

**A NOTE ON
THE MAINTENANCE OF EMBANKMENTS**

**CENTRAL WATER & POWER COMMISSION
Ministry of Irrigation & Power
GOVERNMENT OF INDIA**

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INTRODUCTION

In India, a total of 3000 miles of embankments was existing prior to 1954. During the last 10 years, an additional length of 4300 miles has been constructed. For deriving the benefits of these embankments for which they have been designed, it is essential that adequate maintenance should receive high priority. Instructions have been issued by the various State Governments for the maintenance of the embankments to suit the local conditions. Detailed instructions are also contained in the "Embankment Manual" published by Central Water and Power Commission. The purpose of this note is to draw out general instructions on the maintenance of embankments, and also to stress the importance and scope of public cooperation in this work. The need of providing adequate communication facilities in efficient maintenance of embankments has also been dealt with in the note.

1. MAINTENANCE OF EMBANKMENTS

The maintenance of embankments can be divided under the following three heads:

- (1) Pre-monsoon maintenance.
- (2) Ordinary maintenance during monsoon season.
- (3) Emergent situations that may arise during monsoon season.

(1) Pre-monsoon Maintenance

The pre-monsoon period is generally covered from 15th of October to the end of May in next year except in Assam where it is between October and April. Maintenance to be done during this period covers the following:

- (i) Restoring embankments to designed sections.
- (ii) Opening and refilling of leaks.
- (iii) Repairing the masonry works.

- (iv) Plantation.
- (v) Inspection of river courses and programme of works.
- (vi) Filling of borrow pits on the land side.
- (vii) Preparations for wetting of embankment during ensuing monsoon period.

These are dealt with in the following paragraphs:

(i) Restoring Embankments to Designed Sections.

The embankments have to be repaired and restored in advance so that these can safely withstand pressure of likely highest water level against them during the ensuing monsoon season. Therefore, it is essential to bring the embankments to the proper grade, levels and sections. For this purpose the requisite free board over the designed or higher flood levels (in case this has been attained subsequent to the construction of embankments) should always be maintained. The free board is necessary against any unexpected settlements, rise in the bed of the river, wave action or occurrence of floods higher than the designed. A careful study of the statement of high flood levels at the gauges at each mile of the embankment will show at a glance whether the required free board is available. If not, the embankment is to be raised and strengthened.

In the case of retired or loop embankments not exposed to the river, the level at each mile gauge is to be taken the same level as at the bund on the main embankment. If the free board thus found over the year's maximum is less than the free board over the previous maximum, the loop embankment requires to be raised. Having thus determined the available free board according to the records, the correct free board at the site has to be found by actual levels. Top levels of all the main and loop embankments must be restored annually to designed levels. This to be done by the overseer subject to a minimum check of 10 per cent by 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 side slopes (including berm levels) of the front as well as the loop embankments. True and accurate data should be kept of the annual levelling done, showing the names of the levellers and in case of check levelling, of the checking officer together with the dates and all details. Such data should be readily available for inspection in a separate register, with cross reference to the actual field books in which the original levelling record is entered and should form important records which should be destroyed only after the approval of

Superintending Engineer has been obtained. From this data graphs should be drawn to compare in each mile the actual top level and ground level with the highest flood level of the previous year and of the other years.

Sufficiently before the monsoon season, the entire embankment reach under his charge should be inspected by the Executive Engineer and he should give a certificate that he has inspected the embankments and is satisfied with the repairs carried out during the working season. If there is anything wrong he should put the same in writing and take steps for completing the necessary repairs before the onset of monsoon. The Superintending Engineers should also inspect the most vulnerable reaches in the embankments in their circles and satisfy themselves that everything is all right.

