearing etc. of hoist mechanism well lubricated.		
	(h) Is the operation of the above, smooth and satisfactory? If not, list out individual result and observations.		
	(i) Are the embedded parts of spillway gates, emergency gates and stop logs in sound conditions and free from corrosion, uneven wear cracking, chipping and dents. If not state the nature of defects or deficiencies and observatories if any regarding such defects.		
	(j) Check the following for structural soundness of all members and welded bolts and riveted connections uneven wear, uneven bearing, cracking chipping and dents and indicate the findings.		
	(i) Gate leaf and stiffeners.		
	(ii) End arms.		
	(iii) Trunnion griders.		
	(iv) Lifting beams.		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	(v) Stop logs.		
	(vi) Gantry crane.		
	(vii) Tracks		
	(viii) Bridge structures.		
(k)	Are the to trunnion bearing of radial gates properly lubricated?		
(l)	Is there any damage or weathering caused to the seal plates? If so, indicate the nature of damage noticed.		
(m)	Is the full length of wire rope of the hoist in sound condition and free from broken strands?		
(n)	Is the alternative Power system for gate operating working properly?		
(o)	Give the details of generating sets and stand by units and the time required to operate all gates on the alternative power system, on the basis of actual trial operation check for diesel stock for operation of generator, battery charger available, Battery in spare.		
(p)	Is the operation, which is stand by in case of electrical hoists, tried and found satisfactory? Please take test trial and ascertain.		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	(q) Are all the nuts of connecting bolts and anchorages properly tightened? (Note: After inspection of the various items it is necessary to draw up a list of actions needed to be taken and pursue matters with the concerned agency).		
	(r) Are the hydraulic hoists working satisfactory?		
	(s) Are the trunnion hub and the brackets well maintained?		
	(t) Are the trunnion likely to get submerged during actual working of the spillway? As if so, ascertain the cause for the same and specify. Please enquire for occurrence of such evently, if any.		
	(u) Are any of the mechanical or the structural components and fastening or seals subjected to excessive wear? If so, please give details. Is there any tendency for recurring damage to any particular components? If so, please give details.		
	(v) Is sufficient stock of spare which need frequent replacement maintained at site.		
	(w) Is the staff posted at the site, maintenance and operation of Gates, Gates, equipments and electrical installation well experienced fully trained and conversant with the job requirements and responsibilities?		
	(x) What is the excercising frequency? When were the gates last exercised.		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	(y) Performance during inspection.		
	(z) Change over switches for main power supply to generator supply are provided?		
5	Spillway bridge, hoist bridge catwalks, and other bridges where applicable.		
	(a) Are the checking, girders and structural supports of spillway bridge, hoist bridge and catwalks structurally sound?		
	(b) Is the floor of the bridge structurally sound and safe?		
	(c) Is there satisfactory arrangements to prevent unauthorised entry into the control structures and bridges.		
	(d) Are the structural members and joints sound and free from the corrosion?		
	(e) When were the steel components painted last?		
	(f) Is the surface of steel work and paint satisfactory?		
	(g) Is the parapet or railing over the bridges sound and safe?		
	(h) Are the bearings, bearing Pads and pier caps structurally sound?		
	(i) Are all the track plates for the gantry cranes laid over such bridges structurally sound and intact?		
6	Energy dissipation arrangements:		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	(a) Can the tail pond be drained easily for inspection of the stilling basin? If not what are the short comings? Please ascertain and indicate the last event of inspection of stilling basin.		
	(b) From the examination of the levels and contour plans and reference marks in tail channels, ascertain if there is progressive erosion and retrogression in the tail channel. If so, indicate the extent and the location of such erosion with reference to the various components of dam, spillway outlet, Power House etc.		
	(c) Is the concrete surface of the stilling basin and apron in good condition? Are there any indications of the pitting cracking, spalling or wearing of the surface of bedding concrete? If so, please give the details of the nature and extent of the damage.		
	(d) Is there any indication of abrasion and cavitation damage (pitting of concrete) especially at friction block, chute blocks the surface near the lower tangent point and the still? If so, please give the details of nature and extent of damage.		
	(e) Is the under-drainages of the stilling basin satisfactory?		
	(f) Are all the open drain holes clear and functioning well?		
