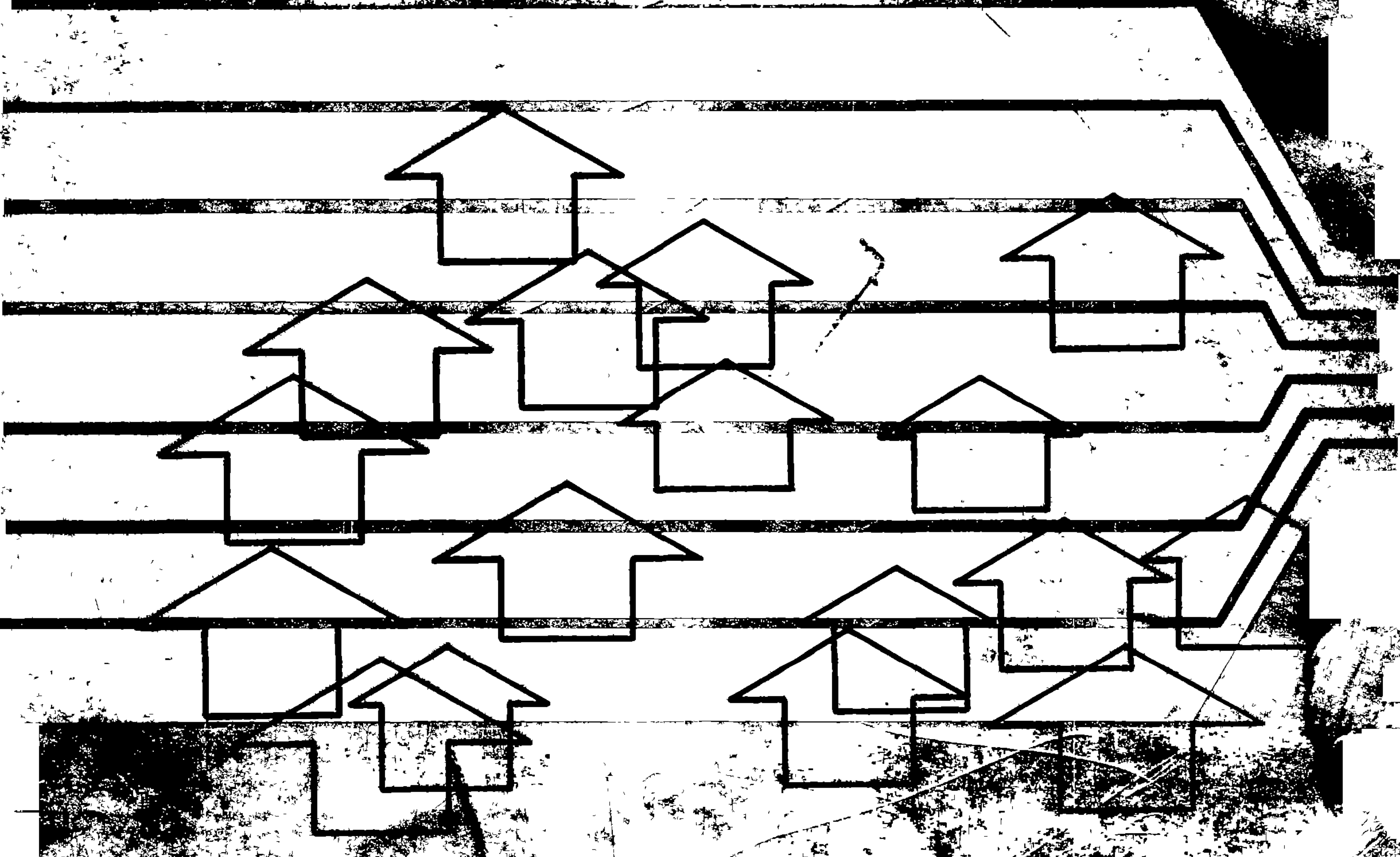
LATION



REPUBLIC OF

Republic of the Philippines
NATIONAL WATER RESOURCES COUNCIL

The National Water Resources Council (NWRC) is the body responsible for coordinating and integrating all activities related to water resources development and management. Its principal objective is to achieve scientific and orderly development and management of all the water resources of the country consistent with the principles of optimum utilization, conservation and protection to meet present and future needs.

RURAL WATER SUPPLY
CONSTRUCTION AND INSTALLATION MANUAL
VOLUME II

REPUBLIC OF THE PHILIPPINES
NATIONAL WATER RESOURCES COUNCIL
QUEZON CITY PHILIPPINES

FOREWORD

The national government is embarking on a massive program to provide water to all areas of the country by providing technical, financial and institutional assistance to local communities. This will require the adoption of appropriate technologies especially for rural water supply systems and the transfer of such technologies to local engineers that will be involved in the implementation of projects.

There will be a need to develop local expertise on the technical aspects of water supply projects to support the program. Local engineers will have to be trained in the design, construction, operation and maintenance of water supply projects.

With this in mind, the National Water Resources Council, through its Task Force on Rural Water Supply, undertook studies on rural water supply including the preparation of a three-volume technical manual. The three volumes are on Design, Construction and Installation, and Operation and Maintenance.

This manual is intended to be used as reference and training materials for local engineers who will be involved in the construction and supervision of water supply systems serving a population of not more than 4,000. It discusses the construction and installation of the different components of a small water supply system.

Although the contents of this manual are the product of many years of experience of and studies made by the consultants and NWRC, it is felt that there is room for further improvement and refinement of this manual.

Comments and suggestions regarding the contents of this manual would be most welcome and should be sent to the National Water Resources Council.

Special thanks and appreciation are due to the World Bank for Supporting part of the studies on rural water supply and the DCCD Engineering Corporation for preparing the drafts of the technical manuals.

ANGEL A. ALEJANDRINO
Executive Director

Republic of the Philippines
NATIONAL WATER RESOURCES COUNCIL
Quezon City

2 July 1981

MEMORANDUM

F O R : THE HONORABLE MEMBERS
National Water Resources Council

SUBJECT : **Rural Water Supply – Construction and Installation Manual**

We are pleased to submit herewith the Rural Water Supply Construction and Installation Manual which is Volume II of the three-Volume Technical Manual on Rural Supply Systems.

This manual was prepared to serve as reference for training local engineers and construction supervisors in the construction and installation of small water supply systems.

We hope that it would help the national government in its effort to provide water to all people by the year 2000.

ANGEL A. ALEJANDRINO
Executive Director

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CHAPTER 1

GENERAL CONSIDERATIONS

1.01 PLANNING

Planning is extremely important in all phases of the construction and installation work. The schedule of work should be well planned so as to complete the work on time without sacrificing quality. Planning should include the determination of the available local materials and labor, both skilled and unskilled. Since most of the available labor are not skilled in this type of undertaking, the work should be so organized that each worker is aware of his duties and responsibilities. Also, in places where there are distinct dry or summer months and wet or winter months, it will be wise to consider these seasons of the year when planning.

1.02 CONSTRUCTION MATERIALS AND SUPPLIES

The exact requirements for materials and supplies must be anticipated in advance to assure that these are both available to meet the project's needs. This requires a careful study of the quantities and kinds of materials required, sources of supply available, transportation requirements, priorities of deliveries and the need for storage facilities. As much as practicable, the use of locally available indigenous materials should be maximized. Hence, if bamboo poles or forest wood trunks could substitute for GI pipes in constructing scaffoldings and head frames, the former should be used.

1.03 CONSTRUCTION EQUIPMENT

Because of the prevailing economic condition, it is seldom that construction equipment normally found in urban sectors are available in rural areas. It is important that as much as practicable, the use of sophisticated equipment should be avoided in favor of manual labor. Thus, for example, the use of a hand-operated pump in jetting a well operation should be resorted to in favor of a power-driven pump whenever applicable.

1.04 LABOR

The use of local labor should be availed of as much as possible in favor of imported sophisticated machines. It is usual that there is an excess of cheap labor in rural areas. Trenching operation and mixing concrete should be done by manual labor instead of mechanical equipment.

This serves a three-fold purpose: (1) it provides employment opportunities to the otherwise unproductive manpower, (2) it increases economy in costs, and (3) it provides the users knowledge of the work thereby facilitating operation and maintenance. Of course, cheap labor should not mean exploitation of labor.

1.05 CONSTRUCTION TIME

The significance of time here relates to the need of the community to utilize the system at the earliest time possible. It has been the experience that people in the rural areas appreciate more an impact project that benefits them directly. Such impact projects are better appreciated if people are made aware of it so they can enjoy the benefits as soon as possible, especially if they have long been suffering from the lack of water supply. Hence, the construction of the project must not drag.

1.06 SAFETY AND DURABILITY

This is an important factor to consider in constructing the system. Safety and durability should not be sacrificed for speed and economy. Because of limited resources, it is often difficult for rural communities to afford frequent repair costs, so that as much as possible, all constructed system parts should be durable enough to withstand rough handling and the elements of nature. This can be achieved through proper selection of needed equipment and materials and close supervision during construction.

1.07 SIMPLICITY AND ECONOMY

Simple design, requiring mostly available local construction materials and supplies, and the minimum of skilled labor should be adopted. During construction, the types and sizes of wires, lumber and other materials needed should be reduced to the minimum, but without endangering the safety of workers. Sizes of materials common in the area should be used. Also re-use of these materials as related to construction planning should be considered. Drainage should be by open ditches. Open storage areas should be used as much as the weather, security and nature of materials to be stored would permit.

1.08 WEATHER

As much as possible, construction should be done during dry season. It has been the experience that cost of construction is usually higher if it is done during rainy season due to the following reasons:

1. The materials for construction may be lost or destroyed or contaminated if not stored and handled properly due to flooding of trenches, etc.

2. Increase in labor cost. The progress of work is usually slower for the same job item, hence, there is a corresponding increase in labor cost.

3. Increase in energy cost. In pipe laying, it is necessary to render the trench dry before pipes are laid. Removal of water, usually by pumping, would entail additional cost.

4. Weakening of structures and foundations.

5. Working conditions are difficult. In the excavation of trenches, it is usually necessary to provide additional support to avoid cave-ins.

6. Detection of leaks during leakage testing is rendered more difficult.

CHAPTER 2

CONSTRUCTION MATERIALS

Construction materials available in the market today may either be locally made, fabricated or imported. They are usually identified by various commercial names and trademarks. Imported materials are rarely available and are very expensive. On the other hand, locally made or fabricated materials are always handy and most of the time can be obtained at much lower costs. Hence, as much as possible the size of local or native materials should be maximized.

2.01 CONCRETE

Concrete is widely used as a construction material for roads, bridges, houses, pipings, tanks and many others. Concrete is prepared by blending portland cement, fine aggregates, coarse aggregates and water. Concrete is discussed in detail in Chapter 8, Concrete Design and Construction.

A. Portland Cement

Portland Cement is prepared by blending and calcining or burning of lime-containing or clayey materials. Chemically, it consists of four major compounds: tricalcium silicate, dicalcium silicate, tricalcium aluminate and tetracalcium aluminum ferrate.

1. Type of Portland Cement

Portland cement available in the market today are of two types, namely: General purpose and Hi-Early-Strength Cement.

a. **General Purpose or Type I Cement** – is the most common type of portland cement available in the market today and is widely used for construction of concrete structures. Its required setting time is 28 days.

b. **Hi-Early Strength or Type II Cement** – High-early strength cement is employed only when early strength of a concrete structure is required. This type of cement develops its maximum strength in 7 days and this is achieved by increasing the amount of tricalcium silicate.

2. Storage of Cement

All cement should be stored in a weather-tight and properly ventilated structure and should be stacked on pallets or similar platforms. This is to permit proper circulation of air in the storage area to remove moisture, thus preventing absorption of moisture by the cement which causes cement hardening.

It is recommended that cement be stacked no higher than 14 bags for a storage period of less than 30 days and 7 bags for longer storage periods. Similarly, it is recommended that the oldest stacked cement found in the storage room be used first. Portland cement should not be stored for more than 60 days.

B. **Aggregate**

Aggregates which comprises about 75 per cent by weight of a typical concrete mix include natural sand, gravel and crushed stones. Since it is a major component, it greatly affects the strength and durability of concrete structures. Aggregates used in concrete mixes should be clean, strong and properly graded. Aggregates are considered clean if they are free from excess clay, silt, chemical salts, organic matter and other deleterious matter. To be considered adequate in strength, an aggregate should be hard and tough enough to support the load imposed on it thereby retaining dimensional stability under any temperature or moisture changes. Also, grading or uniformity of particle size has a definite effect on the workability of concrete. Grading can be improved through screening. Washing improves the quality of aggregates. It removes chemical salts, fine particles like silt, clay and fine sand, and organic matter.

1. **Fine Aggregates or Sand**

Fine aggregates is defined as the aggregates which pass thru Sieve No. 4 (screen opening = 4.76 mm). It may be composed of natural sand grains, manufactured grains obtained by crushing larger size rock particles, or a mixture of the two. Fine aggregates for use in concrete mixes should be hard and durable and should not contain excessive amounts of clay, silt, dust, organic matter or other impurities to such extent that it is impossible for the concrete to attain the required characteristics when employing normal proportions of ingredients.

2. **Coarse Aggregate**

Coarse aggregate is defined as gravel or crushed rock or a mixture of these two materials whose particle sizes range from 4.76 mm (Sieve No. 4) to 15 cm (6 in). Coarse aggregates used for concrete mixes should be hard, durable and must be free from deleterious substances such as clay, silt and other fine materials. Also, gravel or rock fragments which are friable or which tend to degrade during processing, transporting, or storage should be avoided.

C. **Water**

Water is used in making a cement paste which is responsible in gluing the aggregates together. Water used for mixing concrete should be free of materials which significantly have hydration reactions with portland cement. These materials are salt, acids, alkali, sugar, oils and other organic matters. Water that is fit for drinking can generally be regarded as acceptable for use in mixing concrete. To determine whether a water contains materials that significantly affect the strength development of cement, tests should be made comparing the compressive strength of mortars made with water from a certain source with that of mortars made with distilled water. If the average results of these tests on specimens prepared using the water being evaluated are less than 90 per cent of that obtained with specimens using distilled water, the water represented by the test sample should not be used for mixing concrete. These tests are normally done in laboratories of the Ministry of Public Works which are located all over the country.

D. **Admixtures**

Admixtures are ingredients added to a concrete mix before or during mixing to improve the properties of concrete. It should only be employed when desired characteristics of concrete is not economically attainable by adjusting the basic mixtures (portland cement, aggregates and water). Also, admixtures must be used with care since improvement of one characteristic may result in an adverse effect on other characteristics. Admixtures available in the market today are identified by various names or trademarks. Generally, admixtures can be classified into:

1. **Water-Reducing and Set Controlling Admixtures** – This type of admixture is employed to reduce the amount of water used in the preparation of concrete mix and control of setting time. Reduction of the volume of water is accomplished by covering each cement particle, whose surface may be positively or negatively charged with admixtures causing the cement particles to repel each other and making it easier for the water to reach each particle. This water-reducing action produces greater plasticity and workability in the fresh concrete, improves impermeability and reduces shrinkage in the hardened concrete.

   On the other hand, set retardation is attributed to reaction of the admixture with portland cement forming an alumina-silica-gel precipitate which is deposited on the cement particles and slows down the hydration process. The delay in the setting will ensure sufficient delivery time, placement and compaction of concrete thereby producing a concrete structure with high compressive, flexural and tensile strengths.

2. **Calcium Chloride ($CaCl_2$)** – This type of admixture accelerates the setting and development of strength of concrete and is employed oftenly in concreting structures where speeding up of the set and reduction of protection time is necessary. Test shows that the addition of 2 percent by weight of $CaCl_2$ causes the reduction of the initial setting from three to one hour, final setting from 12 to 6 hours and the doubling of one-day strength. However, the problem associated with the use of this type of admixture is the impairment of volume stability due to shrinkage.

3. **Pozzolands** – Pozzolands are siliceous substance which react with lime in the presence of water. They are often used in mass concrete applications where the saving on the cement cost and the reduction in heat

liberation is significant. Disadvantages in the use of this type of admixtures are the slow development of final strength, increased drying shrinkage, and impaired durability.

4. **Water-Proofing Admixtures** — Water-proofing admixtures are employed to make the concrete structure impermeable by densifying the molecular structures of concrete by reducing the size of the voids and capilliary tracks in the concrete.

2.02 REINFORCING STEEL BARS AND WIRE MESH

A. Reinforcing Steel Bar

1. General

Reinforcing steel bars are employed to increase the tensile and compressive strength of concrete structures thereby reducing the size of concrete structures. They are also used to control strains due to temperature and shrinkage, and distribute load to the concrete and other reinforcing steels.

Steel bars available in the market today are standardized using the American Society of Testing Materials (ASTM) Standards as reference. The ASTM Standard designates a number for a given size of diameter of steel bars. This number is equivalent to 8 times the diameter of the reinforcing bar. Shown in Table 2.1 are the different sizes of bars commonly available in the market today.

Table 2.1

ASTM STANDARDS FOR REINFORCING BARS SIZES & WEIGHTS

Bar Size Designation Number		Nominal Diameter		Weight	
Metric	English	Cm	Inches	Pounds/ Foot	Grams
5	2	0.635	0.250	0.167	2.48
8	3	0.953	0.375	0.376	5.60
10	4	1.270	0.500	0.668	9.94
12	5	1.587	0.625	1.043	15.52
16	6	1.905	0.750	1.502	22.35
18	7	2.222	0.875	2.044	30.42
20	8	2.540	1.000	2.670	39.73
22	9	2.865	1.128	3.400	50.60
26	10	3.225	1.270	4.303	64.04
28	11	3.581	1.410	5.313	79.07
34	14	4.300	1.693	7.650	113.85
46	18	5.732	2.257	13.600	202.39

2. Handling and Storage

Reinforcing bars should be handled and stored in a manner that they would not come in contact with mud and other deleterious materials. If power hoisting equipment is not available, reinforcing bars may be unloaded using an inclined plane or ramp which extends from the truck bed to the ground. When stacking bars on the ground, timber must be placed under the steel bars to keep them free of mud.

B. **Wire Mesh**

Wire mesh are usually employed in the reinforcement of ferrocement concrete structures, reinforced concrete pipes and floor slabs. Wire mesh consists of a rectangular grid of uniformly spaced wires welded at all intersections. Wire mesh offers the advantages of easy and fast placement of both longitudinal and transverse reinforcement and as crack control because of high mechanical bond with the concrete.

2.03 WOOD AND PLASTICS

A. **Lumber**

Lumber is usually graded commercially to enable the users to buy the quality which best suit their purpose. The grading of lumber is based on the texture of the wood; on the number, character and location of strength-reducing features like blemishes and knots; and on factors affecting durability and utility.

Various technologies have been developed to improve strength and dimensional stability of wood in various service atmospheres. One is the introduction of preservatives to combat decay and decay-causing organisms. Another is the modification of the wood structure. This is done by bonding thin sheets of wood. For further modifications, the bonded thin sheet structure may be compressed to increase the density or strength. Such treatment improves the chemical resistance, decay resistance and dimensional stability of wood.

B. **Plastics**

Plastics or synthetic resins are organic high polymers. Polymers are compounds in which the basic molecular level or sub-units are long-chained molecules. Plastics are the main components of the many construction materials found in the market today. For instance, polyethylene, polyvinyl chloride and polybutylene pipes are made of plastics.

CHAPTER 3

EARTHWORK

The complexity of structural foundations and the selection and laying of pipe materials for water distribution systems are greatly affected by the type of soil. In loose ground formation for instance, it may require the driving of piles for support of structures, sheeting or bracing to prevent cave-ins during excavation and pipe laying, and trench bedding to provide uniform support for piping. Plastic pipes are usually selected for piping to be laid in acidic soil because metallic pipes are easily corroded.

3.01 SOIL

Soil is the most common material used in supporting the different components of the water distribution system. A working knowledge of soil properties and factors that affect them is essential in order to make the best use of all materials available at hand. When constructing a base or foundation for structures, the problems are to determine whether the soil can support such structures and to select and combine available materials to obtain properties which can provide satisfactory bedding. Also, in backfilling of trenches, suitable materials should be selected for backfilling. In any case, it is necessary to know how to identify and classify soil materials and to understand their engineering significance.

A. Principal Soil Types

Soil is commonly classified into five principal types, namely: gravel, sand, silt, clay and organic soil. Each type has distinctive properties which can be readily identified in the field and engineering characteristics which may be of practical use.

1. **Gravel**

   a. **Description and Identification:** Gravel is a type of soil whose grain sizes range from 6.5 mm (0.25 in) to 150 mm (6 in). It is identified readily by inspection.

   b. **Engineering Characteristics and Usage:** Well graded and compacted gravel with suitable fines or filler is the most stable natural foundation material, hence, it is normally used as based material for foundation of structures. Gravel is easy to compact and is very permeable (allows water to pass through).

2. **Sand**

   a. **Description:** Sand consists of mineral grains with maximum size of 6.4 mm (Sieve No. 3) and minimum size of 0.053 mm (Sieve No. 270). Sand particles larger than 0.84 mm (Sieve No. 20) are called coarse sand while those smaller than 0.18 mm (Sieve No. 80) are called fines.

   b. **Identification:** Sand is identified by visual inspection or by sieve analysis.

c. **Engineering Characteristics and Usage:** Well graded sand is a desirable foundation material. It is relatively easy to compact, and is permeable.

3. **Silt**

a. **Description:** Silt consists of mineral grains with maximum size of 0.053 mm (Sieve No. 270). Silt lacks plasticity (plasticity is the capacity of soils to be deformed rapidly without cracking or crumbling and then maintain that deformed shape after the force is withdrawn) and possesses little or no cohesion (do not hold together) when dry.

b. **Identification:** Two simple tests can be made in the field to positively identify silt.

i. **Shaking Test.** Prepare a pat of wet soil, adding water when necessary. Then shake horizontally in the palm of the hand. For typical inorganic silt, such action will cause water to come to the surface of the sample. In this condition, the sample appears glossy and rather soft. Squeezing the sample between the fingers causes the water to disappear from the surface which seems to dry up. Then the sample stiffens and finally cracks or crumbles.

ii. **Breaking Test.** Allow the sample to dry. Test its cohesion and feel by crumbling with the fingers. Typical silt shows little or no cohesion when dry, and possesses a smooth feel in contrast to the grittiness or roughness of fine sand for which it is sometimes mistaken. Frequently, silts are misclassified as clays due to their fineness and color.

c. **Engineering Characteristics:** All silty soil formations are unstable. Due to their inherent instability, slight disturbances in the presence of water (such as traffic vibration) may cause the soil formation to become loose. Silts are difficult to compact, and not permeable (does not allow water to pass through readily).

4. **Clay**

a. **Description:** The individual grains of clay are the finest, with particle sizes smaller than 0.005 mm (0.0002 inch). All clays display stickiness or plasticity which is used for classification purposes.

b. **Identification:** The character of clay in its plastic range and its hardness in the dry state afford means of identification.

i. For examination in the plastic range, a piece of clay is tested by working it with the fingers, adding water when the stiffness requires it. Under these conditions, its plasticity is evidenced by its susceptibility to kneading like a dough or being rolled like a thread.

ii. Hardness of a dried sample of clay is measured by intensity of finger pressure required to break up the sample. The force required to break dry clay is much greater than the force to break dry silt.

c. **Engineering Characteristics:** Clays found in beds may range from hard, medium, soft or very soft depending upon the moisture content and degree of consolidation or compaction. Hard clay requires the use of a pick for excavating while soft clay can be excavated readily by using a shovel. Clays are difficult to compact.

5. **Organic Soil**

a. **Description:** Organic soils are of two types: peaty soils, consisting largely of partly decomposed vegetation and fine grained plastic and non-plastic mineral sediments containing varying amounts of finely divided vegetable matter, such as organic sandy silt, organic silt-clay or organic clay.

b. **Identification:** Since organic matter in peaty soils is coarse and fibrous, identification is made by visual inspection. In organic silts and clay, however, organic matter usually is so finely divided that it cannot be detected by visual inspection. In many cases, the organic odor is strong enough to be detected easily. When in doubt, the odor can be intensified by quickly heating a sample.

c. **Engineering Characteristics:** All peaty and plastic organic soils are unsatisfactory when use as a subgrades or bedding material due to their high compressibility and low resistance to deformation. In general, organic soils are removed and replaced with selected soil as bedding or foundation for structures or pipings.

B. **Selection of Soil**

Soil found in nature often exist as mixtures with varying proportions of the five principal types. Some combinations are excellent subgrade, base and surfacing material for they form a stable formation. More frequently, it is necessary to combine separate soils to produce a satisfactory combination. Presented in Table 3.1 is the Unified Soil Classification. It presents descriptions of the different types of soil mixtures and their suitability as construction materials.

3.02 EXCAVATION OF TRENCHES

Excavation is the removal of materials like soil during construction of trenches for drainage canals, foundation of structures and bedding and support of pipelines. The difficulty of the excavation process depends upon the stability of the soil formation which in turn is primarily dependent upon the type of soil to be excavated. Furthermore, in cases where stability is a problem, benching and/or trench wall support or bracing would be necessary to prevent cave-ins during excavation.

A. **Pipeline Trench Excavation**

1. Importance

Trenches are dug so that the proper bedding and cover of pipelines can be properly piped. The bedding and cover materials distribute the stress evenly on the pipe thereby protecting it from damage.

2. Location and Alignment

The trench alignment follows the pipeline routes as shown in the working drawings.

Table 3.1

Unified Soil Classification

Division	Typical Names	Suitability as Foundation Material
Gravelly soils	– Well-graded gravel-sand mixtures, with or without fines.	Excellent
	– Poorly graded gravel and gravel-sand mixtures with little or no fines.	Good to Excellent
	– Gravel with fines, silty gravel, clay type gravel, poorly graded-sand clay mixtures.	Good
Sandy Soils	– Well-graded sands and gravelly sands, little or no fines.	Excellent
	– Poorly graded sands, gravelly sands, Little or no fines.	Good
	– Sand with fines, silty sands, poorly graded sand clay mixtures.	Fair
Fine Grained	– Inorganic silts and very fine sand clay silts with slight plasticity.	Fair
	– Inorganic clays of low to medium plasticity, gravelly clay, sandy clays, silty clays, lean clays.	Good to Fair
	– Organic silts and organic silty clays of low plasticity.	Fair
	– Inorganic elastic silts	Poor
	– Inorganic clays of high plasticity, fat clays.	Poor
	– Organic clays of medium to high plasticity, organic silts.	Poor
Organic Soils	– Peat and other highly organic swamp soil.	Not Suitable

3. Trench Depth

The trench depth is the sum of the depth of cover, thickness of bedding and outside diameter of the pipe. The depth of the cover is dependent upon the local condition and pipe material while the thickness of the bedding is greatly influenced by the soil condition. For plastic pipes installed in heavy traffic roads, depth of trench cover is 0.5 to 0.6 meters. For G.I. pipes installed in areas where no cargo utilities pass, the depth of trench cover is 0.3 to 0.5 meters.

4. Trench Width

The trench must be wide enough to permit the proper laying and jointing of pipes as well as the compaction of backfill. Presented in Table 3.2 are standard trench widths for laying PVC and G.I. pipes. For PB and PE pipes, the width of trench is narrower as compared to the width of trench for PVC and G.I. pipes.

5. Safety When Excavating Trenches

Excavating long stretches of trenches in advance of pipe laying should be avoided to reduce hazards to traffic and workmen, and to minimize the possibility of flooding of trenches during rains. It is a good practice to complete pipe laying (including excavation, laying of pipe in trenches and backfilling up to the pipe top) in a day or two. This can be achieved by proper sectioning of the area under construction and scheduling of work.

6. Excavation Tools

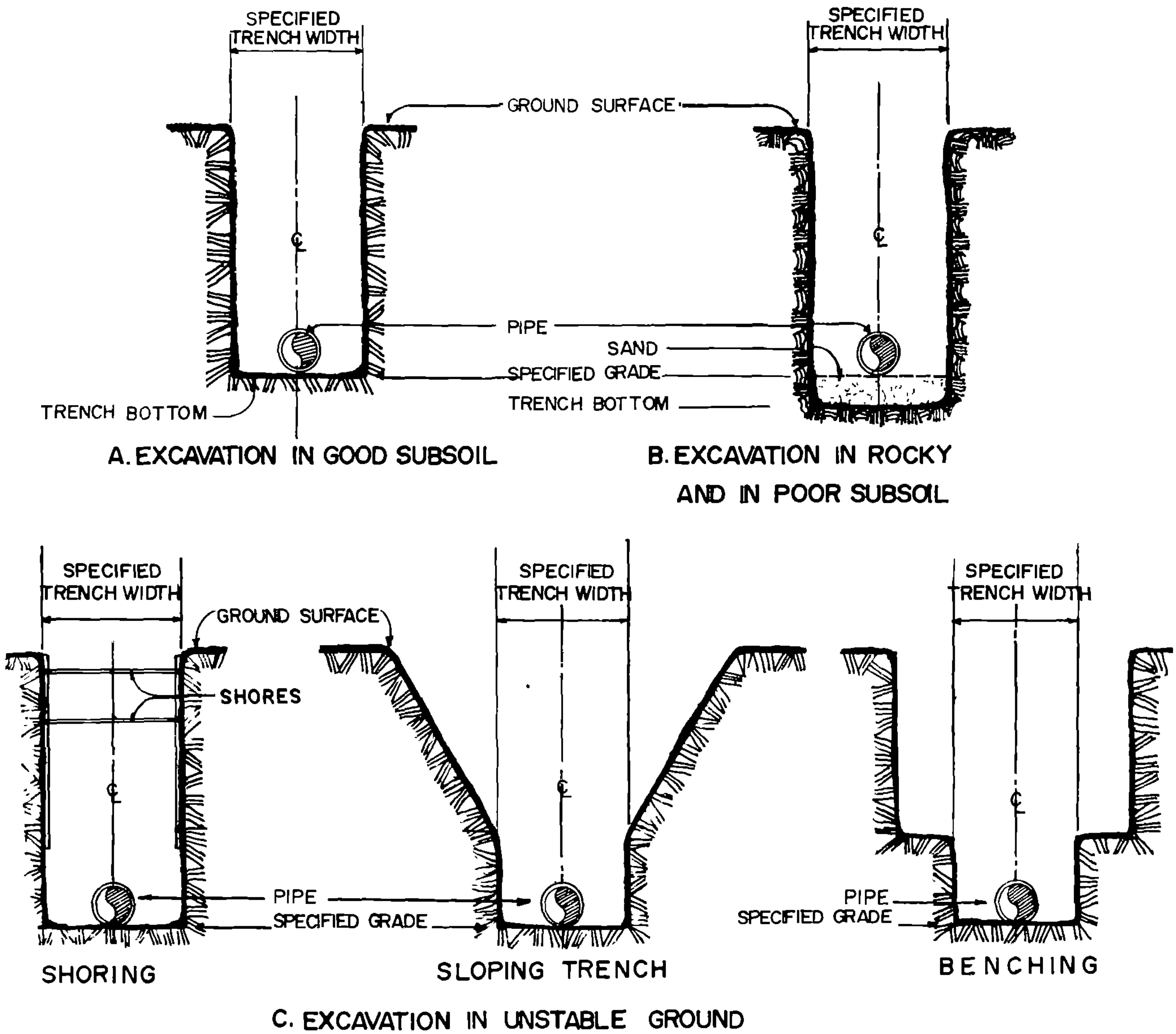
a. Pick-axe
b. Pick Mattock
c. Spade
d. Crowbar

7. Procedure for Excavation of Trenches

a. Mark the alignment and width of trench as specified in the plans.

b. Install safety devices (barricades, warning lights, etc.) for the protection of the public.

c. Excavate to Grade. Trenches should be excavated with vertical sides wherever possible (Figure 3.01). The trench bottom must be uniform and must provide good bedding to the pipe, free of humps, large hard objects and tree roots. To obtain a uniform trench bottom, trim the bottom using a string line as reference. It is very important that the pipe bottom is in contact with the pipe bedding or the ground along its entire length.



NOMINAL SIZE (mm)	TRENCH WIDTH (M)	NOMINAL SIZE (mm)	TRENCH WIDTH (M)
13	0.30 - 0.60	50	0.30 - 0.60
19	0.30 - 0.60	63	0.30 - 0.60
25	0.30 - 0.60	75	0.60
31	0.30 - 0.60	100	0.60
38	0.30 - 0.60	150	0.70

TABLE 3.2

STANDARD TRENCH WIDTH FOR PVC AND G.I. PIPES

FIGURE 3.01

CONSTRUCTION OF PIPELINE TRENCHES

The depth of trenches excavated as pointed out in sub-section 3.02C is dependent upon the type of soil and existing soil condition. Presented below are the methods of trench construction for various types of soil:

i. **Excavation in Good Soil**

In good quality soil containing no rocks or sharp pointed objects, excavate up to the specified grade (Figure 3.01A) as shown in the plans.

ii. **Excavation in Rocky Soil**

Excavate the trench to at least 6 cm but not more than 10 cm. below the specified grade. Replace the excavated material with approved bedding materials up to the specified grade (Figure 3.01B) and then compact them by tamping.

iii. **Excavation in Poor Subsoil**

Where the bottom of the trench is found to be unstable or contains ashes, cinders, refuse, vegetables and other organic materials, excavate to at least 6 to 10 cm below the specified grade. Replace the excavated material with approved bedding materials up to the specified grade and then compact them by tamping.

Where the bottom of the trench consists of materials that are unstable to such degree that in the opinion of the engineer, it cannot be removed and replaced with an approved material thorougly compacted in place to support the pipe properly, construct a concrete foundation.

iv. **Excavation in Unstable Ground**

Shown in Figure 3.01C is the correct way of constructing trenches in unstable ground. It is shown that to prevent cave-ins, shoring or sloping or benching of trench is required.

8 Stockpiling of Excavated Materials

a. Where space is not available on the sidewalk, place the excavated material between the trench and traffic.

b. If soil excavated is sandy or fitted to be used as backfill material, stockpile it separately from other discarded materials.

c. Place excavated materials at least 0.6 meter from the edge of trench.

B. **Excavation of Trenches for Foundation of Structures**

The complexity of the excavation works primarily depends on the depth of the trench and the type of soil formation. If the trench to be excavated is at least 3.0 M in depth and/or the trench to be excavated is located in loose ground formations, benching (Figure 3.02) or trench wall support (Figure 3.03) would be necessary. When the structure to be constructed will be located in a sidehill, benching should be extensive enough to insure stable foundation. This is usually accomplished by cutting into the sidehill a depth of 1.2 meters.

3.03 BACKFILLING

Backfilling is the replacement with approved backfill materials to raise the ground level to the specified grade (the ground level where the invert of pipelines or the bottom footing of structures will be supported) to fill the gap between the outside wall of structures and soil formation to cover the installed pipes, and to level the ground. Materials used for backfilling must be free of stones, sharp or pointed objects, garbage, vegetable and other organic matters. Gravel with fines and sand are good backfill materials.

A. **Care in Backfilling**

1. Where the groundwater is high, remove water from the trench before backfilling. This is usually done by use of a pump.

2. Place the backfill materials evenly and tamp in layers of 10-15 cm. Avoid direct application of backfill materials on the pipes or on any structures.

B. **Backfilling of Pipeline Trenches**

After the pipelines have been laid and tested for pressure and leakage they should be backfilled immediately to protect them from falling boulders and to prevent dislocation due to flooding of open trenches and cave-ins should there be rain. The backfilling process consists of shovelling backfill materials into the trench and then compacting it. The procedure of backfilling is as follows:

1. Backfilling Up to the Pipe Top

   Using a shovel, put backfill evenly along both sides of the pipe and then compact the soil by hand tamping or through flooding and jetting if backfill material is sand (Figure 3.04).

2. Backfilling Up to 20 cm Above the Pipe Top

   Continue backfilling the trench with the selected material. To get good results, place backfill materials in 10 cm layers with each layer being carefully compacted before the next layer is placed (Figure 3.04B).

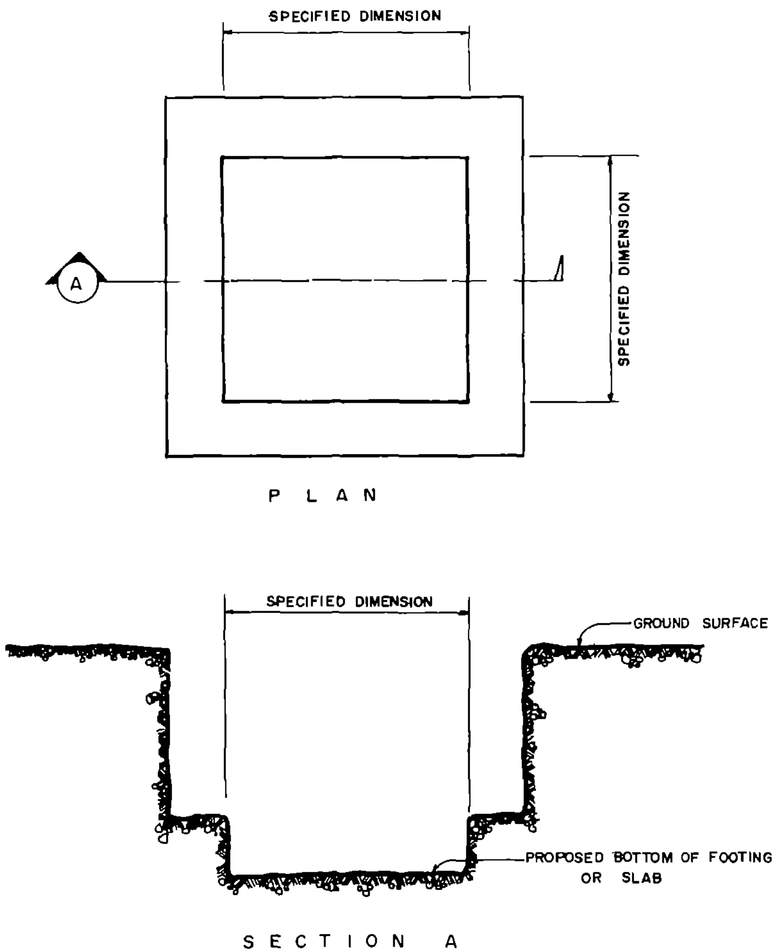


FIGURE 302

BENCHING

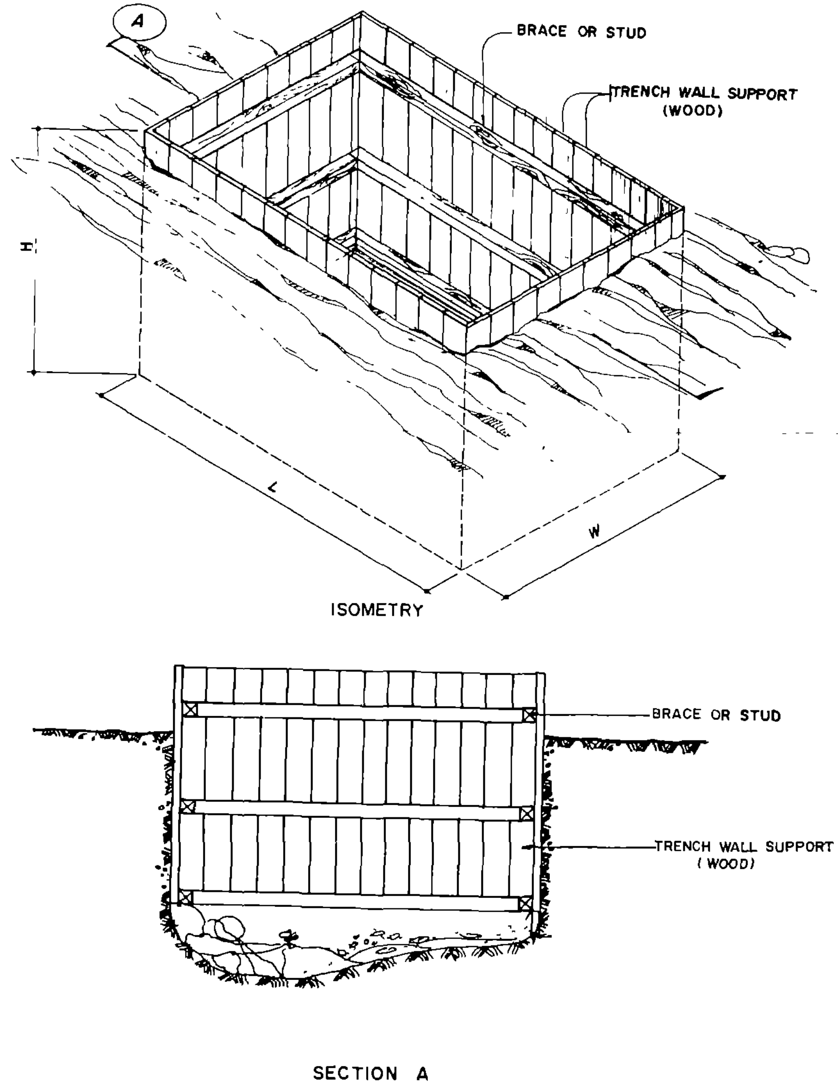


FIGURE 303

TRENCH WALL SUPPORT

3. Backfilling to the Ground Level

Backfill from 30 cm above the pipe to the ground level with the original soil free from stones and sharp objects and then compact the backfill (Figure 3.04C).

C. Backfilling Around and Beneath Proposed Structures

1. Backfilling Beneath Proposed Structures

Before the bottom slab or footing of structures is constructed on the soil foundation, it is necessary to even up the trench bottom and if the trench depth is excavated to greater than the specified grade, backfilling should be done to bring the trench bottom to the specified elevation. Also, to insure a good bond between the soil foundation and fill, the foundation surface should be scarified to a depth of about 15 cm (6 in.) and watered to the approximate optimum moisture content before the first layer of fill is placed. Standard specification prescribes that backfills be placed and compacted in layers not exceeding that which will provide the specified relative compaction through the full depth of the layer by the specified compaction equipment to be used. For tamping by rollers, the thickness of the layer should not be more than 15 cm. and for tamping using a tamper, the layer should not be more than 15 cm. However, soils vary widely as to the amount of compactice effort necessary to reach the specified degree of compaction. When difficulty is encountered in obtaining the required compaction, the first remedial measure to be taken is to reduce the thickness of the layer since soils compact more readily in thin layers. For foundation of structures, it is necessary that the soil should be compacted up to 95% of the maximum density.

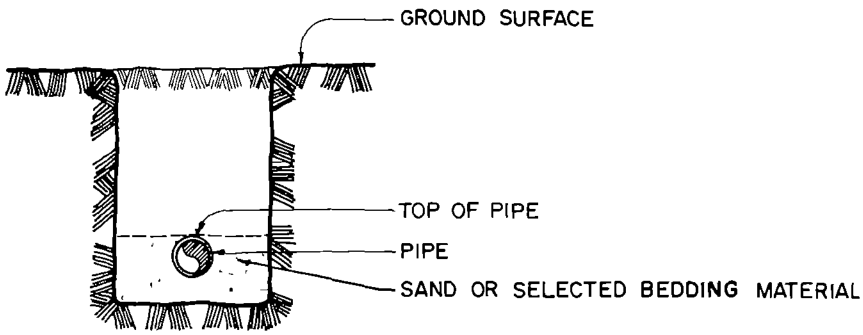
2. Backfilling Around the Constructed Structures

After the construction of a structure, the gap between the wall of the structure and trench should be filled. Before starting the backfilling operation it has to be made sure that the concrete structure has attained sufficient strength to withstand the loads to be imposed.

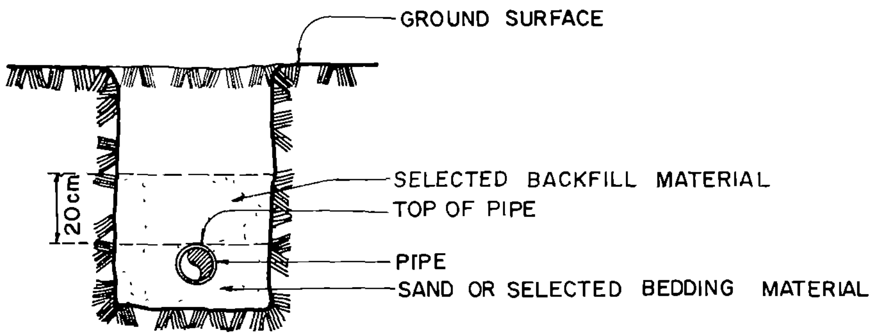
The backfilling procedure is similar to the procedure discussed in subjection one except that the soil should be compacted up to 90 percent of the maximum density.

D. Backfilling Beneath and Around Concrete Reservoirs

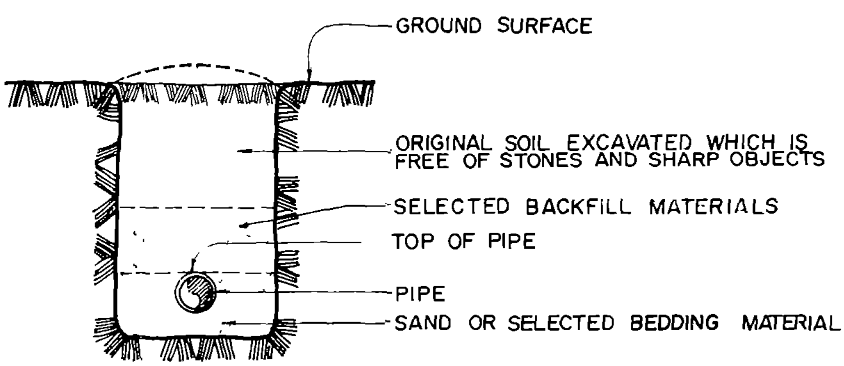
The backfilling works when constructing reservoirs may be classified as backfilling beneath and around structures. However, unlike the structures, reservoirs have underdrains (Figure 3.05) which require a special backfilling procedure. The underdrain is necessary to prevent uplift pressure from lifting or dislocating the reservoir when it is emptied say during cleaning operations at



A. BACKFILLING UP TO THE TOP OF PIPE



B. BACKFILLING UP TO 20 cm. ABOVE THE TOP OF PIPE



C. BACKFILLING UP TO THE GROUND SURFACE

FIGURE 3 04

BACKFILLING OF PIPELINE TRENCHES

a time when the ground water level happens to be at the reservoir elevation. The backfilling procedure is as follows:

1. Following foundation grade preparation, excavation and construction of an underdrain system, 15 cm (6-in) thick layer of drain rock shall be placed as shown in Figure 3.05. Drain rock shall be clean gravel or crushed stone 0.6 – 10 mm in diameter and shall be durable and free from slaking or decomposition under the action of alternate wetting and drying.

2. The drain rock layer is then compacted and the surface layer immediately beneath the reservoir is stabilized with hot applied liquid asphalt or equivalent, after the surface of the drain rock has been graded to required elevation.

With respect to backfilling around the outside wall of reservoirs, the procedures discussed in backfilling of structures will suffice. Backfill materials shall be placed in layers not exceeding 10 cm before compaction. The backfill shall be brought evenly with each layer moistened and compacted to 90 percent of maximum density. Flooding, ponding or jetting should be permitted. Also, during the entire backfilling process, the reservoir should always be full of water.

3.04 SOIL COMPACTION

Soil compaction is a process of bringing soil particles closer together thereby forming a dense closely packed formation. This is usually accomplished by the application of force or through flooding or jetting when sand is used as backfill. The degree of compaction of backfill in trenches must at least be comparable to the density of the surrounding soil.

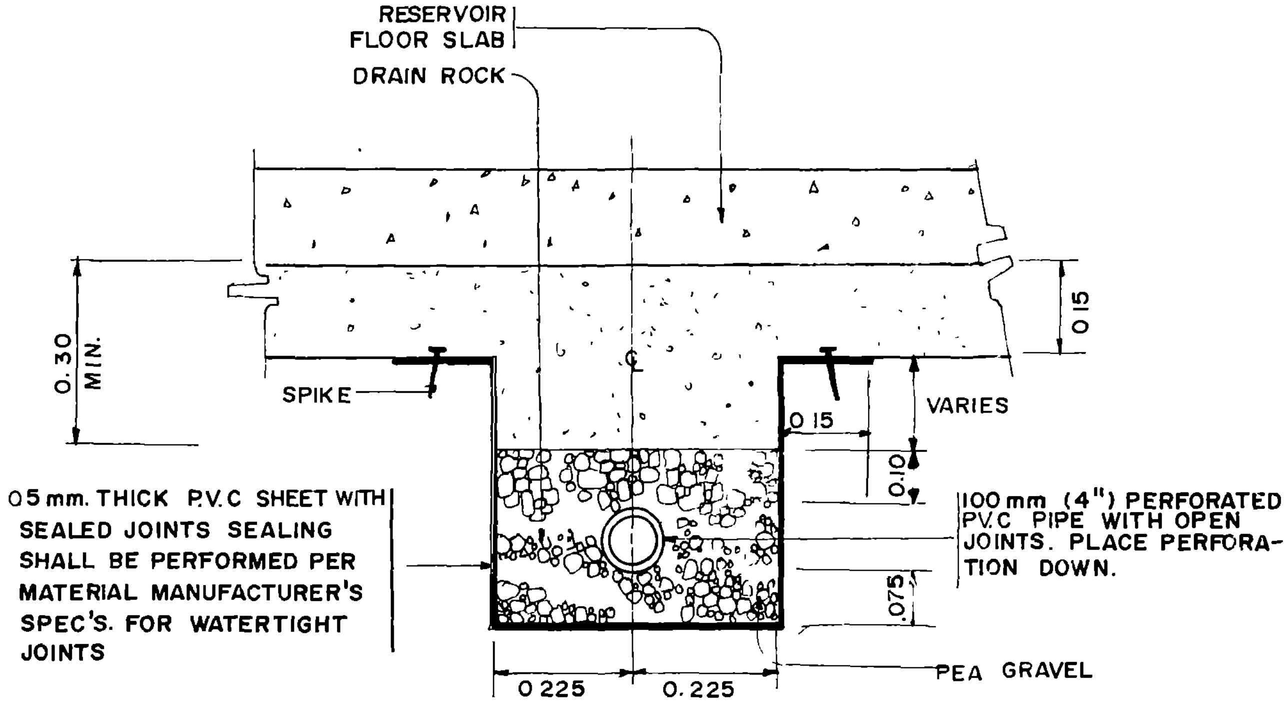
A. Moisture Content

Proper compaction of soil depends largely on the moisture content in the soil. Soil is said to have the right moisture content when it contains enough water to act as lubricant between soil particles so that during compaction, these particles will be brought closer together and in the process air is expelled.

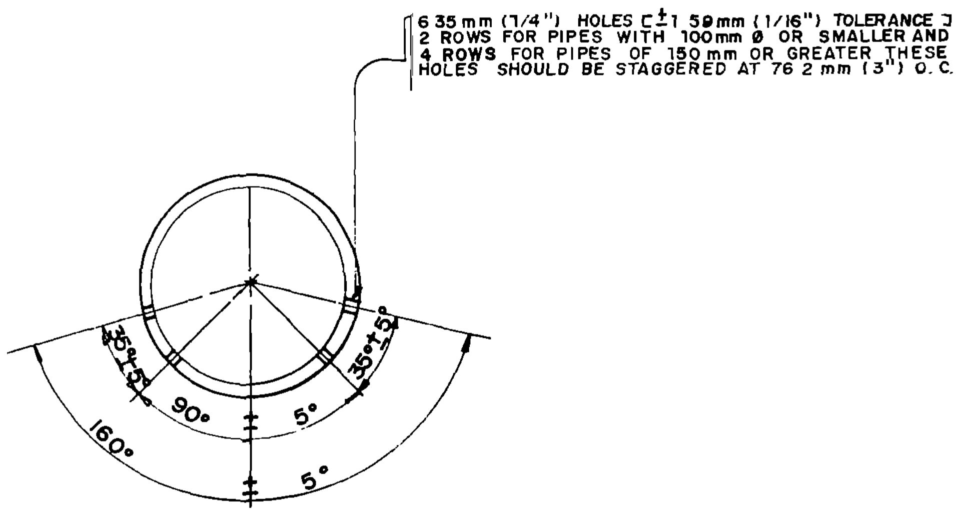
Also, a soil with proper moisture content is moldable by hand and when dropped should break into a minimum number of pieces (2-4 pieces). Such soil is suited for compaction. However, if the soil contains too much moisture, it becomes plastic. This is evident when there are traces of moisture left on the fingers after handling it or when the soil stays in one piece when it is dropped. Such soil should be dried prior to compaction. On the other hand, if soil is too dry, the soil mold will break into 5 or more pieces when dropped. Water must therefore be added before compaction.

B. Thickness of Lift or Soil Layer

Proper compaction also depends on the correct choice of the thickness of soil layer which usually varies from 10-15 cm depending upon the type of



TRANSVERSE SECTION AT TRENCH



SECTION THRU PIPE HOLES

FIGURE 3.05

DRAINROCK LAYER IN RESERVOIR UNDERDRAIN

soil and compaction equipment. For instance, when compacting clay soils, lamination (or splitting of the lift into thinner layers) will occur when the lift selected is too thick. Water then seeps between the layers making it impossible for the soil particles to be bound together.

C. **Number of Blows and Passes the Soil is Subjected**

Equally important is the number of passes (number of times the roller is allowed to pass on the surface of the soil to be compacted) if rollers are used, or blows if rammers or tampers are used in compaction. The number of passes/blows is determined through a compaction test. It should be observed that there is a relation between the thickness of the lift and the number of passes/blows required to achieve a specified density. For 10-15 cm. lift, 20-25 passes or blows are usually required.

D. **Compaction Equipment**

1. Tamper

Shown in Figure 3.06A is a tamper. It is made of cylindrically-shaped concrete or wood block with a wooden handle.

Compaction is brought about by raising the concrete or wooden cylinder to a certain height and then dropping it to the soil surface to be compacted.

2. Cylindrical Roller

Shown in Figure 3.06B is a roller. It is made of metal or concrete. Compaction is effected by rolling it on the surface of the lift or layer to be compacted. The degree of compaction depends on the weight of the roller and the number of passes.

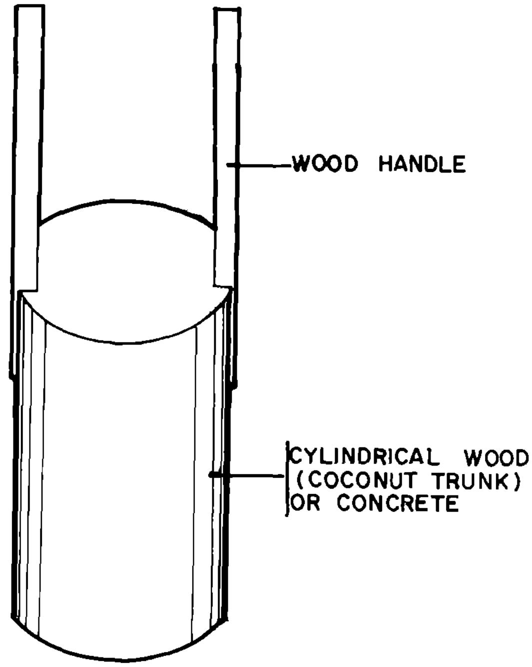
3. Tamping Bars

Tamping bars (Figure 3.07A) are employed when compacting soil below and around the pipes. As shown, there are two types of tamping bars, namely: tamping bar with a narrow blade or head, and tamping bar with a flat head. The first type is employed in compacting soil under pipes, while the second type is utilized when compacting soil at the sides and top of pipes.

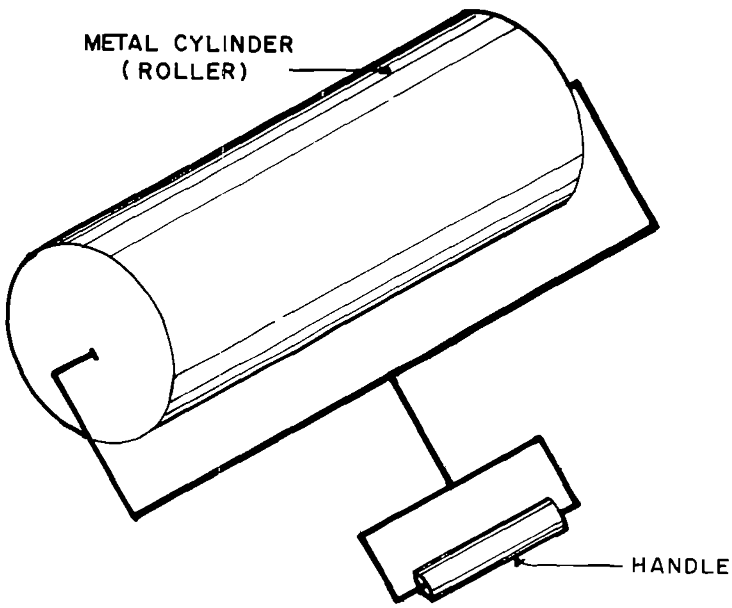
E. **Compaction Methods**

1. Mechanical Compaction

Mechanical compaction is effected by applying force or energy using mechanical compaction equipment (sub-section D) into the soil. This application of force causes the removal of excess water and closing of air voids resulting in a denser soil texture. Also, it should be pointed



A TAMPER



B CYLINDER ROLLER

FIGURE 3.06

MANUAL COMPACTION EQUIPMENT

out that the key to a good tamping job is the proper calculation of the amount and uniformity of placement of the soil to be tamped.

a. **Compaction of Backfill Under and Around Structures**

Place the soil in 10-15 cm layers and compact using a tamper or roller, whichever is appropriate or available. If a roller is used, allow the roller to pass on the backfill 20-25 times and if a tamper is employed, allow 20-25 blows to strike the material to be compacted. Continue the process of alternately placing the backfill in 10 cm layers and mechanical compaction until the specified grade or ground surface is reached.

b. **Compaction of Backfill Under and Around Pipelines**

Place the soil in a 10 cm layer and then tamp it using the tamping bars. When compacting soil under the pipe, use the tamping bar with a narrow head (Figure 3.07B) and when compacting soil on the sides and top of pipe use the flat tamping bar (Figure 3.07). Compaction employing these bars is effected by alternately raising and dropping the tamping bars into the backfill until the soil in the trench is as dense or denser than the soil surrounding the trench.

Continue the process of alternately placing the backfill in 10 cm layers and tamping until the ground surface is reached.

2. Flooding and Jetting Method

Flooding and jetting are usually employed when backfill material is sandy or in trenches where water drains away quickly. However, it is not recommended in clay soil since clay expands when wet and shrinks when it dries thereby creating voids.

Procedure:

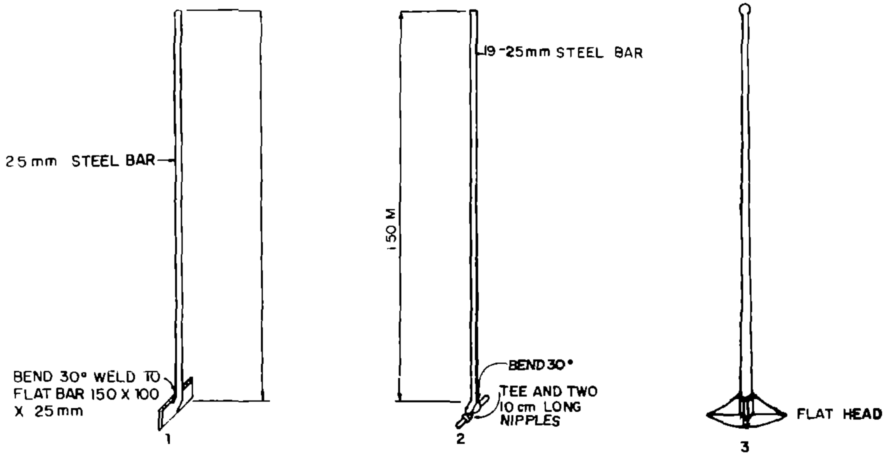
a. Place backfill materials in layers not greater than 40 cm.

b. Add enough water to settle the backfill. It should be pointed out that if insufficient water is applied, voids spaces will form. When the area to be backfilled is sloping, construct a dirt dam. This will prevent the flow of water with soil to low areas.

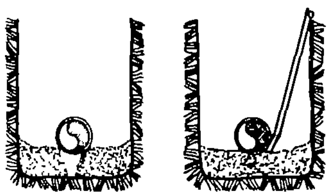
c. Alternately, to achieve best results, rodding is employed after flooding. During the rodding process, avoid contact of the rod with the pipe as this may damage the latter.

F. **Field Compaction Test**

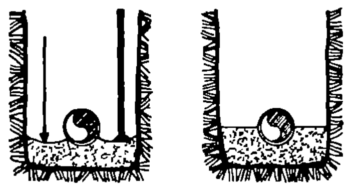
Field compaction testing is necessary to determine whether the soil has



A TAMPING BARS



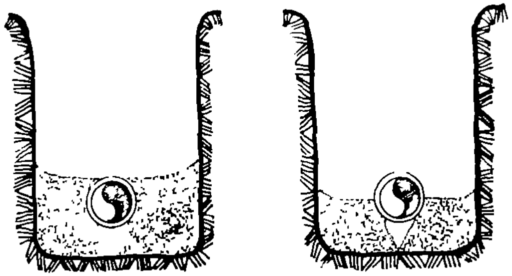
B USE TAMPING BAR 1 AND 2 NARROW HEAD WHEN TAMPING SOIL BENEATH PIPES



C USE A TAMPING BAR WITH FLAT HEAD WHEN TAMPING SOIL AT THE SIDES AND TOP OF PIPE

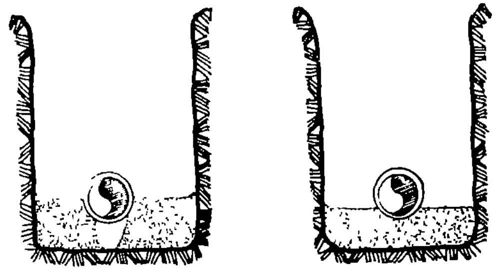
FIGURE 3.07

COMPACTION OF PIPELINE BACKFILL BY HAND TAMPING



BEFORE TAMPING — WRONG — AFTER TAMPING

A TOO MUCH SOIL WAS PLACED BEFORE TAMPING TAMPING BAR CANNOT COMPACT BACKFILL PROPERLY UNDER PIPE THUS LEAVING A VOID UNDER THE PIPE



BEFORE TAMPING — CORRECT — AFTER TAMPING

B JUST ENOUGH BACKFILL MATERIAL WAS PLACED BEFORE COMPACTION BACKFILL CAN BE TAMPED PROPERLY UNDER PIPE THUS GETTING A FIRM BED

FIGURE 3.08

COMPACTION OF BACKFILL UNDER PIPE INVERT been properly compacted as specified. A soil is said to be satisfactorily compacted if its density is similar to the density of the undisturbed surrounding soil formation, or better.

