# 11. Shore-based infrastructure and renewable energy


## SUMMARY

Fishing ports, large and small, need a whole range of supporting infrastructure to function and this includes the water supply system, refuelling facilities, cold rooms, landing and sorting halls, office space, electricity supply and a host of other small-scale civil works.

This chapter reviews the various infrastructure requirements in civil and mechanical works to render the port functional. It also reviews many of the specifications against which the components should be designed in line with international guidelines.

Whereas guidance is primarily given to those engaged in port planning, those responsible for making policy decisions in relation to fisheries management would also benefit through a better understanding of the intricacies and implications of port planning and operation.

## CONTENTS

## 11.1 WATER SUPPLY AND STORAGE

### 11.1.1 Peak daily demand

Fishing harbours, small and large, need clean water to function. The adage or rule of thumb stating that *"No water – No port"* is often taken too lightly by planners and fishing ports have been known to be missing a water supply system in their shore-based infrastructure. To plan the water supply system for a harbour, it is first necessary to estimate the peak daily demand for water for which good landing statistics are required. These statistics should include:

- peak (seasonal) fish landings, in kilograms or tonnes;
- number, size and type of vessels likely to use the harbour during peak landings;
- size of the crews on board the vessels and the maximum number of port workers; and
- demand for water from secondary sources (processors, intermediaries, food outlets, etc.).

Table 1 shows how the water requirement may be calculated.

In the table:

- The gross daily volume for fish rinsing should be 1.25 times the peak daily landing.
- The volumes of water required for hosing down the auction hall and washing of fish boxes may be reduced by over 50 percent if high-pressure cleaning machines are used instead of a plain water hose.
- The volume for personal hygiene also includes allowance for showers.

TABLE 1
**Daily water requirement**

| Activity | Quantity of water required |
|---|---|
| Fish rinsing | 1 litre per kg of fish landed every day |
| Auction hall hose down | 10 litres per square metre of covered area |
| Fish box washing | 10 litres per fish box |
| Personal hygiene | 100 litres per person (including crews, unloaders, port staff) |
| Canteen | 15 litres per person |
| Vessel bunkering | Dependent on type of vessels |
| Ice | Peak daily requirement – sales records |

### 11.1.2 Sourcing water supply

Internationally accepted guidelines on water supply in fishing ports stipulate non-contaminated water; this water may be either freshwater or raw seawater. Table 2 illustrates the applications that may safely use clean seawater if adequate supplies of freshwater are not available. Chapter 12 describes the quality of the water required.

TABLE 2
**Replacement of freshwater with seawater for certain operations**

| Activity | Freshwater | Raw seawater |
|---|---|---|
| Fish rinsing | Yes | Yes |
| Auction hall hose down | Yes | Yes |
| Fish box washing | Yes | Yes |
| Personal hygiene | Yes | No |
| Canteen | Yes | No |
| Vessel bunkering | Yes | No |
| Ice | Yes | Not recommended |

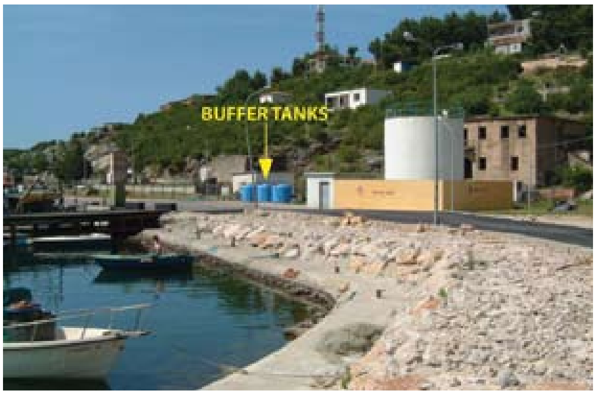
Freshwater may be sourced from a town's supply or a borewell and may be augmented by a rainwater harvesting system if environmental conditions permit. In extreme cases, it may also be desalinated on site from brackish or seawater.

Raw seawater may be sourced from a nearby clean beach or a distant clean beach, but in both cases it must be drawn from inside the sand and not directly from the water column.

### *11.1.2.1 Town water mains*

Many fishing ports in developing countries lie within or close to a town's water supply network and, in theory, hooking up the port's network to a water main should not present any problems. In practice, however, many such supplies often prove to be very erratic, with water trickling in at a very low rate or none at all for days on end. In such cases, the supply may need to be augmented or adequate buffer storage provided, Figure 1.

FIGURE 1
**Buffer tanks to even out fluctuations in town mains supply**

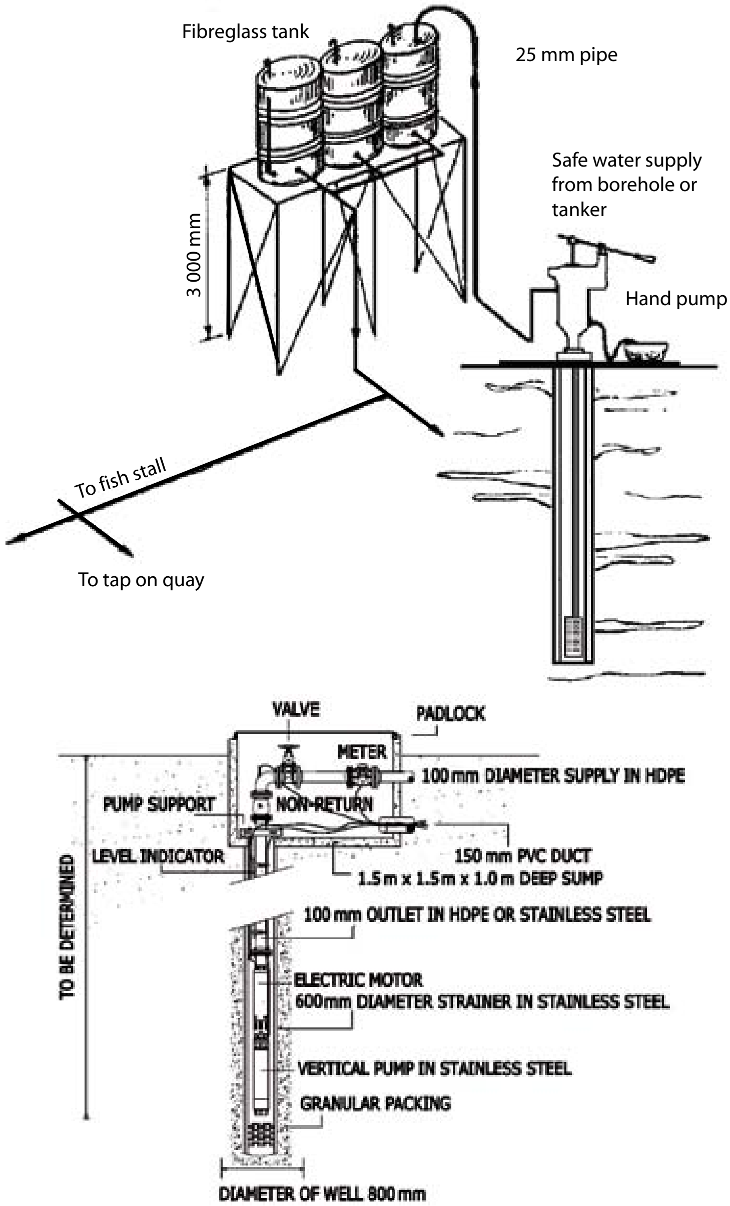



### *11.1.2.2 Borewells*

Borewells may be drilled in and around the port or some distance away. The geological investigation of the substrata is generally carried out by a specialist subcontractor. This investigation consists in the drilling of a small diameter borehole (80 mm to 100 mm diameter) and the recovery of water samples (Figure 2). Samples are then

FIGURE 2
**Drilling an exploratory borewell**

FIGURE 3
**Artisanal borewell (top) and typical borewell with vertical pump (bottom)**




taken for analysis. More than one borehole may be required for a complete assessment. The depth to which the borehole is driven does not depend on the local water table. Instances frequently occur when a shallow waterbody (easily contaminated) overlies a "submerged" freshwater reservoir several metres below it. The "porosity" or permeability of the water-bearing deposits will determine the maximum rate of extraction of water. Figure 3 shows diagrams of an artisanal borewell and a typical borewell with vertical pump.

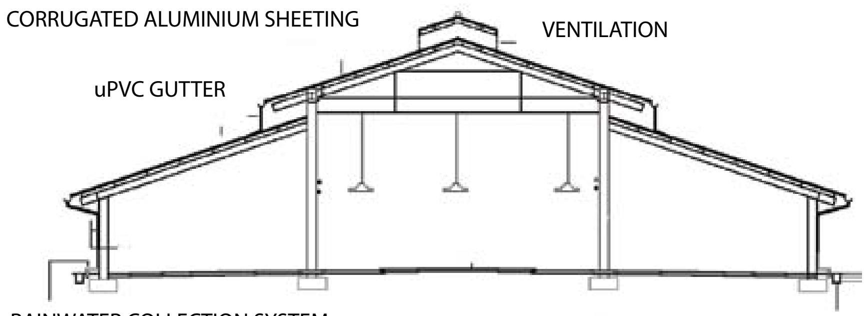
### *11.1.2.3 Rainwater harvesting*

In areas with high precipitation, rainwater harvesting is the best way for augmenting the freshwater supply, especially if large roof surfaces are available.

The rainwater thus collected should be pumped to the port's reservoirs (see further on) where it can be chlorinated before use. To prevent the potential for the roof runoff

to pick up contaminants from bird droppings, the initial runoff during a precipitation should be channelled off into the floor drainage collector, Figure 4.

FIGURE 4
**Rainwater harvesting from roof areas**

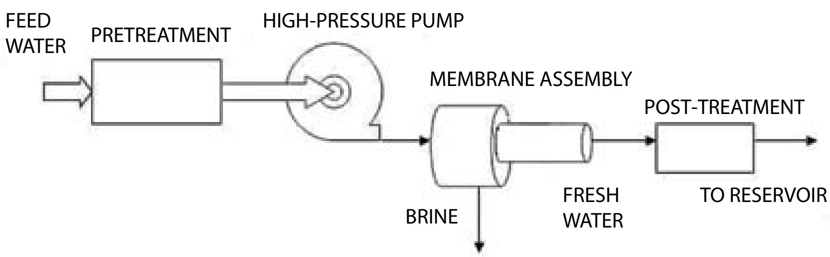



### *11.1.2.4 Desalination*

Desalination is a process that removes dissolved minerals (including but not limited to salt) from seawater, brackish water or treated wastewater. A number of technologies have been developed for desalination but the most commonly used system nowadays is reverse osmosis (RO). In reverse osmosis, feed water is pumped at high pressure through permeable membranes, separating salts from the water, Figure 5. The feedwater is pretreated to remove particles that would clog the membranes. The quality of the water produced depends on the pressure, the concentration of salts in the feedwater, and the salt permeation constant of the membranes. Product water quality can be improved by adding a second pass of membranes, whereby product water from the first pass is fed to the second pass.

Desalination plants may use seawater (directly from the sea through offshore intakes or from wells located on a beach), brackish groundwater, or reclaimed water as feedwater. Since brackish water has a lower salt concentration, the cost of desalinating brackish water is generally less than the cost of desalinating seawater. Intake pipes for desalination plants should be located away from sewage treatment plant outfalls to

FIGURE 5
**Flow diagram of a reverse osmosis system**




**Pretreatment to post-treatment**

| Pretreatment | Pressurization | Separation | Post-treatment |
|---|---|---|---|
| Conventional filtration<br>Cartridge filtration<br>Chlorine and anticoagulant<br>Antiscalant | High-pressure pump | Reverse osmosis | pH adjustment<br>Sterilization |

prevent intake of discharged effluent. If sewage treatment discharges or other types of pollutants are ingested in the intake, however, the pre- and post-treatment processes should remove the pollutants.

RO desalinators produce a water product that ranges from 10 to 500 ppm in total dissolved solids (tds). The recommended World Health Organization (WHO) drinking water standard for maximum tds is 500 mg/l, which is equivalent to 500 ppm. In desalination plants that produce water for domestic use, post-treatment processes are often employed to ensure that the product water meets the health standards for drinking water as well as recommended aesthetic (organoleptic) and anti-corrosive standards (pH value). The desalinated product water is usually more pure than drinking water standards, so when water product is intended for domestic use, it is mixed with water that contains higher levels of total dissolved solids. Pure desalination water is highly acidic and is thus corrosive to pipes, so it has to be adjusted for pH value, hardness and alkalinity before being piped to a domestic reservoir.

Pretreatment processes are needed to remove substances that would interfere with the desalinating process. Suspended solids and other particles in the feedwater must be removed to reduce fouling of the membranes.

