

# STANDARDS/MANUALS/ GUIDELINES FOR SMALL HYDRO DEVELOPMENT

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**2.4**

**Civil Works –**

**Maintenance of Civil Works (Including Hydro-Mechanical)**

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Sponsor:

Ministry of New and Renewable Energy  
Govt. of India

Lead Organization:

Alternate Hydro Energy Center  
Indian Institute of Technology Roorkee

December 2012

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*AHEC-IITR, "24 Civil Works– Maintenance of Civil Works (Including Hydro-mechanical)", standard/manual/guideline with support from Ministry of New and Renewable Energy, Roorkee, December 2012.*

## **PREAMBLE**

There are series of standards, guidelines and manuals on electrical, electromechanical aspects of moving machines and hydro power from Bureau of Indian Standards (BIS), Rural Electrification Corporation Ltd (REC), Central Electricity Authority (CEA), Central Board of Irrigation & Power (CBIP), International Electromechanical Commission (IEC), International Electrical and Electronics Engineers (IEEE), American Society of Mechanical Engineers (ASME) and others. Most of these have been developed keeping in view the large water resources/ hydropower projects. Use of the standards/guidelines/manuals is voluntary at the moment. Small scale hydropower projects are to be developed in a cost effective manner with quality and reliability. Therefore a need to develop and make available the standards and guidelines specifically developed for small scale projects was felt.

Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee initiated an exercise of developing series of standards/guidelines/manuals specifically for small scale hydropower projects with the sponsorship of Ministry of New and Renewable Energy, Government of India in 2006. The available relevant standards / guidelines / manuals were revisited to adapt suitably for small scale hydro projects. These have been prepared by the experts in respective fields. Wide consultations were held with all stake holders covering government agencies, government and private developers, equipment manufacturers, consultants, financial institutions, regulators and others through web, mail and meetings. After taking into consideration the comments received and discussions held with the lead experts, the series of standards/guidelines/manuals are prepared and presented in this publication.

The experts have drawn some text and figures from existing standards, manuals, publications and reports. Attempts have been made to give suitable reference and credit. However, the possibility of some omission due to oversight cannot be ruled out. These can be incorporated in our subsequent editions.

This series of standards / manuals / guidelines are the first edition. We request users to send their views / comments on the contents and utilization to enable us to review for further upgradation.

## Standards/ Manuals/Guidelines series for Small Hydropower Development

<b>General</b>	
1.1	Small hydropower definitions and glossary of terms, list and scope of different Indian and international standards/guidelines/manuals
1.2 Part I	Planning of the projects on existing dams, Barrages, Weirs
1.2 Part II	Planning of the Projects on Canal falls and Lock Structures.
1.2 Part III	Planning of the Run-of-River Projects
1.3	Project hydrology and installed capacity
1.4	Reports preparation: reconnaissance, pre-feasibility, feasibility, detailed project report, as built report
1.5	Project cost estimation
1.6	Economic & Financial Analysis and Tariff Determination
1.7	Model Contract for Execution and Supplies of Civil and E&M Works
1.8	Project Management of Small Hydroelectric Projects
1.9	Environment Impact Assessment
1.10	Performance evaluation of Small Hydro Power plants
1.11	Renovation, modernization and uprating
1.12	Site Investigations
<b>Civil works</b>	
2.1	Layouts of SHP projects
2.2	Hydraulic design
2.3	Structural design
2.4	Maintenance of civil works (including hydro-mechanical)
2.5	Technical specifications for Hydro Mechanical Works
<b>Electro Mechanical works</b>	
3.1	Selection of Turbine and Governing System
3.2	Selection of Generators and Excitation Systems
3.3	Design of Switchyard and Selection of Equipment, Main SLD and Layout
3.4	Monitoring, control, protection and automation
3.5	Design of Auxiliary Systems and Selection of Equipments
3.6	Technical Specifications for Procurement of Generating Equipment
3.7	Technical Specifications for Procurement of Auxiliaries
3.8	Technical Specifications for Procurement and Installation of Switchyard Equipment
3.9	Technical Specifications for monitoring, control and protection
3.10	Power Evacuation and Inter connection with Grid
3.11	operation and maintenance of power plant
3.12	Erection Testing and Commissioning

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# **MAINTENANCE OF CIVIL WORKS (INCLUDING HYDRO-MECHANICAL)**

## **1.0 SCOPE OF WORK**

The scope of this publication is to provide details on maintenance of civil works including hydro-mechanical components of a SHP plant for efficient and trouble free operation.

## **2.0 REFERENCES**

R1	IS 4839 (Part-I): 1992	Maintenance of canal – Code of practice: Part 1 Unlined Canal (Reaffirmed 2008)
R2	IS 4839 (Part-II): 1992	Maintenance of canal– Code of practice: Part 2 Lined Canal (Reaffirmed 2008)
R3	IS 7349: 1989	Guidelines for Operation & Maintenance of barrages & weirs (Reaffirmed 2005)
R4	IS:15183 (Part-I): 2002	Guidelines for Maintenance Management of Buildings – Part 1: General
R5	IS:15183 (Part-II): 2002	Guidelines for maintenance management of buildings – Part 2: Finance
R6	IS:15183 (Part-III): 2002	Guidelines for maintenance management of buildings – Part 3: Labour (Reaffirmed – 2007)
R7	ESHA, 2004	Guide on How to Develop a Small Hydropower Plant, European Small Hydropower Association
R8	Ruppall GS and Singh Paveljeet, 2008	Manual for Maintenance for Hydro-mechanical Works of Water Conductor Systems, Penstocks, Gates, Trash Racks and Trash Rack Cleaning Machines, P&R Infra projects Limited, Chandigarh
R9	INHA, 2005	Hand Book on Operation and Maintenance of Hydropower Stations, Indian National Hydropower Association, Faridabad

## **3.0 INTRODUCTION**

Regular maintenance is essential for safe and efficient running of an installation. Though maintenance can be reduced to some extent by good designs, but it can never be eliminated. Maintenance in relation to safety must take precedence over economic considerations. There should be a permanent maintenance arrangement for relatively small number of regular maintenance jobs. The work of maintenance gang consists of inspection, testing, minor repairs, a few minor new works and improvements. The gang may be of the owner or can be outsourced. Large repair works should be let out on contract, though in remote areas there may be no contractor available to undertake such works. In such case the maintenance squad must be increased in size and preferably sub-divided into small squads capable of working independently or together in accordance of the need.

Some broad guidelines for the maintenance of various works of SHP projects are as follows:

- (i) A register of all as built /construction drawings should be maintained and available to the maintenance team. It should accompany with the main design

- assumptions and regulation procedures for various works which should be prepared in consultation with the designers.
- (ii) A schedule of inspection of the various works should be prepared and strictly adhered to. Necessary amendments, as and when needed, should be incorporated in the same.
  - (iii) Sufficient quantities of materials required for maintenance should be kept in the store. The quantities of various items may be worked out on the basis of experience and recommendation of supplier.
  - (iv) A log book for each important work and equipment should be maintained. It should indicate date of inspection, maintenance requirements noticed, corresponding orders to the maintenance staff and note regarding compliance.
  - (v) In case of hydro-mechanical works, maintenance manuals prepared by the manufacturer(s) should be kept handy and they should be adhered to. Adequate spare parts, oils and lubricants etc. as advised by the manufacturer(s), should be maintained in the store.

## **4.0 MAINTENANCE OF CIVIL WORKS**

### **4.1 Diversion Structure**

Diversion structure should be inspected daily during monsoon (rainy) months by some responsible person of the maintenance gang and any damage, if noticed, should be immediately reported to the engineer-in-charge. In any case the diversion structure should be inspected by the engineer-in-charge just before monsoon, after the monsoon and also after any heavy flood at other times and damages as and when noticed should be repaired expeditiously.

#### **4.1.1 Partial weir**

This is usually a temporary structure made of mud and stones, which diverts water towards intake. This type of structure does not extend all the way across the stream as shown in Fig. 1. The structure helps stream flow to head up near the intake so that a portion of the stream discharge gets diverted towards the power channel. This being a temporary structure works only during lean flows and may get washed away during the floods and requires replacement after the floods. Being an extremely fragile structure, it requires regular maintenance in the form of replenishing stones/wire crates (Gabions) which may get dislodged/washed away. This type of dam can be strengthened with the help of cages made of bamboos or wooden ballies with the vertical bamboos/ballies of the cages adequately driven into the river bed.

#### **4.1.2 Gabions weir**

Gabion weir comprises steel wire crates, geofabric gabions, cages made of bamboos / wooden ballies all filled with suitable size stones and placed across the stream to head up the stream flow so that it could be diverted into the intake. This type of structure is a semi permanent structure which may get washed away fully or partially during floods and need regular maintenance even during lean season. A typical section of Gabion weir is shown in Fig. 2.

