कार्यालय मुख्य अभियंता
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स्वारा भवन, कोलार रोड़ लिंक रोड़ न-3
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प्रति,

समस्त मुख्य अभियंता

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विषयः– प्रारूप तकनीकी परिपत्र 42 में संशोधन बावत्।

उपरोक्त विषयांर्तगत तकनीकी परिपत्र क्रं 42 ड्राफ्ट संशोधित कर प्रारूप आपकी ओर सुझाव/अभिमत हेतु संलग्न कर प्रेषित है। विभागीय वेब साइट पर भी प्रदर्शित है, कृपया संशोधन/सुझाव कछारीय कार्यालय स्तर एकत्रित कर इस कार्यालय को अवगत करावें।

अनुरोध है कि उपरोक्त विषय में अभिमत/टीप से अवगत कराना चाहेंगे, जिससे तकनीकी परिपत्र में संशोधन किया जा सके।

सहपत्रः–प्रारूप तकनीकी परिपत्र 42

3/1/19

(भरत गोसावी)
मुख्य अभियंता (बोधी)
जल संसाधन विभाग
भोपाल

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प्रतिलिपिः–

1. प्रमुख अभियंता, जल संसाधन विभाग भोपाल की ओर सूचनार्थ। अनुरोध है कि उपरोक्त संशोधन प्रस्ताव पर सुझाव/अभिमत से इस कार्यालय को निर्देश देना चाहेंगे।
2. वेब मेनेजर, जल संसाधन विभाग भोपाल की ओर विभागीय वेब साइट पर अपलोड किये जाने हेतु प्रेषित।

सहपत्रः–प्रारूप तकनीकी परिपत्र 42

(भरत गोसावी)
मुख्य अभियंता (बोधी)
जल संसाधन विभाग
भोपाल

Madhya Pradesh Water Resources Department
Design Series Technical Circular No. 42
Guidelines for design of small Earth Dams

TC 42 ORIGINAL	TC 42 REVISED AS PER IS 12169-1987	ABSTRACT OF IS CODE	COMMENTS (if any)
1 GENERAL	**1.0 GENERAL**		
A large number of small embankment dams are being **designed by the local design office and built in the state. In designing a small embankment dam, use of IS 8826-1978 (Guidelines for design of large earth and Rock-fill dams) is made. This sometimes, results in uneconomical and unwarranted provisions in design. It is therefore, felt necessary that a separate Technical Circular should be available for guiding the design of a small embankment dam in the state.**	A large number of small embankment dams are being designed by the local design office and built in the state. In designing a small embankment dam, use of IS 8826-1978 (Guidelines for design of large earth and Rock-fill dams) is made. This sometimes, results in uneconomical and unwarranted provisions in design. It is therefore, felt necessary that a separate Technical Circular should be available for guiding the design of a small embankment dam in the state. *Previously issued Design series T.C. No-42 is now revised in view to adding details not-furnished before.*		
1.1 Small Earth Dam	**1.1 Small Earth Dam**		
An earth dam may be termed as a small earth dam if it fulfils all the following criteria :	An earth dam may be termed as a small earth dam if it fulfils all the following criteria;		
1. Its height is less than 15m above the deepest riverbed level;	1. Its height is less than 15 m above the deepest river bed level		
2. The volume of earthwork involved in dam construction is less than 0.75 million meter cube;	2. The volume of earthwork involved in dam construction is less than 0.75 million meter cube		
3. Storage created by the embankment is less than one million meter cube; and	3. Storage created by the embankment is less than one million meter cube		
4. The maximum flood discharge from the intercepted catchment area is less than 2000 cumec.	4. The maximum flood discharge from the intercepted catchment area is less than 2000 cumecs.		
2.0 . SCOPE	**2.0 SCOPE**		
This technical circular provides guidelines to design a small earth dam.	This technical circular provides guidelines to design a small earth darn. This TC is based on IS: 12169 – 1987 (Reaffirmed 2013).		
3.0 TERMINOLOGY	**3.0 TERMINOLOGY**		
For the purpose of this circular, following definitions shall apply:-	For the purpose of this circular, following definitions shall apply:-		
3.1 Casing or Shell: — All, zones other than core in a zonal earth dam are called Casing.	**3.1 Casing or Shell**: - All zones other than core in a zonal earth dam are called casing.		

3.2 Core: — A zone of impervious earth within azoned earth dam.	**3.2 Core**: - A zone of impervious earth within a zoned earth dam.		
3.3 Cut-off: — A barrier of impervious ,-material provided in foundation of a dam, to reduce seepage of water through foundation and abutments.	**3.3 Cut-off**: - A barrier of impervious material provided in foundation of a dam, to reduce seepage of water through foundation and abutments.		
3.4 Edging:- A short protection on the downstream edge of the top width of dam.	**3.4 Edging**: - A short protection on the downstream edge of the top width of dam.		
3.5 Embankment Dam: — A dam composed of any type of soil including rock	**3.5 Embankment Dam**: - A dam composed of any type of soil including rock.		
3.6 Free board: — The vertical distance between the top, bund level of an embankment and the maximum reservoir water level.	**3.6 Free board**: - The vertical distance between the top bund level of an embankment and the maximum reservoir water level.		
3.7 Full Reservoir Level (FRL): - It is the highest level of the reservoir at which water is intended to be held for various uses including part or total of the flood storage without allowing any passage of water through spillway.	**3.7 Full Reservoir Level (FRL)**: - It is the highest level of the reservoir at which water is intended to be held for various uses including part or total of the flood storage without allowing any passage of water through spillway.		
3.8 Homogeneous Earth Dam: - An embankment dam composed of single type of material	**3.8 Homogeneous Earth Dam**: - An embankment dam composed of single type of material.		
3.9 Horizontal Filter:- A layer of uniform or graded pervious material placed within body of the dam horizontally	**3.9 Horizontal Filter**: - A layer of uniform or graded pervious material placed within body of the dam horizontally.		
3.10 Impervious Blanket or Clay Blanket:- An upstream impervious soil layer of specified thickness laid over a relatively pervious stratum and connected to the core.	**3.10 Impervious Blanket or Clay Blanket**:- An upstream impervious soil layer of specified thickness laid over a relatively pervious stratum and connected to the core.		
3.11 Impervious Strata: - The strata having range of permeability similar to core material.	**3.11 Impervious Strata**: - The strata having range of permeability similar to core material.		
3.12 Inclined/Vertical Filter Or Chimney Filter - A layer of uniform or graded perviousmaterial placed inclined/vertical in the body of the dam.	**3.12 Inclined / Vertical Filter Or Chimney Filter**: - A layer of uniform or graded pervious material placed inclined/vertical in the body of the dam.		
3.13 Inner Cross Drain:- A trench filled with filter material to collect seepage from inner longitudinal drain and carry it to toe drain.	**3.13 Inner Cross Drain**:- A trench filled with filter material to collect seepage from inner longitudinal drain and carry it to toe drain.		

3.14 Inner Longitudinal Drain:- A trench filled with filter material and laid along the down stream toe of the core of dam to collect seepage from core of the dam.	**3.14 Inner Longitudinal Drain**:- A trench filled with filter material and laid along the downstream toe of the core of dam to collect seepage from core of the dam.		
3.15 Lowest Water Level (LWL) or Minimum Draw Down Level (MDDL): - The lowest level to which a reservoir may be lowered keeping in view the requirements for hydropower generation or irrigation and other needs.	**3.15 Lowest Water Level (LWL) or Minimum Draw Down Level (MDDL)**: - The lowest level to which a reservoir may be lowered keeping in view the requirements for hydropower generation or irrigation and other needs.		
3.16 Maximum Water Level (MWL): It is the highest level to which the reservoir water will rise while passing the design flood with the spillway facilities in full operation.	**3.16 Maximum Water Level (MWL)**: - It is the highest level to which the reservoir water will rise while passing the design flood with the spillway facilities in full operation.		
3.17 Pore-pressure: - The pressure developed in the air-water fluid within the voids of the soil mass under external force when drainage is prevented.	**3.17 Pore-pressure**: - The pressure developed in the air-water fluid within the voids of the soil mass under external force when drainage is prevented.		
3.18 Relief Well: - Vertical wells or bore holes, downstream of or in down stream shoulder of an earth dam, to collect and control seepage through or under the dam so as to reduce water pressure.	**3.18 Relief Well**: - Vertical wells or bore holes downstream of or in downstream shoulder of an earth dam, to collect and control seepage through or under the dam so as to reduce water pressure.		
3.19 Rip-Rap: - It is a protection to an embankment material against erosion due to wave action, velocity of flow, rain wash, wind action etc., provided by placing a protection layer of rock fragments or manufactured material.	**3.19 Rip-Rap**: - It is a protection to an embankment material against erosion due to wave action, velocity of flow, rain wash, wind action etc., provided by placing a protection layer of rock fragments or manufactured material.		
3.20 Rock-toe Boulder toe: - A zone of free draining material comprising of rock fragments I boulders / cobbles etc., provided at the toe of the dam.	**3.20 Rock-toe/Boulder toe**: - A zone of free draining material comprising of rock fragments / boulders / cobbles etc., provided at the toe of the dam.		
3.21 Sudden Draw-Down: - The rate of lowering of reservoir water level which does not allow full dissipation of pore pressure simultaneously with the lowering of the reservoir water level.	**3.21 Sudden Draw-Down**: - The rate of lowering of reservoir water level which does not allow full dissipation of pore pressure simultaneously with the lowering of the reservoir water level.		
3.22 Toe Drain: - A trench filled with filter material or without it along the downstream toe of an earth dam to collect seepage from horizontal filter and lead it to natural drain.	**3.22 Toe Drain**: - A trench filled with filter material or without it along the downstream toe of an earth dam to collect seepage from horizontal filter and lead it to natural drain.		