(ii) Opening up and Refilling of Leaks

A register of leaks should be maintained showing the exact position and action taken during the monsoon period (i. e. whether it had been fully opened out and refilled with good soil duly watered and rammed or just plugged at its upstream face). During the monsoon season deep nicks on the slopes and sides are left at the site of each leak as well as pegs indicating the number assigned in the leak register so as to facilitate tracing their location on site. It is essential that leaks which could not be treated during the monsoon period should be attended to immediately afterwards as indicated below.

The leakage area should be opened out in the full width of the embankment, particular care being taken to trace it to its upstream ends. It should then be filled with good earth in six inch layers, watered and rammed, the old earthwork being stopped or benched and new earthwork properly bonded and interlocked into the old. Where good earth is not available, pure sand should be used for refilling the opened portion. Whenever sand or sandy soil is used it should invariably be covered with at least 2 ft. layer of good clay soil.

Rodents and other burrowing animals make holes, cavities and tunnels through and under embankments. These are very serious and often cause leaks and excessive seepages and even serious breaches during floods. Such holes should be carefully located, opened up and refilled with good earth and properly rammed.

When the water touches the embankment, the leak points should be carefully watched in order to close them effectively in advance of floods.

(iii) Repairs to the Masonry Works

It is important to inspect very carefully all masonry works so that there is no danger of seepage of water along the plane of contact between the earth and the masonry. The earthwork adjacent to the masonry work should be brought to designed sections laying in their layers and consolidating them by rammers. The return walls where they are low must be raised at least 1 ft. above the highest flood level. The scour holes should be properly filled in and brought to design section. The apron should be carefully checked and reconstructed by designed sections.

Particular attention should be paid to the maintenance of the gates for the sluices. It should be seen that they are properly lubricated, repaired and cleared of silt deposits. It should be ensured by actual lifting the gates 2 or 3 times that the lifting arrangements are in working condition before the commencement of the flood season. The Assistant Engineer should certify that all the masonry structures and gates have been inspected by him and they are in satisfactory condition. Painting of steel and wooden shutters should be carried out wherever necessary.

(iv) Plantation

The planting of trees on embankments should not be allowed because their roots tend to loosen the structure of the embankments when shaken by wind storms and also encourage cracks and the development of leaks. When trees are removed, it is necessary to remove the roots thoroughly because if the roots are left in, when the organic matter decays, it leaves dangerous hollows which cause settlement and lead to trouble. Growing of grass on the berm should be encouraged as this gives good protection against erosion of the bank.

In this connection, the following instructions should be followed:

The side slopes of all embankments and land beyond the toes upto 20 ft. on the countryside and 10 ft. on the water side should be kept clear of all trees and other growth except the short grass. 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 remove all trees which are dead or which show tendency to fall. When clearing away trees, care must be taken to have the roots thoroughly removed and the embankment or ground properly made up.

It is necessary that adequate attention should be given to the growth of short grass and small bushes as these have been found by experience to be cheapest and most effective form of protection against erosion.

(v) Inspection of River Course and Programme of Works

The Executive Engineer in charge of the embankments should inspect the river course in his charge immediately after monsoon season and formulate programme of work required to be done during the working season for the safety of the embankment before the on-set of next monsoon. In framing these programmes, he should keep in view the changes that have taken place in the course of the river during the previous monsoon season. Reaches where river is eroding the bank and likely to cut through a loop upstream of the embankment, should be carefully inspected. Any material change in the course of the river can be judged by careful inspection. After the programme is framed, estimates for the schemes should be prepared for execution. The estimates should be completed preferably by the end of November, so that there is ample time for processing the same and executing the works well in time. If it is apprehended that the river may come against the embankments, a full report together with suitable proposals of river training should be forwarded to the Superintending Engineer for immediate action.

(vi) Filling up of Borrow Pits on Land Side

Any borrow pits on the land side made in an emergency during the 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 of the embankment. These should be properly filled up.