1. **Procedure:**

   a. Select an area of 0.25 square meters. Remove all loose soil found in the selected area with a square pointed shovel. It should be pointed out that the surface upon which the test is to be made should be below the level which has been disturbed by compaction equipment.

   b. Place a metal plate with a hole cut in the center, on the selected area (Figure 3.09).

   c. Excavate a soil specimen through the test hole. Every particle loosened in this excavation is removed from the test hole and is placed in a clean dry container with a tight lid.

   d. Fill the test hole with dry sand of known density (D_s) from a container. The weight of sand in the container before and after the placement of dry sand into the test hole should be noted down to determine the weight of the sand (W_s) consumed to fill the hole. This will determine the volume of the test hole.

   e. Weigh the soil specimen taken from the test hole and then dry it under the sun for 5-7 hours. After drying, determine the weight of the sample. The difference in weight is the moisture content of the soil.

2. Computation Procedure for the Degree of Compaction

   a. Calculate the volume of the test hole given the density and weight of the sand placed in the test hole.

   Volume of soil excavated = Volume of test hole

   $$\text{Volume of test hole, } V_s = \frac{\text{Weight of Sand, } W_s}{\text{Density of Sand, } D_s}$$

   b. Calculate the field density or the density of soil excavated.

   $$\text{Field Density, } F_d = \frac{\text{Weight of moist soil excavated, } W_t}{\text{Volume of Soil excavated, } V_s}$$

   c. Calculate the percent moisture of soil specimen

   $$M = \frac{W_t - W_d}{W_d} \times 100$$

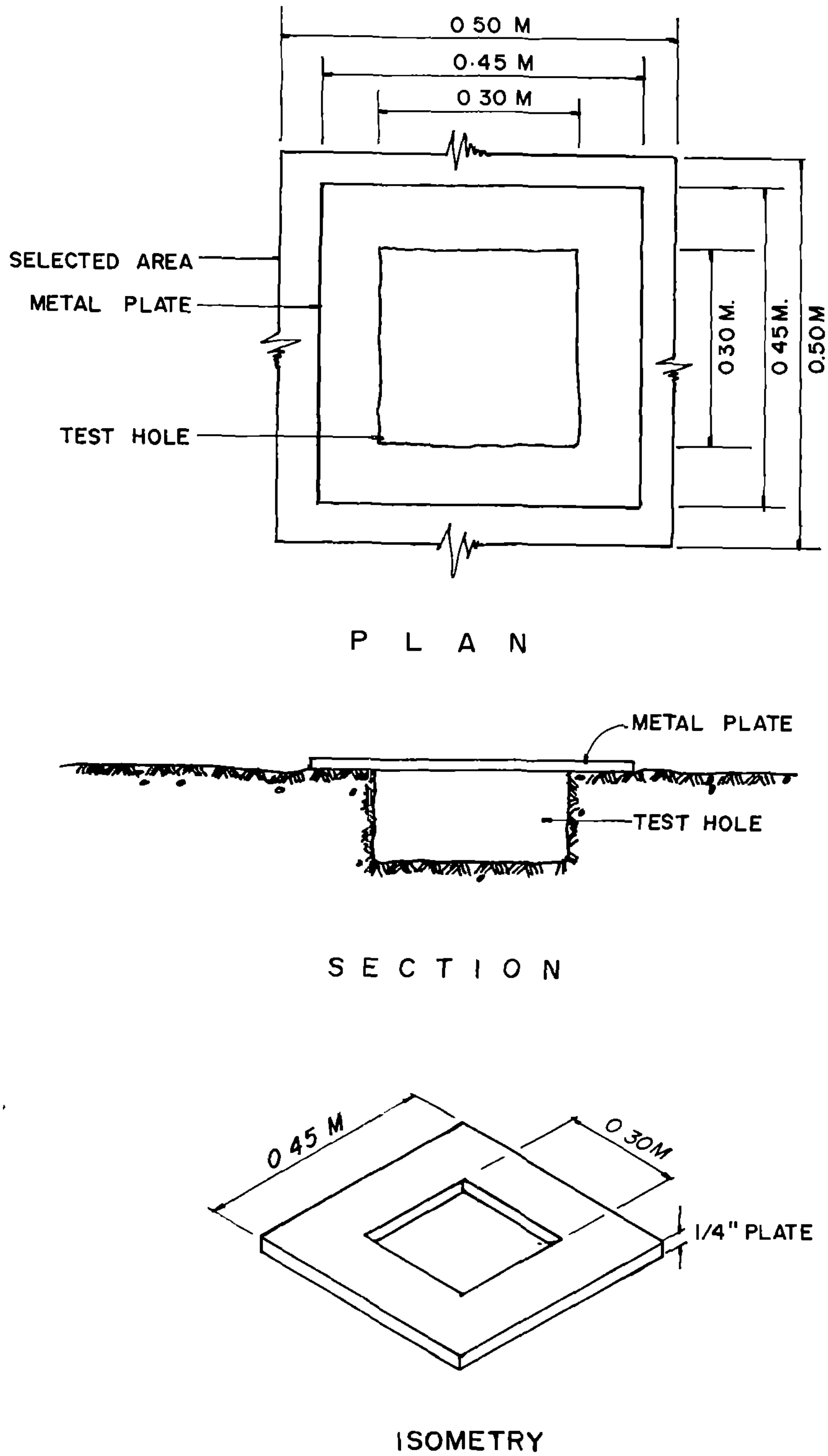


FIGURE 3 09

FIELD COMPACTION TEST

Where: M = % moisture
W_t = Weight of moist soil
W_d = Weight of dried soil

d. Calculate the dry density of soil specimen

$$\text{Dry density, } D_d = \frac{\text{field density, } F_d}{1 + M/100}$$

e. Calculate the % compaction of soil specimen

$$\text{\% compaction} = \frac{\text{dry density, } D_d}{\text{maximum density, } M_d} \times 100$$

Table 3.3
MAXIMUM DENSITY AND OPTIMUM MOISTURE CONTENT

Soil Type	Optimum Moisture Content	Maximum Density
Clays	20 – 30%	1.45 – 1.70 gm/cc
Silty Clays	15 – 25%	1.77 – 1.82 gm/cc
Sand Clays	8 – 15%	1.77 – 2.16 gm/cc

Example 3.1: Compute the degree of compaction given the following data obtained during the field compaction test.

Data:

A. Soil Specimen

Weight of soil excavated, W_t = 53.5 kg.

Weight of soil after drying, W_{td} = 48.6 kg.

B. Test Sand

Density, D_s = 2.2 gm/cc = 2,200 kg/M^3

Initial Weight of Sand + Container, W_{si} = 70 kg.

Final Weight of Sand + Container, W_{sf} = 10.6 kg.

Solution:

1. Calculate the volume of soil excavated or test hole, V_s

$W_s = W_{si} - W_{sf}$ = 70.0 – 10.6 = 59.4 kg.

$$V_s = \frac{W_s}{D_s} = \frac{59.4 \text{ kg}}{2,200 \text{ kg/M}^3} = 0.027 \text{ M}^3$$

2. Calculate the Field Density, F_d

$$F_d = \frac{W_t}{V_s} = \frac{53.5 \text{ kg}}{0.027 \text{ M}^3} = 1980 \frac{\text{kg}}{\text{M}^3} \text{ or } 1.98 \text{ gm/cm}^3$$

3. Calculate the percent moisture content of soil specimen, M.

$$M = \frac{(W_t - W_{td}) \times 100}{W_{td}} = \frac{(53.5 - 48.6) \times 100}{48.6}$$

$$= 10\%$$

4. Calculate the dry density of soil specimen, DD

$$DD = \frac{FD}{1+M/100} = \frac{1.98}{1+10/100} = \frac{1.98}{1.10} = 1.8 \text{ gm/cm}^3$$

5. Calculate the percent compaction of soil specimen

$$\% \text{ Compaction} = \frac{DD}{MD} \times 100$$

Where maximum density is taken from Table 3.3

Assume that soil specimen is silty clay, and the MD for this type of soil is equal to 2.0 gm/cm^3 or 2,000 kg/M^3.

$$\% \text{ Compaction} = \frac{1.8 \text{ gm/cm}^3}{2.0 \text{ gm/cm}^3} \times 100 = 90\%$$

3.05 SOIL STABILIZATION

Soil formations encountered are not at all times stable and suited for foundation of structures. In such cases, they should be first corrected prior to usage. Presented in Table 3.4 are typical soil deficiencies, types of failures, the probable causes of instability and the possible remedies. As outlined in the table, soil for foundation can be altered to conform to desired characteristics through mechanical and/or chemical stabilization and/or through the provision of drainage to remove excess water. Provisions for drainage is discussed in section 3.06.

A. Mechanical Stabilization

Mechanical stabilization can be effected by compaction or by blending different types of soil particles closer together causing them to interlock and form a denser texture. Compaction is discussed in detail in section 3.04. Blending the different types of soil causes the alteration of the properties of the individual soil and may be used to obtain a mixture of better characteristics. For example, loose granular soils can be made suitable as foundation material by mixing/adding clay soil.

Table 3.4

SOIL DEFICIENCIES AND THEIR REMEDIES

Soil Deficiency	Type of Failure It May Cause	Probable Causes Of Its Instability	Possible Remedies
1. Slope Instability	Slides on slopes	High moisture content of soil	– Drain and/or flatten slope.
		Loose granular soil Weak Soil	– Compaction – Mechanical and/or chemical stabilization. – Sodding.
	Mud flow or soil erosion	Excessive water	– Exclude water through provision of drainage.
	Slides caused by the movement of toe.	Toe instability	– Chemical stabilization and draining of excess water
2. Low soil bearing capacity.	Excessive settlement.	Saturated clay	– Compaction and draining of excess water.
		Loose granular soil	– Compaction and draining of excess water, chemical stabilization, increase footing depth.
		Weak soil	– Mechanical and/or chemical stabilization.
3. Heaving	Excessive rise	Expansion of clay	– Mix existing clay soil with granular like sand and gravel (mechanical stabilization) – Drain excess water
4. Excessive permeability	Seepage	Pervious soil	– Mix existing soil with clay or selected material. – Mechanical stabilization; Chemical Stabilization.

B. **Chemical Stabilization**

Chemical stabilization of soil is brought about by using bituminous or portland cement. These stabilizers if used in surface treatment will make the stability of compacted soil more lasting, while if used for subsurface treatment, will increase the bearing capacity and decrease the permeability of soil. Surface treatment is accomplished by spreading concrete or bitumen (asphalt) on the soil surfaces while in subsurface treatment, the stabilizers are used to fill the voids in soil, to cement the particles together and form a rock-like structure.

3.06 SLOPE STABILIZATION

When a structure is to be supported on inclined soil strata, the possibility of soil movement should be considered. Under the constant load due to the structure, soil on slopes tend to move downward. This movement is however resisted by passive pressure of the soil below, friction and cohesion between soil particles and surface elements such as vegetation. When the forces tending to cause movement exceeds the resisting force, a slide will occur. To prevent sliding, slope stabilization is necessary. This can be done by constructing a stone wall or by sodding.

A. **Stone Wall**

Shown in Figure 3.10A is a stone wall. It consists of stone 5-15 cm (2-6 inches) in diameter arranged in a manner that they would interlock with each other. The interlocking between stones is increased by putting cement mortar in between them.

B. **Sodding**

All excavations or embankment slopes steeper than three (3) units horizontal to one (1) unit vertical should be stabilized by sodding (Figure 3.10B). The sods to be used should not be more than three (3) years old, of sufficient thickness to prevent excessive breakage and must be stripped in the largest practicable widths and lengths (say 30 cm square or greater). Sods are upper layer of grassland and include the grass, its roots and earth where the roots are anchored. The placement procedure is as follows:

1. Make the surface even by using a rake or trowel.

2. Place 10-20 mm layer of graden soil above the evened soil surface.

3. Place the sods and then tamp them in place. All sods not in good condition after tamping should be removed and replaced.

4. Water the newly planted sods using a sprinkler.

5. Continue daily watering until sods are growing healthy.

3.07 DRAINAGE

Drainage is employed to collect and convey surface water into natural drainage channels. Removal of excess water preserves the stability of soil formation, hence, foundation of structures, because strength of soil generally decreases with an in-

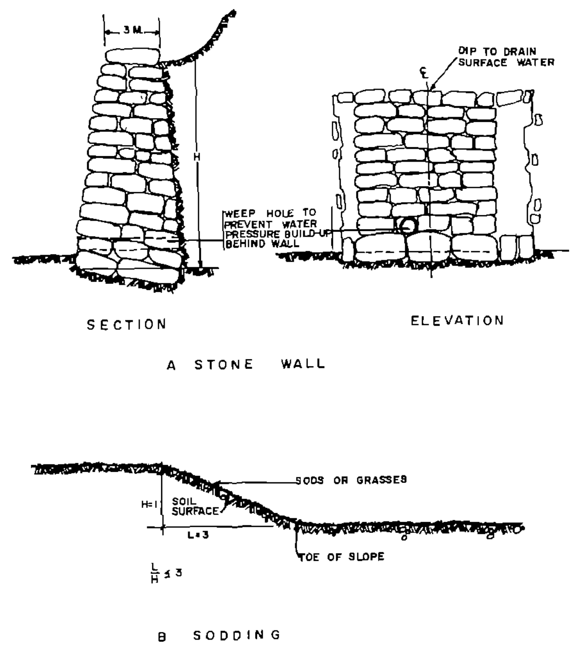


FIGURE 3.10

SLOPE STABILIZATION

crease in amount and pressure of water in the pores or voids in soil formations. Also, drainage prevents the flooding of the surroundings of wells and ground level reservoirs such as spring box, thus, preventing the infiltration of surface water to these water retaining structures. The essential requirements for drainage are:

1. Transverse slope to allow surface water to flow by gravity into the drainage canal. The surface of this slope is usually stabilized using puddled clay or by concreting to prevent soil erosion.

2. Open canals or ditches to collect and remove surface water. The wall of the canals may be made of cement or stones grouted with cement mortar. However, if finances will not permit the construction using the above alternatives, clay walls may suffice. However, digging deeper canals will be more frequent.

3.08 SURFACE RESTORATION

After excavation, construction of structures, backfilling and compaction, the construction area becomes topsy turvy. The soil surface is not level and the area is littered with broken concrete blocks, wood and other materials. Levelling of the ground surface and removal of litter is therefore necessary. After cleaning, make the surrounding area of the structures presentable by landscaping and/or by planting ornamental plants. This section is discussed in detail in Chapter 16, Site Improvement.

CHAPTER 4

HANDLING AND JOINTING PIPES

4.01 GALVANIZED IRON (G.I.) PIPE

A. General

Galvanized iron (G.I.) pipes are available commercially in many sizes and in lengths of 6 M. In rural water supply systems; 13, 19, 25, 31, 38, 50, 63, 75 and 100 mm pipes are commonly used. G.I. pipes are joined by the use of threaded or screwed fittings. The fittings have the female threads while the pipes have the male threads.

B. G.I. Fittings

G.I. fittings are of two types; the plain type (Figure 4.01) and the banded type. The difference between the two is that the banded type has a raised rim at each end as compared to the plain type which has plain ends. Both types of fittings are suitable for rural water supply systems but the plain type is cheaper, hence, it is usually used.

C. Cutting of Pipe

G.I. pipes with diameter of 38 mm and below can be effectively cut using a hacksaw. For sizes larger than 38 mm, a manually operated heavy duty cutter (3 or 4 wheel type) may be used.

Procedure:

1. Mark the pipe to be cut with a pencil and then place it in a vise (Figure 4.02A). Adjust the jaws of the vise to hold the pipe in place. Alternately, place the pipe in a miter box (Figure 4.02B) and secure the pipe in place by a clamp.

2. Cut the Pipe at the Pencil Line

   a. **Using a hacksaw** – Hold the saw at right angles to the pipe at a rate not greater than 60 strokes per minute. Sawing too fast will heat the saw causing the softening of the teeth. Cutting a pipe using a hacksaw is shown in Figure 4.02.

   b. **Using a Pipe Cutter** – Set the cutting tool (Figure 4.03) over the pipe with the cutter positioned on the pencil mark. Allow the cutter wheel to get in contact with the pipe by turning the handle. Swing the tool around the pipe to make an initial cut and check whether the cutting wheel is on the right track. Continue turning the cutter around the pipe, tightening the cutter after each turn until the pipe is cut.

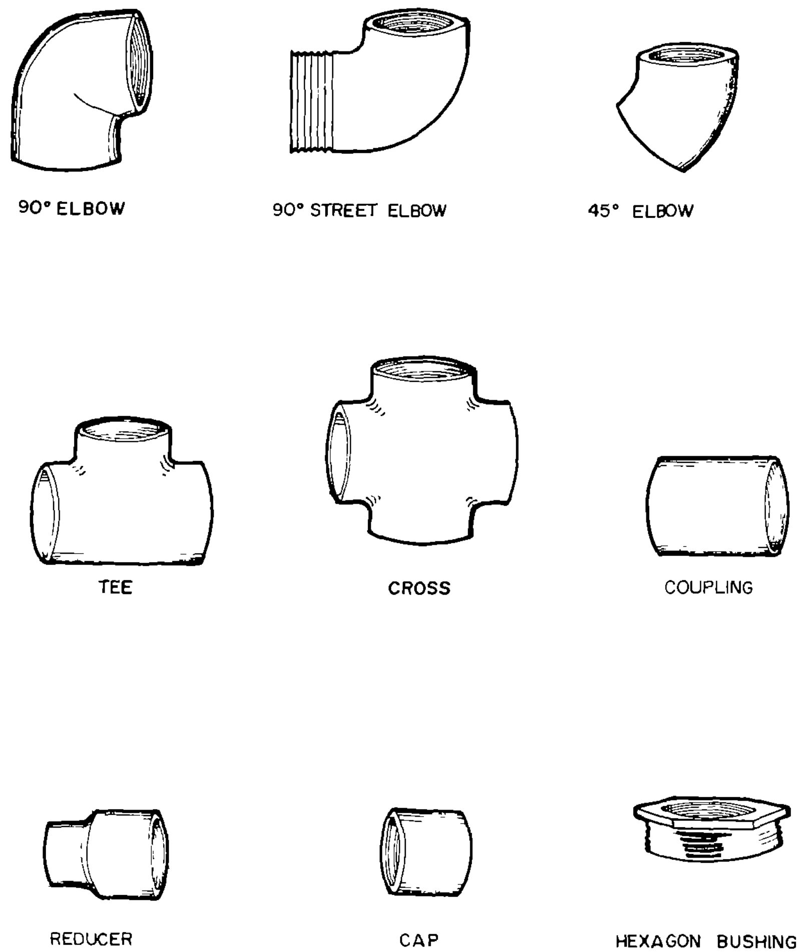


FIGURE 4 01

GALVANIZED IRON (GI) FITTINGS
(PLAIN TYPE)

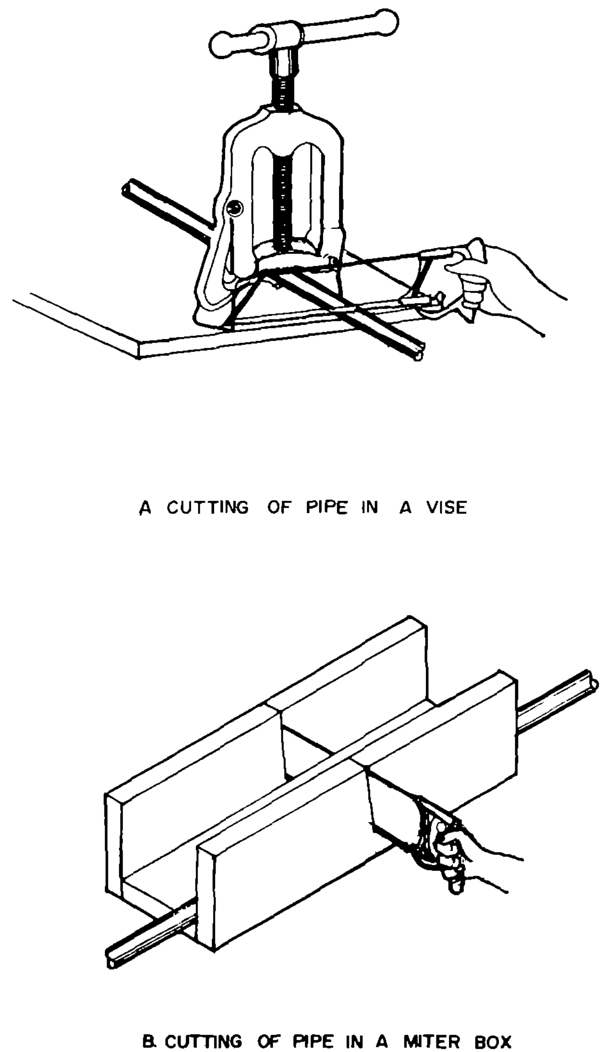
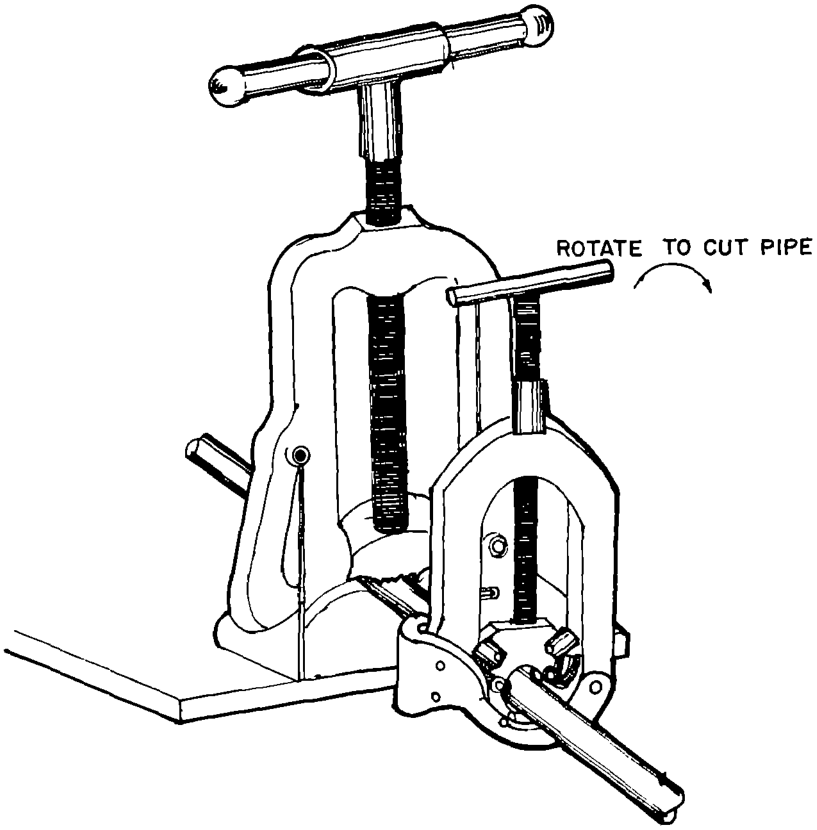
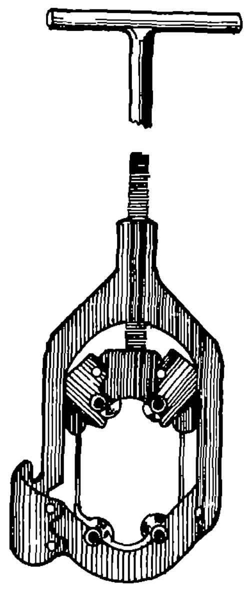


FIGURE 4 02

CUTTING OF PIPE USING A HACKSAW



A CUTTING OF PIPE BY WHEELED PIPE CUTTER



B WHEELED PIPE CUTTER

FIGURE 4.03

CUTTING OF G.I. PIPE USING A WHEELED PIPE CUTTER

D. **Threading of Pipe**

1. Tools Needed

   a. Pipe thread-cutter and die set
   b. Pipe vise
   c. Thread-cutting oil

2. Procedure

   a. Check whether the die to be used in threading the pipe is of correct size, properly adjusted, clean and sharp.

   b. Mark the length of pipe to be threaded. The correct length of thread can be determined by measuring factory cut threads.

   c. Set the pipe on the pipe vise.

   d. Place the threader on the pipe end and press the die firmly against it (Figure 4.04). Turn the handle clockwise at the same time keeping the handle perpendicular to the pipe being threaded. Continue turning the die until the mark length is reached.

   e. Remove the die from the pipe and clean the threaded end from metal chips.

E. **Jointing of Pipe**

1. Tools Needed

   a. Pipe vise
   b. Pipe wrench

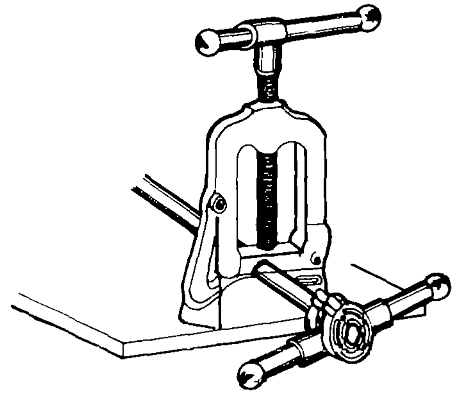
2. Procedure

   a. Clean and paint with non-toxic paint the entire pipe thread. The paint will help in sealing the joint and in lubricating the threads.

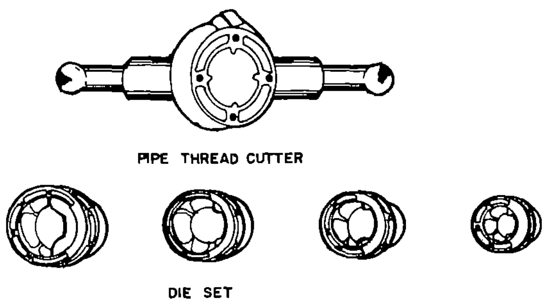
      Fitting threads should not be painted because during the insertion of pipe into the fitting, the paint may pile up resulting in the partial closing of pipe.

   b. Set the pipe in the vise with threaded end close to the vise.

   c. Place the fitting on the pipe and turn the fitting clockwise until it can no longer be turned. Further tighten the joint by using a pipe wrench. Avoid overtightening the joint as this may cause the cracking of the fitting or ruining of the threads. To connect a valve to a pipe, place a flat-jawed wrench on the end of the valve next to the pipe (Figure 4.05) while rotating the pipe clockwise. This method will prevent the twisting of the valve which might cause its deformation.



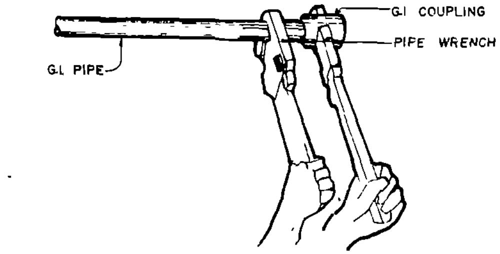
A THREADING OF PIPE SET UP



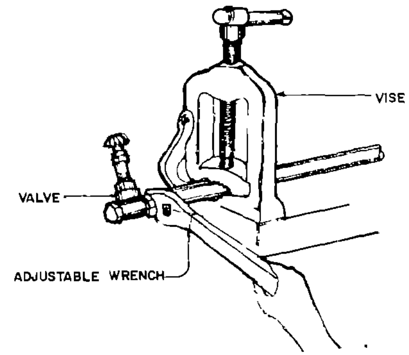
B PIPE THREAD CUTTER AND DIE SET

FIGURE 4 04

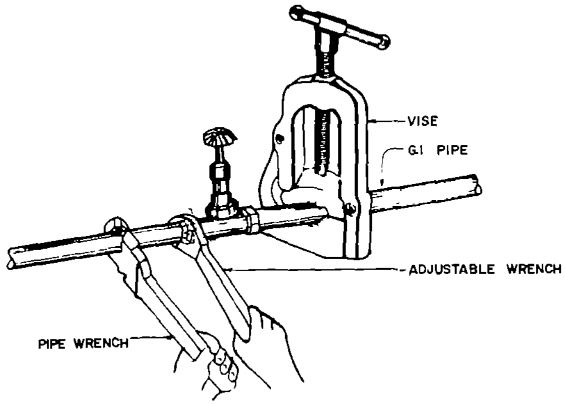
THREADING OF PIPE



A SCREWING OF G I FITTING TO G I PIPE



B SCREWING OF A BRASS VALVE AT THE END OF A PIPE



C SCREWING OF A PIECE OF PIPE INTO A BRASS VALVE

FIGURE 4 05

UOINTING OF G I PIPE AND APPURTENANCES

4.02 POLYVINYL CHLORIDE (PVC) PIPE

A. General

PVC pipes which are commonly used in rural water supply systems are 13, 19, 25, 31, 38, 50, 63, 75 and 100 mm in diameter and are commercially available in lengths of three (3), six (6), and nine (9) meters. PVC pipes can be joined using the Taper Sized Solvent Welding (TS) Method where pipes are joined using solvent cement, and the Rubber Ring Method where pipes are joined using a rubber ring.

B. PVC Fittings

There are three general types of PVC fittings: 1) the plain or TS type which is used when joining PVC pipe by TS Method, 2) the bell type which is used when joining PVC pipe by Rubber Ring Method and 3) the threaded type which is used when joining PVC pipes to G.I. pipes. For rural water supply, the plain or TS type is normally used. Shown in Figures 4.06 and 4.07 are the TS type fittings.

C. Handling and Storage

1. Care in Transportation of Pipes

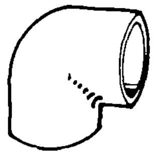
   In transporting PVC pipes for short distances, let two persons carry it on their shoulders, one person at each opposite end. Avoid rolling or dragging the pipe as this may cause damage. To transport pipe using a motor vehicle, use a truck with a long body so that the entire length of the pipe is supported. During loading and unloading, extreme care should be exercised to prevent contact of the pipes with any sharp edges that may cause damage.

2. Checking of the Delivered Material

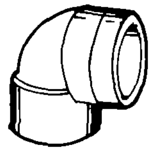
   Carefully inspect the delivered materials and see to it that the goods ordered are complete and as specified.

3. Field Storage

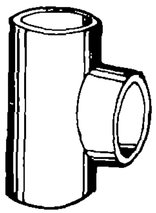
   Select a ground surface which is relatively flat and free of stones or sharp objects. Lay the sleepers on the ground selected and then placed on these the pipes with packings still intact (Figure 4.08). To prevent the pile from collapsing, tie a rope around the piled pipes and anchor the rope to stakes driven into the ground. In addition, protect the pile from direct heat of the sun by providing an opaque cover. It should be emphasized that straight lengths should be given adequate support at all times. They should not be stacked in large piles to avoid distortion of the bottom pipes. Furthermore, keep PVC pipes in places where they will not come in contact with compounds that may cause damage such as gasoline, lubricating oil, muriatic acid, gas or liquid fuels, paint, solvents, turpentine, etc.



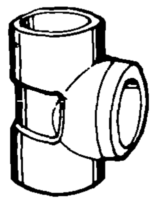
ELBOW 90°



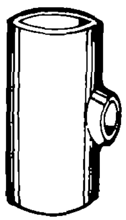
ELBOW 90°



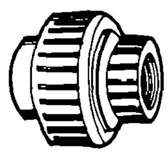
TEE 90°, EQUAL



TEE 90°



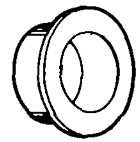
TEE, 90° REDUCING



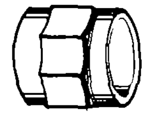
ADAPTOR UNION

FIGURE 4.06

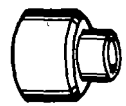
POLYVINYL CHLORIDE (PVC) FITTINGS



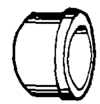
FLANGE ADAPTOR



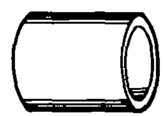
ADAPTOR SOCKET



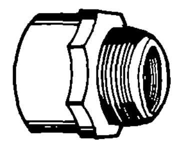
REDUCING SOCKET



CAP



SOCKET



ADAPTOR BUSHING

FIGURE 4.07

POLYVINYL CHLORIDE (PVC) FITTINGS

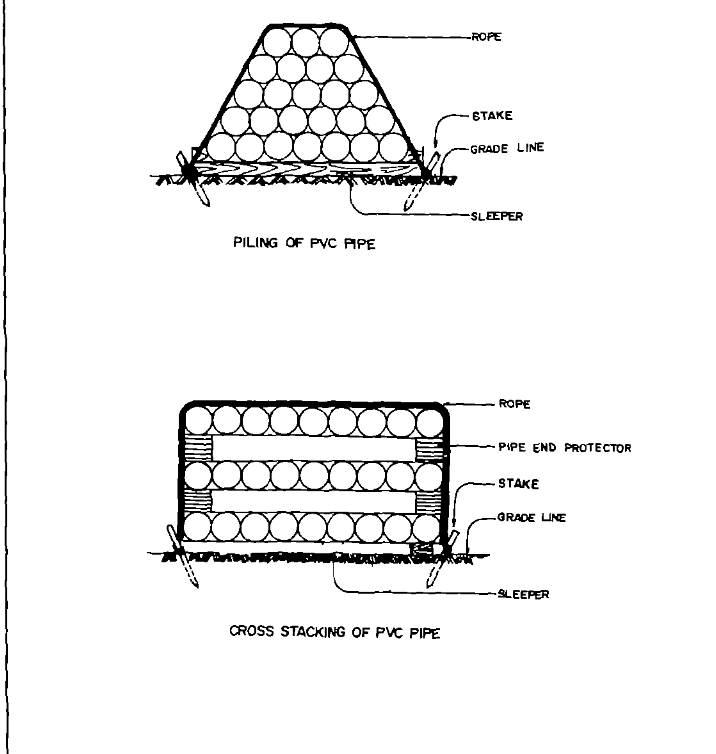
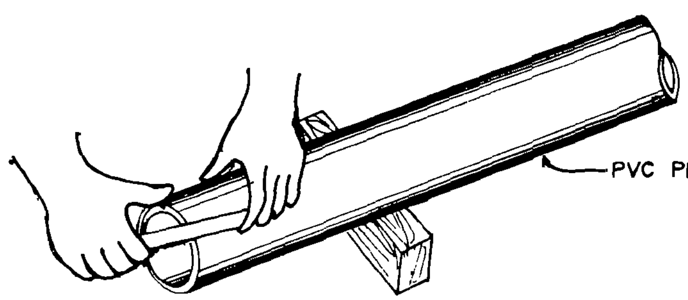


FIGURE 4 08
FIELD STORAGE OF PVC PIPES

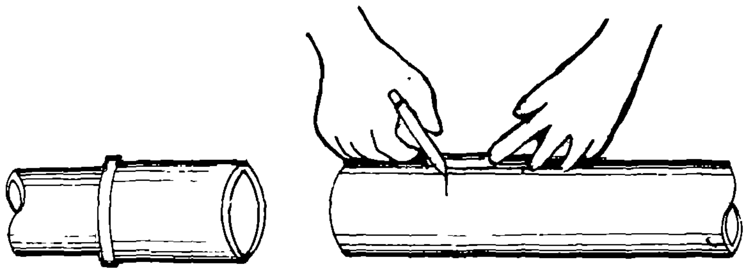
D. Joining of PVC Pipes

1. Taper Sized Solvent Welding (TS) Method



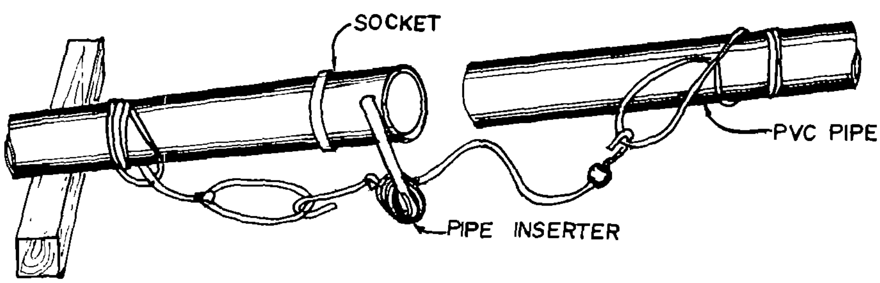
SMOOTHING THE OUTSIDE SURFACE OF THE SPIGOT END.

a. Measure accurately the length needed and mark it with a pencil. Cut the pipe squarely on the pencil line using a hacksaw. Trim off any burrs left from sawing with a knife or half round file.



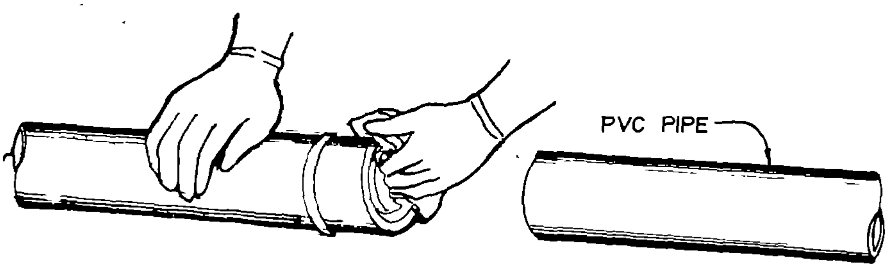
MARKING THE ENGAGEMENT LENGTH

b. Position the spigot end into the socket or any fitting and mark the engagement length.



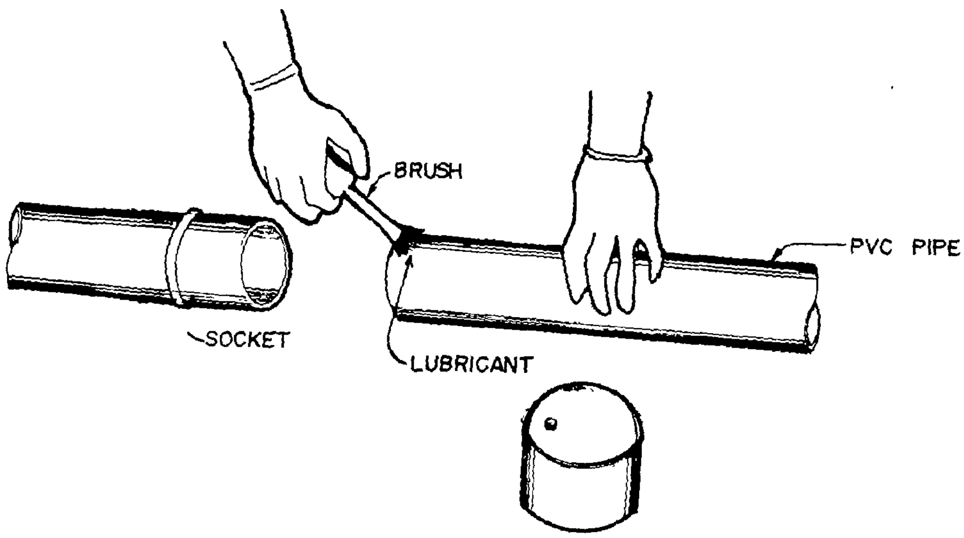
SETTING UP OF PIPE INSERTER

c. Remove with the fitting and set up the pipe inserter. For pipes with diameter less than 50 mm. insertion of the spigot end to the socket can be done manually.



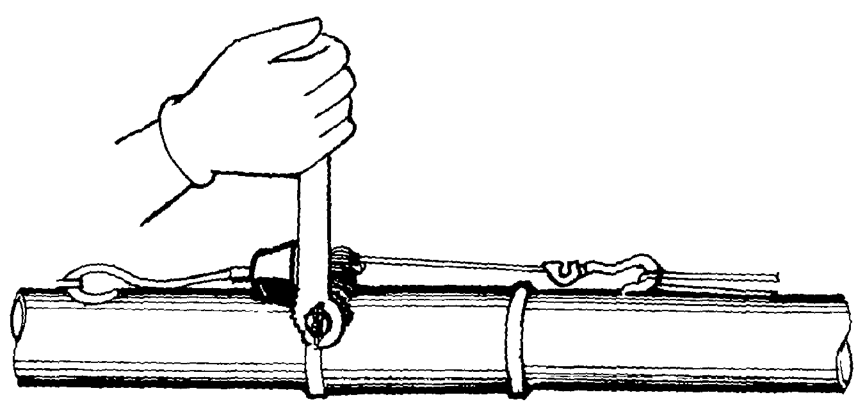
CLEANING OF THE SPIGOT END AND FITTING

d. Clean the inside of the socket and the outside of the spigot end with a dry cloth. If oil and grease are present, remove them with a cloth wet with acetone or other oil solvents.



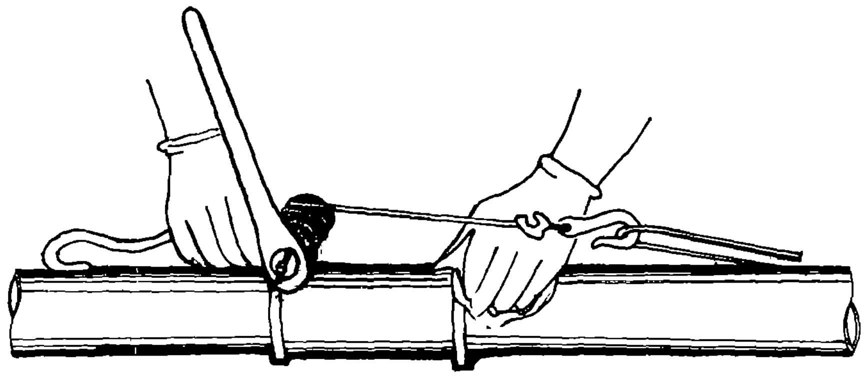
APPLYING OF SOLVENT CEMENT

e. Apply solvent cement evenly to the inside of the socket and the outside of the spigot end. The cement applied on the inside of the socket should be thinner than the cement applied to the outside of the spigot end. Be sure to read carefully the application instructions printed on the cement container before using.



INSERTING OF THE SPIGOT END INTO THE SOCKET

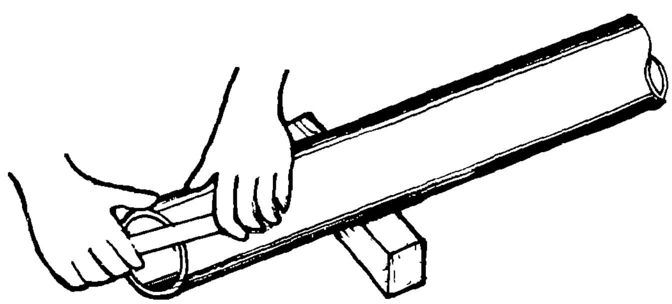
f. Align the spigot end of the socket. Using the pipe inserter, push the spigot end into the socket up to the pre-marked line.



ALLOWING THE CEMENT TO SET

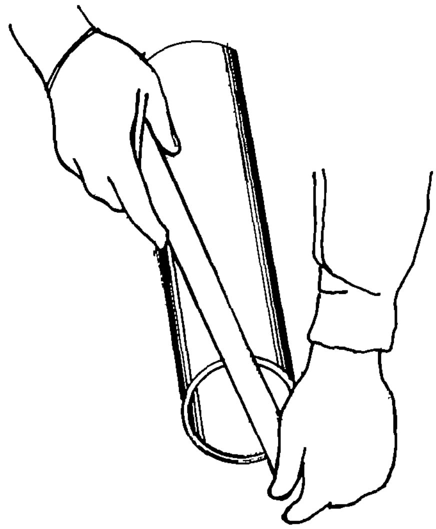
g. Hold the joint together firmly for 1–2 minutes until the cement starts to set. Wipe off the excess cement. Handle the joint carefully for a few minutes or until the cement has set firmly. Remove the pipe inserter. Do not disturb the joint for at least thirty (30) minutes.

2. Rubber Ring Method

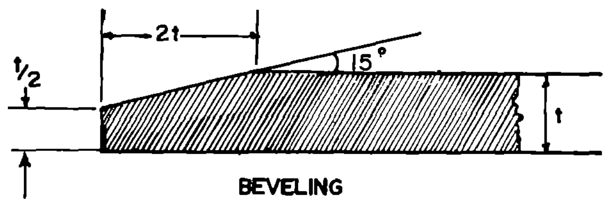


TRIMMING AND SMOOTHING SPIGOT END

a. Measure the length required and mark it with a marker pen or pencil. Cut the pipe squarely at the pencil line with a hacksaw. Trim and smooth the spigot end with the use of a knife or a half round file. Cut off any deeply scratched end as this may cause leakage.



ISOMETRIC

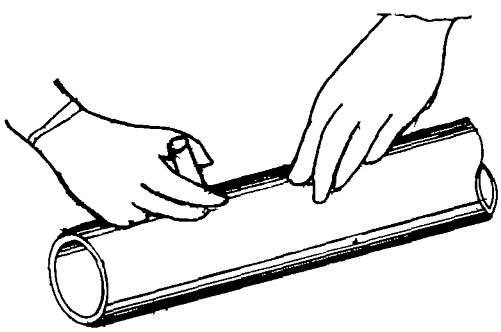


BEVELING

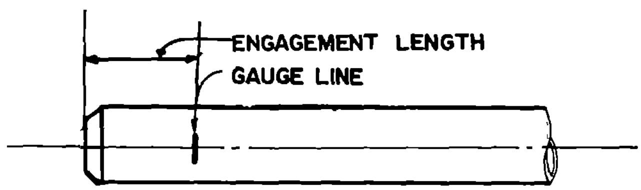
DETAIL OF THE BEVELLED SURFACE

BEVELLING OF THE SPIGOT END

b. Bevel the outer edge of the spigot end. Bevelling is necessary to avoid the scratching or twisting of the rubber ring during the insertion of the spigot end to the socket.



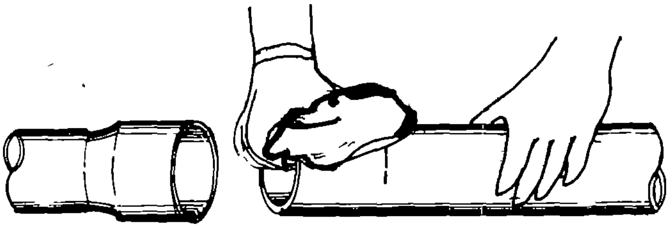
ISOMETRIC



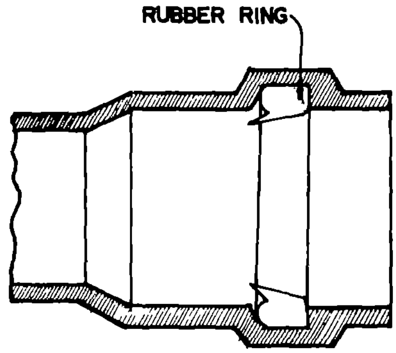
DETAIL OF THE SPIGOT END

MARKING OF THE ENGAGEMENT LENGTH

c. Mark the engagement length of the spigot end. The engagement length will be the length to be inserted into the socket.



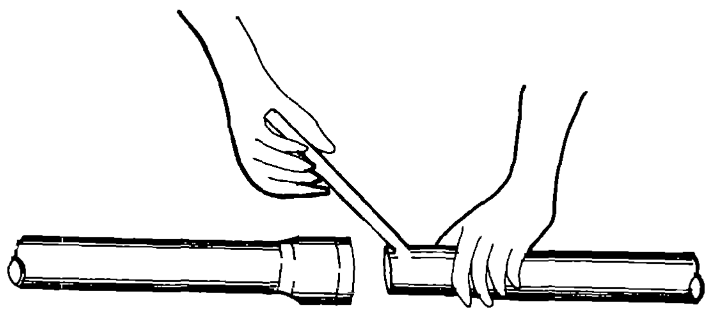
ISOMETRIC



CORRECT FITTING OF RUBBER RING

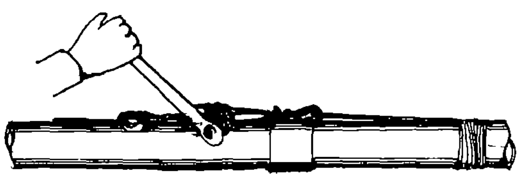
REMOVING, CLEANING AND REPLACING RUBBER RING

d. Clean the socket and spigot end from dirt and dust. To clean the rubber ring, remove it from ring groove. Wipe the adhering dirt particles with a clean cloth. Replace the ring in the groove without twisting letting the lip face inward.



APPLYING LUBRICANT

e. Apply lubricant to the spigot end especially on the bevelled edge. Do not use oil, grease, or other petroleum product, as this will damage the rubber ring.

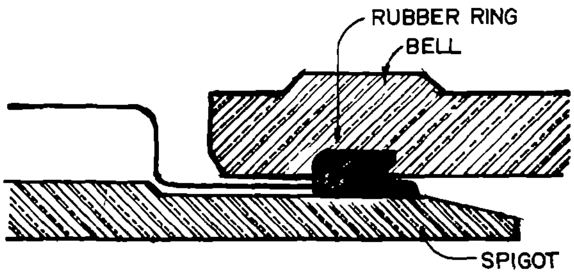


BY USE OF PIPE INSERTER

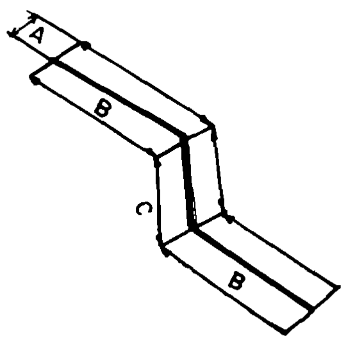
MANUALLY BY TWO PERSON

INSERTING THE SPIGOT END INTO THE SOCKET

f. Align the spigot end of the socket with the pipe inserter, push the pipe up to the pre-marked line.



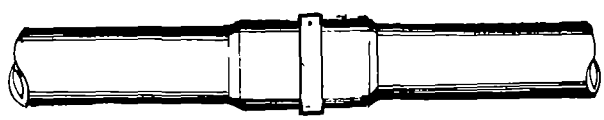
INSERTION OF THE THICKNESS GAUGE BETWEEN THE JOINT



DETAIL OF THICKNESS GAUGE

CHECKING FIELD ASSEMBLY

g. Check whether the length between the rubber ring and the socket end is uniform over the entire circumference using a thickness gauge. After jointing, keep the joint from bending and tension as far as possible.



THE JOINTED PIPE

E. **Pipe Inserter**

Figure 4.09A and Figure 4.09B show us how to install a pipe inserter when joining a pipe to socket and pipe to socket-end pipe, respectively. Figure 4.9C shows the feature of the coil-end wire rope.

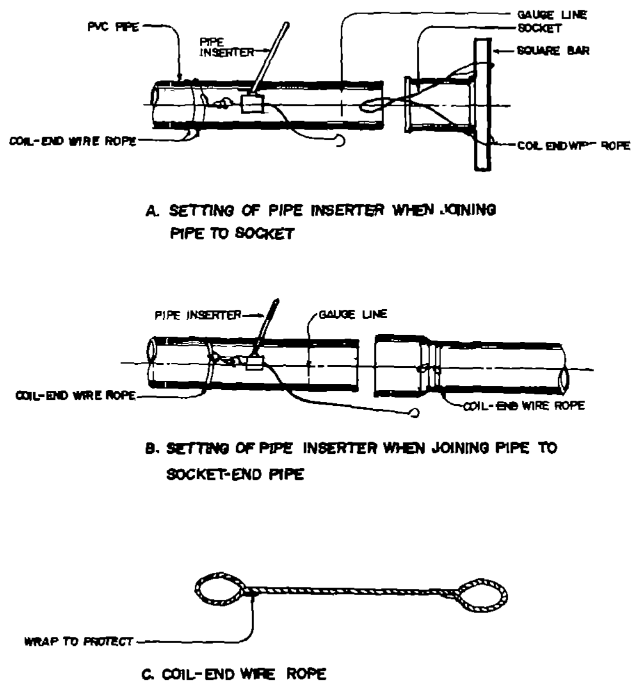


FIGURE 4.09

SETTING OF PIPE INSERTER

4.03 POLYETHYLENE (PE) PIPE

A. General

Polyethylene (PE) pipe is made of flexible but strong materials. It is designed to withstand soil loads and movements, and can be laid following the contour of the area. It can be bent around obstacles along curves and in trenches.

PE pipes are available in 13, 19, 25, 31, 38, 50, 63, 75, 100, 125, 150, 200, 250 and 300 mm diameter and in rolls of 100 M or longer for the smaller sizes. PE pipes can be jointed by butt welding method or by the use of clamps.

B. PE Fittings

PE pipes can be bent and the smaller sizes are available in rolls so that the number of fittings needed is relatively small. Fittings are necessary when branching pipes, when changing direction sharply, when joining two PE pipes, and when jointing a PE pipe to G. I. pipe. Shown in Figure 4.10 are the different types of PE fittings.

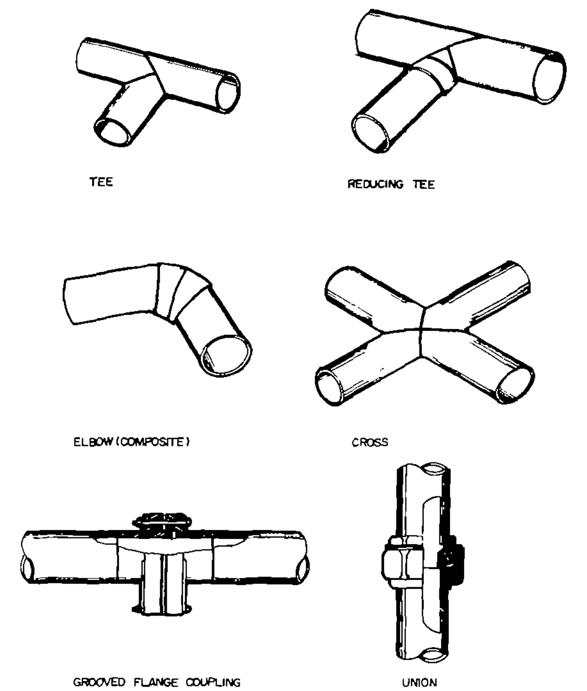
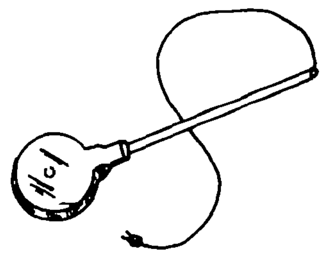


FIGURE 4.10

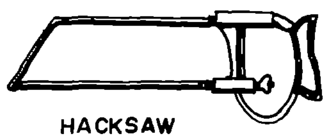
POLYETHYLENE (PE) PIPE FITTINGS

C. Joining of PE Pipes

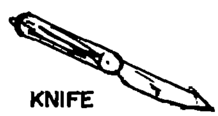
1. Butt Welding Method



METAL PLATE (HEATER)

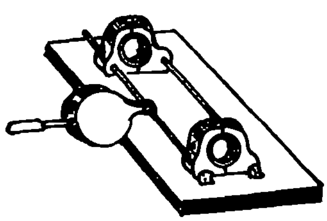


HACKSAW



KNIFE

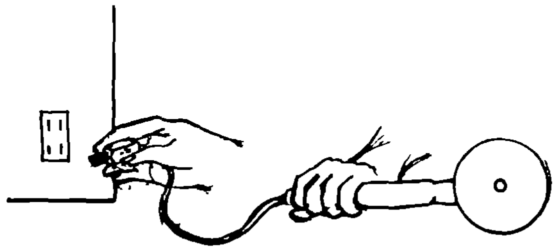
CLEAN RAGS



BUTT WELDING EQUIPMENT (IF AVAILABLE)

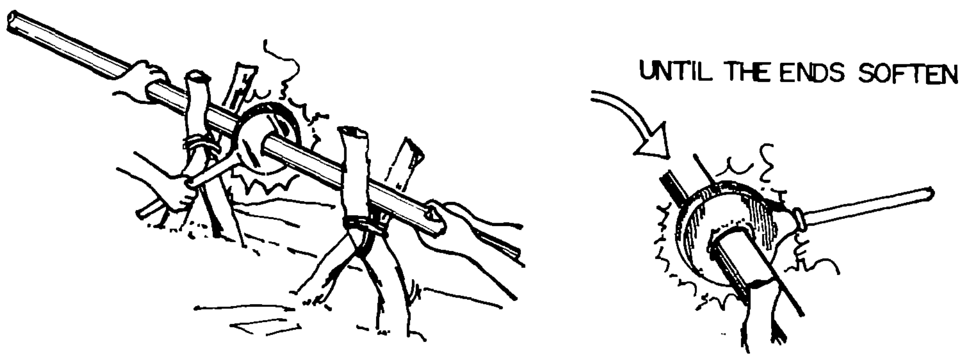
ASSEMBLING OF TOOLS AND AND EQUIPMENT FOR JOINING PE PIPES

a. Assemble all the needed materials for joining of PE pipes.



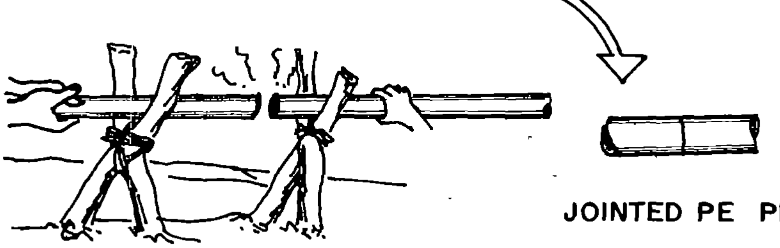
HEATING THE METAL PLATE BY ELECTRICITY

b. Measure accurately the length of pipe needed and mark it with a pencil. Cut the pipe squarely on the pencil line using a hacksaw. Heat the metal plate using an electrical heater.



SOFTENING OF THE ENDS BY HEATING

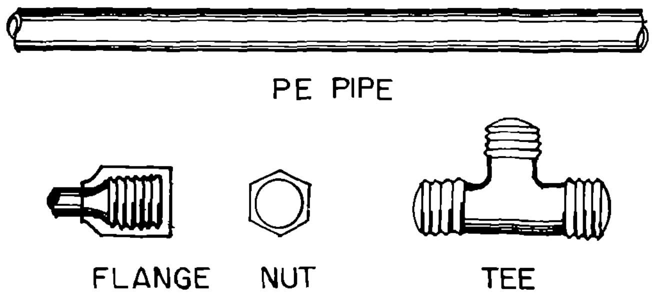
c. Press the heated metal plate at the ends of the PE pipes to be joined. Continue pressing until the ends soften.



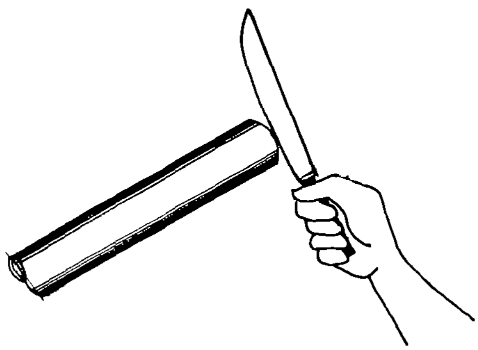
JOINTING OF PE PIPES

d. Remove the metal plate and press the softened ends together.

2. Joining by Use of Clamps

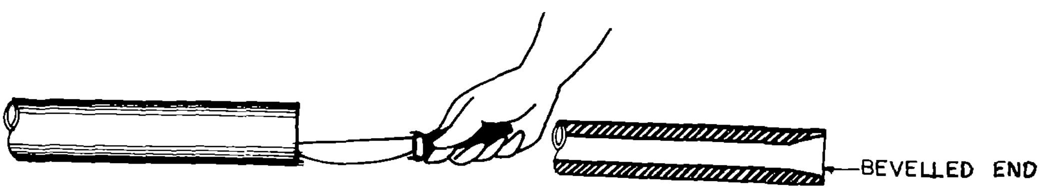


MATERIALS NEEDED IN JOINING TWO PE PIPES



TRIMMING OF THE FLARED END

a. Measure accurately the length needed and mark it with a pencil or marker pen. Cut the pipe squarely on the pencil line using a hacksaw. Trim off any burrs with a knife.



BEVELLING

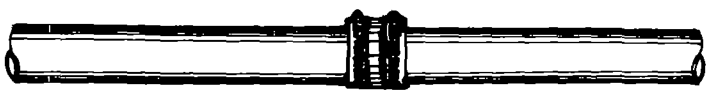
b. Slightly bevel the inside edge of the ends of the pipes to be joined.

INSERTION OF CLAMPS

c. Set the clamps at the ends of the pipes to be joined.

INSERTION OF FITTINGS

d. Insert the fitting into one of the pipes, then move the clamps over the tail of the fitting and tighten the screw.



THE COMPLETED JOINT

4.04 POLYBUTYLENE (PB) PIPES

A. General

Polybutylene (PB) pipes are available in diameters of 10, 13, 19, 25, 31, 38, 50 and 63 mm, and in lengths of 30, 60, 90, 150, and 300 M. PB pipes are joined by flaring and with the use of an appropriate fittings.