3.23 Turfing: - it is a cover of grass grown over downstream slope of an embankment to prevent erosion of soil particles by rain-wash and wind action.	**3.23 Turfing**: - It is a cover of grass grown over downstream slope of an embankment to prevent erosion of soil particles by rain-wash and wind action.		
3.24 Zoned Or Zonal Earth Dam: - An earth dam composed of zones of different types of soils.	**3.24 Zoned Or Zonal Earth Dam**: - An earth dam composed of zones of different types of soils.		
4 CLASSIFICATION	**4. CLASSIFICATION**		
Based on materials used in construction, an earth dam can be classified as hereunder: -	Based on materials used in construction, an earth dam can be classified as here under: -		
4.1 Homogeneous Dam: - As defined in para-3.8 above.	**4.1 Homogeneous Dam**: - As defined in para-3.8 above.		
4.2 Zoned Or Zonal Earth Dam: - As defined in para-3.24 above.	**4.2 Zoned Or Zonal Earth Dam**: - As defined in para-3.24 above.		
	4.3 Modified Homogeneous Embankment Dam *: - An embankment dam in which small quantities of pervious material, selected to control the action of seepage, are carefully placed in an otherwise homogeneous dam.*	IS CODE 12169-1987 (REAFFIRMED 2003) Para-2.3.1 **Modified Homogeneous Embankment Dam: -** An embankment dam in which small quantities of pervious material, selected to control the action of seepage, are carefully placed in an otherwise homogeneous dam.	
	4.4 Rockfill Dam *: - An embankment consisting of various sizes of rock to provide stability and an impervious core of membrane to provide water tightness.*	IS CODE 12169-1987 (REAFFIRMED 2003) Para-2.4 **Rockfill Dam: -** An embankment consisting of various sizes of rock to provide stability and an impervious core of membrane to provide water tightness.	
5 FUNCTIONS AND DESIGN REQUIREMENTS OF DIFFERENT COMPONENTS OF THE DAM	**5 FUNCTIONS AND DESIGN REQUIREMENTS OF DIFFERENT COMPONENTS OF THE DAM**		
5.1 Components	**Components**		
Different components of an earth dam may be listed as below:-	Different components of an earth dam may be listed as below:-		
i) Core or hearting	i) Core or hearting		
ii) Casing or shell	ii) Casing or shell		
iii) Internal drainage arrangement	iii) Internal drainage arrangement *and foundations*		
iv) Slope protections	iv) Downstream Inclined Filter/Vertical Filter		
v) Edging	v) Edging (Rock Toe)		
vi) impervious or clay blanket	vi) Toe Drain		
vii) Cut-off (puddle trench)	vii) Out Fall Drain		
viii) Relief wells.	viii) Slope protections		

ix) Downstream drainage arrangements.	ix) Downstream drainage arrangements(Undre-Seepage Control measures)		
	x) Cut-off /Puddle trench.		
	The following components are provided in special cases:		
	i) Relief Wells		
	ii) Impervious or clay blanket		
5.2 Core Or Hearting	**5.1 Core Or Hearting**		
Core is a zone of impervious earth and provides an impermeable barrier within the body of the dam.	*Core is a zone of impervious earth and provides an impermeable barrier within the body of the dam. Impervious soils are generally suitable for the core. IS: 1498-1970+ may be referred to for suitability of soils for the core. Appendix A gives recommendation based on IS: 1498-1970+. However, soils having high compressibility and liquid limit and having organic content may be avoided, if possible, as they are prone to swelling and formation of cracks.*	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.2.1 Core is a zone of impervious earth and provides an impermeable barrier within the body of the dam. Impervious soils are generally suitable for the core. IS: 1498-1970+ may be referred to for suitability of soils for the core. Appendix A gives recommendation based on IS: 1498-1970+. However, soils having high compressibility and liquid limit and having organic content may be avoided, if possible, as they are prone to swelling and formation of cracks.	
5.2.1 Location Of Core	**5.1.1 Location Of Core**		
For small dams core should be centrally located.	For small dams core should be centrally located. *The core may be located either centrally or inclined upstream. The locations will depend mainly on the availability of materials, topography of site, foundation conditions, diversion considerations, etc. The main advantage of a central core is that it provides higher pressure at the contact between the core and the foundation reducing the possibility or leakage and piping. On the other hand, inclined core reduces the pore pressure in the downstream part of the dam and thereby increases its safety. It also permits the construction or downstream casing ahead of the core. The section with an inclined core allows the use of relatively large volume of random material on the downstream side.*	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.2.2 The core may be located either centrally or inclined upstream. The locations will depend mainly on the availability of materials, topography of site, foundation conditions, diversion considerations, etc. The main advantage of a central core is that it provides higher pressure at the contact between the core and the foundation reducing the possibility or leakage and piping. On the other hand, inclined core reduces the pore pressure in the downstream part of the dam and thereby increases its safety. It also permits the construction or downstream casing ahead of the core. The section with an inclined core allows the use of relatively large volume of random material on the downstream side.	
5.2.2 Dimensions Of Core	**5.1.2 Dimensions Of Core**		

Following considerations govern the core thickness:-	Following considerations govern the core thickness:-		
i) Availability of suitable impervious material for core;	i) Availability of suitable impervious material for core;		
ii) Resistance to piping;	ii) Resistance to piping;		
iii) Permissible seepage through dam;	iii) Permissible seepage through dam;		
iv) Availability of other material for casing, filter etc.,	iv) Availability of other material for casing, filter etc.,		
	Minimum width that will permit proper construction.	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.2.3 e) Minimum width that will permit proper construction.	
In general, slopes of central core are to be provided as 1:1 on both upstream and downstream. However, depending upon availability of core material, slopes may be provided steep up to 1/2(H): 1(V) after satisfying the property requirement of core material and recording reasons for the same.	In general, slopes of central core are to be provided as 1:1 on both upstream and downstream. However, depending upon availability of core material, slopes may be provided steep up to 1/2(H): 1(V) after satisfying the property requirement of core material and recording reasons for the same.		
5.2.2.1 Top Width Of Core	**5.1.2.1 Top Width Of Core**		
It should be provided as 3m minimum.	It should be provided as 3 m minimum. **The thickness of the core at any section shall not be less than 30 percent (preferably not lesser than 50 percent) of maximum head of water acting at that section.**	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.2.3 The thickness of the core at any section shall not be less than 30 percent (preferably not lesser than 50 percent) of maximum head of water acting at that section.	
5.2.2.2 Top Level Of Core	**5.1.2.2 Top Level Of Core**		
For small earth dams, the top level of the core be provided at a level equal to MWL+0.5m.	For small earth dams, the top level of the core be provided at a level equal to MWL + 0.5 m.		
5.2.2.3 Suitable Core Material	**5.1.2.3 Suitable Core Material**		

To determine suitability of soil as core material, its testing is necessary. Soil groups generally suitable for core construction are indicated in Annexure-1. Specifically, soils having permeability less than 10^{-5} cm/second, Plasticity Index (P.1.) >15, clay content >30% and liquid limit between 30 to 50% are suitable for core construction. To avoid swelling tendencies the P.1 shall not exceed 30. Soils having P1 less than 10 may have dispersive qualities and should be used with utmost care.	*Impervious soils are generally suitable for core. IS: 1498-1970 may be referred to for suitability of soils for the core* . To determine suitability of soil as core material, its testing is necessary. Soil groups generally suitable for core construction are indicated in Annexure-1. Specifically, soils having permeability less than 10^{-5} cm/second, Plasticity Index (P.I.) >15, clay content >30% and liquid limit between 30 to 50% are suitable for core construction. To avoid swelling tendencies the P.I. shall not exceed 30. Soils having P.I. less than 10 may have dispersive qualities and should be used with utmost care. *However, soils having high compressibility and liquid limit and having organic content may be avoided, if possible, as they are prone to swelling and formation of cracks.*	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.2.1 However, soils having high compressibility and liquid limit and having organic content may be avoided, if possible, as they are prone to swelling and formation of cracks.	
5.3 Casing Or Shell	**5.2 Casing Or Shell**		
On outer side of core, a cover of relatively pervious soil is provided. This protects the core from external damages such as erosion from the rainwater, weathering and also under conditions of sudden draw down and steady seepage. Shell helps core to retain its moisture content and thus prevents cracks in it.	On outer side of core, a cover of relatively pervious soil is provided. This protects the core from external damages such as erosion from the rainwater, weathering and also under conditions of sudden draw down and steady seepage. Shell helps core to retain its moisture content and thus prevents cracks in it.		
5.3.1 Casing Material	**5.2.1 Casing Material**		
The relatively pervious soils are suitable for casing. These are not subject to cracking on direct exposure to atmosphere and are relatively free draining. Soil groups suitable for casing are shown in Annexure-I. Soils with coefficient of permeability greater than 10^{-2}cm/second develop no pore pressure and are free draining. Moorum is a casing soil.	The relatively pervious soils are suitable for casing. These are not subject to cracking on direct exposure to atmosphere and are relatively free draining. Soil groups suitable for casing *based on IS:1489-1970* are shown in Annexure-I. Soils with coefficient of permeability greater than 10^{-2} cm/second develop no pore pressure and are free draining. Moorum is a casing soil.		
5.3.2 Top Width	**5.2.2 Top Width**		