	Condition of the dam:		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	Please give general assessment of safety of dam for normal operation. Please enumerate all your observations which you feel are adverse to the safety of the dam for normal operation.		
7	Walls: Guide walls / Divide walls, junction wall / Return Walls / Spray walls etc. (Strike out whichever is not applicable).		
	(a) Are all the location of the such accessible for inspection, maintenance and repairs?		
	(b) Is the drainage of back sides of the walls (whenever applicable) from the weep holes satisfactory? If not indicate the nature of deficiencies.		
	(c) Is there any tendencys for the water to under cut the ends of the walls?		
	(d) Is there any foundation erosion or occur noticed in the vicinity of such walls? If so, give the details of nature and extent of such damage.		
	(e) Is there any surface erosion/damage caused to face or body of such walls?		
	(f) Do any of the walls show symptoms of unequal settlement development of cracks and tilting?		
	(g) Is there any damage to guide bunds, if so, give details of the damage.		
8	End weir:		
	(i) Is it accessible.		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	(ii) Is there any erosion pitting or spalling of the concrete or masonry surface?		
	(iii) Is there any scour noticed on the immediate downstream of such weir? If so, give details of location and extent of such damage.		
9	Hydraulic Performance of Energy dissipation and apron:		
	(a) Do the flow conditions in the stilling basin have a tendency to draw rocky material in to the bucket and cause its churning and abrasion damage to the surface of buckets baffle blocks, apron and sill?		
	(b) Is the hydraulic performance in proper agreement with the results of modal studies. Ascertain the performance from observed tail water racing curves and deficient observation at any such as weep outs and excessive erosion under plunge pools and location of secondary rollers and secondary rollers and retrogression.		
10	Instruments installed and observations:		
	(a) Are the instruments installed property assessible. Are the locations properly lighted ventilatd and adequately protected from the possibilities of damage.		
	(b) Are the all the instruments in proper working order. Ascertain the cases of instruments going out of order and indicate.		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	(c) Are all the registers of observations posted upto date? Please take test observations and initial the registers.		
	(d) Are all the plottings of the instruments completed upto date.		
	(e) Are sufficient checks of spares, gauges, master gauges stationary items etc. maintained at the data collection.		
11	Outlet-		
	(a) Is the airvent periodically cleaned?		
	(b) Are here any structural damage to the intake walls. Such as leakage noticed throughy walls?		
	(c) Is there any leakage observed through the conduit, concrete or masonry? If so, give details of the location and extent.		
	(d) Is there any damage noticed to the conduit concrete, breast wall and gate slots?		
	(e) Is the bye pass value (wherever provided) operating satisfactorily.		
	(f) Take operating trials of the following as provided and record the observations and defects noticed, if any.		
	(i) Service gate / s.		
	(ii) Emergency gate / s.		
	(iii) Stop-log gate / s.		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	(iv) Strike - gate / s.		
	(g) Are the trash racks (wherever provided) cleaned before monsoon.		
	(h) Are there vibration and noise noticed in operation of outlet gates at any time? If so, are any periodical observations take to ascertain their severity.		
	(i) Is the energy dissipation arrangement working satisfactory for all discharges?		
	(j) Is there any structural damage, to the energy dissipation structure? If so, give the details of nature and extent of the damage.		
	(k) Is the conduit structurally sound and reasonable leak proof? If not, give details of nature and extent of the effects. Is it possible to examine the conduit from inside?		
	(l) Is there any seepage noticed around the conduits as ascertained from the observations of the downstream conditions? If so, is conditions? If so, is it likely to cause (in case of earth dams) erosion and piping.		
12	Outlet gates:		
	(a) Is the surface of gates and the point deterioted?		
	(b) Are the connecting belts of rubber seals loosened or damaged?		
	(c) Do the rubber seals show signs of weathering and damage and need		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	replacement?		
	(d) Are the rubber seals of sides and bottom touching the bearing surface uniformly?		
	(e) Do all the rollers touch the track plates?		
	(f) Are the rollers wall lubricated?		
	(g) Is the operation of outlet gates smooth?		
	(h) Are the stem rods for lifting the gate straight?		
	(i) Are the actual operation of lifting and lowering of the gates and hoist mechanism smooth and satisfactory.		
	(j) Are all the gears and hoist mechanisms well lubricated?		