(vii) Proposals for Wetting of Embankment during Ensuing Monsoon Period

The proposals for wetting of all the embankments during ensuing monsoon should be carefully considered in advance. Any

levelling of the river side land that is necessary should be got done in the working season so that effective measures for leading the low level water obtaining in the early monsoon period to the embankment by necessary cuts in the river lip or by low gravity channels can be commenced and executed in time. For loop embankments and those reaches of the main embankment which cannot be wetted by gravity channels, pumping water into high level wetting channels leading to these reaches is to be considered.

In addition to the above listed items, the pre-monsoon maintenance should include the following:

- (i) Repairs to ghats, cross fences, and longitudinal fences near villages.
- (ii) Upkeep of road on top of the embankments.
- (iii) Removal of all unwanted growth on slopes and top.
- (iv) Attending to plantation beyond 20 ft. of toe of embankment on country side and 10 ft. on the river side.

(2) Ordinary Maintenance During Monsoon

The principal maintenance of embankments comes during monsoon season when the safety of the bunds is threatened. Frequent inspections particularly in the case of new embankments or valuable sections of old embankments and constant attendance on the embankments within their charge by everybody from the Beldar to the Executive Engineer are essential.

Patrolling commences as soon as water comes against an embankment. The temporary headquarters of the overseer, Assistant Engineer and Executive Engineer should as far as possible be located near the dangerous and important reaches of the embankments in their charge. Temporary shelter huts should be provided for the use of the overseers and the Assistant Engineers at suitable places. The Executive Engineer and Assistant Engineer should, whenever necessary and as far as possible patrol frequently at night. There should be a shift system in patrol establishment from beldar upwards to the Overseer, the duration of each shift should be left to the discretion of the local officer. The overseer should, however, form one unit of establishment for purpose of working the shift system. The duties of the officers and

staff engaged on patrolling of embankments are given below:

(i) Executive Engineer

The Executive Engineer must be present on the embankments when the water is rising. On a falling river the presence of Executive Engineer is not obligatory provided upper gauges show that no rise is to be anticipated. In the event of a rise after a fall in level the same procedure will apply.

It will be incumbent on the Executive Engineer to watch the upper river gauges and to satisfy himself by personal inspection before the flood arrives that all necessary arrangements have been made to meet flood conditions throughout the length of the embankments.

After the river has attained a constant level, for 3 days or more, the Executive Engineer may use his discretion as to whether he can safely leave the embankments until another rise occurs. In coming to a decision in regard to this, conditions obtaining at the gauges and local conditions of weather and wave wash must be taken into account.

When an exceptionally urgent inspection is required elsewhere, the Executive Engineer may leave the embankment after satisfying himself that all arrangements to meet the flood situation have been made.

The Executive Engineer who suspects that abnormal conditions may occur, must keep his Superintending Engineer informed that immediate attention is to be concentrated on remedial measures.

(ii) Assistant Engineer

The embankments will be generally in charge of an Assistant Engineer, who will be responsible for every thing that occurs in his jurisdiction. He should take an intelligent interest in the river levels obtaining and the river levels likely to occur against the embankments in his jurisdiction. He should visit the embankments at odd hours by day and night and see that the establishment is on the alert and every thing is alright. It is his duty to inform the Executive Engineer of all happenings daily and to make suggestions for the efficient conduct of the work. His establishment will consist of overseers, work mistries, work sarkars, mates and beldars. He will arrange for the proper distribution of this establishment and for the due discharge of the duties

having regard to the various needs at different points of his reach and the necessity of concentrated strength in dangerous sections. He should remain in contact with these officers atleast once a day and keep himself in touch with up to date conditions of the embankments and river in his charge.

(iii) Overseers

The overseer is required to pay surprise visits to see that all leaks, wave wash action and wetting of the embankments are properly attended to and that all the establishment is busy with the work allotted to them. He should pay close attention to the gauge readings and if any abrupt rise or fall is observed, he must at once find out the cause and take necessary action before it is too late. A high standard of tact and resource is expected from the overseer. He should submit wetting reports, daily, weekly and fortnightly. He must take immediate steps to meet any actual or apprehended danger, if necessary, without waiting for orders. During high floods, the overseers should observe velocities by current meter/floats at critical and important points along the embankments and should also note the direction of flow at these places.