Top width for small earth dam should be kept minimum as 4.5m uniformly throughout the length of the dam. Surface drainage of crest should be provided by sloping the crest in a grade of 1 in 50 to drain towards upstream. The design series technical circular (T.C.) No. 10 " Crest Width of Earth / Rock fill Dams" should be referred for the purpose.	The width of the dam at the crest should be fixed according to the working space required at the top. Top width for small earth dam should be kept minimum at 4.5 m uniformly throughout the length of the dam. Surface drainage of crest should be provided by sloping the crest in a grade of 1 in 50 to drain towards upstream. The design series technical circular (T.C.) No. 10 "Crest Width of Earth / Rock fill Dams" should be referred for the purpose.		
5.3.3 Slope And Section	**5.2.3 Slope And Section**		
The slopes of casing depend upon soil properties. General guidelines for embankment section are recommended in Annexure-II.	The slopes of casing depend upon soil properties. General guidelines for embankment section are recommended in Annexure-II.		
5.3.4 Free Board	**5.2.4 Free Board**		
The objective of free-board is to provide assurance for safety of the am against overtopping due to inflows into the reservoir, wind set up, wave run up, 'nd slides, seismic activities, extreme settlement of the embankment and/or its foundation. For computation of free board, design series technical circular No.22 issued by BODHI may be referred-to. Minimum free board to be adopted is 2m.	The objective of free-board is to provide assurance for safety of the dam against overtopping due to inflows into the reservoir, wind set up, wave run up, 'and slides, seismic activities, extreme settlement of the embankment and/or its foundation. For computation of free board, design series technical circular (T.C.) No .22 issued by BODHI may be referred to. Minimum free board to be adopted is 2 m.		
5.3.5 Shrinkage And Settlement Allowance	**5.2.5 Shrinkage And Settlement Allowance**		
Shrinkage and settlement allowance shall be provided: -	Shrinkage and settlement allowance shall be provided: -		
i) For dams founded on rock: - The allowance shall be provided at a rate of 1% of the height of the dam.	i) For dams founded on rock: - The allowance shall be provided at a rate of 1% of the height of the dam.		
ii) For dams founded on soil or compressible foundation, the allowance shall be considered as 2% of the height of the dam.	ii) For dams founded on soil or compressible foundation, the allowance sha be considered as 2% of the height of the dam.		

The shrinkage allowance is to be computed on above guidelines for various heights i.e. wherever there is a berm or change of slope and also for top bund level of the dam. These points should be raised vertically by the magnitude of shrink age allowance to be provided. The points so obtained shall be joined starting from original base width.	The shrinkage allowance is to be computed on above guidelines for various heights i.e. wherever there is a berm or change of slope and also for top bund level of the dam. These points should be raised vertically by the magnitude of shrinkage allowance to be provided. The points so obtained shall be joined starting on original base width.		
5.4 Internal Drainage Arrangement	**5.3 Internal Drainage Arrangement**		
An internal drainage arrangement helps in safe passage of seeping water. This arrangement as far as, possible shall be provided with locally available sand and gravel. The arrangement comprises as hereunder: -	An internal drainage arrangement helps in safe passage of seeping water. This arrangement as far as, possible shall be provided with locally available sand and gravel. *For the design of the components of the internal drainage system IS:9429-1980 may be referred to* .		
	The design of filter consists applying the conventional filter criteria which take into account only the grain size distribution and the shape of the grains. However, in addition to the grain size, the stability of the base soil adjacent to a given filter depends on its resistance to drag forces.	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.4.2 The design of filter consists applying the conventional filter criteria which take into account only the grain size distribution and the shape of the grains. However, in addition to the grain size, the stability of the base soil adjacent to a given filter depends on its resistance to drag forces.	
	In view of this, when the soil containing 20 percent or more clay is used as a basse soil and has non-dispersive properties, the filter criteria may not be enforced strictly and the clean sand available locally may be used irrespective of the gradation. This relaxation should be applied to dams upto 10 m height only. For dams of height more than 10 m, the criteria for filters protecting cohesive soil may be relaxed by the designer depending upon his judgement and experience. The arrangement comprises as here under :	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.4.2 In view of this, when the soil containing 20 percent or more clay is used as a basse soil and has non-dispersive properties, the filter criteria may not be enforced strictly and the clean sand available locally may be used irrespective of the gradation. This relaxation should be applied to dams upto 10 m height only. For dams of height more than 10 m, the criteria for filters protecting cohesive soil may be relaxed by the designer depending upon his judgement and experience.	
5.4.1 Horizontal Filter	**5.3.1 Horizontal Filter (Base Filter)**		
This filter is provided in the downstream portion of the dam. It collects seepage from chimney filter, body of the dam and also from its foundation and leads seepage, thus collected, to the downstream toe drain.	This filter is provided in the downstream portion of the dam. It collects seepage from chimney filter, body of the dam and also from its foundation and leads seepage, thus collected, to the downstream toe drain.		

5.4.1.1 Thickness	**5.3.1.1 Thickness**		
Horizontal filter of graded pervious material satisfying filter design criteria as described in IS: 9429-1980 - Code of practice for drainage system for earth and rock-fill dams shall be provided. The thickness of sand filter layer shall be kept as 1 m. If suitable gravel is available at dam site in plenty, this may be used in filter. In this case, gravel layer of about 0.3m may be provided sandwiched between two layers of graded sand of 0.3m thickness each over and beneath the gravel layer. The bottom layer of sand may be omitted if the dam foundation is rock. The slope of these layers shall be **1** in 100 towards rock toe.	Horizontal filter of graded pervious material satisfying filter design criteria as described in IS: 9429-1980 - Code of practice for drainage system for earth and rock-fill dams shall be provided. The thickness of sand filter layer shall be kept as 1 m. If suitable gravel is available at dam site in plenty, this may be used in filter. In this case, gravel layer of about 0.3 m may be provided sandwiched between two layers of graded sand of 0.3 m thickness each over and beneath the gravel layer. The bottom layer of sand may be omitted if the dam foundation is rock. The slope of these layers shall be 1 in 100 towards rock toe.		
5.4.1.2 Extent	**5.3.1.2 Extent**		
The horizontal filter may be extended in to the body of the dam up to the downstream edge of the core. In case of a homogenous dam where core is not provided, the filter may be extended up to a point where imaginary hearting line with 1:1 slope touches the stripped ground level.	The horizontal filter may be extended in to the body of the dam up to the downstream edge of the core. In case of a homogenous dam where core is not provided, the filter may be extended up to a point where imaginary hearting line with 1:1 slope touches the stripped ground level.		
5.4.2 Chimney Filter	**5.3.2 Chimney Filter**		
Chimney filter collects seepage from core and allows it to flow to horizontal filter. Chimney/vertical filter being a pervious barrier intercepts all potential transverse cracks through body of the dam and prevents piping. This is useful in case of homogeneous section where the dam is made of dispersive silty and clayey soil. Chimney filter is a costly preposition and requires strict quality control and layout standard during construction. Hence before a provision is made in the dam section its necessity should be utmost established.	Chimney filter collects seepage from core and allows it to flow to horizontal filter. Chimney/vertical filter being a pervious barrier intercepts all potential transverse cracks through body of the dam and prevents piping. This is useful in case of homogeneous section where the dam is made of dispersive silty and clayey soil. Chimney filter is a costly preposition and requires strict quality control and layout standard during construction. Hence before a provision is made in the dam section its necessity should be utmost established.		
5.4.2.1 Location	**5.3.2.1 Location**		

