Chapter 2
Maintenance and Repair of Civil Works

The civil works shown in Figure 2.1 are crucial components of MHP plants and vulnerable to natural mishaps such as rains, floods, or landslides. Routine maintenance schedules for these components are given in Chapter 6 and performance of routine maintenance is described more fully in the manual on 'Operation and Management'. This chapter is concerned with the non-routine maintenance and repairs of these civil structures. The term 'non-routine maintenance' is used to describe situations in which damage is not extensive and repair/maintenance is needed as a result of normal wear and tear or some minor mishap. The term 'non-routine repairs' refers to extensive repairs that have to be carried out as a result of major damage or breakdown.

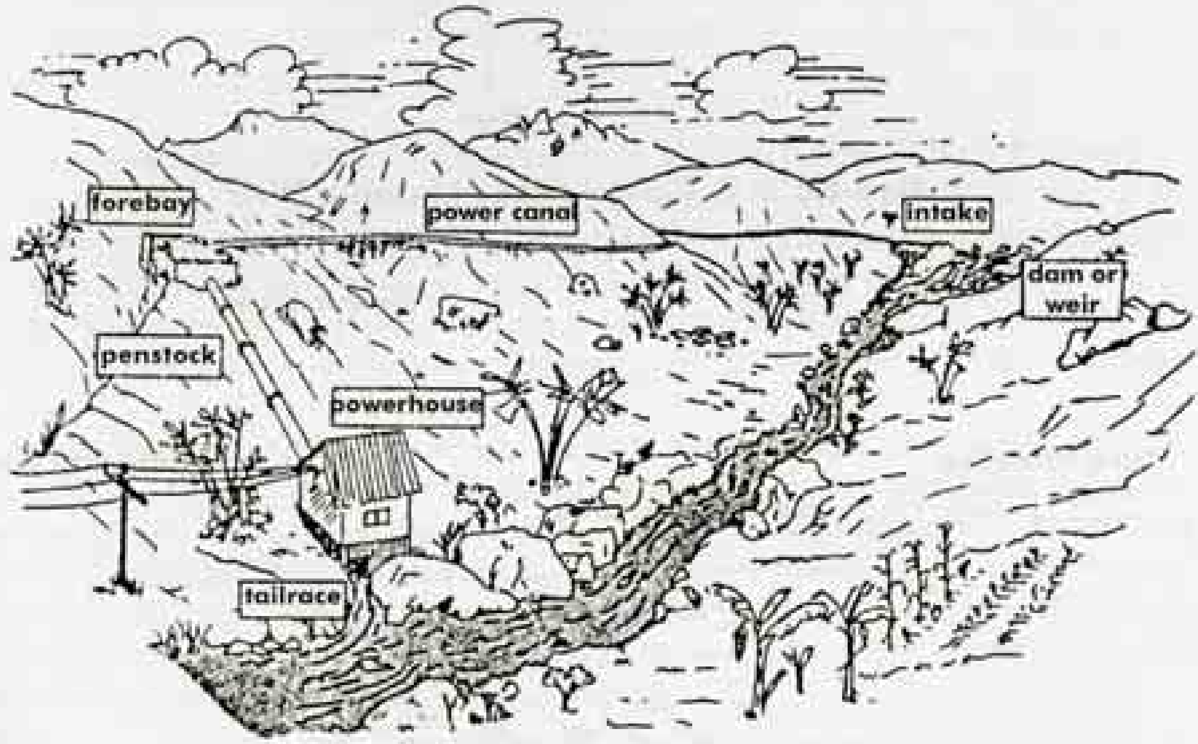


Figure 2.1: Civil Works and Other Components of a Typical MHP Scheme

2.1 The Weir or Partial Dam

The function of a weir is to maintain a constant water level to ensure that a constant flow enters the power canal all the year round, irrespective of low or high flow in the stream (Figure 2.2). A partial dam may have been built in place of a weir. This is usually a temporary structure made of mud and stones that diverts water into the intake mouth but does not extend all the way across the stream (Figure 2.3). A partial dam can be extended when the flow is low in the river and dismantled when flow increases in the stream, so that less water is diverted into the intake.