(iv) Work Mistries

The work mistry should constantly keep in touch with all the establishment so that he may know at once everything that is happening and deal with all urgent calls throughout his beat. He must maintain the materials in his charge such as oil etc. and daily check the labour muster roll. He should visit the whole of his beat atleast once during the day and night and inspect dangerous portions very often, his beat being reduced during dangerous parts of the monsoons so as to make it possible especially in lengths needing careful watch and patrolling. It is essential that all work mistries of the embankment should be energetic, intelligent and capable of rising to emergency. The selection of mistries for embankment work must be made carefully, the mistries being specially selected for their past experience on embankments and should preferably be promoted literate work sarkars of long experience. It is preferable to have mistries who know swimming.

One mistry for 18 to 20 miles for active embankment line depending on local conditions is generally to be provided on the annual establishment. During monsoon, the number of work mistries may be doubled or even trebled.

(v) Work Sarkars

The work sarkar supervises the work of mates and beldars. He must muster the labour daily, check the readings of all the gauges and report the readings daily and more often if necessary, to both the mistry and overseer. When the mistry is resting in shift, responsibilities of a mistry are assumed by the work sarkar.

(vi) Mates and Beldars

These are the men who maintain and watch the embankment both during the pre-monsoon as well as monsoon period. Each mate will have 1 to 4 miles of embankment in his charge according to the importance of the reach and beldars will be engaged at the rate of 2 to 8 men per mate. In dangerous sections, beldars may be further increased if found necessary. The increase in number of beldars is dependant on the patrol required according to the height of the water against the embankment line and the danger involved. Where there is any real danger anticipated more men must be employed freely.

Among the mates and beldars on an embankment, there should be a suitable number of professional fishermen or boatmen as they are very necessary when the work is to be done in deep or flowing water. It may prove of more use if they are retained in the same boat.

As soon as the water comes against the embankment, the patrolling by beldars should commence. The beldars should work in pairs, one of the pair being always on duty while the other rests. During intensive patrolling, short shifts of 6 hours give better results, as it is difficult to expect vigilant and attentive patrolling over longer shifts. It is the duty of beldar to move along the water line pressing the embankment slope with their feet and also to examine the embankment immediately above water level for rat holes and whirls. They should complete the circuit by returning along the rear slope looking all the while for leaks. Immediately a whirl pool is observed in the front, the beldar must find out if water is oozing out of back slope and if he finds this is so, he should at once close the leak holes. He should also close all rat holes found on the upstream face. Similarly if while patrolling along the back slope he notices turbid water emanating through the embankment, carrying silt with it, indicating a leak, he must at once try to find out a whirl pool at the water line in the front slope and take all steps necessary for closing the leak. At the same time, he should take measures to

inform the mate and the mistry of the beat. The latter should in turn inform the Overseer, Assistant Engineer and also the Executive Engineer.

All patrols should carry lamps at night and be vigilant. The mate must see that each beldar is patrolling the embankment as required and that all leaks are immediately and properly tackled. He should also inform officers above him of all accidental happenings.

Every mate is responsible for the proper custody of the monsoon period materials stacked at various places in his beat and to arrange for the proper burning of lamps after sunset. At vulnerable places gas lamps alternatively on the land and river side edge of the top of embankments are most useful in lighting up the embankment for acute vigilance. There should be two such gas lamps one on each side within a furlong.

Apart from beldars intended for only patrolling the embankment a reserve gang or two of few labourers be kept at convenient posts for employment should emergency arise. While waiting for emergency calls, they should be kept usefully employed on odd jobs on the embankments.