B. PB Fittings

PB fittings are of two types: the threaded type and the non-threaded type. The non-threaded type is made of polybutylene and it requires a male adapter when jointed by flaring. On the other hand, the threaded type which is usually made of steel, iron, copper, etc. has a male thread which can be screwed directly to the flange butt. Figure 4.11 shows the different types of PB fittings.

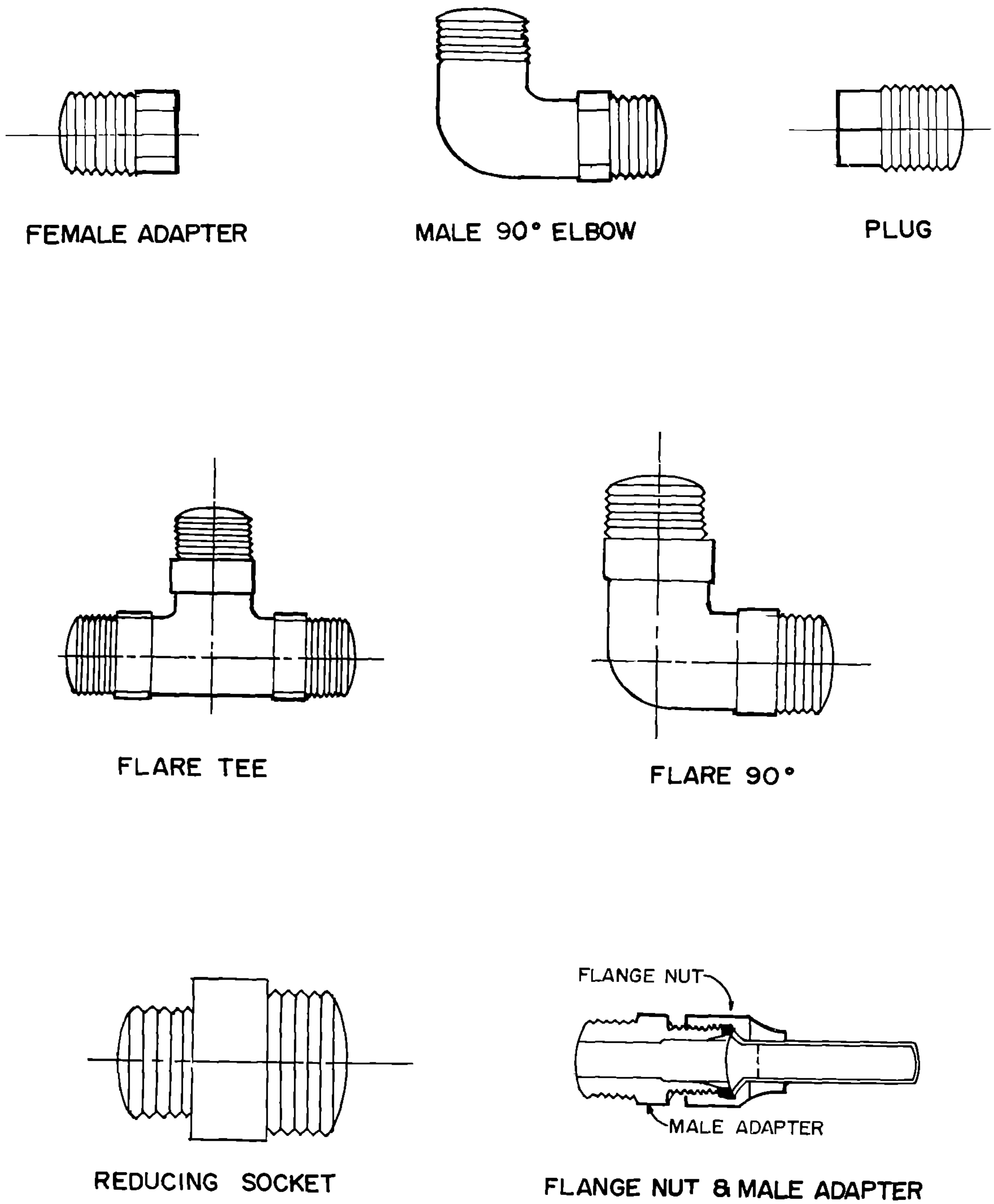
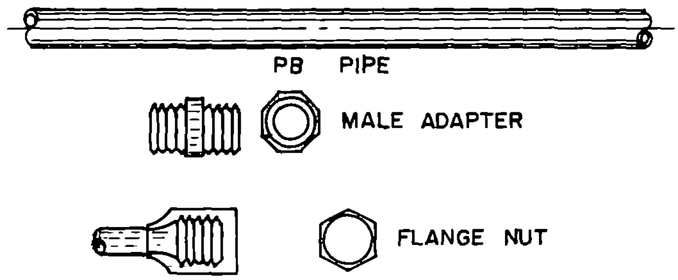


FIGURE 4.11

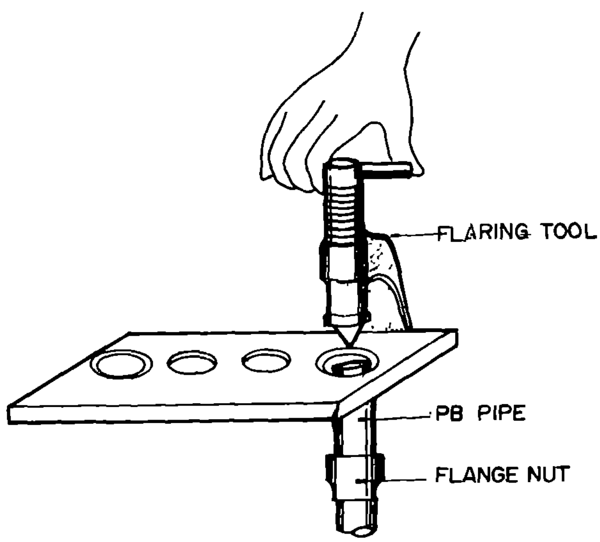
POLYBUTYLENE (PB) PIPE FITTINGS

C. Joining of Polybutylene (PB) Pipes

1. Joining of Two PB Pipes

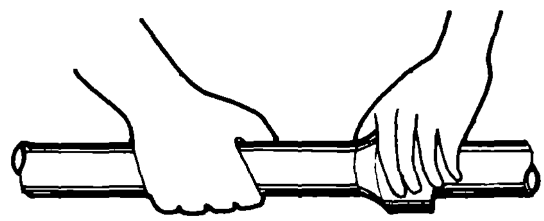


MATERIALS NEEDED IN JOINING TWO PB PIPES



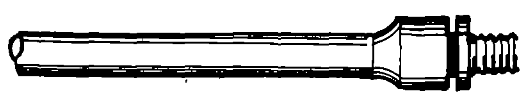
FLARING

a. Measure the length required and mark it using a pencil or a marker pen. Cut the pipe squarely on the pencil mark with a hacksaw. Insert the flange nut at the end of the two pipes to be joined.



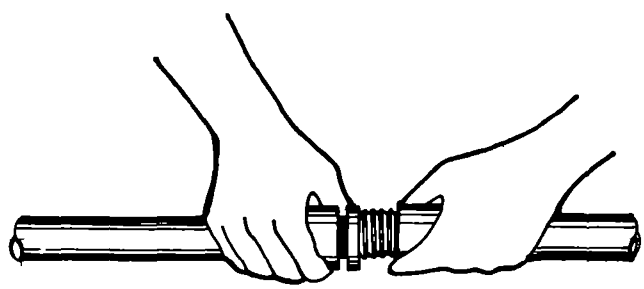
INSERTION OF FLANGE NUT

b. Flare the ends after inserting the flange nut.



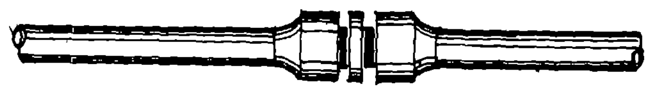
INSERTION OF THE MALE ADAPTER

c. Insert the male adapter to the end of one pipe and screw it tightly to the flange nut to hold the flare end of the pipe in place.



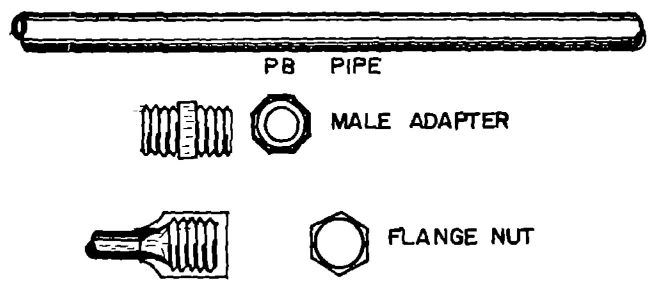
SETTING THE OTHER END OF THE MALE ADAPTER TO SECOND PIPE.

d. Set the other end of the male adapter to the end of the second pipe. Tighten the joint by rotating the flange nut clockwise.

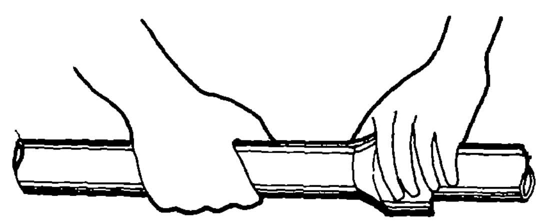


THE JOINTED PIPE

2. Joining a PB Pipe to a Threaded Fitting.

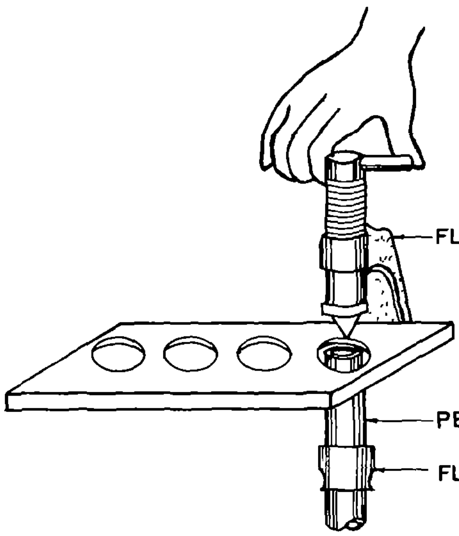


MATERIALS NEEDED IN JOINING TWO PB PIPES



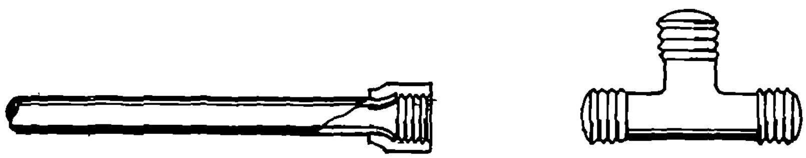
INSERTION OF FLANGE NUT

a. Measure the length required and mark it using a pencil or marker pen. Cut the pipe squarely on the pencil mark with a hacksaw. Insert the flange nut at the end of the pipe to be joined.



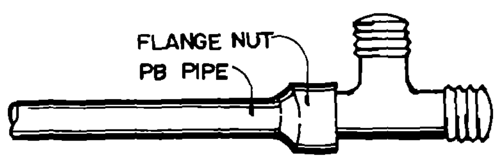
FLARING

b. Flare the end of the pipe after inserting the flange nut.



SETTING OF THE FITTING INTO THE NUT

c. Set the fitting into the end of pipe with flange nut and then screw the fitting to the flange nut tightly to hold the flare end of pipe firmly embedded between the inside of the flange nut.



F. THE JOINTED PIPE

CHAPTER 5

INSTALLATION OF PIPELINES, VALVES AND FITTINGS

5.01 INSTALLATION OF UNDEGROUND PIPELINES

Outlined below are the fundamental steps for installing underground pipelines. The details of each step are either discussed in Chapter 4 or in the following sections.

1. Preparation of Trenches

   The job includes clearing/grubbing of the site, staking, and excavation works.

2. Setting and Jointing of Pipes

   With plastic pipes and small sizes of G.I. pipes, the pipe can be joined on the ground surface and then lowered into the trench. Where it is necessary to join the pipe in the trench, the trench should be wide enough to permit easy handling of the tools so that a good joint can be made.

3. Measurement of the required pipe length.

4. Construction of pipe supports, thrust and anchor blocks at points where flow of water changes directions.

5. Partial backfilling and compaction of trenches up to the upper surface of pipe laid and leaving the pipe joints exposed. The soil will hold the pipe in place during pressure and leakage testing.

6. Pressure and leakage testing.

   Prior to complete backfilling and compaction of backfill, check whether the pipelines are properly joined.

7. Final backfilling and compaction after all joints are made good.

8. Disinfection of pipelines.

5.02 INSTALLATION OF PIPES BENEATH CONCRETE ROADS AND RAILROADS

A. General

For a rural water supply system, one method for installing pipe underneath concrete roads or railroads is by pushing a G.I. pipe underneath the concrete pavement or railway as shown in Figure 5.01. However, if pushing or driving does not work, bore a hole using an auger. Breaking the pavement should be done only when all other methods have failed.

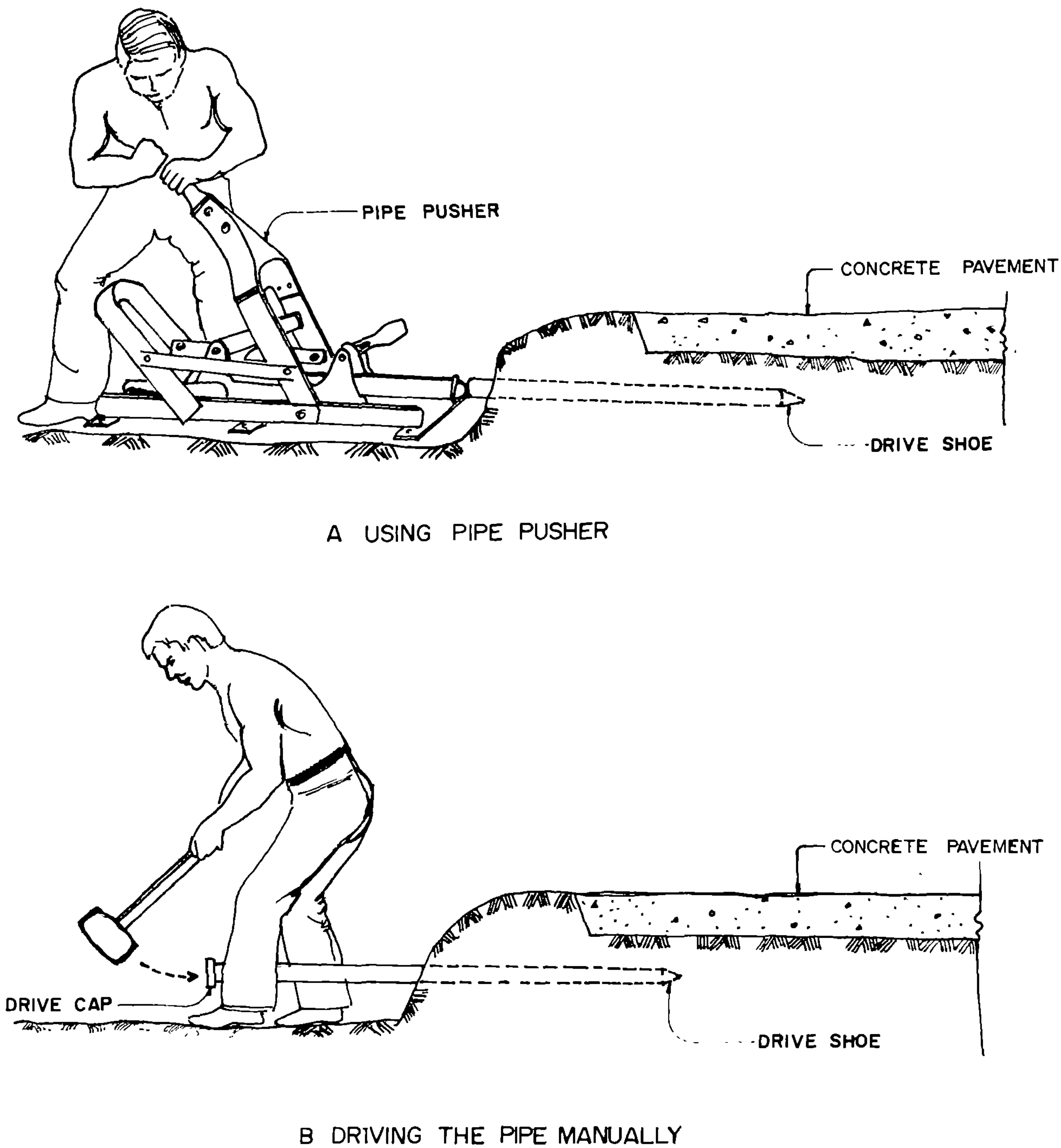


FIGURE 5.01

INSTALLATION OF PIPES BENEATH CONCRETE ROAD

B. **Procedure for Driving Pipes Beneath Concrete Pavement or Roads**

1. Determine the type and density of soil, the load on the pipe, the width of the road or railroad and the diameter of the pipe to be laid or pushed under the concrete structure.

2. Assemble all the equipment needed.

3. Excavate a working space about 0.5 M wide and 3 M long to a practical depth below the pipeline level. This space will be used by the laborer who will push the pipe from one side to the other site of the road/-railroad.

4. Attach a drive shoe at the end of the pipe to prevent earth from entering the pipe while driving.

5. Push the pipe beneath the concrete road or railroad. The depth from the ground surface to which the pipe will be buried depends upon the tonnage of vehicles passing on the road. The pipe can be shoved underneath the road/railroad by using either a mechanical pipe pusher (Figure 5.01A) or by hammering it (Figure 5.01B) with a sledge hammer. If the latter method is employed, protect the end to be hammered by putting a driving cap or wood.

6. In case of the installation of PE, PB or PVC pipe, push a G.I. pipe having an inside diameter large enough to accommodate the plastic pipe to be installed. For PE and PB pipes, the G.I. pipe may serve as the permanent casing or support. For G.I. pipelines, a G.I. pipe one size larger will serve as casing that will allow easy replacement of the line when necessary some years later.

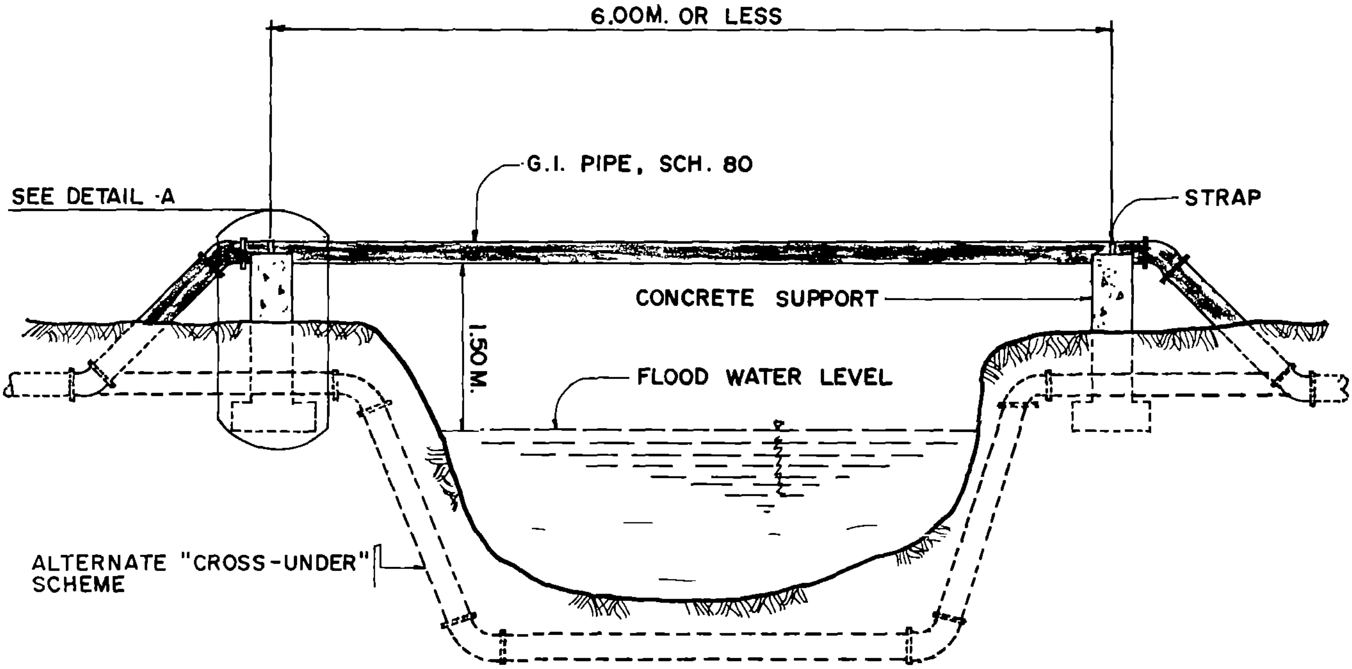
5.03 INSTALLATION OF PIPES ACROSS WATERWAYS

In cases where the source of water and the consumers are separated by a river or creek, it will be necessary to install a piping system across the waterway. Generally, connecting a water source to consumers separated by a waterway 6 M wide or greater entails a high investment cost. Hence, it is usually better to look for a source near the consumers. However, in cases where installation of pipes across a waterway cannot be avoided, the following are the guidelines for installation.

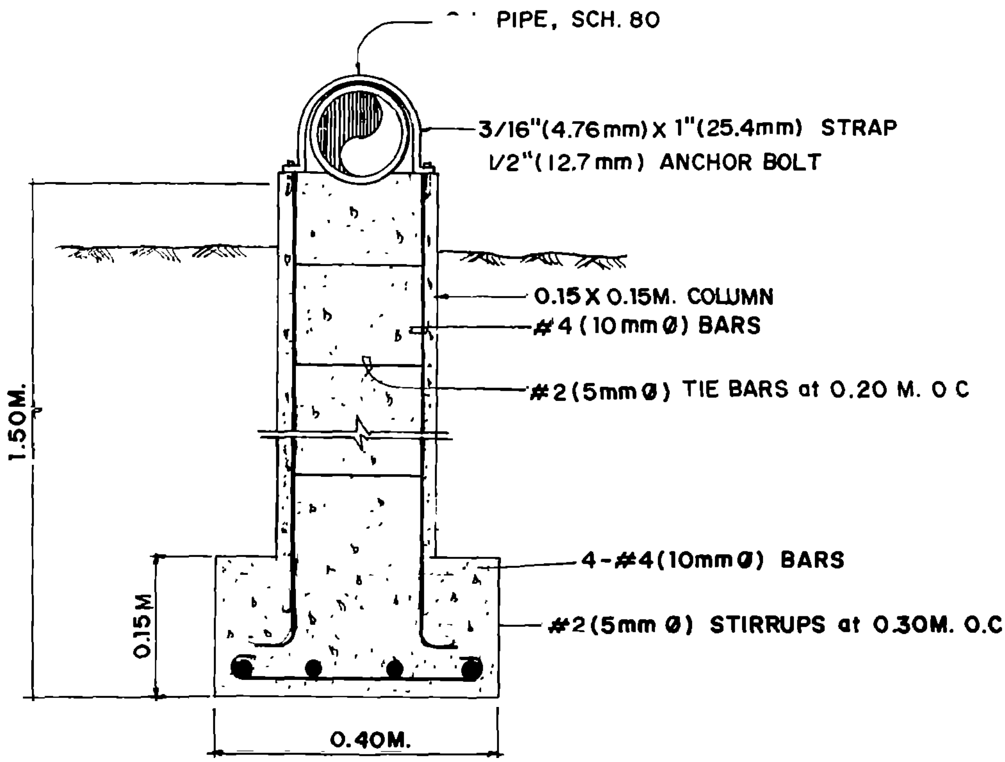
A. **Width of Waterway is 6 M or Less**

1. Construct a concrete pipe support on both banks of the water way (Figure 5.02). The height of the support should be at least 1.5 M above the water surface during flooding time.

2. Place the pipe on the concrete support and strap it in place. The pipe usually used for this purpose is G.I. pipe schedule 80 (Figure 5.02).



SECTION



DETAIL A

FIGURE 5.02

INSTALLATION OF G.I. PIPE ACROSS A WATERWAY (WIDTH OF WATERWAY IS LESS THAN 6.0 M.)

3. If floodwaters overflow the banks of the waterway, adopt a "cross under" scheme.

B. **Width of Waterway is more than 6 M**

1. Construct concrete pipe supports on both banks of the river. The height of the support should be at least 2.5 M above the flood level.

2. Set the G.I. pipe 1.5 M above the flood water level and strap it to the concrete supports.

3. Set the cable at the top of the concrete platform. This cable will prevent the pipe from sagging (Figure 5.03).

4. If floodwaters overflow the banks of the waterway, adopt the "cross under" scheme.

C. **Installation of Pipelines in Bridges**

The problem of installing pipes across a waterway is simplified where there is a bridge to serve as support. However, caution should be observed when the bridge shows signs of weakness. As shown in Figure 5.04, the pipe is held in place at the side of the bridge above the beams using straps. The straps should be provided with cushions that will absorb vibration caused by vehicular traffic.

5.04 INSTALLATION OF PIPES ACROSS CULVERTS

There are two ways of installing pipes across a culvert. One way is to install them below the culvert and the second way is to install them above the culvert. The installation of pipelines below the culvert (Figure 5.05A) is almost adaptable to all conditions while the installation of pipelines above the culvert (Figure 5.05B) is applicable only where the depth of the top of the culvert from the surface of the road is such that enough cover will be left for the installed pipe. When cover will be less than the minimum depth, concrete cover should be provided for the pipeline.

5.05 INSTALLATION OF THRUST BLOCKS

Thrust blocks are devices used to prevent movement of the water mains when subjected to pressure. Thrust blocks are usually provided at all elbows, dead-end mains, tees, reducers, and crosses (Figure 5.06).

Procedure:

1. Construct a form for concreting.

2. Prepare a concrete mixture consisting of one part of cement combined with two parts of sand and four parts of gravel.

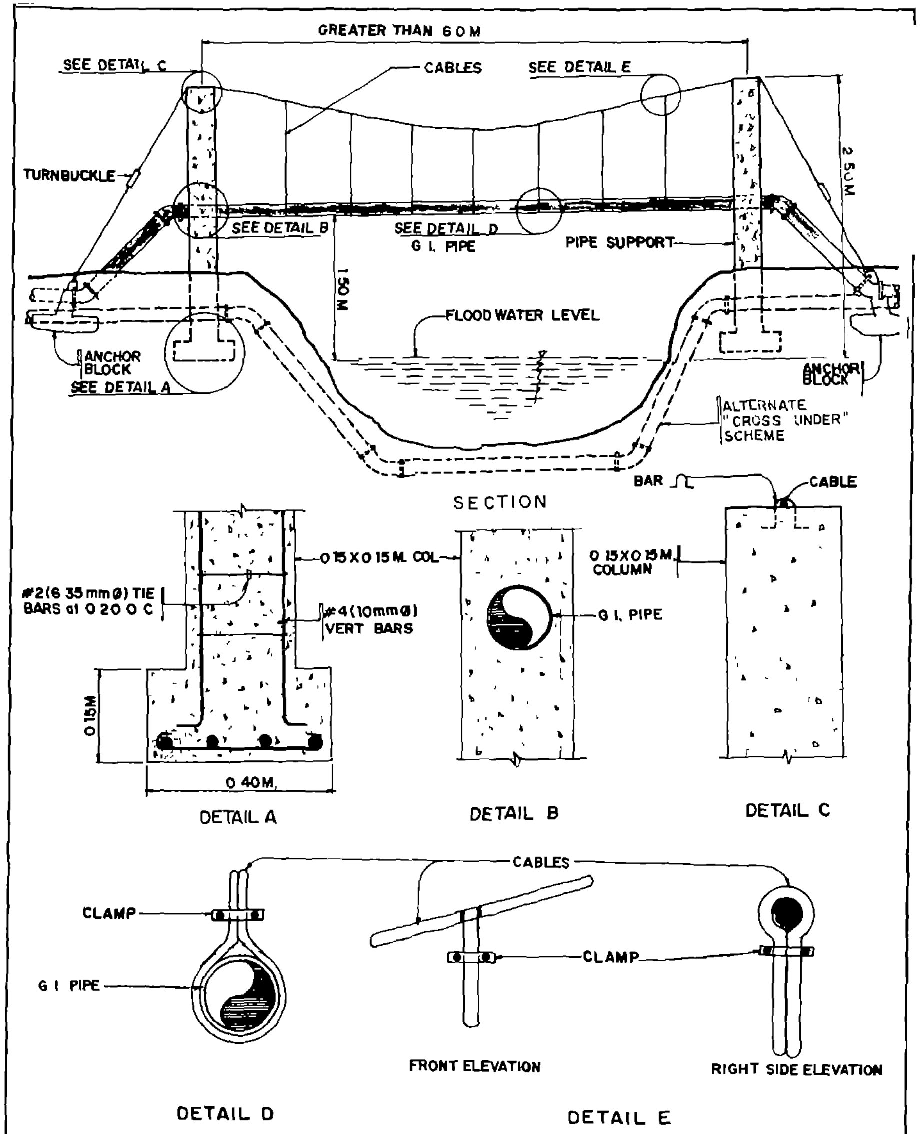


FIGURE 5.03

INSTALLATION OF G.I. PIPE ACROSS A WATERWAY (WIDTH OF WATERWAY IS GREATER THAN 6.0 M)

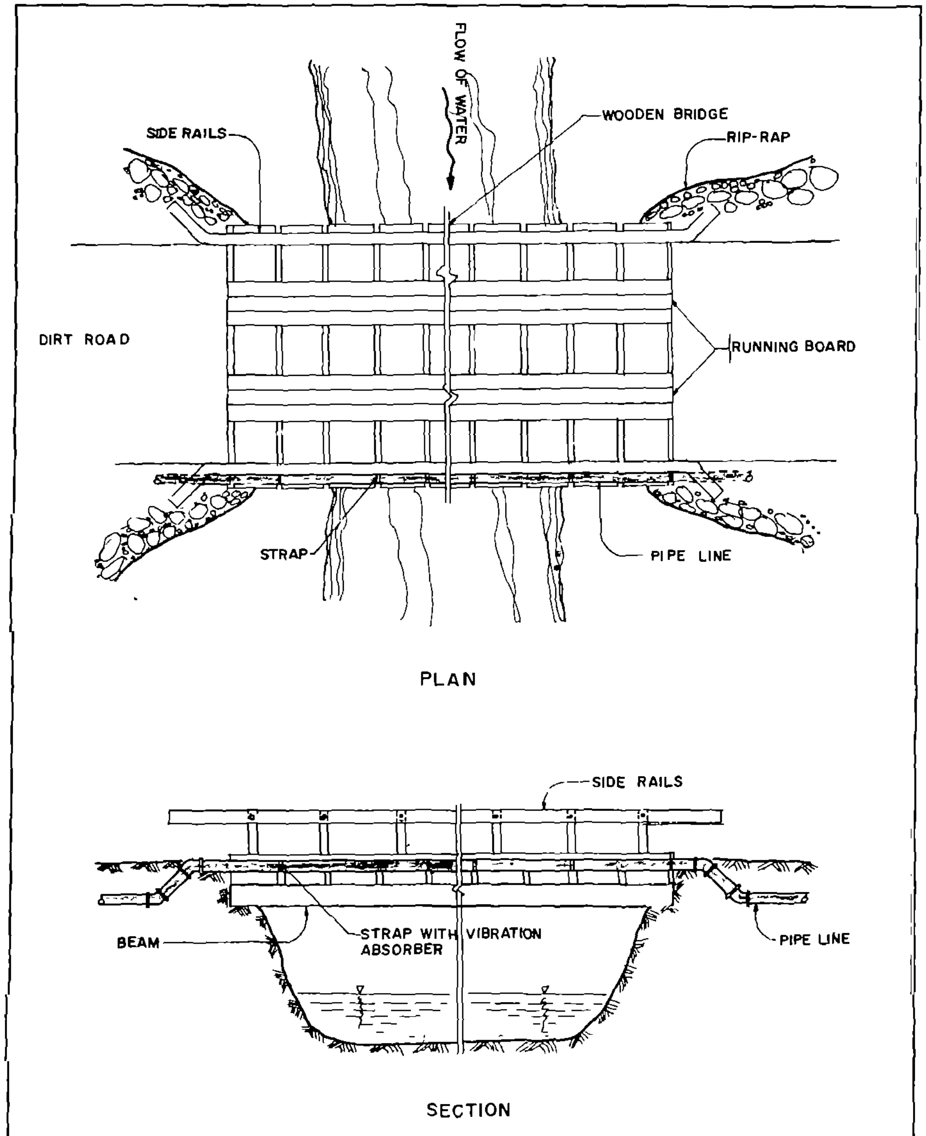
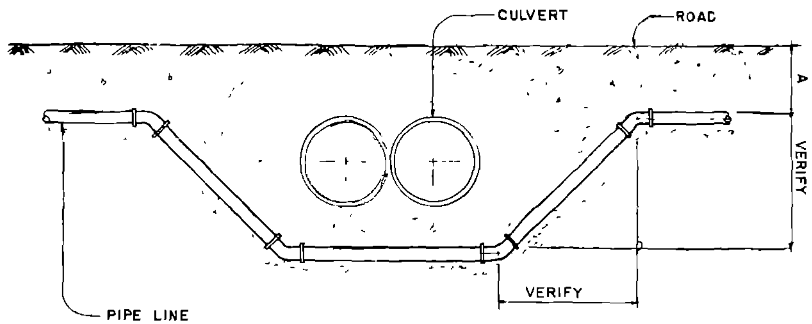
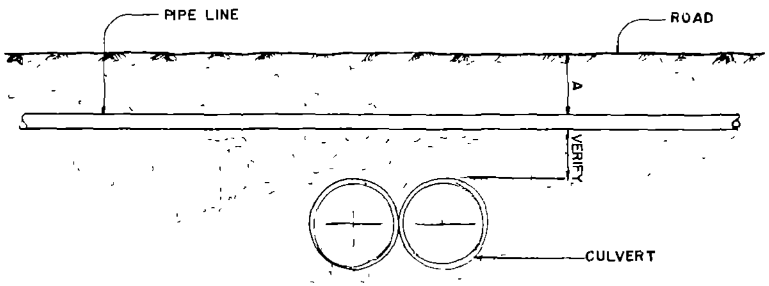


FIGURE 5.04

INSTALLATION OF METAL PIPES IN A WOODEN BRIDGE



A. INSTALLATION OF PIPE BENEATH THE CULVERT



B INSTALLATION OF PIPE ABOVE THE CULVERT

FOR G I PIPE, A = 0 30M MINIMUM
PLASTIC PIPE, A = 0 60M MINIMUM

FIGURE 5 05

INSTALLATION OF PIPES ACROSS A CULVERT

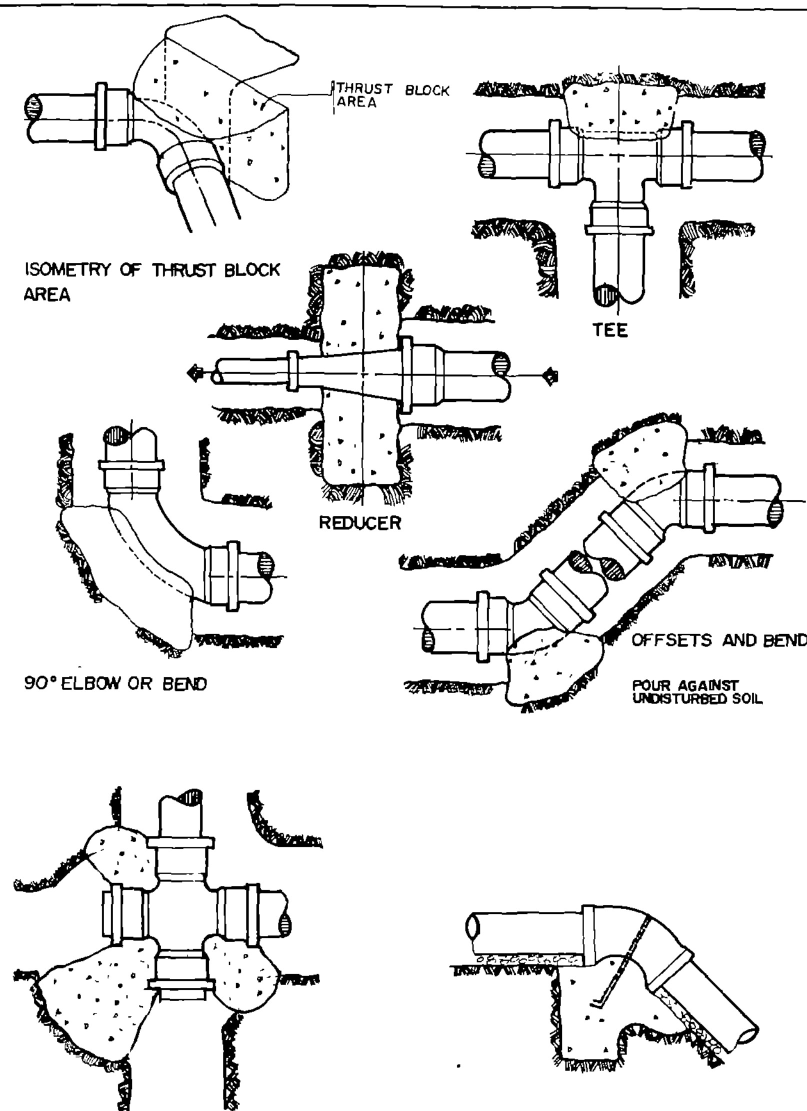


FIGURE 5 06

CONCRETE THRUST BLOCKS

3. Pour the concrete into the form. Make sure that the concrete will not come in contact with the joints so that maintenance men can get at these later.

4. Allow the concrete to set and harden for 7 days before pressure and leakage testing.

5.06 SERVICE CONNECTIONS

Service connections are tubes or pipes connecting public and private faucets to the distribution mains.

A. Galvanized Iron (G.I.) Pipe

G.I. pipes with sizes greater than 100 mm are seldom used for distribution mains because they are very costly. Distribution mains made of G.I. pipe can be tapped by using tees or crosses, and if reduction of pipe sizes is necessary, reducers are installed.

B. Polyvinyl Chloride (PVC) Pipe

PVC tees with nominal diameters of 75 mm and smaller are available for service connections. They can be connected to the distribution mains by TS welding method or by Rubber Ring Method. For sizes greater than 75 mm, PVC saddles are used.

C. Polybutylene (PB) Pipe

Tapping the distribution main using a PB pipe is accomplished with a tee. When the street main is larger than 75 mm, saddles are used in tapping.

D. Polyethylene (PE) Pipe

Special PE fittings are available for making service connections. They are joined by butt welding.

5.07 INSTALLATION OF SADDLES

Saddles are used in making service connections to main lines with diameter of at least 100 mm. They are made of cast iron, bronze or PVC and are installed by bolting or by strapping them to the main line.

Installation Procedure

1. Clean the outer surface of pipe where the saddle will be placed from dirt, grease or oil, and other foreign matter.

2. File this pipe surface to provide a clean and rough surface.

3. Install the saddle in-place and tighten the clamps.

4. Drill an appropriate size outlet in the pipe. In drilling, avoid penetrating the opposite side of the pipe.

5. Saddles available commercially have female threaded ends. Pipes with male threaded ends can be connected directly to the saddles by screwing.

5.08 INSTALLATION OF VALVES

Valves are used to control the operation of water supply systems. They consist of a lid or cover which regulates the flow of water or air in pipelines and reservoirs. Valves commonly used in rural water supply systems are the following:

A. Gate Valve

A gate valve (Figure 5.07A) is usually employed to control the flow of water in pipelines with diameters greater than 50 mm. The flow is controlled by the use of a wedge-shaped gate operated through the valve stem. Closing the gate stops the flow of water.

Gate valves are normally located at street intersections and adjacent to major water supply components such as reservoirs, pumping stations, etc., so that it will be possible to isolate the defective component during maintenance and repair. They are also placed at every kilometer length of transmission mains so that breakdown of one connection will not incapacitate the whole transmission line.

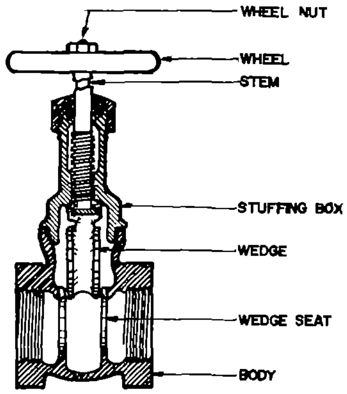
Gate valves with diameters of 150 mm and smaller are available with female threads while those with diameters greater than 150 mm are available with flanged ends.

Gate valves are installed in line with the axis of the pipe. The method of connection for valves 150 mm and smaller is similar to that for connecting a G.I. pipe to a G.I. coupling. For ease in the repair or replacement of the gate valve when it breaks down, a union is usually placed either before or after the valve.

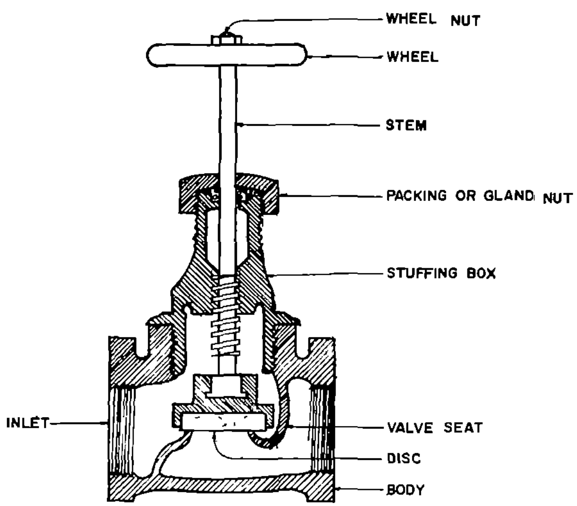
B. Globe Valve

A globe valve (Figure 5.07B) performs a similar function and is installed in similar locations as the gate valve. Compared to a gate valve, a globe valve is less efficient because greater friction losses are incurred when water passes through. However, it is cheaper and easier to operate, and in sizes up to 50 mm, it can be suitably used as a flow regulator.

A globe valve is installed in the run of pipelines with the valve stem in horizontal position (Figure 5.08A). Installing it in an upright position will make the draining of water impossible. Also, the inlet side should be placed in such manner that it will carry the pressure when the valve is closed.



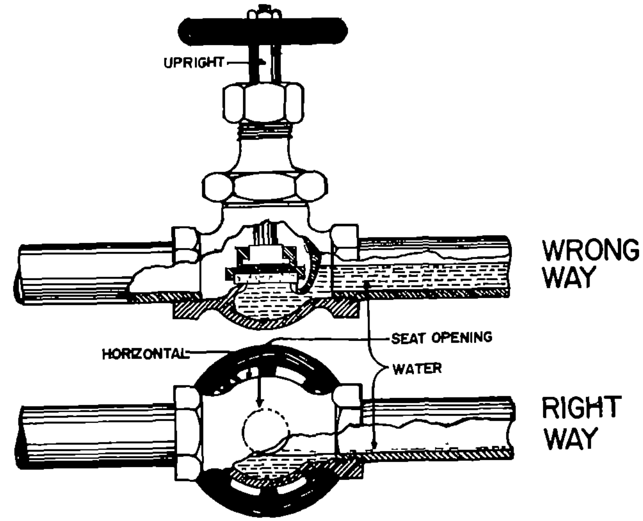
A GATE VALVE



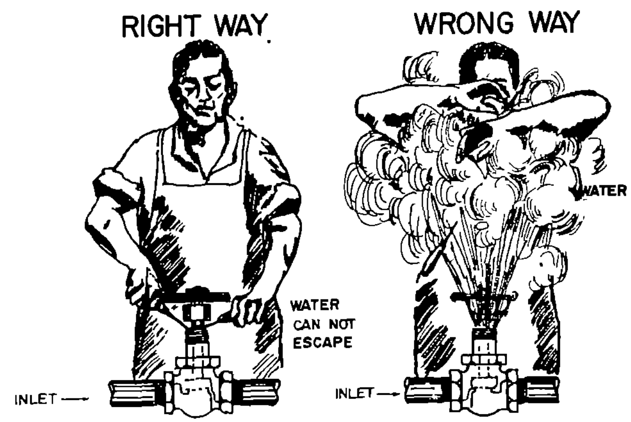
B GLOBE VALVE

FIGURE 5.07

GATE AND GLOBE VALVES



A) RIGHT AND WRONG WAY OF PLACING GLOBE VALVES ON HORIZONTAL LINES



B) RIGHT AND WRONG WAY OF CONNECTING GLOBE TYPE VALVE IN PIPE LINE THE FIGURE ALSO SHOWS THE RESULT IN REPACKING A WRONGLY CONNECTED VALVE

FIGURE 5.08

INSTALLATION OF GLOBE VALVE

Placing the outlet side where the inlet side is supposed to be installed will make repacking difficult. Repacking a wrongly connected valve will result in water spraying upwards (Figure 5.08B).

C. **Check Valves**

A check valve is usually placed after the pump to prevent the back flow of water. It is installed with the flow of water as indicated by arrows in Figures 5.09A, B, and C. Water pressure causes the valve lid to open allowing water to pass through. Should the flow reverse, the lid closes preventing water from flowing back.

Figures 5.09A, B and C shows the three types of check valves. The horizontal swing check-valves are installed in horizontal position and the lift type in a vertical position. Check valves with diameters of 150 mm and below are available commercially with female threads and those greater than 150 mm are available with flanged ends. The method of connecting the threaded valve is similar to that for joining a G.I. pipe to a G.I. coupling.

D. **Angle Valves**

An angle valve (Figure 5.09D) is a valve with the inlet and outlet sides perpendicular to each other. It is used to control the flow of water in pipes which change in direction by 90^{o}.

E. **Foot Valve**

Shown in Figure 5.10A is a foot valve. The operation of a foot valve is similar to that of the lift-type check valve. It is usually placed with a strainer at the end of the suction pipe of pumps to prevent water from going back to the aquifer. The result is that the pump can be operated automatically and priming will no longer be necessary.

F. **Air Valve**

An air and vacuum valve (Figure 5.09E) is usually installed at major summits of transmission mains. Its function is to permit the escape of air during pipeline filling and to allow air to re-enter immediately after water removal. In case air is not removed during pipeline filling, the flow of water is restricted and water hammer is induced.

There are two types available commercially. These are the single and the double types. In a rural water supply system, the single type is usually more suitable.

G. **Blow-Off Valve**

Blow-off valves are globe or gate valves installed at low portions of the water mains, on tee branches, as well as at dead ends. They facilitate removal of sediments or water in the lines during repair.

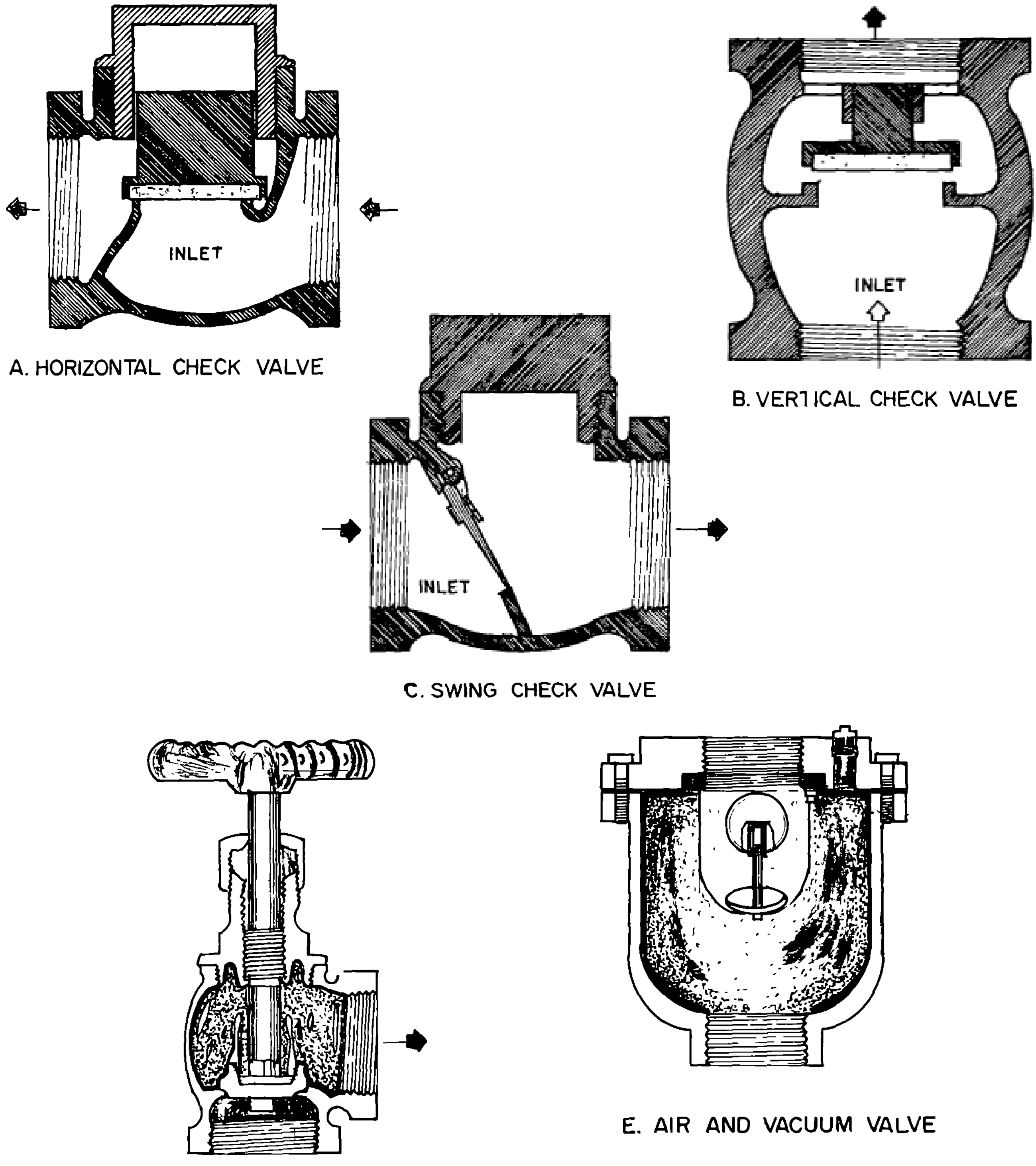


FIGURE 5.09

AIR AND VACUUM, CHECK AND ANGLE VALVES

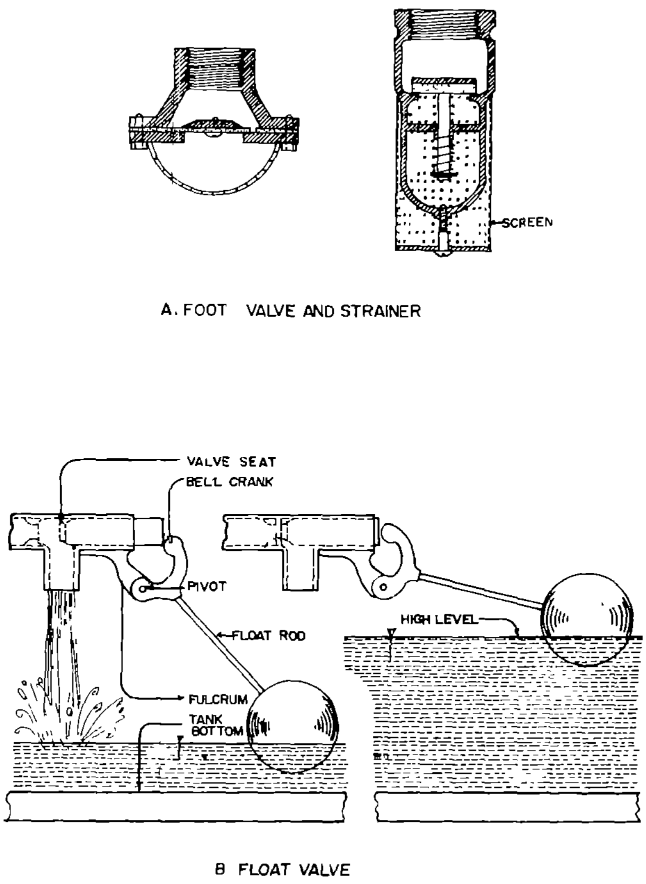


FIGURE 5.10

FOOT AND FLOAT VALVES

H. **Float Valve**

A float valve (Figure 5.10B) is usually installed at the inlet pipe of reservoirs. It is used to automatically shut off the flow of water when the tank is already full.

5.09 SANITARY PRECAUTIONS

All water mains and service connections should be located as far as possible from any source of pollution or contamination. For gravity water mains, pipes are usually installed at least 7.6 m (25 ft) away from ditches or conduits carrying sewage and from any pools or septic tanks. If it will be absolutely necessary to install the water supply line close to a source of contamination, extra protection such as concrete encasement or equivalent, should be provided in the construction.

CHAPTER 6

IMPROVEMENT AND CONSTRUCTION OF WELLS

6.01 GENERAL

A well is a protected hole or a pipe sunk from the ground level to a depth below the water table or into deep water-bearing strata for purposes of extracting groundwater. Groundwater is one of the major sources of water supply and is frequently used for domestic consumption without prior water treatment.

There are several methods of constructing and/or improving wells. The selection of the appropriate method depends on the type, size and depth of well to be constructed or improved.

The following sections describe the typical methods of constructing and/or improving various types of wells. No single method is applicable throughout the country. The proper procedure depends on geological and other field conditions. In actual construction, it is necessary for the field engineer to modify some of the standard procedures in order to suit the actual field conditions. Hence, tools may have to be improvised and certain procedures modified to maximize work efficiency and minimize cost.

6.02 IMPROVEMENT OF EXISTING WELLS

A. Pre-Rehabilitation Phase

Before proceeding to improve an existing well, the following factors will aid in determining what well accessories are to be repaired or replaced, and in estimating the cost of the project:

1. **The location of existing wells with respect to probable sources of contamination.** The well must be situated at least 10 meters away from probable sources of contamination like ditches, latrines or toilets. Also, its mouth must be higher than its surroundings to prevent the entry of contaminated surface water.

2. **The existing conditions of well structures.** The well cover, lining or casing and other accessories must be checked for defects and these defects must be correspondingly repaired or corrected.

3. **Yield of Well.** The capacity of the well must be ascertained. It must be capable of supplying the maximum requirement of the users or intended beneficiaries. In cases where the yield is small compared to the water demand of the community, the well depth must be increased. If, however, the volume of water produced is still far below from what is required, alternative sources of water should be investigated to replace or supplement the yield of existing sources.

4. **Water Quality.** The water produced by the well must be potable, otherwise, a new source must be identified. Water treatment is too expensive and sophisticated for rural water supply systems.

B. Rehabilitation Phase

After the examination and identification of the defects/inadequacies of existing wells, it is then rehabilitated. Presented below are the different methods of improving/repairing existing defective wells:

1. Repair of defective existing driven, jetted and drilled wells. This sub-section is treated in detail in Volume III, Section 2.1, Maintenance and Repair of Wells.

2. This method converts a dug well into a shallow driven or drilled well as shown in Figure 6.01. The following tools and materials are needed:

Tools	**Materials**
Drive well-point	Standard weight casing
Hammer	Plastic compound
Drive pipe with cap	Cement
Shovel	Aggregates
Plastic pail	Clay or bentonite
Rope	Polyphosphate

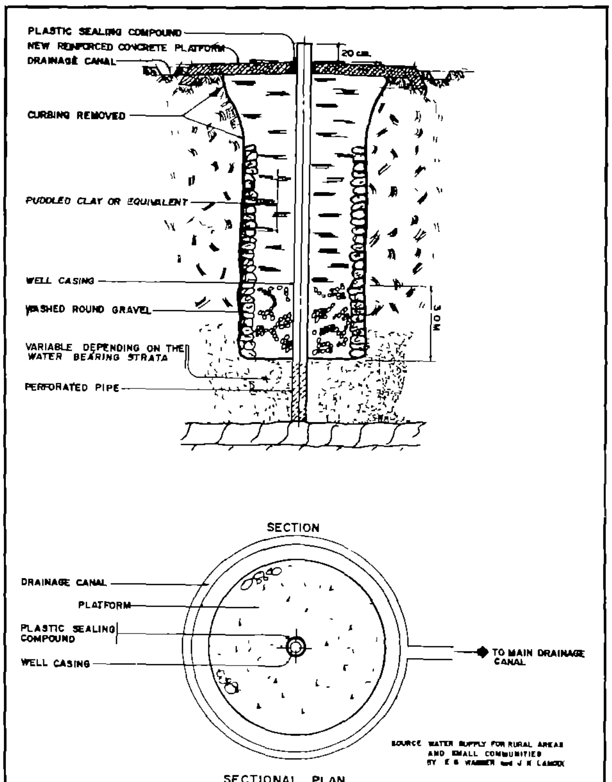


FIGURE 6.01 IMPROVEMENT OF EXISTING DUG WELL (TYPE I)

Procedure

a. Using a shovel, clean the bottom of the well of all debris and undesirable materials. Haul the discarded materials up using the "pail and rope" system, with one worker at the top of well hauling the materials.

b. Remove the upper well curbing up to at least one meter below the ground surface.

c. Install a standard weight casing down through the well bottom using a drive well-point. The casing should be driven until the desired depth is reached.

d. Install the well casing or drop-pipe down to the driven depth. The top of the casing should extend at least 20 cm above the ground surface or concrete pedestal.

e. Fill the open well space with puddled clay up to the ground level or top of the well.

f. Provide the well with a strong concrete platform or apron. The platform should extend at least one (1) meter from the well in all directions.

g. Seal the space between the casing and the platform using mastic sealer or asphaltic seal.

h. Install the required pump unit.

i. Disinfect the well as described in Section 15.04.

3. This method is used if the well does not need any further deepening and requires installing of the necessary well casing and pump only as shown in Figure 6.02.

Tools	**Materials**
Shovel	Standard well casing
Pick-axe	PVC or metal screen
Pail	Cement
Rope	Aggregates
	Wash round gravel
	Gravel

Procedure

a. Clean the well from silt and other undesirable materials using the same procedure as in step (1) of Method B.

b. Remove the upper wall curbing up to at least one meter below the ground surface.

c. Lower a well casing with a screen attached at its lower end.

d. Fill the space around the screen with 6–25 mm washed round gravel up to the neck of the reducer by using at least 50 mm 0 tremie pipe.

e. Build an impervious concrete layer 10 centimeters thick on top of the gravel layer.

f. Fill the rest of the open space around the casing with puddled clay.

g. Follow steps e, f, g, h, and i of Method two.

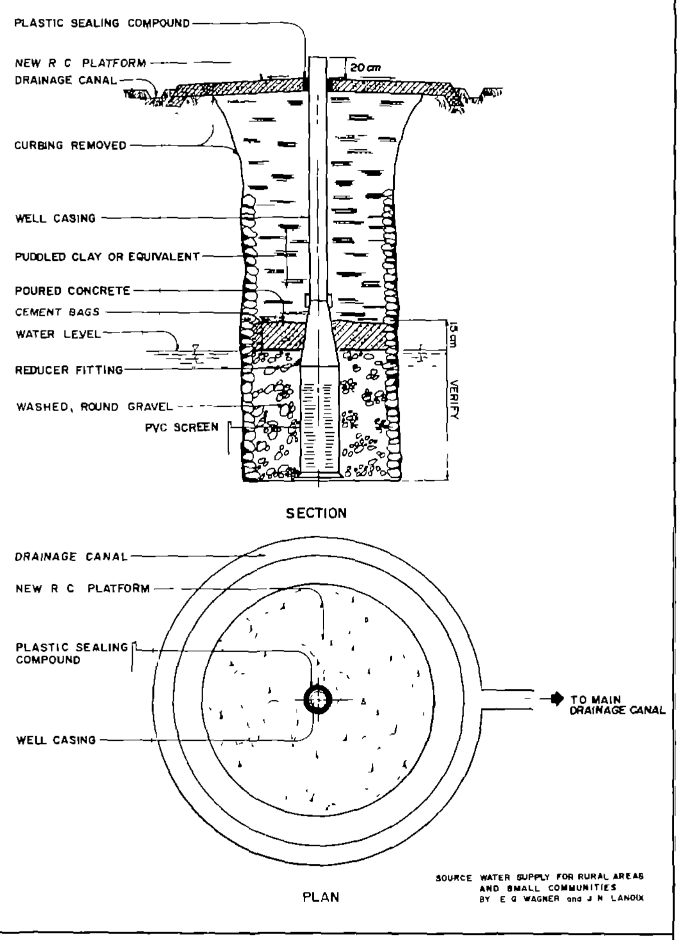


FIGURE 6 02 IMPROVEMENT OF EXISTING DUG WELL (TYPE II)

4. A shallow dug well may be improved by installing a curbing consisting of concrete culvert pipes as shown in Figure 6.03.

   Procedure

   a. Clean and deepen the well following the same procedure presented in Method two and three.

   b. Cover the well bottom with loose stones to support the concrete pipe lining leaving enough space for the pump foot valve setting.

   c. Remove the upper wall curbing as described in method three.

   d. Line the well with concrete culvert pipes. Seal the joints with mastic sealer or asphaltic seal.

   e. Fill the voids between the removed curbing and the culvert pipe with puddled clay.

   f. Provide concrete platform or cover as discussed in previous methods. The cover should be provided with an inspection manhole.

   g. Set the suction pipe in position.

   h. Install pump.

   i. Disinfect well.