	(k) Is the storing arrangements for emergency gate leaves and the stop logs in satisfactory condition.		
	(l) Are the seal plates in sound condition? If not ascertain the type of damage and indicate.		
	(m) Is the full length of wire rope (wherever applicable) of the hoist in sewrviceable condition and free from any broken stands.		
	(n) Are all the nuts of connecting bolts and anchorage properly tightened?		
	(o) Are all the lifting beams in proper order and sound condition.		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	If not ascertain the nature and extent of damage and indicate.		
	(p) Do any of the mechanical or structural parts of the gates, fasteners of hoists show signs of esxcessive wear? If so, please give details.		
	(q) Is there any tendency for the recurring damage to any particular components? If so, give details.		
	(r) Is sufficient stock of spares which needs frequent replacement maintained at the site?		
	(s) Whether hand cracks are kept under lock and key and not attached on hoist mechanism when operated by electrical energy?		
	(t) Whether warning sign indicating danger. Do not switch on is hung during maintenance.		
	(u) Whether the operating crane is in 'A' condition and the operators are instructed to lift the emergency gates/ stop logs in a vertical direction so that allowable carrying capacity is not exceeded.		
	(v) Whether there is a "Standby" power supply.		
	(w) The alternative sources of power:		
	1) Is the generator in the working condition.		
	2) Frequency of exercise.		
	3) Is it developing full voltage.		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	4) Is the wiring in tact? And is the change over switch in working condition?		
	5) Are the spares available at site.		
13	River outlet / river sluice and Gates:		
	a) Is the over all condition of river outlet works / river sluices satisfactory?		
	b) Is the operation of the gate satisfactory as ascertained by taking an operating trial? If not, indicate the defect noticed.		
	c) Are the trash rack (wherever provided) cleaned before monsoon.		
	d) Is there ecessive silting on the upstream of the sluice.		
	e) When where the gates last opened for desilting etc.?		
	f) Please indicate the approximate quantity of the leakage through the gates, if any.		
	g) Is there any seepage or leakage through the conduit surface.		
	h) Is there any damage to the upstream and downstream conveyance structures of the conduit.		
	i) Is the condition of energy dissipation arrangement satisfactory?		
	j) Is there any retrogression noticed in the downstream channel? Is so, give details of nature and extent of damage.		
14	Power Outlet:		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	a) Is the overall condition of power outlet satisfactory?		
	b) Is the operation of gates smooth and satisfactory as ascertained by taking operating trials?		
	c) If not indicate the nature of defects noticed.		
	d) Are the trash rocks cleaned before monsoon?		
	e) Is there excessive silting in the approach channel on the upstream of power outlet?		
	f) Is there any seepage through the conduit surface?		
	g) Is there any cavitation damage to the inside of the conduit and penstock of the HRT and pressure shafts?		
	h) Are all the valves functioning properly?		
	i) Are there any vibrations induced into the dam and appurtenant works while the outlet is opened or the machines are running?		
15	Emergency Preparedness:		
	a) Are the project officers well conversant with the Emergency action Plan, Reporting Procedures, warning Procedures.		
	b) When was the Emergency Action plan last reviewed?		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	c) Are the communication directories updated?		
	d) Are the concerned authorities informed about the system of emergency reporting procedures and warning?		
	e) Are the inundation maps updated.		
	f) Are availble safety spots on the downstream of the dam identified and made known to the concerned authorities?		
	g) Is the communication system working satisfactorily?		
	h) Are adequate warning devices and facilities provided at the dam?		
	i) Is the downstream warning system operational?		
	j) Are proper arrangements made for security of the dam and preventing cases of unauthorised trespass, vandalism and sabotage to the dam works?		
	k) Is downstream warning system operatable on alternative power supply?		
16	Access Roads:		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	(a) Is there a properly constructed and well maintained all weather access road to the dam site?		
	(b) What is the type of pavement of the access road and its condition.		
	(c) Are there properly constructed and well maintained access road arrangements to the following components for inspection, maintenance and repairs? i) Top of dam ii) Spillway iii) Gates and hoisting arrangement iv) Drainage gallery v) Bridge structure vi) Downstream stilling basin vii) Junction and abutments viii) Outlet control tower ix) Outlet gates x) Toe of earth dam downstream drainage arrangements and mearms xi) All saddle dams.		