Mates and Beldars should be provided with umbrellas and other protection during rain storms. The intensity of the patrolling activity should not be allowed to fall down during a rain storm or heavy wind or dust storm. While patrolling is necessary, beldars should not be expected to do other work but at the time of low water or with falling river they can be given light work for six hours a day.

Wetting of Main Embankment and Loop Embankments with Wetting Channels

The wetting of the embankments is an essential process in the maintenance and for the safety of the embankment, particularly in the excessively dry climate. The clay materials ordinarily met with are liable to expand when wetted and to shrink and crack when dry. The soils containing salts are even more treacherous as these lead to holes in the embankments. The conditions to which the embankments are exposed alternatively by the river in flood months and complete dryness during the rest of the year make the gradual wetting of the embankment in advance of the floods impinging upon a dry and unprepared embankment a vital necessity.

The embankment has to be wetted throughout the entire month if the wetting is to serve the designed purpose since embankment is only as strong as its weakest portions. The plan for wetting should be carefully thought out so that the wetting of the whole length of the embankment is completed before the rise in the river.

For wetting the embankments, it is necessary to lead the water to the main embankments. If the fall on the river sides slopes towards the embankment, all that is necessary is to give cuts to the lip at the river edge which is generally somewhat high. If there is low lying land near the embankment on the river side, but there is high land between river and the embankments, low level gravity channels have to be constructed along the contours from the high river edge to the embankment. If wetting by flow water is not possible, sufficiently in advance of the rise of the river, artificial wetting is to be resorted to by lifting water by means of pumps. Where regular wetting bunds and trenches are not available, the bed and low portion of the embankment, which should be soaked in advance by making small longitudinal trenches in front slopes in stages and filling them with water through pumps erected on canal or flood water standing against the embankments. This work should not be thrust upon the patrolling beldars diverting their attention from their equally important work of patrolling. Special gangs of men should therefore be employed for this purpose.

Miscellaneous Items of Maintenance during the Monsoon

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

- (1) Repair of rain cuts.
- (2) Cutting and stacking long grass etc.
- (3) Distributing and storing monsoon period material at suitable central points.
- (4) 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.
- (5) Opening out and refilling rat holes wherever possible.
- (6) Putting the top of embankment in order.
- (7) Taking regular soundings below embankment sluices and closely watching development of scour holes.

(8) Taking regular erosion ordinate measurements.

(3) Special Situations that may Arise during Flood Season

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

- (1) Erosion of main and loop bunds by the rivers.
- (2) Failure of bund sluices resulting from the under cutting of sluice foundation etc.
- (3) Development of leaks into breaches due to rat holes and other reasons as follows:
 - (i) Inadequate free board.
 - (ii) Inadequate cover over the saturation line with consequent heavy percolation.
 - (iii) Presence of rat holes.
 - (iv) Unequal settlement due to lack of wetting arrangements.
 - (v) Lack of arrangements to arrest the development of leaks.
 - (vi) Inadequate supervision and material on site.

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

1. River Erosion

The undermining 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 these methods are not successful, then the only way is to retire the embankment.

2. 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 to 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 sluices 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.

3. Inadequate Free Board

Inadequate free board may be due to undue settlement of banks or an unprecedented rise of water level following an unexpected change in the river course or shortening of the course of the river somewhere upstream.

With rigid insistence on annual levelling 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 over-topping and washing out of the bund; and
- (ii) by wave wash gradually weaving away the top and exposing it to over-topping.

The raising of bunds by emergent measures to avoid over-topping 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 3 to 4 ft. and the bund held for a time, provided earth and labour are available or can be arranged at once.

4. Overtopping

Where overtopping is apprehended during floods, the top of the bund can be raised by one of the following methods:

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 the inner berm of the embankment or by earth brought by boats. The gunny bags should be filled preferably

with clay or loam to make a water tight facing. They should be filled only about 3/4th full so that the bags will fit closely to each other. They should be laid in alternate layers of henders and stretches and kept moist.