In a zonal section, the chimney filter shall be located flushed with downstream slope of the core and connected with downstream horizontal filter layer. Whereas in case of a homogenous dam, chimney filter should be provided vertically with its down stream edge flushed with downstream edge of the top width of dam and properly connected with downstream horizontal extended filter.	In a zonal section, the chimney filter shall be located flushed with downstream slope of the core and connected with downstream horizontal filter layer. Whereas in case of a homogenous dam, chimney filter should be provided vertically with its downstream edge flushed with downstream edge of the top width of dam and properly connected with downstream horizontal extended filter.		
5.4.2.2 Top Level	**5.3.2.2 Top Level**		
The top level of chimney filter in case of a zonal section shall be kept equal to top core level. For homogeneous section, it should be kept equal to FRL + 0.6m, provided it is covered by at least 1.2m earth cover all around.	The top level of chimney filter in case of a zonal section shall be kept equal to top core level. For homogeneous section, it should be kept equal to FRL + 0.6 m, provided it is covered by at least 1.2 m earth cover all around.		
5.4.2.3 Thickness	**5.3.2.3 Thickness**		
Depending upon availability of filter material, thickness of chimney filter should be kept between 2 to 2.5m looking to intermixing of adjacent zones, compaction consideration, earthquake effects etc. Thickness less than this may not be effective on practical consideration. The filter may be constructed using available sand. However, filter design criteria should be ensured. In case the available sand does not satisfy the filter design criteria, liberal provisions in the width of filter can be made, consulting design organisation.	Depending upon availability of filter material, thickness of chimney filter should be kept between 2 to 2.5m looking to intermixing of adjacent zones, compaction consideration, earthquake effects etc. Thickness less than this may not be effective on practical consideration. The filter may be constructed using available sand. However, filter design criteria should be ensured. In case the available sand does not satisfy the filter design criteria, liberal provisions in the width of filter can be made, consulting design organization.		
5.5 Downstream Inclined Filter	**5.4 Downstream Inclined Filter/Vertical filter**		
This filter is provided flushed with inclined upstream	This filter is provided flushed with inclined	IS CODE 12169-1987 (REAFFIRMED 2003)	

surface of rock-toe. It drains seeping water from the downstream portion of the dam and prevents migration of dam earth through boulder toe. This filter is connected with horizontal base filter. Thickness of each layer of gravel and sand constituting the filter should be kept as 0.3m.	upstream surface of rock-toe. It drains seeping water from the downstream portion of the dam and prevents migration of dam earth through boulder toe. This filter is connected with horizontal base filter. Thickness of each layer of gravel and sand constituting the filter should be kept as 0.3 m. *It is desirable to be provided especially to protect silty core material. However, the inclined or vertical filter may be deleted in zoned sections having pervious downstream shell and clayey cores but a transition filter between the core and the downstream shell would be necessary in case of dams where rockfill is used as shell material. In case of dam reaches, where the head of water is 3 m or less, it may not be necessary to provide blanket or chimney filters. Adequate toe protection shall, however be provided. Wherever there is silty material to be filled in the cut-off and the downstream face of the cut-off is sufficiently open to receive soil particles migrating under high seepage gradients, it is advisable to provide a protective filter layer along the downstream face of the cut-off trench also.*	Para 4.4.3 It is desirable to be provided especially to protect silty core material. However, the inclined or vertical filter may be deleted in zoned sections having pervious downstream shell and clayey cores but a transition filter between the core and the downstream shell would be necessary in case of dams where rockfill is used as shell material. In case of dam reaches, where the head of water is 3 m or less, it may not be necessary to provide blanket or chimney filters. Adequate toe protection shall, however be provided. Wherever there is silty material to be filled in the cut-off and the downstream face of the cut-off is sufficiently open to receive soil particles migrating under high seepage gradients, it is advisable to provide a protective filter layer along the downstream face of the cut-off trench also.	
5.6 Rock-toe	**5.5 Rock-toe*/Boulder Toe***		
It is a zone of free draining material consisting of cobble size material provided at the downstream toe of an earth dam. The principal function of a rock-toe is to facilitate drainage of water and protect the lower part of the downstream slope from tail water erosion. It also reduces the possibility of sloughing due to saturation of downstream toe area, in case, where dam seat soil strata are of impervious nature.	It is a zone of free draining material consisting of cobble size material provided at the downstream toe of an earth dam. The principal function of a rock-toe is to facilitate drainage of water and protect the lower part of the downstream slope from tail water erosion. It also reduces the possibility of sloughing due to saturation of downstream toe area, in case, where dam seat soil strata are of impervious nature.		
5.6.1 Height	**5.5.1 Height**		

The height of. the rock-toe or boulder-toe depends upon availability of material, head of water, downstream tail water level and provision of other drainage features of seepage control. For small dams, it is recommended upto 20% of the head of water with maximum and minimum limit of 4m and 1m respectively. The inner slope of rock-toe which flushes with the downstream inclined filter shall be kept as 1:1. The rock toe need not be provided beyond the ground level exceeding the FRL.	The height of the rock-toe or boulder-toe depends upon availability of material, head of water, downstream tail water level and provision of other drainage features of seepage control. For small dams, it is recommended up to 20% of the head of water with maximum and minimum limit of 4m and 1m respectively. The inner slope of rock-toe which flushes with the downstream inclined filter shall be kept as 1:1. The rock toe need not be provided beyond the ground level exceeding the FRL.		
	5.5.2 Location	AS PER OLD TECHNICAL CIRCULAR NO 40/W(M)63 RAIPUR, DATED 18th MAY 1963 Page 63	
	(A) For Dams below 3 meter height (10') :- no special drainage		
	(B) For Dams 3 meter to 10 meter height (10' to 30') :- In the nalla portion there will be boulder toe and extended filter. In flanks there will be leakage drains only and no boulder toe.		
	(c) For Dams 10 meter to 15 meter height (30' to 50') :- In the nalla portion there will be boulder toe and extended filter. In flanks there will be d/s boulder toe and leakage drains but no extended filter below the casing. If the cost of boulder toe is high and leads are uneconomical, the boulder toe could be omitted. In homogeneous sections, boulder toe and filter should be provided in the entire length of dam except where the height is less than 3 meter (10')		
	(d) The boulder toe will be separated from embankment and base by the filter.		
5.7 Toe-drain	**5.6 Toe-drain**		
It collects water seeping through body of the dam and leads it to natural drainage system. Longitudinal and cross drains beyond the toe drains are some times provided when out-fall conditions are poor. Toe drain is usually provided as a part of rock-toe i.e. hidden below rock-toe.	It collects water seeping through body of the dam and leads it to natural drainage system. Longitudinal and cross drains beyond the toe drains are sometimes provided when out-fall conditions are poor. Toe drain is usually provided as a part of rock-toe i.e. hidden below rock-toe.		
5.7.1 Section	**5.6.1 Section**		

The section of the toe drain should be able to carry total anticipated seepage from the dam and its foundation. The minimum depth of toe drain shall be kept as 0.6m and increased gradually towards nallah portion.	The section of the toe drain should be able to carry total anticipated seepage from the dam and its foundation. The minimum depth of toe drain shall be kept as 0.6m and increased gradually towards nallah portion.		
The bottom width of the drain shall be kept as 1 m with side slopes as 1:1. The drain is filled up with filter material and the filter should satisfy filter design criteria.	The bottom width of the drain shall be kept as 1 m with side slopes as 1:1. The drain is filled up with filter material and the filter should satisfy filter design criteria.		
5.8 Out Fall Drain	**5.7 Out Fall Drain**		
Out fall drain shall also be provided away from dam toe depending upon the general ground levels to safely drain the seepage water collected in the toe drain through cross drains at regular interval. In addition, the out fall drain also acts as *rain* water drainage to the downstream area near the toe of the dam.	Out fall drain shall also be provided away from dam toe depending upon the general ground levels to safely drain the seepage water collected in the toe drain through cross drains at regular interval. In addition, the out fall drain also acts as *rain* water drainage to the downstream area near the toe of the dam.		
5.9 Slope Protection	**5.8 Slope Protection**		
5.9.1 Upstream Slope Protection	**5.8.1 Upstream Slope Protection**		
For small dams, upstream slope shall be protected by providing 22crn dry stone hand placed rip-rap (pitching) using picked up boulders, over 15cm. picked up spalls. In case picked up boulders and/or spalls are not available at or near dam site, quarried stones and/or spalls be used for hand placed riprap.	*The upstream slope protection is ensured by providing riprap. For design of the riprap IS : 8237-1985 may be referred. A minimum of 300 mm thick riprap over 150 mm thick filter layer may be provided.*	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.5.1 The upstream slope protection is ensured by providing riprap. For design of the riprap IS : 8237-1985 may be referred. A minimum of 300 mm thick riprap over 150 mm thick filter layer may be provided.	
5.9.1.1 Extent	**5.8.1.1 Extent**		
The protection shall be provided from an elevation (MDDL — 0,6m) to TBL. However, at sites where there is a possibility of flows parallel to the embankment below the MDDL (or lowest water level), and exigencies below **MDDL,** riprap may be extended further below the MDDL as required.	The protection shall be provided from an elevation (MDDL — 0.6 m) to TBL. However, at sites where there is a possibility of flows parallel to the embankment below the MDDL (or lowest water level), and exigencies below MDDL, riprap may be extended further below the MDDL as required.		
i) The riprap shall, as far as possible, be terminated at lower end in a berm provided in the embankment.	i) The riprap shall, as far as possible, be terminated at lower end in a berm provided in the embankment.		
ii) Where berm is not provided due to any specific reason, the riprap shall be terminated duly keyed to a toe support (toe wall).	ii) Where berm is not provided due to any specific reason, the riprap shall be terminated duly keyed to a toe support (toe wall).		
For details, design series T.C.No.8 (First Revision) issued by BODHI shall be referred to.	For details, design series T.C.No.8 (First Revision) issued by BODHI shall be referred to.		