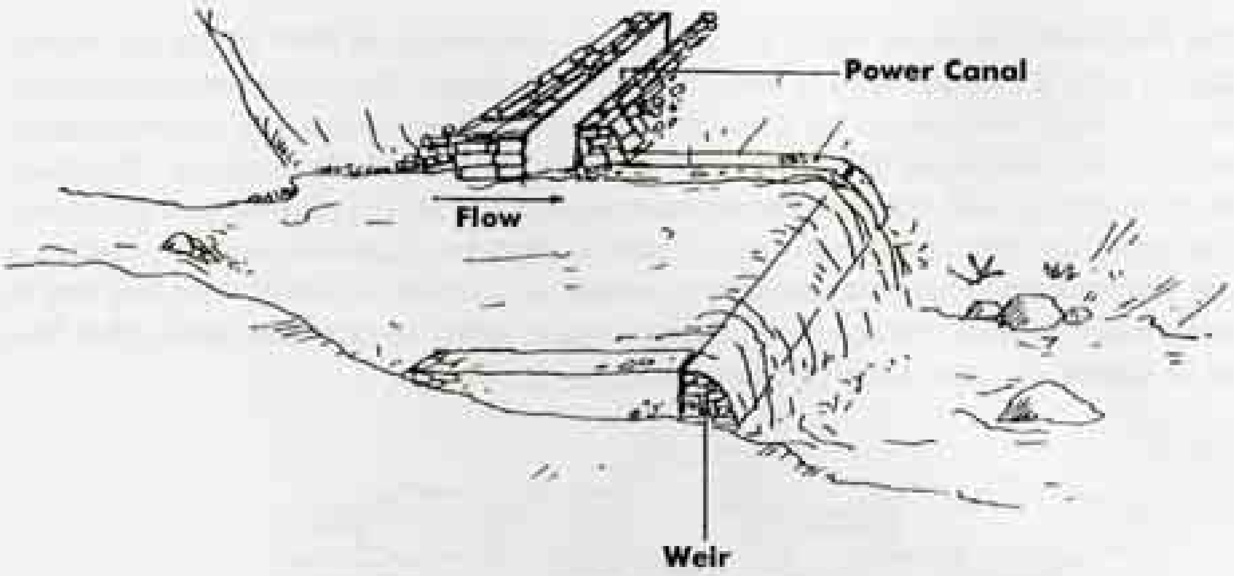


Figure 2.2: A Typical Stone Masonry Weir

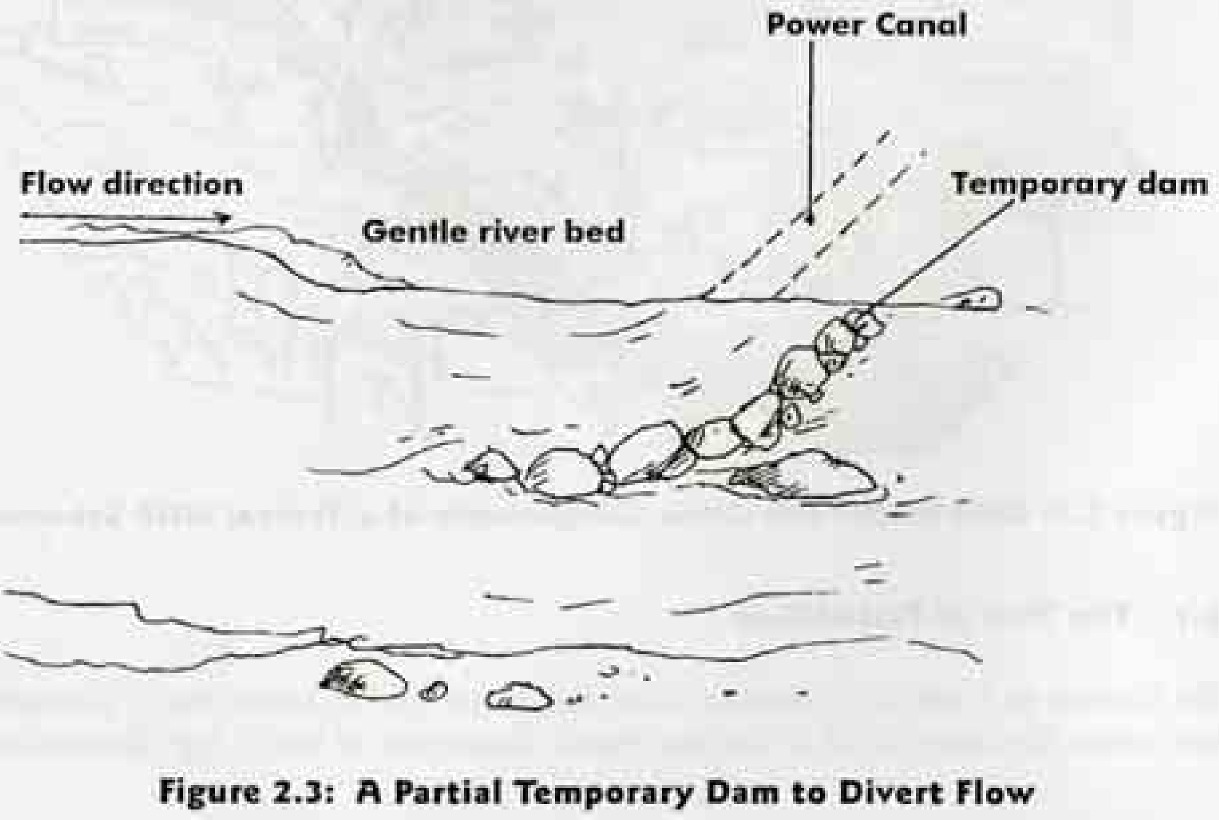


Figure 2.3: A Partial Temporary Dam to Divert Flow

Different types of construction material can be used to make a weir. The weir can be made of stone, in which case dressed stone is used on the wall face with ordinary stones inside; or a gabion or cement-stone masonry wall may have been constructed to make the weir stronger. Concrete weirs are rarely used for MHP plants. Partial dams are almost always constructed from mud mortar and stone, since they are temporary structures able to be washed away, removed partially or fully, or extended according to the requirements of the flow in the canal.

In general, damage to the weir or a partial dam is caused by floods or a high flow in the river which can break the structure or partially wash it away. Sometimes big boulders are carried or rolled by high flows, and these may hit the weir and damage even more permanent structures such as stone masonry walls which otherwise would not be affected by floods. The third source of problems is silt carried in the water, or caused by an upstream landslide. Silt deposits normally raise the level of the weir without breaking it.