5. Wave Wash

The danger due to wave wash can be minimised by encouraging the growth of trees in a belt of 100 to 150 ft. wide on the river side, 5 to 10 ft. 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 mats; and
- (iii) construction of longitudinal groynes on the slopes with their tops 2 ft. above the anticipated high flood level.

6. 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:

- (1) Inadequate bund section.
- (2) Flatter saturation gradient than designed.
- (3) 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 out crops frequently occur without serious danger to the stability of the section. The first indications of a likely slip are soft wet spots on the surface of the rear slope followed by excessive seepage carrying particles of earth with it. Then longitudinal cracks form 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 depending 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 flatterring 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 sufficiently 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 coarse 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.

7. 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, very 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.

8. 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 bund 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 work sarkar and work mistry. Other beldars in the vicinity should also be called but not those 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 in 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 stumping, 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 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 the 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 2 ft. 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 has ceased or not. If it has, the leak 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.

9. *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 "blow outs", may be as large as 3 or 4 ft. 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 "blow out" 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 filled 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 8 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 and 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 filling 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 land side at a short distance from the toe of the embankment.
- (iv) Flattening the land side slope of the embankment or providing pushtas to the embankment.
- (v) Providing plantation shrubs etc. on the river side berms of the embankments for arresting silt.

For deciding the appropriate measure necessary investigation and study of the nature of the soil in the below the embankment and of the embankment itself and other site conditions would have to be made.

10. 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 (1) detection of leaks, (2) location of direction of leak, and (3) taking prompt measures in closing of leaks; breaches can be successfully avoided.

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

- (1) Name of embankment.
- (2) Reduced distance of site of breach.
- (3) Time of occurrence.
- (4) Time at which report of the same reached the Mistry or Overseer.
- (5) Time at which the Mistry or Overseer reached the spot.
- (6) Causes of breach.
- (7) Width of breach at time of report.
- (8) Depth of water at site of breach.
- (9) Nature of Soil.
- (10) Strength of labour and materials at site.

The Mistry or the Overseer 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 repaired in their presence. The assistance of the Army should be sought for only when the

situation is beyond the control of Civil authorities.

Immediately 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 and the end held in position 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 closing of a large river breach is difficult and involves a large expenditure. A fully considered plan has therefore to be drawn to close the breach successfully.

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

- (1) An estimate of the labour required.
- (2) A detailed survey of the sites to determine the best location for the ring bund.
- (3) 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.
- (4) An estimate of the material required and the arrangements necessary to get them.
- (5) An estimate of the different kinds of labour required and the steps necessary to obtain the required strength in due time.
- (6) 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 be made for housing, food, and sanitation for the labour. The amount of dry earth and sand that will be required should be carefully estimated 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.

II. 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 forethought 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) Petrolling

(i) Lamps Hurrisane
 1 for every 2 Beldars.
 1 for every Mate.
 1 for every Mistry.
 1 for every Overseer.
 and 20 per cent of the total as spare.

(ii) Wicks 9" per lamp.
 (iii) Globes 1 spare for each lamp.
 (iv) Burners and caps Spare for 1/3 No. of lamps.
 (v) Torches 1 for Executive Engineer.
 1 for Asstt. Engineer.
 1 for Overseer and 2 spare.

(vi) Cells 1 fill and two spare sets.

(vii) Petromax Lamps At dangerous places as necessary; each lamp with two spare globes, 2 nozzles, 2 washers, 2 wire gauges, 2 needles and 6 mantles. 3/4th of the number should be 300 C.P. & 1/4th 200 C.P.

(viii) Fuel for lighting fire To be collected by beldar establishment.

(ix) Kerosene oil 1 tin per hurricane lanterns (excluding spare) and 2 tins for petromax lamp per season.

(x) Match boxes One dozen match boxes per lamp per season.

(xi) Spirit

(xii) Funnels

(xiii) Oil extractors

(xiv) Spirit cans

1 bottle per petromax
lamp per season.

