IS 11532 (1995): Construction and maintenance of river embankments (levees) - Guidelines [WRD 22: River Training and Diversion Works]

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भारतीय मानक

नदी के तटबन्धों (तटबन्ध) का निर्माण और रखरखाव — मार्गदर्शी सिद्धान्त

(पहला पुनरीक्षण)

Indian Standard

CONSTRUCTION AND MAINTENANCE OF RIVER EMBANKMENTS (LEVEES) — GUIDELINES

(First Revision)

UDC 627.18.03 (026)

BUREAU OF INDIAN STANDARDS
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FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the River Training and Control Works Sectional Committee had been approved by River Valley Division Council.

River embankment (levee) is an artificial bank built along a river for the purpose of protecting adjacent land from inundation by flood. Such type of structure is also called embankment, levee, 'stop-bank', 'bund' or 'dyke' . Construction of embankment to control flood is an age-old practice and is still being followed due to its proven suitability.

Previously construction and maintenance of river embankments were covered in two Indian Standards, namely IS 11532 : 1985 'Guidelines for construction of river embankments (levees)' and IS 12028 : 1987 'Guidelines for maintenance of river embankments (levees)'. For the convenience of users it was felt necessary to amalgamate these two standards and accordingly, the present revision has been taken up. With the publication of this revised standard, IS 12028 : 1987 'Guidelines for maintenance of river embankments (levees)' shall stand withdrawn. In this revision some of the provisions given in the earlier standards have been modified based on the current practices in the field and experience gained with the use of the standards in addition to incorporating a table giving approximate values of maximum dry density and optimum moisture content for different types of soil. Soil classification given in this standard is based on IS 1498 : 1970 'Classification and identification of soils for general engineering purposes (*first revision*)'.

Indian Standard

CONSTRUCTION AND MAINTENANCE OF RIVER EMBANKMENTS (LEVEES) — GUIDELINES

(First Revision)

1 SCOPE

This standard covers the guidelines regarding construction and maintenance of river embankments (levees).

2 CONSTRUCTION OF EMBANKMENTS

2.1 Construction of an embankment should envisage, for the sake of economy, maximum utilization of natural unprocessed materials available locally. Embankments may be homogeneous or zoned. They should generally be of compacted roll fill at controlled moisture content.

Investigation of borrow areas, their location and depth of excavation, foundation preparation, earthwork, compaction, moisture control and slope protection are the important aspects to be carefully attended to during construction.

2.2 Borrow Pits

2.2.1 Borrow areas should preferably be located on the river side of the proposed embankment, because they get silted up in course of time, whereas those located on the countryside remain a permanent disfiguration and are liable to induce or aggravate seepage under the embankment, thereby causing increased maintenance problems.

2.2.2 For low embankment less than 6 m in height, borrow areas should not be selected within 25 m from the toe/heel of the embankment. In case of higher embankment the distance should not be less than 50 m.

2.2.3 Preliminary soil investigation may be done from a few representative auger holes or borrow pits.

2.2.4 After selection of an area apparently suitable for borrow pits in accordance with **2.2.1, 2.2.2** and **2.2.3**, detailed investigations should be undertaken for a systematic mapping and determination of engineering properties such as gradation, permeability, plastic limits, etc, of the soils in the borrow.

2.2.5 Plan showing borrow areas and the quantity of materials for different zones of the embankment section should be used for actual construction.

2.2.6 The recommended mean distance of the borrow pits from the toe of the embankments as well as the depth of borrow pits should generally be as under:

Distance of Borrow Pits	*Maximum Depth of Borrow Pits*	
	River Side	Country Side
m	m	m
25 to 50	1.0	0.6
Over 50 up to 75	1.5	0.6
Over 75 up to 100	2.0	0.6

2.2.7 In order to obviate development of flow parallel to embankment, cross bars of width eight times the depth of borrow pits spaced at 50 to 60 metres centre-to-centre should be left in the borrow pits.