Sand is removed by sand or fine bag filtration methods and suspended solids are removed by special wound cartridge filters. Algae and bacteria can grow in RO plants, so a biocide (usually less than 1 mg/l chlorine) is required to clean the system. Some RO membranes cannot tolerate chlorine, so dechlorination techniques are sometimes required. Ozone or ultraviolet light may also be used to remove marine organisms. If ozone is used, it must be removed with chemicals before reaching the membranes. The filters for the pretreatment of feedwater must be cleaned every few days (backwashed) to clear accumulated sand and solids. The main membranes must be cleaned approximately four times a year and must be replaced every three to five years.

The product water recovery relative to input water flow is 15 to 50 percent for most seawater desalination plants. For every 100 litres of seawater, 15 to 50 litres of pure water would be produced along with brine water containing dissolved solids. The recovery of freshwater varies from plant to plant, partly because plant operations depend on site-specific conditions. In several locations, a small pilot project is proposed first to test plant operations before a full-scale plant is installed. Table 3 illustrates typical power requirements for commercially available RO systems. The figures refer to brackish water with 2 000 ppm and seawater with 35 000 ppm of sodium chloride and an operating temperature of 25 °C. For every 1 °C below 25 °C, efficiency drops by 3 percent. Figure 6 shows a 1 000 $m^3$/day RO assembly.

TABLE 3
**Typical characteristics of RO systems**

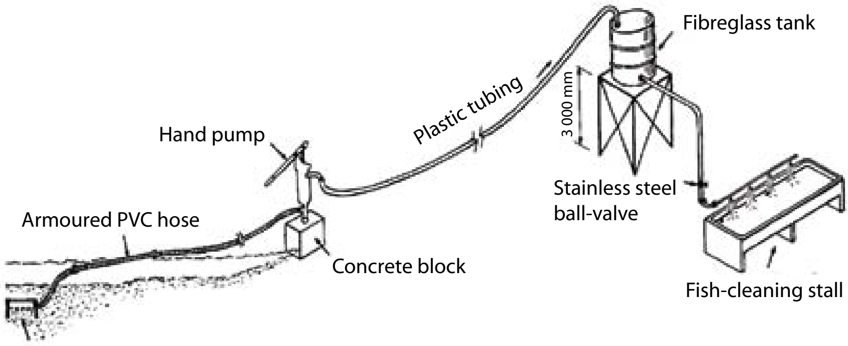
| Feedwater | Operating pressure (bar) | Power requirement (kW) | Water production (cubic metres per day) |
|---|---|---|---|
| Brackish | 45 | 5.0 | 12.50 |
| Brackish | 45 | 5.5 | 25.10 |
| Brackish | 45 | 5.8 | 37.60 |
| Brackish | 45 | 6.8 | 50.10 |
| Brackish | 45 | 11.0 | 100.20 |
| Seawater | 56 | 9.8 | 17.10 |
| Seawater | 56 | 18.2 | 45.60 |
| Seawater | 56 | 37.1 | 91.20 |
| Seawater | 56 | 59.5 | 136.80 |

FIGURE 6
**A 1 000 m³/day RO assembly (courtesy Graham Tek PTY)**

### *11.1.2.5 Raw seawater*

Raw seawater may be drawn off a beach using a sandbox drain or via a proper bore well (Figures 7 and 8).

FIGURE 7
**An artisanal raw seawater supply**

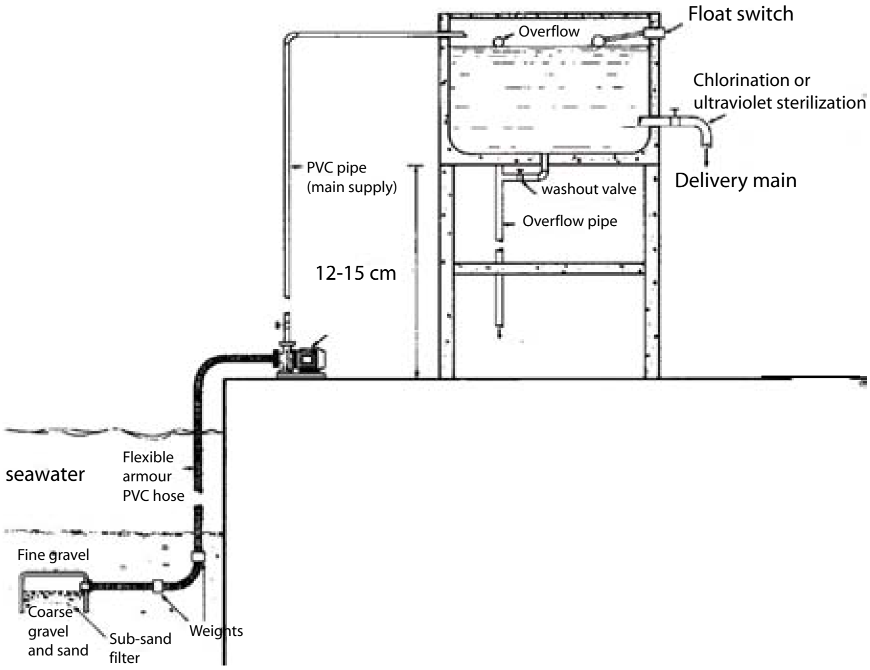



## 11.1.3 Sterilization

A town's water mains would normally supply chlorinated water and hence no extra sterilization precautions would be needed. However, all water derived from augmentation schemes (rainwater harvesting, groundwater bore wells, desalinated water and raw seawater) needs to be sterilized prior to being pumped into storage as a safeguard against pathogenic bacteria. Chlorine has been found to be the most satisfactory chemical for this purpose. The efficiency of chlorine for disinfection purposes depends upon the following six factors:

- The nature of the organisms to be destroyed, their concentration and condition in the water to be disinfected.
- The nature and concentration of the disinfectant employed in terms of the products that it releases when it comes into contact with water.
- The nature of the water to be disinfected. Suspended matter shelters embedded organisms against chemical disinfection.
- The ambient temperature of the waterbody. The higher the temperature, the more rapid the disinfection.

FIGURE 8
**A mechanized raw seawater supply**




- The time of contact. The longer the time, the greater will be the extent of disinfection.
- The pH value of the water. Lower pH values require smaller contact period to kill the same percentage of organisms.

Commercially available automatic chlorinators (Figure 9) utilize a wide range of disinfectants, such as elemental chlorine (chlorine gas in a cylinder), calcium hypochlorite and hypochlorous acid.

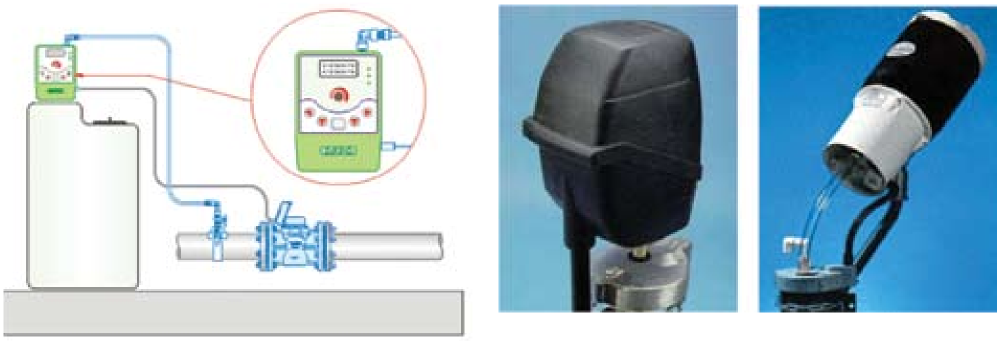
The percentage of available chlorine in the most common compounds is:

| Compound | Chemical composition | % chlorine by weight |
|---|---|---|
| Chlorine gas | $Cl_2$ | 100.0 |
| Hypochlorous acid | HOCl | 135.4 |
| Calcium hypochlorite | $Ca(OCl)_2$ | 99.2 |

From the above it is evident that elemental chlorine or pure chlorine gas is the most efficient disinfectant in terms of weight considerations. The disadvantage, however, is that a gas chlorinator requires a steady supply of chlorine gas cylinders which may pose supply and logistics problems. Calcium hypochlorite is also efficient but comes in powder or tablet form. Hypochlorous acid is in liquid form and is traditionally utilized in small, inexpensive chlorinators.

Dissolved chlorine remains as a residual in treated water and is a safe check against bacteria. Residual chlorine levels should be between 0.05 to 0.20 ppm (parts per million).

FIGURE 9
**Liquid chlorinator (courtesy Oppo) and pellet chlorinators (courtesy G.E.)**



### 11.1.4 Storage

Water storage on site may consist of one of a number of solutions, depending on the quantity of water to be stored. Table 4 shows the recommended water storage structures and Figures 10, 11 and 12 show examples of those structures.

## 11.2 ICE SUPPLY AND STORAGE

The first step in planning ice production is to confirm whether an ice plant is actually required inside the port area. Other ice plants in town may be a reliable source of suitable ice and, even with the additional transport cost, they may still be more competitive. Ice may be produced in blocks of 50 kilograms or less, in flakes, in tube form and plate form. Other than by description of the ice produced, there is no simple way to classify the different types of ice.

TABLE 4
**Recommended water storage structures**

| Stored capacity | Recommended structure |
|---|---|
| Up to 5 cubic metres | Interconnected 1 cubic metre plastic drums, sometimes used as header tanks, gravity feed, suitable for artisanal landings |
| Up to 10 cubic metres | Low-density polyethylene tanks, gravity feed or pumped feed |
| Up to 100 cubic metres | Reinforced concrete water tower or steel modular tanks, gravity feed |
| Over 100 cubic metres | Above or below ground reinforced concrete reservoirs |

FIGURE 10
**Interconnected HDPE 5 m³ tanks and 50 m³ elevated concrete tank**

FIGURE 11
**Modular steel tanks, elevated (top) and at ground level (bottom)**

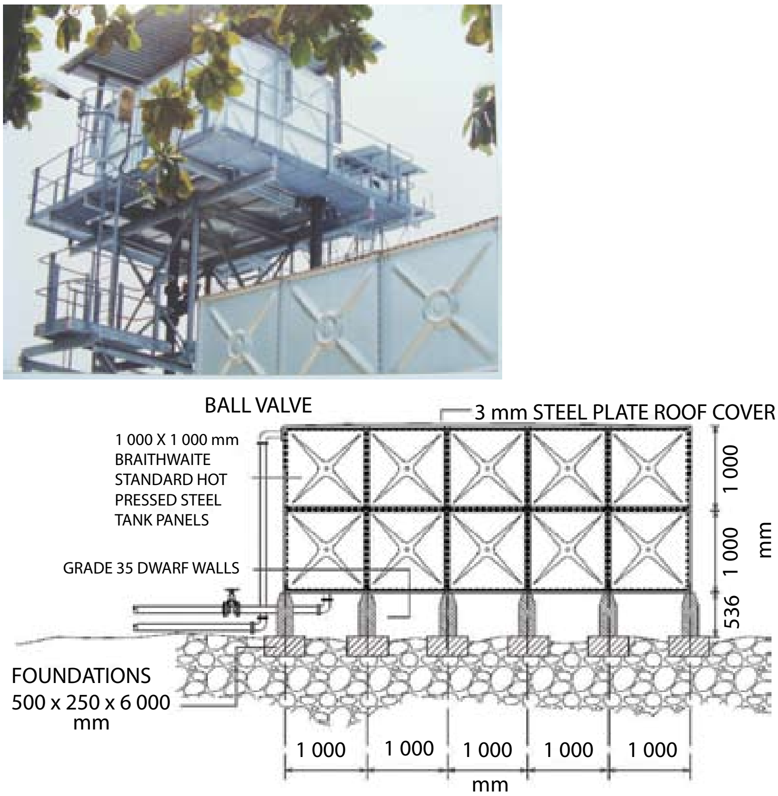
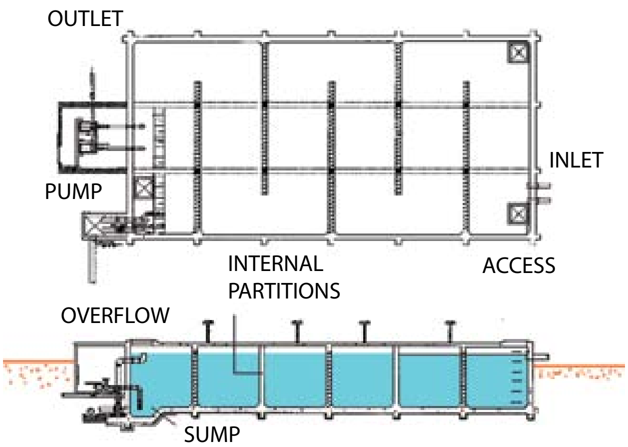



FIGURE 12
**Underground reservoir in reinforced concrete, plan (top) and section**




### 11.2.1 Refrigerants

The Montreal Protocol on Substances That Deplete the Ozone Layer is an international treaty designed to protect the world's ozone layer by phasing out the production of a number of substances believed to be responsible for ozone depletion. Table 5 shows the environmental characteristics of industrial refrigerants. Chlorofluorocarbons (CFCs) are used as refrigerants in some refrigeration systems. CFCs are considered to be 100 percent ozone depleting, meaning that they are the standard for efficiency in the catalytic breakdown of ozone. Trichlorofluoromethane, commonly known as

Freon 11, was for a time utilized extensively as a refrigerant. Its production has been halted in line with the Montreal Protocol because of its role in the destruction of atmospheric ozone.