The damage caused to a weir is likely to be in the form of partial or complete breakage, or raising of height due to deposited silt. A partial dam may be washed away completely since it is a temporary structure anyway. Sometimes the weir or temporary dam may leak and need to be plugged.

Before commencing any repairs, it is necessary to assess the damage through inspection and different checks. For example, a gabion weir should be inspected for damage to the side of the gabion, change in shape, or breaking of the wires. Some foreign material might also have collected around or above the weir, and this will need to be removed. Thus an inspection is necessary to assess the damage and to decide what repairs are needed. The repairs will depend upon the type of structure as well as the extent and type of damage.

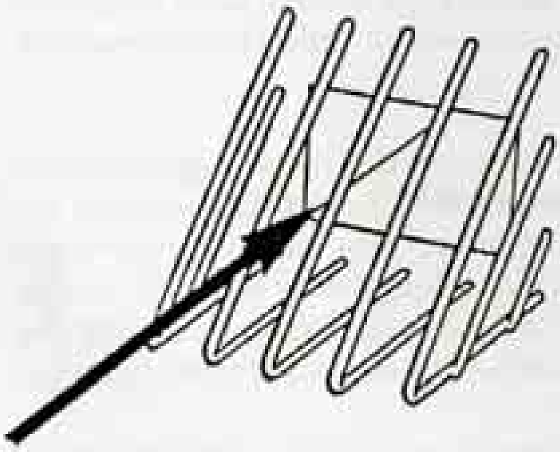
To repair a gabion weir, first remove any foreign material, such as silt, leaves, and sticks, from around the top and sides of the gabion, and then open the wire mesh at the top. Remove all the stone masonry that has bulged or eroded and start reconstruction using dressed stones on the outside and normal stones on the inside as if it was being constructed anew. The wire mesh can be repaired by adding and/or enmeshing similar wire to the original mesh and then closing it at the top by twisting the two wire-ends together and bending them down to the level of the surface.