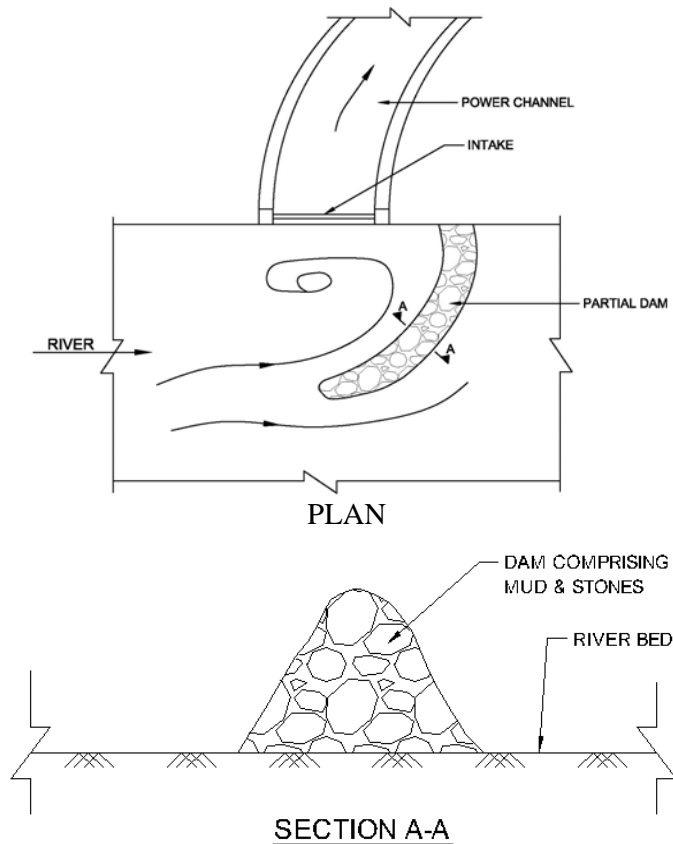
One of the common damages that occur in gabion structure consists in the opening of the gabion net. The latter can be torn away by continuous thrust of materials like gravel, rubble etc. carried by the run off against the gabion fabric. Some times the gabion baskets open, in case they have not been properly closed. For repairing, the gabions need to be



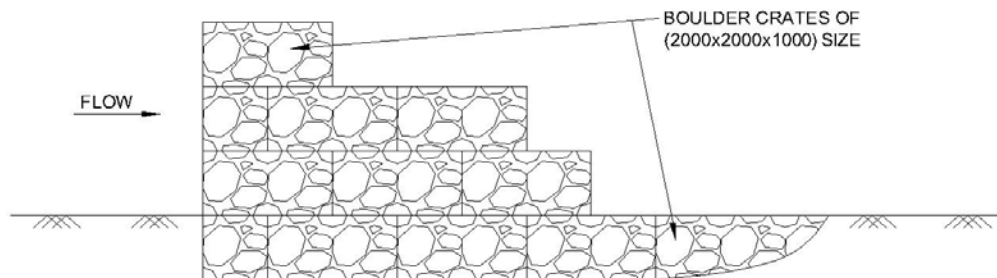
opened completely, inside material emptied, properly refilled and thereafter closed using appropriate tools.

### 4.1.3 Trench weir (Tyrolean)

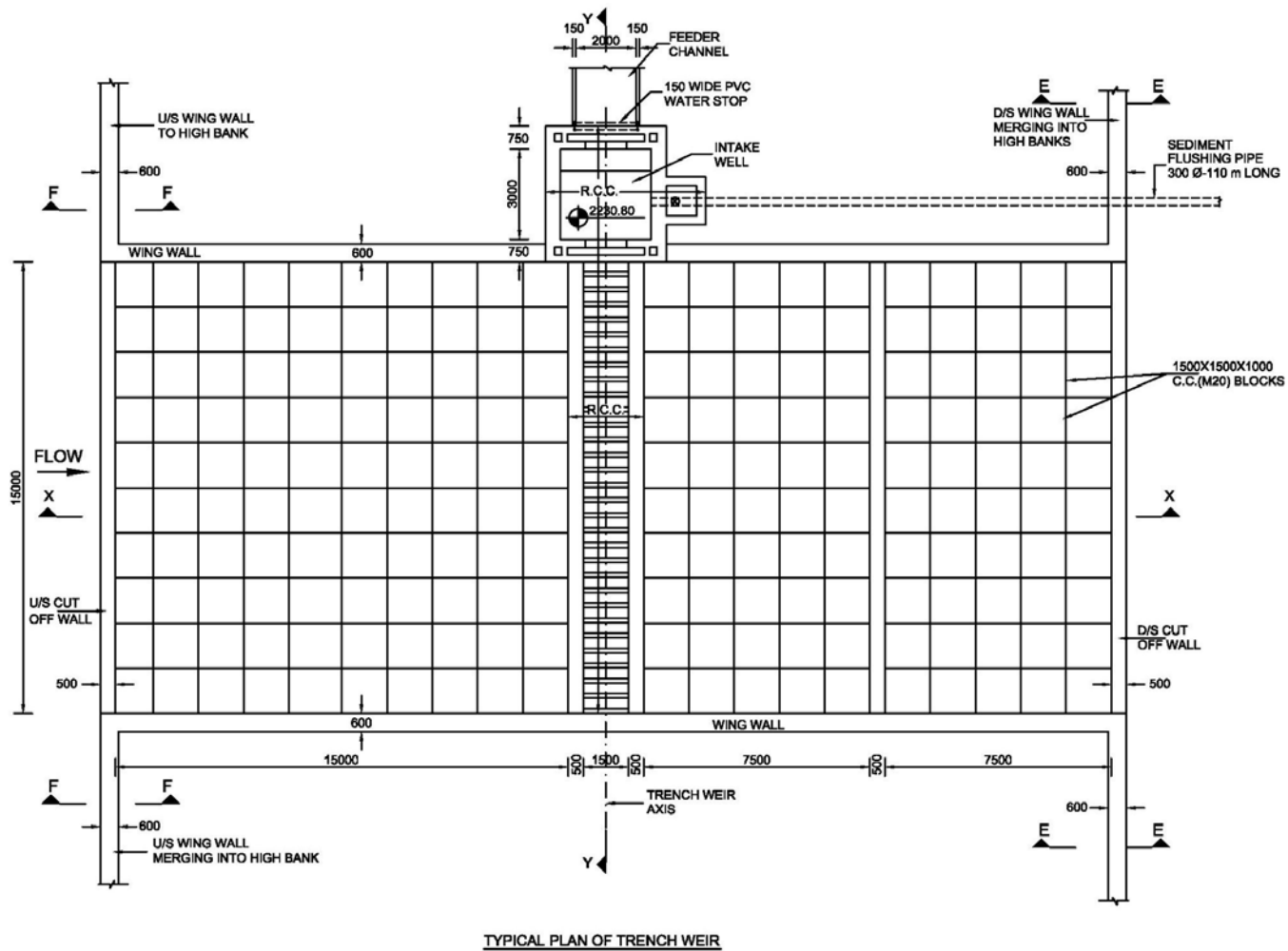
Trench weir (also known as Tyrolean) comprises a RCC trough with steel trashracks at its top constructed across the stream. The top of the trench is kept at the natural river bed level. The trench is protected from the flowing stream by upstream and downstream protection works with upstream and downstream toe walls extended deep enough into the river bed to resist scour. The water collected in the trench gets into an intake chamber, from where the top layers of the water are passed into the intake channel / head race channel / head race tunnel (HRT) and the bottom layers of silt laden water are passed back into the river by a suitable size pipe/open channel. Typical layout of a trench weir is shown in Fig. 3(a) and 3(b).



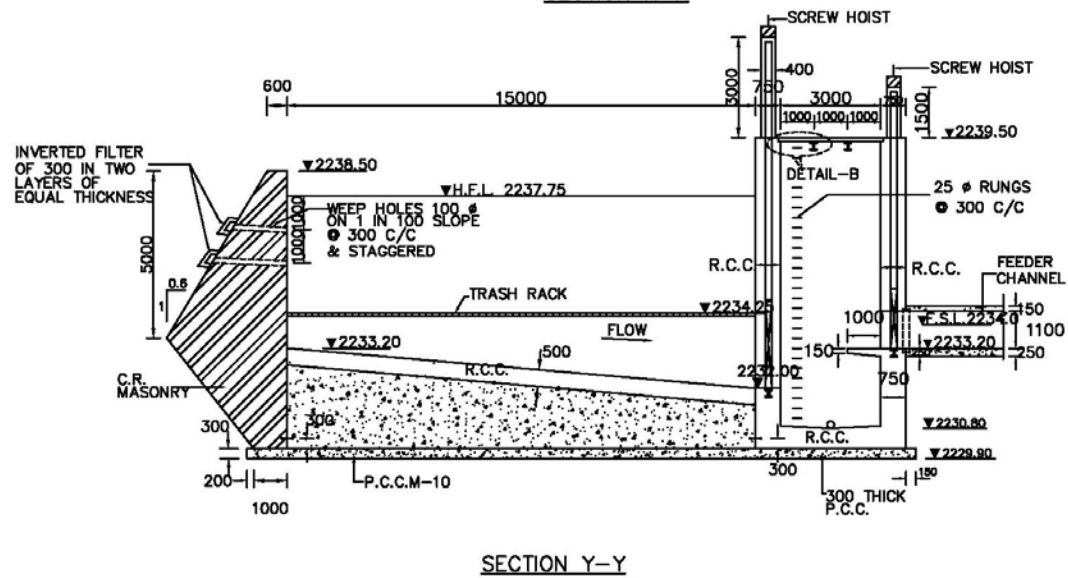
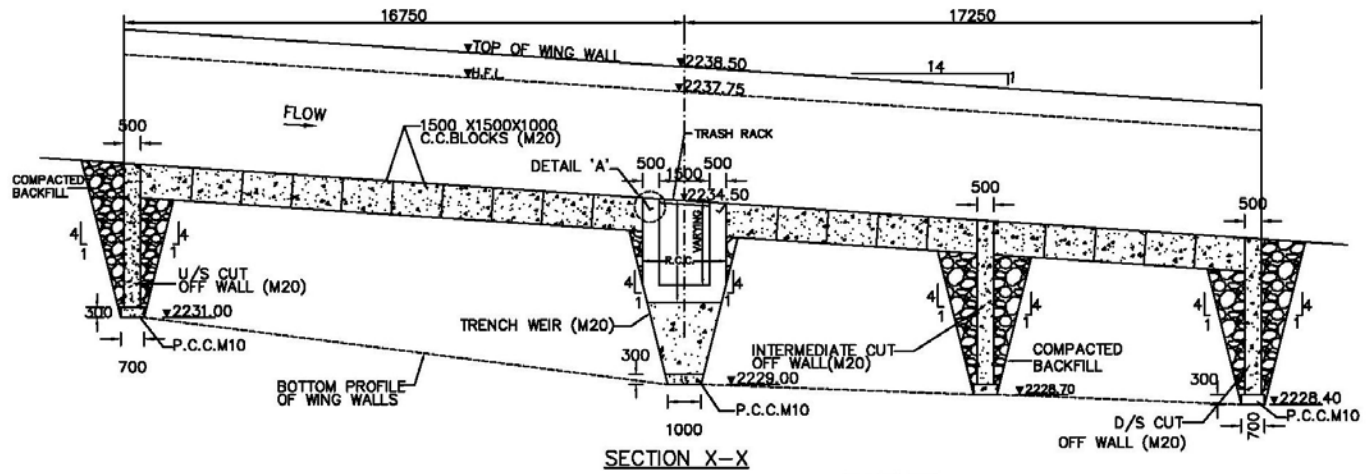
**Fig. 1: Typical Plan of a Partial Dam**