5.9.2 Downstream Slope Protections	**5.8.2 Downstream Slope Protections**		
To protect downstream slope, turf shall be provided on its entire length. The slope shall also be properly drained. For details of drainage arrangement, design series T.C.No.9 issued by BODHI should be referred-to.	To protect downstream slope, turf shall be provided on its entire length. The slope shall also be properly drained. For details of downstream slope protection IS 8237-1985 may be referred.		
	5.8.3 Surface Drainage		
	For surface drainage of the downstream slope of the dam, design series T.C. no. 9 issued by BODHI and I.S.8237-1985 may be referred.		
5.10 Under- Seepage Control Measures	**5.9 Downstream drainage arrangements (Under-Seepage Control Measures)**		
Suitable under-seepage control measures for a small earth darn, depending upon site condition, geology, importance of dam and economic value of water stored in the dam may be determined on the basis of design series T.C. No.27 issued by BODHI.	Suitable under-seepage control measures for a small earth darn, depending upon site condition, geology, importance of dam and economic value of water stored in the dam may be determined on the basis of design series T.C. No.27 issued by BODHI.		
	5.10 Cut off/Puddle:		
	5.10.1 *To reduce loss of stored water through foundations and abutments, and to prevent subsurface erosion by piping.*	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.1.1 To reduce loss of stored water through foundations and abutments, and to prevent subsurface erosion by piping.	
	5.10.2 *The type of cut-off should be decided on the basis of detailed geological investigation. It is desirable to provide a positive cut-off. Where this is not possible, partial cut-off with or without upstream impervious blanket may be provided on the downstream which may, inter-alia. Include relief well. cut-off may be in the form of trench, sheet or other impervious materials.*	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.1.2 The type of cut-off should be decided on the basis of detailed geological investigation. It is desirable to provide a positive cut-off. Where this is not possible, partial cut-off with or without upstream impervious blanket may be provided on the downstream which may, inter-alia. Include relief well. cut-off may be in the form of trench, sheet or other impervious materials.	
	5.10.3 *Recommendations for location and size of cut-off are given in 5.10.1 to 5.10.3.5. A drainage cut-off is the most common form of cut-off .*	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.1.3 Recommendations for location and size of cut-off are given in 5.10.1 to 5.10.3.5. A drainage cut-off is the most common form of cut-off .	

	5.10.3.1 *The alignment of the cut-off should be fixed in such a way that its central line should be within the base of the impervious core.*	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.1.3.1 The alignment of the cut-off should be fixed in such a way that its central line should be within the base of the impervious core.	
	5.10.3.2 *In case of positive cut-off, it should be keyed at least to a depth of 0.4 m into continuous impervious sub-stream or in erodible rock formation.*	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.1.3.2 In case of positive cut-off, it should be keyed at least to a depth of 0.4 m into continuous impervious sub-stream or in erodible rock formation.	
	5.10.3.3 *The partial cut-off is specially suited for horizontally stratified foundation with relatively more previous layer near top. The depth of the partial cut-off in deep previous alluvium will be governed by:*	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.1.3.3 The partial cut-off is specially suited for horizontally stratified foundation with relatively more previous layer near top. The depth of the partial cut-off in deep previous alluvium will be governed by:	
	a) Permeability of substrata.		
	b) Relative economics of depth of excavation governed usually by cost of dewatering versus length of upstream impervious blanket.		
	5.10.3.4 *The bottom width of the cut-off trench may be fixed taking following factors into consideration:*	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.1.3.4 The bottom width of the cut-off trench may be fixed taking following factors into consideration:	
	a) Provide sufficient working space for compaction equipments,		
	b) Provide sufficient working space to carry-out curtain grouting.		
	c) Provide safety against piping.		

	A minimum width of 4.0 m is recommended. A bottom width of 10 to 30 percent of hydraulic head may be provided to satisfy requirement of piping. This may be suitably increased to satisfy other requirements of mechanical equipments and curtain grouting. The side slope depend upon sub-strata. Side slopes of at least 1:1 or flatter may be provided in case of overburden, while 1:1 and 1:1 may be provided in soft rock and hard rock respectively. The back fill material for satisfy trench shall have same properties as those specified for imperious core in 5.1		
	5.10.3.5 *The cut-off in the flanks on either side should normally extend up to the top of impervious core.*	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.1.3.5 The cut-off in the flanks on either side should normally extend up to the top of impervious core.	
	5.11 Relief wells		
	Vertical wells or bore holes,downstream of or in down stream shoulder of an earth dam, to collect and control seepage through or under the dam so as to reduce water pressure. If relief wells are provided, they should meet the requirements of IS: 5050-1968.	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.8	
	5.12 Impervious Blanket		
	5.12.1 *The horizontal upstream impervious blanket is provided to increase the path of seapage when full cut-off is not practicable on pervious foundations. The impervious blanket may be provided either with or without partial cut-off. Impervious blanket shall be connected to core of the dam as shown in Fig. 2B.*	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.7.1 The horizontal upstream impervious blanket is provided to increase the path of seapage when full cut-off is not practicable on pervious foundations. The impervious blanket may be provided either with or without partial cut-off. Impervious blanket shall be connected to core of the dam as shown in Fig. 2B.	

	5.12.2 *The material to be used for impervious blanket shall have the properties according to IS:1498-1970. Appendix A gives recommendations based on IS:1498-1970. A 300 mm thick layer of random material over the blanket is recommended to prevent cracking due to exposure to impervious blanket.*	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.7.2 The material to be used for impervious blanket shall have the properties according to IS:1498-1970. Appendix A gives recommendations based on IS:1498-1970. A 300 mm thick layer of random material over the blanket is recommended to prevent cracking due to exposure to atmosphere	
	5.12.3 *The impervious blanket may be designed in accordance with IS:8414-1977. As a general guideline, impervious blanket with a minimum thickness of 1.0 m and a minimum length of 5 times the maximum water head measured from upstream toe of the core may be provided.*	IS CODE 12169-1987 (REAFFIRMED 2003) Para 4.7.3 The impervious blanket may be designed in accordance with IS:8414-1977. As a general guideline, impervious blanket with a minimum thickness of 1.0 m and a minimum length of 5 times the maximum water head measured from upstream toe of the core may be provided.	
6 BASIC AND SPECIAL DESIGN REQUIREMENT	**6 BASIC AND SPECIAL DESIGN REQUIREMENT**		
6.1 The basic and special design requirements for the design of embankment dams are to ensure -	**6.1** The basic and special design requirements for the design of embankment dams are to ensure —		
a) Safety against over-topping;	a) Safety against over-topping;		
b) Stability of slopes;	b) Stability of slopes;		
c) Safety against internal erosion; and	c) Safety against internal erosion; and		
d) Control of cracking.	d) Control of cracking.		
6.1.1 Over-topping	**6.1.1 Over-topping**		
Sufficient spillway capacity and free board should be provided to prevent over-topping of embankment during and after construction. For this, proper hydrological studies may be carried out. The free board should be sufficient to prevent over-topping by waves and should take into account the settlement of embankment and its foundation. Freeboard shall be provided as per T.C. No.22 - Freeboard requirement in embankment dams issued by BODHI.	Sufficient spillway capacity and free board should be provided to prevent over-topping of embankment during and after construction. For this, proper hydrological studies may be carried out. The free board should be sufficient to prevent over-topping by waves and should take into account the settlement of embankment and its foundation. Freeboard shall be provided as per T.C. No.22 -Freeboard requirement in embankment dams issued by BODHI. *Free board for wave run up on slope shall be provided in accordance with IS 10635-1983.*		
6.1.2 Stability Analysis	**6.1.2 Stability Analysis**		
6.1.2.1 Necessity	**6.1.2.1 Necessity**		