To repair a dry stone or cement stone masonry weir, again remove all foreign material from around the sides and top of the weir. Then remove the damaged part of the structure in the masonry and start reconstruction using the same materials as used in the original structure.

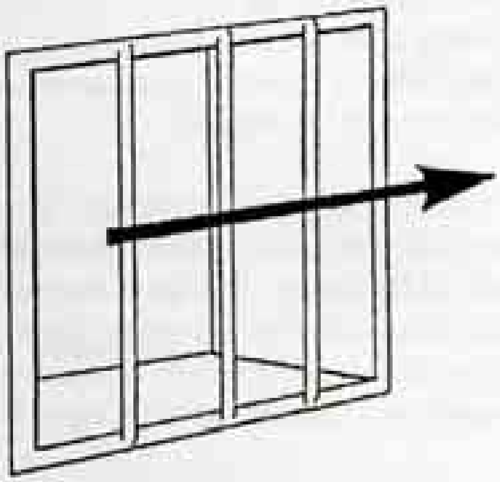
The repair of damage to mud mortar and stone masonry structures, especially partial dams, is simple. Remove the damaged portion and rebuild using the same materials as used in the original structure.

2.2 The Intake

The main function of the intake is to allow a rated flow into the power canal (headrace) and, as far as possible, to block entry of undesirable solid materials such as sticks or stones. For this purpose, either a coarse trashrack or cross-bars are provided at the intake mouth (Figure 2.4). There are three common types of intake in MHP schemes. The most common are simply an opening constructed in the side of the stream leading to the canal. The downstream end of the opening may be extended in the form of a partial dam, as described above. In the second type, a proper wall is constructed containing the intake mouth in the form of a rectangular window (Figure 2.4b). In the third type, a pipe is extended to the middle of the stream where the water is deepest and the pipe mouth remains submerged all the time. When the intake is just an opening in the wall, the sidewalls adjoining the intake area should be properly constructed from dry stone masonry or stone masonry and cement mortar.



a. A coarse trashrack for direct intake



b. Crossbars for a side intake mouth

Figure 2.4: A Coarse Trashrack and Crossbars for the Intake

The main sources of damage to the intake structure are high floods and flows; boulders, logs, or other heavy objects transported by the flow; and deposits of silt at the intake mouth that reduce the flow. Landslides may also either damage or block the structure. Silt and other solids may block the pipe mouth in a pipe intake.

The intake structure or adjoining wall can be damaged or broken; the intake mouth may become wider or smaller, or even blocked; and the trashrack or crossbars can be damaged, broken, or bent. Sometimes, the whole structure may also get washed away as a result of extreme conditions.

Assessment of the extent and type of damage to the intake wall and the mouth should be made through extensive inspection. The size and base level of the intake should be checked.

If the constructed walls of the intake structure are damaged, the damaged portion should first be demolished and then reconstructed using the same materials as used for the original structure, while ensuring that there is no gap between the wall and the actual earthen bank. Any such gap should be filled with soil and stones and compacted properly so that there is no chance of water seeping in. If silt has deposited at the intake mouth, it should be removed and the area cleaned and levelled, not just close to the mouth but extending further along the stream bed so that deposits are avoided in the future. If the crossbars or the trashrack bars are bent, they may be straightened. If they are broken they can be joined by welding, or by fastening steel wires around them. If the damage is extensive, the trashrack or one or more of the crossbars should be replaced.

2.3 The Power Canal

The power canal or headrace carries the design flow of water from the intake to the forebay. It may also incorporate one or more desilting basins and spillways (Figure 2.5). In most cases, open earthen canals are used; however, in some cases, parts of the canal may consist of a pipe or be lined with cement mortar. Sometimes, portions of the canal may have been raised above ground in the form of an aqueduct made of concrete to cross a gully or some other similar difficult area.

The usual sources of damage to the canal are excessive flow, depositing of silt, landslides, rainwater flowing down the hill, or sometimes animals or humans. The damage may appear in the form of leakage from the pipe or canal, or blockage as a result of silt or other foreign materials. The banks or the bed may be eroded, and this could eventually result in part of the canal falling down. Inspection of the power canal to assess the extent of damage should not just be confined to the canal or pipe, but should also cover the surrounding area. All signs of leakage, slip, or other type of degradation must be assessed. All of the affected area will need to be repaired in an appropriate way, depending upon the type and extent of damage, to avoid a serious breakdown in the future.