**Fig. 2 : Typical Section of a Gabion Weir**



**Fig. 3 (a) : Typical Details of Trench Weir (Plan)**



**Fig. 3 (b) : Typical Details of Trench Weir (Sections)**

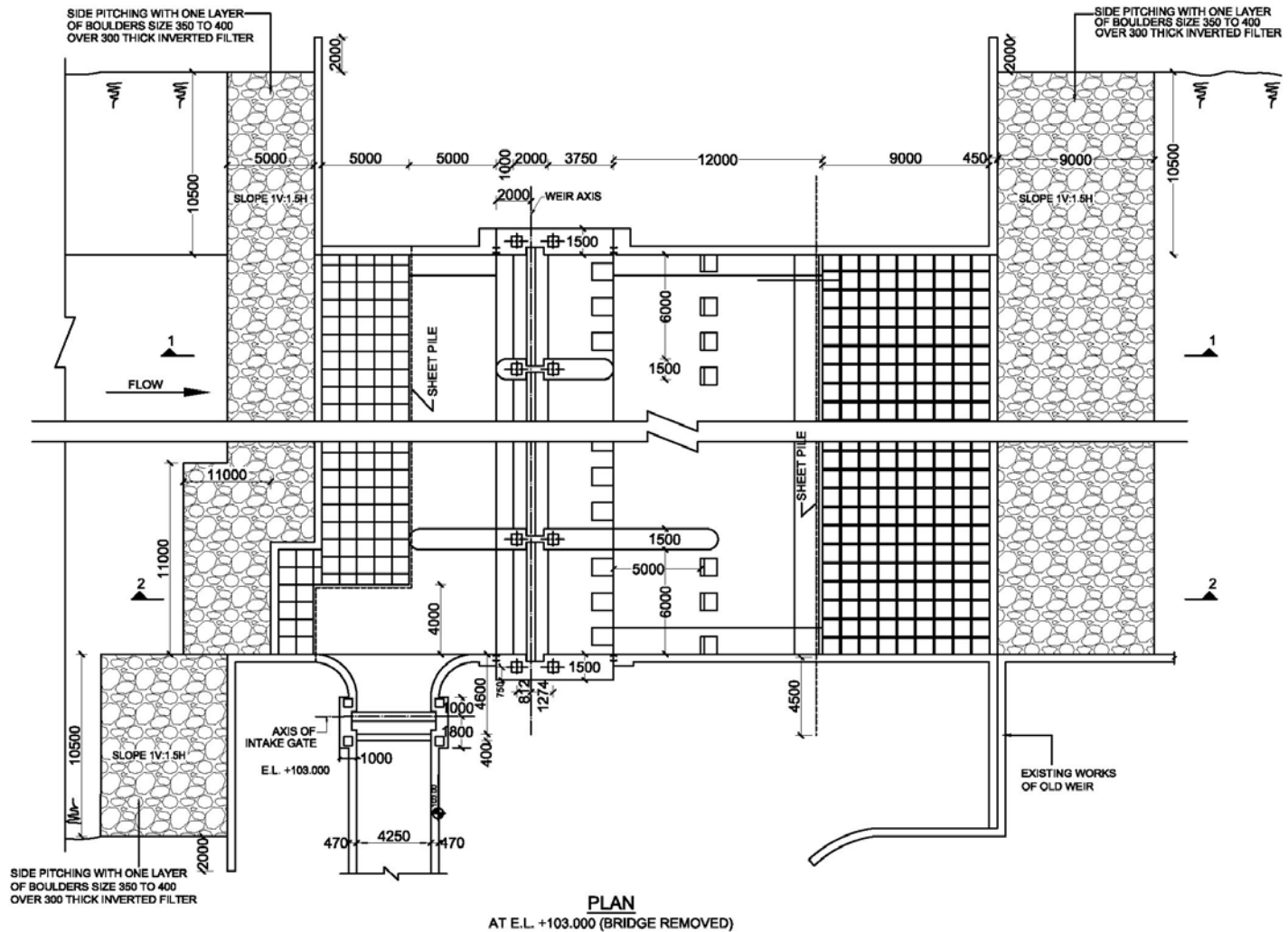
The most common maintenance requirements of a trench weir are as below –

- (i) Erosion of river bed just at the downstream of the downstream protection works generally takes place during heavy stream flows. As such after every excessive flow, soundings of the river bed should be taken and any erosion, if detected, should be backfilled with suitable size boulders.
- (ii) The top of the concrete blocks used for upstream and downstream protection works get eroded due to rolling of the boulders/pebbles/cobbles etc. The protection works, therefore, need to be repaired with high grade concrete not less than M-25. Some times old rails with their heads projecting above the concrete are embedded at the top of upstream and downstream protections. These rails placed parallel to the direction of flow and spaced at 150 to 250 mm centre to centre depending upon the size of the rails are very effective in checking erosion.
- (iii) The trashracks installed at the top of the trench weir have to withstand a lot a wear and tear due to movement of boulders over them. As such the trashracks and the supporting steel sections require heavy repairs after monsoons. The repairs may require replacement of broken steel pieces, rewelding of damaged welds and putting extra metal at worn out locations.
- (iv) Sometimes the trench across the stream and the intake chambers gets filled up with silt when the stream carry heavy amount of silt. In such situation, the silt needs to be removed manually. In order to clean the trench portion, a part of the trashrack is sometimes provided with hinges at its upstream side so that it could be opened. Alternatively a portion of trashracks is kept removable. After removal of the silt, the damages in concrete surface/ trashrack, if any, should be repaired.
- (v) The silt flushing pipe/ channel provided at the bottom of the intake chamber normally gets choked. In order to ensure efficient working of the trench weir, it is very necessary that this pipe/ channel is always kept clean. From proper maintenance point of view, following precautions should be taken right at the construction stage-
  - (a) The pipe/channel should have a regular downward slope.
  - (b) At the outlet end, the bottom of the pipe / channel should be kept at least 0.5 m above the expected high flood level so as to eliminate possibility of backwater entering into the pipe/channel.
  - (c) In case of pipe, it should, as far as possible, be straight and should be assembled with flanged end pipe pieces so that, if need arises, individual pipe segments could be easily dismantled and cleaned.
- (vi) The maintenance of gates at the downstream end of the trench and the upstream end of the intake channel requires oiling and greasing of the gate lifting mechanism, repairing & replacement of gate seals, steel parts of the gates & painting of steel parts. All these maintenance operations should be carried out just before the monsoon and the smooth closing and opening of the gates should be ensured by actually operating them. Maintenance of gates should be carried out as per IS:7349.
- (vii) In the areas experiencing the fragile ice and snow, the fragile ice and snow blocks the trench and hence intake flow is stopped or reduced. Enough care be taken during design for not allowing any freezing or accumulation of snow outside the trench.

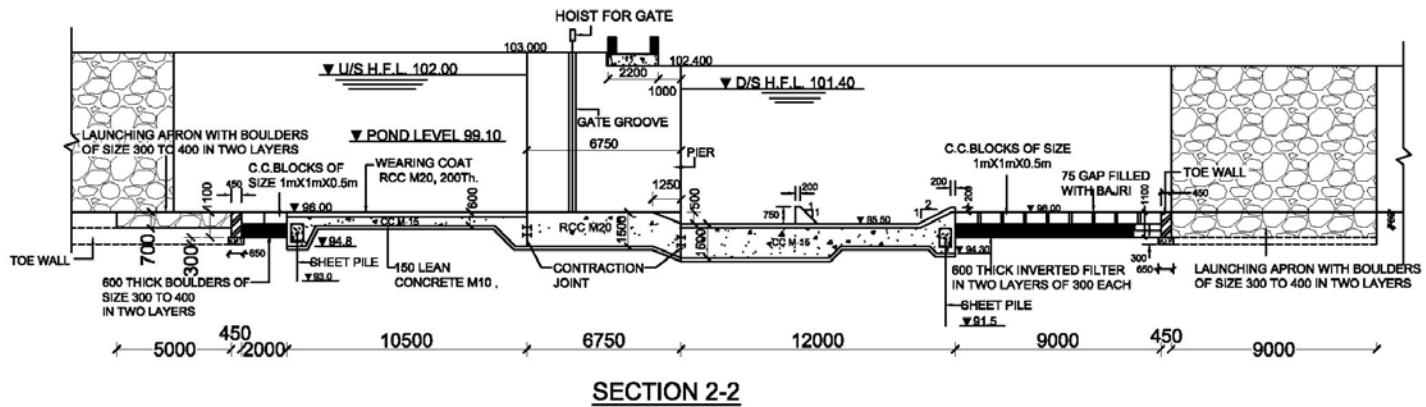
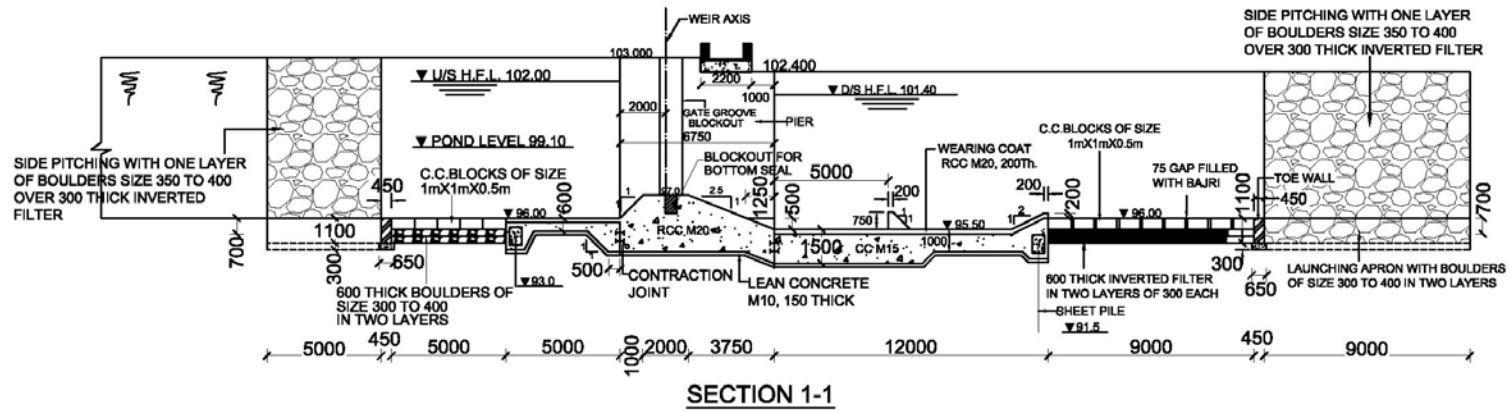
#### 4.1.4 Raised Weir