6.03 CONSTRUCTION OF NEW HAND DUG WELLS

A. General

Hand dug wells are commonly used to extract groundwater in rural areas in the Philippines. They are circular in shape and vary in size from one to 1.5 meters diameter. The walls are commonly lined with reinforced concrete, bricks or adobe. Depending on the nature of the aquifer, water enters the well either through the walls or through the open bottom. When walls are used, the lining is usually made porous by use of perforated reinforced concrete pipes. In which case, the bottom is concreted to prevent upward movement of soil and to facilitate cleaning. However, if water enters through the bottom, the bottom is filled with gravel or loose stones to a depth of at least 20 centimeters.

Hand dug wells are simple to construct. The procedures of construction can be summarized as follows:

1. Prepare the site and set up the construction equipment.

2. Excavate the well hole.

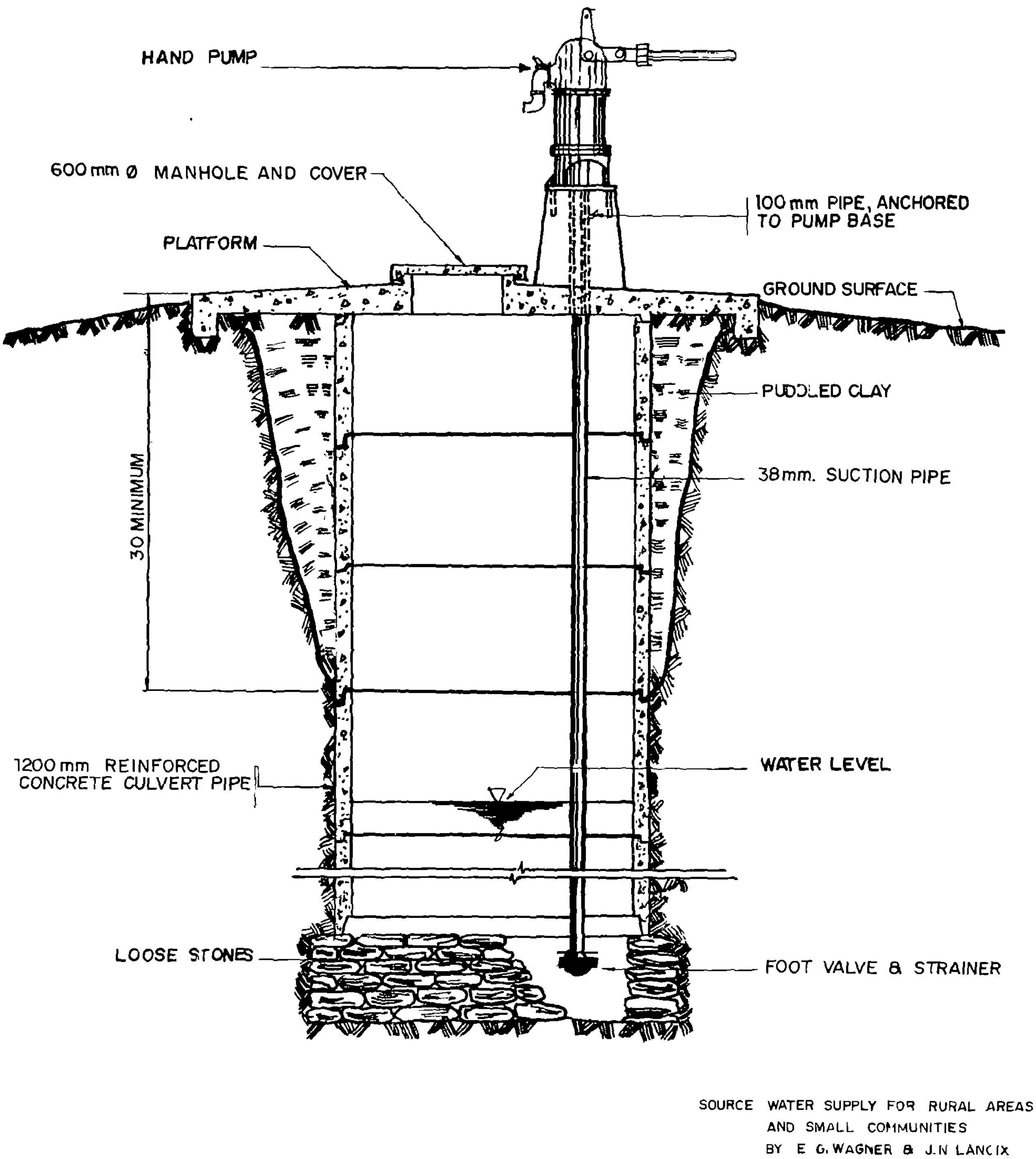


FIGURE 6.03

IMPROVEMENT OF EXISTING DUG WELL (TYPE III)

3. Lower the reinforced concrete pipe casing into the excavated hole. In loose ground formation where cave-ins are imminent, the excavation of the well hole and lowering of reinforced concrete pipe casing are done alternately.

4. Check well alignment.

5. Seal the reinforced concrete pipe joints.

6. Lay the gravel layer at the foot of the well.

7. Grout the space between the permanent casing and the surrounding hole.

8. Build a concrete platform or pedestal and the surrounding drainage canal.

9. Conduct pump tests to determine well capacity.

10. Install pumping facilities or any appropriate water drawing equipment.

11. Disinfect the well with chlorine.

B. **Detailed Procedure for the Construction of Hand Dug Wells**

The procedure presented below is typical. Hence, it is up to the well builders to modify the process to fit the local conditions.

1. Construction Tools and Equipment

   a. Digging tools; e.g. spade, shovel, etc.

   b. Pump, complete with accessories and with capacity of at least 1.5 times the approximate maximum day demand of the households to be served.

   c. Pipe wrenches of suitable sizes.

   d. Pulley system.

   e. Bucket or pail.

2. Construction Materials

   a. Plumbing rod and pegs.

   b. Pre-fabricated reinforced concrete (RC) pipe.

   c. Portland Cement.

   d. Lumber.

e. PVC or G.I. Pipes.

f. Aggregates such as sand and gravel.

3. Construction Procedure

a. Preparation of the Site and Setting of Construction Equipment.

i. Clear and grub the site from all big stones and undesirable vegetation. Provide a working space with a radius of about 5 to 10 meters in the surrounding area.

ii. Mark the diameter of the well on the ground as specified on the plan using a spade or a shovel.

iii. Excavate a hole 0.50 meter deep and construct a lining shutter (Figure 6.04). Backfill the gap between the shutter and the surrounding soil. The lining shutter will remain in place until the pre-fabricated reinforced concrete pipe casing joints are concreted. This structure will prevent the top edge of the well from crumbling, particularly when hit by buckets; serves as a mound around the well top to reduce the risk of objects, e.g. tools or stones from accidentally falling into the well which may injure the workers below; assists in keeping the well plumb; and serves as a fixed level for taking measurements.

iv. Fix the plumbing pegs, and plumbing and trimming rods into position (Figure 6.04 and 6.05). This set up will determine the depth and will check plumbness of hole. During the excavation process, the trimming and plumbing rod is removed from time to time and is replaced only when checking the alignment of the well hole.

v. Mount the tripod which will hold the pulley in place, this pulley system will be used in bringing up the earth to the ground surface (Figure 6.07).

b. Excavation of Well Hole and Installation of Reinforced Concrete (RC) Pipe Casing.

1. **Excavating of Shallow Wells in Firm Ground Formations**

i.1 After site preparation and setting up of equipment, start the excavation process. The process consists of alternate loosening of earth and hauling of loosened earth. (Figure 6.06). Check well alignment for every meter excavated by lowering the trimming rods.

i.2 Continue excavation until the desired depth is reached. However, when the ground appears to be unstable

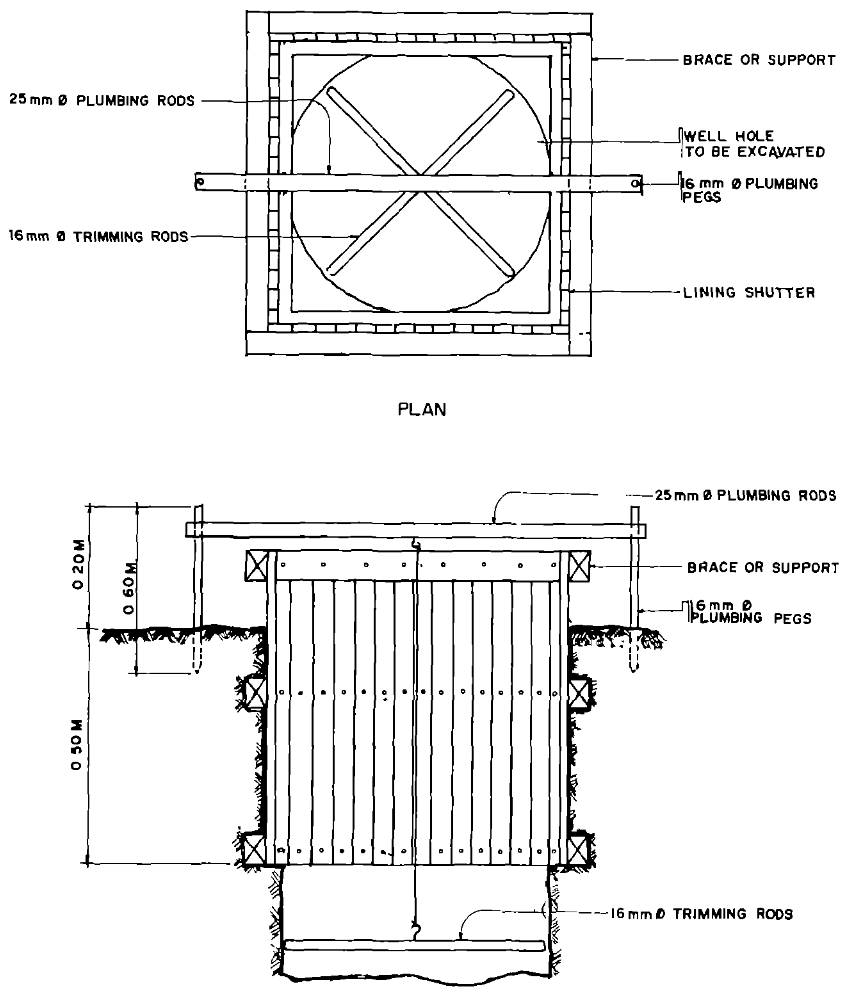


FIGURE 6 04

LINING SHUTTER

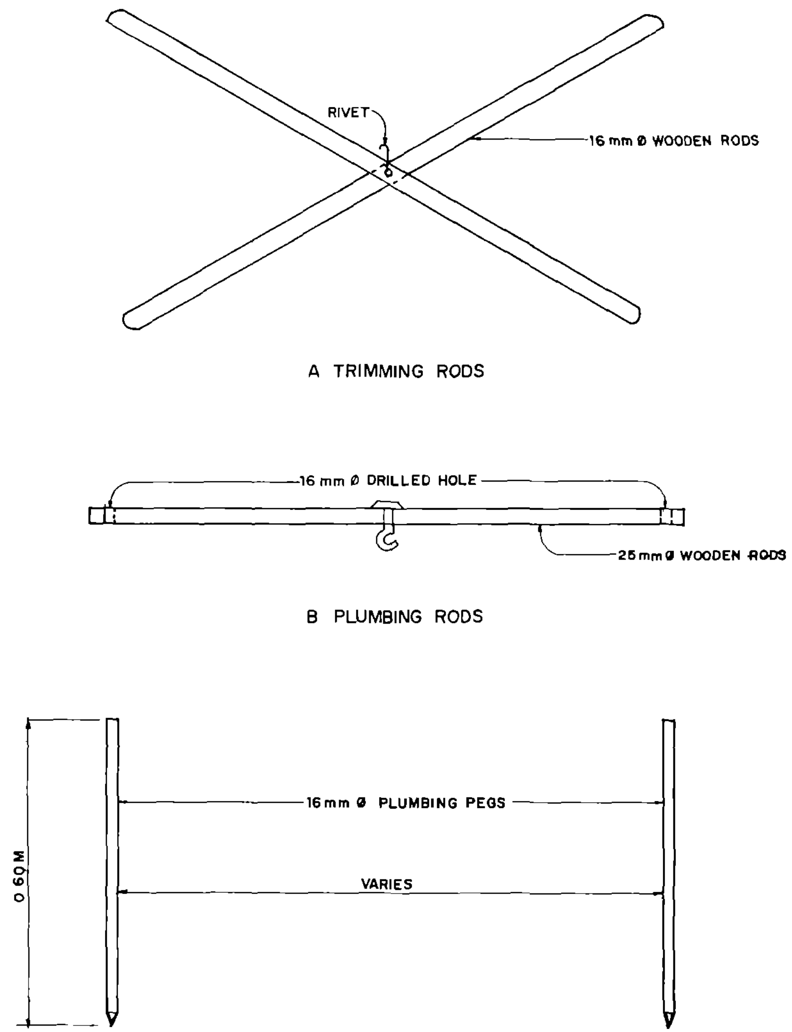


FIGURE 6.05

DETAIL OF PLUMBING PEGS AND RODS AND TRIMMING RODS

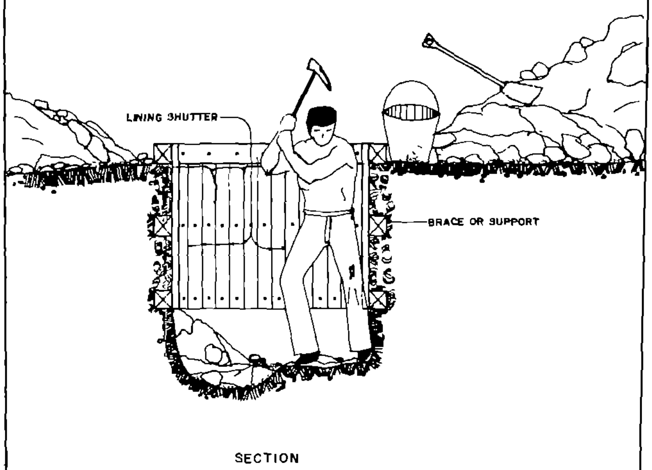


FIGURE 6 06

EXCAVATION OF HAND DUG WELL
IN FIRM GROUND FORMATION

before the desired depth is reached and cave-in is imminent, place a wooden support around the walls of the hole. When water is reached, bail the water out of the well together with the material excavated. The more efficient the well is kept dry, the deeper is the penetration of the well hole into the water bearing stratum. And therefore, the more water the well will yield.

i.3 When the water bearing stratum is sufficiently penetrated, reinforced concrete (RC) pipe casing is lowered into the hole. At the bottom part of the well, a perforated RC pipe is installed. The length of the column of perforated RC pipe depends upon the thickness of the water bearing aquifer penetrated by the well hole.

ii. **Excavating in Loose Ground Formation**

In loose ground formation, excavation and sinking of the well casing can be done as follows: Excavate a 0.50 meter deep hole and then place one length of reinforced concrete (RC) pipe. (Note that the first 3 to 6 lengths of RC pipe buried are perforated depending upon the thickness of the water bearing aquifer to be penetrated by the well hole.)

After placing the pipe in the hole, excavation commences. As the excavator goes down, the RC pipe also goes along with him. When the top-most pipe is about to sink below the shutter-lined wall, another pipe is added on the top-most pipe. The alternate digging and adding of the pipe continues until the desired depth is reached. Figure 6.07 illustrates the construction of hand dug well in loose ground formation.

iii. **Excavation of Deep Dug Wells**

In constructing deep dug wells, cribbing and the danger of cave-in should be carefully considered. The method of construction is very similar to the method used in excavation of wells in loose ground formations.

i.1 Excavate a hole 0.50 meter deep and set in place one length of reinforced concrete pipe in it.

i.2 Allow the pipe to descend under its own weight while excavation progresses.

i.3 When only about 10 centimeters of the pipe remains above the ground, or when the top-most pipe is about to sink below the shutter-lined wall, add another length of pipe on top of the first pipe.

i.4 Continue the alternate digging and adding of pipe until the desired depth is reached.

4. Checking of Well Alignment and Plumbness

After installing the reinforced concrete (RC) pipe casing, check the alignment and plumbness of well by using the trimming rods.

5. Sealing the Joints Between R.C. Pipes

The part joining two R.C. pipes should be sealed to prevent contamination due to infiltration of surface water. The sealing procedure is as follows:

a. Chip off the section joining two R.C. pipes together using a cold chisel to provide a roughened surface where the cement mortar will adhere.

b. Apply mastic sealer or asphaltic seal on the roughened surface.

6. Laying of Gravel Layer at the Bottom of the Well

Provide the well bottom with a gravel layer 20-30 cm deep consisting of graded gravel with diameter ranging from 5 mm (Mesh No. 4) to 25

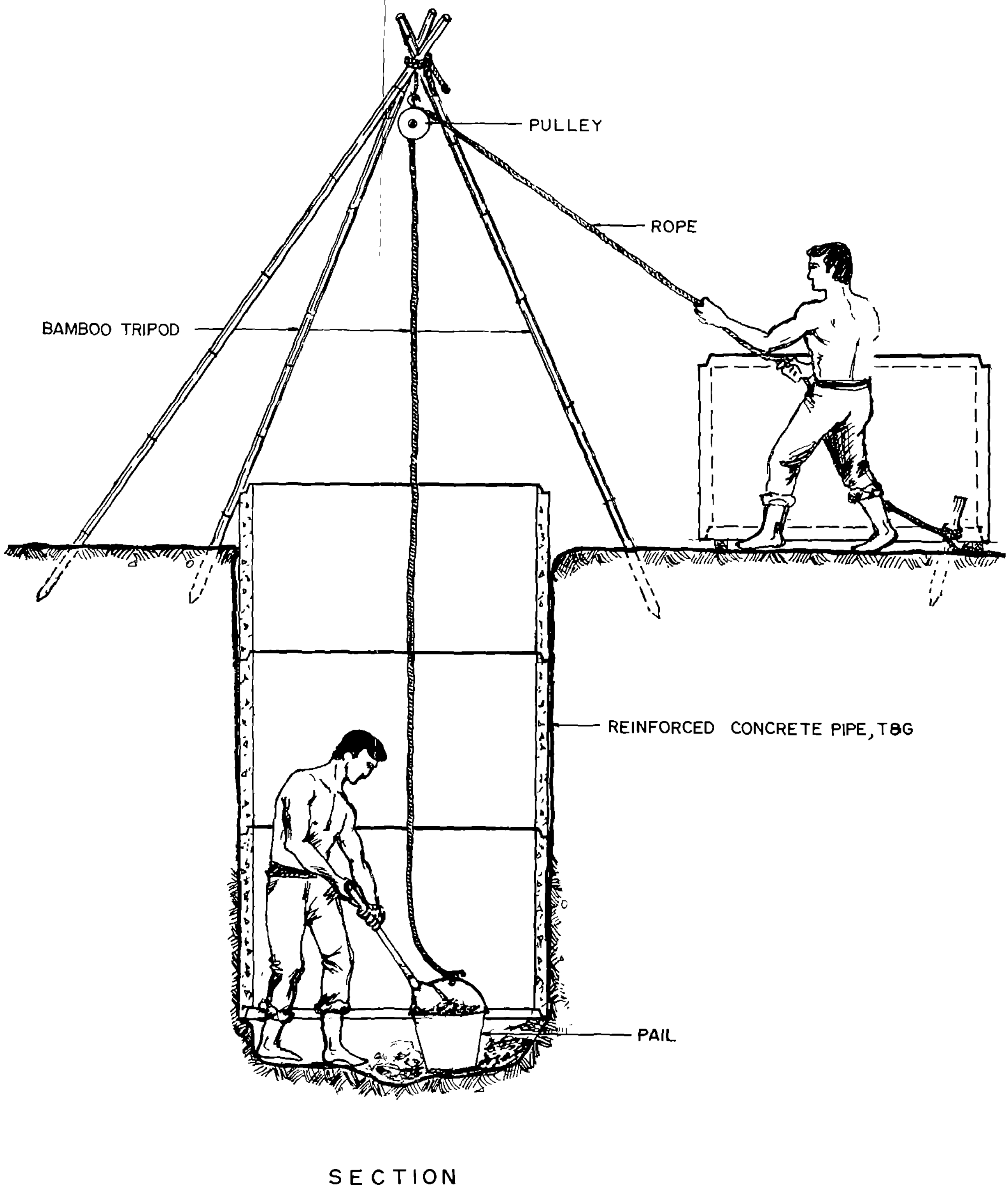


FIGURE 6.07

CONSTRUCTION OF HAND DUG WELLS IN LOOSE GROUND FORMATION mm (Mesh No. 100). The gravel layer is necessary to strain fine sand, thus, allowing the pump or any water drawing equipment to draw clearer water.

7. Grouting

Grout the upper three (3) meters of the dug well to protect it from contamination due to surface water. The detail of the grouting process is presented in Section 6.10.

8. Building of Well Cover and Pedestal

Provide the well with a strong cover and pedestal made of concrete, or other construction materials suitable for the purpose. Make provision for a manhole for maintenance and repair. Dug well covers have the following features:

a. An impervious clay apron 30-40 cm thick and extending at least one meter around the edge of the well. The minimum slope of the apron must be five percent (5 units vertical to 100 units horizontal).

b. An impervious concrete cover 10 cm. thick and extending outward at least one meter around the edge of tne well. The minimum slope of concrete cover must be at least one percent or one unit vertical for every 100 units horizontal.

9. Installation of Pumping Facilities

The installation of pumping facilities is presented in detail in Chapter 13.

10. Pumping Test and Disinfection

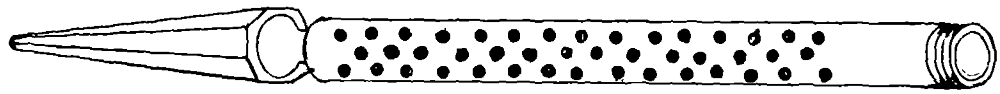
Pumping test to determine the yield and drawdown of wells is discussed in Section 6.13 and disinfection is treated in detail in Chapter 17, Testing and Disinfection.

6.04 CONSTRUCTION OF NEW DRIVEN WELLS

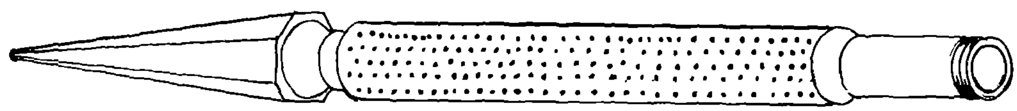
A. General

Driven wells are constructed by hammering with the use of a mallet or a dead weight, a pointed strainer called well point, through the ground and into water-bearing stratum. A well point is a specially made metal tube with a point at the lower end, and holes or slits in the sides through which water can enter (Figure 6.08A and B).

Driven wells have diameters which range from 32 to 50 mm depending on the water demand and can be constructed up to a depth of 15 meters depending on the soil conditions. This type of well is suitable in silt, sand, gravel and to a lesser extent in clay formations, but not in stone formations.



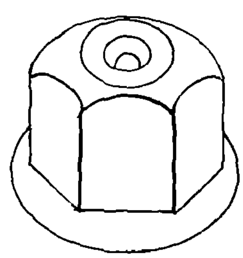
A



B

WELL POINTS

NOTE.
WELL POINTS ARE USUALLY MADE OF FORGED STEEL, STAINLESS STEEL, OR HARD BRASS.



C

DRIVE CAP

SOURCE RURAL WATER SUPPLY AND SANITATION BY F B WRIGHT

FIGURE 6.08

TWO TYPES OF WELL POINTS AND DRIVING CAP

B. **Tools**

Driving materials, tools and equipment are simple and are generally available locally. These are:

a. Rig with pulley system. The rig can be fabricated out of bamboo poles.

b. Drive pipe with cap and well point.

c. Mallet or dead weight.

d. Driving clamp.

e. Plumber's hand tools.

f. Hand digging tools like spade, pick, hoe, shovel, etc.

C. **Materials**

a. Standard weight pipe casing/drive pipe.

b. Cement and aggregates.

c. Rope.

d. Bamboo poles.

D. **Construction Procedure**

1. Preparation of the Site and Setting up of Construction Equipment.

   a. Clear and grub the site. Provide a working space with radius of 3 to 5 meters, taking the site of the well hole as center.

   b. Mark the center of the well on the ground as specified on the plan using a spade or a shovel. Dig a small hole 50-80 cm deep and diameter slightly larger than the diameter of well point using a crowbar. This hole will hold the drive pipe in place.

   c. If the driver to be employed in sinking the well point is a dead weight, mount the drop weight and pulley system on the tripod (Figure 6.09).

2. Sinking of Drive Pipe or Well Point

   a. **Using a Drop Weight** – The sinking of drive pipe and well point is usually performed by two persons: the first person operates the drop or dead weight while the second person aligns the drive pipe with the aid of a pipe clamp. Figure 6.07 shows the set up (the

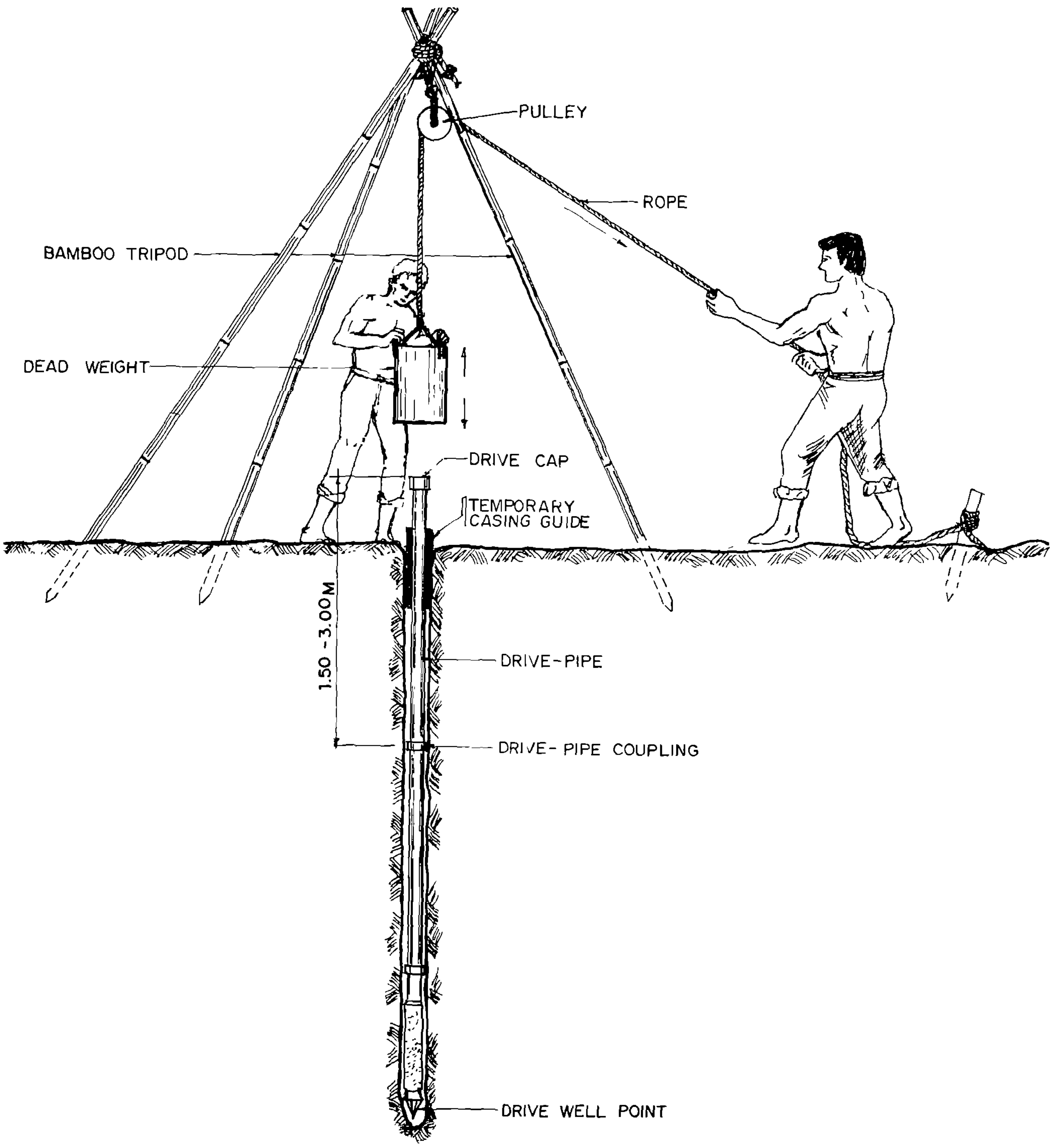


FIGURE 6 09

CONSTRUCTION OF DRIVEN-WELL USING A DEAD WEIGHT second person is not shown in the drawing). The operation of the system consists of raising the dead weight by pulling the rope and then allowing the dead weight to drop hitting the drive cap of the drive pipe.

Procedure:

i. Set the drive pipe equipped with well point vertically into the hole.

ii. Put a driving cap (Figure 6.08C) at the top of the drive pipe. The cap protects the pipe from being damaged due to the impact of the dead weight.

iii. Drive the well point/drive pipe by alternately pulling and releasing the rope. After each blow, check if the pipe joint is tight by twisting it. If it is loose, it must be tightened by means of a pipe clamp and pipe wrench before continuing the driving operation.

iv. Continue driving until approximately 20 cm. of the pipe top remains exposed. Remove the drive cap and connect the second pipe to the first pipe. Replace the drive cap on top of the newly installed pipe and resume the driving operations. The driving and pipe jointing operation is repeated until the desired depth is reached.

v. In case the well point encounters a boulder, it is best to pull out the pipes already in the ground and try a new spot a little distance away.

b. **Using a Sledge Hammer** — Figure 6.10 shows the set-up of sinking a drive pipe/well point using a sledge hammer. The principle in sinking the drive pipe using a sledge hammer is similar to the driving procedure using a dead weight.

Procedure:

i. Set pipe equipped with a well point vertically into the hole.

ii. Put a driving cap or any cushioning material like wood block on the top end of the drive pipe.

iii. While the drive pipe is held in place by means of a pipe clamp by the second person, the first person sinks the well point by hitting the drive cap with the sledge hammer. The portable platform as shown in Figure 6.10 is used when the height of the drive cap is quite high from the ground so that it is difficult for the driver to hit the drive cap. In this case, the driver stands on the platform while hitting the drive cap.

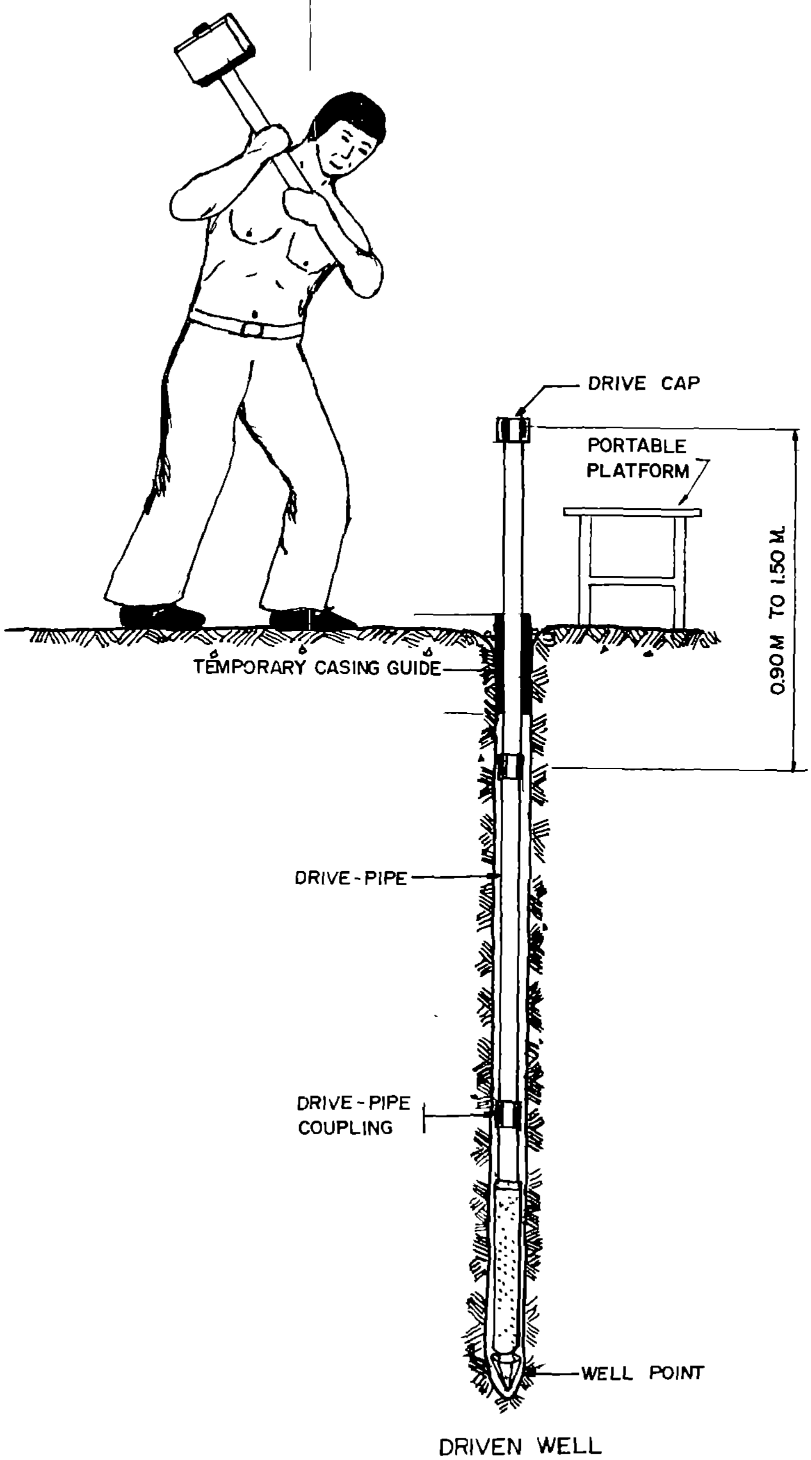


FIGURE 6.10

CONSTRUCTION OF DRIVEN WELL USING A SLEDGE HAMMER

iv. Continue the driving operation until approximately 20 cm of the pipe top remains above the ground surface. Remove the drive cap and connect the second pipe to the exposed end of the first pipe. Replace the drive cap on top of the newly installed pipe and resume the driving operation. The driving and pipe jointing operations are repeated until the desired depth is reached. If during the driving operation, the well point encounters a boulder or hard rock formation, it is best to pull out the pipes already in the ground and try a new spot a little distance away.

3. Checking of Well Plumbness and Alignment

The procedure in checking well plumbness and alignment is presented in Section 6.09.

4. Grouting

The grouting process is presented in Section 6.10.

5. Building a Concrete Platform and the Surrounding Drainage

Section 6.12 presents the detailed procedure of constructing a typical concrete apron or pedestal with surrounding drainage canals.

6. Development of Well

Development of a well is a process of opening the water bearing formation in the vicinity of the well point to increase the water yield. The different methods of well development are discussed in detail in Section 6.13.

7. Pumping Test

Knowledge of the amount of water the well is capable of producing is important in determining the need for a supplementary source to meet the water demand of the population to be served and the size of the pump to be installed. Well yield is determined through a pumping test. The testing procedure is discussed in detail in Section 6.14.

8. Installation of Pumping Facilities.

The installation of pumping facilities is presented in detail in Chapter 13.

9. Disinfection

Disinfection of a newly constructed well is necessary before starting the well drawing operation, to kill disease-causing bacteria. The disinfection process is treated in detail in section 15.04.

6.05 CONSTRUCTION OF NEW BORED WELLS

A. General

Bored wells are constructed by boring a hole using an earth borer or auger. This type of well is suitably constructed in soft soil and alluvial formations free of large gravel and stones. They are usually 40 to 80 mm in diameter and can be installed up to a depth of 15 meters.

B. Construction Tools and Equipment

Shown in Figure 6.11 are typical boring tools for bored well construction.

C. Construction Procedure

1. Prepare working site, tools and materials for construction.

2. Dig a hole 30 to 50 cm deep and of sufficient diameter to allow the introduction of the borer.

3. Bore a well hole employing an earth auger.

   a. **In Stable Soil Formation** – Boring of a hole and removal of loosened soil is accomplished by rotating the earth auger (Figure 6.12A). The shape of the spiral allows the loosened soil or gravel to rise. To remove the remaining loosened soil, raise the borer out of the hole with the soil extracted from time to time.

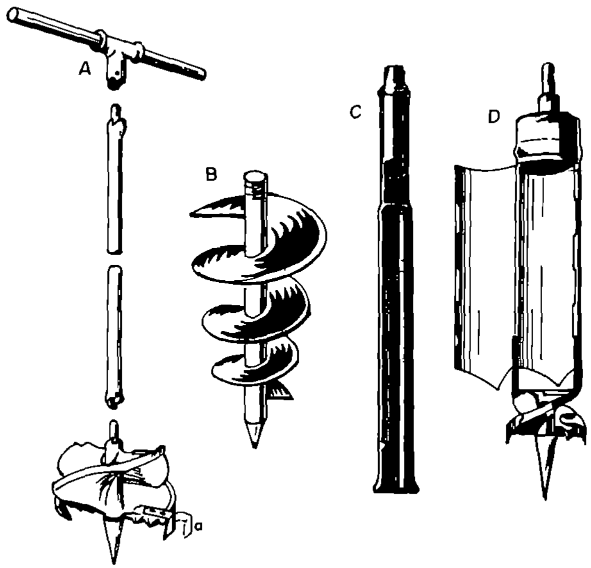
   b. **In Loose Soil Formation** – The principle of boring a well hole in loose soil formation is similar to the principle in boring a well hole in stable soil formation except that a pipe casing which goes down with the earth auger is installed as earth shield to prevent the cave-in (Figure 6.12B). The borer is operated inside the protective pipe and is provided with movable side cutters capable of cutting a hole 3.8 cm bigger in diameter than the pipe to allow the pipe to follow the borer as it descends.

4. When the desired depth is reached, set the well casing and screen in place and grout the well. In cases where the pipe lowered when boring in loose soil formation satisfies the requirements, it can serve as well casing.

5. Build a well apron and drainage canal around the well.

6. Develop the well to increase well yield and conduct pumping test to determine the amount of water that the well can supply.

7. Install pumping facilities or any water drawing equipment and disinfect the well including the casing and pump prior to its commissioning.

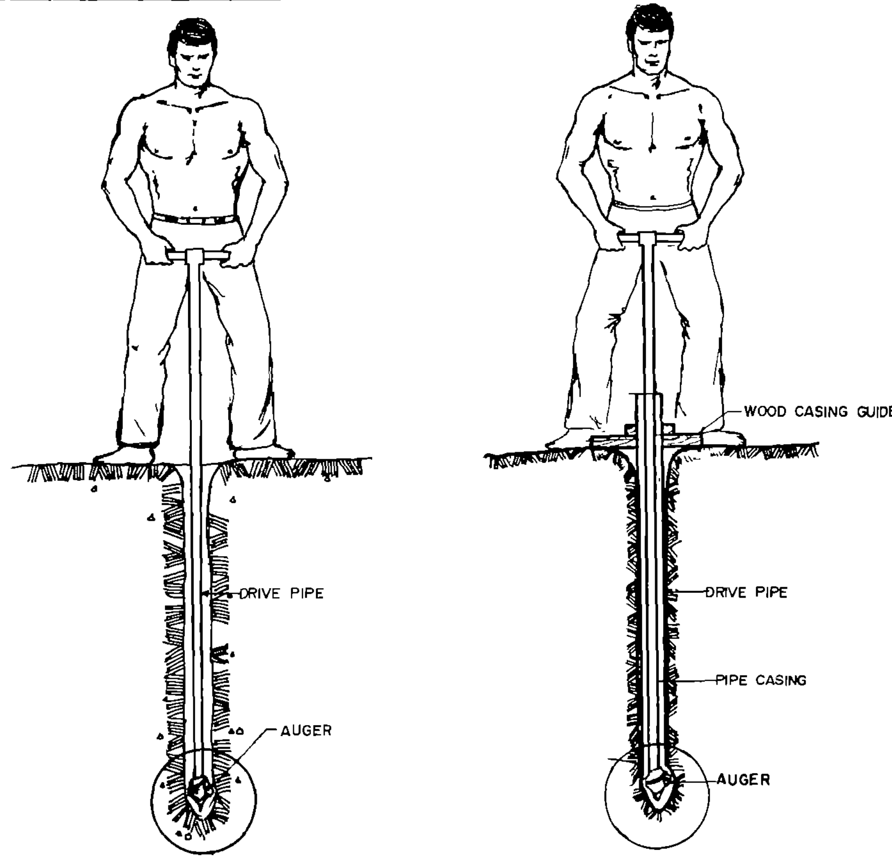


A = TOOL FOR BORING IN TOP SOIL, CLAY, SANDY CLAY, OR FORMATIONS THAT ARE NOT TOO HARD OR CAVING. CUTTER(a) MAY BE ADDED TO PERMIT BORING UP TO 8 cm (3 in) WIDER THAN STANDARD SIZE
B = SPIRAL AUGER
C = REGULAR CLUB BIT FOR BREAKING THROUGH HARD FORMATIONS, LOOSENING ROCK AND BREAKING SOFT ROCK
D = TOOL FOR BORING IN SOFT, WET, SANDY SOILS

SOURCE WATER SUPPLY FOR RURAL AREAS AND SMALL COMMUNITIES BY E G WAGNER AND J N LANOIX

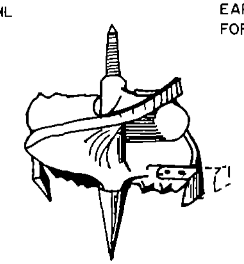
FIGURE 6 11

TYPICAL BORING TOOLS



A BORING WELL BY THE USE OF EARTH AUGER IN STABLE SOIL

B BORING WELL BY THE USE OF EARTH AUGER IN LOOSE GROUND FORMATION



DETAIL OF AUGER

FIGURE 6 12

CONSTRUCTION OF BORED WELL

6.06 CONSTRUCTION OF NEW JETTED WELLS

A. General

Wells can also be constructed by jetting. A stream of water which is introduced into the well hole loosens the soil and carries it to the ground surface. Jetted wells are constructed suitably in fine or sandy soil formations but not in gravel or rock formations. They are usually 40 to 100 millimeters in diameter and can be installed up to a depth of 50 meters. Jetted wells can be constructed by Sludger's or by Conventional methods.

B. Sludger's Method

1. Clear and grub the site. Provide a working space of about 5 to 10 meters radius.

2. Build a bamboo scaffolding and a bamboo fulcrum (Figure 6.13A). The bamboo scaffolding is used as support to enable a person to reach the upper portion of the pipe when he performs a flap-valve-like operation with his hands. On the otherhand, the bamboo fulcrum will be used to support the lever which will be used in moving the pipe up and down.

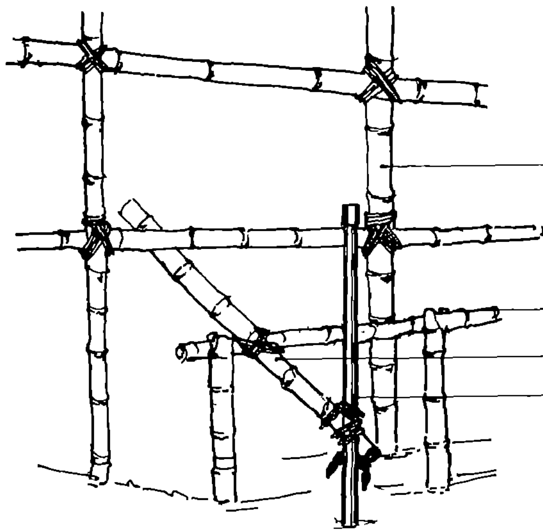
3. Screw a cutter into one end of a 3 M length (Figure 6.13B) G.I. boring pipe. A sharpened coupling may serve as the cutter.

4. Dig a hole about 1 meter square and 0.7 M deep and fill it with water.

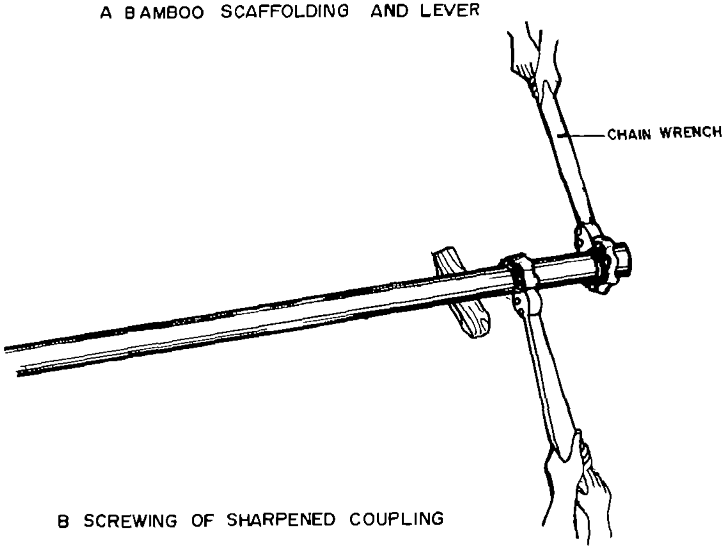
5. Hold the pipe in a vertical position and fasten it to a lever with a chain (Figure 6.14A). The lever is usually manned by 2 to 6 men (diameter not more than 50 mm) who raise and lower the pipe.

6. Start the sinking of the pipe. The pipe is moved up and down using the bamboo lever chained to the pipe. While the pipe penetrates through the earth surface, the soil is loosened and becomes suspended in water. The soil-water mixture is then raised to the ground surface. This is accomplished by a man sitting on a scaffolding operating his hand as a "flap valve" (Figure 6.14B). As the pipe is being raised using the lever, the man covers the mouth of the pipe with his hand, and as the pipe is being dropped, he removes his hand allowing mud and water to rise and trickle down from the pipe to the shallow water-filled mud hole. The action of the hand for every upward and downward motion of the boring pipe creates a vacuum causing the mud to rise.

   As the hole deepens and the pipe is lowered, the chain which fastens the boring pipe and lever together is raised. When the pipe is sunk to its full length, the lever is disconnected and a new length of pipe is added at the top. The lever is then fastened using the chain. Also, during the sinking process, the mud hole must be kept full of water. Add more water and remove appreciable amount of silt if necessary. During the progress of the work, soil samples should be collected for every meter



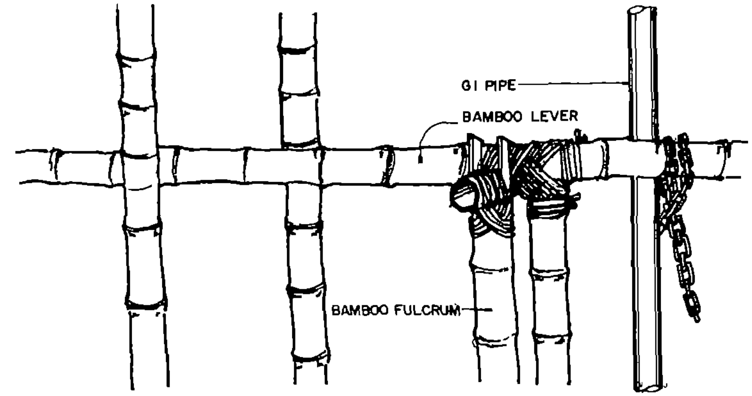
A BAMBOO SCAFFOLDING AND LEVER



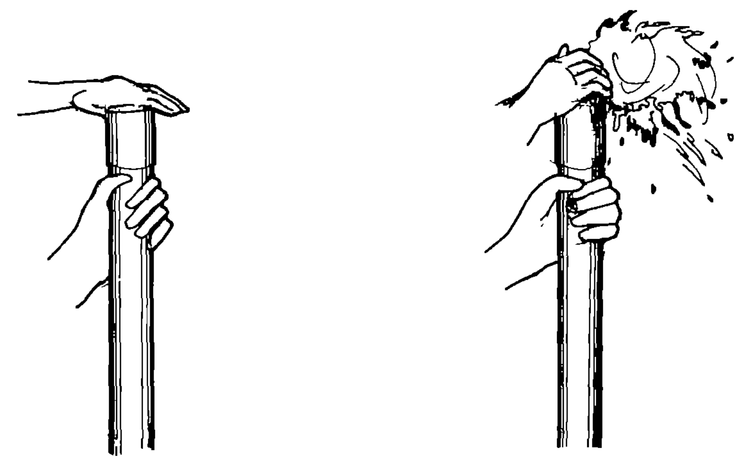
B SCREWING OF SHARPENED COUPLING

FIGURE 6.13

CONSTRUCTION OF JETTED WELLS
(SLUDGER METHOD)



A HOLDING OF PIPE IN VERTICAL POSITION AND FASTENING IT TO A LEVER USING A CHAIN



B MAN OPERATING HIS HANDS AS A FLAP VALVE

FIGURE 6.14

CONSTRUCTION OF JETTED WELLS
(SLUDGER METHOD)

depth or for every change of formation and analyze. Boring continues until the desired depth is reached.

7. Insert the pipe casing with screen or perforated pipe attached to its bottom end inside the boring pipe.

8. Withdraw the whole length of the boring pipe piece by piece using the lever.

9. Check well alignment and plumbness.

10. Develop the well by surging.

11. Determine well yield by pumping test.

12. Complete the construction of well by:

    a. Filling the annular space between the well pipe and the earth hole with compacted impervious clay or concrete to prevent contamination from reaching the water table through this space.

    b. Build a water tight concrete apron or pedestal.

    c. Install the pumping facilities or any water drawing equipment.

    d. Disinfect the well by chlorination.

C. **Conventional Method**

1. Clear and grub the site. Provide a working space of about 5 to 10 meters radius.

2. Set up the jetting equipment and tripod as shown in Figure 6.15.

3. Dig a hole 0.5 to 1.0 meter deep to serve as the starting depth.

4. Attach a cutter to one end of the boring pipe (usually thru meter in length) and a swivel at the opposite end. Suspend the pipe and swivel in pulley and tripod as shown in Figure 6.15. The swivel joint allows water to enter the boring pipe at the same time permitting the boring pipe to revolve without leaking.

5. Start sinking the pipe. The sinking process consists of pumping water into the boring pipe and at the same time twisting it using a chain or pipe wrench. Due to pressure of water and the twisting action, the pipe will start sinking. The more water that can be pumped through the pipe, the faster the pipe will descend and the more suspended matter will be washed out of the hole.

   When the exposed end of the first 3 meters length of the pipe is about 0.3 to 0.6 M from the ground surface, disconnect the swivel and attach

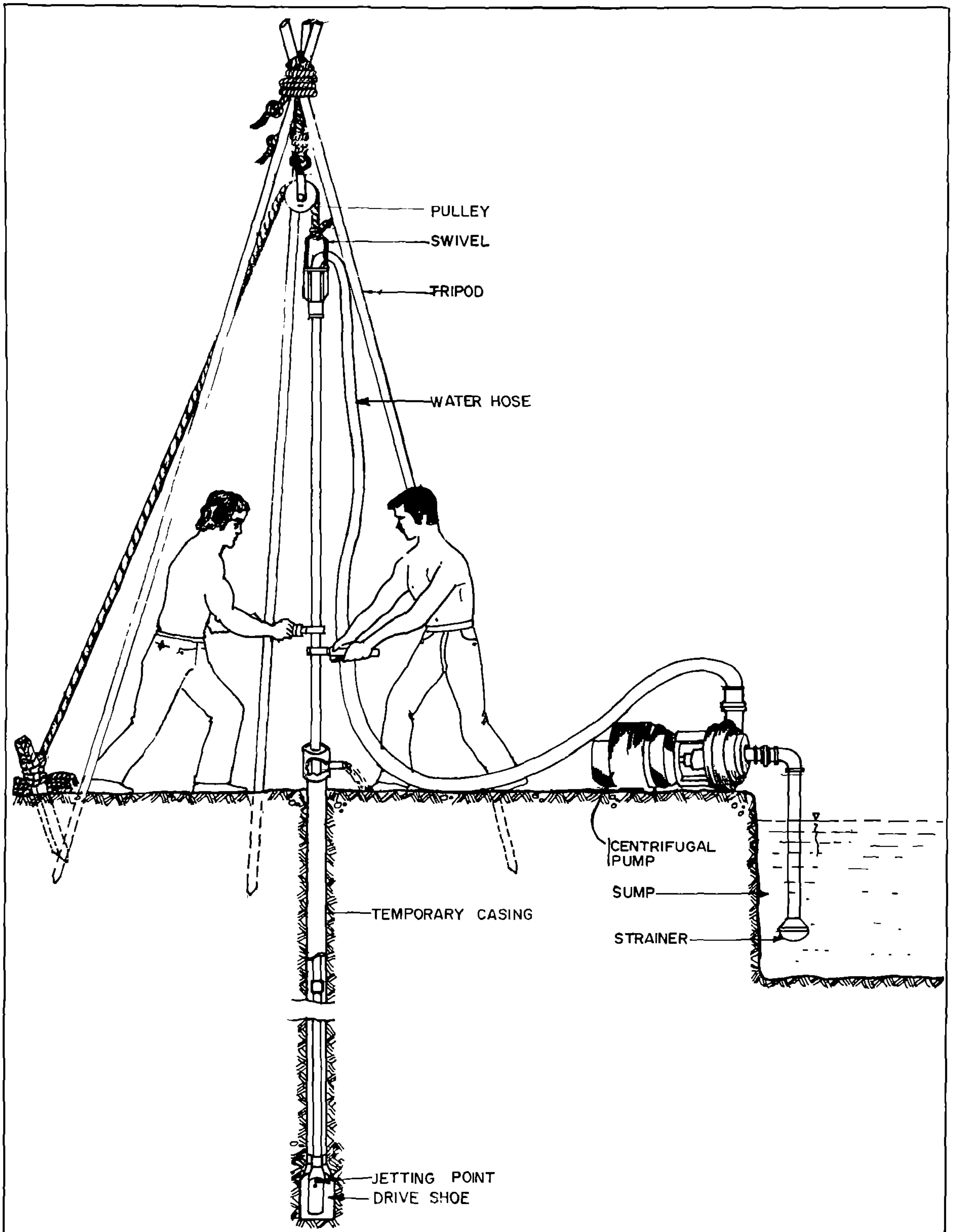


FIGURE 615

CONSTRUCTION OF JETTED WELL IN LOOSE GROUND FORMATION (CONVENTIONAL METHOD) the second pipe. Replace the swivel at the top of the second pipe and start jet boring again. This process is repeated until the desired depth is reached.

6. Remove the whole length of the pipe piece by piece taking care that the hole will not be disturbed.

7. Remove the cutter from the end of the bottom pipe. In its place, install a screen or a properly slotted PVC pipe.

8. Replace the withdrawn pipes into the hole with the perforated PVC pipe or screen attached to the first pipe. It should be observed that it is much easier to lower the pipe this time as the hole has been previously opened. To hasten the sinking of pipes, repeat the jetting process, this time using the screen or perforated pipe as the cutter.

9. Check well alignment and plumbness before permanent installation.

10. Develop well through surging until water is sand-free.

11. Determine well yield by pumping test.

12. Complete the construction of the well as follows:

    a. Fill the annular space between the well pipe and the earth hole with compacted clay or concrete to prevent contamination of the well water through this space.

    b. Build a water tight concrete apron.

    c. Install the pumping facilities or any water drawing equipment.

    d. Disinfect the well by chlorination.

Construction of jetted wells 150 mm in diameter or more will require a more complicated operation and is not within the scope of this manual. It is enough to point out that such an operation will involve the construction of a higher tower and use of bigger pumps. Also, it requires a larger quantity of water for jetting.

6.07 CONSTRUCTION OF NEW DRILLED WELLS

A. General

Drilled wells can be constructed practically in all types of ground formations. They are usually 100 to 600 millimeters in diameter and can be installed up to a depth of 300 meters or more. Drilled wells are generally constructed by the use of rigs designed and manufactured for the purpose.

B. Equipment

Two types of rigs are used: (1) percussion and, (2) rotary. The percussion drilling rig, also called the "cable tool" rig, is the more common and simpler of the two. Figure 6.16 shows a percussion type drill rig. It consists of a derrick and a hoisting and control equipment mounted on a truck. The derrick serves as the tower from which the drilling tools, well casings, screens and all materials and equipment used to construct the well are suspended and manipulated. The rigs vary in size and are expensive. A small portable percussion rig powered by a small gas engine is available here in the Philippines at cost of about P35,000.00. It is easy to operate and can put down a jet or drilled well 75-150 mm (3-6 in.) in diameter to depths of 50-100 meters depending upon the diameter and the geology of the areas. Small enterprising well drillers who cannot afford this equipment have devised a simple inexpensive percussion rig as shown in Figure 6.17. It is fabricated out of bamboo poles with a pulley system suspended at the top. Drilling is accomplished by continuous raising and dropping of the drill bit through the manipulation of the rope.

One advantage that the small portable rigs have over the large truck-mounted rigs is that they can be used to drill wells in any place; while big rigs are limited to sites that are accessible to trucks. Whether it be a power driven or manually operated percussion drill, the principle of drilling is the same. Both operate on the chiselling action of a tool which is alternately raised and dropped into a bore-hole.

The rotary type has practically the same features, except that it is equipped with a rigid drill pipe that is turned by a rotary plate, and a mud pump and a hose which pumps water or mud down the hole as drilling proceeds. The loosened materials are bailed out by the flushing action of the water with the mud. Drilling is accomplished by the rotary action of the drill bit which loosens the materials encountered. Drilling wells with the use of these expensive rigs is a specialized work and requires experienced and skilled operators. Hence, this type of rig may not be suitable for rural water supply system constructions where funds are limited.

C. Manual Percussion Drilling

The construction of a drilled well through manual percussion drilling is the least expensive and the most adaptable process for drilling wells in rural areas. The procedure is as follows:

1. Prepare the site and set up the drilling equipment as shown in Figure 6.17.

2. Bore a hole with a depth equivalent to the length of the drill bit (usually ranges from 0.5 to 1.0 meter) with the use of an earth auger to serve as drilling guide.

   Mount the drill stem fitted with a drill bit vertically in a tripod with a piece of rope and with drill bit centered in the hole.

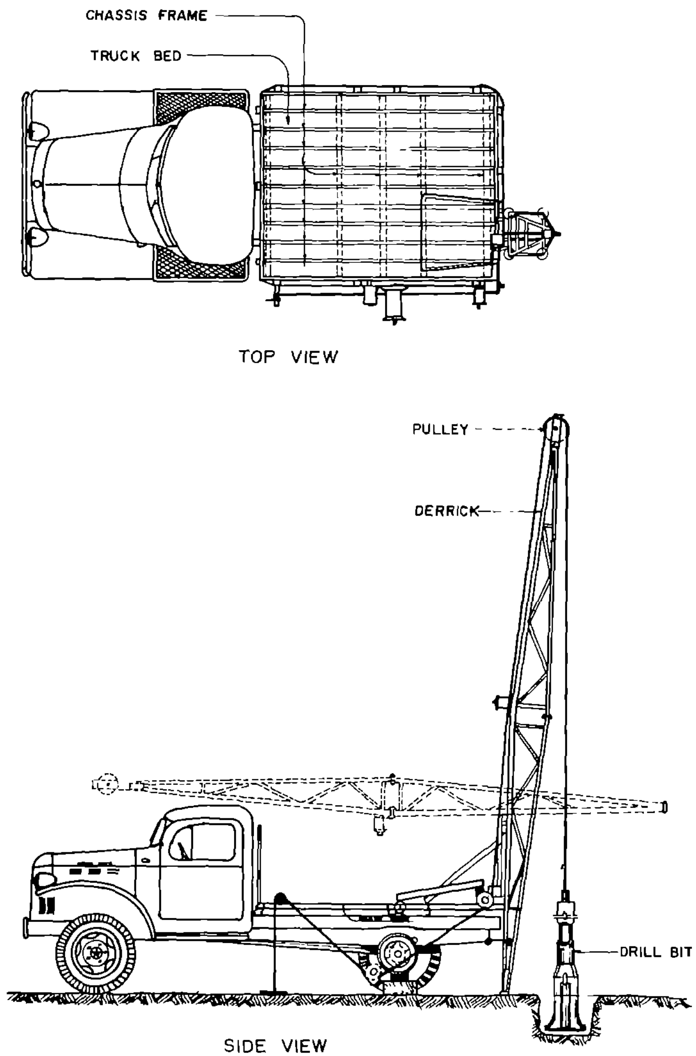


FIGURE 6 16 PERCUSSION TYPE DRILL RIG (TRUCK MOUNTED)

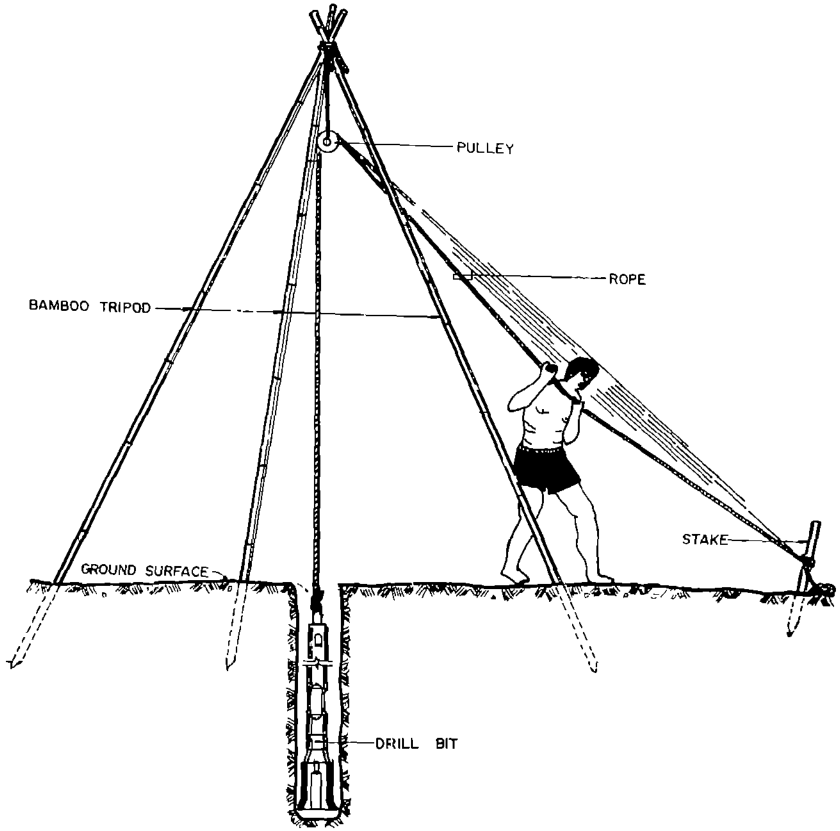


FIGURE 6 17 MANUAL PERCUSSION TYPE DRILL RIG SET-UP

3. Start drilling the well hole. Drilling is accomplished by repeated raising and dropping of the string of tools with a chopping or drill bit attached to the lower end. The cuttings remain in the hole until removed by a bailer or sand pump. The raising and lowering of the drilling bit (Figure 6.18A) is accomplished by a man holding the drill line. To maintain a round and straight hole, the chopping bit is rotated by a hook racket-type rope which is mechanically actuated by the raising and dropping of the drill bit.