TABLE 5
**Environmental characteristics of industrial refrigerants**

| Refrigerant | Type | Ozone depletion potential | Global warming potential |
|---|---|---|---|
| R-11 | CFC[1] | 1.0 | 1.0 |
| R-12 Freon | CFC | 1.0 | 2.1 |
| R-22 Freon | HCFC[2] | 0.05 | 0.43 |
| R-142b | CFC | 0.06 | 0.46 |
| R-32 | HFC[3] | 0 | 0.14 |
| R-125 | HFC | 0 | 0.71 |
| R-134a | HFC | 0 | 0.34 |
| R-500 | CFC | - | - |
| R-503 | CFC | - | - |
| Ammonia | - | 0 | 0 |
| R-404a | HFC | 0 | 0 |

[1] **CFC** = Chlorofluorocarbon.
[2] **HCFC** = Hydrochlorofluorcarbon.
[3] **HFC** = Hydrofluoorocarbon.

In many refrigeration systems R-22 or Freon, a hydrochlorofluorocarbon (HCFC), is utilized. HCFCs are considered to be only 5 percent ozone depleting and are less of a danger to the ozone layer. However, non-ozone layer depleting refrigerants are the most desirable. The refrigerants with the required characteristics under the Montreal Protocol are ammonia and R-404a, both with a zero ozone depleting and global warming potential. R-404a is an HCFC and consists of a blend of 52 percent R-143a, 44 percent R-125 and 4 percent R-134a and is designed as a replacement for R-22 Freon. Ammonia is not as popular due to the danger of inhalation of toxic fumes in case of leakage. However, the port planner should take into consideration agreements made by his or her government under the schedule for phasing out HCFC since the requirements differ for developed and developing countries.

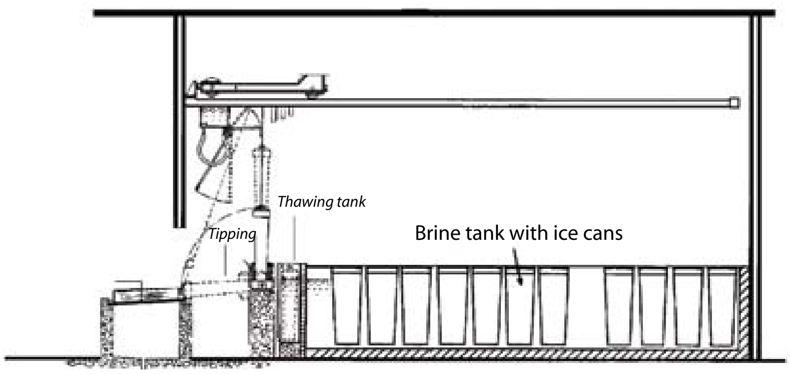
### 11.2.2 Block ice

The traditional block ice factory makes ice blocks in steel cans which are submerged in a tank containing circulating refrigerated sodium or calcium chloride brine. The dimensions of the can and the temperature of the brine are usually selected to give a freezing period of between 8 and 24 hours. Too rapid freezing results in brittle ice. The block weight can vary from 12 to 150 kilograms, depending on requirements; 150 kilograms is considered the largest size of block one man can conveniently handle. Blocks less than 150 mm thick are easily broken and a thickness of 150 mm to 170 mm is preferable to prevent the block from toppling. The size of the tank required is related to the daily production. A travelling crane lifts a row of cans and transports them to a thawing tank at the end of the freezing tank, where they are submerged in water to release the ice from the moulds.

The cans are then tipped to remove the blocks, refilled with freshwater and replaced in the brine tank for a further cycle. This type of plant often requires continuous attention and a shift system is operated by the labour force which may be 10 to 15 workers for a 100 tonne/day plant. Block ice plants require a good deal of space and labour for handling the ice. The latter factor has been the main reason for the development of modern automatic ice-making equipment. Block ice still has a use, and sometimes an advantage, over other forms of ice in tropical countries. Storage, handling and transport can all be simplified if the ice is in the form of large blocks; simplification

is often obligatory in small-scale fisheries and in relatively remote situations. With an appropriate ice-crushing machine, block ice can be reduced to any particle size, Figure 13, but the uniformity of size will not be as good as that achieved with some other forms of ice, particularly flake ice. In some situations, block ice may also be reduced in size by a manual crushing method. The rapid block ice plant can produce blocks in only a few hours and this means that the space requirements are considerably reduced compared with a conventional block ice plant. Block sizes vary with 25, 50 and 150 kilograms each being typical. In one type of machine, the relatively quick freeze is obtained by forming the block in a tank of water, around tubes through which the refrigerant is circulated. The effective thickness of ice to be frozen is a good deal less than in a conventional block ice plant. The tubes are arranged so that as the ice builds up it fuses with the ice on adjacent tubes to form a block with a number of hollow cores. These blocks are released from the tubes by a defrost procedure and they can then be harvested automatically from the surface of the tank.

FIGURE 13
**Cross-section of a block ice plant and block ice crushers in use (top). Both the ice cans and the ice crushers should be in stainless steel**




Some manual effort is required for storage or feeding to a breaker if the ice is required in the crushed form. In another type of rapid ice machine, the refrigerant is circulated through a jacket around each can of water and also through pipes running through the centres of the cans. Ice then forms simultaneously both at the outside and at the centre of the can. After a hot gas defrost, blocks are then removed by gravity. An advantage of a rapid block ice plant is that it can be stopped and started in a relatively short time, since there is no large tank of brine to be cooled initially as in the conventional block ice machine in which the refrigeration system is often kept in continuous operation even when ice production has ceased.

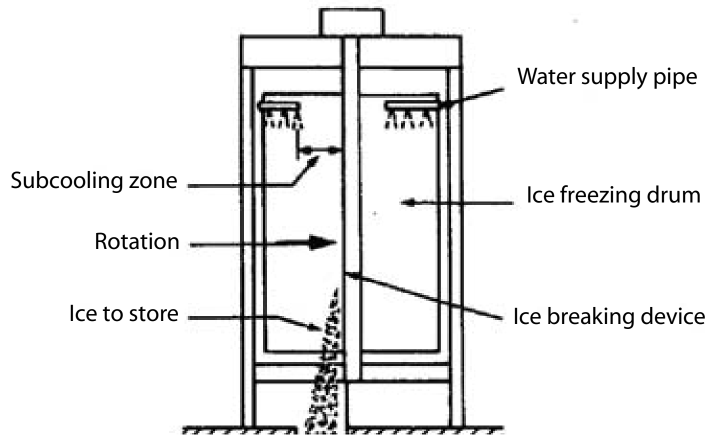
### 11.2.3 Flake ice

This type of machine forms ice 2 mm to 3 mm thick on the surface of a cooled cylinder and the ice is harvested as dry subcooled flakes usually 100 mm to 1 000 mm$^2$ in area (Figure 14). In some models, the cylinder or drum rotates and the scraper on the outer surface remains stationary. In others, the scraper rotates and removes the ice from the surface of a stationary drum, in this case, built in the form of a double-walled cylinder. It is usual for the drum to rotate in a vertical plane but in some models the drum rotates in a horizontal plane. One distinct advantage of the rotating drum method is that the ice-forming surfaces and the ice-release mechanism are exposed and the operator can observe whether the plant is operating satisfactorily. The machine with the stationary drum has the advantage that it does not require a rotating seal on the refrigerant supply and take-away pipes.

However, this seal has been developed to a high degree of reliability in modern machines. The ice is subcooled when harvested, the degree of subcooling depending on a number of factors but mainly the temperature of the refrigerant and the time allowed for the ice to reach this subcooled temperature. The subcooling region of the drum is immediately before the scraper where no water is added for a part of the drum's rotation and the ice is reduced in temperature. This ensures that only dry subcooled ice falls into the storage space immediately below the scraper. The refrigerant temperature, degree of subcooling and speed of rotation of the drum are all variable with this type of machine and they affect both the capacity of the machine and the thickness of the ice flakes produced. Other factors such as ice make-up water temperature also affect the capacity of the machine. Thus, the optimum operating conditions will depend on both the local conditions and the thickness of ice preferred. The normal refrigerant temperature in a flake-ice machine is -20 to -25 °C, a good deal lower than in other types of ice makers. The low temperature is necessary to produce higher ice-making rates, thus keeping the machine small and compact. The extra power requirement resulting from operating with a lower temperature in the ice maker is somewhat compensated for by the fact that the method does not require defrosting. There is, therefore, no additional refrigeration load incurred by the method of releasing the ice from the drum.

The range of unit sizes for this type of machine now extends from units with a capacity of 0.5 to 60 tonnes/24 hours. However, rather than use a single unit, it is often expedient to use two or more. This gives a better arrangement for operating at reduced capacity and also provides some degree of insurance against complete breakdown. This advice is also applicable to other types of automatic ice makers. Flake-ice plants have

FIGURE 14
**A flake-ice machine**



the added advantage that they may be placed at the water's edge and the ice loaded directly into fishing vessels (Figure 15).

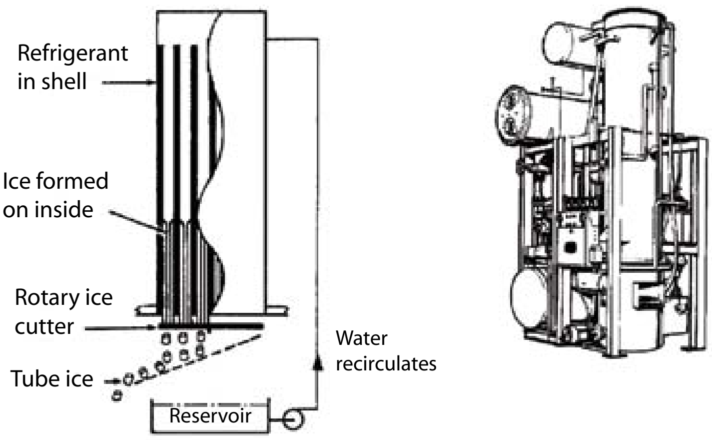
FIGURE 15
**Typical flake-ice plants located at the water's edge**

### 11.2.4 Tube ice

Tube ice is formed on the inner surface of vertical tubes and is produced in the form of small hollow cylinders of about 50 mm x 50 mm with a wall thickness of 10 mm to 12 mm (Figure 16). The tube-ice plant arrangement is similar to a shell and tube condenser with the water on the inside of the tubes and the refrigerant filling the space between the tubes. The machine is operated automatically on a time cycle and the tubes of ice are released by a hot gas defrost process. As the ice drops from the tubes a cutter chops the ice into suitable lengths, nominally 50 mm, but this is adjustable. Transport of the ice to the storage area is usually automatic, thus, as in the flake-ice plant, the harvesting and storage operations require no manual effort or operator attendance. Tube ice is usually stored in the form it is harvested, but the particle size is rather large and unsuitable for use with fish. The discharge system from the plant therefore incorporates an ice crusher which can be adjusted to give an ice particle size to suit the customer's requirement. The usual operating temperature of this type of plant is -8 °C to -10 °C.

The ice will not always be subcooled on entering the store but it is usually possible to maintain the store at -5 °C since the particle size and shape allow the ice to be readily broken up for discharge, especially with a rake system.

FIGURE 16
**Tube-ice machine (schematic and actual shape)**



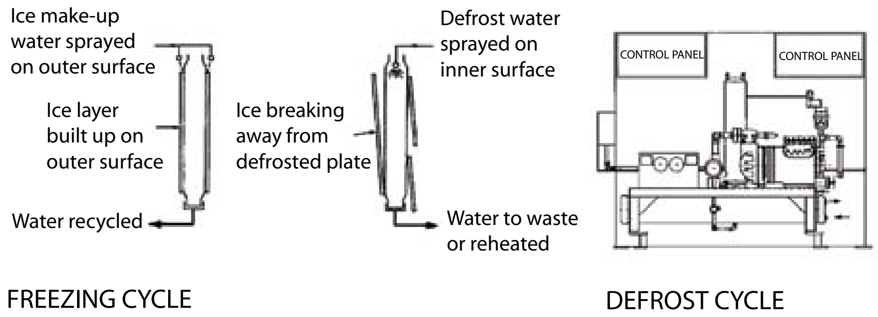
### 11.2.5 Plate ice

Plate ice is formed on one face of a refrigerated vertical plate and released by running water on the other face to defrost it. Other types form ice on both surfaces and use an internal defrost procedure (Figure 17).