Raised weir may comprise a fully gated structure across the stream or a masonry/ concrete weir combined with a gated structure to act as under-sluice towards the intake. Typical plan and sections of the above two types of structures are shown in Fig. 4(a), 4(b), 5(a) and 5(b). Inspection of barrages and weirs is necessary just after monsoon by means of underwater lamps and sounding rods. In addition, detailed inspection in stages should be carried out after drying the upstream floor and aprons by isolating the portion to be inspected once in every five years. The repairs as found necessary as a result of inspection should be carried out well before the on-set of the next monsoon.

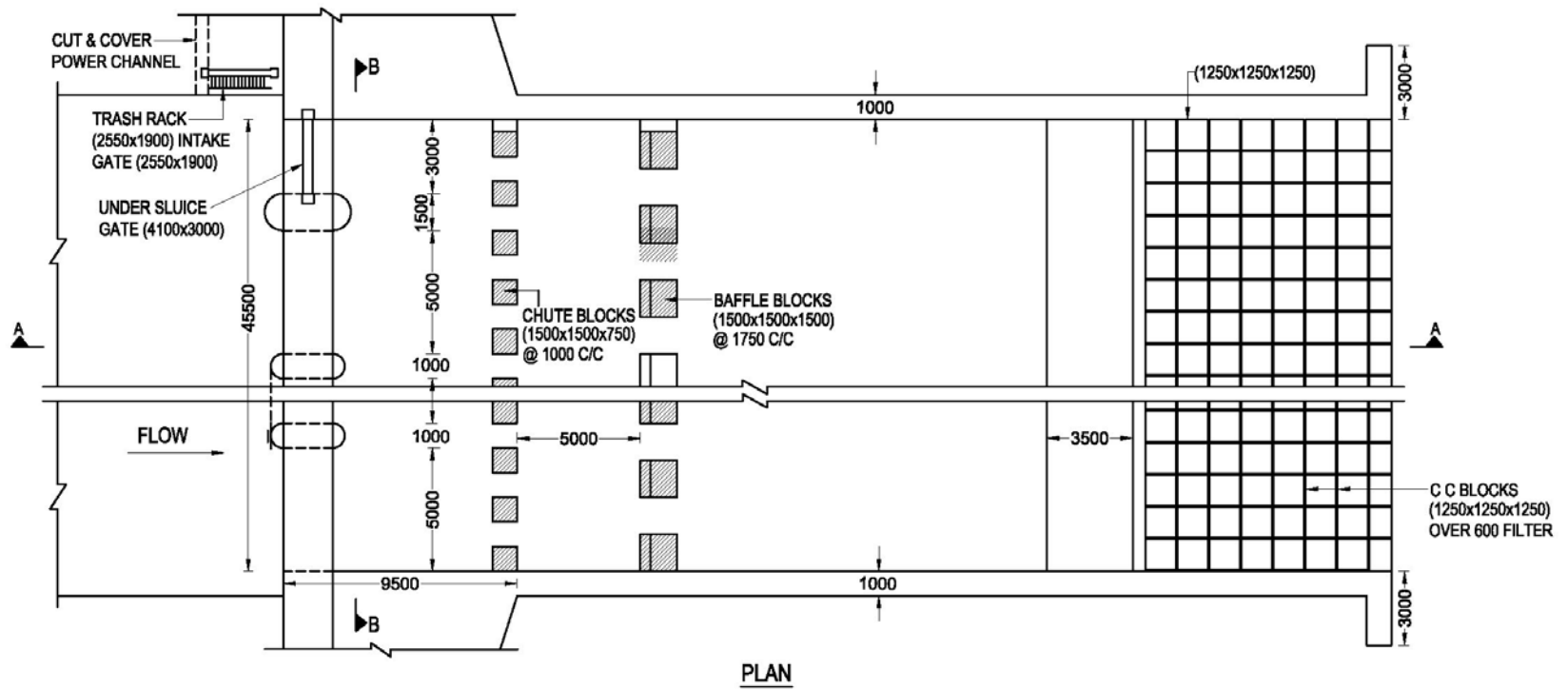
- (a) **Maintenance of aprons** – The soundings of the area should be taken every year after monsoon in order to assess scour & launching of aprons and remedial measures, if necessary taken. Downstream apron needs particular attention.
- (b) **Impervious floors** – A thorough inspection of upstream and downstream floors should be done after monsoon. Careful inspection of the joints of the stone sets is very important for structure located in boulder reaches of the river. While minor repairs can be done under water, major repairs should be carried out by isolating the area.
- (c) **Retrogression** – Retrogression of river bed can be expected on the downstream of the structure. As such soundings of this area should be taken just after monsoon and scour holes as and where detected should be filled with suitable size stones.
- (d) **Hydro-mechanical works-** The maintenance of gates and hoists shall comprise the following and shall be carried out as per IS: 7349.
  - (i) Removal of all debris, driftwood, moss and silt from the gates.
  - (ii) Adjustment needed to keep the gates and counter balance boxes level & plumb.
  - (iii) Painting of all surfaces of the gates except machined surfaces & surfaces of stainless steel, brass or bronze.
  - (iv) Machined surfaces and surfaces of stainless steel, brass & bronze should be protected by a coating of gasoline- soluble rust preventive non-corrosive compound.
  - (v) Checking of gate seals against wear and tear and deterioration. Then adjustment and replacement of the disoriented and damaged ones.
  - (vi) Cleaning of wire ropes to remove all dust and lubricating them with suitable grease at least once in a year for portions above water and thrice a year for portions inside the water. For inspection of wire rope clamps, the clamping devices should be declamped and reclamped at least once in three years.
  - (vii) The roller trains need to be examined at least once in a year and they should be cleaned and greased or replaced, if required. Sliding /fixed rollers should be extracted, cleaned & greased properly. Worn out pins should be replaced.
  - (viii) All winches & lifting drums need to be inspected once in a year and thereafter cleaned & lubricated. All grease fed bearings need to be cleaned, old grease removed and fresh grease applied. The shafts need to be checked for their correct alignment and their coupling bolts tightened.
  - (ix) Super structure for the hoists should be painted at least once in two years. The wooden planking, where provided in the decking, should be checked, damaged portions replaced and all loose nuts and bolts tightened. The wooden planking need to be applied with two coats of creosote oil at least once in two years.



**Fig. 4(a) : Typical Details of a Raised Weir on Erodible Foundation**

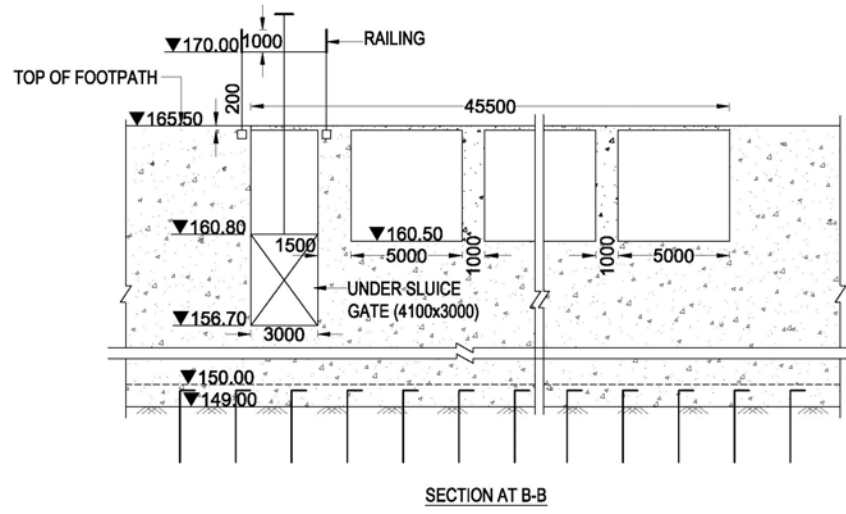
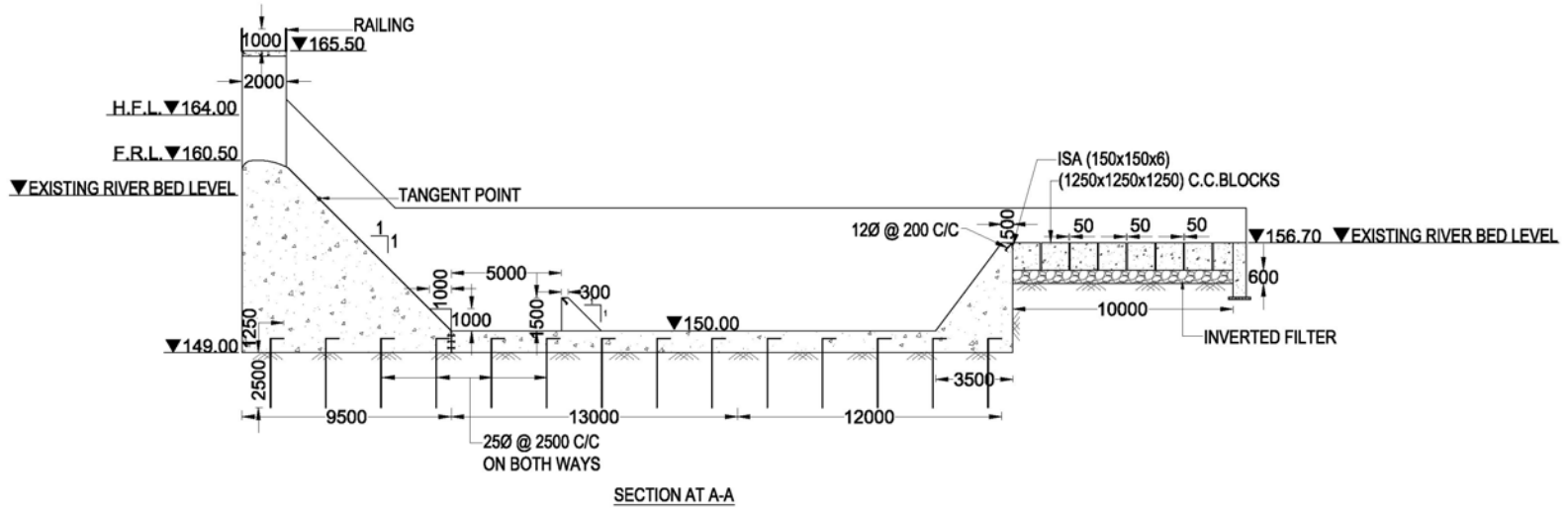