   The bailer (Figure 6.18C) consists of a length of pipe with a check valve at the bottom. The valve may be either of a flat pattern (Figure 6.18D) or a bailer-and-tongue pattern called a dart valve.

   Alternately, drill cuttings can be removed using a sand pump (Figure 6.18B) which is actually a bailer fitted with a plunger. When the plunger is pulled upward, a vacuum is created resulting in the opening of the valve and the sucking in of the sand or slurried cuttings into the pipe. The bottom of the sand pump is always a flat-pattern valve.

   Furthermore, in drilling through unconsolidated or loose ground formations, the hole should be encased with a pipe. Drilling is carried out inside the pipe casing, and the casing is driven down periodically to maintain the position of its lower end near the chopping action of the drill bit. Also, when drilling soil formations which are dry, it is necessary to add water to loosen the soil. Upon reaching the desired depth clean the hole using the sand pump.

4. Remove the drill bit.

5. Perform preliminary pumping test to check well yield. If found insufficient to meet water demand, continue the drilling operation.

6. Install the casing and screen or perforated pipe to the desired design of the well.

7. Check well alignment and plumbness.

8. Make proper well development.

9. Determine well capacity.

10. Complete the construction of the well by:

    a. Grouting the upper 3 meters annular space between the well hole and casing.

    b. Building a concrete apron.

    c. Installing pumping facilities or other water drawing equipment.

    d. Disinfection and completion of the well.

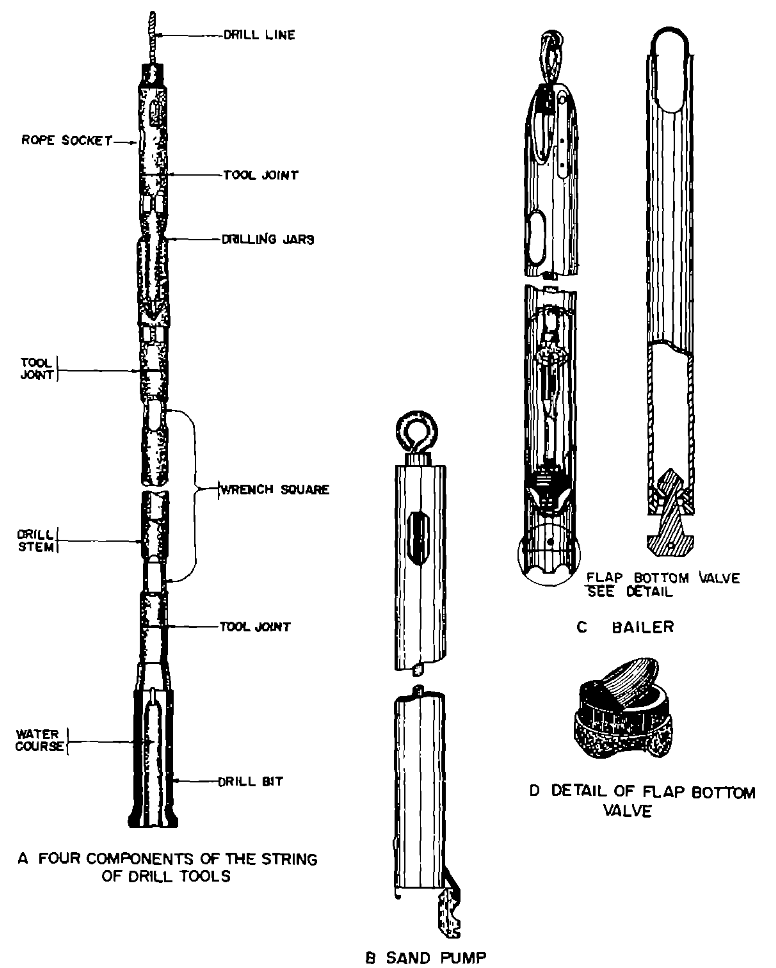


FIGURE 6.18

DRILLING TOOLS

6.08 PLACEMENT WELL CASING

A. General

The pipe casing serves as the lining of a well. Its functions are to prevent the collapse of the well hole, entrance of dirty undesirable water into the well, and escape of good water from the well to the surroundings. Well casing may be made of pre-fabricated reinforced concrete (RC) pipe, galvanized iron (GI) pipe, steel pipe or PVC pipe. Reinforced concrete pipe is commonly used in dug wells while GI, steel and PVC pipes are often used in driven, jetted, bored and drilled wells.

Well casings may be installed during or after excavation of the well hole. In firm ground formation, it is usually lowered after the excavation process (except in constructing driven wells where the pipe casing goes with the sinking of the well point). On the other hand, if a well is constructed in loose ground formation, the permanent or temporary pipe casing is lowered together with the excavation of the hole to prevent cave-ins.

B. **Procedure for Sinking Pipe Casings**

1. Sinking of Pre-fabricated Reinforced Concrete Pipe Casing

Shown in Figure 6.19 is the set up for sinking RC pipe casing in dug wells. The RC pipe is suspended in the tripod using a rope. The pipe is lowered by slowly releasing the rope while a man is aligning the pipe in the hole.

Sinking of GI or PVC Pipe Casing

Shown in Figure 6.20 is the set up for sinking GI or PVC pipe casing. The principle of lowering the pipe is similar to the principle in sinking RC pipes. An added feature is the use of either wood or steel clamp to hold the lowered casings suspended while connecting the next length of casing.

6.09 CHECKING WELL ALIGNMENT AND PLUMBNESS

A. **General**

Well alignment and plumbness should be checked to see whether they are within the allowable limits prior to the installation of pumping facilities. Alignment is necessary in determining whether a pump of given size can be installed in the well to a desired depth. If the well bore or well casing is crooked beyond a certain limit, the pump discharge column and bowl will simply not go in. A well must also be plumb. Although a pump can be installed in a well that is aligned but out of plumb, its efficiency and usefulness is reduced significantly. Alignment refers to the straightness or crookedness of the well hole while plumbness is the deviation of the well hole from the vertical.

B. **Checking of Well Alignment**

The well alignment can be tested using a set up consisting of a tripod and a dummy (Figure 6.21). The dummy may be a pipe with diameter slightly smaller than the well casing (preferably two commercial pipe sizes smaller than the well casing) and length (normally 12 M) sufficient to detect undesirable deviations from the straight line. In general, the well is acceptable if the dummy move freely throughout the length of the casing or to the depth the pump column is intended to be lowered.

Procedure:

1. Assemble the tripod and install the pulley system as shown in Figure 6.21.

2. Tie the upper end of the dummy pipe with a rope and suspend it from the tripod. Make sure that the lower end of dummy pipe is pointing directly to the center of the well.

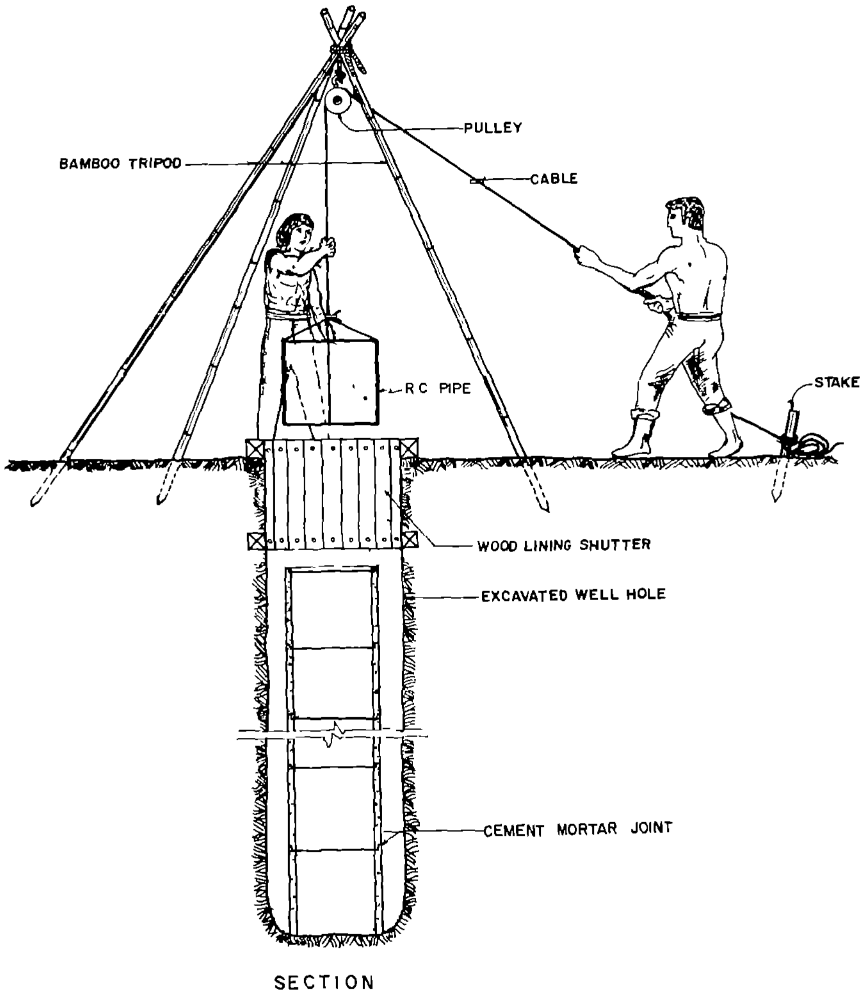


FIGURE 6.19

LOWERING OF REINFORCED CONCRETE (R C) PIPE IN DUG WELL

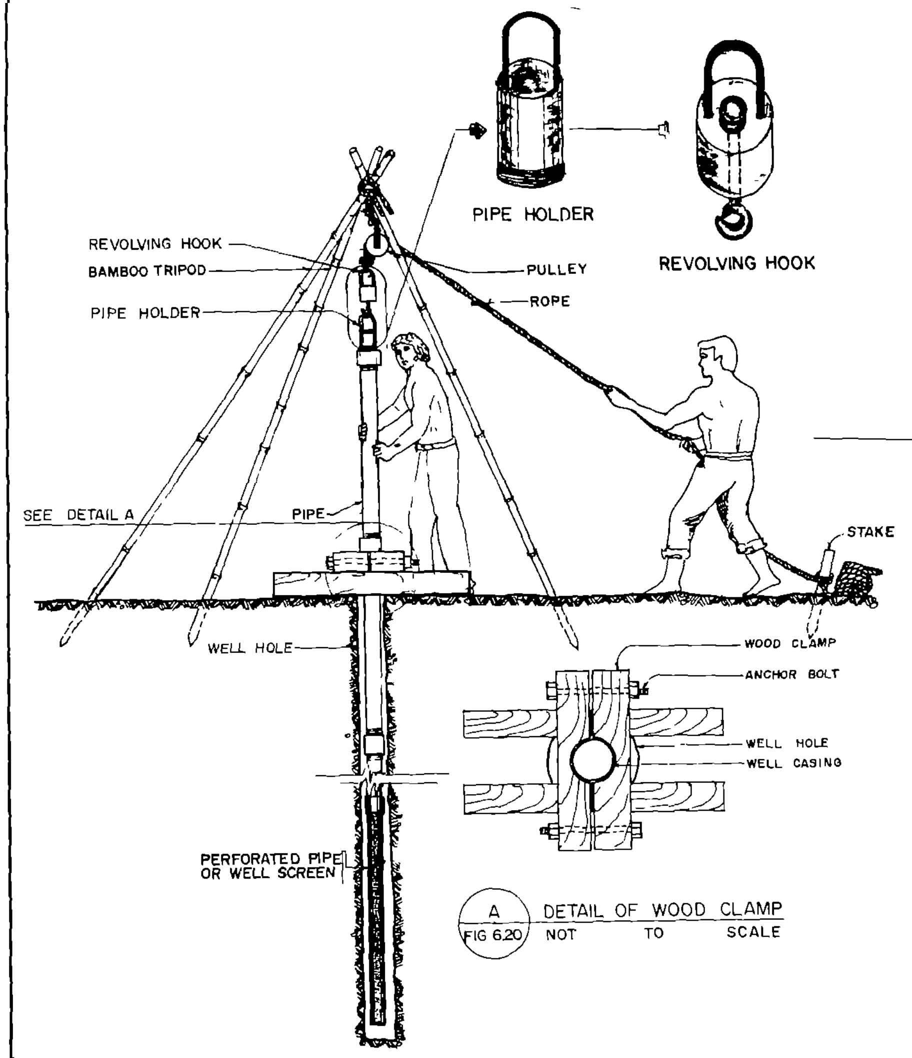


FIGURE 6.20

LOWERING OF G.I OR PVC PIPE INTO THE WELL

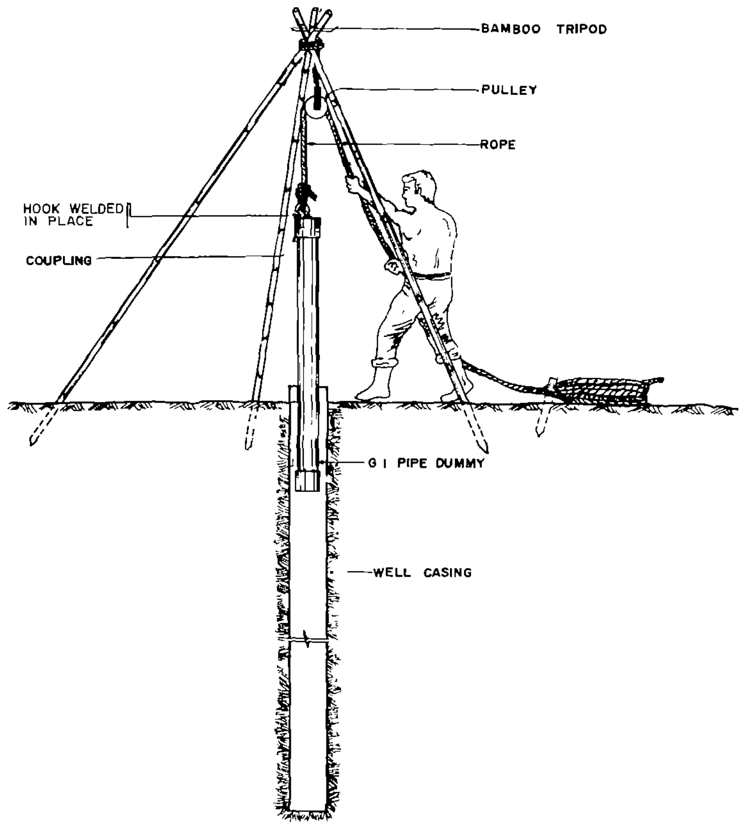


FIGURE 6 21

DETERMINATION OF WELL ALIGNMENT

3. Lower the dummy into the well slowly in order not to damage screen or casing. For a well to be acceptable, the dummy pipe should be able to reach freely the depth the pump column is intended to be lowered.

C. **Checking of Well Plumbness**

Well plumbness or the extent of the deviation of the well hole from the vertical can be tested using a plumb bob. The process consists of lowering the plumb bob into the well and noting the distance between the plumb bob string and the edge of the top of the casing as the bob strikes the side of the casing at various depths. The horizontal distance traversed by the plumb bob is then determined by proportion. It represents the deviation of the well hole from the vertical. In general, a well to be acceptable should not deviate more than 0.70 times the casing diameter for each 30 M length.

Procedure:

1. Assemble the tools and equipment in a manner shown in Figure 6.22. Hang the plumb bob slightly above the well casing and adjust the plumb guide until the plumb bob is on the exact center of the well.

2. Put four marks on the top of the well casing. These marks will serve as end points of two imaginary perpendicular lines which intersect at the center of the well and will be used as reference points during the determination of the direction of the deviation of the well hole from the vertical. Name the four points south, north, east and west.

3. Measure the vertical distance from the center of the pulley to the top of the well casing. The center of the pulley is called the datum point.

4. Lower the plumb bob and measure the distance traversed by the plumb line from the center taking your mark points (north, south, east and west) as reference points for every meter distance the plumb bob is lowered. Should the plumb line touch the well casing, shift the point before taking the measurement.

5. Calculate the deviation of the well hole from the vertical.

    a. **If the Datum Point is Not Shifted** – Figure 6.23 illustrates the relative position of the plumb bob and plumb string from the datum point and line. From the figure it is shown that the deviation of the well hole at point D can be computed by ratio and proportion (Triangles CAB and EAD are similar triangles). Stated mathematically.

    $$DE = \frac{BC\ (AC + CE)}{AC}$$

    where DE = Deviation of the well hole from the vertical depth CE, mm.

    BC = Traverse distance of the plumb string at the mouth of the casing, mm.

    AC = Elevation of the datum point, M

    CE = Depth, M.

    b. **If the datum point is shifted.** (Figure 6.24), the deviation of the well from the vertical can be determined by the following equation.

    $$DE = \frac{(AC + CE)\ (BC + AA') - AA'}{AC}$$

    where AA' = distance the datum point is shifted, mm.

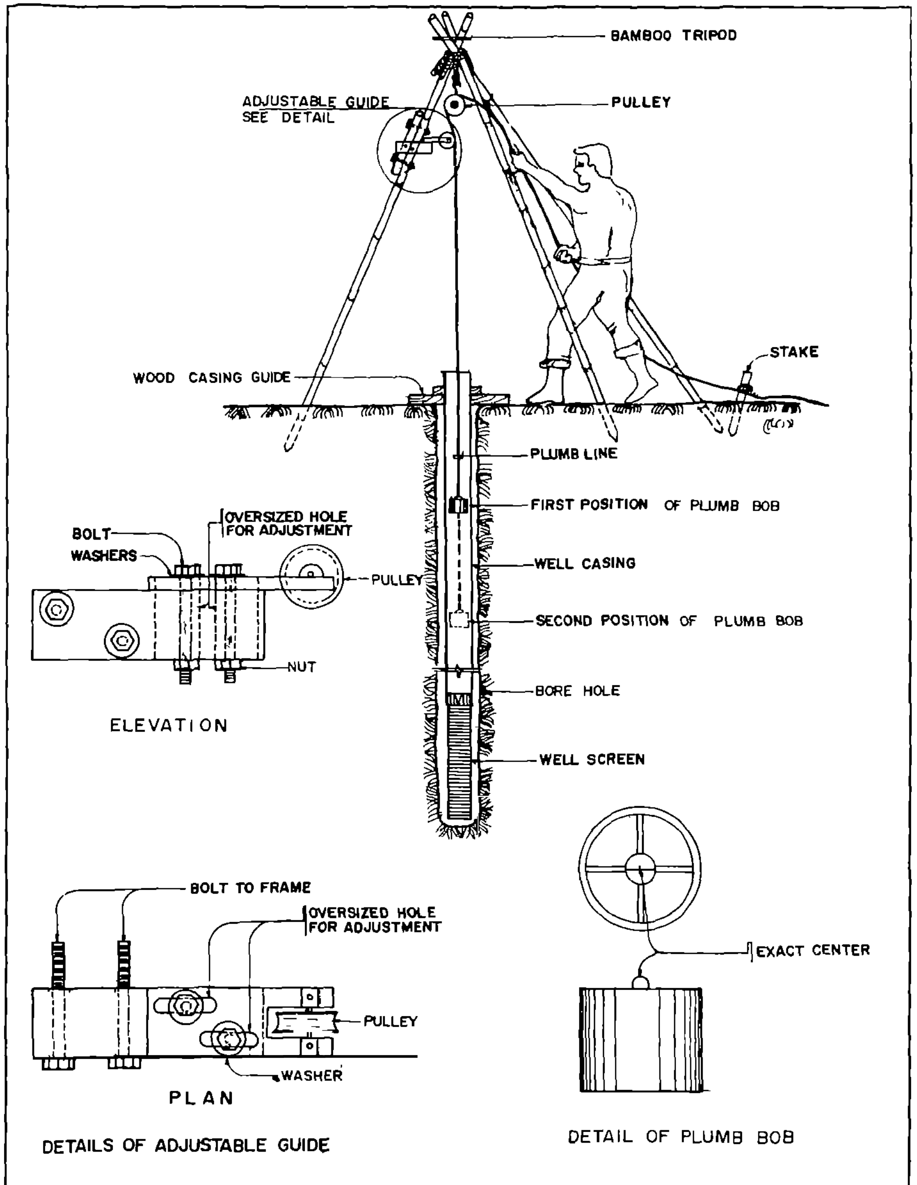


FIGURE 6 22

EQUIPMENT SET-UP FOR CHECKING WELL PLUMBNESS

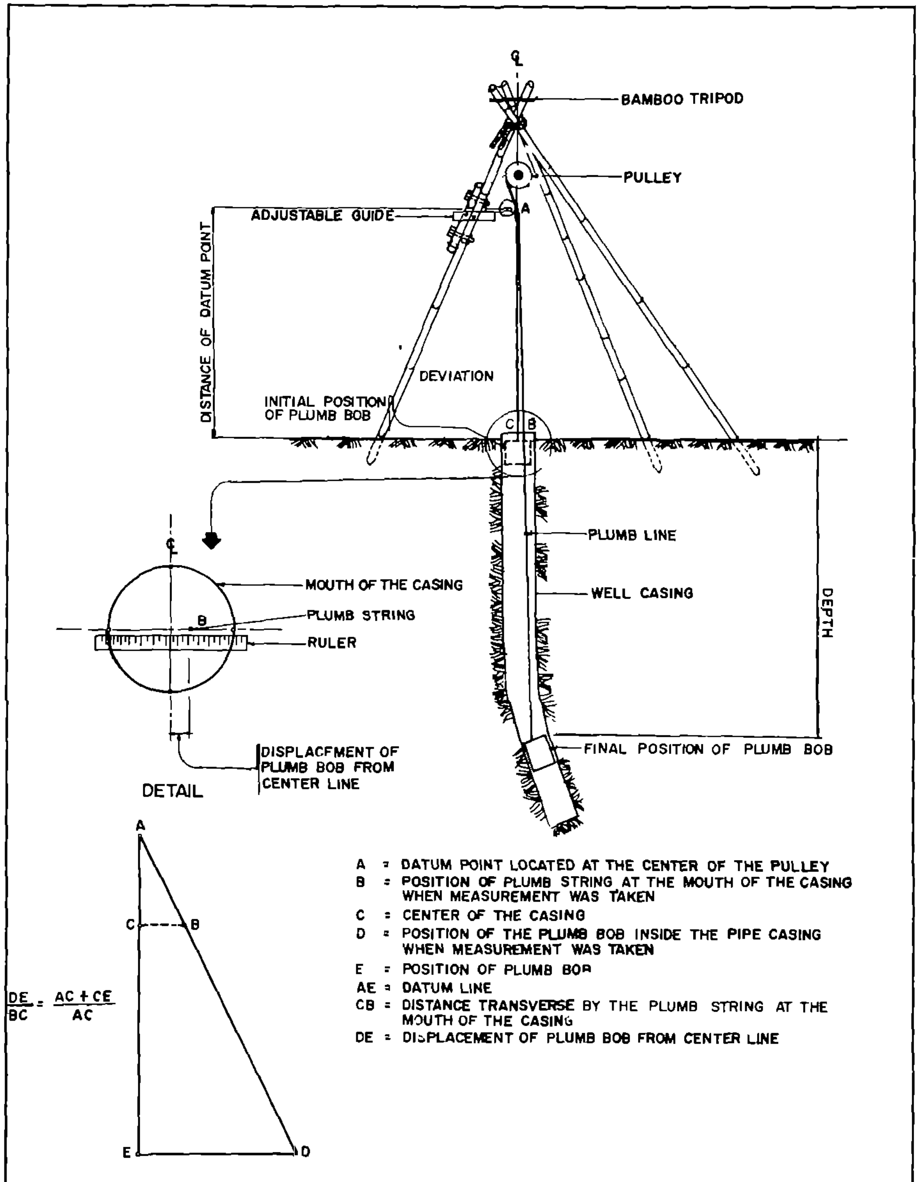


FIGURE 6 23

DETERMINATION OF WELL PLUMBNESS
(WHEN DATUM POINT IS NOT SHIFTED)

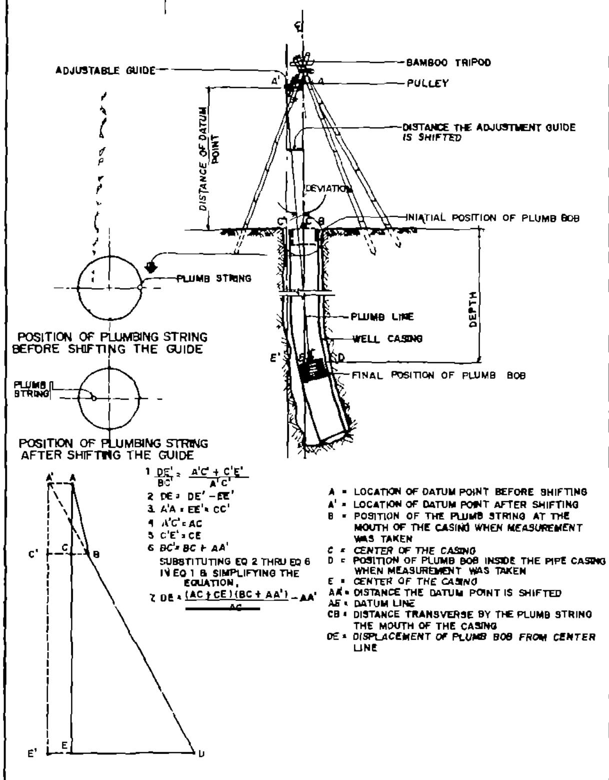


FIGURE 6 24 DETERMINATION OF WELL PLUMBNESS (WHEN DATUM POINT IS SHIFTED)

Example 6.1 After construction, a well was tested for plumbness. Given the data below, determine whether the constructed well is acceptable.

Data:

Well Diameter = 100 mm.

Depth of well = 30 M.

Elevation of the center of the pulley = 5 M.

Traverse distance of plumb string from center of the mouth of pipe casing = 2 mm. See Figure 6.25A for details.

Solution:

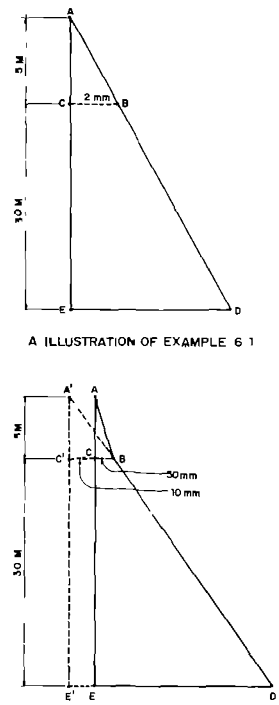
1. Calculate the deviation of the well from the vertical.

$$DE = \frac{BC\ (AC + CE)}{AC}$$

where, BC = 2 mm

AC = 5 M.

CE = 30 M.



A ILLUSTRATION OF EXAMPLE 6 1

B ILLUSTRATION OF EXAMPLE 6 2

FIGURE 6 25

ILLUSTRATION OF EXAMPLE 6 1 AND 6 2

Substitute the above values and simplify

$$DE = \frac{(2\text{ mm})\ (5 + 30)\text{ M.}}{5\text{ M}}$$

$$DE = 14\text{ mm.}$$

2. Calculate the Allowable Deviation

   For a well to be acceptable, the deviation from the vertical of the well hole should not exceed 0.7 times the casing diameter for each 30 M of its length, therefore, the deviation must not exceed (0.7 x 100) = 70 mm.

3. Conclusion

   Since the deviation of the constructed well is less than the allowable deviation, the well is acceptable.

Example 6.2 A well was tested for its plumbness in Dasureco, Davao. Given below are the test results. Determine whether the well is acceptable or not.

Data:

a. Before the Shifting of the Datum Point

Well Diameter = 100 mm.

Depth of well = 30 M.

Elevation of the center of pulley = 5 M.

Distance traverse of plumb string from the center of the mouth of pipe casing = could not be determined for the string touches the side of the well.

b. After the shifting of datum point until the string barely touches the side of the well-distance the datum point of well is shifted = 10 mm. See Figure 6.25B for details.

Solution:

1. Calculate the deviation of the well hole from the vertical

$$DE = \frac{(AC + CE)\,(BC + AA')}{AC} - AA'$$

where, AC = 5 M.
CE = 30 M.

BC = 50 mm.

AA' = 10 mm

Substitute the above values and simplify:

$$DE = \frac{(5 + 30) \times (50 + 10\text{ mm})}{5\text{ M.}} - 10\text{ mm}$$

$$= \frac{35 \times 60}{5} - 10 = 420 - 10 = 410\text{ mm}$$

2. Calculate the allowable deviation
Allowable Deviation = 0.7 x 100 = 70 mm.

3. Conclusion

Inasmuch as the deviation of the well from the vertical (DE = 410 mm) is greater than the allowable deviation (70 mm), the well should be corrected.

6.10 GROUTING

A. General

Grouting is a process of sealing the space between the pipe casing and the bore hole to prevent the entrance of undesirable water into the well which may cause the deterioration of the water quality. If well construction includes the installation of inner and outer casings, the grouting process includes the sealing of the space between the inner and outer casings and the sealing of any opening outside the outer casing. Grouting materials may be cement or puddled clay. Cement grout is prepared by mixing portland cement and water at the ratio of 0.5 to 0.6 liter of water per kilogram of cement. It should be emphasized that a correct water-cement ratio is important for effective bridging of cement particles. Alternately, puddled clay may be used as a grouting material provided it is used at a depth where drying and shrinkage of mud will not occur and where water movement does not wash clay particles away.

The introduction of grouting material is always started at the bottom of the space to be sealed using a grout or tremie pipe 19 mm or 25 mm in diameter. As the grout rises, the grout pipe is raised proportionately. However, its bottom end should remain submerged in the slurry during the entire time that the grout is being placed. In cases where operations are interrupted for any reason, the pipe should be raised above the grout level and should not be lowered into the slurry to continue grouting until all air and water has been displaced from the pipe. This process of introducing grout from the bottom minimizes dilution and has been proven to be effective in distributing cement grout uniformly around the pipe casing. Also, to have uniform bridging of cement particles, cement grout should be placed continuously.

B. Grouting of Shallow Wells Using Grout Tremie Pipes

1. Provide the bottom of the annular space to be grouted (usually 3 meters from the ground surface) with a cement basket (Figure 6.26) which serves as a catch for the grout. The cement basket is installed by bolting it to the pipe casing prior to its lowering into the well hole. The cement basket (see detail in Figure 6.26) is fabricated by welding a 6 mm thick x 25 mm wide flat bar into a holder forming a well-like structure. To seal the joint between bars and to prevent cement from going farther below the basket, a cover made of sack cloth is provided.

2. Prepare a cement grout slurry.

3. Set up the tremie pipes. The bottom end of the first tremie pipe is usually installed near the cement basket while of the second pipe is installed 0.5 meter higher than the first.

4. Start pumping the grout through the first tremie pipe until the bottom end of the second tremie pipe is reached. Transfer the flexible hose which is attached to the pump to the second tremie pipe and start the

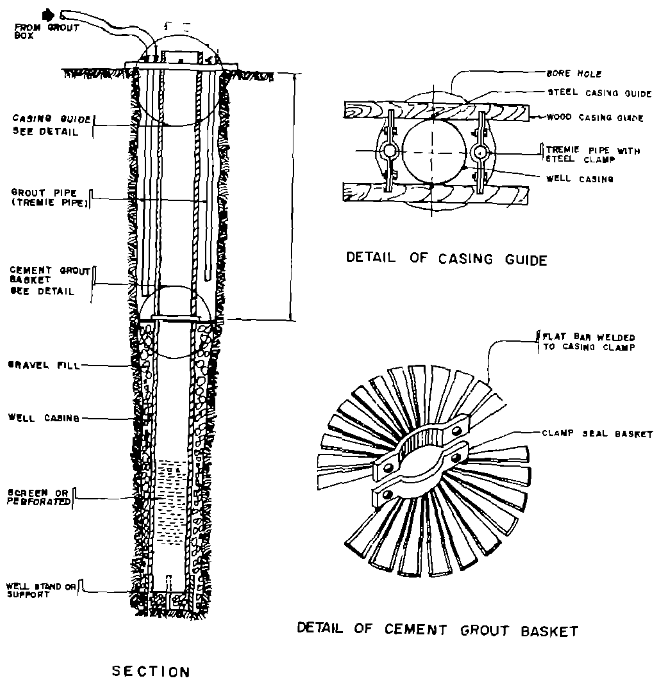


FIGURE 6 26
GROUTING OF SHALLOW WELLS USING TREMIE PIPE

pumping of grout. Also, at that same time, raise the first tremie pipe to a level 0.5 meter above the second tremie pipe. Continue the alternate process of raising the tremie pipe and pumping of grout until the entire length to be grouted is filled up.

5. Allow the grout to set for at least 72 hours before proceeding to the next operation.

C. **Grouting of Deep Wells**

1. Grout Pipe is Placed Outside the Casing

The principle of grouting a deep well is similar to the principle of grouting a shallow well. The casing is driven solidly into the formation at the bottom of a hole and cement grout is placed directly into the annular space using a grout pipe (Figure 6.27A).

2. Grout Pipe is Placed Inside the Casing

a. Place a drillable plug at the bottom end of the casing.

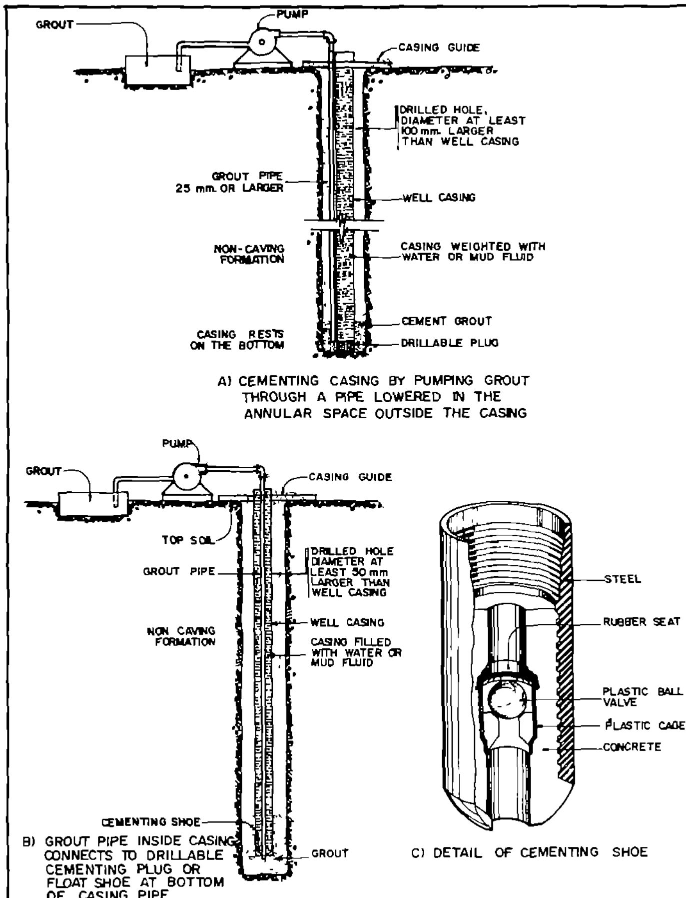


FIGURE 6.27

GROUTING OF DEEP WELLS

b. Place the grout or tremie pipe inside the casing with its bottom end terminating in cementing shoe (Figure 6.27B). The cementing shoe (Figure 6.24C) which is fitted tightly at the end of the casing bottom is equipped with a back pressure valve which prevents the backflow of grout material.

c. Pump the cement grout into the space to be grouted through the grout pipe.

d. Remove the tremie pipe after the completion of grouting.

Method one is preferred over method two because well drilling can be continued within the casing while the cement is hardening, thereby saving considerable time. Also, the hardening time of cement may be reduced by addition of certain materials, such as calcium chloride, to the cement slurry.

6.11 INSTALLATION OF WELL SCREENS OR PERFORATED CASINGS

The well screen is the water intake portion of the well. It prevents the entry of sand into the well while providing an access area for water to enter the well from the aquifer.

2. Continue pumping until the pumped water is already clear. Stop the pump immediately. This action causes the forceful introduction of water back to the well to suspend clay, silt, sand and other fine particles.

3. Allow the well to stay idle from 15 to 30 minutes for recovery.

4. Repeat the above process until the well yields water free of fine materials. Normally, 5-10 repetitions would be enough to produce the desired results.

B. **Surging by Use of Plunger**

1. Introduce a solid plunger which fits the wall of the casing into the blank casing and lower it beneath the water level or near the screen or perforated pipe.

2. Attach the other end of the plunger to a tripod as shown in Figure 6.30 and measure the bottom depth.

3. Move the plunger up and down violently. This will cause water to rush out into the aquifer thereby disturbing the water bearing formation and suspending the fine materials.

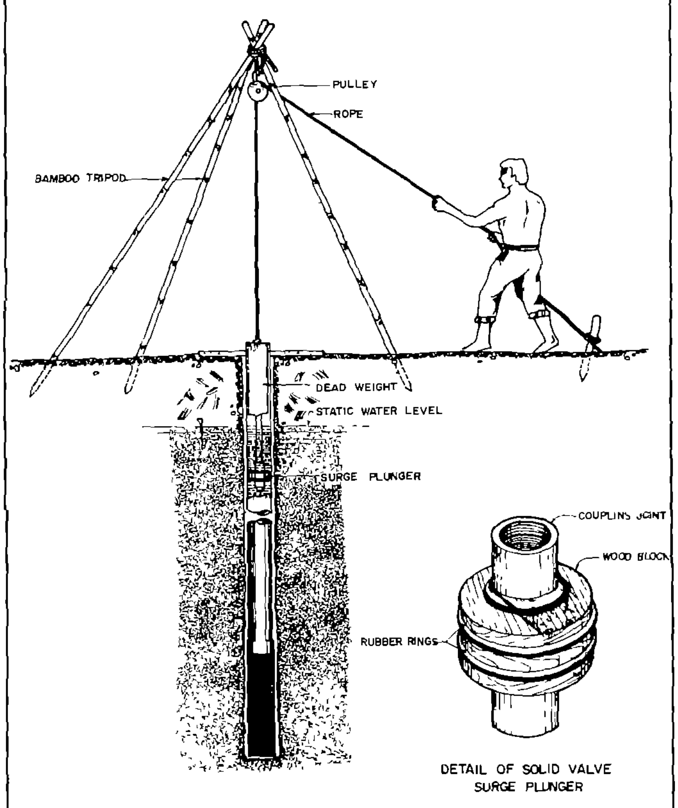


FIGURE 6.30

SURGING BY USE OF PLUNGER

4. Remove the plunger and install the pumping facilities.

5. Remove the suspended materials by pumping.

6. Repeat the above process until the well yields water which is free of fine materials. Normally, 5-10 repetitions would be enough to obtain the desired results.

Surge plungers sometimes produce unsatisfactory results where the aquifer contains clay streaks or clay balls. The action of the plunger can cause the clay to plaster over the screen surface thereby reducing the yield rather than increasing it. Also, enough weight should be attached to the plunger to make it drop readily on the downstroke.

C. **Surging by High Velocity Jetting**

Generally, this is the most effective method of developing a well. It is simple to use and is not likely to cause problems from over application of water.

Simple jetting tools together with a high pressure pump and necessary hose and piping (Figure 6.31) are the principal tools and equipment needed. The forceful action of high velocity jet working out through the screen openings agitates and rearranges the sand and gravel particles of the water bearing formation surrounding the screen. The jetting action breaks up wall cake, disperses drilling mud, and corrects the damages of the formation which resulted from excavation or drilling.

The well development procedure consists of training a horizontal water jet inside the wall in such a way that the high-velocity streams of water shoot out through the screen openings. By slowly rotating the jetting tools and gradually raising and lowering it, the entire surface of the screen receives the vigorous action of the jet. A swivel connection between the hose and pipe makes the operation easier. Also, a pipe clamp should be provided to aid in rotating the jetting tools.

Procedure:

1. Assemble the tools and equipment as shown in Figure 6.31.

2. Start the jetting process.

3. Remove the suspended materials by pumping.

4. Repeat the jetting process until the well yields water which is free of sand or any undesirable materials. Normally, 5–10 repetitions would be enough to obtain desired results.

D. **Air Surging**

Compressed air may be used effectively in well development. Shown in Figure 6.32 is an air surging set up. The compressor to be employed for this

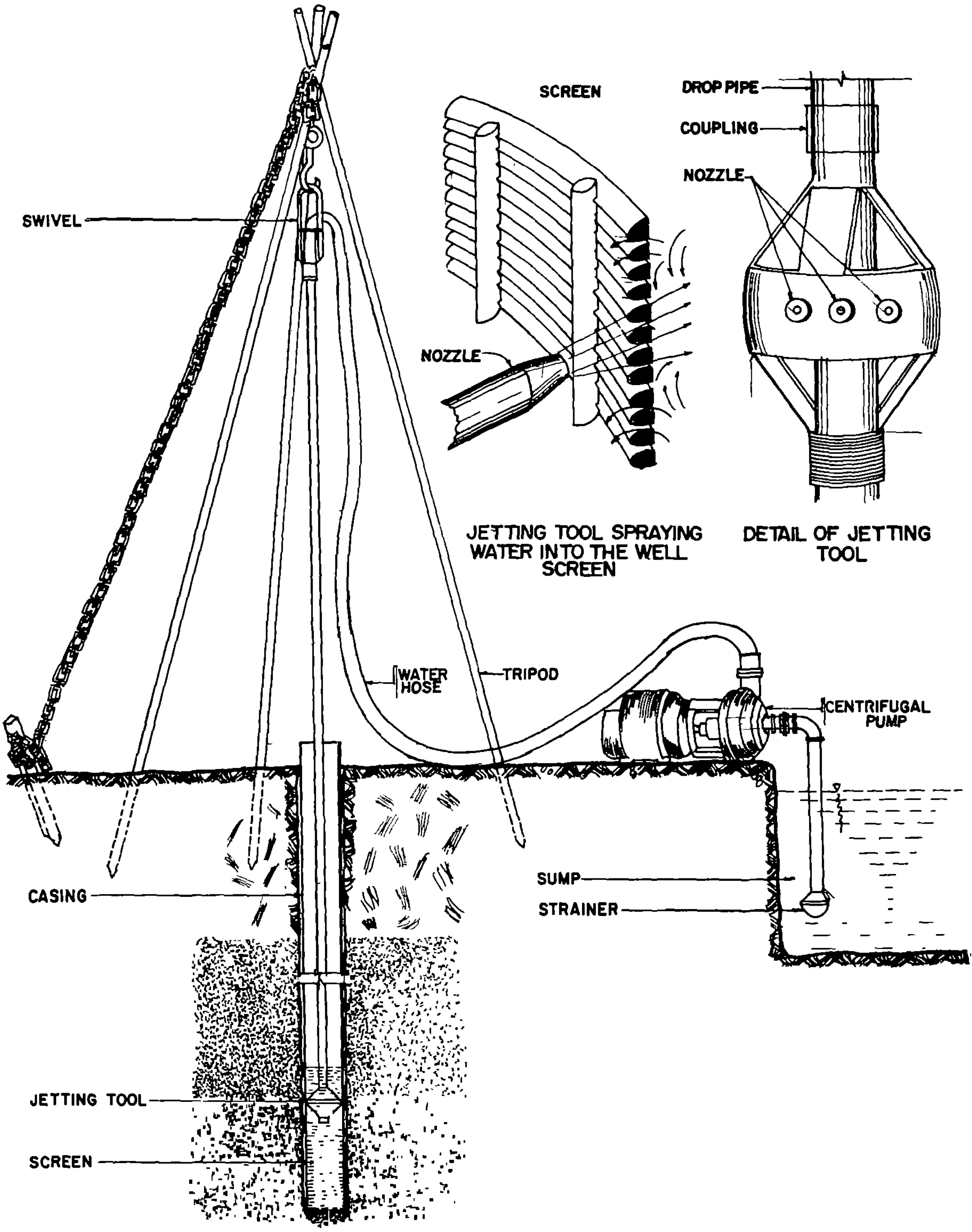


FIGURE 6.31
DEVELOPING OF WELL BY HIGH VELOCITY JETTING

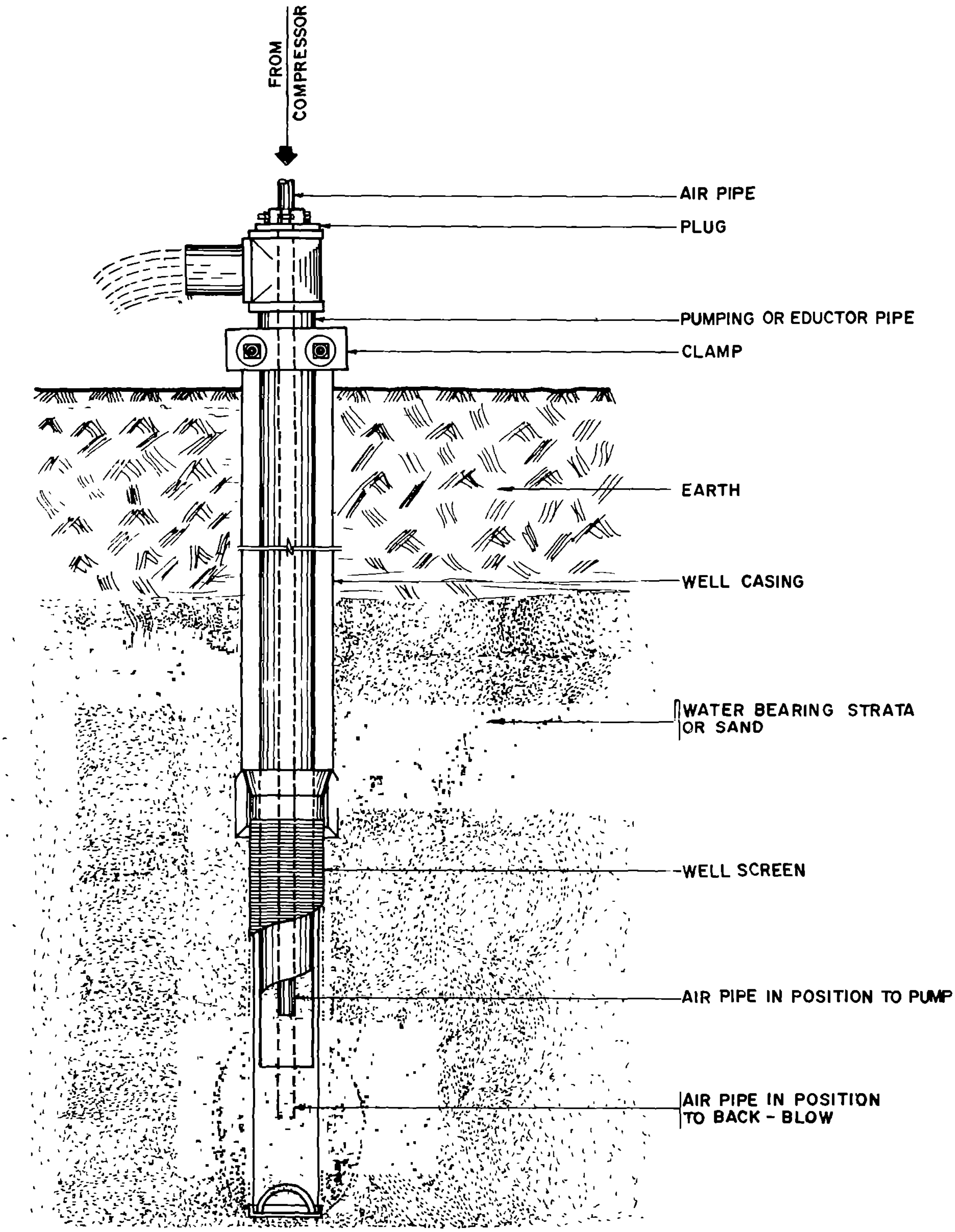


FIGURE 6 32

DEVELOPING OF WELL BY AIR SURGING

purpose should be capable of developing a maximum pressure of at least 40 meters (100 psi), and 60 percent of the total length of air line should be submerged in water while pumping to achieve best results.

Air surging is accomplished by injecting high pressure air from the compressor into the well. This reverses the flow through the screen openings and towards the water bearing stratum causing its disturbance and the suspension of fine sand and other materials. These suspended particles are removed by pumping.

6.14 TESTING FOR YIELD AND DRAWDOWN

Upon completion of well construction, it is important that its capacity to provide water should be ascertained. The purpose is to have a firm basis for selecting and purchasing the right size of pump. Measuring well yield may last for 24 hours and in some cases up to 4 days or even longer depending on the time available, degree of reliability and rate of well recovery. Because the yield of a new well is about 10 to 30 percent greater than the yield at the same rate of pumping after some use, pumping tests should be repeated after the well has been in normal use for several weeks or months. The well pump should be installed with this condition stipulated.

During the tests, the water level in the well before pumping and after stabilization should be measured to determine the drawdown. A complete description of the various methods of measuring water level is presented in Chapter 10 of Volume I: Design Manual.

CHAPTER 7

OTHER WATER SOURCES AND COLLECTION STRUCTURES

The collection and storage of water from various sources for domestic use involve the construction and installation of the necessary facilities and appurtenances. The type of facilities to be provided and the construction procedures to be followed depend to a large extent on the nature of the water source, i.e., rain, groundwater or surface water, the cost and the availability of local construction materials and skilled labor.

7.01 RAINWATER CATCHMENT AND STORAGE TANK

Rainwater may be used as a source of water supply in places where rain is relatively uniformly distributed throughout the year and where groundwater is not available. Tapping rainwater for domestic use entails the construction of a storage tank and a collection system. Shown in Figure 7.01 is a typical rainwater storage and collection system.

A. Catchment Area

The catchment system may consist of roofs of houses, buildings or barns, gutters and downspouts. Roofs serve as the main catchment area, the gutter collects the rain from the roof and conveys it to the downspout while the downspout transmits it to the storage tanks. The roof can be made of galvanized iron or aluminum sheets or tiles but not of thatch or nipa. The gutter should be installed in a position where it slopes towards the downspout. The top of the downspout should be screened to keep leaves and other debris from entering. Ordinary chicken wire with openings of at least 12.7 mm square can be fashioned out into a ball-shaped screen and fitted at the entry point of the downspout.

B. Storage Tank or Cistern

The collected water is usually conveyed and stored in a cistern conveniently located near the house. Cisterns can be made of either reinforced concrete, concrete hollow blocks (CHB), galvanized metal, steel drums or plastic containers. The size of the cistern and the type of construction depend primarily on the estimated demand, the available rainfall and the cost of the structure. The cistern should have the following appurtenances.

1. Downspout with a bypass section to allow wasting of the first 5 to 10 minutes of rain.

2. A flapper valve at the junction about 0.5 meters from the top of the tank. The function of the flapper valve is to route the first 5 to 10 minutes of rain to the bypass pipe for wasting. The closing and opening of the valve is accomplished by manipulating a piece of wire or string attached to it.

3. An overlapping removable cover.

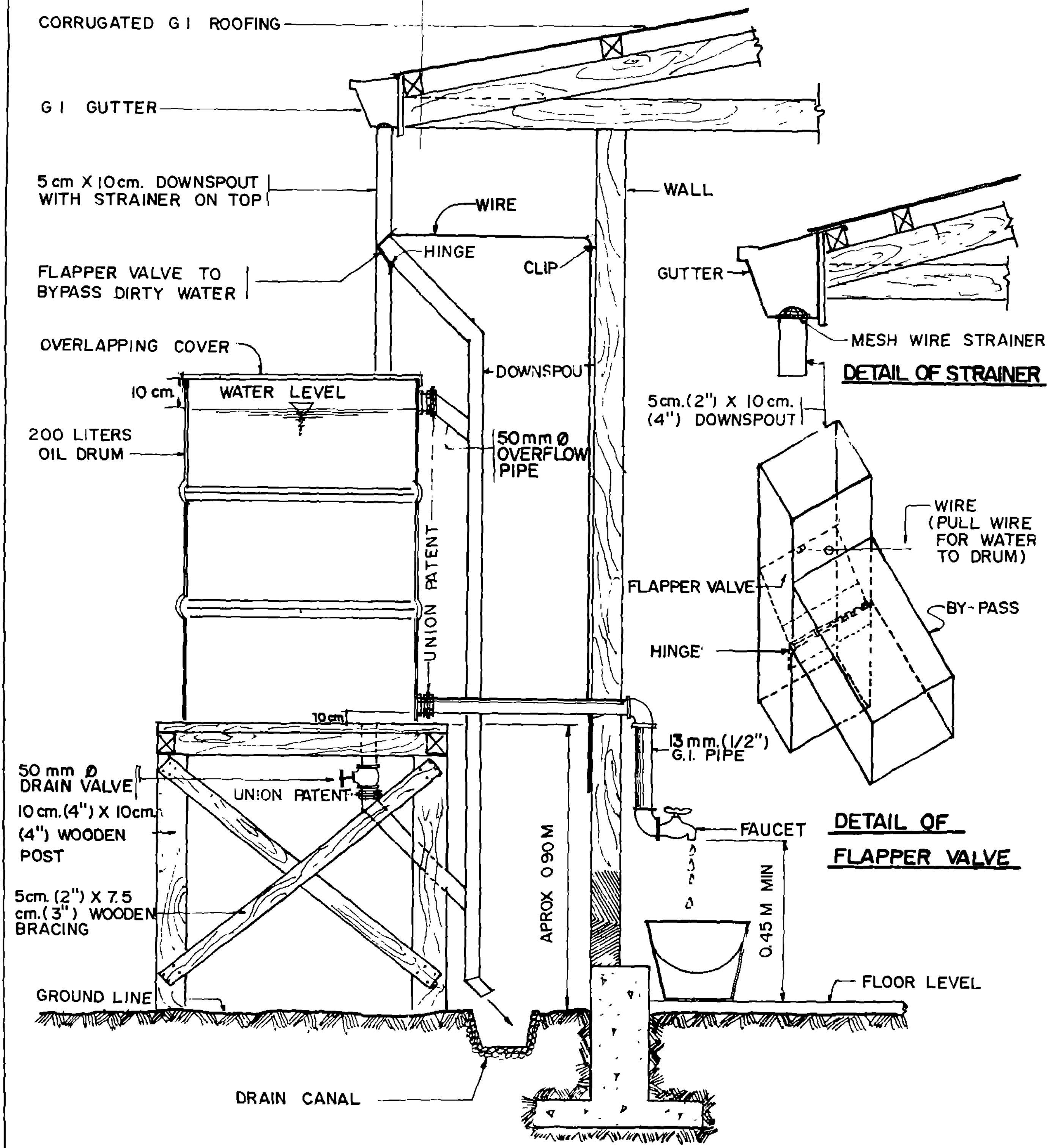


FIGURE 7.01

RAINWATER CATCHMENT AND STORAGE

4. An overflow pipe situated at least 10 centimeters from the top of the tank. The overflow pipe may be connected to the downspout portion leading to the drain.

5. A drain valve which is opened only during cleaning.

6. A delivery pipe fitted with an ordinary faucet.

For constructing an inexpensive household rainwater storage tank, the following materials are needed:

1. Oil drum, 200-liter (55 gal.) capacity.

2. Wooden platform.

3. Downspout, either PVC pipe or G.I. sheet, gauge 26.

4. G.I. pipe.

5. Globe valve.

6. Faucet.

7. Fittings.

The cistern and the piping system are installed as shown in Figure 7.01. The tank platform should be at least one meter above the ground level. The platform must be able to support at least 3–5 oil drums. If two or more drums are to be used, they can be connected by means of a 13 mm ø G.I. pipe installed at least ten centimeters above the bottom of the drums. The delivery pipe should be installed at least ten centimeters above the bottom of the drum. A 13 mm ø ordinary faucet is provided at the delivery pipe extending inside the house for drawing off water.

7.02 SPRINGS

Springs are outcrops of groundwater and often appear as small water holes or wet spots at the foot of hills or along river banks. High yielding springs can be tapped as a source of domestic water supply for a small community. However, before it can be used as a source it must first be developed to obtain its maximum potential flow.

A. Developing of Springs

1. Tools and Materials

The following tools and materials will be needed to develop a spring, including the construction of the necessary spring box.

Tools	Materials
Crowbar	Cement
Pick-axe and Hammer	Aggregates (Sand and Gravel)
Shovel and Pail	Form lumber
Pipe wrenches	Tie wires
Trowel and Float	G.I. pipes
Carpenter's Level	Valves and Fittings

2. Procedure

   a. Clean and grub the site of weeds and all undesirable vegetation.

   b. Using a crowbar and/or pick-axe, enlarge the "eye" of the spring by excavating the area around the hole down to the impervious water-bearing layer. Remove the silt, rocks and other excavated materials. During the excavation, care must be exercised to avoid disturbing the underground rock formation as this may deflect the spring to another direction or rock formation.

   c. Pile loose stones against the eye of the spring to prevent the spring from washing the soil around the eye and also to serve as foundation for the spring box.

B. **Construction of Spring Box**

The spring box stores and protects spring water from contamination. It can be constructed as follows:

1. Construct the spring box using either reinforced concrete or CHB as shown in Figure 7.02.

2. Provide an access man hole covered with a removable concrete cover. The manhole should have raised edge to prevent surface water from entering the box. The top of the box should be at least 0.3 meter above the highest ground elevation in the vicinity.

3. Provide an outlet pipe above the bottom of the spring box, but below the eye of the spring, if possible. The end of the outlet pipe inside the box should be screened to prevent stones, rubbish and sometimes frogs from blocking the pipes.

4. Provide an overflow pipe fitted with a screen to prevent the entrance of insects. The pipe must be at least 25 mm in diameter or larger to carry the maximum flow of the spring during the wet season.

C. **Drainage and Protective Structures**

1. Construct a drainage ditch at least 8.0 meters uphill and around the spring box to intercept surface water and prevent it from entering the spring box (Figure 7.03). Build a ridge by piling excavated soil on the downhill side.