S.No.	Item of Inspection	Observation and recommendations, if any of	Remarks of Reviewing Officer.
1	2	3	4
	(d) What is the general condition of all structures on various access roads. Are all the structures on the access roads adequately safe, for allowing passage of plant machinery for emergent repairs?		
17	Communication facilities: Are following facilities available at dam site?		
	i) Wireless		
	ii) Telephone		
	iii) Telegraph		
18	General Assessment of condition of the dam: Please give general assessment of safety of dam for normal operation. Please enumerate all your observations which you feel are adverse to the safety of the dam for normal operation.		

ANNEXURE - II (a)

GOVERNMENT OF INDIA
CENTRAL WATER COMMISSION
(DAM SAFETY ORGANISATION)

WHAT TO CHECK BEFORE AND DURING MONSOON FOR SAFETY OF DAM

INTRODUCTION

Every dam which impounds water for the benefit of mankind, can also be source of potential danger and risks would be increased by neglect of proper and timely maintenance of the dams.

As higher water levels in the reservoir have the maximum potential for instability and as higher water levels are kindly during monsoons, taking benefit from the knowledge of past futures and distresses of dams, a very brief guidelines to he followed before the onset of monsoons and during the monsoon period are enumerated in the following chapters. It is stressed again that these guidelines provide pored points to be taken care of and is not and exhaustive one.

CHAPTER -I

EARTH AND ROCK FILL DAMS

1. Check stockpiles at vulnerable locations on the downstream, of suitable and sufficient quantities of filter materials, rock fill materials, sand, gravel, empty cement bags, bricks bats, wire crates etc., for use in any emergency.
2. Check for any holes by burrowing animals, cracks, depression, wet patches, sloughing, erosion of materials from foundation and abutments, seepage at interfaces between the earth dam and masonry/concrete dam/retaining walls, sluices, outlet conduits and regulators, integrity of

surface drains etc., and seepage through interfaces between foundation and structures.

3. Examine the data observed 'from various instruments, if any, installed and analyse the data for corrective measures where necessary.
4. Look for boils in the entire reach that many occur on the downstream.
5. Sec if any material is being washed out with the seepage water taking careful measurement of silt content of seepage NN ater.
6. Check the spillway channel against all obstructions and safe carriage of designed flood discharge .
7. Look for the cracks, both longitudinal and transverse near the outlet locations.

CHAPTER - II

MASONRY/CONCRETE DAMS

I. Check for excessive settlement. deflection, seepage, uplift pressures, deterioration of concrete/mortar.
2. Inspect the drainage system in the foundation and dam, leaks, cracks. spalling on the surface of the dam and opening, scour downstream of the spillway.
3. Ensure normal conditions by timely remedial measures where necessary.
4. Ensure availability of access to vital parts and adequate lighting facilities.
5. Where provision for pumping of the drainage water exists, ensure alternative source of' power supply to ensure uninterrupted pumping.

ANNEXURE- - II (b)

CHECK LIST FOR FLOOD PREPAREDNESS BY WATER RESOURCES DEPARTMENT

I . Have pre-monsoon maintenance carried out at all irrigation works.

2. Have adequate arrangements for precautionary materials and patrolling of irrigation works round the clock been made adequately for all the sites.

3. Have danger levels of all-important rivers and towns determined and all concerned informed of the same.

4. Have corresponding areas, villages, towns etc. been identified as well he affected on water crossing such danger levels.

5. Have flood posts indicating danger levels been fixed at all important aabadi areas, towns and notified to all concerned.

6. Have higher ground and safer buildings been identified and well publicized' for evacuation during distress.

7. Has training been imparted to police and Home guards personnel for flood fighting.

8. Have all the pumping sets and boats repaired and are in condition to be deployed with their accessories at likely distress area.

9. Is there a complete inventory list of boats, pumping sets, tools and plants and other precautionary materials available at different places for utilization during floods.

10. Have adequate number of rain gauge stations, self recording rain gauge stations and river gauge sites established in different river basins which will give important parameters for flood forecast.

11. Have adequate arrangements made for establishing contact points for data collection and is their a reliable net work of transmission system of such data to the required points.

12. Have temporary telephones and wireless stations established at important places to transmit information about rainfall, river gauges and information.
13. Has a flood control room established at divisional/regional headquarter for timely dissemination of flood forecast message.
14. Has annual subscription been sent to Indian Meteorological Department for getting direct rainfall and flood warning.
15. Have adequate arrangements been made for entering rate contracts for supply of labour and material during emergency.
16. Has a pre-monsoon meeting arranged with the district administration and representatives of public to apprise of condition of flood works and measures taken for flood fighting.
17. Has action been taken on implementing suggestions received from public representatives or district authorities during such meeting.
18. Has district contingency plan been prepared for each district in consultation with district administration.