**Fig. 4(b) : Typical Details of a Raised Weir on Erodible Foundation (Section)**



**Fig. 5(a) : Typical Details of a Raised Weir on Rock Foundation (Plan)**





**Fig. 5(b) : Typical Details of a Raised Weir on Rock Foundation (Section)**

## **4.2 Power Channel**

Power channels need to be inspected at least once in a month during lean periods and daily during monsoon months and just after any heavy downpour. Any silt or blockages observed should be removed immediately. Vegetation, if any, should be extracted along with their roots and the affected portions repaired. In case of any breach, inflow of water in to the channel should be stopped immediately by closing the intake gates and necessary repairs carried out. In hilly terrains, where the power channels are sometimes covered, they should be provided with manholes at regular intervals so that they could be inspected from inside, necessary repairs could be carried out and any deposited silt could be removed. In hilly terrains, longitudinal drains provided on the hill side along with the outlet pipes/ culverts should be cleared of all debris, stones, etc well before the onset of monsoon. For maintenance of unlined and lined channels IS:4839 (Part-I) and (Part-II) shall also be referred to.

## **4.3 Power Pipe**

In cases pipes are used for conveyance of water from intake to surge tank / forebay. The pipes may be of mild steel, ductile iron, PVC, HDPE or GRP (Glass fibre Reinforced Polyester) and pre-stressed cement concrete.

- (a) Steel Pipes – The maintenance of underground and surface power pipes shall be similar to those penstocks as mentioned in para 4.7.1 and 4.7.2 respectively.
- (b) Concrete, PVC, HDPE and GRP pipes – While PVC and HDPE pipes are expected to be installed underground, concrete and GRP pipes can be installed on surfaces also. All these pipes are almost maintenance free except for the following for which annual inspection once after monsoons is essential.
  - (i) If installed on surface, concrete and GRP pipes may get damaged by rock falls. In such cases the damaged pieces will have to be replaced by new ones.
  - (ii) The joints of the pipes may develop leakage such joints will have to be opened and rejointed.

## **4.4 Power Tunnel**

Normally the power tunnels, if properly designed and constructed, do not need much maintenance. In case of pressure tunnels, normally these are not dewatered for many years. Still it would be a healthy practice to dewater and inspect the power tunnel once in every 10 years and defects, if any, rectified. However, if any rock or concrete pieces are detected in the turbines, the water conductor system should be closed immediately from the intake, tunnel dewatered at a slow pace, duly inspected and damaged portions repaired. The free flow tunnels should, however, be inspected just before and after the monsoons and damages, if any, repaired and silt and vegetation, if found, removed. The portals of the tunnels need particular attention and slope protection measures in the form of rock bolting, shot-creting, easing of slopes, etc. should be taken up to eliminate possibility of rock falls, which may other-wise close the inlet / exit ends of the tunnels.

## **4.5 Desilting Tank**

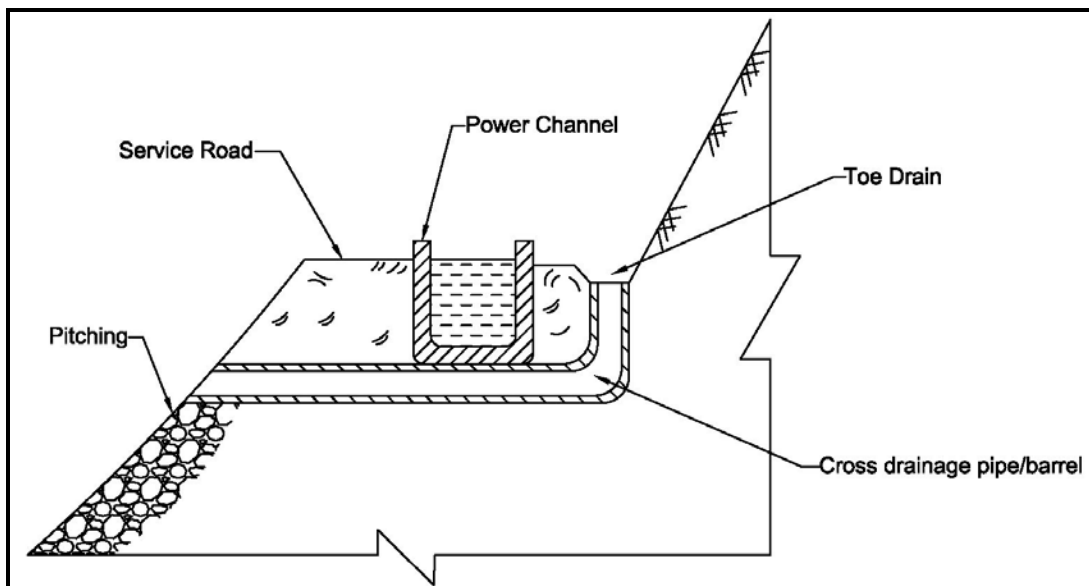
The desilting tank should be inspected before the onset of monsoon and silt found within the tank should be removed. Any vegetation found in the interior or the exterior surfaces of the structure should be pulled out along with roots and the damage carried out by

the vegetation promptly repaired. The desilting pipes should be thoroughly cleaned and design flow should be ensured through these pipes. The gate / valves of the desilting pipes should be checked and their proper functioning ensured. The drains carrying the flushing discharge back into the river or to a nearby drainage should also be inspected. They should be cleaned and any damage found therein should be rectified. The desilting tank, desilting pipes, valves and the drains should be inspected immediately after monsoon also and any silt deposition should be removed and any structural damages rectified. The silt parts per million (ppm) of the water diverted into the intake of the system should be checked at least two times a day during monsoon season and the water conductor system should be closed if the ppm exceeds a certain threshold limit. The threshold limit of the ppm can be fixed after having an experience of 3 to 4 years of operation of the desilting tank or from similar catchments.

#### 4.6 Cross-Drainage Works

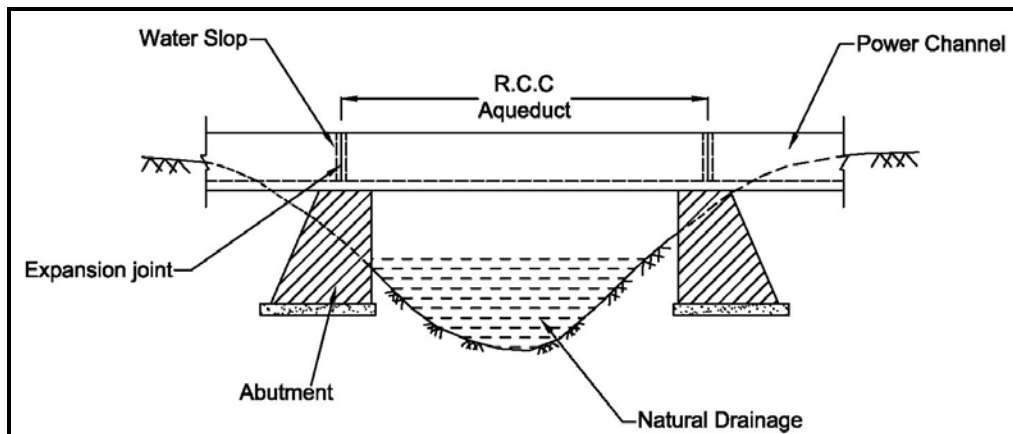
Cross-drainage works may broadly be of three different types

- (a) Drainage crossings provided at regular intervals below a power channel to pass rain water from hill side to valley side as shown in Fig. 6. In these works the following works need to be carried just before the onset of monsoon.