Stability analysis may not be necessary for small dam's upto 10m. height provided a good foundation is available at dam site. Stable slopes can be decided on the basis of experience.	*The slopes of the embankment shall be stable under all loading conditions. They should also be flat enough so as not to impose excessive stresses on foundation.*	IS 12169-1987 (REAFFIRMED 2003) Para 5.1.2.1 The slopes of the embankment shall be stable under all loading conditions. They should also be flat enough so as not to impose excessive stresses on foundation.	
For small dams up to 10m-height, section may be decided as per general guidelines for the section and the recommended slopes as given in Annexure-11.2 Embankment where height is above 10m and up to 15m, stability analysis may be carried out in accordance with the IS: 7894-1975 — Code of practice for stability analysis of earth dams.	Stability analysis may not be necessary for small dams up to 10 m height provided a good foundation is available at dam site. Stable slopes can be decided on the basis of experience. *However, where weak foundation conditions viz. fissured clay, expensive soils, shales, over consolidated highly plastic clays, soft clays dispersive soils, etc, are met within the substratum in the dam-seat, extensive investigations of the foundation soil and borrow area soil are required to be carried out and the design of the embankment dam carried out in accordance with IS : 7894-1975*	IS 12169-1987 (REAFFIRMED 2003) Para 5.1.2.2 However, where weak foundation conditions viz. fissured clay, expensive soils, shales, over consolidated highly plastic clays, soft clays dispersive soils, etc, are met within the substratum in the dam-seat, extensive investigations of the foundation soil and borrow area soil are required to be carried out and the design of the embankment dam carried out in accordance with IS : 7894-1975	
	For small dams up to 10m-height, section may be decided as per general guidelines for the section and the recommended slopes as given in Annexure-2. Embankment where height is above 10 m and up to 15m, stability analysis may be carried out in accordance with the IS: 7894-1975 — Code of practice for stability analysis of earth dams.		
6.1.3 Cracking	**6.1.3 Cracking**		
Cracking of impervious zone may be one of the root causes of failure of embankment dam; leading to erosion, piping, breaching etc. Cracks are mostly due to differential settlement in embankment earthwork on account of abrupt changes in foundation grade .The other causes of crack could be poor quality control during construction, use of faulty construction materials and earthquakes etc.	Cracking of impervious zone may be one of the root causes of failure of embankment dam; leading to erosion, piping, breaching etc. Cracks are mostly due to differential settlement in embankment earthwork on account of abrupt changes in foundation grade .The other causes of crack could be poor quality control during construction, use of faulty construction materials and earthquakes etc.		
6.1.3.1 Preventive Measures	**6.1.3.1 Preventive Measures**		
The following measures if adopted during construction, will help to check the occurrence of cracks in embankment:	The following measures if adopted during construction, will help to check the occurrence of cracks in embankment:		

i) For the hearting or core, soils having values of P.I.>15 should be used. Soil should be compacted at OMC or slightly more than OMC.	i) For the hearting or core, soils having values of P.I. (Plasticity Index) >15 should be used. Soil should be compacted at OMC or slightly more than OMC. *In case of less plastic clay, 2 to 5 percent bentonite of 200 to 300 liquid limit may be mixed to increase the plasticity.*	IS 12169-1987 (REAFFIRMED 2003) Para 6.1.1 a) In case of less plastic clay, 2 to 5 percent bentonite of 200 to 300 liquid limit may be mixed to increase the plasticity.	
ii) Well graded filter should be provided in the downstream side of the core (chimney filter) so that even if cracking occurs, harmful effects will be prevented;	ii) Well graded filter should be provided in the downstream side of the core (chimney filter) so that even if cracking occurs, harmful effects will be prevented;		
iii) Low density deposits in foundation may be removed, if it is economically viable or other alternative site/design be followed	iii) Low density deposits in foundation may be removed, if it is economically viable or other alternative site/design be followed		
iv) Any vertical steps or ledge rock in the abutment should be 'avoided. Steep slope of abutment should be dressed to about 1(H): 2(V).	iv) Any vertical steps or ledge rock in the abutment should be 'avoided. Steep slope of abutment should be dressed to about 1(H): 2(V).		
v) The size of hearting core should be increased to reduce the possibility of transverse or horizontal cracks extending through it.	v) The size of hearting core should be increased to reduce the possibility of transverse or horizontal cracks extending through it.		
	vi) Careful selection of fill materials to reduce the differential movement. To restrict the rockfill in lightly loaded outer casings and to use well graded materials in the inner casings on either side of the core.	IS CODE 12169-1987 (REAFFIRMED 2003) Para 6.1.1 c) Careful selection of fill materials to reduce the differential movement. To restrict the rockfill in lightly loaded outer casings and to use well graded materials in the inner casings on either side of the core.	
	vii) Wide transition zones of properly graded filters of adequate width for handling drainage, if cracks develop.	IS CODE 12169-1987 (REAFFIRMED 2003) Para 6.1.1 d) Wide transition zones of properly graded filters of adequate width for handling drainage, if cracks develop.	
	viii) Special treatment. such as preloading, pre saturation, removal of weak material, etc, to the foundation and abutment if warranted.	IS CODE 12169-1987 (REAFFIRMED 2003) Para 6.1.1 e) Special treatment. such as preloading, pre saturation, removal of weak material, etc, to the foundation and abutment if warranted.	
	ix) Delaying placement of core material in the crack region till most of the settlement takes place.	IS CODE 12169-1987 (REAFFIRMED 2003) Para 6.1.1 f) Delaying placement of core material in the crack region till most of the settlement takes place.	

	x) Arching the dam horizontally between steep abutments.	IS CODE 12169-1987 (REAFFIRMED 2003) Para 6.1.1 g) Arching the dam horizontally between steep abutments.	
	xi) Flattening the downstream slopes to increase slope stability in the event of saturation from crack leakage.	IS CODE 12169-1987 (REAFFIRMED 2003) Para 6.1.1 h) Flattening the downstream slopes to increase slope stability in the event of saturation from crack leakage.	
	xii) Cutting back the steep abutment slopes.	IS CODE 12169-1987 (REAFFIRMED 2003) Para 6.1.1 j) Cutting back the steep abutment slopes.	
6.1.4 Stability At Junctions	**6.1.4 Stability At Junctions**		
Junctions of embankment dam with foundation abutments, masonry structure like over-flow and non-overflow dams and outlets need special attention with reference to following criteria:	Junctions of embankment dam with foundation abutments, masonry structure like over-flow and non-overflow dams and outlets need special attention with reference to following criteria:		
a) Good bond between embankment dam and foundation;	a) Good bond between embankment dam and foundation;		
b) Adequate creep length at junction.	b) Adequate creep length at junction.		
c) Protection of embankment dam slope against scouring action; and	c) Protection of embankment dam slope against scouring action; and		
d) Easy movement of traffic.	d) Easy movement of traffic.		
6 .1.4.1 Junction With Foundation	**6 .1.4.1 Junction With Foundation**		

Embankment dam may be founded on soil over burden or rock. For foundation on soils or non-rocky strata, vegetation like bushes, grass roots, trees etc., should be completely removed. After removal of these materials, the foundation surface should be moistened to the required extent and adequately rolled before placing embankment material. For rocky foundation surface should be cleaned off all loose fragments including semi-detached and over hanging surface blocks of rocks. Proper bond should be established between the embankment and the rock surface of the foundation. For achieving this, a 10cm thick layer of cohesive soil in muddy form be pasted on the clean rocky foundation and rolled. This treatment after drying leaves a base for earthwork. Due to rolling, the mud also fills up the cracks and joints of foundation up to some extent.	Embankment dam may be founded on soil over burden or rock. For foundation on soils or non-rocky strata, vegetation like bushes, grass roots, trees etc., should be completely removed. After removal of these materials, the foundation surface should be moistened to the required extent and adequately rolled before placing embankment material. For rocky foundation surface should be cleaned off all loose fragments including semi-detached and over hanging surface blocks of rocks. Proper bond should be established between the embankment and the rock surface of the foundation. For achieving this, a 10cm thick layer of cohesive soil in muddy form be pasted on the clean rocky foundation and rolled. This treatment after drying leaves a base for earthwork. Due to rolling, the mud also fills up the cracks and joints of foundation up to some extent.		
6.1.4.2 Junction With Abutment	**6.1.4.2 Junction With Abutment**		
In order to get good contact between the impervious core of the embankment and the rock overhanging, the rocky abutment should be suitably shaped and prepared. Vertical surface should be excavated to form slopes, not steeper than 0.25(H) to 1(V). A wider impervious zone and thicker transition should be provided, at the abutment contact to increase the length of path of seepage and to protect against erosion. In addition to para 6.1.4.1, sufficient creep length should be provided between impervious section of the dam and the abutment so as to provide safety against piping_ The creep length should be not less than four times the hydraulic head.	In order to get good contact between the impervious core of the embankment and the rock overhanging, the rocky abutment should be suitably shaped and prepared. Vertical surface should be excavated to form slopes, not steeper than 0.25(H) to 1(V). A wider impervious zone and thicker transition should be provided, at the abutment contact to increase the length of path of seepage and to protect against erosion. In addition to para 6.1.4.1, sufficient creep length should be provided between impervious section of the dam and the abutment so as to provide safety against piping. The creep length should be not less than four times the hydraulic head.		
6.1.4.3 Junction With Non-Overflow Dam	**6.1.4.3 Junction with Non-Overflow Dam**		