If there is any leakage from the canal, the water should be stopped at the intake and the damaged area inspected to determine whether a retaining wall underneath the damaged portion is needed; or whether it will be necessary to use a better masonry system such as cement-stone masonry for the wall. Usually, a portion of the bank beyond the damaged portion should be removed and then reconstructed from the same or better materials such as cement-stone or mud-stone masonry. If there is a very small crack in a stone masonry or concrete wall, it can be blocked with the help of bitumen. If a large amount of silt has been deposited on the bed of the canal, it should be removed in such a way that the bed is maintained at its original level. If a portion of the canal bank has col-

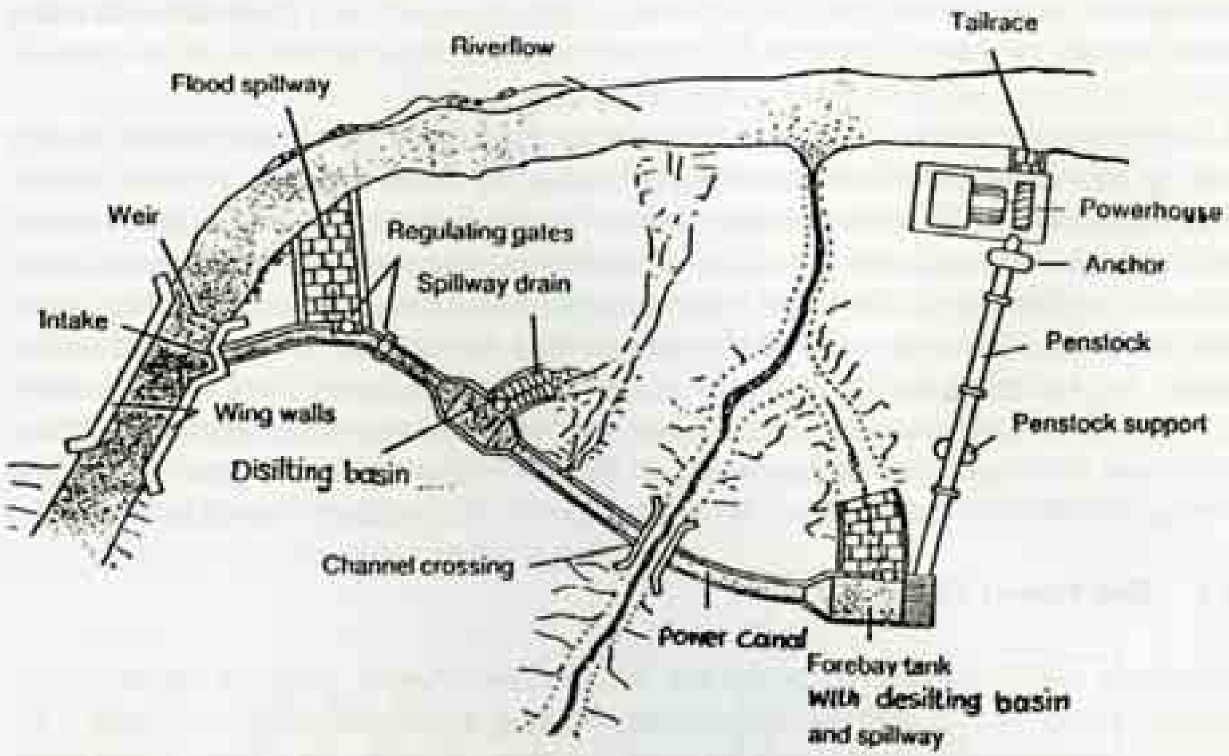


Figure 2.5: Main Components of a Micro-hydro Scheme Including Power Canal and Desilting Basins

lapsed, it will be necessary to dig deeper into the mountainside until a more stable soil or surface is reached. Then stone soling should be placed along the bottom in a horizontal direction, and a sloping stone or gabion wall built up the side to the level of the canal wall (Figure 2.6). The space between the mountainside and the wall should be filled with stone and earth in layers (~300 mm thick) and compacted well. If the canal has been damaged by a landslide from the slope above it, then a larger portion of the canal should be dug out, extending beyond the damaged area until a firm base is reached. Stone soling should be placed at the base and a canal wall built as described above. Sometimes, a landslide from the upper side of the canal may completely destroy the canal and the supporting area beneath. In this case, construction should be started from down below where there is firm ground using stone soling (about 3 metres below) as described above. A retaining wall should also be built above the canal to stabilise the mountain slope. If a portion of a cement-stone masonry canal has been damaged, or has slipped down as a result of a landslide on the upper side or erosion on the lower side, then more care needs to be taken in rebuilding the canal. Much thicker stone soling should be provided at the base to support more weight. Construction of the retaining wall and canal may then be carried out as described before.