Multiple plate units are arranged to form the ice-making machine and often these are self-contained units incorporating the refrigeration machinery in the space below the ice maker.

The optimum ice thickness is usually 10 mm to 12 mm and the particle size is variable. An ice breaker is required to break the ice into a suitable size for storage and use. Water or defrost requires heating if its temperature is less than about 25 °C; below this value the defrost period is too long, resulting in a loss in capacity and an increase in cost. This machine, like the tube-ice machine, operates on an automatic timed cycle and the ice is conveyed to the storage area, or if the machine can be located directly above the storage space harvesting can be achieved using gravity flow.

FIGURE 17
**Plate-ice machine (schematic and actual shape)**




### 11.2.6 Ice and space requirements

Table 6 presents the approximate ice requirements for various activities.

The on-board figures may be reduced by 30 to 50 percent if the hold is refrigerated. The space requirement for machinery depends largely on the type of plant. Modern ice makers are compact compared with conventional block ice plants, but a direct comparison of the space requirements of the various types cannot be readily made. The capacity varies with the operating conditions and it is usual to quote a capacity range when referring to ice-manufacturing capabilities. Some types of plants are more suited to high rates of production than others and are made in large units whereas others are made in small unit sizes only. Table 7 gives some idea of the space requirements for a number of the more widely-used types of ice makers, producing 50 tonnes of ice per day.

TABLE 6
**Ice requirements**

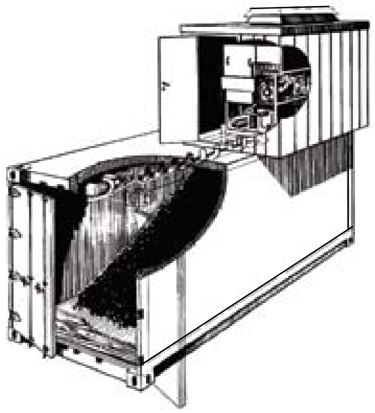
| Activity | Quantity required |
|---|---|
| On-board, trip greater than 1 week | 1.0 tonne of ice per 2 tonnes of fish (temperate waters) |
| On-board, trip less than 1 week | 0.7 tonne of ice per 2 tonnes of fish (temperate waters) |
| On-board, short duration | 1.0 tonne of ice per 1 tonne of fish (tropical waters) |
| Auction hall, repacking | 1.0 tonne of ice per 1 tonne of fish (hot waters) |

TABLE 7
**Typical space requirements**

| Type of ice plant | Output (tonne/24 hours) | Floor space ($m^2$) | Height (m) |
|---|---|---|---|
| Block ice | 50 | 190.0 | 5.0 |
| Rapid ice block | 50 | 30.0 | 3.5 |
| Plate | 50 | 15.0 | 1.8 |
| Tube ice | 50 | 3.3 | 6.6 |
| Flake ice | 50 | 2.7 | 3.7 |

The space requirements given in Table 7 are for the ice maker only. Since the ice maker is comparatively compact in modern types of plants (plate, tube and flake ice), the requirements for refrigeration machinery and handling and storage space are far in excess of the above figures. Like most machinery of this type there is an effect of scale, with larger sizes generally requiring less space per unit of ice-making capacity. In some plants it is also possible to stack the units over-and-under and both floor space and height can be varied to suit individual requirements, especially if the plant is installed at the water's edge to discharge directly into vessel holds, Figure 15. Self-contained units with a rating of up to 10 to 20 tonnes/24 hours can be located within the floor space required for storage, with the ice maker and refrigeration equipment on top, Figure 18.

FIGURE 18
**Containerized ice maker and store**



## 11.2.7 Ice storage

Ice manufacture and demand rates are seldom in phase. Storage is therefore necessary to ensure that the plant caters for peak demand. Storage allows the ice maker to be operated 24 hours per day. It also acts as a buffer against any interruption to the ice supply due to minor breakdowns and routine maintenance procedures.

TABLE 8
**Typical storage parameters for ice**

| Type of ice | Floor space $m^2$/tonne |
|---|---|
| Flake ice | 2.2–2.3 |
| Tube ice | 1.6–2.0 |
| Crushed blocks | 1.4–1.5 |
| Plate ice | 1.7–1.8 |

Therefore, a potential buyer should calculate the storage capacity necessary to satisfy the above requirements (Table 8). Account should be taken of both short-term and seasonal variations and also variations in the capacity of the ice maker. Peak demand for ice in the warmer seasons also coincides with adverse plant operating conditions when make-up water and condenser cooling water temperatures are higher. There is no general rule for estimating ice-storage capacity requirements. This is normally done by plotting the likely pattern of ice production and ice usage over a period of time, and selecting a storage capacity which will ensure that ice will be available at all times. In most cases, ice-storage capacity is never less than twice the daily rate of production and more usually it is four or five times this value. Storage space requirements for different types of ice vary in relation to their bulk density. Although flake ice requires more storage space for a given weight, this subcooled ice can be stored to a greater depth in a silo, thus floor space requirements will be much the same as for more compact types of ice.

Silo storage is generally used with a free-flowing subcooled ice such as flake ice and, in order to be effective, it must have an independent cooling system to maintain the ice in this subcooled condition. The cooling is usually by means of an air cooler in the jacket space between the silo and the outer insulated structure. The air cooler is normally placed at the top of the jacket space adjacent to the ice maker and the air space is cooled by gravity or fan circulation. Ice is collected by gravity flow with the aid of a chain agitator which scrapes the ice from the walls of the silo. The silo allows for a first-in-first-out (FIFO) system of storage but, if the storage space is not cleared periodically, only the central core of ice is used, leaving a permanent outer wall of compacted ice. An access hatch should therefore be provided at the top of the silo so that a pole can be inserted to collapse the outer wall of ice into the central core at least once daily. Silo storage is expensive for small quantities of ice and although units are made for as little as 10 tonnes, this method of storage is more suited for storing 40 to 100 tonnes of ice.

Bin storage may mean anything from a box holding no more than 500 kilograms to a large installation of 1 000 tonnes or more. Bin storage can be used for any type of ice and may incorporate a separate cooling system. Whatever the size of system used, ice storage should always be within an insulated structure since the saving made by reducing ice melt, particularly in warmer climates, is always worth the extra cost of the insulation. An insulation thickness of 50 mm to 75 mm of polystyrene is suggested. Small bins may be arranged with the ice maker above the storage space; the bin is filled by gravity and a FIFO system is operated by removing the ice at a low level. This simple bin system is suitable for processors making and using their own ice, such as that in Figure 18. Large bins require considerable floor space because the recommended maximum depth of storage is limited to about 5 metres, due to the fact that excessive storage depth increases pressure and results in fusion of the ice. A large-capacity storage bin will require a mechanical unloading system.

### 11.2.8 Ordering an ice plant

The general rule when ordering an ice plant is that the buyer should supply as much information as possible. The more facts the buyer supplies, the easier it will be for ice-plant manufacturers to submit competitive tenders which can be compared on a common basis. At this stage of planning, some decisions should have been made and specific instructions given on such things as type of ice required, site location, building layout and services available. The following is a checklist of the information the buyer should provide when ordering an ice plant, and Tables 9, 10, 11 and 12 provide useful information for decision-making.

Main purpose for which ice is intended:

- type of ice required (block, flake, tube, plate, freshwater, seawater ice, etc.);
- ice production capacity (tonnes of ice/24 hours); and
- local maximum ambient temperature and humidity or exact location of plant.

Information on ice make-up water:

- purity (details of hygienic quality, hardness, etc.);
- temperature range (°C); and
- pressure ($kg/cm^2$).

Information on condenser cooling water:

- type available (tap, well, river, sea, etc., with details of quality);
- quantity available;
- cost;
- temperature range; and
- pressure.

Information on electricity supply:
- reliability;
- voltage;
- frequency (Hz);
- phase;
- maximum installed power (kW);
- maximum starting current allowable; and
- details of separate power source if required, generator, direct drive, engine, etc.

General characteristics:
- refrigerant preferred (ammonia);
- ice-storage capacity (tonnes of ice or m³);
- type of storage preferred (silo, bin, bin with mechanical unloading of ice);
- whether a prefabricated or site-built store is required;
- preferred method of discharging ice (gravity, rake, bucket or screw);
- rate of discharge required (tonnes of ice/hours); and
- details, with sketch, of any existing plant and store buildings.

TABLE 9

**Weight of ice needed to chill 10 kilograms of fish to 0 °Celsius**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Starting temperature of fish (in °C)** | 5 | 10 | 15 | 20 | 25 | 30 |
| **Weight of ice required (kg)** | 0.7 | 1.3 | 1.9 | 2.5 | 3.1 | 3.8 |

TABLE 10

**Effect of temperature on ice production**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Ice make-up water temperature (in °C)** | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 |
| **Ice production (in tonnes)** | 4.3 | 4.2 | 4.0 | 3.9 | 3.8 | 3.7 | 3.6 | 3.5 |

TABLE 11

**Energy consumption in ice production**

| Type of ice | Energy consumption (kWh/tonne) | Energy consumption (kWh/tonne) |
|---|---|---|
| | **Temperate climate** | **Tropical climate** |
| Flake ice | 50–60 | 75–85 |
| Tube ice | 40–50 | 55–70 |
| Block ice | 40–50 | 55–70 |

TABLE 12

**Useful constants**

| | |
|---|---|
| Density of freshwater at 15 °C | 1 kg per litre |
| Density of seawater 0 °C – salinity of 3.5% | 1.027 kg per litre |
| Latent heat of fusion | 80 kcal/k freshwater<br>77-80 kcal seawater |
| Freezing point of seawater – salinity of 3.5% | -1.9 °C |
| 1 horsepower | 0.736 kW |
| 1 kcal/h | 1.163 kW |

## 11.3 REFUELLING

### 11.3.1 Design

Fuel and oil are the commonest constituents of water pollution and this is due to either incorrect storage methods or improper handling of fuel at the quay side. Safety, security, access and maintenance needs should all be considered when designing fuel and oil storage facilities, irrespective of size. Table 13 shows the characteristics of common fuels.

TABLE 13
**Characteristics of common fuels**

| Product | Specific gravity |
|---|---|
| Diesel | 0.83–0.86 |
| Kerosene | 0.77–0.84 |
| Petrol | Volatile at ambient temperature |

Ideally, fuel should not be stored in significant risk locations (that is, within 10 metres of a quay or watercourse or 50 metres of a well or borehole).

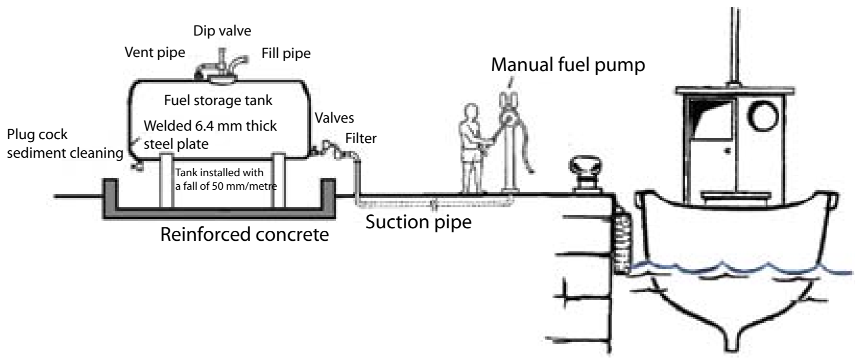
Fuel should be stored in a tank of sufficient strength, shape and structural integrity to ensure that it is unlikely to burst or leak in ordinary use. The tank or tanks should be in steel and above ground. Figure 19 shows an artisanal refuelling facility. For facilities up to 10 000 litres, Figure 20, consideration should be given to prefabricated proprietary tanks tested to a recognized standard and produced to that standard under a quality assurance system. Larger facilities should be in custom-welded tanks, Figure 21, installed by technicians registered within a professional scheme, Figure 22.

Secondary containment should be provided to prevent fuel escaping to the environment in the event of leakage from the tank or ancillary equipment, Figure 19. All tanks and their ancillary equipment should be situated within an oil-tight secondary containment system such as a bund. The potential escape of fuel beyond the bund area by jetting can be minimized by keeping the primary container as low as possible and increasing the height of the bund wall.