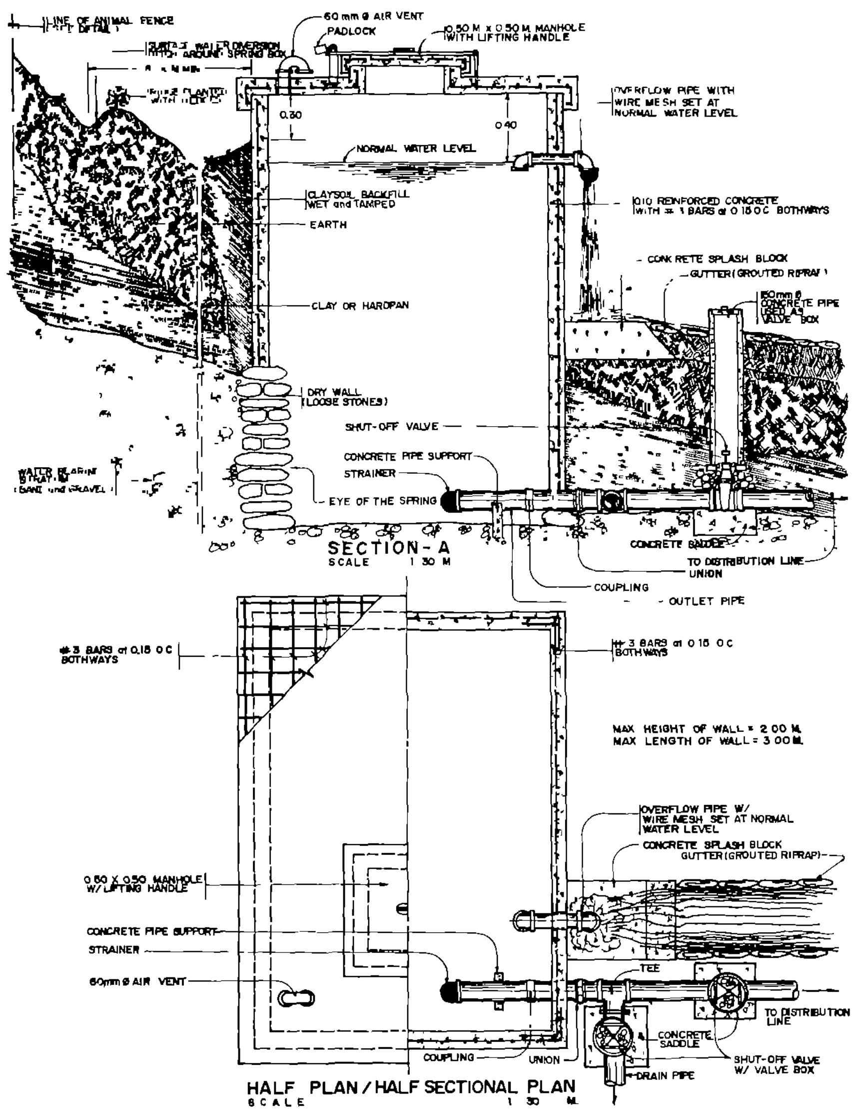


FIGURE 7.02

DETAILS OF SPRING INTAKE BOX

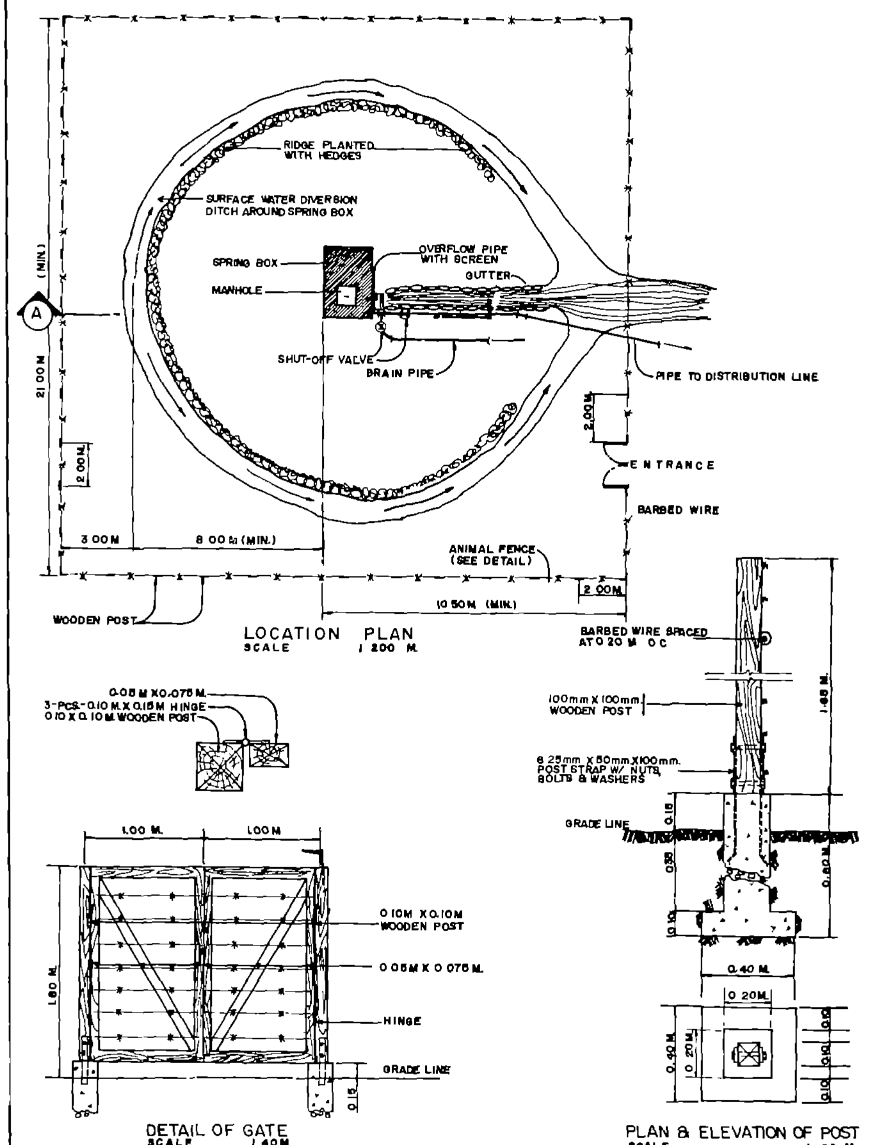


FIGURE 7.03

LOCATION PLAN & DETAIL OF FENCE & GATE

2. Fence the area around the spring box to keep stray animals and people away. The fence (Figure 7.03) can be made of interlink wire or barbed wire nailed to wooden posts. It should be high enough to prevent any animal from leaping over it.

7.03 INFILTRATION GALLERIES

An infiltration gallery is a horizontal well which collects water practically over its entire length as shown in Figure 7.04 and 7.05. It is a simple means of collecting naturally filtered water. It consists of perforated pipe collectors and a well. The collector pipe is closed at one end. The other end leads to a collecting well from where the water is pumped to a reservoir or directly to the distribution system. Materials for collector pipes include vitrified clay, and concrete. PVC or G.I. pipes can also be used. They are available in longer lengths.

A. Site Location

An infiltration gallery is normally constructed near a lake, river or stream which feeds the aquifer where the collector pipes are located. Generally, the collector pipe is installed in a porous formation such as sand and gravel at a distance of 15 meters or more from the bank of a river. This enables the collecting system to intercept the groundwater flow to the river. An elevated site from which the collected water could flow by gravity would also be an ideal location. An infiltration gallery should be located away from all possible sources of pollution.

B. Tools and Materials of Construction

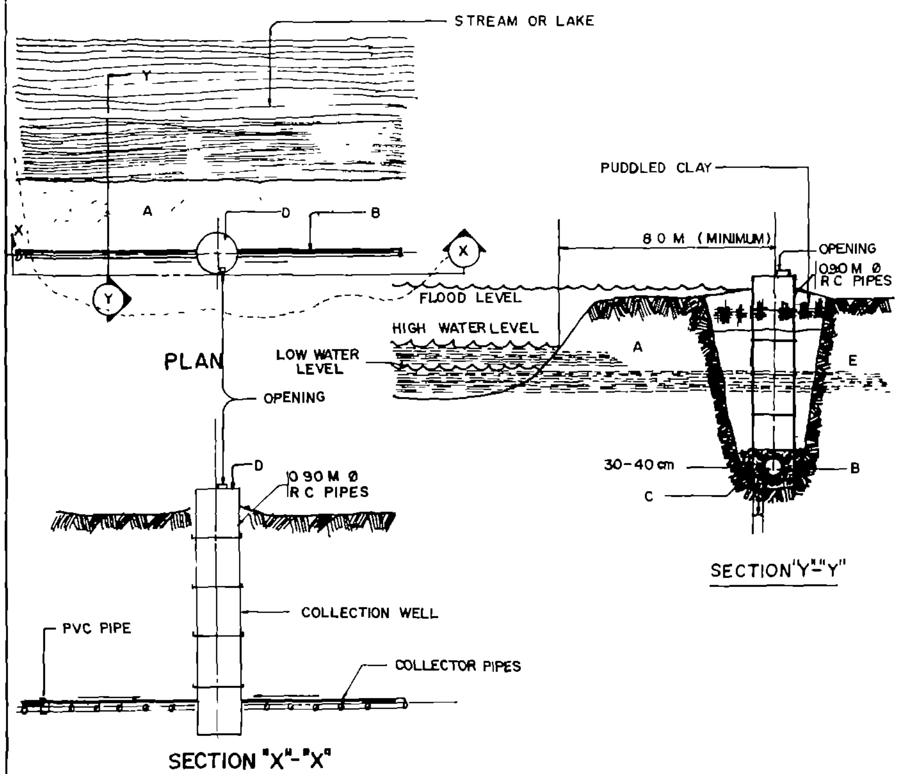
Tools and materials needed in constructing a small scale infiltration gallery:

Tools	Materials
Crowbar	Perforated PVC or G.I. Pipes
Pick-axe	Reinforced Concrete (RC) Pipes
Spade or shovel	Cement and aggregates
Dewatering Pump	

C. Construction Procedure

1. With a crowbar and/or a pick-axe, excavate a trench to a depth of at least 1.5 meters below the groundwater table. Place some walling materials such as bamboo to prevent caving-in specially if depth of excavation exceeds 2.0 meters.

2. Dewater the trench using a powerful dewatering pump. A 50 HP pump would be sufficient for this purpose.



A = SAND BANKS BESIDE STREAMS

B = PERFORATED PIPE SHOULD BE LAID ON A PREPARED FILTER BED AND MORE FILTER GRAVEL SHOULD BE PLACED OVER IT

C = A LAYER OF ROUND STONES, 12-25 mm IN DIAMETER SHOULD BE LAID AROUND THE PIPE COLLECTORS AND AROUND THE STONE LAYER, A 30-40 cm LAYER CONSISTING OF GRADED SAND AND GRAVEL SHOULD BE PLACED

D = WELL IN THE MIDDLE OF GALLERY FOR MOUNTING PUMP AND COLLECTING WATER

E = WATER TABLE

FIGURE 7.04

CONSTRUCTION OF AN INFILTRATION GALLERY

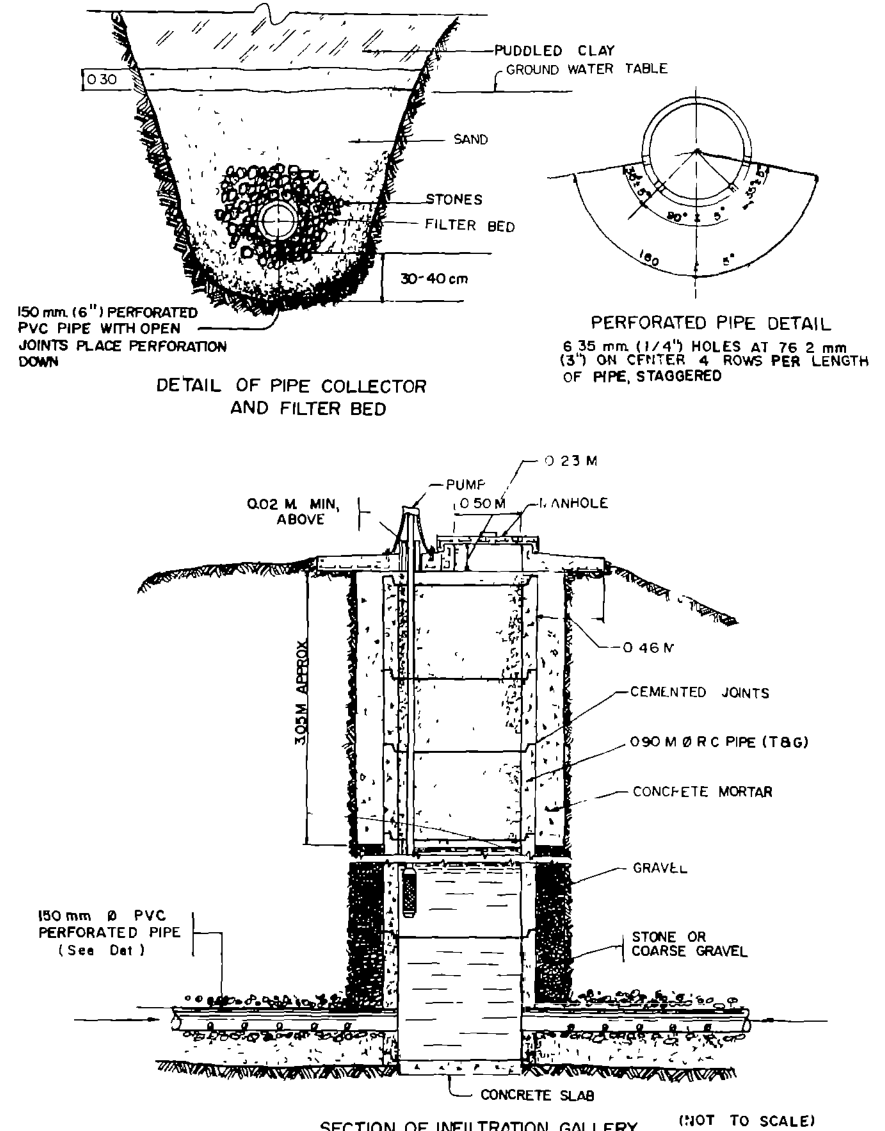


FIGURE 7.05

DETAILS OF AN INFILTRATION GALLERY

3. Install a reinforced concrete caisson at least 0.90 meter in diameter. Seal the bottom of the cylinder by pouring a 10 cm thick concrete slab.

4. Lay the perforated PVC pipes horizontally with the perforated portion at the bottom side. If two or more pipes are used, they must be connected with open joints.

5. Connect the discharge points of the pipes to the concrete caisson through pre-cast portholes in the caisson. Figures 7.04 and 7.05 show the details of the installation.

6. Fill the space around the pipes with round stones or gravel, 12 to 25 millimeters in diameter to prevent fine materials from entering the pipes.

7. Place 30 to 40 centimeters thick layer of filter sand around the gravel layer. Backfill with additional sand up to at least 0.30 meter above the ground water table.

8. Place a layer of puddled clay above the filter sand up to the ground surface elevation.

9. Provide a concrete cover of at least 10 centimeters thick over the well. The cover can be pre-fabricated or poured in place.

10. Depending on the need to pump the water, a pumping unit can be installed similar to a well pump as discussed in Chapter 13.

D. Testing and Disinfection

To determine the discharge capacity of the gallery, pump testing similar to the determination of a well discharge should be conducted. Similarly, disinfection of the collection system and the distribution line should be performed before the system is put to service. The disinfection procedures are similar to that used in well disinfection.

CHAPTER 8

CONCRETE DESIGN AND CONSTRUCTION

Concrete is widely used in the construction of various structures used in water supply systems. It is rocklike mass consisting of aggregates bound together with a hardened paste of portland cement and water. Aggregates is the inactive part of concrete which provides most of the volume, while cement is the chemical ingredient which reacts with water to form a paste which hardens with time and binds the aggregates together.

8.01 IMPORTANT PROPERTIES OF CONCRETE

The properties of concrete can be modified to meet the characteristics required through the manipulation of the proportion of its ingredients. These properties are as follows:

A. Workability

Workability is a property of concrete which determines its capacity to be placed and consolidated properly and to be finished without harmful segregation. It determines the compactability which is affected by the grading, particle shape and proportions of aggregate, the amount of cement and admixtures and the consistency of the mixture. Figure 8.01 shows the effects on the workability of concrete when varying the ratio of fine aggregate and coarse aggregate.

B. Consistency

Consistency is the wetness of the concrete mixture. It is measured in terms of slump, (slump test is discussed in detail in Section 8.05A), i.e., the greater the slump, the wetter the mixture. Consistency can be varied to suit construction requirements which are as follows:

1. Stiff consistency for mass concrete, pavements, foundations, floors, and heavy wall (Figure 8.02A).

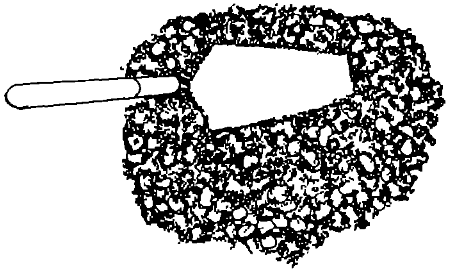
2. Medium consistency for reinforced concrete walls, slabs and beams (Figure 8.02B).

3. Fluid consistency for heavily reinforced sections, thin walls, and columns. (Figure 8.02C).

Consistency is controlled by the proportion of water-cement paste to be combined with fine and coarse aggregates.

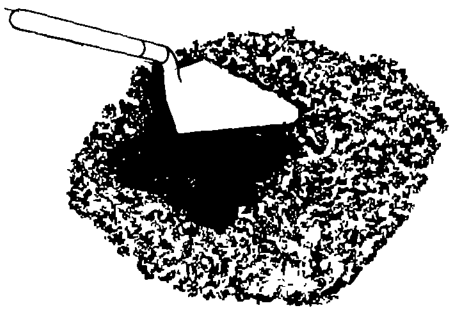
C. Strength

The strength of concrete depends upon the quality and proportion of materials used and curing conditions such as age, temperature and moisture. For a given set of materials and conditions, concrete strength is determined



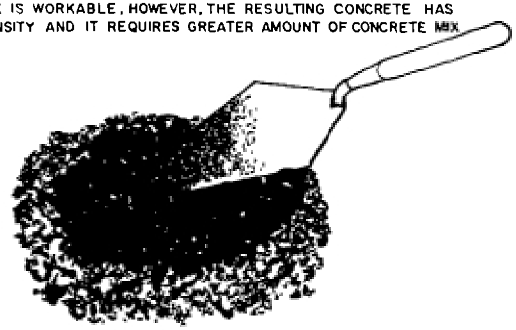
A UNWORKABLE HARSH MIXTURE

THIS CONDITION IS THE RESULT OF HAVING TOO MUCH GRAVEL IN THE CONCRETE MIX



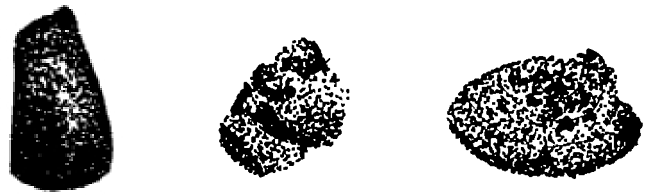
B CONCRETE MIX WITH TOO LITTLE GRAVEL

THIS MIX IS WORKABLE, HOWEVER, THE RESULTING CONCRETE HAS LOW DENSITY AND IT REQUIRES GREATER AMOUNT OF CONCRETE MIX



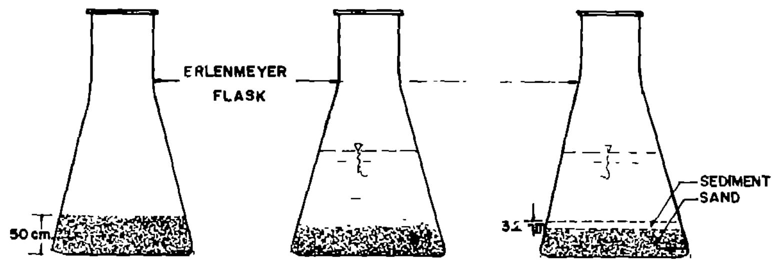
C WORKABILITY MIX WITH PROPER AMOUNTS OF COARSE AND FINE AGGREGATES

FIGURE 8 01 THE EFFECT OF VARYING THE RATIO OF FINE TO COARSE AGGREGATES ON THE WORKABILITY OF CONCRETE MIX



A STIFF　　B MEDIUM　　C. FLUID

CONSISTENCIES OF FRESH CONCRETE



D SAND SAMPLE INSIDE THE FLASK

E FILLING THE FLASK WITH WATER

F IDENTIFICATION OF THE PRESENCE OF CLAY AND SILT PARTICLES

FIGURE 8 02 IDENTIFICATION OF THE DIFFERENT CONSISTENCIES OF CONCRETE AND TESTING FOR THE PRESENCE OF CLAY AND SILT PARTICLES IN EXCESSIVE QUANTITIES IN SAND to the net quantity of water used per unit quantity of cement. (The smaller the water-cement ratio, the stronger is the concrete). The net water content excludes the water absorbed by the aggregates. It should be noted that 4.2 kg of cement only requires 1 liter of water. Differences in strength for a given water-cement ratio may be due to the changes in the size grading, surface texture, shape, strength and stiffness of aggregate particles; differences in cement types and sources; and the use of admixtures which affects the cement hydration process. Trial batches should be conducted to determine the right proportions for vital concrete structures such as reservoirs, columns and beams. The concrete strength is then determined in the laboratory.

D. **Durability**

Durability refers to the ability of concrete to withstand weathering, chemical action, and wear when subjected to service. Use of a low water-cement ratio will prolong the life of concrete by reducing the penetration of aggressive liquids. Durability may also be enhanced by the use of admixtures which allows proper workability of the concrete mix at low water-cement ratios.

E. **Watertightness**

Watertightness of a concrete structure can be improved by reducing the amount of water in the mix. Excessive water leaves voids and cavities after evaporation and if they are interconnected, water can penetrate or pass through the concrete. The use of admixtures, and prolonged and thorough curing may increase watertightness.

8.02 ESSENTIALS OF A GOOD CONCRETE

To produce a good concrete of desired uniform quality, the following guidelines should be observed:

A. **Select the Right Materials Properly**

1. Portland Cement

   Determine the requirements of the concrete structure being built. If it is required that the concrete should achieve its maximum strength at the earliest possible time, use High-Early Strength Portland Cement, otherwise, use general purpose cement.

2. Aggregates

   Fine and coarse aggregates should be of good quality and uniform in grade. This is accomplished through proper selection of materials, screening and proper storage. This subject is discussed in detail in section 8.03, Preparation of Aggregates.

3. Water

Water used for mixing concrete should be free of substances with concentrations that prevent the hydration reaction of portland cement. These substances are salts, oils, acids, alkali and organic matter.

4. Admixtures

Admixtures provide special properties to concrete which can not be attained during normal combination of the basic ingredients. However, its use must be carefully evaluated because it may improve one property but at the same time it may cause adverse effects to other properties. Table 8.1 shows the effects of the different types of admixtures on concrete.

B. Select the right proportion of ingredients to produce a workable mixture with proper consistency required for a given concrete structure. Also, the selected proportion should develop the specified strength and durability upon hardening.

Presently there are two methods of selecting concrete proportions, namely: the conventional and trial batching methods. The conventional method employs the rule of thumb volumetric measurement. It is employed where the concrete structure being constructed is not vital. Trial batching on the other hand is employed when a structure requires a concrete mix of defined strength, durability and other properties. This is true in cases of constructing foundations where the inability to hold the load above them will cause the collapse of the structure they are supporting.

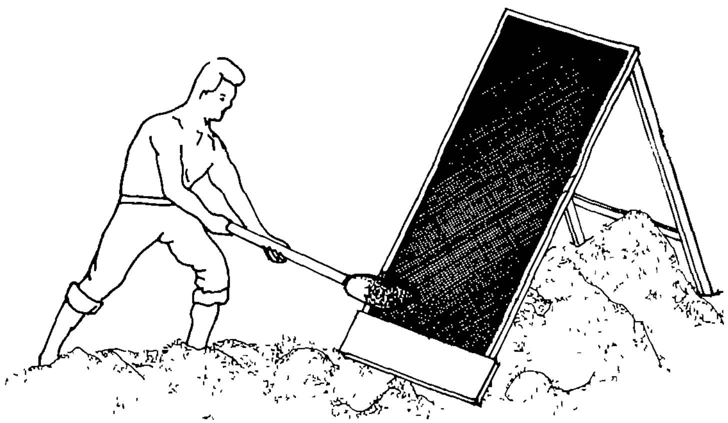
C. Control the proportion and mixing of the ingredients to produce a homogenous mixture and to achieve uniform batches so that all parts of the structure will be equally strong.

D. Convey and place the newly mixed concrete properly to produce a dense, well-compacted mass free of honeycombs.

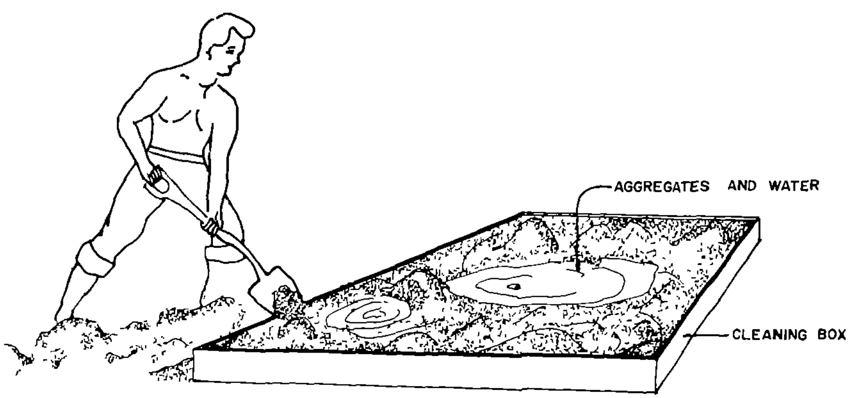
E. Cure the concrete structure until it has aged and attained its maximum strength. Failure to do so will cause cracking of the concrete structure.

8.03 PREPARATION OF AGGREGATES

Preparation of aggregates consists of making its grading uniform through screening and the removal of undesirable materials through washing. For small jobs, aggregates may be screened and washed using a portable screen mounted in wood frame (Figure 8.03A) and wood trough (Figure 8.03B), respectively. If it is desired to screen and at the same time wash the aggregates, a set up shown in Figure 8.04 can be employed.



A MANUAL SCREENING OF AGGREGATES



B MANUAL WASHING OF AGGREGATES

FIGURE 803

PREPARATION OF AGGREGATES

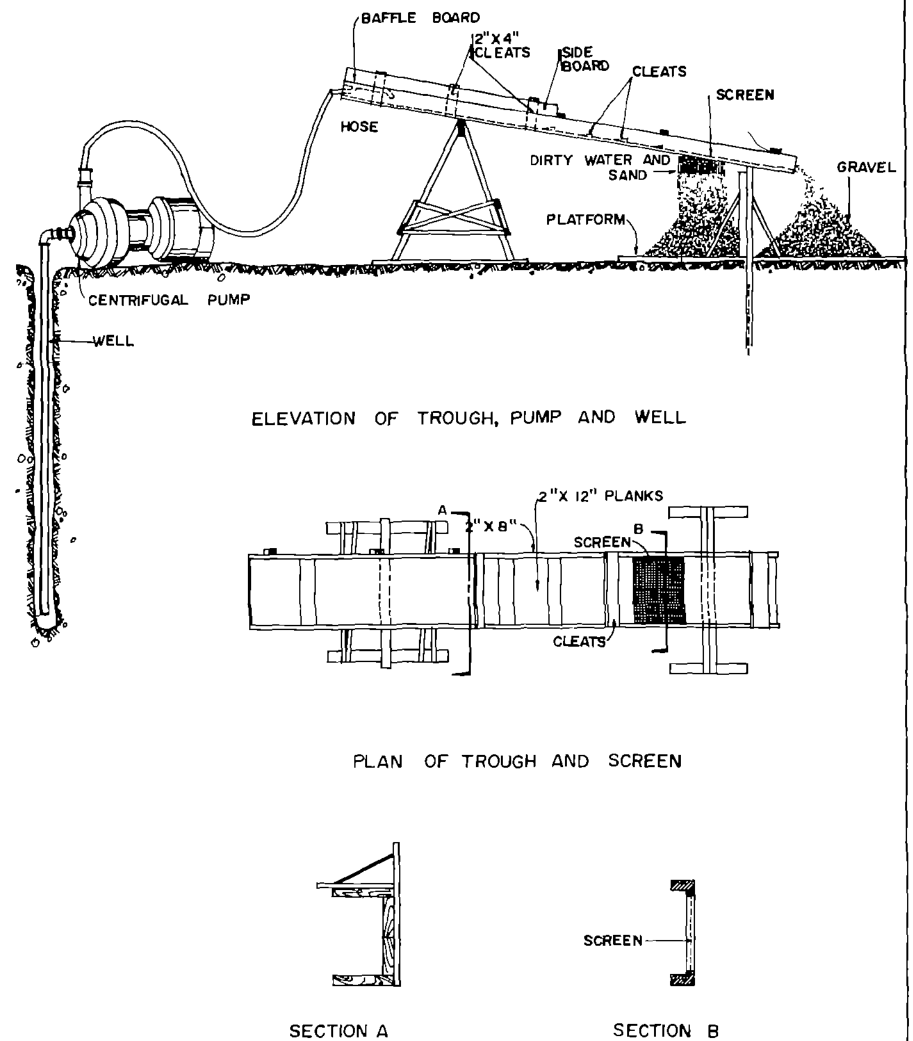


FIGURE 8 04

TROUGH FOR SCREENING AND WASHING OF AGGREGATE

Table 8.1
Concrete Admixtures

Admixtures	Purposes	Effects on Concrete	Advantages	Disadvantages
Accelerator	Hastens setting	Improves cement dispersion and increases early strength.	Permits earlier finishing, forms removal, and use of the structure	Increases shrinkage decreases sulfate, resistance, tends to clog mixing and handling equipment.
Air-Entraining Agent	Increases workability and reduces mixing water.	Reduces segregation, bleeding and increases strength.	Increases workability and reduces finishing time.	If excessive will reduce strength and increases slump bulk concrete volume.
Bonding Agent	Increases bond to old concrete	Produces a non-dusting slip resistant finish.	Permits a thin topping without roughening old concrete, self-curing.	Quick setting and susceptible to damage from fats, oils, and solvents.
Densifier	To obtain dense concrete.	Increases workability and strength.	Increases workability and water-proofing characteristics.	Care must be used to reduce mixing water in proportion to amount used.
Foaming Agent	Reduces weight	Increases insulating properties.	Produces a more plastic mix, reduces dead weight loads.	Its use must be very carefully regulated following instructions explicitly.
Retarder	Retards setting.	Increases control of setting.	Provides more time to work and finish concrete.	Requires stronger forms.
Water reducer and retarder.	Increase compressive and flexural strength.	Reduce segregation bleeding, absorption, shrinkage, and increase cement dispersion.	Easier to place and work, provide better control.	Performance varies with cement use in.

A. **Fine Aggregate or Sand**

The best sand is one which is well graded from fine to coarse; should be hard; strong and uncoated and the silt and clay contents do not exceed 3 percent of the total weight. Presented in Table 8.02 are the suitable gradation for fine aggregates.

Table 8.02

Grading Requirements for Fine Aggregates

Mesh No.	Screen Opening or Aperture		% of the total sample passing specified sieve
	mm	in	
4	6.35	0.250	95 — 100
16	1.19	0.047	45 — 80
50	0.30	0.012	10 — 30
100	0.15	0.006	2 — 10

Clay and silt present in excessive quantities can be detected by conducting the following tests:

1. Fill a quart jar (1.14 liter) or Erlenmeyer flask (Figure 8.02D) with sand to a depth of 5.0 cm. (2 in.).

2. Add water until the jar or flask is 3/4 full (Figure 8.02E).

3. Shake the contents for about one minute with the last few shakes in a sidewise direction.

4. Allow the jar to stand idle for 30 minutes.

5. Observe the top of the sand. If there is more than 3.2 mm layer of sediment, (Figure 8.02F), the sand where the sample was taken is unsuitable for construction purposes. However, the aggregates in question can be used after washing and removal of undesirable materials.

B. **Coarse Aggregate**

Proper gradation is more important in coarse aggregates than in the fine aggregates. The smaller stones should fill the spaces between the larger particles so as to give a dense mixture. Table 8.03 gives a suitable gradation for coarse aggregate.

Table 8.03

Grading Requirements for Coarse Aggregates

Screen Opening or Aperture	Percent by Weight
Passing Maximum Allowable Size.	95 - 100
Passing one-half of the Maximum Allowable size.	35 - 70
Passing Sieve No. 4.	0 - 10

Generally, the maximum size of aggregates should be the largest that is economically available and consistent with the dimensions of the structure. In no event should the maximum size exceed one-fifth of the narrowest dimension between sides of forms nor one-third the depth of slabs, nor three-fourths of the minimum clear spacing between individual reinforcing bars. The reason for selecting the maximum size of aggregates is to minimize the amount of cement mortar, hence, the cost of construction.

8.04 CONCRETE PROPORTION AND CONSISTENCY

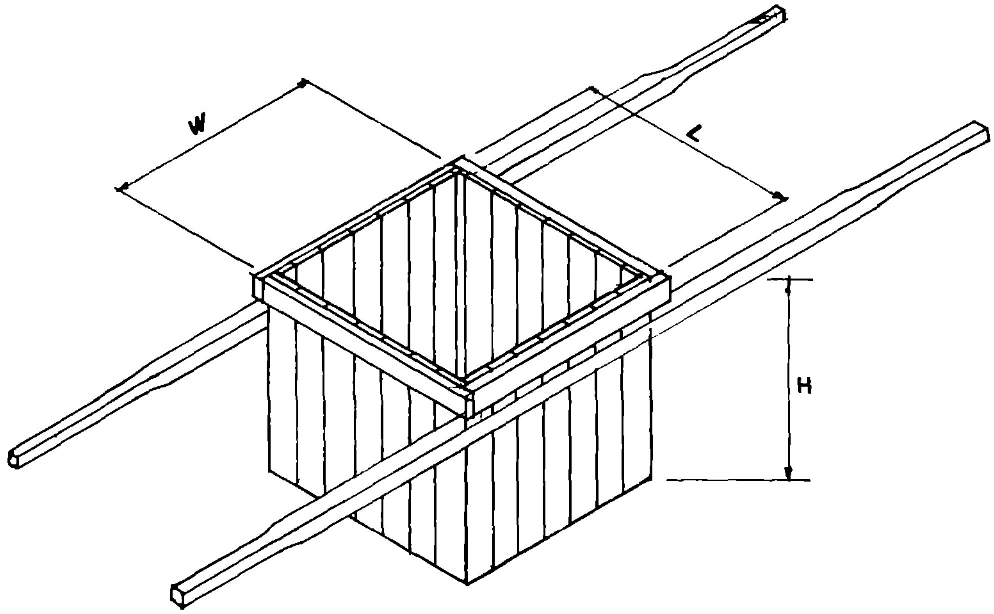
The selection of concrete proportions involves a balance between reasonable economy and requirements for placeability, strength, durability, density and appearance. The required characteristics are governed by the use to which the concrete will be put and by the conditions expected to be encountered at the time of placement. At present, there are two widely used methods in selecting the right proportions. They are the conventional or volumetric method, and the trial mix or batch method.

A. Conventional or Volumetric Method

The volumetric method of proportioning the ingredients is widely used in rural area in the Philippines. The process consists of measuring the different ingredients of a concrete mixture using a container of known volume and then mixing them in a mixer. Figure 8.05 shows a typical volumetric measuring box with a volume of 0.028 M^3 (1 ft^3) while Table 8.04 shows typical concrete mixes and their uses.

Example 8.1 Determine the amount of cement, aggregates, and water required for concreting a column using the conventional method. The required concrete volume is estimated to be 50 cubic meters. Other data of the proposed structure are given below:

Data: Narrowest dimension between sides of forms — 152 mm (6 in.)
Spacing between individual reinforcing bars — 50 mm (2 in.)



ISOMETRY

TABLE 8.9

CAPACITY		INSIDE MEASUREMENTS					
		LENGTH, L		WIDTH, W		HEIGHT, H	
$FT.^3$	$M.^3$	IN.	CM.	IN.	CM.	IN.	CM.
1.00	0.0283	12	30.48	12	30.48	12.0	30.48
1.25	0.0354	15	38.10	15	38.10	9.625	24.45
1.50	0.0425	15	38.10	15	38.10	11.50	29.21
1.75	0.0495	15	38.10	15	38.10	13.50	34.29
2.00	0.0566	18	45.72	18	45.72	10.625	26.99
2.25	0.0637	18	45.72	18	45.72	12.0	30.48
2.50	0.0708	18	45.72	18	45.72	13.625	34.61
2.75	0.0779	18	45.72	18	45.72	14.625	37.15
3.00	0.0849	18	45.72	18	45.72	16.0	40.64

FIGURE 8.05

VOLUMETRIC MEASURING BOX

Table 8.04

Typical Concrete Mixes and Their Uses

Typical Concrete Mixes (in Unit Volume)					Quantity of Materials per M^3 of Concrete				
Class	Cement	Water*	Sand	Gravel	Cement		Sand	Gravel	USAGE
					Bags	Volume (M^3)	(M^3)	(M^3)	
AA	1.0	0.7 – 1.0	1.5	3.0	10.4	0.294	0.44	0.88	Foundations
A	1.0	0.7 – 1.0	2.0	4.0	7.9	0.223	0.45	0.90	Beams & Slabs
B	1.0	0.7 – 1.0	2.5	5.0	6.5	0.184	0.46	0.92	Columns
C	1.0	0.7 – 1.0	3.0	6.0	5.5	0.156	0.47	0.94	Flooring on fill, and pavements.
D	1.0	0.7 – 1.0	4.0	8.0	4.8	0.136	0.48	0.96	Big Mass Footings.

*Amount dependent upon the moisture content of aggregates.

Solution:

1. Determine the maximum size of aggregates. The maximum size of aggregates should not exceed one-fifth of the narrowest dimension between sides of forms nor three-fourths of the minimum clear spacing between individual reinforcing bars.

   a. Taking the dimension of the forms as the basis, the maximum aggregates size is:

      Max. aggregate size – 1/5 x 152 = 30.4 mm.

   b. Taking the spacing of the individual reinforcing bars as the basis, the maximum size is:

      Max. aggregate size – 3/4 x 50 mm = 37.5 mm.

      The maximum aggregate size selected is therefore 30.4 mm.

2. Determine the Concrete Proportion

   From Table 8.04, the recommended concrete proportion for the construction of column is Class B and is shown below.

* Computations:

$$\text{Cement} = \frac{0.184 \text{ M}^3 \text{ cement}}{1 \text{ M}^3 \text{ of Concrete}} \times 50 \text{ M}^3 \text{ Req. Concrete} = 9.2 \text{ M}^3$$

$$\text{Water} = \frac{0.13 \text{ M}^3 \text{ Water}}{1 \text{ M}^3 \text{ of concrete}} \times 50 \text{ M}^3 \text{ Req. Concrete} = 6.5 \text{ M}^3$$

$$\text{Sand} = \frac{0.46\ M^3 \text{ sand}}{1\ M^3 \text{ concrete}} \times 50\ M^3 \text{ Req. Concrete} = 23\ M^3$$

$$\text{Gravel} = \frac{0.92\ M^3 \text{ Gravel}}{1\ M^3 \text{ Concrete}} \times 50\ M^3 \text{ Req. Concrete} = 46\ M^3$$

Materials	From Table 8.04		Calculated*
	Volume ratio (Empirical)	Volume Ratio Per M^3 of Concrete	Amount of Material required
Cement	1.0	0.184 M^3 (6.5 bags)	9.2 M^3 (325 bags)
Water	0.7	0.13 M^3	6.5 M^3
Sand	2.5	0.46 M^3	23.0 M^3
Gravel	5.0	0.92 M^3	46.0 M^3

B. **Trial Mix or Batch Method**

Trial Mix or Batch Method of proportioning materials is employed only if it is required that the characteristics of concrete should be ascertained. This is usually true if the concrete structure under construction is vital. An error in the concrete mix will cause its collapse or failure. This method is, however, complicated and is beyond the scope of this manual.

8.05 TESTING OF CONCRETE MIXES

A. **Slump Test**

The slump test is employed to measure the consistency and workability of fresh concrete. It is usually accomplished using the cone method. The procedures for determining the slump are as follows:

1. Prepare the mold which is fabricated from no. 18 gage galvanized iron. The mold (Figure 8.06A) is in the form of a frustrum of a cone in which the diameter of the base is 0.20 M (8 in.), diameter of the top surface is 0.10 M (4 in.) and height is 0.3 M (12 in.).

2. Dampen the cone and place it on a flat, moist, non-absorbent surface like concrete slab.

3. Fill the cone with a sample of freshly mixed concrete in three equal layers and with each layer rodded with 25 strokes using a 16 mm (5/8 in.) diameter, 0.60 M (24 in.) long bullet pointed rod (Figure 8.06B). Also in filling the cone with concrete mix, move the trowel around the cone as the concrete slides, in order to insure a symmetrical distribution of concrete within the cone.

4. After the top layer is thoroughly rodded, scrape off the excess cement.

5. Gently raise the mold vertically and place it besides the specimen. Do not tilt the cone during the removal process.

6. Measure the difference between the height of the mold and the specimen to the nearest 6 mm (Figure 8.06C). This represents the drop of mass of concrete below the original 0.3 M (12 in.) height, or the slump. Shown in Figure 8.02A are the illustrations of the consistencies of fresh concrete.

7. After the slump test, tap the side of the concrete gently with the tamping rod. This is to determine the cohesiveness, workability and placeability of the concrete mix. A well-proportioned, workable mix will slump gradually while a poor mix will crumble, segregate, and fall apart.

B. **Unit Weight Test**

The unit weight test is employed to determine the density of the prepared concrete mix. This is usually done after the completion of mixing.

Procedure:

1. Assemble the Equipment Needed

   a. Weighing scale.

   b. A container of known volume and weight. Usually, a cylindrical container 0.014 cubic meter (0.5 cubic foot) is employed for mixing with a maximum aggregate size of 5 cm or less and 0.035 cubic meter (1 cubic foot) if the maximum aggregate size is greater than 5 cm.

2. Fill the container with the prepared mix until it is half full and vibrate or rod its contents.

3. Fill the container until it overflows and again vibrate or rod its contents.

4. Scrape off the top or remove the excess concrete mix.

5. Weigh with a scale the container filled with concrete.

6. Compute the density by dividing the weight of concrete by its volume.

Example 8.3 Determine the density of concrete mix given the following data.

Data:

C. Volume of the cylindrical container, $V_c = 0.014\ M^3$.

Weight of empty container, $W_c = 3$ kg.

Weight of container filled with concrete, $W_w = 35.2$ kg.

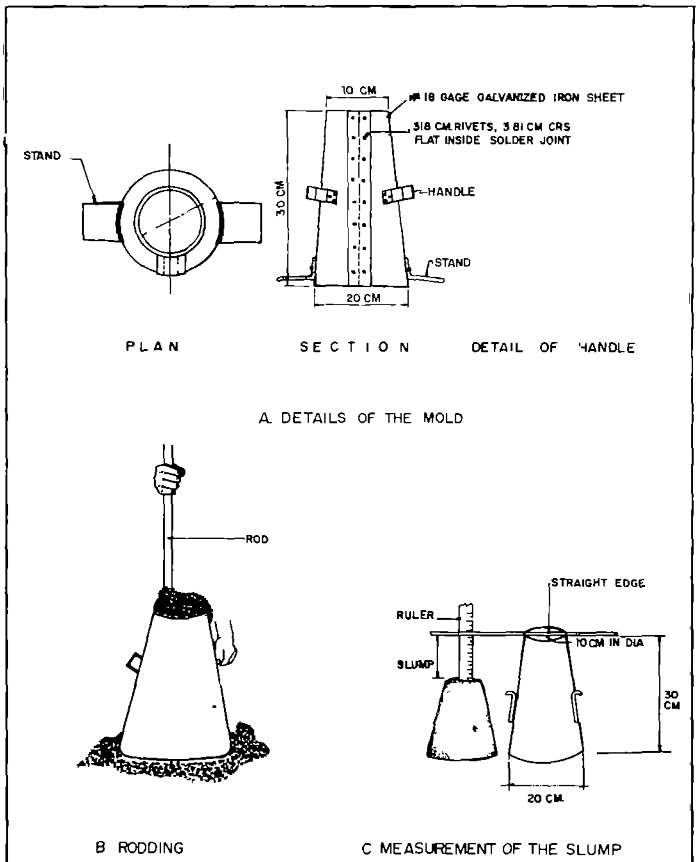


FIGURE 8 06

SLUMP TEST

8 15

Solution:

$$\text{Density} = \frac{\text{Weight of Concrete}}{\text{Volume of Concrete}}$$

Weight of concrete $= W_w - W_c = 35.2 - 3$ kg. $= 32.2$ kg.

Volume of Concrete = Volume of Container = 0.014 M^3

$$\text{Density} = \frac{32.2 \text{ kg}}{0.014 \text{ M}^3} = 2{,}300 \text{ kg/M}^3 = 2.3 \text{ g/cm}^3 \ (143.5 \text{ lb/ft}^3)$$

C. **Strength Test**

The strength test is employed to determine the compressive and tensile strength of prepared concrete mix. The test is usually conducted in the laboratory.

Procedures:

1. Take 3 random samples from a mixer for a given batch.

2. Mix the 3 collected samples into one uniform sample with a shovel, to make a composite sample.

3. Fill a mold in 3 equal layers, rodding each layer 25 times. When rodding the second and the third layer the rod should penetrate the lower layer. The rod should be 15 mm (5/8 in.) round steel rod, 60 cm (24 in.) long and bullet pointed at one end. Avoid using a reinforcing rod.

4. Scrape off top or excess concrete and cover the mold with a piece of glass or metal plate to prevent evaporation.

5. Place the sample on rigid horizontal surface free from vibration and store it for 24 hours; then remove the sample from the mold.

6. Cure the samples for either the 7-day or 28-day test.

7. Send the sample to the laboratory for testing as soon as possible.

8.06 BATCHING

Batching is the preparation of materials to be mixed per batch of concrete. The process consists of measuring the required amount of aggregates, water and cement. This is accomplished using a volumetric measuring box (Figure 8.05) if the proportion of concrete mix is in terms of volume; or a weighing scale if the proportion of concrete mix is in terms of weight. Batches are usually determined by whole bags of cement. The use of fractional sack batches is not advisable, hence, it is seldom practiced.

8.07 MIXING

Mixing is the process of making the mixture of sand, gravel, cement and water homogenously. It may be accomplished by hand or by machine mixing. Generally, machine mixing is superior to hand mixing, both in quality of concrete produced and in economy of time and labor, hence, it should be employed whenever a machine is available.

A. Hand Mixing

Hand mixing is usually accomplished in a platform as shown in Figure 8.07A. The mixing box commonly used has an approximate area of 3 square meters. The volume of batches for hand mixing is usually limited to 0.76 cubic meter (1 cubic yard) or the amount that can be placed in 30 minutes or less.

Procedure

1. Spread sand evenly to a depth of roughly 9 cm on a water tight platform or mixing box.

2. Spread the cement evenly over the sand and mix until mixture is uniform in color. Three turnings are usually sufficient.

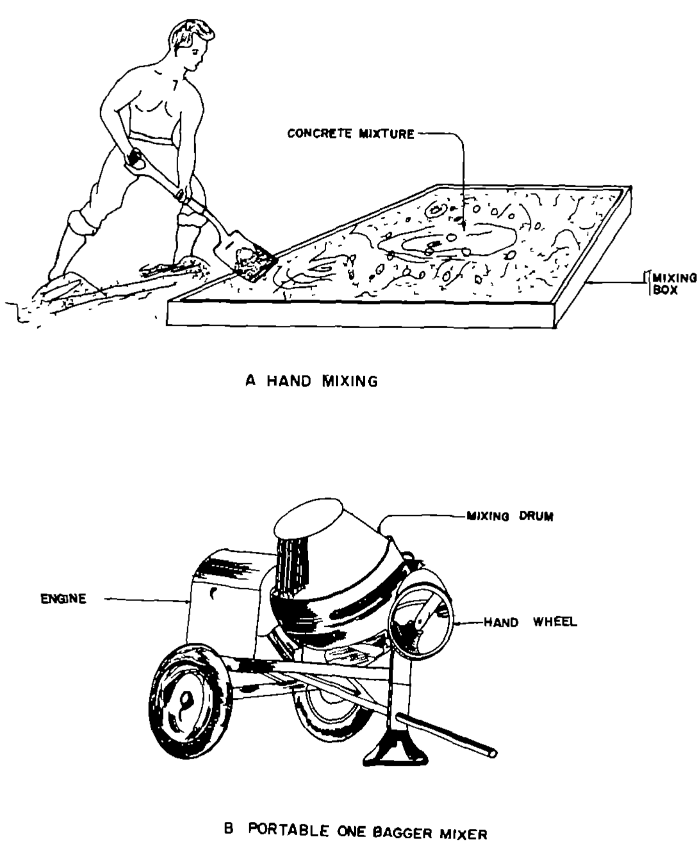


FIGURE 8 07

MIXING OF CONCRETE

3. Add approximately 10-20 per cent of the required quantity of water as determined by water-cement ratio and mix. If hand mixing is accomplished on a concrete pavement form a pond-like hole bounded by cement sand mixture before adding water. The purpose of impounding the added water is to prevent its escape into the surrounding and bringing along the cement suspended in it.

4. Allow the water to be absorbed by the mixture and then turn it until a homogenous mixture is obtained. Usually, three turnings are sufficient.

5. Add coarse aggregate to the water-sand-cement mixture and then add the remaining 80-90 per cent of the required amount of water. In case mixing is accomplished on concrete pavements, adding of water should be carefully regulated to prevent its escape to the surroundings.

6. Turn the mixture three or four times until a homogenous mixture results.

B. **Machine Mixing**

Mixers, either run by an engine or by an electric motor, can be employed in mixing of concrete. Shown in Figure 8.07B is a typical one cubic yard (0.76 cubic meter) capacity mixer. Mixing is accomplished by revolving or turning the drum which is equipped with blades. It should be pointed out that mixers should never be charged more than the rated capacity indicated by its manufacturer to produce best results and at the same time prolong their useful lives.

Procedure for Machine Mixing

1. Estimate the amount of materials to be charged into the mixer per batch. The suitable volume per batch is selected by considering the rated capacity of the mixer and the amount of mix which can be placed within 30 minutes. If the rated capacity of the mixer gives a smaller figure, then use this volume, otherwise the second factor will govern.

2. Charge the batch into the cement mixer. To avoid balling of the cement, it is preferable to charge it into the mixer with aggregates and have it mixed before adding water. In this way, the aggregates tend to disperse the dry cement into the mixture and to some degree, provide a protective shroud enclosing the cement during charging. Add approximately ten per cent of the mixing water first and then add the remaining mixing water continuously during the entire time that the solids are turning in the mixer.

3. Mix the concrete mixture thoroughly until it becomes homogenous. Usually the minimum mixing time is 1.5 minutes if the amount being mixed is 0.76 cubic meter (1 cubic yard) plus 0.5 minute for every 0.76 cubic meter (1 cubic yard) capacity over 0.76 cubic meter after all materials have been placed in the mixer. In no case should the maximum mixing time exceeds three times the minimum mixing time. Over-mixing may remove entrained air thus requiring more water to maintain the required workability. Increasing the water-cement ratio decreases the strength of the concrete.

Concrete should be placed within 30 minutes after mixing. If a batch is kept in a mixer for more than 30 minutes, it should be remixed prior to discharge with additional water and cement to restore its plasticity. A batch that is not used within 1.5 hours should be wasted. Mixer drum must be thorougly cleaned before shutting down on each run.

This is accomplished by charging aggregates of volume equal to one-half batch, and then allowing the drum to revolve for about 5 minutes. The mixer is then flushed with water.

8.08 FORMWORKS

A. **General**

Forms are employed to mold concrete to a desired shape and smoothness as specified in the plans. They are constructed so that concrete slabs, walls and other members will be of correct sizes, dimensions, shape, alignment, elevation and position.

B. **Materials**

The selection of materials suitable for formwork should be based on maximum economy consistent with safety and quality required in the finished work. Presented in Table 8.05 are form materials and their usage.

Table 8.05

Form Materials and Their Usage

MATERIALS		USAGE
1.	Lumber	Form framing, sheathing and bracing.
2.	Plywood	Form sheathing or lining.
3.	Steel	Heavy forms and falseworks.
4.	Concrete	Form footings.
5.	Rubber	Form lining
6.	Form ties, anchors and hangers	For securing forms work against loads and pressures.
7.	Coatings	Facilitate form removal

For rural water supply system, lumber and plywood are usually employed for formworks. If lumber is employed, it should be dressed at least on one side to insure uniform thickness and on two edges to insure light, smooth form walls. If only rough, non-sized lumber is available, commercial form liners, sheet metal, plywood and bituminous paper will give a smooth surface and prevent leakage of cement mortar. Forms should be constructed with a view of using the materials again, either formworks or for other purposes.

C. **Essential Parts of Forms**

1. **Form lining or Sheathing.** It is the part of the form which is in contact with the concrete. It is usually made of plywood or lumber.

2. **Studs.** It supports the linings.

3. **Wales.** It supports the studs. Wales should be straight, so that every stud will have full bearing on the walls, otherwise, the pressure caused by

the placing and consolidation of concrete may move the form lining and detrimentally affect the alignment of the surface of the concrete structure. For small forms wales are usually deleted.

4. **Reinforcement of Forms.** This is necessary to maintain the required dimension and alignment of the resulting concrete structure. This is usually accomplished through bracing and/or with the use of form ties.

   a. **Bracing.** Footing and wall forms are usually supported using diagonal bracings (Figure 8.08A), floor forms by the use of posts and girders, and column forms using yokes and inclined braces (Figure 8.09).

   b. **Form Ties.** Form ties are used to keep the opposing walls of forms from spreading under the pressure of fluid mass of concrete.

      This is usually accomplished using wire or bolts, which become imbedded in the concrete and are cut on the outside when forms are removed. Wire is fastened to stud supports or wales (Figure 8.08A). To prevent forms from closing together when wired or when bolts are tightened, spreader or struts are used between forms and these are removed as the concrete rises. Forms should be checked for tightness and bulging during pouring operations and any loose tie wires or bolts should be tightened.

5. **Strongback.** Strongbacks are employed only when supporting wales for high walls and long spans.

6. **Form Anchors.** Form anchors are devices used to secure form on a firm ground or to a previously placed concrete of adequate strength. Anchors used may be wooden stake or bolt.

D. **Types of Forms**

1. Footing and Wall Forms

   Shown in Figure 8.08 are the features of this type of form.

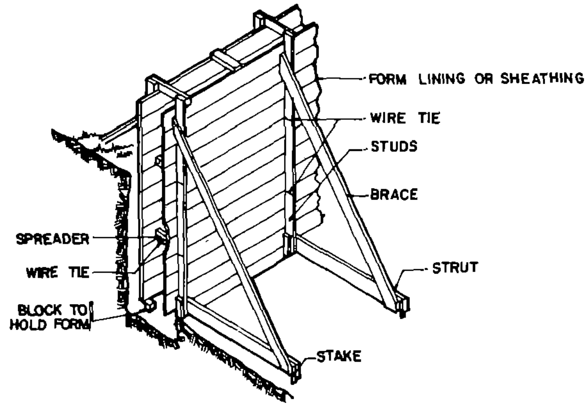
   a. Form lining or sheathing may be of 13 mm x 100 mm (1/2" x 4") lumber or 13 mm to 25 mm (1/2" to 1") thick plywood.

   b. Studs, struts, braces and wales may be made of 25 mm x 75 mm (1" x 3") or 50 mm x 100 mm (2" x 4"') thick lumber. The selection of appropriate size of materials will depend upon the thickness and height of the wall or footing.

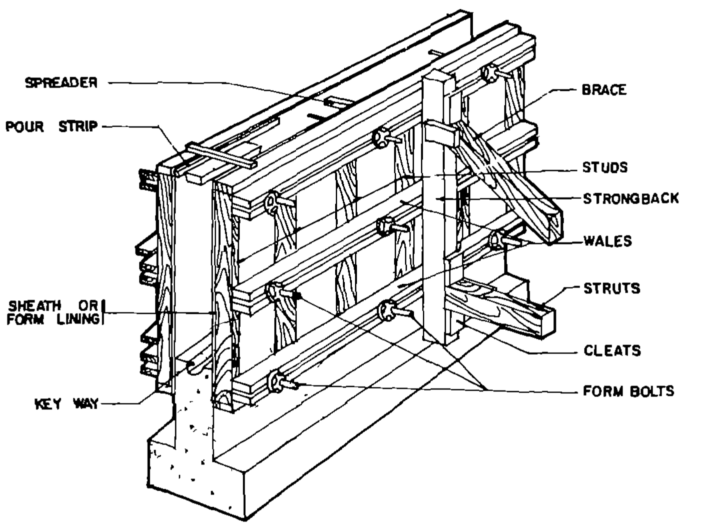
   c. Strongbacks may be made of 50 mm x 100 mm (2" x 4") thick lumber.

2. Slab Forms

   The lining for the slab forms may be made of 13 mm or 25 mm thick lumber. Joints are usually supported by adequate anchor supports.



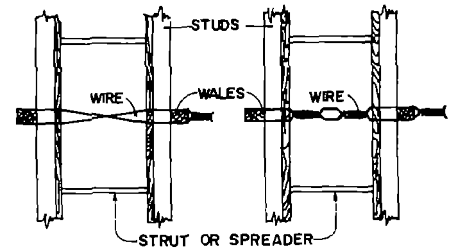
A FORM LAID IN FIRM GROUND



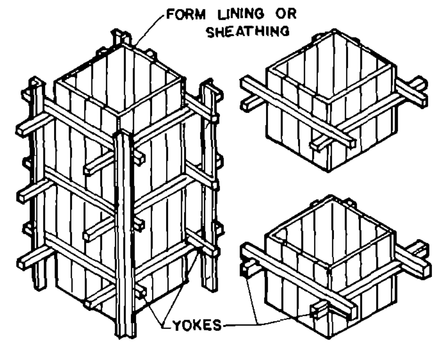
B FORM CONSTRUCTED ON THE EXISTING CONCRETE STRUCTURE

FIGURE 8.08

FOOTING AND WALL FORMS



A FORM TIES



B COLUMN FORMS

FIGURE 8.09

FORM TIES AND FORMS FOR COLUMNS

3. Earth Forms

Where earth is stable, it can be used for forms for foundations and similar works.

4. Column Forms

Shown in Figure 8.09 are typical wood column forms. The lining used may be 25 mm (1") thick plywood or lumber whichever is readily available.

E. **Preparation of Forms**

Prior to placement of concrete, all forms must be cleaned, fixed if they have some defects and protected from deterioration. The preparation includes:

1. Removal of Debris such as Sawdusts and Shavings

   If form material has been used previously, all dry concrete must be removed from inside of forms.

2. If forms have knotholes, they must be patched up with sheet-metal, water-proof paper or putty depending upon their size.

3. Application of oil to prevent the concrete from adhering and to aid in their removal. Oil protects the form from deterioration due to weather and shrinkage. Oil is usually applied either by spraying or brushing before the placement of reinforcing bars. It should be emphasized that oil must be kept out from construction joint surface or reinforcing bars because it interferes with the bond.

F. **Removal of Forms**

If time permits, it is important that concrete should be allowed to harden sufficiently before the forms are removed. Leaving the forms in place aids in the hardening process by preventing concrete from drying. Normally, forms should remain in place longer for reinforced concrete than for plain concrete and longer for horizontal than for vertical members. Presented in Table 8.06 are the minimum time required before the removal of forms if general purpose or standard portland cement is used.

Table 8.06

Time Required Before the Removal of Forms

Structure	**Time Days**
Walls	1 - 3
Thin Walls	2 - 5
Columns	2 - 4

8.09 PLACING OF CONCRETE

A. Factors to be Considered During Placing of Concrete

Placement and consolidation of concrete affect the appearance, durability and strength of a concrete structure to a large extent. Presented below are the factors to be considered during placement:

1. Fresh concrete mix should be of good quality as determined in terms of water-cement ratio, slump and homogeneity. Separation or clusters of coarse aggregate are objectionable and should be scattered prior to placing of concrete to prevent rock pockets and honeycomb in the completed work.

2. The concrete mix should be deposited at or near its final position during placement to eliminate the tendency of the coarse aggregate to separate. On sloping surfaces, concrete should be placed at the lower portion of the slope first and progressing upwards (Figure 8.10B).

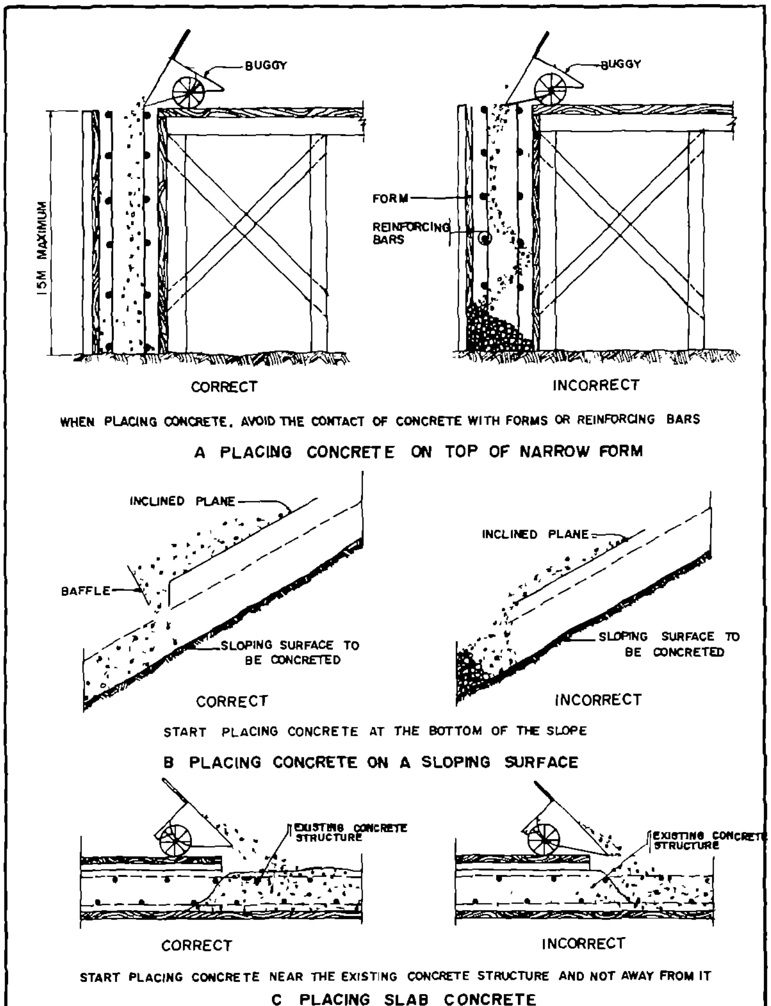


FIGURE 8 10

PLACING OF CONCRETE

3. When concreting starts, placing should be continuous until a definite section is completed. High velocity discharge should be avoided because it may cause segregation and formation of laitance. Laitance is a whitish, chalky substance composed of cement particles, silt, and clay that gathers on the surface of wet concrete mixture. Excess water and laitance should be drained off.

4. Concrete mix should be placed in horizontal layers not exceeding 60 cm. (2 feet) in depth. Each concrete layer should be placed while the underlying layer is still responsive to consolidation, and layers should be sufficiently shallow to permit the knitting of the two layers together through proper tamping or rodding, or vibration.

B. **Preparation of Surface to be Concreted**

1. Clean up subgrade steel reinforcements and forms from embedded items, dirt and other debris. Reinforcing steel should be clean in its correct position, and well supported and secured prior to the start of concrete placement. It is not necessary to remove tightly adherent rust and mortar from the reinforcing steel but loose adhering materials should be removed.