1/2 dozen per Mistry.

1/4 dozen per Mistry.

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, 1 maund per mile.

(3) Leaks

(i) Gunny bags

(a) Where High Flood
Depth is less than 6 ft.
and the embankment is
generally safe - 100 bags
per mile.

(b) Where High Flood
Depth is greater than
6 ft. or the embank-
ment is known to give
trouble of leaks - 200
bags per mile.
100 to 200 stakes per
mile.

(ii) Stakes

(iii) Baskets

1 Basket of Toot per
Beldar or a basket of
lai per Beldar and 1
spare.

(iv) Sutli

1 lb. or 1/2 seer per
100 bags.

(v) Needles

1/2 dozen with each
Work Sarkar.

(vi) Sand

Collection of 100 to
200 cft.

every mile for
dangerous lengths.

(4) Breaches

Provision for materials required should be made for one or more small breach length each 250 feet long depending upon the embankment.

Materials for protecting ends of one breach and constructing one 250 feet long, are approximately as under:

(i) Big stakes or Sal ballies	Every 5 feet apart; with 100 per cent spare.
(ii) Split Sal ballies or Bamboos	For horizontal bracing of vertical ballies-10' long each (for the entire length).
(iii) Split Sal ballies or Bamboos	For cross bracing of vertical ballies-10' long one for each vertical ballie.
(iv) Matresses of split bamboos or pilchi or other locally available material.	For sufficient length.
(v) Brushwood or local material	For sufficient length.
(vi) Stakes	1-1/2 feet centre long each.
(vii) Munj Rope	row of frame.
(viii) Coir Ropes	Enough quantity.
(ix) Gunny bags	2,500 per Asstt. Engineer.
(x) Sutti	1 lb. 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 embankments.

III. STRENGTH OF ANNUAL AND MONSOON PERIOD ESTABLISHMENT

The matter of engaging the annual and monsoon establishment is left to the discretion of 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 8 to 20 miles of embankment line depending on local conditions.
- (ii) Mates- Each mate will have 4 to 8 miles of embankment line in his charge, according to the importance of the embankment in the monsoon.
- (iii) Beldars- One for every mile for clearing jungle and closing rain cuts etc.

(2) Monsoon Establishments

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

- (i) Work Mistry- Each work mistry should have six to ten miles of embankment line depending upon the relative importance of the reach.
- (ii) Work Sarkar- Each work sarkar should have 3 to 5 miles 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 reach.
- (iv) Beldars- 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 16 men, or more per mile, if found necessary. Where the Assistant Engineer cannot obtain extra beldars at a short notice locally, a large number of beldars must be engaged from the beginning of the season and kept busy on other jobs.
- (v) Telephone Operators or Messengers- One or more telephone operators 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 earthwork is required.

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

(IV) 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 gauges and flood warnings are possible only when adequate data of rainfall, river gauges and discharges are available. The location of raingauges 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 5 to 10 miles. They should also be fixed at the junction of various rivers, rivulets and local drainages joining the river on which the embankments have been constructed. The gauge readings should be taken 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 recording and fitted with transmitting arrangements. The gauge readings 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 stations should be maintained in a register. These data form the basis for flood forecasting studies, raising and strengthening of embankments and for design of works 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 flood 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 arrangement for receiving data by telephone, telegram and wireless. Wireless transmitting arrangements should be invariably 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 warnings so that the patrolling arrangements can be organised as necessary. As far as possible telephone facilities should be provided at intervals of 8 to 10 miles. 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 embankments. In the long run, the cost involved for such a facility will outweigh 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 the embankments most of the time.

V. PUBLIC CO-OPERATION IN MAINTENANCE OF EMBANKMENTS

The network of embankments which have been constructed along the rivers in various States in the country is primarily intended for the protection of agricultural land and property and therefore the benefits of the embankments are enjoyed by the village community. It is therefore essential that the persons inhabiting the villages along the embankments should be aware of the benefits which they give and should be made to realise the importance of maintaining them in good condition, in their own interest. They should be induced to take active part in works which are required for the efficient maintenance of the embankments.