If there is a passageway for flow of rainwater above the canal, then it should also be cleaned by removing stones or other debris to keep it functional. Otherwise, the flow may be blocked and may enter the canal.

If a pipe has been used for all or part of the headrace, it may get blocked with silt. For example, if a break-pressure tank has been damaged and that end of the pipe closed, then the silt already present in the water would deposit in the pipe. Silt deposits in the pipe can be removed by force flushing or by inserting a long wooden pole in the pipe to scrape the silt, but care must be taken to avoid damaging the pipe during this operation. If a proper slope had been calculated for the pipe at the time of the design, and the pipe had been properly installed, there should be no deposition of silt.

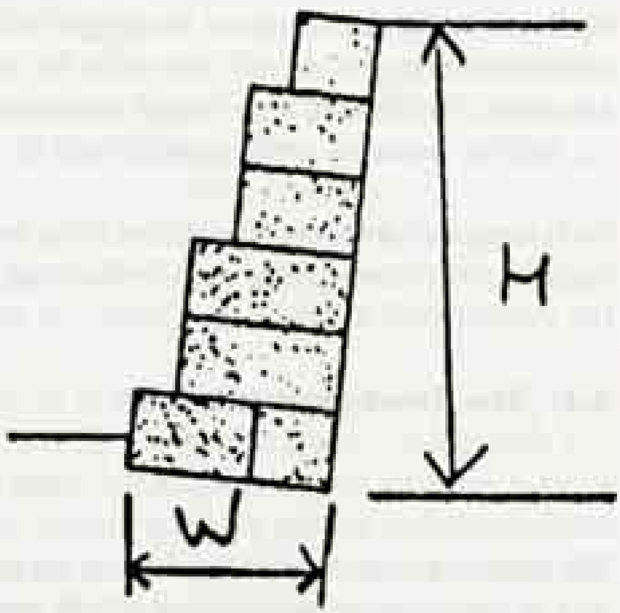


Figure 2.6: A Gabion or Masonry Retaining Wall

One unusual type of damage was reported in Nepal; a stone entered the HDPE pipe headrace and got stuck at the lip of a joint between two pipe lengths. It was very difficult to determine the location of the blockage. A simple technique was devised whereby a smooth heavy piece of steel was tied to a rope and allowed to slide into the pipe from the top until it reached the blocked location and stopped. The length of the rope was measured and in this way the point of the blockage was located. The pipe was cut at this point and the stone removed.

If a large crack has developed in an HDPE pipe, the best way to deal with it is to cut the cracked portion and insert and join an equivalent new piece. If the crack is small, the simple method of repair is to wrap a piece of rubber around the crack and use one or more screw clamps to keep the rubber in place to stop the leakage.

2.4 The Desilting Basin

The function of the desilting basin is to remove silt or heavier suspended particles carried by the flowing water. This is done by slowing down the speed of the water and making it calmer so that heavier particles settle on the bed. Desilting basins are usually constructed using cement-stone masonry with a properly plastered surface. The desilting basin is three to five times as wide as the canal, and the length is about 2.5 times the width.

The main sources of damage for desilting basins are landslides, floods or flows carrying excessive silt, and unstable ground. The most common types of damage are filling up of the basin with silt or debris; leakage, which means cracking of plaster or masonry; and sinking because of unstable ground underneath.

Molten bitumen can be used to plug small cracks in the plaster or repair leakage. Rich cement mortar (1:2 or 1:3) can also be used to close small cracks. If the damage is extensive, the affected area should be replastered. Before replastering, the damaged plaster and the masonry underneath should be removed by chiselling.