2.2.8 All borrow areas/pits should be stripped of the top soil, sod, loam and other objectionable materials considered unsuitable for use in the embankment.

2.3 Laboratory Tests

For important and also for embankments higher than 6 m, representative samples obtained from the borrow areas should be tested in the laboratory to determine the engineering properties of soils, such as gradation, permeability, plastic limits, shear strength, dry density, compaction tests, etc, as given in design.

2.4 Preparation of Foundation

The seat of the embankment should be properly prepared for fill placement. It should be ensured that all stumps, brush, large roots, top soil and other objectionable materials are completely removed before placement of the fill. Any ridges or mounds, which are in line of embankment, should be loosened by ploughing or stepped or dug or provided with V-cut benching at intervals running

parallel to the centre line. The prepared surface should enable proper bond with the fill material to be placed thereon.

2.5 Earthwork

2.5.1 Embankment Profile

A complete profile of the embankment with its correct height, width and all slopes dressed to true form should be laid by pegs, bamboo posts and strings at 50 m intervals or by actual construction of the embankment of 3 m length at 150 m intervals. The actual construction should, however, be done by giving suitable settlement allowances which may be about 1 to 2 percent of the embankment height.

2.5.2 Embankment Involving Mechanical Compaction

In case of embankment involving mechanical compaction, the materials free from all organic matter should be compacted in layers of 15 to 20 cm for the full width of the embankment and carried up regularly in accordance with embankment section. All clods should be broken up to a size having not more than 5 cm diameter. Each layer should be properly watered and compacted. The surface should be well graded and crowned in the centre so that during rain the surface water is carried rapidly to the slopes of the fill.

2.5.3 Embankment Involving Manual Compaction

In case of embankment involving manual compaction, the layers not exceeding 15 cm thickness should be placed slightly sloped towards the centre of the crest so that rainfall will naturally consolidate the embankment during the construction. The materials should be free from organic matter. The top layer forming the crest of the embankment should be suitably graded so that rainwater does not accumulate and create maintenance problems.

2.5.4 Remodelling of Embankments

When adding new earthwork to existing embankment, the old bank should first be cut or benched into steps with the treads sloping slightly towards the centre of the embankment and the surface of the old work should be wetted so that new earth may adhere to the old. Similarly, junctions should be made by cutting grips or forks in the side slopes of the old embankment.

2.5.5 Incomplete Embankment

In case the whole length is not taken up simultaneously, the incomplete embankment should have steps not steeper than overall longitudinal slope of 1 in 5 to permit satisfactory bond with the portion to be taken up later.

2.6 Compaction

2.6.1 The basic criteria of the quality and suitability of the work done is the degree of compaction attained. For effective quality control of compaction, data on optimum moisture content and maximum dry density obtained from laboratory compaction tests are required. For small embankments, in the absence of such laboratory data, values given in Table 1 may be used. The best result is obtained by spreading materials with a moisture content 1 to 2 percent less than the optimum moisture content in layers of limited thickness and rolling with properly designed rollers with sufficient number of passes. Smooth contact surface between successive layers should be avoided and uniform density throughout the fill should be achieved.

Table 1 Approximate Values of Maximum Dry Density and Optimum Moisture Content for Different Types of Soils

Soil Classification	Proctor Compaction	
	Maximum Dry Density g/cm^3	Optimum Moisture Content percent
(1)	(2)	(3)
GW	>1.907	<13.3
GP	>1.762	<12.4
GM	>1.826	<14.5
GC	>1.843	<14.7
SW	1.907 ± 0.08	13.3 ± 2.5
SP	1.762 ± 0.032	12.4 ± 1.0
SM	1.826 ± 0.016	14.5 ± 0.4
SM-SC	1.907 ± 0.016	12.8 ± 0.5
SC	1.842 ± 0.016	14.7 ± 0.4
ML	1.650 ± 0.016	19.2 ± 0.7
CL	1.730 ± 0.016	16.8 ± 0.7
MH	1.314 ± 0.064	36.3 ± 3.2
CH	1.506 ± 0.032	25.5 ± 1.2

NOTE —± Entry indicate 90 percent confidence limits of the average value.