2. Check all bracing. Forms should be strong and tight to prevent loss of mortar.

3. Wet subgrade and forms to minimize their tendency to absorb water from the mix. Subgrade should be moistened up to a depth of 15 cm (6 in.).

C. **Preparation of Concrete Slabs**

Place concrete mix as close as possible to its final position. If there is an existing concrete structure, place new concrete against previously placed concrete and not away from it (Figure 8.10C). As each batch of concrete is placed in the forms, consolidate and work it into all corners and around the steel by hand spading, rodding or vibrating.

D. **Preparation of Concrete Walls and Other Vertical Structures**

Start placement of concrete at the opposite ends and proceed to the middle to prevent water from forming in corners. When placing concrete, the mix should be directed as close to its final location as possible.

Do not allow mix to bounce off from the reinforcement or forms. As the desired thickness is reached, consolidate the concrete by rodding, tamping or vibrating.

E. **Bonding of Fresh Concrete to Existing Concrete Structure**

In joining fresh concrete to existing concrete structure, the old surface should be roughened with a pick or cold chisel and all loose materials and dirt should be removed. The cleaned surface is moistened, then a coat of water-cement mixture about 13 mm thick is applied and then cover carefully with a layer of concrete. Placing of fresh concrete may then be resumed.

8.10 CONSOLIDATION OF CONCRETE

Consolidation of concrete is necessary to bring the concrete particles together to produce a homogeneous and high strength concrete structure. Consolidation can be effected through vibration of rodding.

A. Consolidation by Vibration

Vibration is the most effective method of consolidating concrete, permitting the placement of concrete containing less water than required when concrete is not vibrated. In addition to improved quality and economy resulting from these mix proportioning changes, superior appearance and workmanship are obtained.

Procedure

1. Insert the vibrator vertically into the newly placed concrete (Figure 8.11) layer allowing it to penetrate through the entire layer of the newly placed concrete and through the previously placed concrete to have an effective blending of the two layers. When consolidating concrete in a sloping surface always start the consolidation from the bottom of the slope. Vibration is usually indicated by vibrator resuming normal speed after an initial slowdown.

2. Withdraw the vibrator slowly and reinsert it into the concrete 40 to 70 cm away from the previous point. Avoid dragging it through the concrete during the withdrawal and transfer. Continue the above process until the entire area is consolidated. Vibration is completed when the surface of concrete has a glistening appearance, the rise of entrapped air indicated by bubbles on concrete surface ceases and the coarse aggregate blends with the surface but does not disappear. Avoid over-vibrating the concrete mix.

B. Consolidation by Rodding

Consolidation by rodding is effected by raising a rod up and down through the layer of newly placed concrete until the entire area being concreted is covered. The rod should at least penetrate a few centimeters into the previously placed concrete to produce a monolithic concrete structure.

8.11 CONSTRUCTION JOINTS

Construction joints are usually provided in preparing concrete surfaces where bonding between two sections of concrete is required or according to plans. They are usually located in places where they cannot impair the strength of the structure.

A. **Horizontal Construction Joints**

Horizontal construction joints are employed when joining two sections of concrete in floor slabs, beams and other horizontal structures. This is usually done by extending reinforcing steel across the horizontal joint or by embedding stones half their diameter or by the use of waterstops in concrete reservoirs. Construction joints in floors should be located near the center of spans, slabs, beams or girders.

B. **Vertical Construction Joints**

Vertical construction joints are required in walls to hold the separately poured sections in line and to form a monolithic concrete structure. Vertical construction joints may be accomplished by using a V or a bevelled key form (Figure 8.12A) or by extending iron bars (Figure 8.12B).

C. **Reservoir Construction Joints**

Waterstops are usually employed in reservoir construction joints. Shown in Figure 8.13B are the flat and centerbulb waterstops, and in Figures 8.13C, 8.14A, 8.14B and 8.14C are the manner of installation in floor slabs, wall, roof slabs and wall-floor construction joints, respectively.

Procedure

1. Install the waterstops as shown in the plans. In cases where bonding of a waterstop to another waterstop is required, this can be accomplished by butt welding or by heating their ends to be bonded and then pushing them together. During heating, extreme care must be taken not to get the heating iron too hot that it will change the bonding property of plastic. After welding, every weld should be carefully checked by visual inspection and by actually bending the joint to check whether the bond will hold.

2. Examine waterstop after it has been placed and see to it that the holding devices are placed only on the edge of the waterstop.

3. Place concrete very carefully around the waterstop and be sure concrete is satisfactorily vibrated or rodded to eliminate voids and rock pockets.

8.12 CURING OF CONCRETE

A. **General**

Curing is necessary to insure the availability of water for the hydration of cement and to maintain a temperature within the concrete that will result in the desired strength gain. Curing can be accomplished by application of water through ponding or spraying or by providing a moist environment through the use of saturated cover materials such as burlaps, cotton mats, rags, earth or hay or by preventing the loss of mixing water from concrete by means of sealing materials such as impervious sheets of plastic or by application of a membrane forming curing compound to the freshly placed concrete.

B. **Curing by Direct Application of Water or by Providing a Moist Environment**

Curing by direct application of water or by providing a moist environment is generally considered to be the ideal method. However, these methods are satisfactory only as long as the presence of water is continuous and there is no opportunity for the concrete to dry to such degree that the hydration of the cement ceases. Intermittent wetting and drying especially after an initial 2 or 3 days of satisfactory curing will allow continued strength gain although not as rapid as continuous curing. Intermittent curing during the early stages of hardening is likely to result in surface cracks or reduced service durability.

C. **Curing Period**

Curing period and materials are dependent upon cost of labor and materials, the need for early accessibility or protection of a surface during subsequent construction operations and the desired concrete quality. In no case should the curing period be less than 14 days. Normally, strength is used to measure the relative quality of concrete. A specified strength will be attained in the shortest time by continuous curing. Whenever curing is interrupted before the desired strength is attained, subsequent curing whether from natural sources such as rain or artifical application of water will result in further gain in strength but at a much slower rate.

8.13 FINISHING OF CONCRETE SURFACES

Immediately after the stripping of forms, concrete surfaces must be inspected and any poor joints, voids, rock pockets and other areas must be repaired and all form tie fastener holes must be filled. Stripping of forms is usually done after 14 days of curing.

Procedure

1. Prepare a grout by mixing one part portland cement and one part fine sand which pass a No. 16 sieve with sufficient water to give a consistency of a thick paste.

2. Wet the concrete surface to be grouted.

3. Apply the freshly prepared mortar into the concrete surface with a wood float filling all small air holes.

4. Keep the surface moist for an hour or more until the grout hardens sufficiently and it can be scraped from the surface with the edge of a steel trowel without disturbing mortar in the air holes.

5. Remove all surface grout using a steel trowel and allow the surface to dry. After drying, rub it with burlap or cotton rag to remove completely all surface grout so that there is no visible paint-like film of grout on the con-

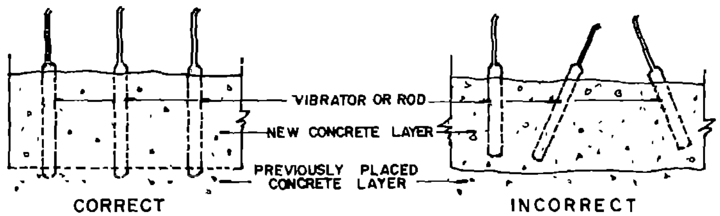
CORRECT

START PLACING AT BOTTOM OF SLOPE SO THAT COMPACTION IS INCREASED BY WEIGHT OF NEWLY ADDED CONCRETE VIBRATION CONSOLIDATES

INCORRECT

TO BEGIN PLACING AT TOP OF SLOPE UPPER CONCRETE TENDS TO PULL APART ESPECIALLY WHEN VIBRATED BELOW AS VIBRATION STARTS FLOW AND REMOVES SUPPORT FROM CONCRETE ABOVE

WHEN CONCRETE MUST BE PLACED IN A SLOPING LIFT



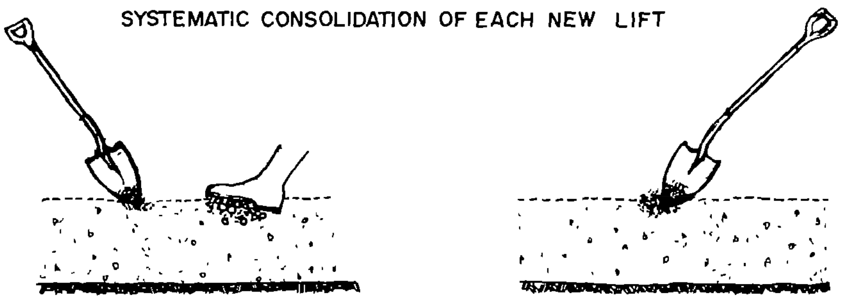
CORRECT

VERTICAL PENETRATION OF VIBRATOR A FEW INCHES INTO PREVIOUS LIFT (WHICH SHOULD NOT YET BE RIGID) AT SYSTEMATIC REGULAR INTERVALS FOUND TO GIVE ADEQUATE CONSOLIDATION

INCORRECT

HAPHAZARD RANDOM PENETRATION OF THE VIBRATOR AT ALL ANGLES AND SPACINGS WITHOUT SUFFICIENT DEPTH TO ASSURE MONOLITHIC COMBINATION OF THE TWO LAYERS.

SYSTEMATIC CONSOLIDATION OF EACH NEW LIFT



CORRECT

SHOVEL ROCKS FROM ROCK POCKET ONTO SOFTER, AMPLY SANDED AREA AND TRAMP OR VIBRATE

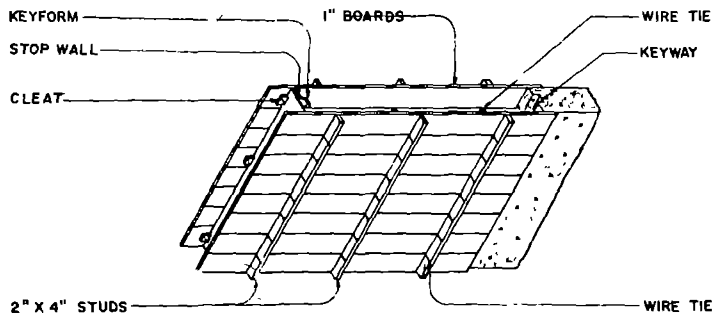
INCORRECT

ATTEMPTING TO CORRECT ROCK POCKET BY SHOVELLING MORTAR AND SOFT CONCRETE ON IT

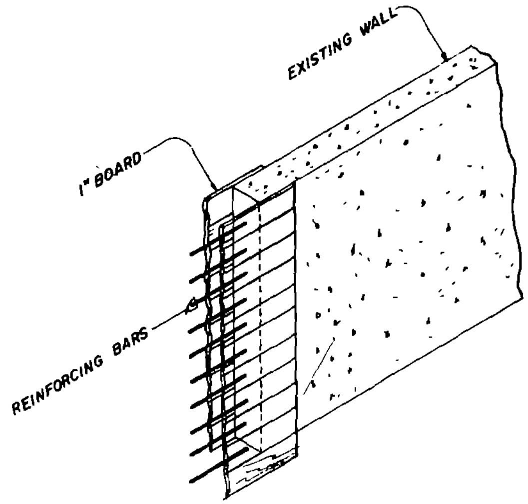
TREATMENT OF ROCK POCKET WHEN PLACING CONCRETE

FIGURE 8 11

CONSOLIDATION OF CONCRETE



A VERTICAL CONSTRUCTION JOINT IN WALL WITH KEYWAY



B VERTICAL CONSTRUCTION JOINT IN WALL BY EXTENDING IRON BARS

FIGURE 8 12

VERTICAL CONSTRUCTION JOINTS

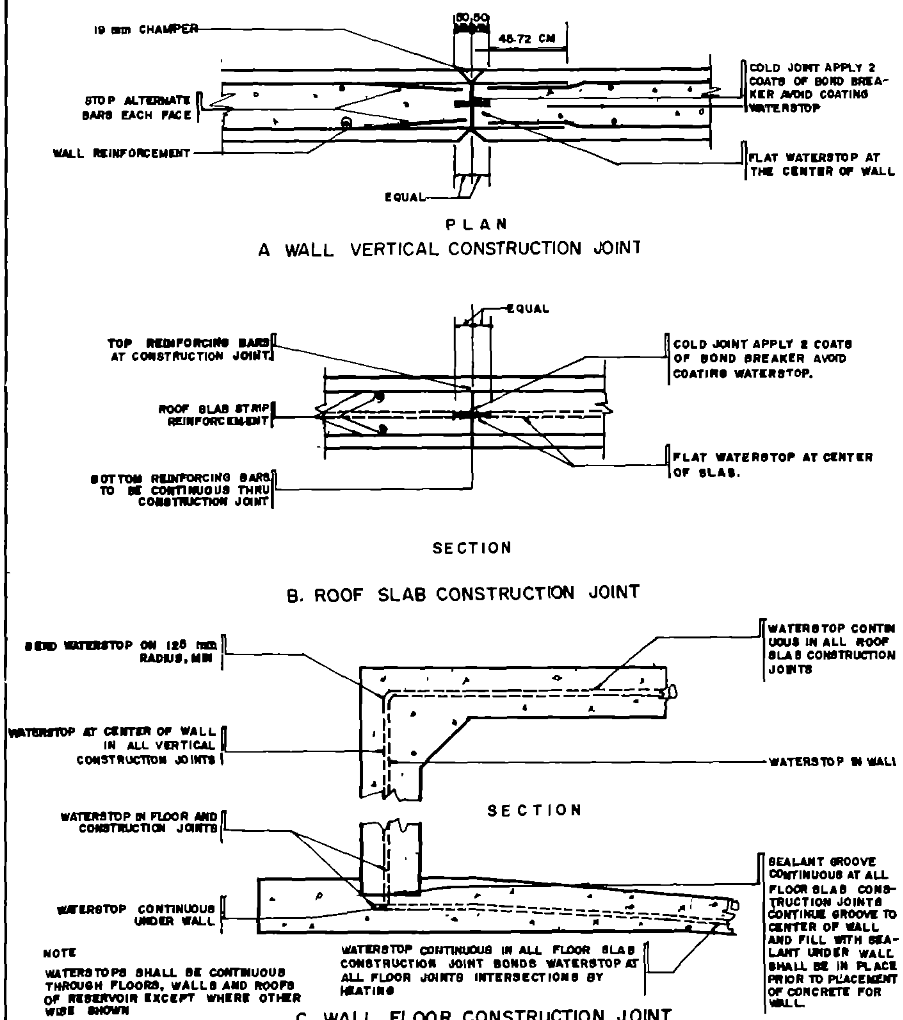


FIGURE 8 13

RESERVOIR CONSTRUCTION JOINTS

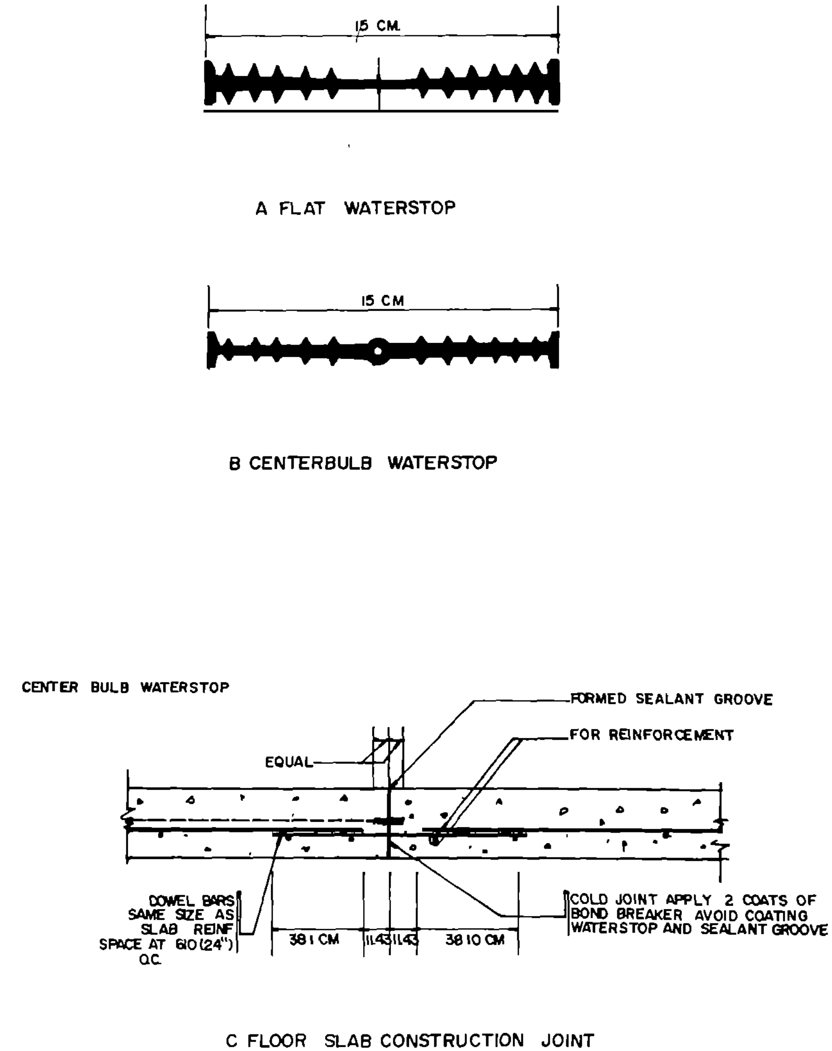


FIGURE 8 14

RESERVOIR CONSTRUCTION JOINTS

crete. The entire cleaning operation for any area must be completed the day it is started and no grout must be left on the concrete surface overnight.

8.14 TREATMENT OF SURFACE DEFECTS

A. General

After the removal of forms, all exposed concrete surfaces must be examined for defects and any irregularities must be immediately rubbed or ground in a satisfactory manner with carborundum bricks in order to secure a smooth, uniform and continuous surface. Plastering or coating of surfaces to be smoothened usually do not produce a good result, hence, they are not recommended. Also, concrete containing voids, holes, honeycombs or similar depression defects must be completely removed and replaced with a cement mortar. In no case should extensive patching of honeycombed concrete be permitted because the bonding of cement mortar to existing concrete will not be strong and durable.

B. Preparation of Concrete Surfaces to be Repaired

1. Make a thorough examination of the imperfections.

2. Remove all concrete of questionable quality and clean hole thoroughly. Edges of hole should be cut as straight as possible at right angles to surface or slightly undercut to provide a key for the patch. For holes left by the tie rods of forms, ream and clean them to make them clean and rough.

3. Wet the surfaces within the trimmed holes for several hours prior to placing new concrete. Best method is to pack hole with wet burlap or cotton rag.

4. Immediately before placing the cement mortar, clean the hole again so as to leave the surface completely free of chipping dust, dried grout and all other foreign materials.

C. Treatment of Surface Defects Using a Dry Pack

Dry pack is employed to plug holes with depths equal to or greater than the least surface dimension such as form tie holes. It is usually not employed in filling holes wherein lateral restraint cannot be obtained and for filling in back of considerable lengths of exposed reinforcement.

Application Procedure

1. Brush off with stiff mortar or grout the surfaces of the holes to be filled. The grout will serve as the bonding agent between the dry pack and the existing concrete surfaces. The grout is prepared by mixing 1 part cement and 1 part fine sand by volume with sufficient water to form a consistency of a thick paste. It is not recommended to paint the

surfaces of the holes with neat cement grout as this would make the dry pack too wet and cause high shrinkage.

2. Prepare a dry pack by mixing 1 part portland cement to 2-1/2 parts of sand that will pass Sieve No. 16. A trial mix should be prepared to determine the amount of white cement needed if matching of the color of the existing concrete is necessary.

3. Place immediately the dry pack into the hole before the bonding grout has dried. Dry pack should be placed and packed in layers having a compacted thickness not greater than 9-1/2 mm. Thicker layers will not be well compacted at the bottom. After placement of each layer, pack it by use of a hardwood stick and a hammer. Much of the tamping should be directed at a slight angle toward the sides of the hole.

4. Finishing is completed by laying the flat side of a hardwood piece against the pack and striking it with several good blows. A few light strokes with a rag may improve the appearance.

D. **Treatment of Surface Defects by Concrete Replacement**

This method of repairing concrete defects is applicable when holes in unreinforced concrete are more than 0.10 square meter (1 square foot) in area and 100 mm (4 in.) or more in depth or when holes in reinforced concrete are more than 0.05 square meter (0.5 square foot) in area and deeper than the reinforcing steel.

1. Preparation of the Concrete Surfaces

   Before starting the replacement of concrete, the existing concrete surfaces should have the following features:

   a. Top edge of hole should be cut fairly horizontal with a 1:3 slope from back to front. This is essential to eliminate air pockets.

   b. The bottom and sides should be cut straight and at right angles to the face.

   C. All interior corners should be rounded.

   d. Clearance should be 25 mm around reinforcing bars.

2. Procedure of Repair

   a. Construct a form if it is necessary to prevent concrete mortar from escaping from holes being repaired.

   b. Prepare the concrete mix to be applied. The composition of the mix should be similar to the mix used for the original structure. Low slump should be used to minimize shrinkage.

c. Place the prepared mix into the hole and consolidate it by tamping. When placing in layers, placement should not be continuous. A minimum period of 30 minutes should elapse between lifts.

d. Remove the forms the day after casting. After the removal of forms, scrape the bulging edges and level the surface by use of steel trowels.

E. **Treatment of Surface Defects by Mortar Replacement**

This method is used if the holes are too wide to dry pack or too shallow for concrete replacement, and for all comparatively shallow depressions, large or small which extend no deeper than the far side of the reinforcing bars nearest the surface.

1. Preparation of Concrete Surfaces to be Repaired

   a. Flare holes outward at 1:1 slope and round all corners.

   b. Remove all loose concrete and other foreign materials.

   c. Moist the surfaces to be repaired.

2. Application Procedure

   a. Mix 1 part cement to 3 parts sand by volume which is well graded and passing sieve no. 16 with sufficient water to make a consistency of a thick paste.

   b. Fill the hole with cement mortar slightly more than full. The mortar should be applied in layers not more than 19 mm to avoid sagging and loss of bond. Allow the mortar to harden.

   c. Shave off the excess material with a steel trowel to produce a uniform surface.

CHAPTER 9

CONCRETE MASONRY

9.01 GENERAL

Discussion on concrete masonry in this chapter is devoted to the construction of concrete structures using concrete hollow blocks (CHB). The construction procedure consists of staggered placement of courses of blocks, filling of the hollow portion of the blocks with cement mortar and the placement of mortar on the upper face of the block to serve as bonding agent between the previously placed course and the succeeding course. Also, to increase the strength of the CHB structure, reinforcing bars are embedded at specified intervals between courses and inside the hollow portions of the blocks. Concrete hollow blocks are fabricated by mixing cement and graded sand with sufficient water to form a very dry mix. The mixture is then fed into a block-forming machine where it is molded under heavy pressure and vibration. Blocks are then transferred to a curing room and then to a storage yard.

Concrete hollow blocks commercially available in the market today have the following standard dimensions.

a. 100 mm x 200 mm x 400 mm (4" x 8" x 16")

b. 150 mm x 200 mm x 400 mm (6" x 8" x 16")

c. 200 mm x 200 mm x 400 mm (8" x 8" x 16")

9.02 PREPARATION OF CEMENT MORTAR

Cement mortar is employed in filling the hollow portion of concrete blocks and the bonding of CHB courses. Hence, to construct a strong and well-knit wall, a good mortar is necessary. The strength of the bond is affected by various factors – the type and quantity of cementing material, the workability or plasticity of the mortar, the surface texture of the mortar bedding areas, the water retentivity of the mortar and the quality of workmanship in laying up the units. The type of concrete mix employed in masonry works depends upon its uses. Masonry or CHB walls subjected to severe stresses require mortars that are stronger and more durable than walls that are exposed to ordinary service. Tabulated in Table 9.01 are typical concrete mortar mixes. Mortar should be mixed in power mixers except for very small jobs where it may be mixed by hand.

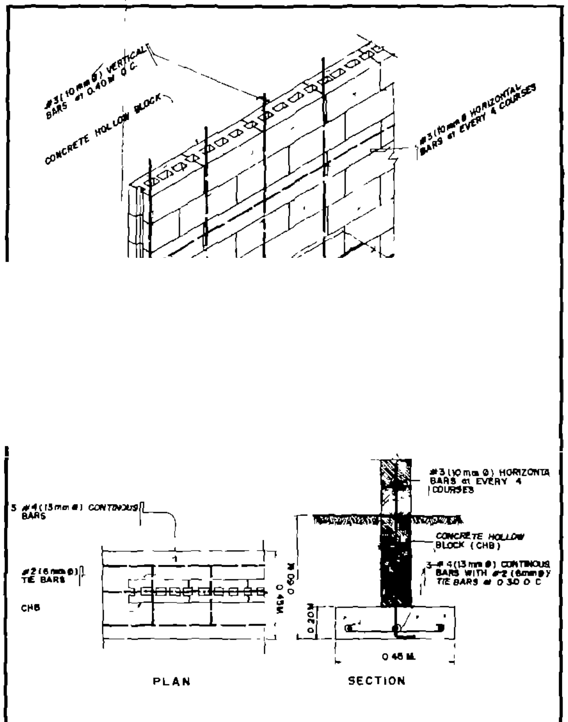


FIGURE 9.01

LAYING OF CONCRETE HOLLOW BLOCKS

Table 9.01

Recommended Mortar Mixes*

	Type of Service	Cement	Sand
1.	For ordinary service	1.0	3.0
2.	For structures that are subjected to extremely heavy loads, violent winds, earthquakes.	1.0	2.0

*Proportions by volume

Mortar that has stiffened on the mortar board because of evaporation should be retempered to restore its workability by thorough remixing and by the addition of water as required. Mortar stiffened by hydration (setting) should be discarded. Since it is difficult to distinguish between these two causes of stiffening, the practical method of determining suitability of mortar is on the basis of time elapsed after initial mixing. Mortar should be used within 45 minutes after original mixing and any mortar not used after this time limit should be discarded.

9.03 CUTTING OF HOLLOW BLOCKS

Concrete hollow blocks are usually available in full-length units of 400 mm. To fit special job conditions, it is sometimes necessary to cut a block. A hammer and chisel are commonly used to cut blocks. Alternately, the sharp edges of a steel trowel can be employed. The process consists of scoring or scratching on the marked line on both sides of the block to obtain a clean break. For fast and neat cutting, masonry saws are often used. Blocks should be cut dry when masonry saws are used so as not to increase the moisture content of the block.

9.04 LAYING OF BLOCKS

A. Construction of Foundation

The construction of the foundation of CHB structures consists of the following steps:

1. Mark the proposed location of structure by referring to the plans. Mark the location of the corners of the proposed structure using wooden stakes. Tie a string to the wooden stakes, connecting them together. This string will serve as a guide in aligning the trench to be excavated.

2. Excavate a trench approximately 0.6 M deep and 0.45 M wide.

3. Install the steel reinforcements as shown in Figure 9.01.

4. Prepare a Class "A" concrete mix by mixing one (1) part cement to two (2) parts sand and four (4) parts gravel by volume, with sufficient water to form a thick mix.

5. Pour the freshly prepared concrete mix into the excavated trench to serve as foundation. The foundation of structure should be approximately 0.2 M thick and 0.45 M wide.

B. Laying the First Course of Concrete Blocks

The first course of concrete masonry should be laid with great care, making sure that it is properly aligned, leveled and plumbed. This is necessary in building a true straight wall. The laying procedure is as follows:

1. Carefully place the corner blocks before the foundation mix attains initial set. These blocks will serve as the guide in aligning the center blocks.

2. Tie a string connecting the two corners together. The elevation of the string should be equal to the elevation of the upper face of the newly placed blocks.

3. Start placing the center blocks and align them with the string as guide.

4. Fill all the hollow portions of the blocks with cement mortar.

C. Laying the Succeeding Courses of Concrete Blocks

1. Prepare a concrete mortar with Table 9.01 as reference.

2. Place approximately 9 mm thick mortar layer on the upper face of the previously laid blocks. This layer will form a bond which will hold in place the previously placed course and the succeeding course. To assure a good bond, mortar should not be spread too far of actual laying of

the block or it will stiffen and lose its plasticity. Should there be any delay long enough for the mortar to stiffen on the block, the mortar should be removed and reworked on the mortar board to restore its plasticity.

3. Lay the next course of concrete hollow blocks. Start by placing the corner blocks which will be used in aligning this course. Also, the joints of the blocks in this course should be staggered with reference to the proceeding batch of blocks (Figure 9.01).

4. Check the alignment with the use of a mason's line or a string which is aligned with reference to the corner blocks. Make adjustments as found necessary.

5. Level and align the blocks with reference to the mason's line by tapping each block with the trowel handle until they are in the correct position. These adjustments to final position should be made while the mortar is still soft and plastic. Any adjustment made after the mortar has stiffened will break the mortar bond.

6. Remove the excess and extruding mortar from the joints with the use of a trowel. The removed mortar is usually thrown back into the mortar board for reworking to restore its plasticity.

7. Repeat the above procedure starting from "B" until the second to the last course is fixed.

8. Lay the closure blocks. Before lowering the closure blocks to their final place, all of the openings and vertical edges should be buttered with mortar. Also, if during the laying of the blocks, any of the mortar falls out thereby leaving an open joint, the closure block should be removed and fresh mortar should be applied to replace the mortar that has separated.

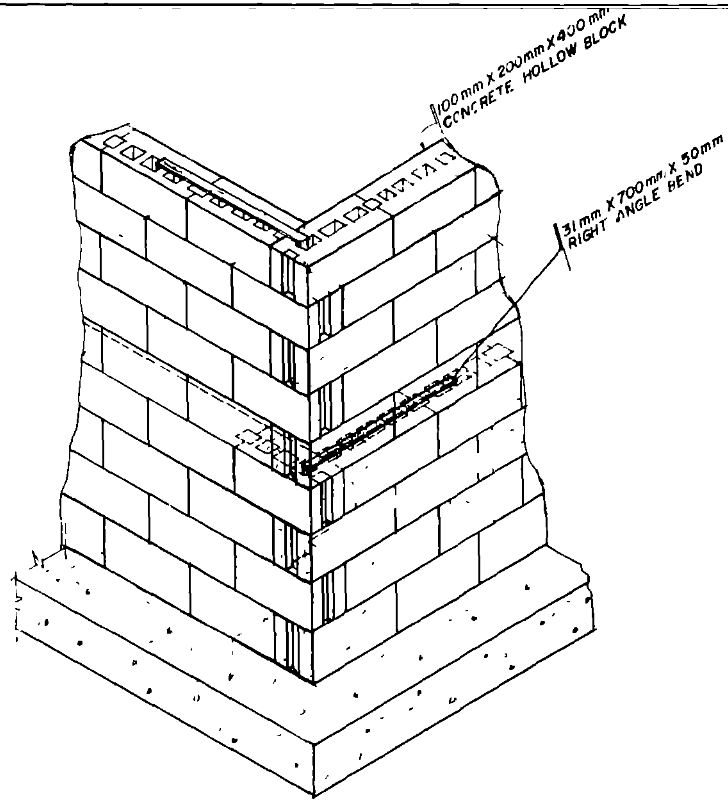
D. **Laying of CHB at the Intersection of Walls**

Intersecting CHB bearing walls should not be tied together in a masonry bond except at the corners. Instead, one wall should terminate at the face of the other wall with a control joint at that point. For lateral support, bearing walls are tied together with a metal tie bar 6 mm (1/4 in.) thick, 31 mm (1-1/4 in.) wide and 70 cm (28 in.) long, with 5 cm. (2 in.) right angle bends on each end (Figure 9.02). These tie bars are spaced not over 1.25 M (4 feet) apart vertically. The bends at the ends of the tie bars are embedded in cores filled with mortar or concrete. Pieces of metal lath placed under the cores support the concrete or mortar filling.

Alternately, a set up shown in Figure 9.03 can be used. It consists of joining two walls in a reinforced concrete post. The reinforced concrete post may be either be prefabricated or cast-in-place.

9.05 PATCHING AND CLEANING

After laying of concrete hollow blocks, all holes left by nails, line pins and others should be patched with fresh mortar. During patching, particular care should be made to prevent smearing of mortar on the surface of the block for it destroys the



ISOMETRY

FIGURE 9.02

LAYING OF BLOCKS AT THE INTERSECTION OF WALLS

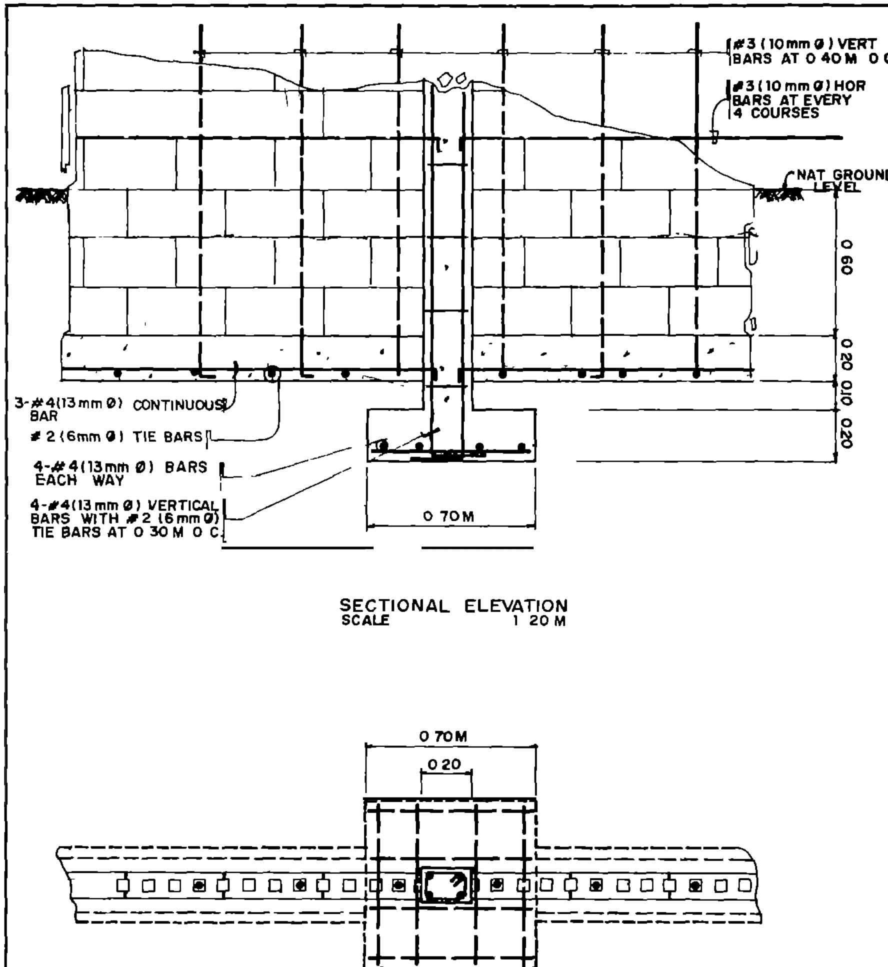


FIGURE 9.03

LAYING OF BLOCKS AT THE INTERSECTION OF WALLS neat appearance of the finished wall. Also, paint cannot be depended upon to hide these mortar smears. Likewise during construction, to produce a clean wall, mortar smears or droppings should be prevented. In case where these can not be prevented, allow the mortar smears to dry before removing them using a steel trowel. The remaining mortar not removed by the steel trowel can be removed by brushing. It is not recommended to remove mortar smears or dropping while they are still wet.

9.06 PLASTERING AND FINISHING

Concrete masonry walls may be coated with 12 mm (1/2 in.) thick coat plaster if a plastered finish is desired. This may be done in one or two coatings. Two coatings is preferable than a single coating as they produce a better finish. Cement plaster may be prepared by mixing 1 part portland cement to 2-1/2 parts graded sand by volume with sufficient water to form a thick paste or by making use of the proportion utilized in bonding the CHB together. Proprietary portland cement based coating that have been specifically prepared for waterproof basement walls can also be used as a plastic coat.

A. Plastering of CHB Walls Using One Coating

1. Clean the wall surface from mortar smears and droppings by using a steel trowel and by brushing.
2. Spray the surface with water to wet it. This will prevent the block from absorbing excessive water from the plaster and will assure a better bond.
3. Apply the 12 mm (1/2 in.) thick coat.
4. Keep the surface just applied with plaster moist for 48 hours.

B. Plastering of CHB Walls Using Two Coatings.

1. Follow steps 1 and 2 outlined above for single coating.
2. Trowel firmly the first 6 mm thick coat over the masonry.
3. Allow the plaster to harden partially and then roughen the surface to provide a good bond for the second coat.
4. Keep the first coat damp for 24 hours.
5. Apply the second coat. Just before the application of the second coat, the roughened surface should be dampened with water but not soaked to control suction for a good bond.
6. Moist-cure the second coat for at least 48 hours after application.

C. Tooled Joint Finishing

Another popular type of finishing is the "tooled-joint" finish. There is no plastering needed in this type of finish. Each vertical and horizontal joint in the courses is simply cleaned up, accentuated, and smoothed out with cement paste using the trowel and a grooving tool. A short piece of 13 mm reinforcing bar serves as a grooving tool.

CHAPTER 10

METALWORKS

10.01 GENERAL

Metals are widely used materials of construction for water supply systems. They are often used in making reservoirs, pipes, nails, bolts and as structural reinforcement. With these variety of uses, it is therefore necessary to have a working knowledge on how to use metals in construction.

10.02 REINFORCING STEEL BARS

Concrete has high compressive strength but has low tensile strength. For this reason, it is necessary to add steel rods or bars to concrete structures subjected to bending. Also, reinforcing bars are added to concrete structures to permit the use of smaller structural members.

Reinforcing steel bars available in the market today may be round or square and may be either plain or deformed. Deformed bars usually produce a better bond with the concrete because it has a rougher surface than plain bars.

A. Preparation of Reinforcing Bars

To insure a good bond between the concrete and the reinforcing bars, it is recommended that the bars be free of undesirable materials. The cleaning procedure is as follows:

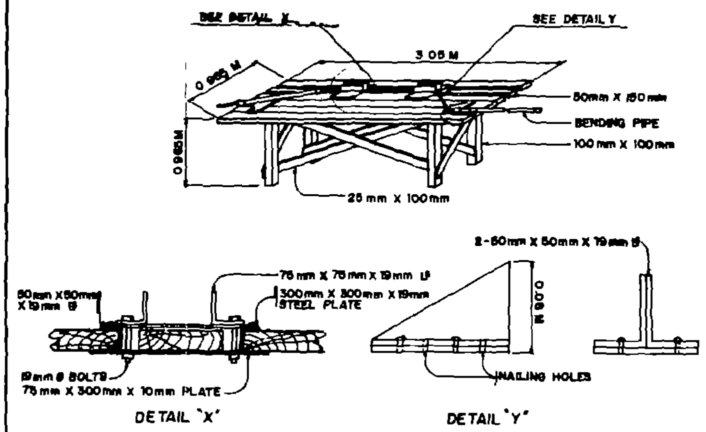
1. Remove all loose rust and other related materials. Any loose rust and mill scale that fly off when the bar is bent or struck with a hammer must be removed. However, if the rusts are firmly attached to the reinforcements, it is recommended to leave it intact as this may augment the holding capacity of the bar, thus, increasing the bar-concrete bond.

   Also, if a bar appears to have rusted excessively, and its cross-sectional area was reduced significantly, it is suggested that it should be rejected.

2. Remove all objectionable coatings such as paints, oils, grease, dried mud and loose concrete because they tend to decrease the bar-concrete bond.

B. Cutting and Bending of Bars

Steel bars may be cut and bent to shape as specified in the plans either in the shop or in the field. Shown in Figure 10.01A is a typical table for bending bars. Bending of bars may be done cold or with heating. If bending and straightening is aided by heating, heat the steel bar in a manner that the cherry red color is not exceeded, to maintain the structural strength of the bar. Also, the heated bar should be air-cooled slowly and uniformly.



A TABLE FOR BENDING STEEL REINFORCING BARS

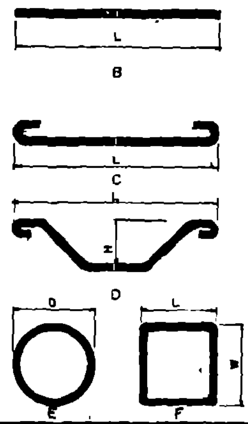


TABLE 10.01
CUTTING AND BENDING TOLERANCES

FIGURE	BAR DIAMETER	TOLERANCE
B	ALL SIZES	± 25mm (1") FOR L
C	22.2 mm OR SMALLER 25.4mm OR LARGER	± 13mm (0.5") FOR L ± 25mm (1") FOR L
D	ALL SIZES 22.2mm OR SMALLER 25.4mm OR LARGER	± 13mm (0.5") FOR H ± 13mm (0.5") FOR L ± 25mm (1") FOR L
E	ALL SIZES	± 13mm (0.5") FOR D
F	ALL SIZES	± 13mm (0.5") FOR L ± 13mm (0.5") FOR W

FIGURE 10.01
CUTTING AND BENDING OF REINFORCING STEEL BARS

Furthermore, it is difficult to cut and bend bars exactly as the plans require. To take care of this problem, tolerances or maximum allowable deviations are prescribed. These are presented in Table 10.01.

C. **Splicing**

Splicing is the bonding or jointing of two or more lengths of steel bars. It is usually employed in the formation of the reinforcement steel network in floor slabs, columns, beams and other structures. Splicing in these structures is usually located in places where the tensile stress is less than half the permissible stress. Splicing may be accomplished either by the use of tie bars or by welding.

1. Types of Ties Using Tie Wires

   Tie wires usually employed in tying reinforcing bars are the no. 16 gauge blacks, soft-annealed wires. Heavier gauge such as no. 15 or no. 14 gauge wire may be used when tying bars in heavily reinforced walls to maintain the proper position of the horizontal reinforcement.

The type of ties to be used when securing reinforcing bars depends primarily on the type of structure. Presented below are the different types of ties used in reinforced concrete construction.

a. **Snap or Single Tie** – Snap or single tie (Figure 10.02A) is used in flat horizontal work. The tying process consists of wrapping once around the two crossing bars in a diagonal manner followed by twisting the ends of wire together until the wound wire has tightly secured the joint. The excess ends of wire are then cut using a pair of pliers and then flattened to prevent their protruding through the top of concrete.

b. **Wrap and Snap Tie** – Wrap and snap tie (Figure 10.02B) is employed when tying wall reinforcement to prevent shifting of horizontal bars. The tying process consists of wrapping the wire around the vertical bars 1-1/2 times and then diagonally around the intersecting horizontal bars. The end of the tie wires are then trimmed.

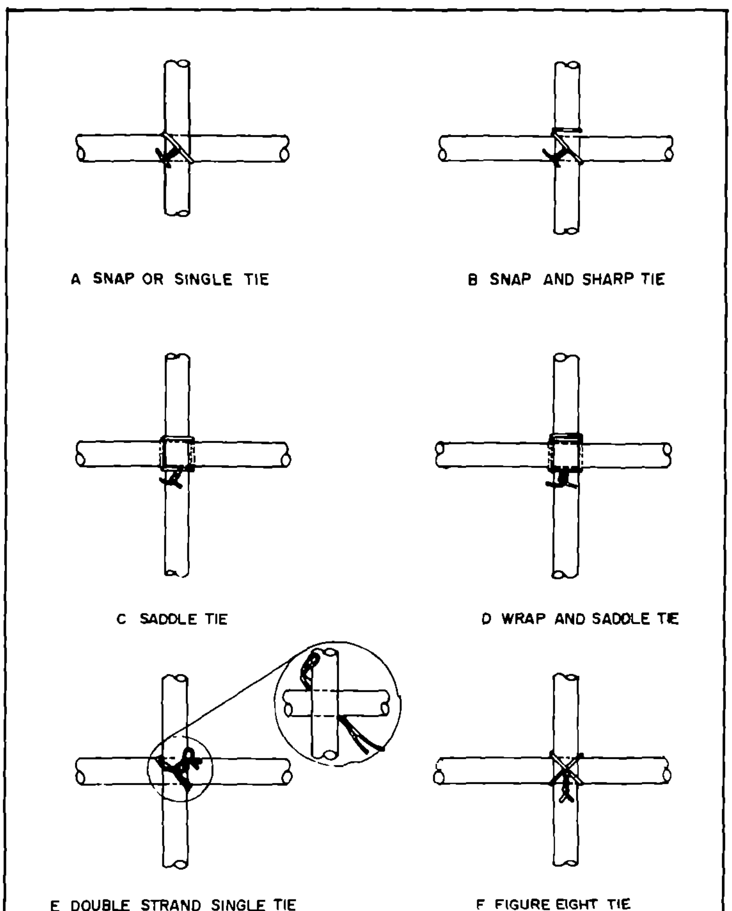


FIGURE 10 02
TYPICAL REINFORCING STEEL BAR TIES

c. **Saddle Tie** – Saddle tie (Figure 10.02C) is employed in tying reinforcement in footings or other mats. As shown in the figure, the wires pass half-way around one of the bars on each side of the crossing bar, then up and around the first bar where two ends are twisted together.

d. **Wrap and Saddle Tie** – Wrap and saddle tie (Figure 10.02D) is also often employed in tying reinforcement in footings or other mats. The tying process consists of wrapping the wire around the first bar 1-1/2 times and then proceed to the process of tying wires by saddle method.

e. **Double Strand Single Tie** – Double strand single tie (Figure 10.02E) is usually used for heavy works or in flat horizontal works which are always being subjected to heavy pressure. The tying process is similar to the single or snap tie except that the number of wires is doubled.

f. **Figure Eight Tie** – Figure eight tie (Figure 10.02F) is used in tying reinforcements to a nail employed as spreader or spacer to hold bars away from the forms. The tying process consists of wrapping a wire once around the nail head; then around the outside bar of the wall and then drawing the bars securely against the nailhead by twisting the ends of the wire.

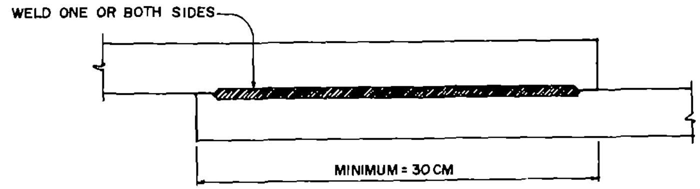
2. Lap Splicing

Lap splicing is employed in jointing two parallel bars together either by use of tie wires or by welding. The minimum length of the joint should be 40 times the bar diameter but shall not be less than 30 cm (12 in.).

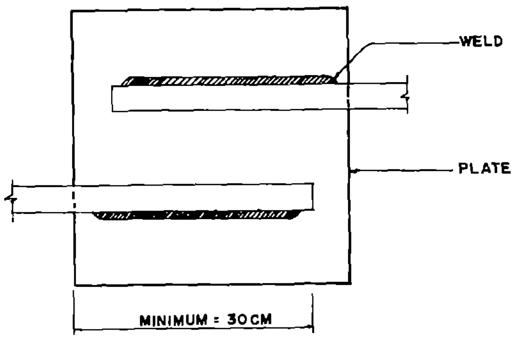
a. **Use of Tie Wires** – Bars with diameters 3.58 cm. (#11) and below may be spliced by overlapping and wiring them together.

b. **Welded Lap Splicing** – Welded lap splicing is recommended only for 1.59 mm ø (#5) bars or smaller. It may be accomplished with or without a back-up plate. Shown in Figures 10.03A and 10.03B is lap splicing without a back-up plate and with backplate, respectively. Also, for splicing bars in narrow concrete members where the offset between bars in a single lap splice may buckle the members, a double lap joint (Figure 10.03C) is recommended.

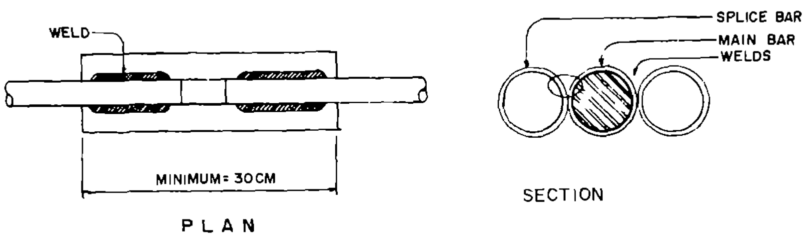
c. **Splicing by Butt Welding** – Butt welding is one of the widely used methods in splicing. Shown in Figure 10.04 are typical welded splices. Single-Vee Groove Weld (Figure 10.04A) and Double-Vee Groove Weld (Figure 10.04B) are employed for welding horizontal bars together. Single-bevel Groove Weld (Figure 10.04C) for vertical bars and Double-beveled Groove Weld (Figure 10.04D) are used for jointing column verticals.



A WELDED CONTACT LAP SPLICE



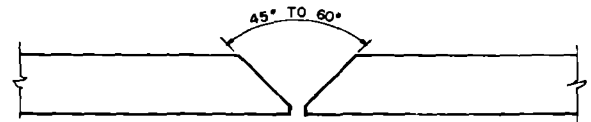
B WELDED LAP SPLICE WITH PLATE



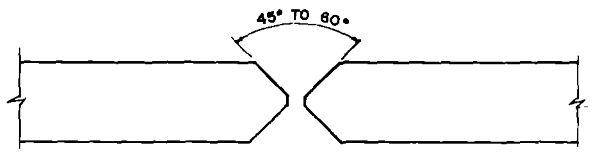
C WELDED DOUBLE LAP JOINT

FIGURE 10 03

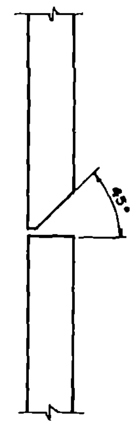
TYPICAL LAP JOINTS



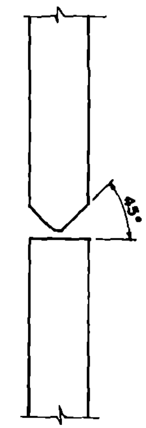
A SINGLE-VEE GROOVE WELD



B DOUBLE-VEE GROOVE WELD



C SINGLE-BEVEL GROOVE WELD



D DOUBLE-BEVEL GROOVE WELD

FIGURE 10 04

SPLICING BY BUTT WELDING

D. Placement of Reinforcing Bars

1. Placement Tolerance

The strength of the finished concrete depends greatly on the correct position of reinforcements. For instance, a 13 mm (1/2 in.) deviation of bars in a 150 mm (6 in.) deep slab could reduce its load carrying capacity by 20 percent. Therefore, as much as practicable, reinforcements should be placed as specified. However, wnile it is essential that reinforcements be placed where called for in the plans, some tolerances are necessary. Presented below are the allowable placement tolerances.

a. Reinforcement of beams and slabs should be within 6.4 mm (1/4 in.) of the specified distance from the tension and compression face. Lengthwise, a placement tolerance of 50 mm (2 in.) is normally acceptable. If length of embedment is critical, the length of bars should be 75 mm (3 in.) longer than the computed minimum to allow for accumulation of tolerances.

b. Spacing of reinforcements in wide slabs and walls may be permitted to vary by 13 mm (1/2 in.) or slightly more if necessary to clear obstructions so long as the required number of bars are present.

2. Distance of Reinforcement From the Concrete Surface

Main reinforcement bars should be at least 25 mm (1 in.) from the nearest face of the concrete section for slabs or light structural members, 38 - 50 mm for heavy structural members, and 50 - 100 mm for important members exposed to sea or alkaline water.

3. Spacing

Spacing of reinforcements affects the distribution of load throughout the concrete structure. In case the spacing is unequal, an unequal distribution of load will result which will eventually cause a crack in the concrete surface. For reinforced concrete structures, the maximum spacing of principal slab reinforcements should not exceed 3 times the slab thickness. Also, the minimum spacing in slabs, beams and columns should not be less than 63 mm except at laps or intersections.

E. Check List During Bar Placing

After placing the bars and before proceeding to the concreting of the structure, the following items should be checked:

1. The number of pieces, sizes, lengths, (if bars are straight), shape (if bent) and grade of steel for all bars required in each structural member.

2. The proper positioning of bars in each member whether this conforms to the specified tolerances.

3. The height and location of all bar supports.

4. The location and length of all splices.

5. The location, projection and embedment of all bars.

6. The proper amount of concrete cover space between forms and steel for all members.

10.03 WELDING

Electric arc welding is commonly used to join metal surfaces. The process consists of melting and fusing of a metal electrode with the contiguous metal surfaces to be joined. The welding heat is obtained from the electric arc formed between the electrode and the parts to be welded. The arc temperature is approximately 10,000^{o}F.

A. Welding Electrodes

Electrodes are one of the vital elements in welding, hence, they must be handled in a manner that they will not bend and the coating is kept intact. Also, they should be protected from wetting due to rain, dew and other sources of moisture. One way is to limit the number brought out from the storage area. This number is equivalent to the amount which can be used in one day. In no case should damp electrodes be used in welding metals, for when used, a white vapor can be observed and a fierce cracking or explosive sound can be heard.

Procedure for Detecting Damp Electrodes

a. Pick up 3 to 5 electrodes and then place their ends in a circle made by placing the tip of the first finger in contact with the tip of the thumb finger in both hands.

b. Shake them and listen to the rattling sound as the electrodes strike each other. If a hard shrill metallic sound is produced, the electrodes are dry or contain little moisture. On the other hand, if a hollow sound is produced, the electrodes are damp and should be dried prior to use.

B. Type of Welded Joints

The selection of the type of welded joints depends upon the force to which the joint will be subjected. As a rule, the larger the surface being fused together, the stronger is the joint. However, the cost of welding also proportionately increases with an increase in the amount of electrodes used and the power cost. Shown in Figures 10.05 and 10.06 are the different types of welded joints.

C. Procedure of Welding

1. Gap and Groove Preparation

   a. Trim the surfaces to be jointed in accordance with weld ends preparation drawing. This may be accomplished by machining and grinding or by flame cutting and grinding.

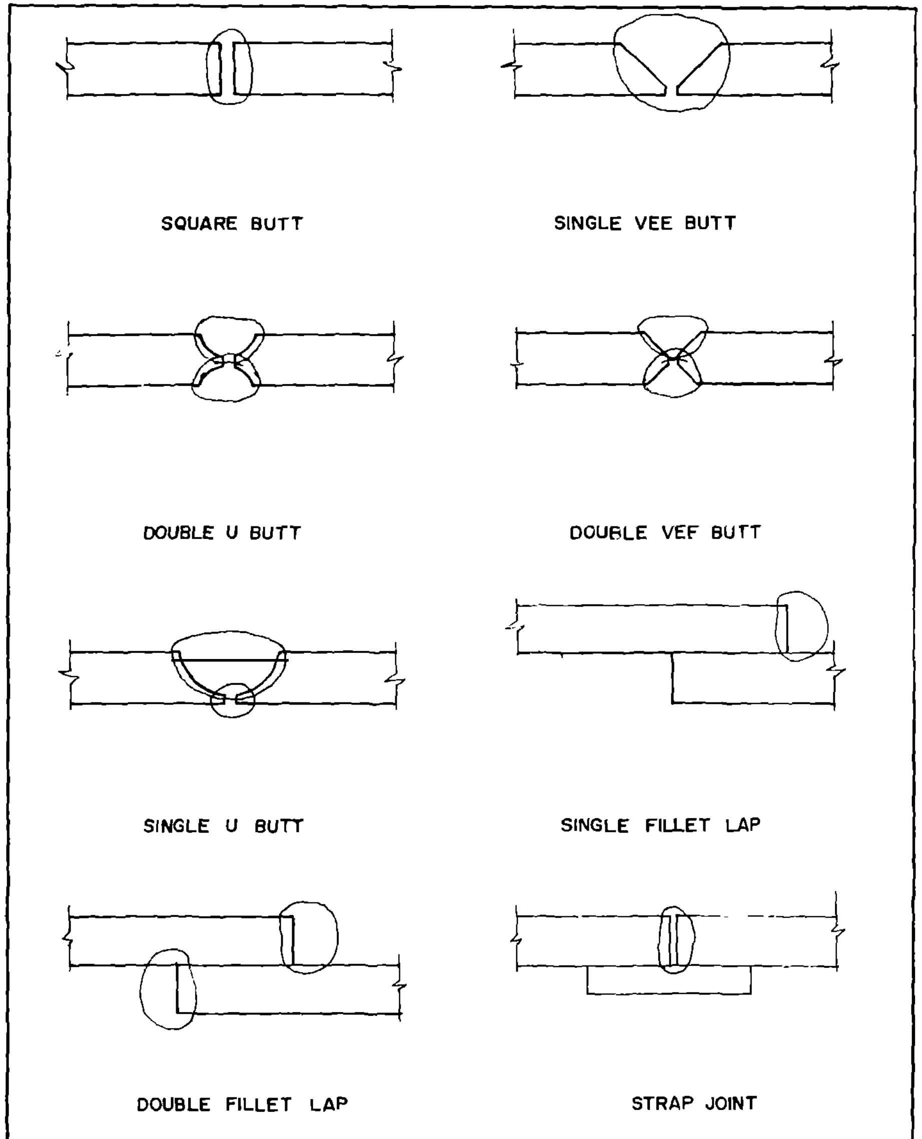


FIGURE 10.05

TYPES OF WELDED JOINTS

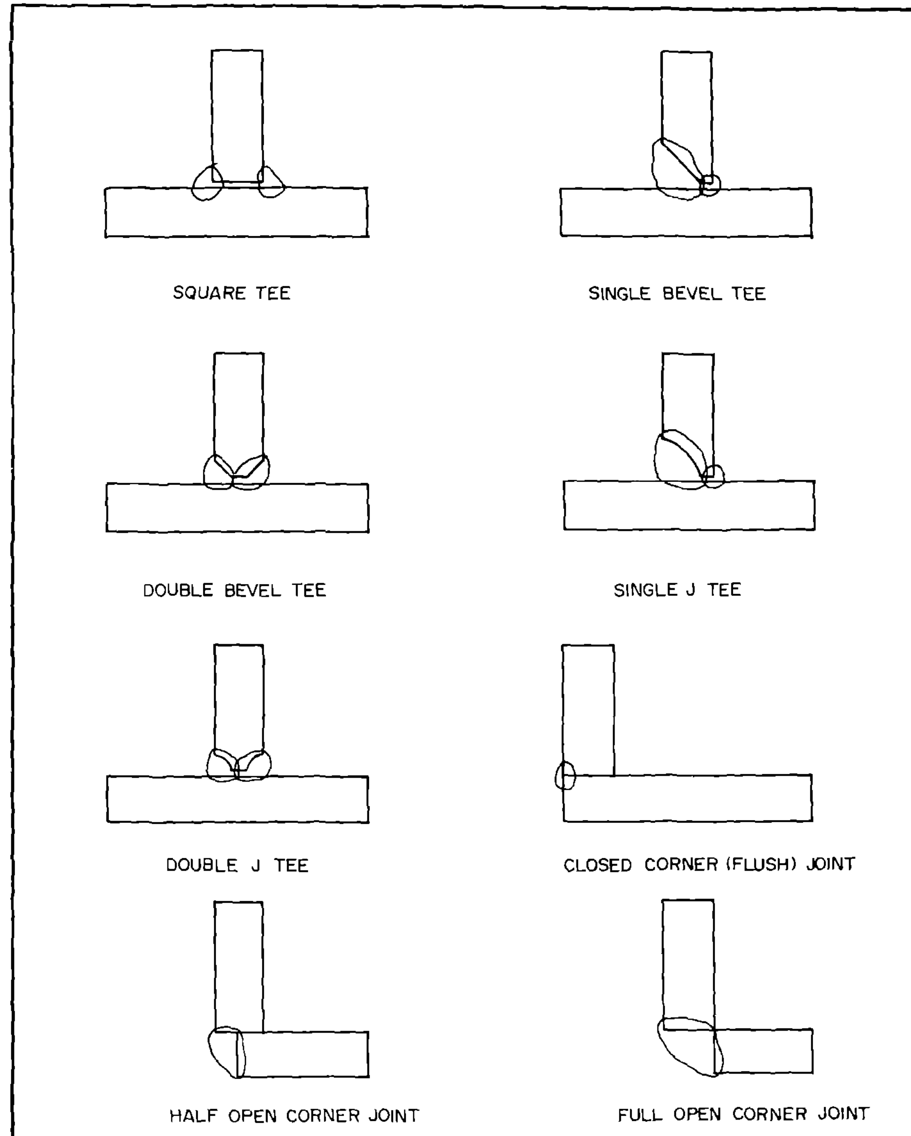


FIGURE 10.06

TYPES OF WELDED JOINTS

b. Smoothen the surfaces in the welding groove by removing all the notches and other irregularities.

c. Clean the edges to be welded by removing all grease, oil, rust, scale and other foreign materials.

2. Welding of Joints

Welding should not be carried out when the surfaces to be welded are wet or when raining or during high winds unless the work and the operator are properly shielded.

Procedure:

a. Put the "ground" of the electric welding machine in contact with the metals to be welded.

b. Allow the contact of the electrode which is connected to the electric welding machine with metal surfaces in the welding groove. Upon contact with the metal surface, an electric arc is generated and the electrode is melted and is fused in between the two surfaces to be joined. If the desired number of welding layers is more than one, clean each deposited layer of welded metal before additional welded metal is applied to its surface.

c. Check the welded surfaces and trim all irregularities. Finished weld heads should be central to the seam and the finished joint should be free from depressions, undercut edges, burrs, irregularities and valleys (Figure 10.07).

D. Causes and Cures of Weld Defects

Outlined below are the different weld defects, their causes and remedies.

1. Spattering

a. Causes

i. Electric current used is too high.

ii. Electrodes used are faulty.

b. Remedy

i. Whitewash parts in weld area.

ii. Adjust current to proper arc length.

iii. Change electrodes.