Junction of non-overflow masonry or concrete dam with embankment dam is provided by a batter not steeper than 1(H) to 2(V) to the end face of the non-overflow section block coming in contact with the impervious core. A wider impervious zone, a thicker transition shall be provided at the abutment contacts to increase the length of path of seepage and to protect against erosion. Sometimes, the junction of earth dam with non-overflow dam is provided with earth retaining walls perpendicular or skew at the junction of non-overflow dam.	Junction of non-overflow masonry or concrete dam with embankment dam is provided by a better not steeper than 1(H) to 2(V) to the end face of the non-overflow section block coming in contact with the impervious core. A wider impervious zone, a thicker transition shall be provided at the abutment contacts to increase the length of path of seepage and to protect against erosion. Sometimes, the junction of earth dam with non-overflow dam is provided with earth retaining walls perpendicular or skew at the junction of non-overflow dam.		
7.0 This circular supersedes T.C.No.401W (M) 63 dated 18-5-63 — Type profile of earth dams.	***7.0*** *This circular supersedes T.C.No.42/BODHI/R&C/TC date 17.01.2001.*		
List of Indian Standards	**List of Indian Standards**		
IS 12169-1987 : Design of small embankment dams	IS 12169-1987 : Design of small embankment dams		
IS 8826-1976 :Guide lines for design of large earth and rock fill dams.	IS 8826-1976 :Guide lines for design of large earth and rock fill dams.		
IS 7894-1975 :Code of practice for stability analysis of earth dams.	IS 7894-1975 :Code of practice for stability analysis of earth dams.		
IS 8237-1985 :Code of practice for protection of slope for reservoir embankment	IS 8237-1985 :Code of practice for protection of slope for reservoir embankment		
IS 8414-1977 :Guidelines for design of under seepage control measures for earth and rockfill dams.	IS 8414-1977 :Guidelines for design of under seepage control measures for earth and rockfill dams.		
IS 9429-1980 : Code of practice for drainage system for earth and rockfill dams.	IS 9429-1980 : Code of practice for drainage system for earth and rockfill dams.		
1S 10635-1993 : Free board requirement in embankment dams-guidelines.	1S 10635-1993 : Free board requirement in embankment dams-guidelines.		
IS 1498-1970 : Classification and identification of soils for general engineering purposes.	IS 1498-1970 : Classification and identification of soils for general engineering purposes.		

ANNEXURE 1

SUITABILITY OF SOILS FOR CONSTRUCTION OF EARTH DAMS

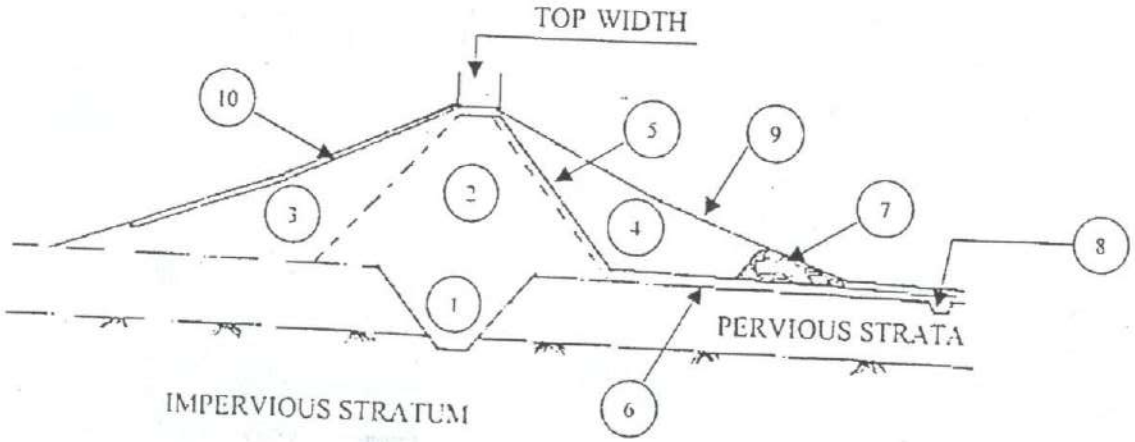
S.NO.	RELATIVE SUITABILITY	HOMOGENOUS DYKES	ZONED EARTH DAMS		IMPERVIUOS BLANKET
			IMPERVIOUS CORE	CASING	
1	VERY SUITABLE	GC	GC	SW,GW	GC
2	SUITABLE	CL,CI	CL,CI	GM	CL,CH
3	FAIRLY SUITABLE	SP,SM,CH	GM,GC,SM,SC,CH	SP,GP	CH,SM,SC,GC
4	POOR		ML,MI,MH		
5	NOT SUITABLE		OL,OI,OH,Pt		

ANNEXURE-2

TABLE 1 GENERAL GUIDELINES FOR EMBANKMENT SECTIONS

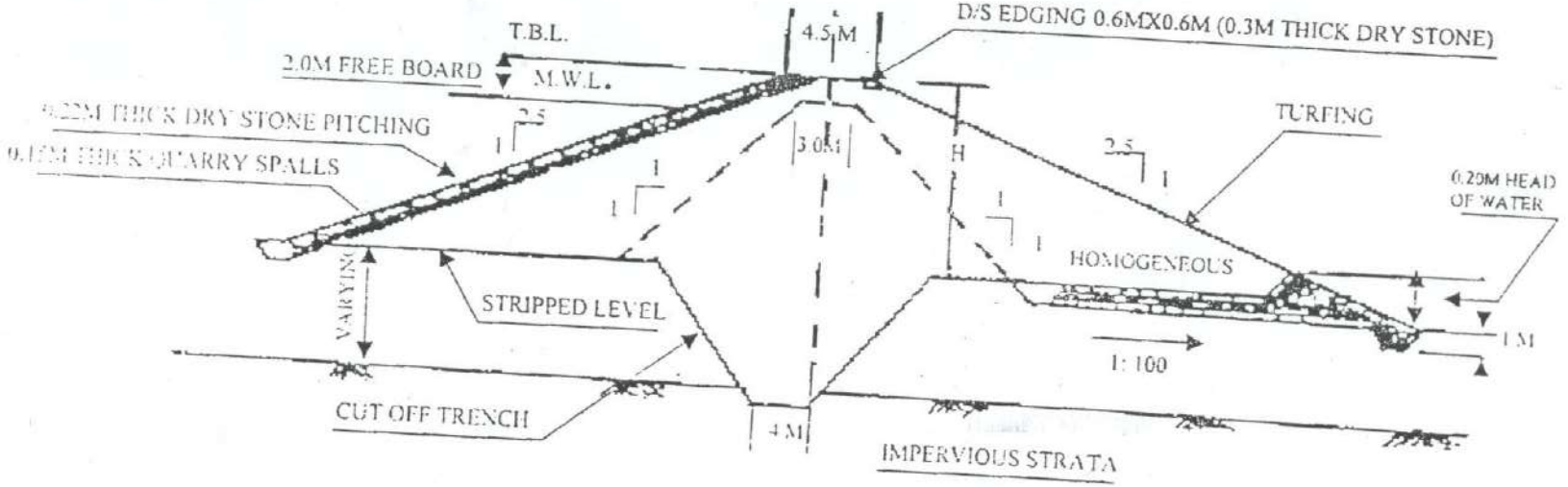
(*Clause* 5.1.2.3)

Sl No.	Description	Height Up to 5 m		Height Above 5 m and Up to 10 m		Height Above 10 m and Up to 15 m	
i)	Type of section	Homogeneous section/Modified homogeneous section		Zoned section/Modified homogeneous section/Homogeneous section		Zoned section/Modified homogeneous section/Homogeneous section	
ii)	*Slopes*	*Upstream*	*Downstream*	*Upstream*	*Downstream*	*Upstream*	*Downstream*
	a) Coarse grained soil (GW, GP, SW, SP)	Not suitable		Not suitable		Not suitable for core Suitable for casing zone	
	b) Coarse grained soil (GC, GM, SC, SM)	(H) (V) 2 : 1	(H) (V) 2 : 1	(H) (V) 2 : 1	(H) (V) 2 : 1	Section to be decided based upon the stability analysis in accordance with IS : 7894-1975	
	c) Fine grained soil (CL, ML, CI, MI)	(H) (V) 2 : 1	(H) (V) 2 : 1	(H) (V) 2·5 : 1	(H) (V) 2·25 : 1	do	
	d) Fine grained soil (CH, MH)	(H) (V) 2 : 1	(H) (V) 2 : 1	(H) (V) 3·75 : 1	(H) (V) 2·5 : 1	do	
iii)	Hearting zone	Not required	–	May be provided		Necessary	
	a) Top width		–	3 m		3 m	
	b) Top level		–	0·5 m above MWL		0·5 m above MWL	
iv)	Rock toe height	Not necessary up to 3 m. Above 3 m height, 1 m height of rock toe may be provided		Necessary $H/5$, where H is the height of embankment		Necessary $H/5$, where H is the height of embankment	
v)	Berms	Not necessary		Not necessary		The berm may be provided as per design. The minimum berm width shall be 3 m. The berm may be provided also on the downstream slope for facilities during maintenance.	