The secondary containment structure should be impermeable to fuel and water and there should be no direct outlet to any drain, sewer or watercourse. The oily water collected from inside the secondary containment must be treated via an oily water separator before being discharged into a sewer or watercourse. The secondary containment system must provide storage of at least 110 percent of the tank's maximum capacity. If more than one container is stored, the system must be capable of storing 110 percent of the biggest container's capacity or 25 percent of their total capacity, whichever is the greater. The 10 percent margin is intended to take into account a range of factors. These include:

- loss of the total contents, for example, due to vandalism;
- sudden tank failure;
- overfilling;
- containment of fire-fighting agents;
- overtopping caused by surge following tank failure; and
- an allowance for rainwater in the bund.

FIGURE 19
**An artisanal refuelling facility**



Any valve, filter, sight gauge, vent pipe or other ancillary equipment should be situated within the secondary containment system and arranged so that any discharges of oil are contained. A filter or isolating valve fitted in a gravity feed to protect the draw-off pipe or downstream equipment is not considered to be ancillary to the container. These should be located within the secondary containment. To prevent the risk of the tank contents draining from a leak in a gravity-feed system, the outlet should be a top draw-off pipe.

A security fence with controlled access should be constructed around the fuel tank if the secondary containment bund is too low.

All pipework should be properly supported and should be sited above ground to make inspection and repair easier. Fill pipes, draw-off pipes and vent pipes should be positioned away from any vehicle traffic to avoid collision damage. Pipework should be adequately protected against corrosion. Underground pipework should be clearly marked and adequately protected from physical damage such as that caused by excessive surface loading or ground disturbance. If mechanical joints have to be used, they should be readily accessible for inspection under a manhole cover. Underground pipework should have adequate facilities for detecting leaks. Continuous leak detection devices should be maintained in working order and tested at appropriate intervals.

Work areas should be illuminated to the minimum intensity required by national legislation.

Tanks, pipes, fences, canopies, motor cabinets, transformers, generators, metallic switchgear panel boards and all other exposed conductive items should be grounded to protect them against fault current and lightning.

FIGURE 20
**Prefabricated proprietary fuel tanks**

FIGURE 21
**Custom-designed facility in cross-section**

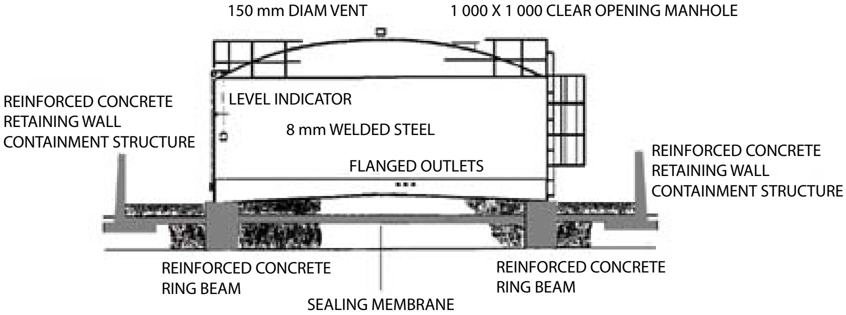


FIGURE 22
**Typical 100-tonne facilities**

Marine refuelers or fuel dispensers, Figure 23, should have a flow rate of between 100 to 300 litres per minute depending on the type of vessels calling at the port. They should be positioned to minimize the risk of collision damage, be fitted with a non-return valve in the feed line and protected from unauthorized use. Roadside fuel pumps or gravity-fed mobile tanks, Figure 24, are not suitable for vessels requiring in excess of 100 litres fuel. Figure 25 shows examples of improper storage of fuel.

FIGURE 23
**Marine refuelers with a flow rate of 300 litres/minute**

FIGURE 24
**Unsuitable fuel pumps for trawlers (flow rate 40 litres/minute)**

FIGURE 25
**Examples of improper storage of fuel**

## 11.4 POWER AND LIGHTING

### 11.4.1 Introduction

When designing a new port or upgrading an existing facility, the first step in the electrical engineering design process should be the energy audit. An energy audit is required to calculate the power requirements of the port. Briefly, the power requirements may range from a few kilowatts for an artisanal landing to several hundred kilowatts for a medium-sized fishing harbour complete with ice-producing facilities and cold storage. Power may be required for:

- water extraction (borehole pumps) and storage (header tank pumps);
- ice production facilities;
- cold storage (chill rooms and cold stores);
- slipway winch;
- workshop equipment;
- hygiene facilities if hot water showers are provided;
- lighting and security;
- commercial outlets, if present on site; and
- cathodic protection of immersed steel structures when present.

The energy audit should be followed by a breakdown of the power sources to be tapped in relation to their carbon footprint. The carbon footprint of a port is the total set of greenhouse gas emissions, caused directly and indirectly, expressed as $CO_2$ equivalent. In the case of port operations, both direct and indirect greenhouse gas emissions are of concern. This encompasses direct emissions from any standby generators inside the port as well as emissions from vessel engines. The indirect emissions cover the electricity usage to run lighting, heating, cooling and powering of equipment inside the port.

Solar photovoltaic (PV) panels are suitable for water extraction and storage, office equipment and all lighting needs inside the port, and solar water heaters are suitable for providing hot water in showers. The rest of the equipment requires a disproportionately large amount of energy and should be sourced from the mains supply.

Micro-wind turbines may also be used in conjunction with solar PV panels to augment the charging of batteries if the local annual average wind speed is 6 m/s or more.

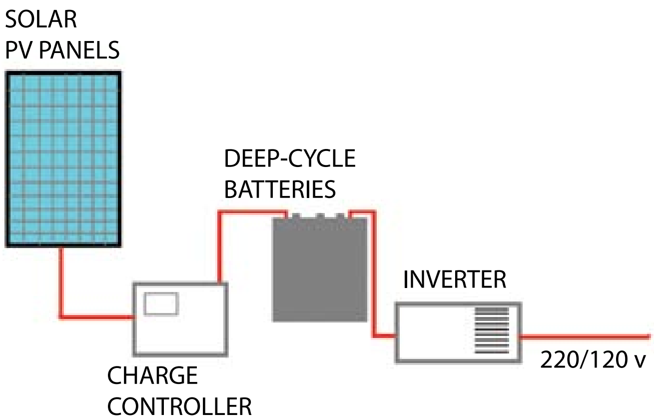
Generators should only be installed as a backup to the mains supply or a solar PV system (to charge batteries during long overcast spells) and never as the primary source of power, especially for ice production. In many remote areas, generator spares, maintenance and fuel logistics render the whole operation unsustainable.

### 11.4.2 Photovoltaic systems

Photovoltaic (PV) systems use cells to convert solar radiation into electricity. The PV cell consists of one or two layers of a semiconducting material, usually silicon. When light shines on the cell it creates an electric field across the layers, causing electricity to flow; the greater the intensity of the light, the greater the flow of electricity.

PV systems generate no greenhouse gases and now come in a variety of shapes and colours, ranging from grey "solar tiles" that look like roof tiles, to panels and transparent cells that can be used to provide shading as well as generating electricity. If the roof surface is in shadow for parts of the day, the output of the system decreases. Solar panels are heavy and the roof must be strong enough to support their weight, especially if the panel is placed on top of existing trussed roofs with light galvanized sheeting. Solar PV installations should always be carried out by a trained and experienced installer. The average cost of a PV system at 2009 prices is approximately US$8 000 per kW of power installed. This figure can vary according to the geographical latitude (insulation coefficient) and number of days of sunshine per year for a particular site. Expert advice is required when dimensioning PV systems.

FIGURE 26
**The four primary components for producing solar electricity**




The four primary components for producing electricity using solar power are the solar PV panels, the charge controller, storage batteries and the inverter, Figure 26. The PV panels charge the battery, the charge controller ensures proper charging of the batteries and the converter converts the output to 220 or 120 V in alternating current.

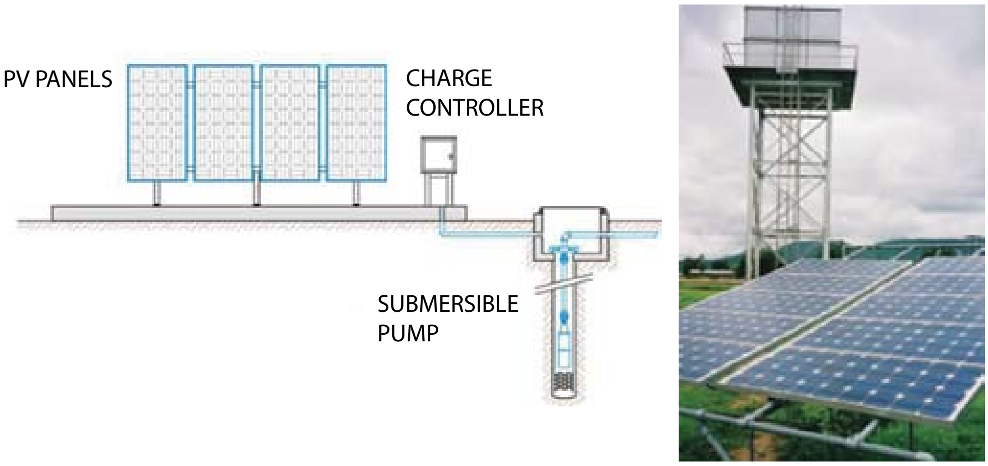
#### *11.4.2.1 Water supply systems*

Solar-powered water pumps typically consist of a PV array connected directly to an electric motor via a charge controller. The water is pumped into an overhead storage tank that provides a gravity feed for the entire port area, Figure 27. There are two basic types of solar pumping systems:

- lower-flow deep-well direct current submersible pumps; and
- higher yield alternating current surface pumps.

Solar pumps are equally suited to any off-grid application, whether as a stand-alone system or part of an off-grid energy solution.

FIGURE 27
**Solar-powered water supply**




### *11.4.2.2 Lighting systems*

Solar-powered lights, both wired indoor systems and autonomous outdoor systems, are also commercially available worldwide.

Typical indoor lighting systems consist of roof-mounted PV panels feeding a four-component circuit like the one illustrated in Figure 26. An independent indoor circuit then distributes the power to all the light fittings inside the building. The light fittings may be of the energy-saving type or LED units.

Typical outdoor systems are fully independent, stand-alone systems. They consist of flat PV panels mounted above the luminaire and the maintenance-free gel battery as illustrated in Figure 28. All fittings are in aluminium and stainless steel and, when mounted on timber piles, they are ideal for port applications (no corrosion potential). No cables are required.

FIGURE 28
**A 2.50 kW array for office lighting and solar-powered outdoor lighting**

## 11.4.3 Wind-powered systems

Small-scale wind-powered systems are particularly suitable for remote off-grid locations where conventional methods of supply are impractical. Most small wind turbines generate direct current electricity, which may be used to top-up the charge in the batteries during long overcast spells but only if the local annual average wind speed is 6 m/s (metres per second) or more. Wind power is proportional to the cube of the wind speed, so relatively minor increases in speed result in large changes in potential output. Individual turbines vary in size and power output.

The electricity generated at any one time by a wind turbine is highly dependent on the speed and direction of the wind and the wind speed itself is dependent on a number of factors, such as location, height of the turbine above ground level and nearby obstructions. Ideally, a professional assessment of the local wind speed for a full year at the exact location of the port should be undertaken. Wind speed increases with height, so it is best to have the turbine high on a mast or tower. Generally speaking, the ideal siting is a smooth flat coastline with clear exposure, free from excessive turbulence and obstructions such as large trees or other buildings.

Systems up to 1 kW will cost around US$2 000 at 2009 prices whereas larger systems in the region of 2.5 kW to 6 kW would cost between US$12 000 to US$22 000 installed, inclusive of the turbine, mast, inverters, battery storage (if required) and installation. Final costs, however, depend on location and the size and type of system. Turbines can have a useful life of up to 22.5 years but require service checks every few years to ensure they work efficiently.

### 11.4.4 Generators

Diesel-powered electric generators are very dependable, have good efficiency ratings, simple maintenance and relatively low capital cost for small ratings. Generators can supply two kinds of power: standby power (for continuous electrical service during interruption of normal power) and prime power (for continuous electrical service).

As a general rule, generators should not be installed as prime power but only as standby power to a grid or solar PV supply. Experience has demonstrated that the spares and fuel logistics for remote sites renders generators unreliable as prime sources of power. The fuel consumption ranges from 0.20 to 0.30 kg/kWh.

## 11.5 BUILDINGS

Buildings are required within the port boundary to house the different operations required to make the fishing port functional. Typically, the following buildings are required:

- administration building;
- market or sorting hall;
- cold storage (chill rooms and cold stores);
- hygiene facilities;
- ancillary buildings (workshop, crate washing facility, guardhouse, generator room, pump room, winch room, gear stores, food stalls, restaurants, etc.); and
- fishermen's rest and net repair platforms.