2.6.2 Compaction of each layer of fill materials should proceed in systematic, orderly and continuous manner so as to ensure the specified coverage by the compactors. Sheepfoot roller or tamping type roller is generally accepted as the best available means of ensuring proper compaction for average type embankment material. The acceptable limit of compaction as compared to the dry density at optimum moisture content would depend on the desired shear strength for the stability of side slopes. For mechanical compaction the minimum compaction should be 90 percent and for manual compaction 85 percent. Adequate quality control and field tests are needed to ensure this.

2.6.3 If the soil is granular with practically no cohesion, road rollers are considered quite adequate for compaction.

2.6.4 Those parts of the fill which cannot be reached by rolling equipment should receive equivalent manual compaction or mechanical tampers. Particular care should be taken for suitable compaction and jointing of embankments with the structures.

2.7 Moisture Control for Mechanical Compaction

2.7.1 Proper moisture control of the material is very important in order to ensure proper compaction. Materials may be conditioned to the desired moisture content either at the site of excavation, on the embankment or under same condition at both the borrow pit and during placement. It is necessary that some rapid and convenient methods be employed to determine whether or not the materials have the desired moisture content as they are placed on embankment.

2.7.2 The penetration resistance needle, which makes use of the penetration resistance-moisture relation for the material being placed, is very useful for the purpose. It is desirable to establish field laboratories to carry out tests in the field while compaction operation goes on.

2.8 Slope Protection

The surface protection of embankment against action of rain and wind is usually achieved by turfing. In case of embankment using non-cohesive material, a cover of 0.3 to 0.6 m thick cohesive material can be given. Since velocities along river side slopes of embankment are expected to be low, no slope protection may ordinarily be required and turfing on both sides may suffice. If river action is more severe, suitably designed slope protection should be adopted.

2.8.1 The planting of trees on embankment should not be permitted because their roots tend to loosen the structure of the embankment when shaken by wind storm which, in turn, causes cracks and leaks. Shrubs, thorny bushes and short grass growing on the slopes of embankments provide good protection against erosions, wave wash and stray cattle. Generally the side slopes and 0.6 metre width in top from the edges of the embankments should be turfed with grass sods and this turfing should extend beyond the toe to country-side and the river side by 6.0 metres and 3.0 metres respectively.

3 MAINTENANCE

3.1 Proper maintenance of embankments is extremely important as breaches in them can be disastrous and may cause even greater damage than the inundation by the floods where no embankments are provided. The maintenance work can be divided into 2 parts:

a) Pre-monsoon maintenance, and
b) Monsoon maintenance.

3.1.1 *Pre-monsoon Maintenance*

3.1.1.1 Existing embankments have to be repaired or reconditioned to the original designed section in advance for their efficient performance during the ensuing monsoons. The free board may be checked up for any rise in the bed level of the river or other constrictions which may result in higher design flood level and provided/maintained accordingly.

3.1.1.2 All hollows and depressions in the embankment's section, wherever existing, should be made up with rammed earth after clearing the site of all loose and vegetal materials. Where the top material is sandy or silty, it is desirable to provide a cover of soil containing 10 to 15 percent of clay well rammed or rolled.

3.1.1.3 A register of leaks should be maintained indicating the location and action taken during the monsoon period. The leaks, which could not be fully treated during the monsoon period, should be attended to immediately afterwards. Such leakage sites should be opened in the full width of the embankment taking care to trace to its upstream ends, and then be refilled with good earth in 15 centimetre layers, watered and rammed, the old earth being stepped or benched back at the sides and new earthwork properly bonded and interlocked into the old.