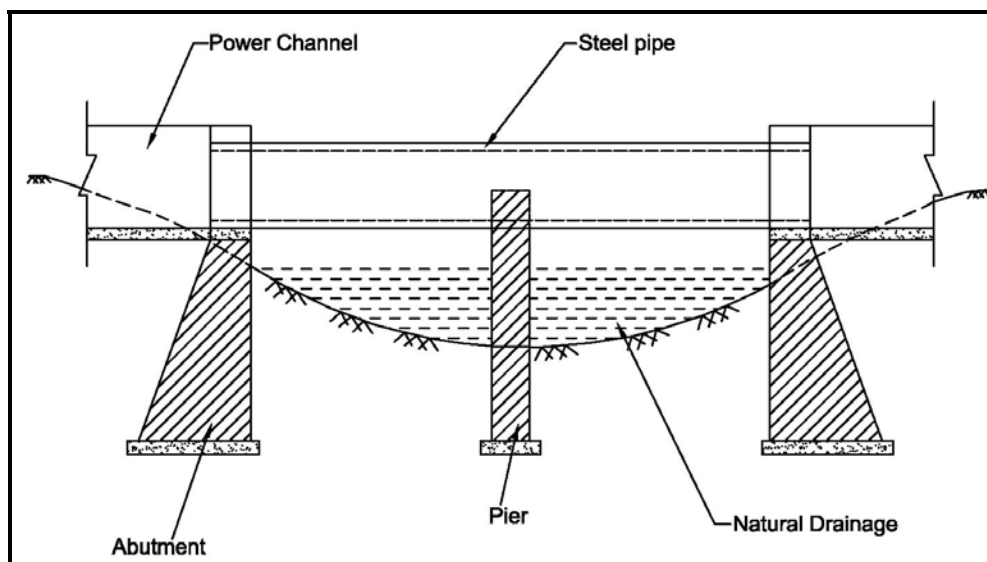


**Fig. 6 : Typical Section of a Cross-drainage Works**

- (i) The toe drain provided on the hill side needs to be cleaned of all debris and its bed slope aligned towards the cross-drainage works.
- (ii) The cross-drainage pipe / barrel needs to be cleaned of possible deposit of boulders / debris etc.
- (iii) The valley side slope needs to be protected against damage due to flowing drain water.
- (b) Aqueduct across a major drainage – The power channel may be required to cross a major drainage by constructing an RCC aqueduct or carrying the power flow through steel pipe supported on piers as shown in Figs. 7 and 8.



**Fig. 7 : RCC Aqueduct**



**Fig. 8 : Pipe Aqueduct**

These works need to be inspected once in a year and necessary maintenance and repairs carried out. The likely works may be as follows

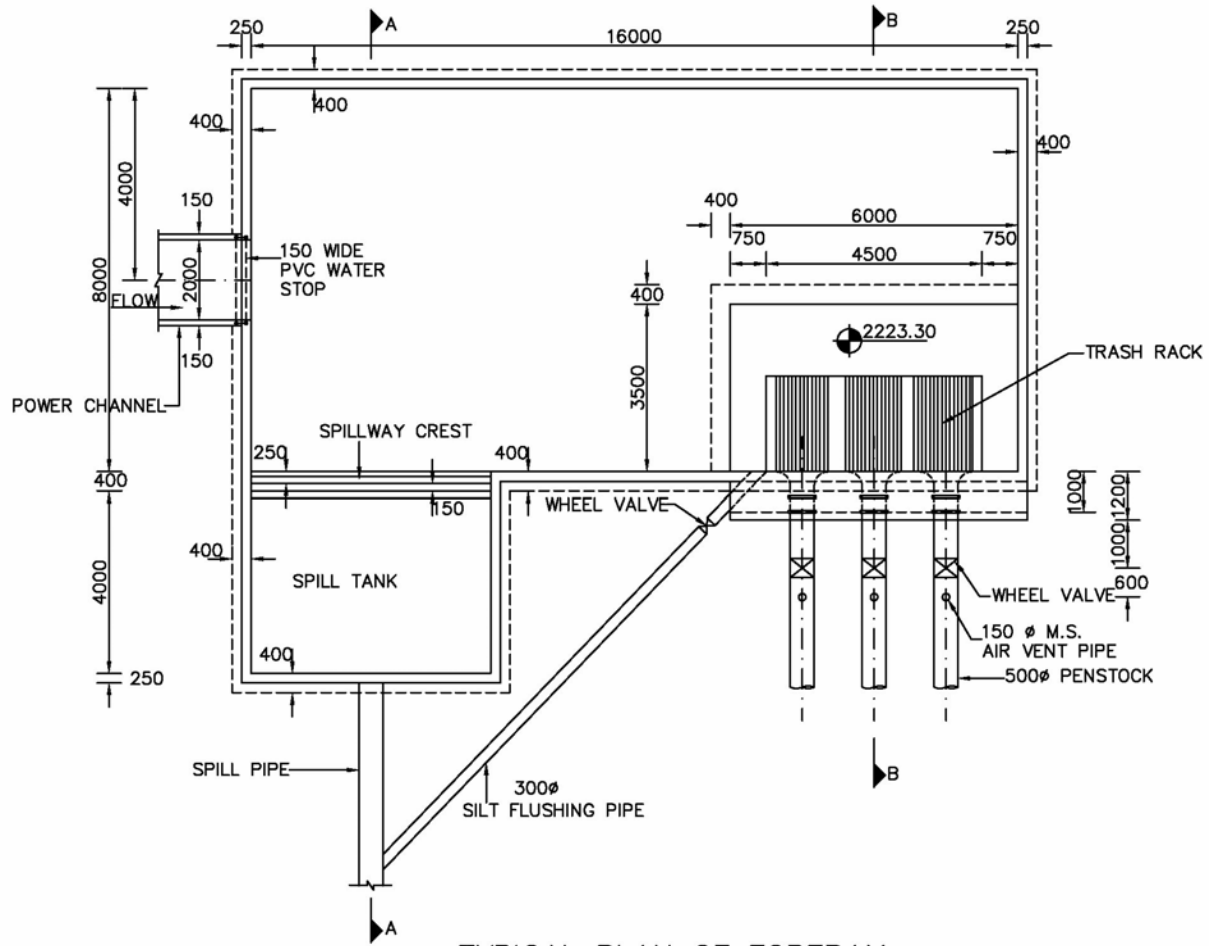
- (i) There may be leakage through expansion joints or cracks in the concrete, which need repairs
- (ii) Steel pipes should be painted in order to resist corrosion.
- (iii) Vegetation which may be sprouting out of the crevices of concrete / masonry should be pulled out and crevices closed with rich cement mortar / bitumen / epoxy paint.

#### **4.7 Forebay**

The forebay should be inspected before and after the monsoon to detect distress or leakage and necessary repairs carried out. The forebay generally comprises the following components

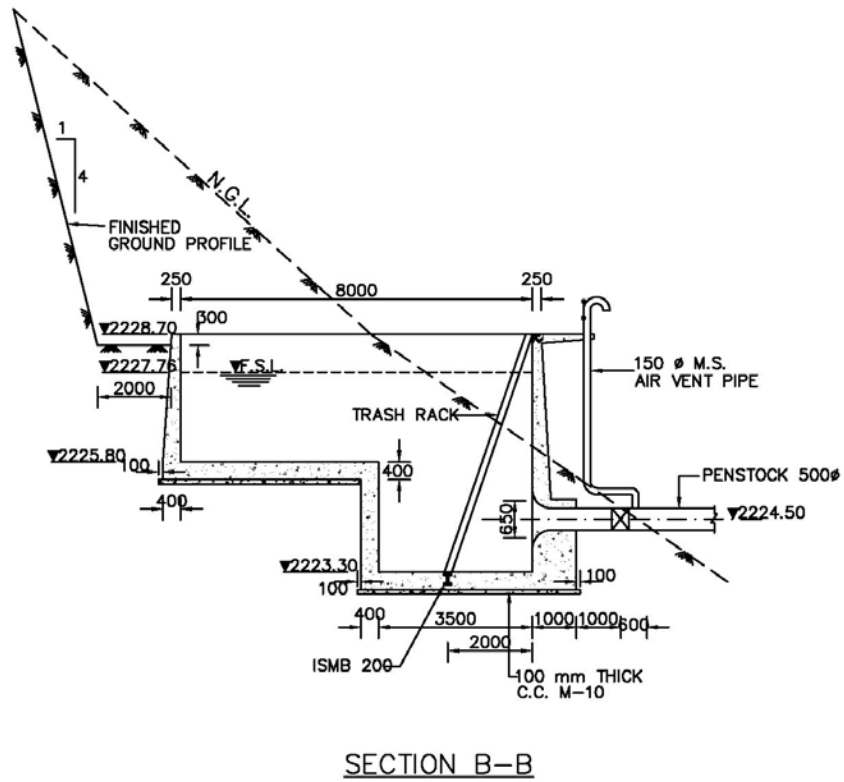
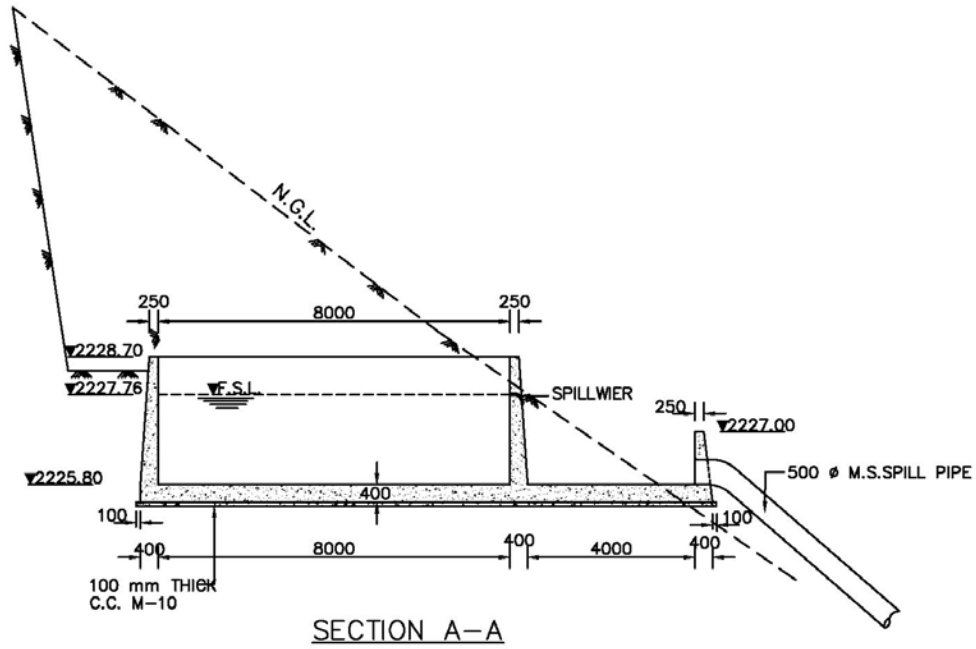
- (i) Main forebay tank
- (ii) Spilling chamber