### 11.5.1 Designing for durability

As a general rule, all buildings should conform to the national architectural and sanitary standards, irrespective of the size of the port. However, due to the aggressive nature of the salty environment in and around a port or fisheries landing, buildings should be designed for durability by:

- specifying higher grades of concrete than normal in columns, beams and foundations (Grade 35 minimum recommended);
- using special admixtures in the external rendering to make it resistant or impervious to sea spray or salt;
- avoiding the use of untreated mild steel in external applications, see Chapter 9 for more details;
- preventing galvanic corrosion by avoiding dissimilar metals from coming into contact (screws holding fittings should be of the same metal), see Chapter 9 for more details;

- specifying heavy-duty PVC to replace the use of timber and metal for door and window frames; and
- ensuring that all plumbing is in HDPE plastic.

Coupled to these specifications, a strict quality assurance programme should be adopted during the construction phase.

### 11.5.2 Designing for a low carbon footprint

Port buildings should be designed for a low carbon footprint at the inception stage, both through design features as well as installed equipment.

In hot climates, the design features should include:

- correct orientation of buildings to make the best use of shade to cut down on cooling requirements;
- if not possible, application of appropriate eaves or shades to prevent the build up of heat from direct sunlight;
- large windows with white internal paint schemes to cut down on lighting requirements, Figure 29; and
- abundant landscaping to absorb reflected light, provide shaded areas and absorb treated wastewater.

FIGURE 29
**Fisheries management organization offices – small windows versus large windows with eaves**

The equipment features should include:

- installation of roof-mounted solar PV panels to power lights and most office equipment;
- installation of two separate power circuits, one for heavy loads and one for solar-powered loads;
- energy saving light bulbs or LED units applied directly to fittings (no ballast);
- use of laptops as workstations (easier to recharge and do not emit the same amount of heat as a tower personal computer [PC];
- installation of ceiling fans to reduce the use of air-conditioning systems (except for monitoring, control and surveillance rooms [MCS] with radar screens);
- installation of smart energy systems to conserve power, like trip switches on windows and doors to shut down air-conditioning automatically if windows or doors are opened;
- installation of rainwater harvesting coupled to large water reservoirs to augment water supply for hygiene services; and
- installation of sewage treatment for use in the landscaping.

### 11.5.3 Administration buildings

Irrespective of the size of a fish landing or fisheries port, an administration building should always be included in the layout. An administration building may consist of a single room with one desk for the harbour master to a proper building with offices for the harbour master, statistics officers and other key personnel. Generally speaking, the larger the port, the more management staff are required and, hence, the larger the building required.

FIGURE 30

**Typical layout of a large two-storey administration building (left) and a small administration building run by a fisheries management organization (right)**

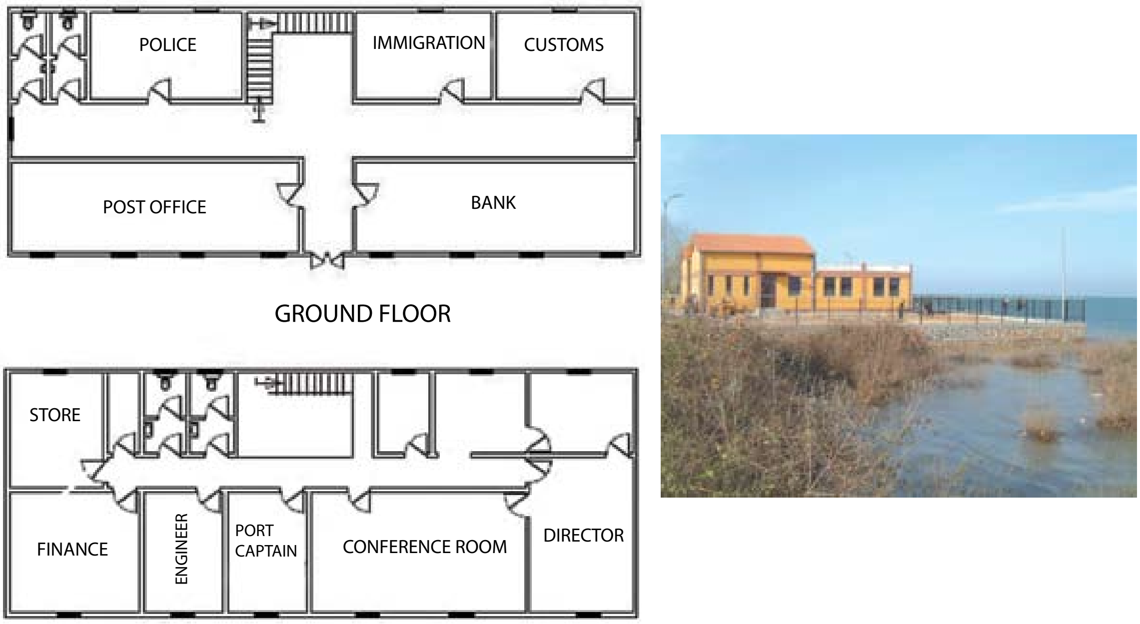



Figure 30 illustrates a typical ground-floor plan for a two-storey building suitable for port administration. The top floor should be reserved for the management staff, whereas the ground floor should include all types of interface services, such as police, customs and immigration, if required, and bank or post office. Office space destined for the installation of MCS radar screens should have adequate air-conditioning facilities.

### 11.5.4 Market or sorting hall

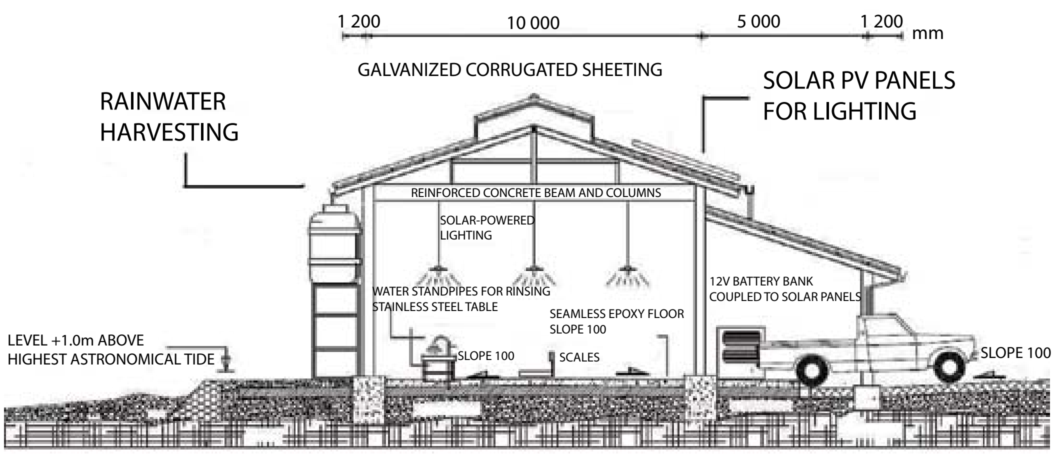
In designing new fish marketing or sorting premises, a smooth sequence of operations from the receipt of the fish to its loading and transportation should be achieved. All operations should be conducted off the floor, at a height convenient for workers to perform their tasks in a standing position. In some Asian countries where workers prefer to crouch, low integral sorting platforms, about 150 mm high, and draining melt water to a dish channel should be included in the design, Figure 31.

FIGURE 31
**Crouching-only sorting platforms under construction**

The structure should be a single-storey building – a short distance from the landing area – to enable fast handling of fish along the quay and marketing operations inside the market hall. This type of design will also allow easy access to vehicles for loading purposes. Figure 32 illustrates a small artisanal auction hall.

Ample, natural air circulation should be provided for covered halls. In hot climates hollow-brick walls or chain-link fences are often used. Properly designed long eaves for protection against direct sunlight and rain are essential. An adequate pitch of the roof serving a rainwater collection system is also an important factor in areas with high rainfall. Vehicles waiting to load fish should be under cover to prevent spoilage of fish from heat. Orientation in relation to the prevalent direction of the elements (sunlight and wind) should also be taken into consideration.

FIGURE 32
**A small artisanal auction/market hall**




## Floors

Floors should ideally be hard-wearing, non-porous, washable, seamless, easy to drain, non-slip and resistant to possible attack from brine, weak ammonia, fish oils and offal.

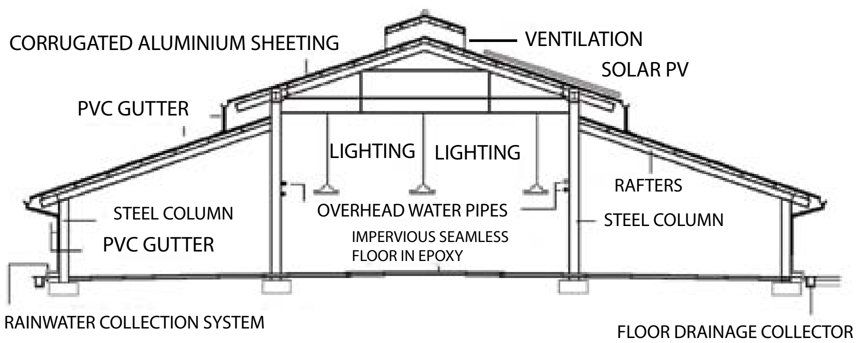
The choice of the flooring materials will depend on the characteristics of the materials available in the area and their cost. In artisanal situations, granolithic concrete, terrazzo and clay tiles can be used, but clay tiles are preferable. Generally speaking, the harder the tiles, the less absorbent but the more slippery they are. Tiles with slightly abrasive surfaces are less slippery. All paving should be light coloured to reflect light and show up dirt. Tile laying on a cement mortar requires professional supervision to ensure that

all the joints between the tiles are complete and permanently sealed. The junctions with the walls should be curved for ease of cleaning. A slope of 2 percent from the highest point of the floor to the drainage channel around the hall should be adequate. Steeper slopes may be required in small halls to drain water away faster. If finances permit, an epoxy floor should be considered as this is the only kind of floor finish that satisfies all the requisites of functionality, hygiene and low maintenance. Epoxy floor finishes are described in detail in Chapter 9.

### Drainage

The floor should drain sideways into appropriate dish channels and the runoff channelled to a plastic or stainless steel basket drain where solids (wet wastes) may be collected prior to the effluent entering any pipework (Figure 33). Drainage pipes should not be smaller than 100 mm in diameter. Sharp bends in the drainage system (pipework or deep channels) should be avoided as these are difficult to clear in case of blockages (from waste paper, vegetation and plastic bags, etc., that occasionally find their way into the system). The roof drainage system should incorporate a rainwater collection network.

FIGURE 33
**A modern, all-steel construction fish hall – no side walls**




### Walls

Walls should be constructed of materials that have smooth, washable and impervious surfaces. Walls should be painted in light colours to increase the brightness inside the building and make dirt more visible. For easy cleaning, they should be rounded at the junctions with other walls, and ceilings should be kept as free as possible from ledges, projections or ornamentation to avoid dust collection. If walls are not tiled, then they should be finished in plaster and good-quality, washable paint. Walls which are intended primarily as partitions should be strong enough for fish boxes or other light equipment to be piled up against them. The lower part of all walls should preferably consist of a solid *in situ* concrete wall, as this area receives the most impacts (from equipment). Hollow block walls, once punctured and not immediately patched up, are prone to infestation by vermin. Modern fish halls are built entirely in steel without side walls, especially in hot climates. Internal partitions for box storage areas, for instance, may be in chain-link fence.

### Doors

Doors should be of simple and functional design. The main doors should be sufficiently high and wide to permit circulation by internal transport vehicles such as box trolleys, forklifts, etc.

When forklifts are in use a 2.8-metre-high door will be required with a width of between 1.5 to 2.5 metres. Internal doors should be self-closing and fitted with metal

kick plates at the bottom. Due to the wet nature of the working conditions inside a fish hall, it is preferable to use light metal doors in aluminium or polyvinyl chloride (PVC). Timber doors are not recommended as they absorb water, need a lot of maintenance and may be subject to attack by wet rot.

### Lighting

The building should provide adequate natural light for most operations to be carried out. Adequate windows and skylights should be provided to reduce the need for electric lighting. Artificial overhead lighting should be provided in order to allow personnel to work early in the morning before sunrise. Fluorescent lighting is particularly suitable (daylight type) for fish-market areas where a shadowless light with very little glare is required continuously for a long time; even though the initial costs are relatively higher than other lighting systems, operational costs are lower. A light level of 220 lux as minimum is considered adequate. All lighting fixtures should be watertight. Metal fittings, conduits, etc., should be avoided. Cabling should be adequate for peak demands and suitable for the environment. Given the size of most roofs, due consideration should be given to installing solar PV panels on the roof in order to run the building lights on solar power. Additional strengthening of the roof to support the PV panels is normally required.