There is ample scope for such a participation by the people in the villages of the Panchayati Raj. While voluntary labour on Shramdan basis can be expected from them, such a proposition may not be practicable.

The scope for participation by the Panchayati Raj in the various maintenance operations discussed in the earlier sections is dealt with in the following paragraph.

1. Maintenance During Pre-monsoon Period

While the routine normal maintenance during the premonsoon period can be effectively done by the Annual Establishment which is in the permanent roll of the Flood Control Department, Panchayati Raj can participate in the execution of special repair works such as raising and strengthening of embankments, river training works etc. They can either term co-operative unions for carrying out such works or provide the requisite labour for departmental work. They can also provide transport for the material required in these works..

The Panchayati Raj should inform the Flood Control Department of the existence of such Unions or indicate the number of people whom they can muster for the departmental work. The Department should give preference to the local people if they come forward in such works.

Payment for the work done will be made by the Flood Control Department on the basis of contract rate or daily labour rate.

No special training is required in the implementation of these works.

2. Maintenance During Monsoon

There is more scope for participation by the villagers during the monsoon season. Their services can be utilised in the patrolling of banks and in the works for meeting emergent situations. A large number of mates and beldars are required for temporary duty during monsoon season. These can be provided by the Panchayati Raj. If such help is assured by the Panchayati Raj, it will be in the interest of both the villagers as well as the Department. The villagers will get casual employment and the department will not be required to maintain a large reserve due to the fear that the requisite staff cannot be raised at short notice. However it is necessary to have a fool-proof arrangement in this regard since the safety of the embankment cannot be jeopardised. For this purpose the requirement of additional monsoon maintenance staff at different reaches should be worked out by the Executive Engineer and he should inform the Panchayat Chiefs of his requirements of different categories of staff. He should take an assurance from the Panchayat Chiefs and the officers to whom they are responsible that such staff will be made available at short notice.

The nature of work which these personnel are required to do has been described in the earlier sections. It is necessary that the villagers who are to discharge these duties when called for should be familiar with them. This should be done by actual field training through the annual maintenance staff and also by organising special lectures and practical demonstration on the maintenance of embankments by Engineer Incharge. These courses should bring out the objectives of the embankments, what their failure will mean and the various maintenance works during and after monsoon and the emergent situations that may arise during the floods.

The total number of personnel to be trained and kept on the call register may be roughly 25 per cent more than the actual requirement. It is not necessary that the number required in each reach should be made available by the concerned Panchayat. It can be more or less but the overall strength should be ensured by the villages along the embankments.

Payment for the service rendered during the flood season as and when called for is to be made by the State Flood Control Department according to the authorised rates.

3. Emergent Situations

The Panchayats can play an important role during situations created by the breaches in embankments. Their labour Unions can provide requisite labour during such emergencies, organise transport for the speedy carriage of materials and also help in the relief operations.

The villagers should be acquainted with the havoc caused by the breaches and how they are normally closed, screening of documentary films in this connection will be very useful.

Payment for the labour and material supplied by the Panchayats for work during emergencies will be made by the State Flood Control Department.

Village Communication

The Panchayat Raj should pay adequate attention to the roads in their villages adjoining the flood banks. The roads should be so maintained that they are above the normal flood level and in a fit condition

when emergent situations arise. They should also ensure that all approaches to the embankments are well-maintained so that the patrolling and supervisory staff have easy access to the embankments. These approaches should be above the normal water level.

The maintenance of these roads should be carried out from the funds of the Panchayat and should not be a charge on the Flood Control Department.

The local Block Development Officers of the Community Development Organisation should help the officers of the State Flood Control Department in enlisting the cooperation of village Panchayats and in arranging the training programme even though the training will be imparted by the Flood Control Officials.



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