- (iii) Spilling pipe / channel
  - (iv) Trashracks
  - (v) Bell mouth entry of penstocks, control gates/ valves and air vent pipes. A typical layout of the forebay tank is shown in Fig. 9(a) and 9(b).
- (i) **Main forebay Tank** – Main forebay tank is normally a rectangular reinforced cement concrete tank and the floor of which may be at two different levels. The geometry of forebay may be irregular to suit to the site conditions and to meet the primary objective of minor storage and submergence. The lower portion of the tank is used to install the penstocks in a way to have sufficient water cover over the penstock opening even at the lowest surge level so as to prevent entry of air into the penstocks. An important aspect of this structure is to keep the trashracks upstream of the penstock opening sufficiently trash free so that there always remains enough water cover over the penstock opening to resist vortex formation, which may lead to air entry into the penstock. The tank is required to be checked for any crack or any other damage. At the joint between the headrace channel and the tank, a water stop is provided. An incorrectly installed or damaged water stop may lead to leakage at the joint of the tank and the head race channel. As such this area should be specially checked and leakage, if any, should be promptly repaired.
- (ii) **Spilling Chamber** – It is a chamber adjacent to the main forebay tank, where excess water than the power house requirement gets spilled. This chamber is generally constructed monolithically with the forebay tank. Floor of this chamber is liable to erosion due to falling of water from a height. As such this portion may be inspected and any damage, if noticed, should be attended. Sometime the spilling portion is installed as side spillway on the channel itself to suit the site conditions for good energy dissipation.
- (iii) **Spilling Pipe/ Channel** – A spilling pipe or an open channel is provided to dispose off the spilled water into the spilling chamber and upto a nearby natural drainage. The spilling pipe is normally of mild steel. The maintenance of steel pipes and their supporting system is similar to that of penstocks. Spilling channel is usually a masonry or reinforced cement concrete (RCC) channel of rectangular section with bed aligned in steps along the natural slope of the terrain. Maintenance of these channels requires repairing of the damaged reaches. In case of unstable foundation strata, a section of the channel may get washed away and will require reconstruction. The outlet ends of the spilling pipes/ channels need special attention of the maintenance staff as this portion is subjected to high velocity in the pipe/ channel and also in the natural drainage and is liable to get washed away. The maintenance may require dumping of boulders, repairing/ reconstruction of outlet ends and the end toe walls.
- (iv) **Trashracks** – Steel trashracks are provided at the upstream side of the penstocks inlet. The maintenance of trashracks involves the following–
- (a) Pulling out of racks from their grooves at least once in a year.
  - (b) Welding / replacement of broken pieces.
  - (c) Sand blasting and painting of the racks and guides with asphalt paints.
  - (d) Replacement of racks in their grooves- It would be a good practice to have about 10% of extra rack pieces so that racks requiring major repairs could be replaced without loosing time in maintenance work.



TYPICAL PLAN OF FOREBAY

**Fig. 9 (a) : Typical Details of Forebay (Plan)**



**Fig. 9 (b) : Typical Details of Forebay (Section)**

- (v) Bell mouth entry of penstocks, control gates / valves and air vent pipe – Bell mouth entry of penstocks is either moulded in the concrete or entrance of the penstock is fabricated in the shape of bell mouth and embedded in concrete. This portion generally does not require any regular maintenance. Control gate/ valves & their control mechanism, however, require annual maintenance. These should be checked once a year and their faultless operation should be ensured. The gate and valve seals may require occasional repair/replacement. The lifting mechanism should be regularly greased and oiled. The exposed surfaces of the gates should be painted. IS:7349 should be referred in this regard. Air vent pipe is welded at the top of the penstock just downstream of the penstock control gate/ valve. It would need annual painting.

#### **4.8 Surge Tank**

Normally the surge tanks do not need much maintenance. Still they should be inspected once in a year and any damage, if noticed, should be repaired. In case of metallic tanks, they along with their supporting structure, should be painted at least once in a year. The operation of the gates/ valves provided in the surge tanks should be checked at least once in a year to ensure their smooth working during emergency conditions. The maintenance of hydro-mechanical parts should be done as mentioned in para 4.1.4 (d).

#### **4.9 Penstocks**

Penstocks may be installed underground or at the surface of the ground following the natural terrain.

##### **4.9.1 Underground Penstocks**

Before installation, underground penstocks are painted with epoxy paint and wrapped with a material, which eliminates rusting. Instead of wrapping, the outer surface may also be provided with 75 mm to 100 mm thick coat of shortcrete. Though it would not be possible to inspect penstocks of sizes lesser than 1.5 meter diameter, big size penstocks of diameter more than 1.5 meter may, however, be inspected once in about 5 years and their inside surface painted, if required. Manholes at suitable locations should be provided for this purpose.

##### **4.9.2 Surface penstocks**

Surface penstocks are supported on anchor blocks and saddles. Steps/ ladders should be provided along the alignment of the penstocks, so that they are always approachable for maintenance. Surface penstocks need to be inspected periodically and especially after monsoons or some heavy showers to check any damage of the surface slopes which may trigger collapse of anchor blocks/ saddles. If any distress is noticed, it should be rectified immediately. Painting of the outer surface of the penstocks should be carried out once in a year just after rains. Painting inspection procedure of the inner surface of the surface penstocks will be similar to that of underground penstocks. Steel plates with groove at top are normally provided on the top of the saddles to reduce friction between the penstock and the saddles. These plates should be greased with grease guns through the grooves before and after rains

Expansion joints are provided in the exposed penstocks just at the downstream end of the anchor blocks. These joints take care of the changes in the length of the penstock due to



temperature variation. These joints should be inspected periodically to see if there is any leakage or some other distress signs. In Sleeve type expansion joints, which are provided in high head penstocks, leakage can be checked by tightening of gland bolts. In case the leakage does not get eliminated by tightening of the bolts, the expansion joint will have to be dismantled and its packing rings will have to be replaced (Fig. 10).

Other type of expansion joints are bellows type, which are normally used for heads below 20 meters only. (Fig. 11). There is no sliding surface in this type of joint. Expansion/contraction is obtained by flexibility of the thin plates known as flexible diaphragm forming the joint. The flexible diaphragm will either stretch or compress in the direction of the pipe to allow for the longitudinal movement of the pipe. This type of joint needs regular painting and replacement of flexible diaphragms, if the same get cracked/damaged.

Manholes are provided in the penstocks for inspection purposes. Manholes may also be a source of leakage. If that is so, the leakage can be checked either by tightening of the manhole cover plate bolts or by replacement of gasket below the cover plate.

#### **4.10 Power House**

Civil maintenance of a power house involves maintenance of the following

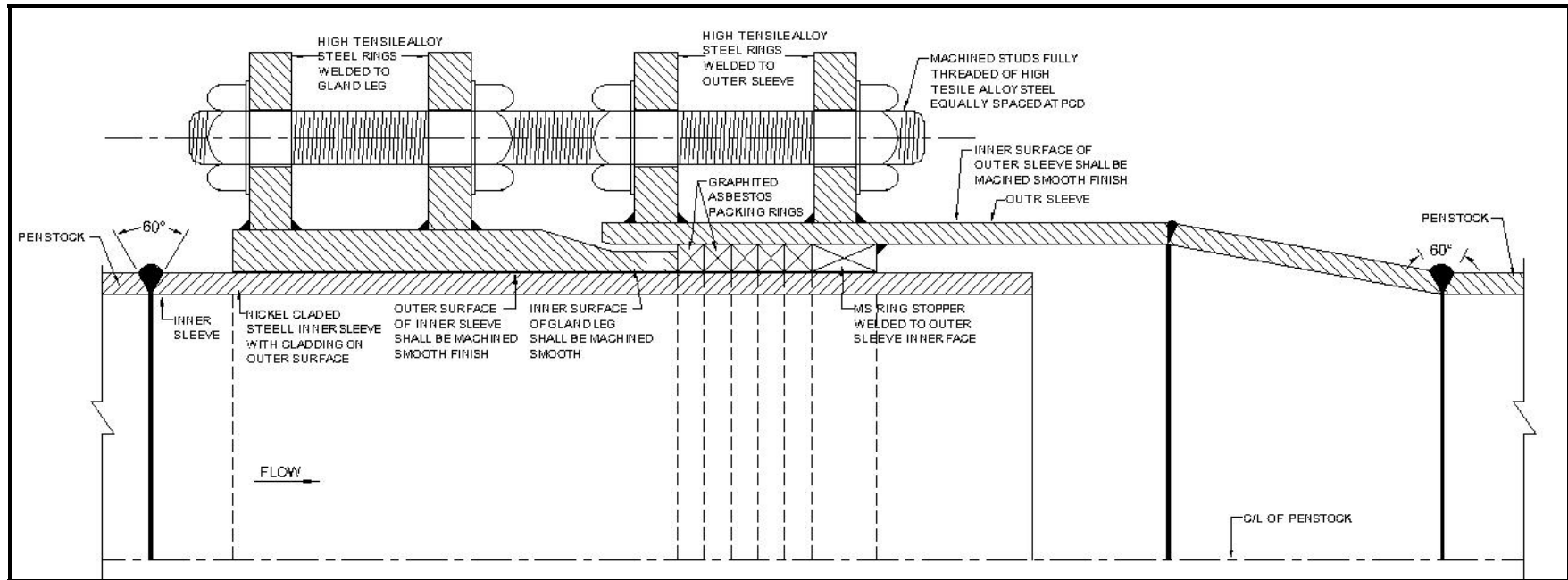
- (i) Maintenance of Power House Building
- (ii) Maintenance of area around power house including approaches to the intake and draft tube gates, drainage of the area, approach road, fencing etc.