### Sanitary facilities

Adequate sanitary facilities should be provided for the staff, fishers, handlers and merchants working in or around the fish hall. Chapter 11 describes this topic in detail. In particular, toilets should be constructed to the highest possible standards to guarantee the maximum working life of the facilities with the lowest maintenance costs. Bad design (cheap materials) and lack of supervision during construction generally lead to facilities with a working life measured in weeks or months. This situation gives rise to "toilets of opportunity" elsewhere, exacerbating hygiene conditions inside the port. Hygiene blocks should be equipped with an adequate number of wash-hand basins.

Signs and billboards spelling out sanitary regulations should form part of the infrastructure. Sanitary facilities should not open onto a working area lest a blocked drain causes flooding.

## 11.5.5 Cold rooms

Refrigerated chill rooms are required for the temporary storage of freshly iced fish (Figure 34). The operating temperature inside a chill room is around 1 °C. Chill rooms are expensive and need to be designed properly by an expert.

FIGURE 34
**Small sorting hall with a 2-tonne chill room**

The design should take into account:

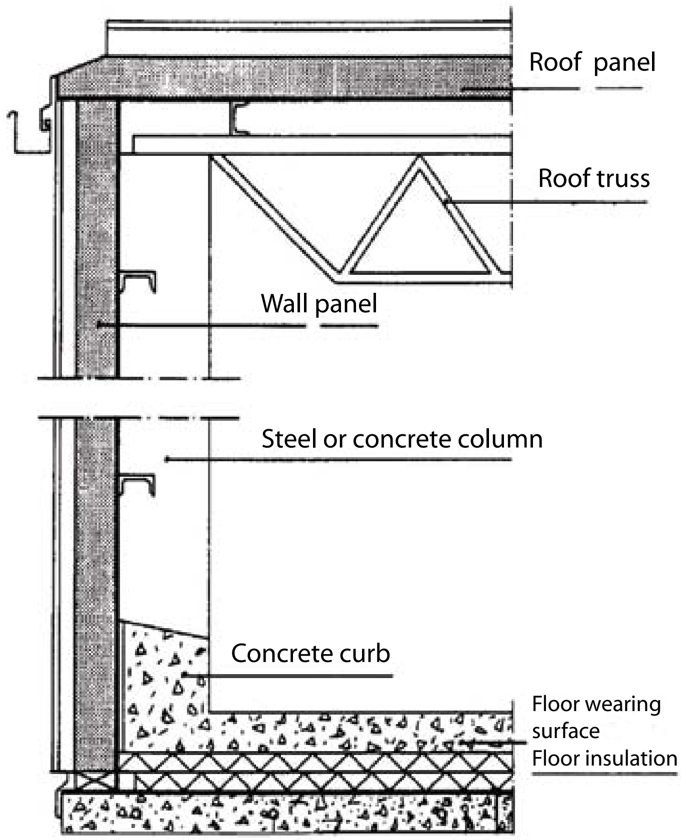
- total maximum weight of products to be stored;
- handling methods to be employed;
- ambient temperature of the products entering the chill store; and
- availability and cost of electricity, labour and servicing facilities.

Standby equipment should also be provided for emergencies.

### 11.5.6 Cold stores

Cold stores generally consist of a single-storey building having a single or a multiple number of cold rooms operated at temperatures in the range -24 °C to -30 °C (Figure 35). Cold stores are very expensive items in a port's inventory and due to their complexity it is recommended that cold storage specialists handle such projects, all the way from feasibility to commissioning, including supervision and training of the local management responsible for the future operation of the cold store. For further information on cold stores, the reader is referred to other more specialized texts; see bibliography.

FIGURE 35
**Typical cross-section through a simple prefabricated cold store**




### 11.5.7 Hygiene facilities

Hygiene facilities are required inside the administration building, the market/sorting hall and as stand-alone facilities spread around the port area, Figures 36 and 37.

In areas around the sorting or market hall, the ratio of male to female facilities needs to be adjusted to reflect local employment customs.

FIGURE 36
**Typical layout for toilets near offloading areas**

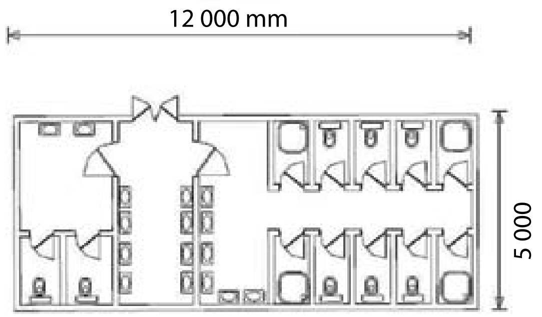
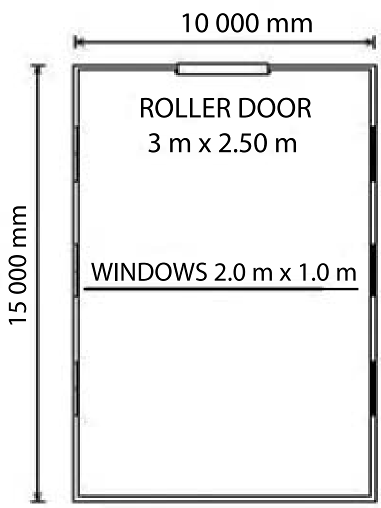



FIGURE 37
**Wash-hand basins and showers**

The building should be simple in layout, airy, brightly coloured with plenty of ventilation and light. All the floor drains inside the building should be bar drains placed centrally across the room with water draining away from the walls to prevent flooding. The drains should be in plastic and easily removed to clear blockages.

The provision of showers in small- to medium-sized ports is important for crews returning from long fishing trips. Hot water is very desirable and should be provided by solar water heaters.

FIGURE 38
**Workshop building**




### 11.5.8 Workshop facilities

Workshops are an integral part of a fishing port (Figure 38). Both engine and hull workshops are normally required, the one dealing with the inboard or outboard engines and the other with timber or metal hulls.

The workshop building may be built in an all-metal construction as illustrated in Figure 39 or in concrete and masonry as illustrated in Figure 40. Both single-phase and three-phase power is normally required to run equipment. Compressed air lines fed from a central compressor are also an added advantage.

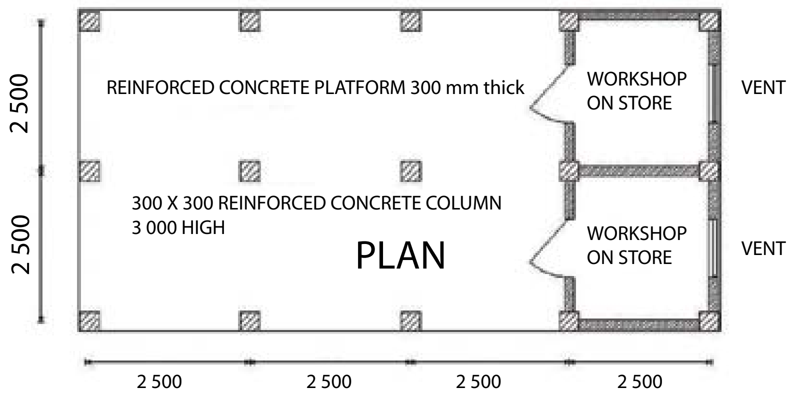
FIGURE 39
**All-metal workshop under construction**

FIGURE 40
**Workshops in concrete (outboards only, left, inboard, right)**

### 11.5.9 Net repair and social meeting platforms

Artisanal fish landings located on beaches require a clean level platform for the repair of nets. This platform often incorporates small gear stores for the storage of bulky equipment, Figure 41.

FIGURE 41
**Typical small-scale net repair platform with integral stores (mm)**




Platforms should be designed to drain runoff away from the work areas and should be located away from all sources of pollution, like oils and fuel (Figures 42 and 43). Fishers also use the platforms as social meeting points during their time between fishing trips.

FIGURE 42
**Small-scale net repair platform and an ad hoc shade on a quay**


FIGURE 43
**Large-scale net repair structures**


## 11.6 PARKING AREAS

A detailed picture of vehicle traffic movements would have emerged from the environmental impact assessment study if one was performed for the fishing harbour; otherwise, a traffic study assessment should be performed before planning any parking areas, and the port's as well as the town's master plan, should be consulted.

### 11.6.1 Parking densities

The parking density is a measure of how many vehicles may be squeezed into a parking lot without loss of access to any one vehicle. Typical car dimensions may vary from one country to another depending on local preferences. The dimensions illustrated in Figure 44 to Figure 47 may have to be increased by 15 percent to allow for large vehicles, insulated vans or pick-ups.

FIGURE 44
**In-line parking area per vehicle 20 m² against a kerb or 23.8 m² against a wall**

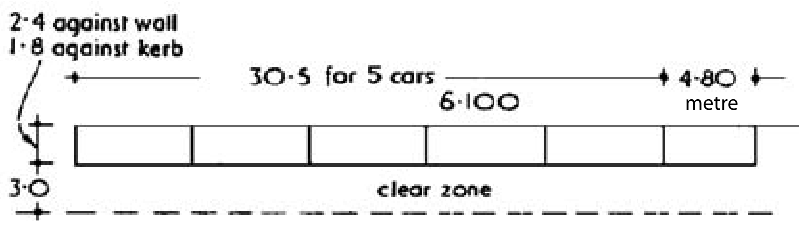


FIGURE 45
**Individual standard vehicle parking bay**

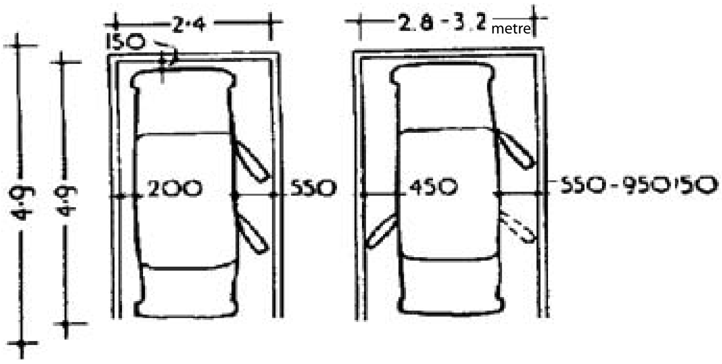



FIGURE 46
**Echelon parking (45°), area per car 22 m² or 9.2 m² where interlocking in adjacent rows**

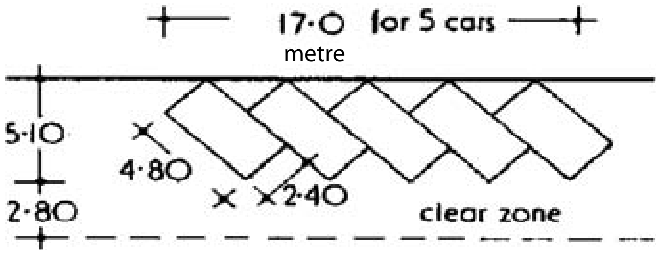
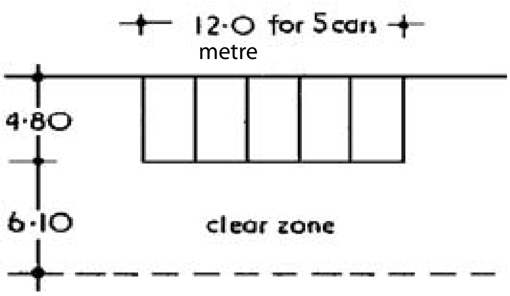



FIGURE 47
**Head-on parking, area per vehicle 18.8 m²**




## 11.6.2 Turning radii

In addition to the actual areas occupied by the vehicles and the clear zones for manoeuvring, vehicle turning radii are also important, Table 14.

TABLE 14
**Turning radii**

| Type of vehicle | Turning radius (outer wheel) in metres | Swept radius (truck body) in metres |
|---|---|---|
| Cars and pick-ups | 3.0 | 3.0 |
| Small 1 tonne van | 6.1 | 6.4 |
| Long 2 tonne van | 6,55 | 7.0 |
| 2-axle lorry or truck-mixer | 9.15 | 9.45 |
| 2-axle 16 tonne flatbed lorry | 10.5 | 11.0 |
| 3-axle tractor with ISO cargo container | 12.0 | 15.0 |
| 5-axle articulated with refrigerated body | 12.0 | 15.0 |

### 11.6.3 Paved areas

Depending on the size of the fishing port and the landings, various types of vehicles will call at the port to either deliver supplies, such as fuel, ice, etc., or to pick up fish. The vehicle sizes may range from a simple half-tonne pick-up to a full-sized, containerized refrigerated articulated truck. Even in small artisanal harbours, it is not uncommon to find large containerized refrigerated trucks, Figure 48, parked by the quay for a number of days to collect a full payload of around 40 tonnes of fish. Paving is an expensive but necessary cost in a fishing port and the type and quality of the pavement will depend on the type (and hence the weight or axle load) of vehicles intending to use the facility, the typical use for the pavement (main access, parking area, lay-by, quayside, refuelling area, etc.) and the type of existing ground (sandy cohesionless reclaimed land, cohesive clayey land, etc.).