If silt deposits have remained in the basin for a long time and dried and hardened, it may be difficult to remove them just by flushing. In this case, the usual method is to dig out the deposit with a shovel.

2.5 The Break Pressure Tank

A break pressure tank is constructed when HDPE or other types of pipe are used for the headrace so that it is not necessary to use a very thick pipe to withstand higher pressure. The break pressure tank is provided at an appropriate location, water comes out of one pipe at atmospheric pressure and enters another. The small tank is very small, about one metre or so high, and is constructed in a similar way to the forebay using cement-stone or cement brick masonry. It is properly plastered both inside and out.

The sources and type of damage are similar to those for the forebay. The tank may subside, or be filled with debris or silt which needs to be cleared. Sometimes, the tank may develop cracks that have to be plugged. Since the inside area is small (less than $1 m^2$), getting inside and plugging leaks or removing debris may be difficult. Debris can usually be removed by shovelling.

2.6 The Forebay

The forebay is the last open link between the canal and the closed penstock pipe, and its function is to facilitate the flow from an open system into a closed one. At the same time, the trashrack removes any remaining floating debris from the flowing water. Sometimes, a desilting basin may be incorporated in the forebay so that any remaining silt is also removed at this stage. Usually, the forebay is constructed from cement-stone or cement-brick masonry and is properly plastered (Figure 2.5). Thus it is a fairly permanent structure and does not normally break or need serious maintenance.

Damage to the forebay may be caused by landslides or boulders falling from above, by floods, or by excessive rainwater. Instability of the ground on which it is constructed may also cause sinking and cracking. The damage may be in the form of cracks, resulting in leaks; or sinking, which may again cause cracking and leaking. The other possibility is excessive accumulation of silt or other material that cannot be removed by normal flushing. As always, it is necessary to inspect the whole area surrounding the damage, especially if the walls have cracked and there may be a possibility of further disintegration of the structure. If this has happened, then the situation is serious and the whole forebay structure should be dug up and reconstructed. If the cracks are small, say less then three mm wide, they can be plugged with molten bitumen or rich cement mortar. If there are larger cracks, then the damaged plaster and masonry underneath should be cut out or scraped and replastered with cement mortar. If the cracking is the result of sinking or landslip and the sinking is considerable, say 10 mm or more, then the best way is to dismantle the forebay structure, dig down through the unstable soil until firm ground or rock is reached, and then reconstruct the whole forebay. Stone soling should be provided at the base, and retaining walls constructed as described in section 2.3.

It should be possible to remove small amounts of silt deposits or debris by flushing two or three times. However, if the amount of debris is quite large, the result of a landslide, for example, then it has to be removed by shovelling.

Sometimes, a leak may develop around the neck of the penstock where it leaves the forebay. This is normally caused by movement of the penstock causing a leak at the interface between the steel pipe and the forebay masonry. Bitumen can be used to fill the crack, or a small recess can be formed by chiselling around the penstock mouth and a piece of rubber forced into the recess with the help of a screwdriver or chisel to make a force fit.

2.7 The Tailrace

The tailrace carries the water exiting from the turbine back to the river, and part of it is located inside the powerhouse. Usually the tailrace is relatively short and on ground where the likelihood of serious damage is minimal. Inside the powerhouse the tailrace is usually built of stone masonry and properly covered by a reinforced concrete or stone slab. Outside the powerhouse, it is an open channel, usually earthen. In rare cases, where the area outside the powerhouse is precious (irrigated cultivated land, for example), the tailrace may be constructed of cement-stone masonry to prevent any leakage to the surrounding area.

Damage to the tailrace can be caused by sinking of the ground or, if the slope of the tailrace is high, erosion and appear in the form of leakage or increased width or depth. In some cases, the tailrace may become filled by debris from a landslide, or from collapsed banks. In this case it can be re-dug by shovelling.

If the channel has become too deep, the ground should be filled to the proper level and compacted, and then covered by stone pitching with a layer of thin stone slabs on the top so that the surface becomes hard and resistant to erosion. Pitching should be provided on the whole inner surface, the bed as well as the sides. If done properly, stone pitching can also stop leakage.

Sometimes a hole is dug by a rodent in an earthen canal. In this case the hole must be located, the surrounding area dug out about 300 mm deep, and then refilled and compacted to plug the hole.