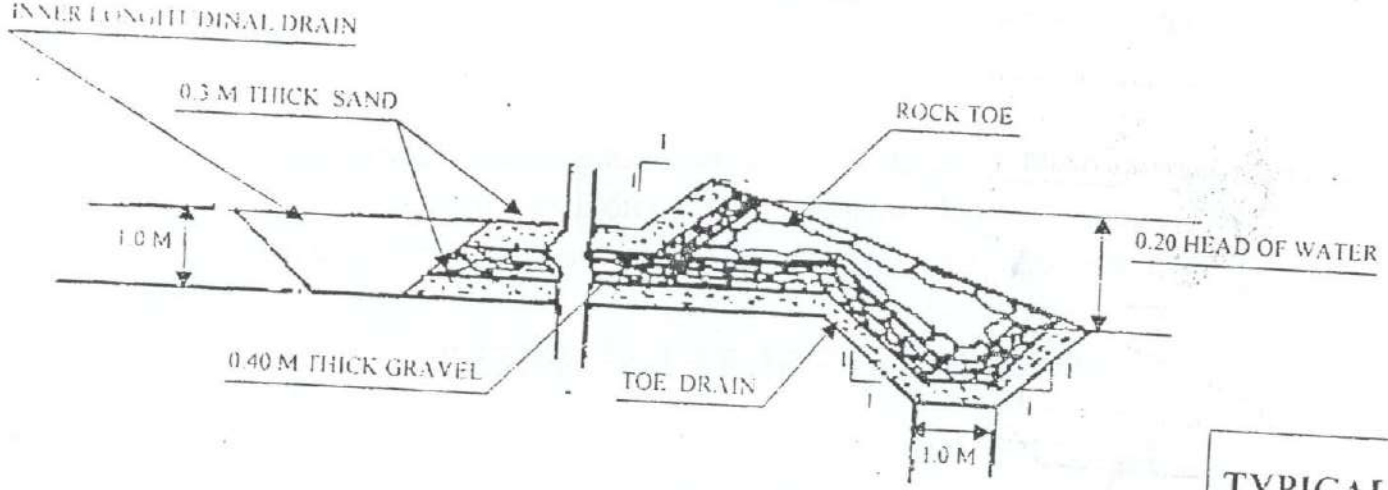


(1) CUT - OFF OR PUDDLE TRENCH (2) IMPERVIOUS CORE (3) UPSTREAM CASING
(4) DOWNSTREAM CASING (5) INCLINED FILTER (6) HORIZONTAL FILTER
(7) ROCK TOE (BOULDER TOE) (8) TOE DRAIN (9) TURFING (10) UP STREAM SLOPE PROTECTION

COMPONENTS OF EMBANKMENT



SECTION

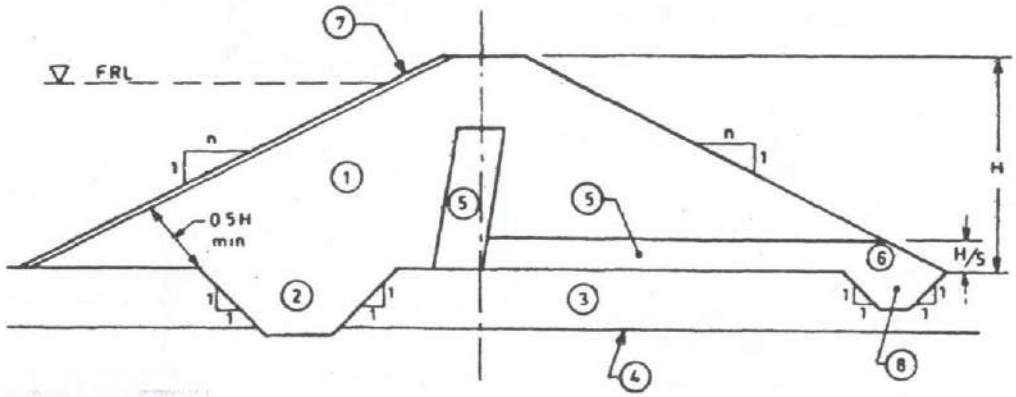


ENLARGED SECTION OF ROCK TOE

NOT TO SCALE

TYPICAL DRAWING FOR SMALL DAM

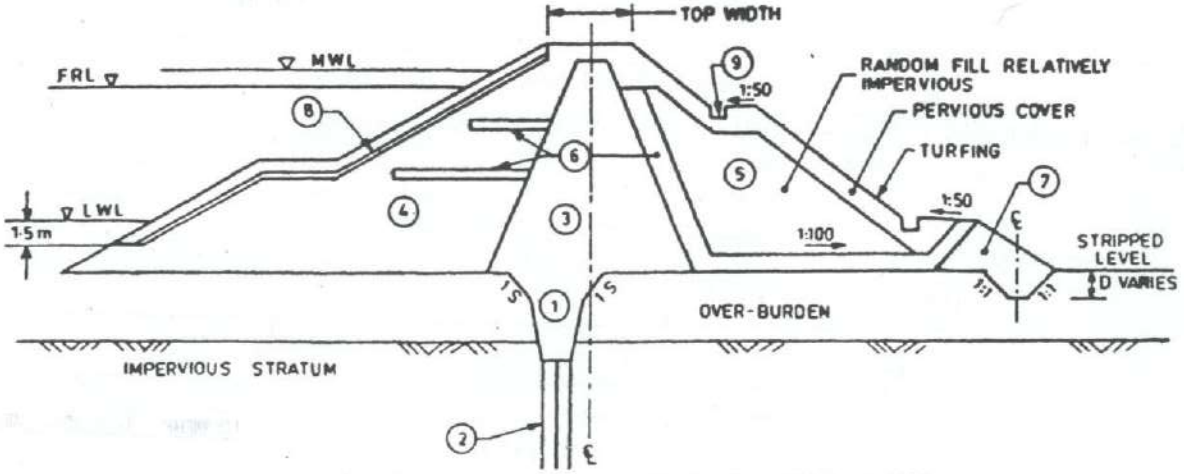
GCPB—2191—CE(Bodhi)—30-1-2001—1000.



1. Selected Earth Fill
2. Impervious Fill
3. Foundation
4. Imperirous Sub-Stratum
5. Sand Filter
6. Rock Toe
7. Rubble Pitching
8. Tee Drain

FIG. 1 CROSS-SECTION OF MODIFIED HOMOGENEOUS EARTH DAM

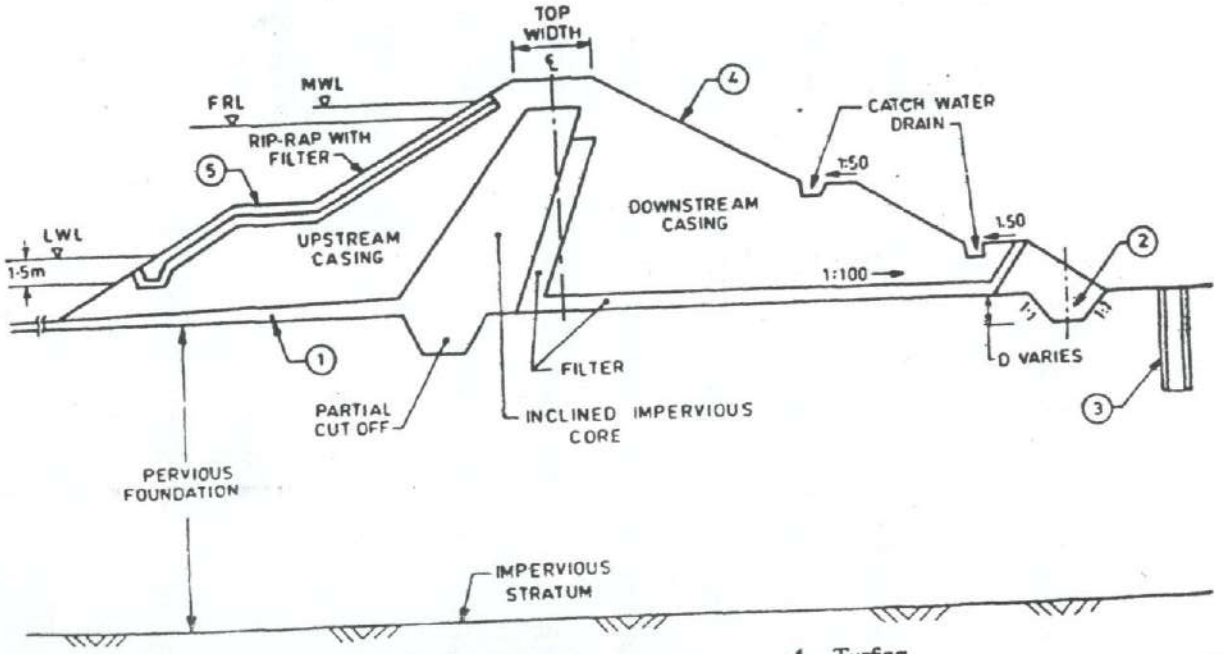
IS : 10149 - 1982



1. Positive Cut-off
2. Grout Curtain
3. Central Impervious Core
4. Upstream Casing
5. Downstream Casing
6. Inclined and Horizontal Filter
7. Rock Toe and Toe Drain
8. Riprap with Filter
9. Catch Water Drain

NOTE — Horizontal filter at intermediate levels are sometimes placed in the upstream casing zone where casing material is of Impervious nature.

2A Embankment Dam with Central Core and Positive Cut-Off



1. Impervious Blanket
2. Rock Toe and Toe Drain
3. Relief Well
4. Turfing
5. Berm

2B Embankment Dam with Inclined Core and Partial Cut-Off

FIG. 2 COMPONENTS OF EMBANKMENT DAM

IS : 1529 - 1964