ANNEXURE III

Check list for preparation of Maintenance & Repairs Estimate for canals

S.No	Quantity	Item	Rate	Unit	Amount
1		Cleaning/clearing trash/debris/obstructions from			
		1) in & around of all structures, pipes, gauge chambers, measuring devices, stilling wells, etc.			
		2) Hydraulic section of the minor (s)/sub-minor(s)/field channel(s).			
		3) Service Road (s) & inspection Path(s)			
		4) Natural drain(s)& drainage schemes(s)/catch-water drains(s).			
2		Bruising, cleaning, oiling & greasing of gates of Head Regulator(s) and outlets.			
3		Painting of gates of Head Regulator(s) and outlets.			
4		Painting of gauge plates and discharge tables of measuring devices.			
5		Providing and fixing gauge plates of measuring devices.			
6		Minor repairs to measuring device including associated upstream and down stream repairs			
7		Minor repairs to gates of Head Regulators and Outlets			

S.No	Quantity	Item	Rate	Unit	Amount
		1- Tightening loose parts			
		2- Straightening bent parts			
		3- Welding broken parts			
		4- replacement of damaged parts			
		5- Providing & fixing missing parts.			
8		Minor repairs to the masonry of the structures:			
		1- Filling up of cracks/cavities			
		2- Filling up of joints between structure and earthwork.			
		3- Minor construction for repairing broken parts .			
9		Minor repairs to pipes:			
		1- Re-fixing disturbed pipes/collars			
		2- Providing prefab reinforced caps on broken/damaged portions of the pipes;			
		3- Providing earth cushion on the exposed pipes.			
10		Minor repairs to earthwork:			
		1- Removal of unauthorized lifting devices/outlets and repairing damages due to such unauthorized installations.			

S.No	Quantity	Item	Rate	Unit	Amount
		2- Filling put holes or ruts in the canal banks and on service roads and inspection paths.			
		3- Resetting scattered/loosened stone revetment and pitching.			
		4- Stopping minor leakages from the channels.			
		5- Closing minor breaches in the channels			
		6- Removal of slight to medium vegetation/plants.			
		- From within hydraulic section			
		- From service roads & inspection paths.			
		- From outer sloes & land acquired for canal purpose.			
		7- Removal of slight to medium silting.			
		8- Restoring minor slips of the earthwork.			
11		Minor Repairs to lining:			
		1- Filling up of small cavities behind lining panels.			
		2- Filling up of disturbed joints of lining slabs/panels.			
		Total			

ANNEXURE-IV

CHECK LIST FOR INSPECTING OFFICER
{Refer PWF&AR rule 24 & 25}

S.No.	Check points	Observation of the inspecting officer
1	Whether dam/canal section are as per design? If not, list deficiencies and action taken 24(XI), 25(XIX).	
2	Whether E.E./ A.E. /J.E. are having all completion drawing, design etc. with them? 24(XXIII)	
3	Whether Government property registers of land, buildings, roads, dam and canals, etc. have been maintained & all property are without any encroachment. {PWF&AR rule 24 (XXI), (XXIV); 25 (XX)	
4	Whether chainages/ & levels are marked at appropriate places & properly painted? 25(II).	
5	Salient feature & other boards are placed & they are properly painted?	
6	Whether all mechanical / Electrical components are properly attended / oiled / greased & are in operative condition? 25(XIX)/F. Memo Annex. XV.	
7	Whether the seepage / leakage etc. are within permissible limits as per designed / anticipated & they are measured? In case of deviation, list the abnormal occurrences and action taken to rectify them. 25(XIX).	
8	Whether adequate T & P etc. are available & ready for use? If not, specify the action taken to acquire them. 25(XXII).	

S.No.	Check points	Observation of the inspecting officer
9	Whether workman employed are given daily task through job card & given training as per requirements? {PWF&AR rule 24 (XII), 25 (XV)	
10	Whether all rain cuts etc. are promptly attended & entered in maintenance register?	
11	Whether all river/dam gauges / rain fall instruments are in order & their readings are recorded as per instructions? Annex. VI.	
12	Whether staff deployed is equipped with all sort of T&P, lantern / torches etc.? F. Memo. Annex. XVI, 25 (XXII).	
13	Whether all the register have been got issued from division office & they are being maintained as per instructions? ACE order No. 2167-81 dt. 7.2.05. 24(XXIII).	
14	Whether all monsoon/flood arrangements have been made as per flood memorandum / instructions?Flood Memorandum Annex. II, VII, XVII.	
15	Whether the vulnerable reaches on dams, canals, embankments etc. have been identified and informed? and staff/ officer posted are regularly watching the vulnerable reaches by physical observations and the record is maintained in watch & ward register? 25(XIX).	
16	Whether maintenance roster have been prepared & sanctioned? Whether annual maintenance program has been prepared & sanctioned? 25(XIX).	
17	Whether all works have been inspected before & after monsoon & reports submitted? . {PWF&AR rule 24 (xi) ; 25 (xix)	