Figure 49 shows four different kinds of pavement, precast concrete rafts or slabs, interlocking precast concrete blocks, rigid concrete and asphalt. The respective thickness and characteristics of the materials employed depend on design considerations; however, interlocking precast concrete block pavements are now an accepted industry standard due to their flexible nature and ease of placing. Interlocking concrete block paving may be designed to take the full range of axle loads (by increasing the thickness of the block), can easily be re-laid if settlement has occurred, does not rut and if laid properly it is practically maintenance-free.

FIGURE 48
**A large truck picking up fish from a small fishing vessel**

FIGURE 49
**Typical types of pavement inside a harbour area**

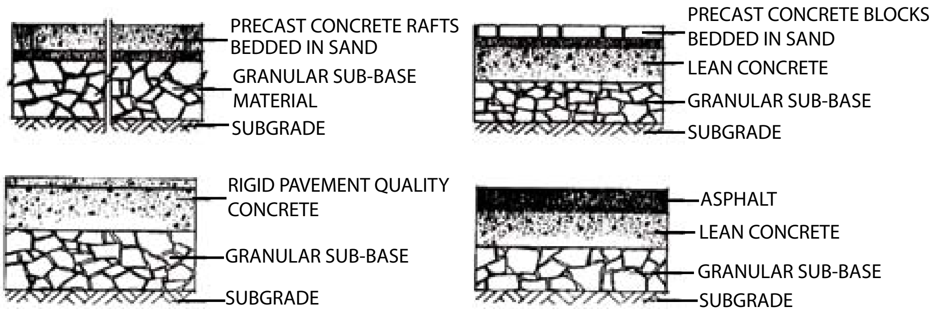
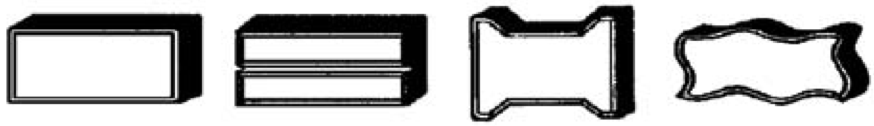


FIGURE 50
**Typical shapes of interlocking concrete blocks**

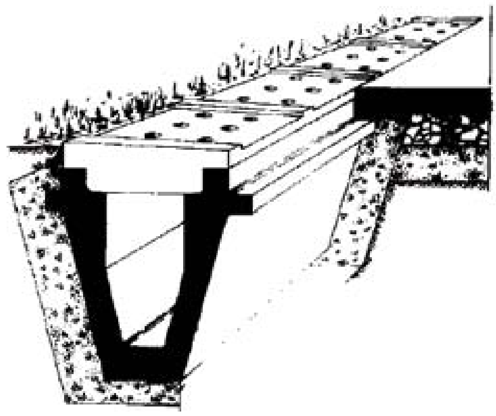


The typical standard rectangular block, Figure 50 left, is 200 mm long and 100 mm wide with a thickness range of 60 mm to 100 mm, depending on the end use of the pavement. Blocks are available in various colours, including grey, red, yellow and green. The blocks are bedded on a graded layer of sand (5 mm maximum size) 50 mm thick, laid over a layer of lean concrete laid to the levels and cross-falls required for drainage. Various laying patterns are possible, both with the standard rectangular block and the non-traditional designs shown in Figure 50. Block paving should not be used in wet market areas.

All paved areas should be laid to cross-falls draining into appropriate channels. Typical falls are 1 to 2 percent (a 1 percent falls 1 metre in 100 metres) and it is common to break cross-falls at least every 10 metres, depending on the local intensity of rainfall (the longer the distance between the breaks, the longer the rainwater has to travel to drain away). Drainage channels should be appropriate and suitable for a particular location. Drainage channels may be of the open type, also known as dish channels, Figure 51, or of the covered type, as illustrated in Figure 52.

FIGURE 51
**Open dish channel**

FIGURE 52
**Heavy-duty covered drains in precast concrete**



Covered channels should not be used in areas where mobile sand is a problem, especially where wind occurrences are very frequent. In these cases, dish channels should be used as these are easy to maintain. Covers over drains may consist of perforated concrete slabs, cast iron bar drains, galvanized steel grilles or glass reinforced polyester. Inside market and processing halls, lightweight glass reinforced polyester grilles should be used as these may be lifted easily by one person to clear clogged drains.

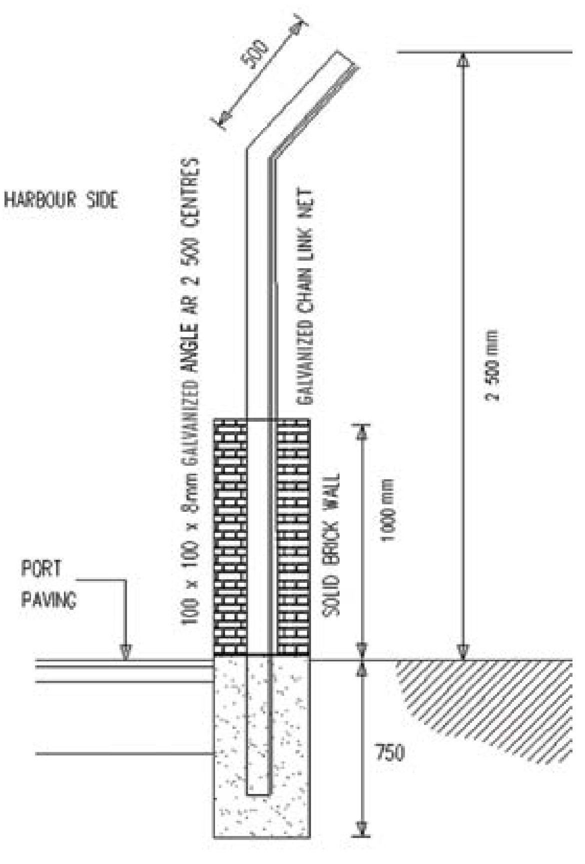
## 11.7 PORT SECURITY

With the exception of open beach landings, fishing ports should be designed as secure areas. Perimeter or boundary walls provide security against theft and vandalism but they also keep out unwanted pests which may otherwise pose a health hazard. When fish and fishery products are exported directly from a fishing port to overseas markets, the standard of the port's security must follow the International Ship and Port Facility Security (ISPS Code).

### 11.7.1 Perimeter wall

Whenever possible, perimeter walls should be built in concrete or brick and provided with adequate manned access gates (Figure 53). Simple wire netting is not satisfactory for this purpose as it is easily breached at road level to gain access. Chain-link fences, on the other hand, are useful for segregating specific areas inside the port boundary, thus limiting access, such as the auction hall area, fish box storage area, open-air net stores, net repair areas, etc.

FIGURE 53
**Typical cross-section across boundary wall**

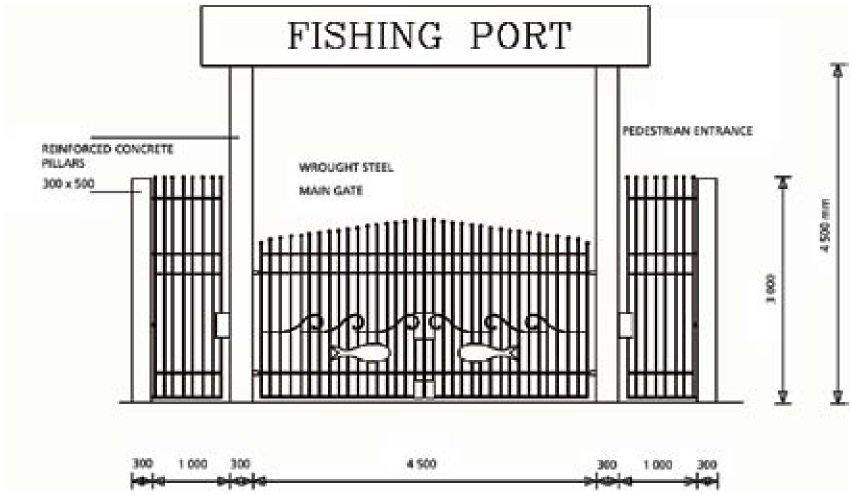



The perimeter wall in mass concrete or masonry should sit on a mass concrete foundation and rise up to 1 metre above finished road level. From 1 metre to 2.5 metres above road level, the wall should consist of galvanized wrought iron railings or sturdy angles bent to shape to hold galvanized chain-link in place. Whenever possible, the perimeter wall should be illuminated at night, especially in the vicinity of the main gate and around the cattle grid.

### 11.7.2 Main gate

The main gate is required to control the influx of people during the landing and marketing hours. During these hours, only people connected with the fisheries should be allowed into the port area, such as the buyers, their loaders and sorters and other fisheries-related staff. Some countries operate a tagging system whereby each operator is handed a number of colour-coded tokens for his staff to come and go as they please.

FIGURE 54
**A typical controlled-entry main gate**




Outside working hours, the gate should be closed to prevent unauthorized entry into the port, or, if the port is a public facility, prevent entry into the market hall. The main gate should be manned at all hours, Figure 54.

Should the port fall under the ISPS Code, the main gate should be the only point of controlled access to the port and all other breaches (such as back entrances) in the perimeter must be sealed off. An area should also be set aside for vehicle inspection purposes as required by the ISPS Code.

When the fishing port is located inside an urban area, the port authorities may allow the general public to wander through the port, especially when restaurants are located nearby. As long as adequate parking is located outside the port, this activity helps to maintain a cleaner environment, as restaurants would then lose customers if the port environment is not kept clean.

### 11.7.3 Cattle grid

In some developing countries, domestic and stray animals are allowed to wander about untethered posing a health risk to fishing port operations. In such cases, the main gate must be equipped with a cattle grid to prevent animals from wandering into the port area. This area should be illuminated at night.

### 11.7.4 Billboard

At the entry to the port, a billboard is required to display information pertinent to the running of the port operations (Figures 55 and 56). This should be placed either at the entrance, outside the main gate, facing outwards over the perimeter fence or inside the port area in a prominent position. The billboard or billboards should list, among other things:

- the port authority that has jurisdiction over the facility;
- the port regulations;

- fishing and/or hygiene by-laws;
- the fines levied for each contravention; and
- prices for services rendered.

Telephone numbers (normally coast guard, police and hospital) are also useful.

FIGURE 55
**Dimensions for a simple billboard (mm)**

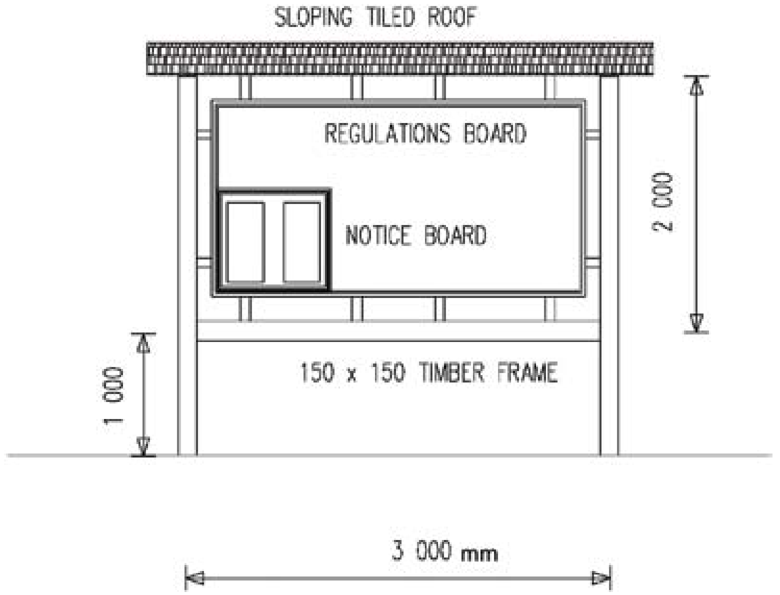



FIGURE 56
**Billboards displaying pricing structure (left) and regulations (right)**


## 11.7.5 Closed-circuit television

When a port exports fish and fishery products directly to overseas markets, then the port's security system is governed by the ISPS Code; see Chapter 1 for more details. In this case, strategically located closed-circuit television monitoring is required as part of the port's security arrangements. Professional assistance should be sought at the design stage to ensure that the appropriate power supplies and connections are installed together with the required illumination standards. Modern video surveillance systems may also be run on solar power.

## 11.8 BIBLIOGRAPHY AND FURTHER READING

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