3.1.1.4 Rodents and other animals make holes, cavities and tunnels through and under embankments. These are sources of danger causing leakage and excessive seepages which may give rise to serious breaches during flood period. Such holes should be carefully located, examined, provided with an inverted filter, filled with earth and rammed. Alternatively such holes should be filled with well rammed stiff clay.

3.1.1.5 All the masonry works should be carefully inspected to detect if there is any danger of seepage of water along the planes of contact between the earth and masonry. The earth adjacent to the masonry work should be laid in 15 cm layers, watered and compacted, and brought to the design section.

3.1.1.6 For embankments which were severely threatened by erosion during the previous monsoon, revetment/rip rap or other river training works should be separately examined. Where stones or bricks, etc, are costly, cheaper means like brushwood matting, etc, may be used. In case of wave action, pitching should be taken at least 0.3 metre above the maximum height of wave expected.

3.1.1.7 Approach roads and also top of embankments, wherever they are designed to carry vehicular traffic, as well as ramps provided for inspection and maintenance should be kept in good condition so that they serve the purpose of transport of materials and inspections both during the pre-monsoon and monsoon periods. No habitation should be permitted on the embankments.

3.1.1.8 All departmental vehicles, boats and launches should be kept operational.

3.1.1.9 All sluice gates, regulation gates and valves should be properly greased, oiled and treated.

3.1.1.10 All tools and equipment including torch lights, hurricane lamps, spades, etc, and flood fighting articles as well as materials for erecting temporary sheds at the work sites for workers should be arranged and stored in suitable places.

3.1.1.11 Proper communication system should be installed for quick transmission of messages to the concerned authorities.

3.1.2 *Maintenance During Monsoon*

3.1.2.1 During monsoon, prompt maintenance of the embankment is required as the flood water of river threatens the safety of the embankment mostly during this period. This is all the more important in case of new embankments and also in case of those reaches of old embankments where breaches occured in the past. The establishment required to be engaged for proper maintenance of an embankment will vary depending upon importance of the embankment and behaviour of the river. As soon as water touches the embankment and river shows rising trend of its water level, round the clock patrolling should start by the establishment engaged for this purpose and continue until water finally receeds from the embankment. During this period, inspection by senior officials should be carried out systematically and all the concerned officers and staff should remain alert to meet any emergent situation.

3.1.2.2 Special vigilance is necessary in the countryside of the embankment to detect any formation of boils due to seepage. This should be immediately attended to by providing loading berm to counter balance exit gradient. A suitable filter material may be placed around the boil below the loading berm to arrest fines in seepage water.

3.1.2.3 Water may seep through a sand stratum under the levee and emerge on the countryside in the form of bubbling springs. Under these conditions, a stream of water bursts through the ground, carrying with it sand which then settles around the edge of the hole. These sandboils may be as large as 1 to 1.3 metres in diameter and may occur from 13 to 100 metres from the levee or even further away.

As a protective measure embankments of earth filled sacks may be built around them thus ponding the water and creating a head on the countryside sufficient to stop the flow of silt through minimising the effective head of water. If other boils take place outside this encircling embankment, it may be necessary to construct sub-levees around the area containing such sand-boils.

3.1.2.4 To prevent the water from overtopping and washing out a portion of the levee, a dowel at the river side of the top of the embankment with sand/earth filled bags may be provided.

The bags should be filled half full only so that they will fit closely against each other. Sand should not be used for filling the sacks, if clay or loamy soil is available. In case of emergency, the material may be taken from the back slope of the levee much above the hydraulic gradient line with respect to maximum flood level.

3.1.2.5 Repair of rain cuts in the embankment, stacking of material and machinery required for repairing, putting the top of embankment in order, etc, should also be made. Scouring and eroding behaviour of the river should also be carefully watched for taking necessary precautionary measures. In this way, by means of proper vigilance and timely action for repair works, flood disaster can be reduced to a great extent.

3.1.2.6 All information connected with rising flood water level and flood situation should be passed on to concerned higher authorities to enable them to take safety measures in time.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act, 1986* to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards Monthly Additions'.

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