S.No.	Check points	Observation of the inspecting officer
18	Whether maintenance works have been identified after monsoon & after the end of canal regulation & proposals submitted for sanction? 25(XIX).	
19	Whether canal / dam roads are motorable? Whether dam & appurtenants works can be approachable during emergency & rainy season? 25(XIX).	
20	Whether dam / canal abutments (top, d/s & u/s slopes) and down stream area up to 30 metre . are free from jungle / undesirable growth of plants etc. ? 25(XIX).	
21	Whether the toe filters are properly functioning, their discharges are measured daily and analyzed and report submitted? 24(XVII), 25(XIX).	
22	Whether Irrigation figures & Irrigation dues are recorded & recovered by revenue offices? 24(XXXVII).	
23	Whether canals are free from silt, jungle, scouring etc. ? 25(XIX).	
24	Whether storage capacity of dam is as per design? 24(XVI), 25(XIX).	
25	Whether WUA's are formed as per Govt. policy & they are functioning as per rules / regulation? jkt0 flapkbZ iz.kkyh ds izcU/ku esa d`"kdksa dh lgHkkfxrk fu;e 2002-	
26	Whether handing over/taken over of charge are effected upon transfer/leave by subordinate/ Junior Engineers as per PWF&AR rule 25 (XXV)?	
27	Whether all inspection notes have been complied and replied? List pending inspection reports pending for replies. .	

S.No.	Check points	Observation of the inspecting officer
	{PWF&AR rule 24 (XXXV); 25 (XXVII)	
28	Whether all FIR cases and recovery cases are pursued regularly and reported? 24 (XXV); 25 (XVIII)	
29	Whether all Govt. buildings under charge and rest houses are properly maintained and upkeep at desired level? 24 (XXV); 25 (XXV)	
30	Whether visitors registers of all guest houses are checked monthly, rent collected and deposited in Govt. a/c.? {PWF&AR rule 25 (XXI)	
31	Whether physical verification of stock, T&P, MAS etc. are conducted (specify dates) and list of unserviceable/surplus stock and T&P etc. submitted (mention dispatch No.) ? {PWF&AR rule 24(XV), I(XXXII); 25 (XXII)	
32	Whether surplus property if any are reviewed and reported? Specify date on which it was last reviewed.24(XXXX).	
33	Whether imp rest a/c, temp. advances, stock , T&P, MAS etc. are submitted in time? Specify date on which it was last submitted. 24(XXXX), 25(XI).	
34	Whether final bills of all projects/works under their jurisdiction have been paid? If not, list the pending final bills with reasons. {PWF&AR rule 24 (XVIII); 25 (X), 22(I)s.	
35	Whether labour to be deploy during emergency have been identified? {PWF&AR rule 25 (XIV)	

Signature
of the Inspecting Officer

LIST OF REFERENCES

01. Embankment Manual, Central Water & Power Commission, New Delhi.
02. Guide Lines for safety inspection of dams, Central Water Commission, New Delhi
03. Manual of flood operation, Central Water Commission, New Delhi
04. What to check before & during monsoon for safety of dam, Central Water Commission, Dam Safety Organisation New Delhi.
05. Form of periodical inspection of large dams category I, Central Water Commission, Dam Safety Organisation, New Delhi
06. Embankment Maintenance & Flood operation manual, Irrigation Department, Rajasthan
07. Dam Safety Manual, Irrigation Department, Maharashtra.
08. Hand book - Instrumentation, Government of Maharashtra.
09. National Seminar on dam safety 27th-28th June, Irrigation Management Training Institute, Tamilnadu.
10. A Note on the Maintenance of Embankment, Central Water & Power Commission, New Delhi
11. Concrete Dam Instrumentation Manual, A Water Resources Technical Publication, United States Department of Interior bureau of Reclamation.