##### **4.10.1 Maintenance of Power House Building**

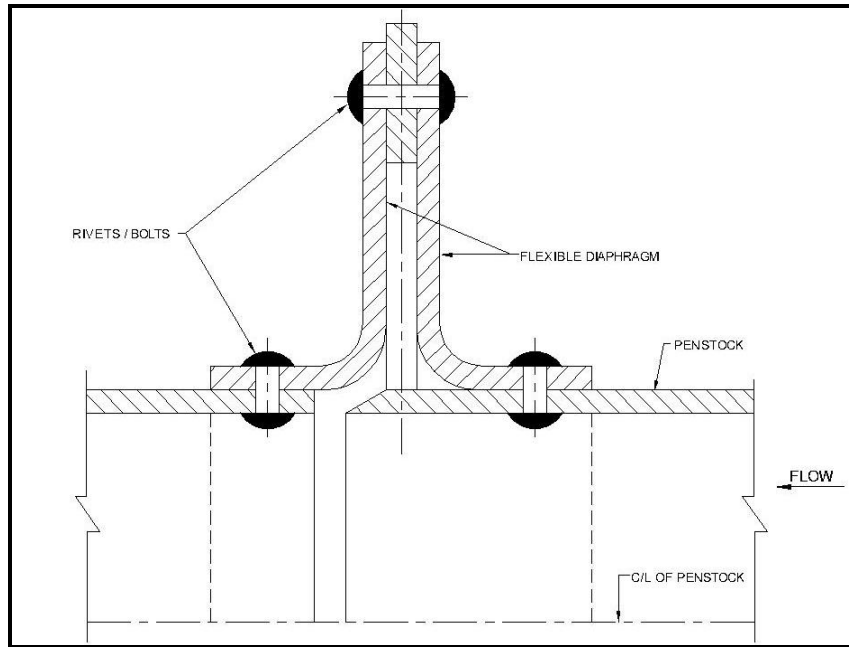
Civil maintenance of power house building shall be carried out as per “IS:15183 – Guidelines for Maintenance and management of Buildings”. A well maintained, neat and tidy machine hall, erection area, control block, office spaces, toilets etc. not only prolong the life of the structure but increase the efficiency of the working personal. Apart from periodic patch repairs, cleaning, white washing, distempering, painting etc., the following areas require special attention as detailed below –

- (i) Erection bay, top floor of the machine hall and workshop area
  - (ii) Generator supporting structure / machine foundations
  - (iii) Battery room
  - (iv) Oil storage rooms
  - (v) Over head crane rails
  - (vi) Roofing
  - (vii) Draft tubes
  - (viii) Amenities
- (i) Erection bay, top floor of machine and workshop area

These portions of the power house have to bear a lot of wear and tear. As such the floors of these areas need continuous maintenance in the form of patch repairs, replacement of floor tiles etc. Tiles provided on these floors should be heavy duty type and a good amount of such tiles should be kept ready in the stores for immediate replacement of damaged ones.



**Fig. 10 : Typical Details of Sleeve Type Expansion Joint**



**Fig. 11 : Typical Details of Below Type Expansion Joints**

(ii) Generator supporting Structure/ Machine foundations

These structures are subjected to continuous vibrations due to running of the machines. As such they are liable to develop cracks specially at the lift joints. The machine bolts and nuts are liable to loosen. In case any cracks are observed, glass, plastic or simple cement mortar telltales may be put across the cracks to monitor if the cracks have any tendency of widening. If such a tendency is noticed, suitable remedial measures should be taken by way of strengthening and repairing of that portion.

(iii) Battery Room

Battery room walls and floors are subjected to the action of acids and acid fumes. At the time of construction, complete floor and walls up to a sufficient height about 1.5 to 2.0 meter should be lined with acid resistant tiles. Sufficient quantities of these tiles need to be kept in stores for use as and when required.

(iv) Oil Storage Rooms

The floors and walls of oil storage rooms and at locations where oils are required to be used, get stained with oil patches and become slippery due to oil spillage. Such locations not only give an unsightly appearance, these being slippery, become accident prone locations. Such areas need to be regularly cleaned with suitable detergents.

(v) Overhead Crane Rails

The bolts & nuts holding the overhead crane rails generally become loose due to constant travelling of the crane. These should be regularly checked and tightened, as and when required.

(vi) Roofing

Roofs, gutters and downpipes need special attention before and after the rains. A leaky roof may be very much dangerous as well as injurious to the electrical & mechanical equipment. At the time of construction, water proofing treatment carried out on the roofs should be heavy duty type. The performance of the treatment should be checked from time to time and repair/ replacement required should be carried out expeditiously. Sufficient quantity of water proofing materials must be kept ready in the stores so that no time gets wasted in their procurement. All gutters, down pipes and drains should be repaired and cleaned before monsoon.

(vii) Draft Tubes

The draft tubes are one of the most vulnerable points, both in regard to their steel lined portion and to the remaining concrete lined portion. Owing the variable conditions of vacuum that exist in the steel liner under varying loads on the turbine, there is a tendency for the liner to vibrate and separated out from the surrounding concrete. Rapid, though comparatively small, temperature changes may take place in the liner when cold water is suddenly passed through the turbine after a fairly idle period. These actions tend to make steel liner loose and sometimes the liners are completely detached and are swept into the tailrace. During construction, the liners should be very well anchored into the surrounding concrete and thereafter carefully grouted. Voids behind the draft tube liners can be readily detected by tapping with a hammer. If some hollow space is detected it should be grouted and supported by extra dowels drilled and grouted into the surrounding concrete. After grouting, any plugs or ties should be finished off flush by welding and grinding. Owing to sub-atmospheric pressures, the concrete lined portions of the draft tubes are subjected to considerable erosion particularly in the vicinity of any irregularities. Faulty areas found during inspection should be deeply cut and patched by guniting process with rich cement sand mortar and surface should be rubbed smooth as soon as the concrete has hardened sufficiently.

(viii) Amenities

It has been found at many power house buildings that there is no proper and regular maintenance of the offices, pantry, toilets etc. resulting in fatigue of the operators and maintenance staff. All regular maintenance of telephone lines, internet, lighting, ventilation, heating, noise, toilets and offices, as we do in general offices and residences be made.

#### **4.10.2 Maintenance of area around power house**

The precincts of the power stations must be kept neat and tidy. A good gardener amongst the maintenance squad should be employed so as to improve the general appearance of the surrounding area. The roads leading to the power house and the surrounding fence must be kept in good order. The entrance gates should be kept closed for safety and security.

#### **4.11 Tailrace**

The tailrace is usually lined with concrete or masonry for a short distance where the greatest turbulence is expected. Upto this point, maintenance is usually very light. Thereafter, in the original river bed, some minor trouble may be expected.

Owing to fluctuating load on the turbines and floods unnaturally rapid rise and fall of the water levels occur at the junction of the river with the tailrace. This phenomenon leads to scouring of the river bed and banks. It is seldom possible to forecast at the design or construction stage the extent of protective works economically necessary to take care of this damage. But after a short period of operation and observation, the need for remedial works in the form of boulder dumping, grouted or dry stone pitching, minor riprap, etc. can be judged and the necessary works undertaken.

#### **4.12 Approach Roads / Foot Paths / Ropeways**

The approaches to the various works of a small hydro project may be in the shape of motorable roads or foot paths or in some rare cases ropeways also. The approaches should be maintained in good serviceable condition so that each and every component of the scheme could be inspected and given necessary attention as and when required.

##### **(a) Roads**

Normally the roads leading to the various components of the SHP are Kaccha hill roads. The top surface of the roads should be kept smooth by putting & compacting earth in the pot holes / ruts etc. Before the onset of monsoon the hill side drains should be cleaned and provided with proper slopes towards the cross-drainage works. The barrels/ culverts of the cross-drainage works should also be cleaned of rolling boulders/ debris.

##### **(b) Foot Paths**

Foot Paths connecting the works of a SHP should be cleaned of all bushes, vegetation etc. in a width of at least 1 meter. At locations where the slope of the foot path happens to be steeper than 1.5 (H):IV steps with paved steps should be provided. Even at locations with a slope steeper than 15H:IV the foot path should be lined with stones to keep it in stable condition. The top surface in such cases should be rough and non-slippery.

##### **(c) Ropeways**

Ropeway maintenance manuals obtained from the supplier and erecting agency should be kept handy at the operating stations and all maintenance guidelines should be adhered to. A list of spare items necessary for regular maintenance of the ropeway shall be prepared with the help of the supplier and kept ready in a store in the immediate proximity of the operating stations. In addition to above the following operations shall be carried out as and when required.

- (i) A minimum vertical clearance between the bottom of the vehicle and terrain lying below including trees, rocks etc. shall be at least 1.5 m when the place is inaccessible to public & 5.00 m when the place is accessible to public. As such regular pruning of the trees and removal of rocks due to rock falls is essential after every rainy season.
- (ii) Equipment for descent such as ladders, ropes etc. shall be kept in good serviceable condition in each cabin for the safety of the passengers.
- (iii) Wire, pulleys, bearings etc. shall be kept well lubricated as per maintenance manual.
- (iv) The ropes shall be withdrawn from service under the following conditions

- a. The loss of strength in the rope due to wear or corrosion or both approaches one-sixth of the original strength,
  - b. The loss of strength in the rope due to fatigue, surface embrittlement or cracked and broken wires approaches one tenth of the original strength.
  - c. The outer wires have lost about one third of their depth as a result of any kind of deterioration.
  - d. The outer wires are becoming loose and displaced.
  - e. The rope has become kinked, distorted or damaged and damaged piece cannot be removed.
  - f. Examination of the rope leaves any doubt as to its safety for any reason whatsoever.
- (v) Fire extinguishers guaranteed to function effectively shall be kept ready in case of need and installed in readily accessible locations.
- (vi) Relief lights in each of the vehicles shall be kept in workable condition.
- (vii) The communication system between the stations operating the cable ways shall be kept in good condition.
- (viii) All the passenger cabins, trestles, etc shall be painted against corrosion at least once in two years.

#### **4.13 General**

SHP plant generates electricity which is an important factor of society development and economic upliftment. Hence the plant should be well maintained as each and every component is important. A budget of 1 to 3% of the capital cost (depending upon the plant capacity) is kept for maintenance purposes for smooth and speedy maintenance.