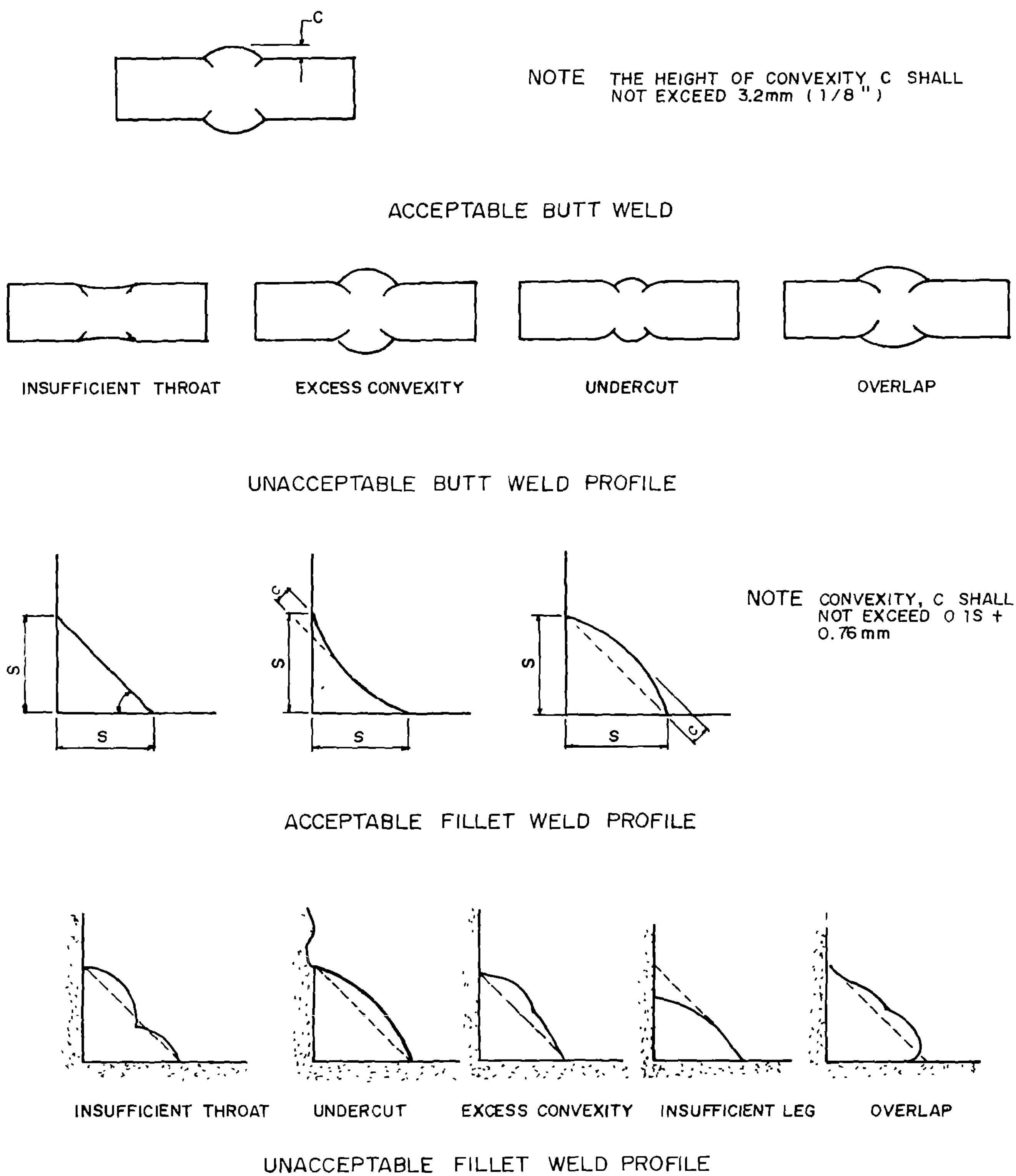


FIGURE 10 07

ACCEPTABLE AND DEFECTIVE WELDS

2. Weld Stresses

   a. Causes

      i. Faulty welds.

      ii. Rigid joints.

   b. Remedy

      i. Move parts slightly in welding to reduce stresses.

      ii. Anneal according to thickness of weld.

3. Distortion

   a. Causes

      i. Uneven heating.

      ii. Deposited metal shrinks.

   b. Remedy

      i. Form and clamp parts properly before welding.

      ii. Distribute welding to prevent uneven heating.

4. Cracked Welds

   a. Causes

      i. Wrong electrode used.

      ii. Welds unbalanced.

      iii. Faulty welds.

      iv. Faulty preparation.

      v. Rigid joints.

   b. Remedy

      i. Design structure and welding procedure to eliminate rigid joints.

      ii. Adjust weld size to parts size.

      iii. Work with amperage that is as low as possible.

5. Poor Fusion

   a. Causes

      i. Current improperly adjusted.

      ii. Faulty preparation.

      iii. Improper electrode size.

   b. Remedy

      i. Adjust electrode and vee sizes.

      ii. Welding heat must be enough to melt sides of joint.

      iii. Adjust current to a level enough for the penetration and deposition of electrode.

      iv. Keep weld metal from curling away from plates.

6. Undercutting

   a. Causes

      i. Faulty electrode manipulation.

      ii. Current too high.

   b. Remedies

      i. Use a uniform weave when welding.

      ii. Use moderate current.

      iii. Weld slowly.

CHAPTER 11

CONSTRUCTION OF RESERVOIRS

11.01 GENERAL

A reservoir is a vital element in a water supply system. It is primarily employed in storing water for use during peak demand periods and in emergencies, and for equalizing pressure within the distribution system.

Reservoirs may be classified according to their functions or manner of operation, relative position with respect to the earth's surface, and as to type of materials of construction. These could be further subdivided into the following sub-groupings:

A. Classification According to Function or Manner of Operation

1. For storing water.

2. For equalizing pressure within the distribution system. Under this division are the Fill-and-Draw and the Floating-on-the-Line reservoirs (Figure 11.01A). A Fill-and-Draw reservoir is employed if the desired system operation is such that water is pumped or conveyed directly from the water source to the reservoir and then distributed to the consumers. On the other hand, if the desired system operation calls for the pumping of water both into the reservoir and to the customers at the same time, the floating-on-the-line reservoir is employed. Actually, in the floating-on-the-line reservoir, water enters the reservoir only during the period of low demand. During the peak demand, the reservoir and the pump are simultaneously supplying water to the consumers.

3. As sump for booster pumps — Reservoir assumes this function in cases where the pressure in the water mains from the water source is not enough to bring water to public taps at a desired pressure. Water is collected in the sump and is then boosted by pumping to the consumers.

B. Classification According to Relative Position With Respect to the Earth's Surface

Illustrated in Figure 11.01 is the schematic diagram of reservoirs classified according to their relative position with respect to the earth's surface. If the reservoir is located above the ground, it is called elevated and if its base is sitting on or is buried in the ground, the reservoir is called ground level. In between these two types is the hydropneumatic pressure tanks (Figure 11.01C) wherein the reservoir is located at ground level, however, the desired pressure to distribute water to the consumers is obtained by compressing air.

C. Classification According to Materials of Construction

Reservoirs for use in water supply system could be fabricated using a variety of construction materials. For rural water supply system, only four types

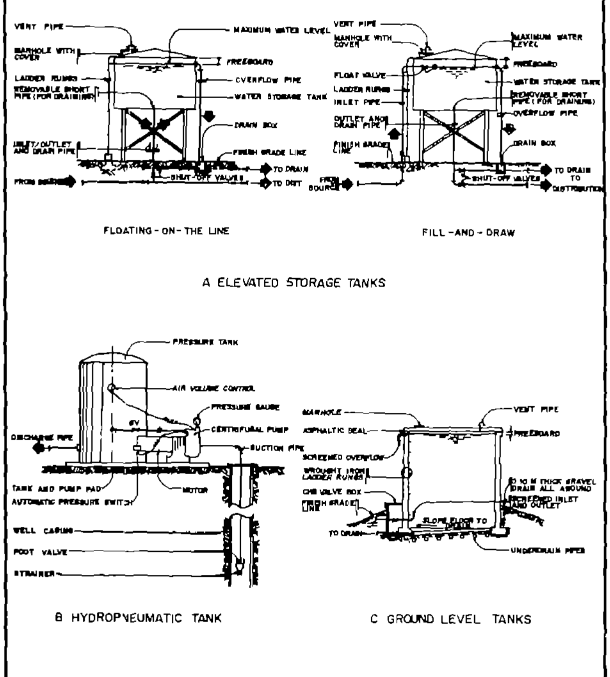


FIGURE 11.01
SCHEMATIC DIAGRAM OF DIFFERENT TYPES OF RESERVOIR

are considered for economic reasons. They are the reinforced concrete, concrete hollow blocks, steel and ferrocement.

11.02 REINFORCED CONCRETE RESERVOIRS

Reinforced concrete reservoirs are fabricated of concrete which is reinforced with steel bars. The process consists of preparing the formworks to serve as mold for concrete, the positioning of steel bars and construction joints or waterstops, the pouring of freshly prepared concrete mix into the forms, curing of concrete, removal of forms, installation of the necessary appurtenances, finishing and waterproofing.

A. Ground Level Reservoir

Shown in Figure 11.02 is a typical ground level reservoir and its appurtenances. The procedure of construction is as follows:

1. Foundation Works

   This division of work consists of the preparation of foundation of reservoir and it includes the following items:

   a. Mark the location of the reservoir as specified in the plans.

   b. Determine the bearing capacity of soil to know whether it is capa-

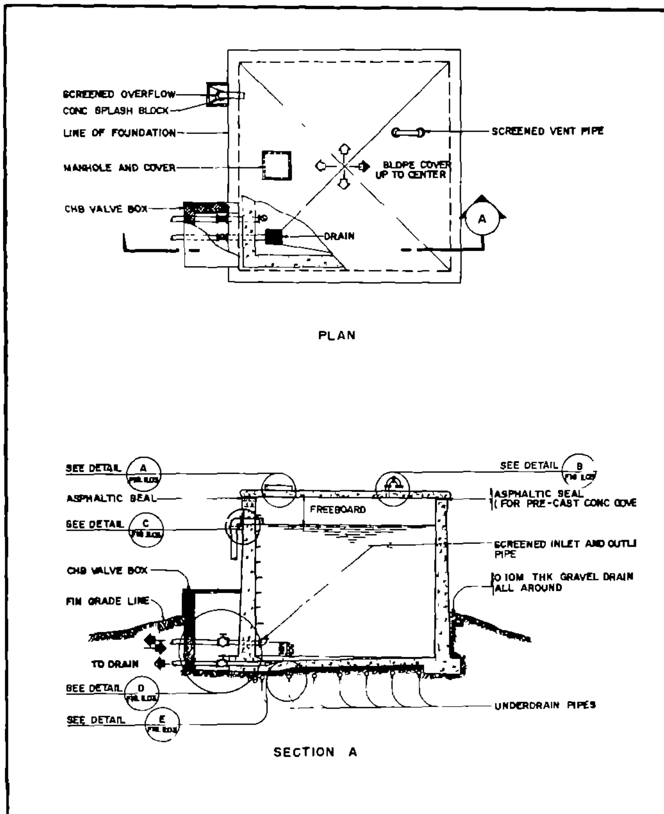


FIGURE II.02
GROUND LEVEL REINFORCED CONCRETE RESERVOIR

ble of supporting the weight of reservoir and its water contents when it is full. However, if it is found incapable, the following measure should be taken in decreasing priorities:

i. Look for a new location of reservoir.

ii. Design the pile foundation and determine whether there is enough funds for its construction.

c. Start the excavation works. For the detail of the excavation process please refer to section 3.02.

d. Prepare the soil foundation and underdrain. Shown in Figure 11.03E is a typical detail of an underdrain. It consists of perforated PVC, PE or AC pipe surrounded by a gravel blanket. For small tanks, pipes could be deleted and the underdrain will consist only of a gravel layer properly compacted to support the imposed load on it. Underdrain is necessary to drain water at the base of the reservoir in order to prevent flotation when empty and the water table is above the base of the reservoir.

2. Construction of the Body of Reservoir and Installation of Reservoir Appurtenances.

a. **Start the installation of forms.** The size and shape should conform to the prepared plans. In making forms refer to section 8.08.

b. Start the placement of reinforcing bars, waterstops and other construction joints. The fabrication and placement procedure is discussed in section 10.02 for reinforcing bars and section 8.10 for construction joints.

c. **Selection of Concrete Proportion** – Refer to section 8.04 for the selection of concrete proportion and consistency.

d. **Batching and Mixing** – The volume of materials per batch is primarily dependent upon the capacity of the mixers and the quantity that can be used within 1-1/2 hours. For details of the procedure, please refer to sections 8.06 and 8.07.

e. **Placement and Consolidation of Concrete** – Sections 8.09 and 8.10 discuss the procedure for the placement and consolidation of concrete, respectively. It is suggested that the contractor should refer to these sections before starting the work.

f. **Curing of Concrete** – To achieve a durable and strong concrete structure, it is suggested that the concrete be cured continuously for 28 days. The curing procedure is discussed in section 8.12.

g. **Placement of Appurtenances** – After at least 14 days of continuous curing, the forms should be removed and the appurtenances shown in Figure 11.03 be installed. The process consists of chipping off of the concrete before it had hardened, the placement of the appurtenances as indicated in the plan and then securing it in place by use of a cement mortar or by use of an asphaltic seal. Alternately, the appurtenances could be installed before the pouring of concrete, during formworks or placement of reinforcing bars.

h. **Finishing** – After the removal of forms, all concrete surfaces should be examined for structural defects such as honeycombs, rock pockets, faulty construction forms, etc. These areas should be repaired in accordance to section 8.14.

i. **Waterproofing** – Waterproofing of reinforced concrete structures could be accomplished in a variety of ways. The most commonly used are the waterproofing admixtures, membranes and external coating. The detailed application procedure is presented in Section 11.07: Waterproofing of Reservoirs.

B. **Elevated Reservoirs**

Shown in Figure 11.04 is a typical elevated reinforced concrete reservoirs. It is constructed using two pre-fabricated reinforced concrete pipe, the first pipe is slightly buried and filled with earth and gravel and the second pipe is placed at the top of the first pipe and their joints are cemented. The detailed construction procedure is as follows:

1. Foundation Works

a. Excavate a trench, 110 cm in diameter and 20-30 cm in depth. This will serve as the foundation of the tank.

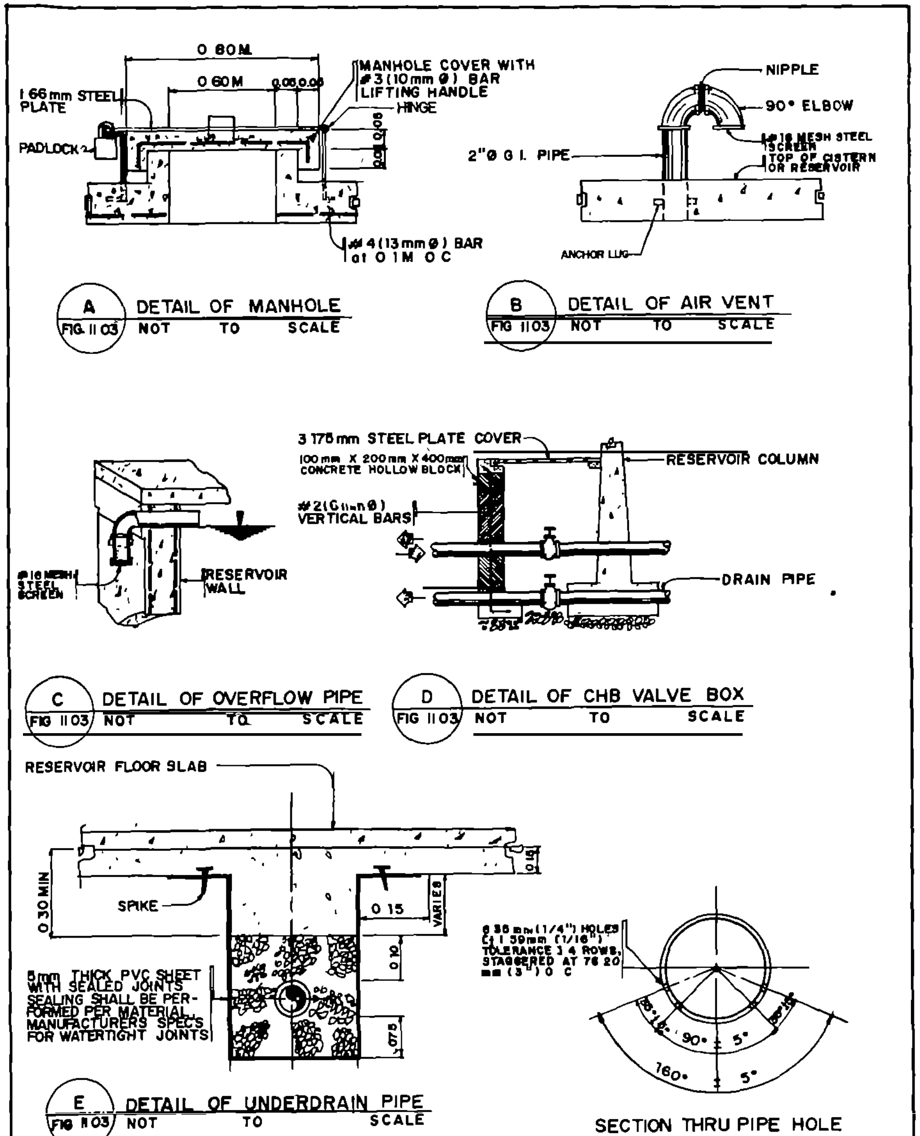


FIGURE 11.03

TYPICAL DETAILS OF GROUND LEVEL REINFORCED CONCRETE RESERVOIR

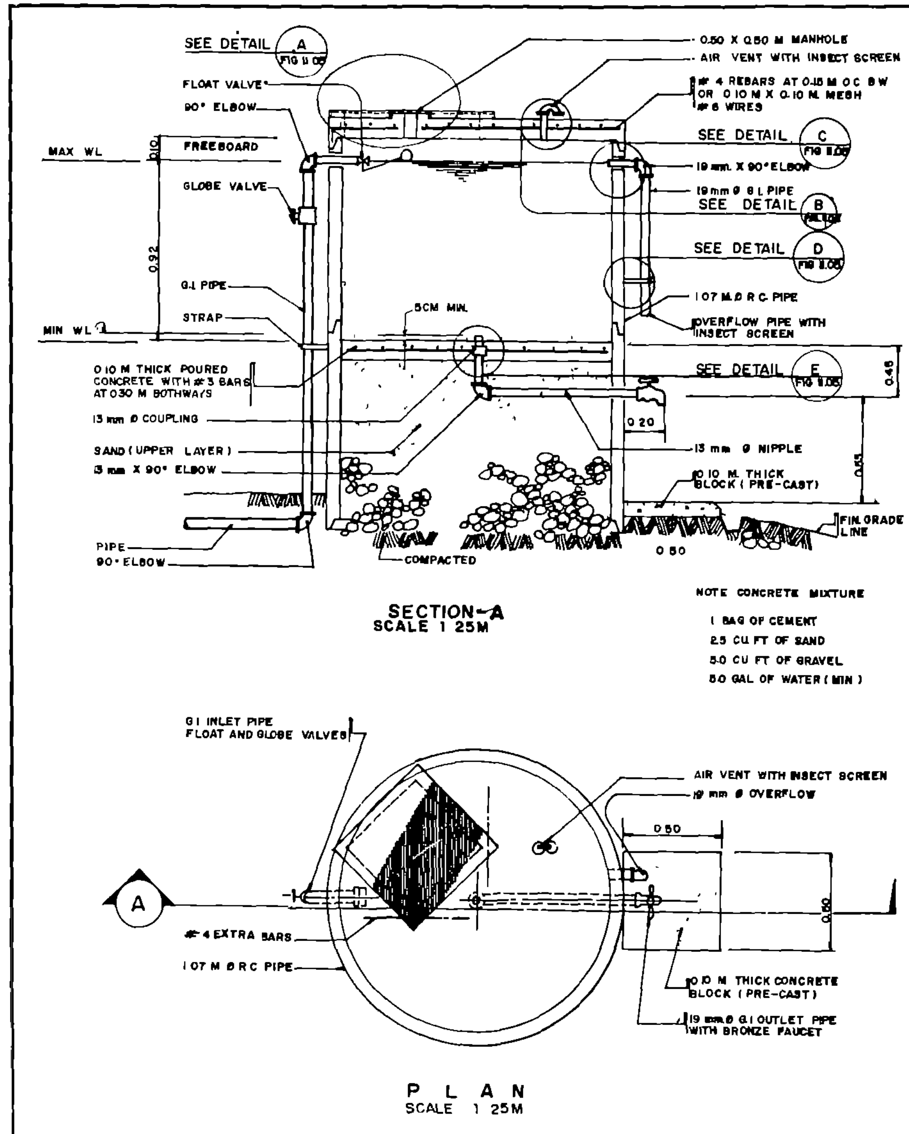


FIGURE 11.04

SLIGHTLY ELEVATED REINFORCED CONCRETE RESERVOIR

CAPACITY = 827 LITERS (220 GALLONS)

b. Consolidate and level the soil at the bottom of the trench and pour a Class C concrete mix until the concrete layer formed is around 10 cm thick.

c. Place the first reinforced concrete pipe on the concrete foundation and grout it in place using a cement mortar which is prepared by mixing 1 part of cement to 2 parts sand. Allow the concrete to harden for 1 day.

d. Fill the pipe with earth and gravel up to the level shown in Figure 11.04. This pipe will serve as the platform or support of the reservoir.

2. Construction of the Body of the Reservoir and Installation of Reservoir Appurtenances.

   a. Position the outlet pipe as shown in Figure 11.04 and detail (E/11.05).

   b. Position the reinforcing bars of the reservoir floor.

   c. Prepare a Class A concrete mix and pour it into the pipe until the thickness of the concrete layer form is approximately 15 cm. This concrete layer will serve as the floor of the reservoir.

   d. Place the second pipe at the top of the first pipe and then sealed their joints using a mastic sealer or asphaltic seal.

   e. Install all the necessary appurtenances of the reservoir as shown in Figure 11.04. The details of these appurtenances is illustrated in Figure 11.05.

   f. Construct a reinforced concrete reservoir cover equipped with manhole provided with cover. Alternately, a pre-fabricated reinforced concrete slab could be employed.

   g. Repair all structural defects of the constructed reservoir and then make it watertight. The waterproofing procedure is discussed in detail in section 11.07.

11.03 CONCRETE HOLLOW BLOCKS RESERVOIR

Concrete hollow blocks is one of the most commonly used materials of construction when building reservoirs for rural water supply systems. The process includes excavation and foundation works, placing of CHB wall, pouring of reinforced concrete floor slab, placement of appurtenances, patching and plastering, curing and waterproofing. The details of the above-mentioned works is presented in Chapter 9, Concrete Masonry.

A. Ground Level Reservoir

Ground level CHB reservoir has similar features as the reinforced concrete reservoir as illustrated in Figure 11.02. The construction procedure are as follows:

1. Foundation Works

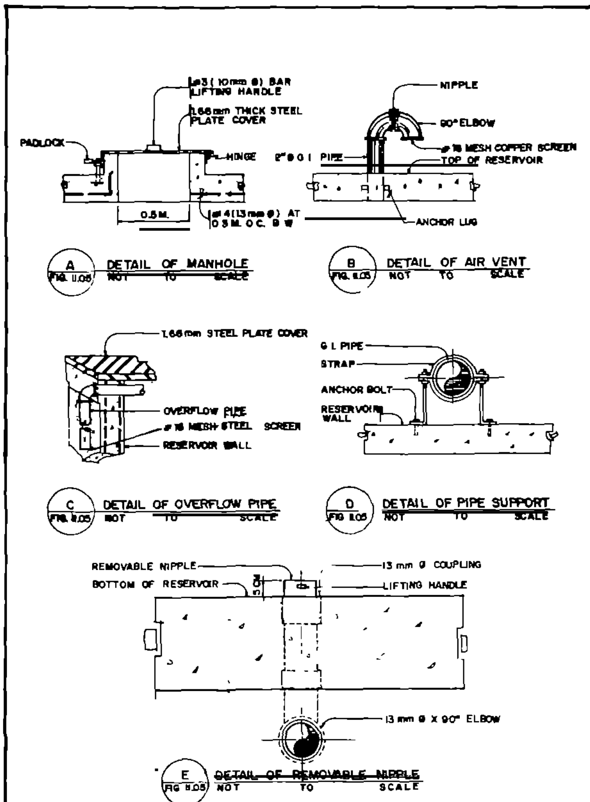


FIGURE 11 05
TYPICAL DETAILS OF SLIGHTLY ELEVATED REINFORCED CONCRETE RESERVOIR

The work included in this subsection is similar to those described in foundation works for the construction of reinforced concrete reservoir as presented in section 11.02.

2. Construction of the Body of Reservoir and Installation of Appurtenances.

   a. Start building the walls of the reservoir. With respect to the process of laying CHB, refer to section 9.04.

   b. Position the reinforcing bars for the reservoir floor.

   c. Prepare a Class A concrete mix and pour it on the floor of the reservoir until the thickness of the concrete layer specified in the plan is reached.

   d. Install all the ncessary appurtenances as illustrated in Figure 11.02. The details of these appurtenances is illustrated in Figure 11.03.

   e. Start patching the holes and plastering of CHB wall using a concrete mortar prepared by mixing 1 part of cement to 2 parts of graded sand.

   f. Construct reinforced concrete reservoir cover equipped with manholes provided with cover. Alternately, a prefabricated reinforced concrete slab could be employed.

g. Make the reservoir watertight. The waterproofing procedure is discussed in detail in section 11.07.

B. **Elevated Reservoirs**

A typical elevated concrete hollow blocks reservoir is shown in Figure 11.06. The construction procedure is as follows:

1. Foundation Works

   a. Mark the location of the proposed reservoir and start digging a trench of 0.6 meter deep and 0.3 meter wide. This will serve as the foundation of your reservoir.

   b. Start laying concrete hollow blocks for the wall of the reservoir. The laying procedure is discussed in detail in section 9.04.

   c. Fill the part enclosed by the CHB wall with sand and gravel up to the level shown in Figure 11.06 and then consolidate the fill. This portion will serve as the platform or support of the reservoir.

2. Construction of the Body of the Reservoir and Installation of Reservoir Appurtenances.

   a. Position the outlet pipe as shown in Figure 11.06 and detail (A/11.07).

   b. Position the reinforcing bars of the reservoir floor.

   c. Prepare a Class A concrete mix and pour it on the compacted gravel and sand layer until the thickness of the concrete layer formed is approximately 15 cm. This concrete layer will serve as the floor slab of the reservoir.

   d. Install all the necessary appurtenances as shown in Figure 11.06. The details of these appurtenances is illustrated in Figure 11.07.

   e. Provide the reservoir with a reinforced concrete cover.

   f. Start the patching and plastering works. For details of the procedure, please refer to sections 9.05 and 9.06.

11.04 STEEL RESERVOIRS

Steel reservoirs for use in rural water supply system are usually fabricated using 3 - 10 mm thick steel plate and anchored in place using a reinforced concrete foundation. The work necessary consists of two stages: the building of the reservoir steel body and reinforced concrete foundation, and the placement of the reservoir body on the foundation.

The building of the reservoir body consists of cutting the steel plate, molding it into the desired reservoir shape and then jointing the metal plates. Jointing may be accomplished either by welding or by rivetting. On the other hand, the reinforced concrete foundations may be either prefabricated or cast-in-place. In both cases, it should be designed to take care of the weight of the reservoir and its contents when it is full of water.

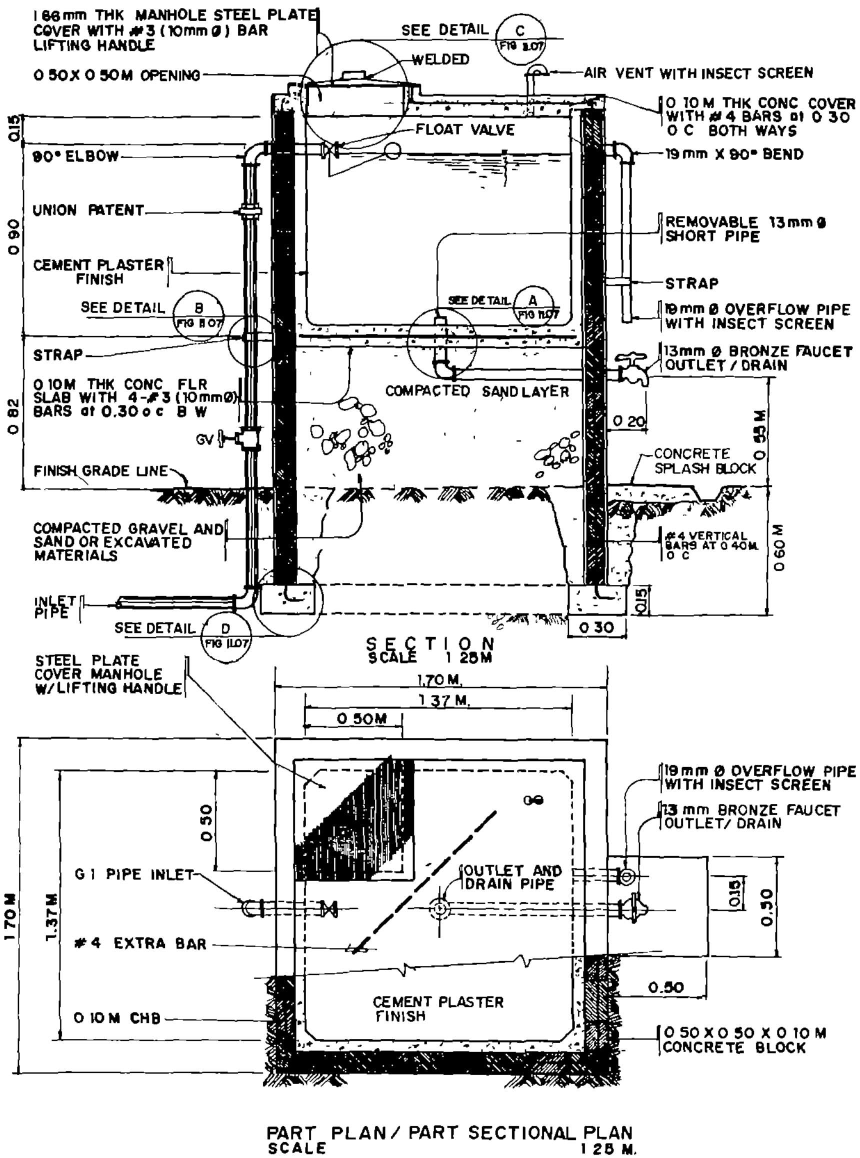


FIGURE 11.06
SLIGHTLY ELEVATED CONCRETE HOLLOW BLOCKS STORAGE TANK
CAPACITY = 1690 LITERS (450 GALLONS)

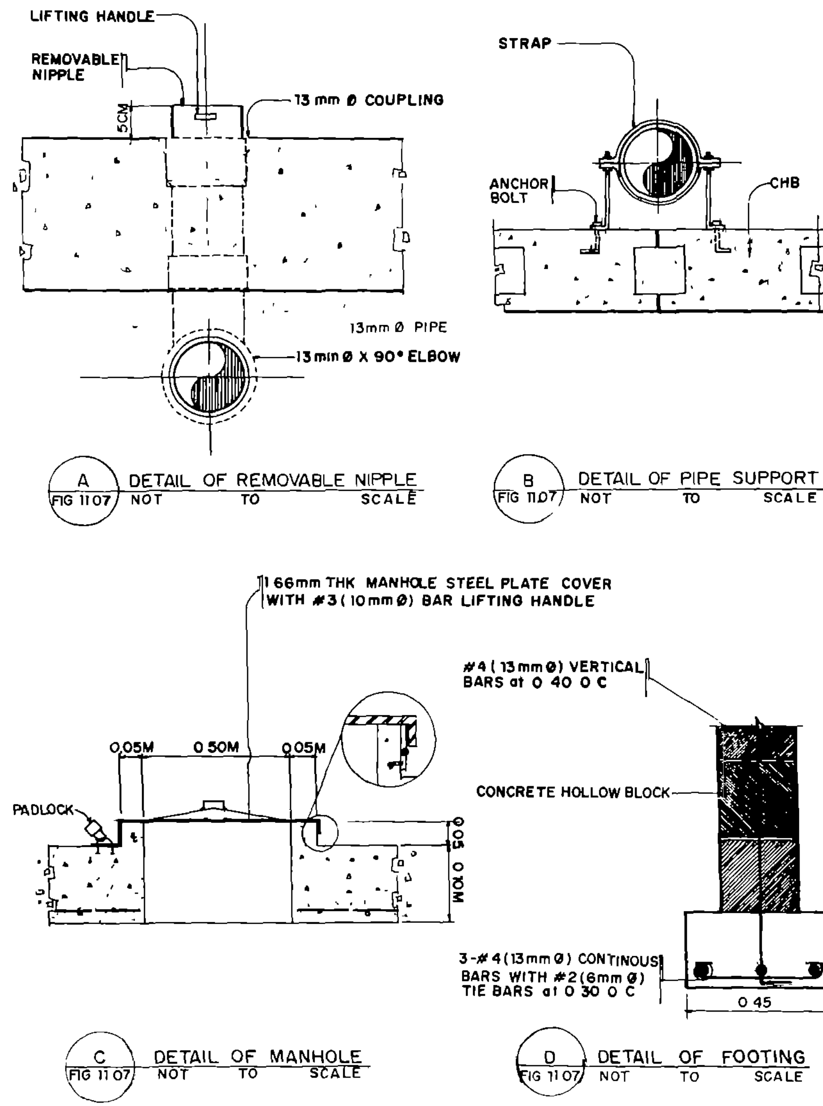


FIGURE 11 07
TYPICAL DETAILS OF SLIGHTLY ELEVATED CONCRETE HOLLOW BLOCKS RESERVOIR

A. **Ground Level Reservoir**

Illustrated in Figures 11.08, 11.10 and 11.13 are three typical assembly of ground level reservoir, its appurtenances and foundations. The construction procedures are as follows:

1. Prepare the foundation of the reservoir. It should be observed that the foundation of these reservoirs are reinforced concrete, therefore, it is suggested that Chapter 8, Concrete Design and Construction should be referred to before starting the job. Presented in this manual are three ways of supporting a steel ground level reservoir. They are:

   a. **Using a Reinforced Concrete Ring Wall** – This type of foundation is illustrated in Figure 11.08 and detail (F/11.09). The reservoir body and the foundation is secured-in-place using a cement grout.

   b. **Using a Concrete Floor Slab** – This type of foundation is illustrated in Figure 11.10 and detail (A/11.10). The reservoir body is secured-in-place using a cement grout.

   c. **Using Reinforced Concrete Footing and an I-Beam.** This type of foundation consists of an I-Beam welded to a base plate which is bolted into a reinforced concrete footing as shown in Figures 11.12 and 11.13, and detail (K/11.11). The reservoir body is connected on the foundation by welding-in-place or by bolting the base of the reservoir to the I-Beam support.

2. Assemble the reservoir body in accordance with Figures 11.08, 11.10 and 11.13. The assembly process consists of cutting the steel plate, the molding of the steel plate into the desired reservoir shape and the jointing of the metal plates either by welding or rivetting.

3. Place the reservoir body on the prepared foundation using the rope and pulley system or by use of a crane.

4. Secure it in place by any of the following methods:

   a. If the foundation used is the type shown in Figures 11.08 and 11.10, the reservoir body could be secured in place by the use of a cement grout.

   b. If the type of foundation used is similar to what is shown in Figure 11.13, the reservoir body could be secured by the use of bolts and/or by welding. Illustrated in Figure 11.12 is the anchor bolt plan and base plate detail.

5. Install the reservoir appurtenances as shown in figures 11.08, 11.10 and 11.13. The detail of the installation is shown in Figures 11.09 and 11.11.

6. Paint the steel surface with anti-rust paints. The type of paint to be used should be the type which does not impart odor and taste to water, and should not be toxic.

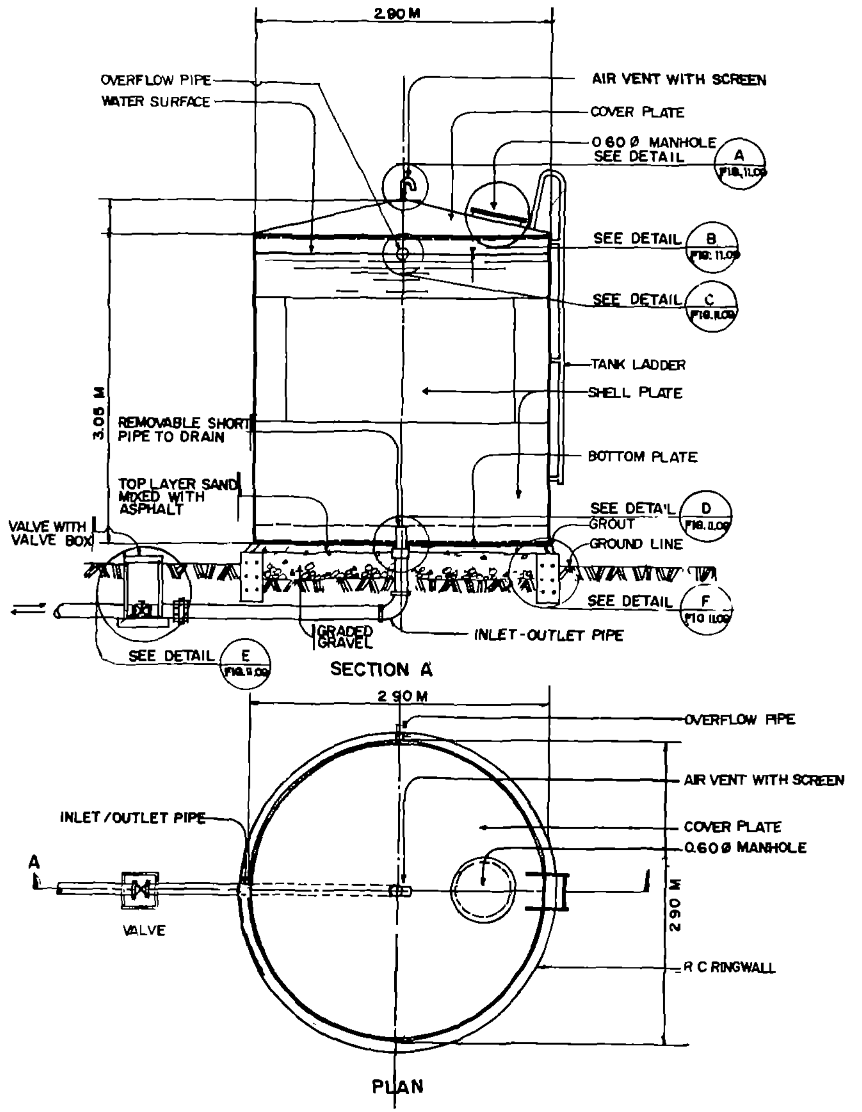


FIGURE 11.08

STEEL TANK ON REINFORCED CONCRETE RINGWALL
CAPACITY = 18,925 LITERS (5,000 GALLONS)

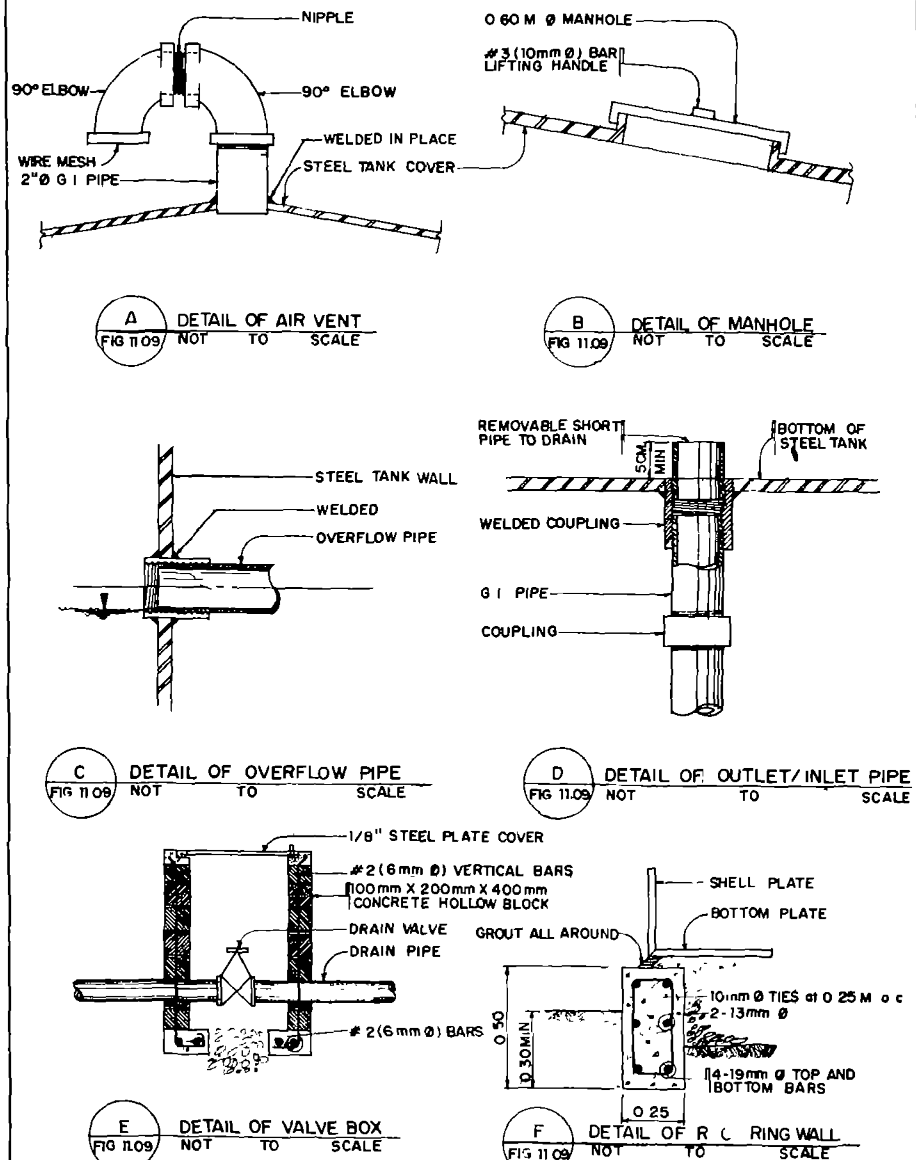


FIGURE 11.09

TYPICAL DETAILS OF STEEL TANKS

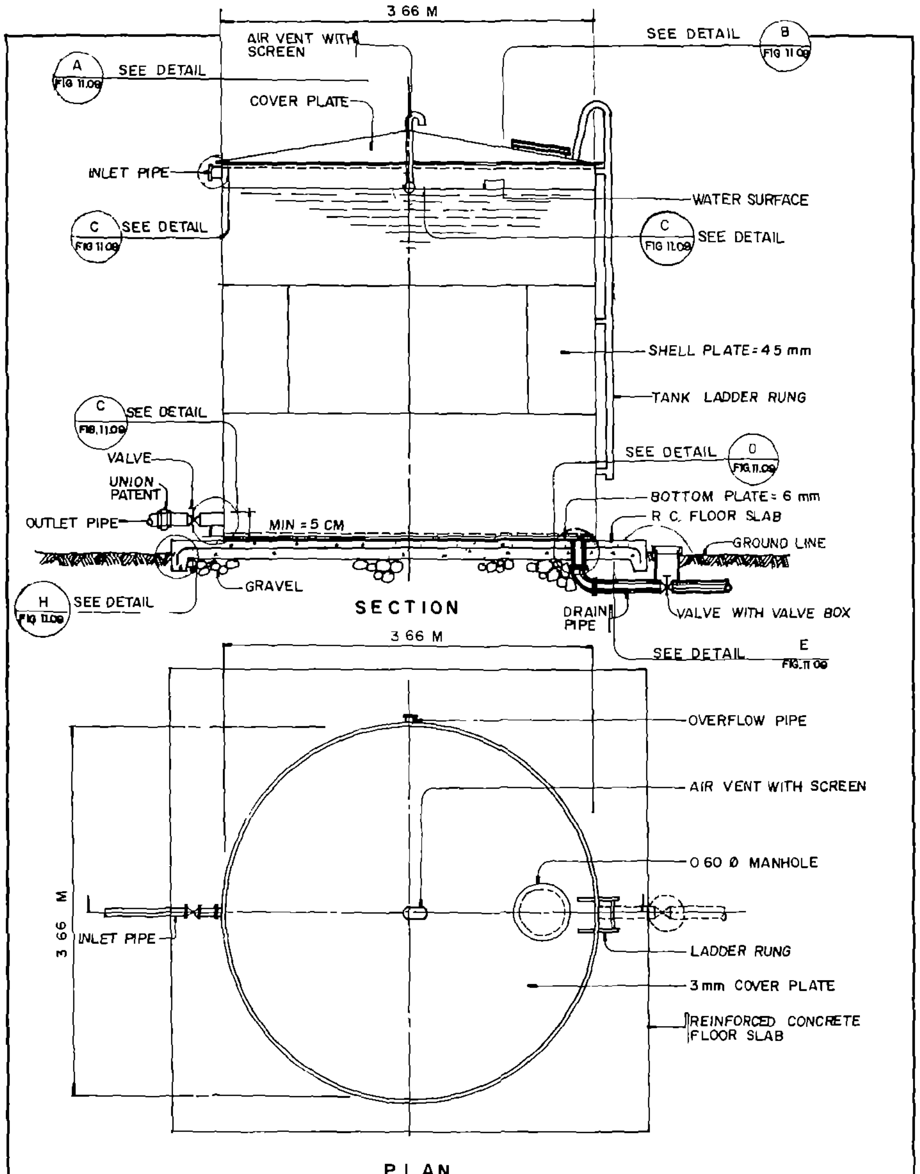


FIGURE 11.10

STEEL TANK ON REINFORCED CONCRETE FLOOR SLAB
CAPACITY = 37,850 LITERS (10,000 GALLONS)

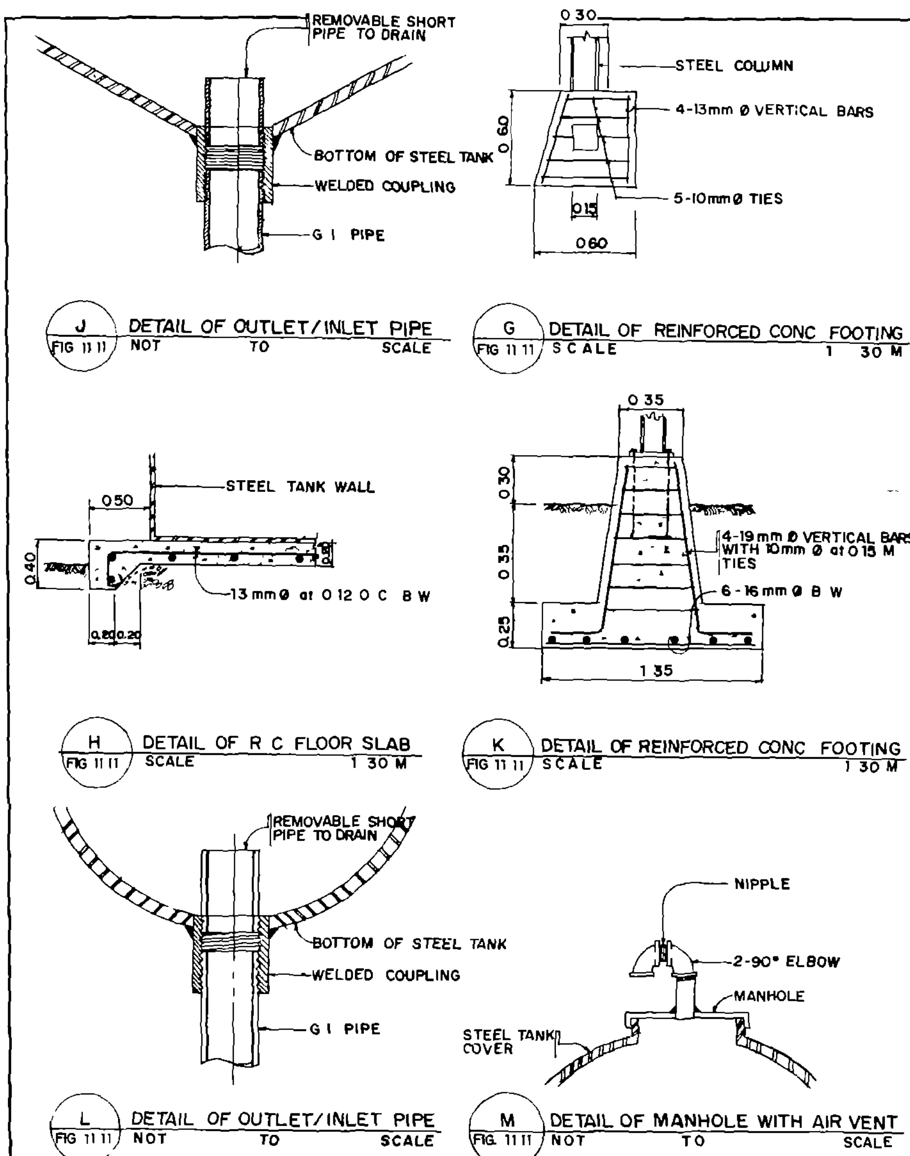


FIGURE 11 11

TYPICAL DETAILS OF STEEL TANKS

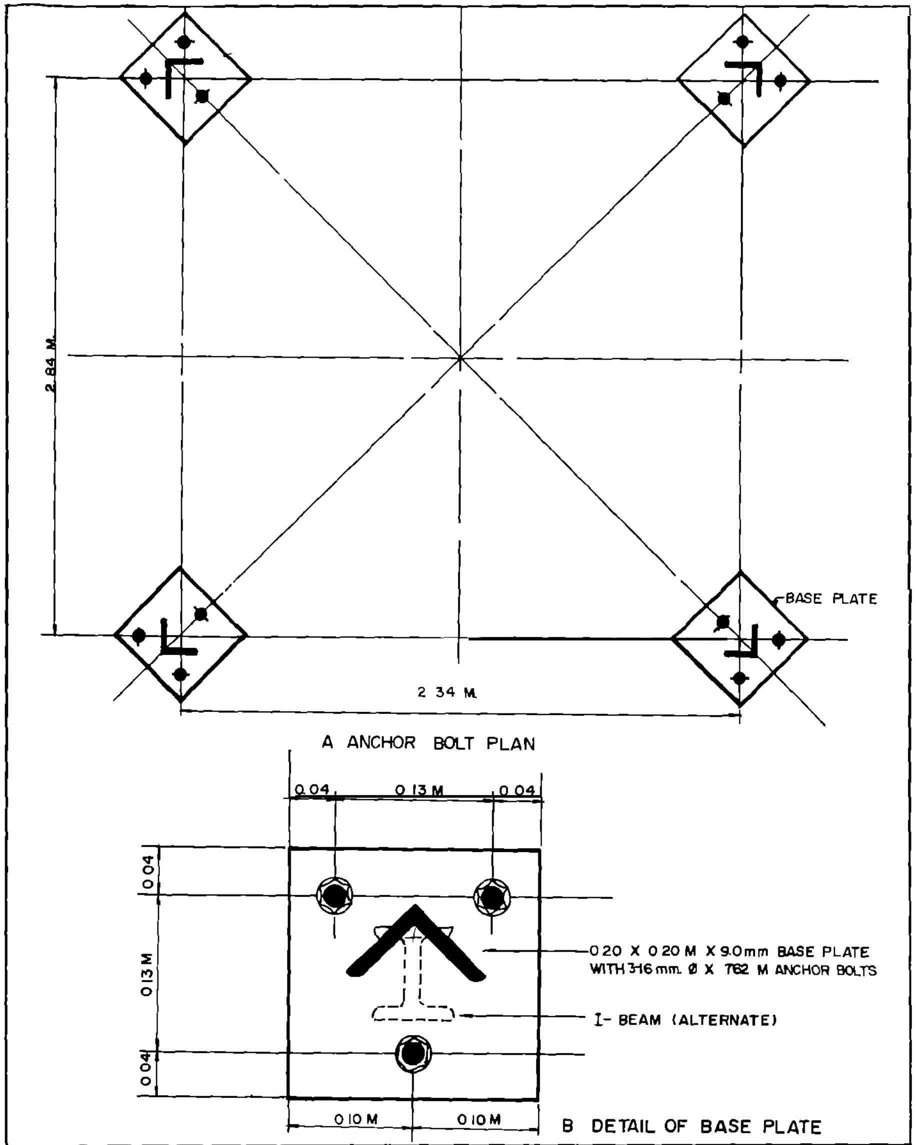


FIGURE 11.12

ANCHOR BOLT PLAN AND BASE PLATE DETAIL

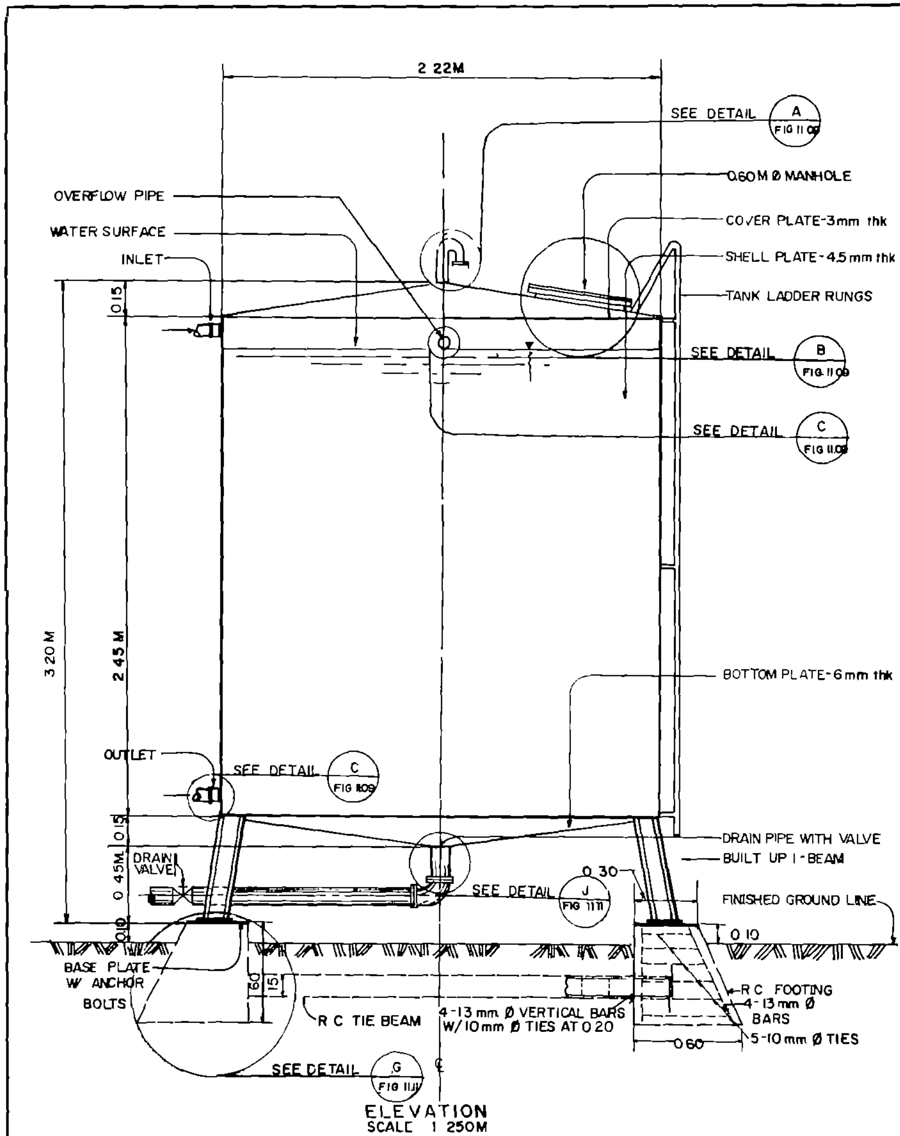


FIGURE 11.13

SLIGHTLY ELEVATED STEEL TANK
CAPACITY = 9,463 LITERS (2,500 GAL.)

B. **Elevated Steel Tanks**

Elevated steel tanks essentially consists of four main parts, namely foundation, reservoir tower or supporting structure, reservoir body, and appurtenances. Illustrated in Figures 11.14, 11.15, 11.16 and 11.17 are four typical assemblies of an elevated steel tank. The construction procedure is as follows:

1. Construct the Foundation of Reservoirs

   Shown in detail (K/11.11) and Figure 11.12 is a typical detail of a reinforced concrete footing, and anchor bolt plan and base plate detail for use as foundation, respectively. The size of the footing foundation is dependent upon the dead load consisting of the reservoir body and supporting steel columns and the live load which is dependent upon the total capacity of the reservoir.

2. Construct the Supports or Columns

   Shown in Figures 11.14 to 11.17 are typical details of the steel columns and bracings. The columns may either be an angle of an I-beam. The thickness of these steel members depend primarily on its live and dead loads. These steel members are usually assembled by bolting or by welding.

3. Assemble the reservoir body in accordance with Figure 11.14 or 11.15 or 11.16 or 11.17, whichever is selected.

4. Place the assembled reservoir body on the prepared foundation and steel column or support using rope and pulley system or by use of a crane, whichever is available.

5. Secure the reservoir body to the supporting steel tower by bolting and/or by welding.

6. Install the appurtenances as shown in the drawings. The detail of the installation is shown in Figures 11.09 and 11.11.

7. Apply waterproofing materials to make the reservoir watertight by use of a brush or by spraying or by any appropriate tools.

8. Paint the steel surfaces with anti-rust paints. The type of paint to be used should be the type which does not impart odor and taste to water, and should not be toxic.

11.05 FERROCEMENT TANKS

A. **General**

Ferrocement is a composite material consisting of concrete reinforced by a number of layers of wire mesh with or without skeletal steel. Ferrocement structures can be cast with or without the use of forms.

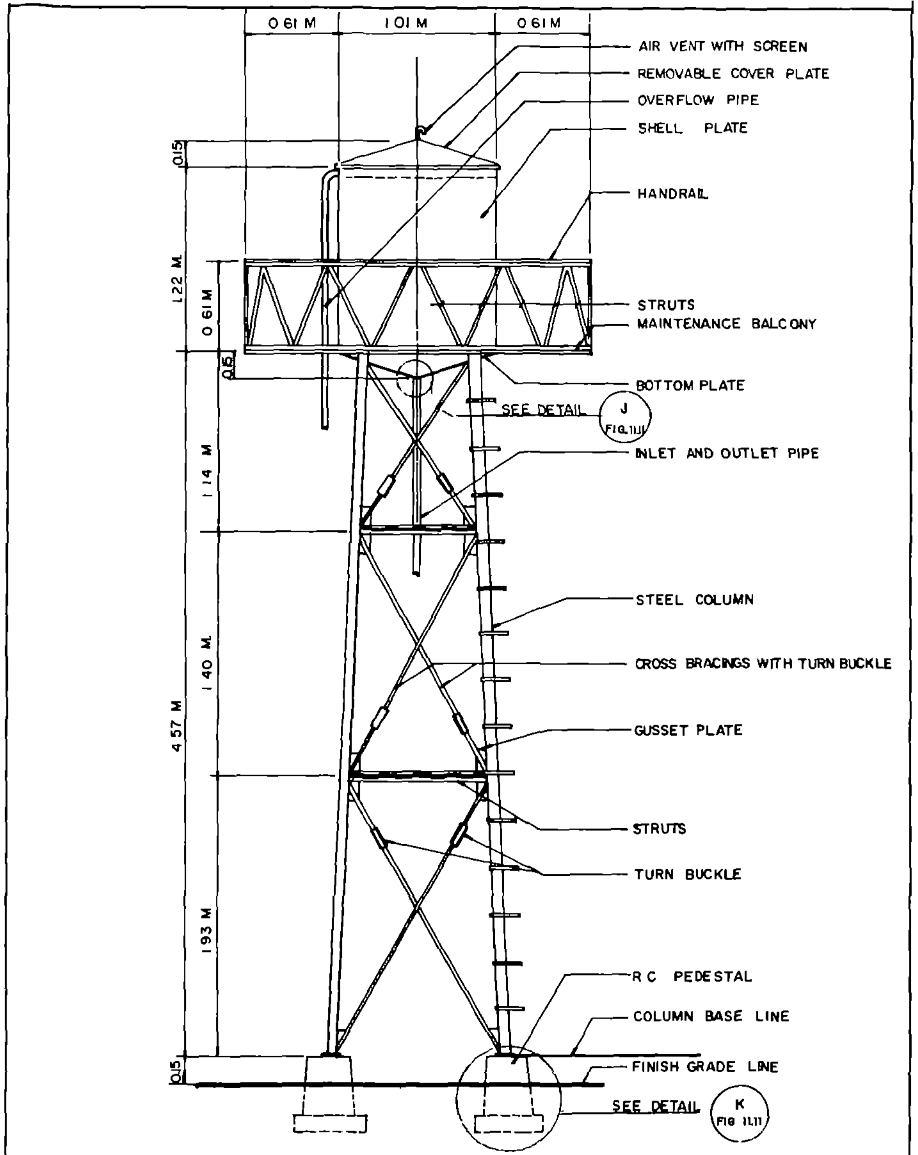


FIGURE 11 14

ELEVATED STEEL TANK
CAPACITY = 950 LITERS (250 GALLONS)

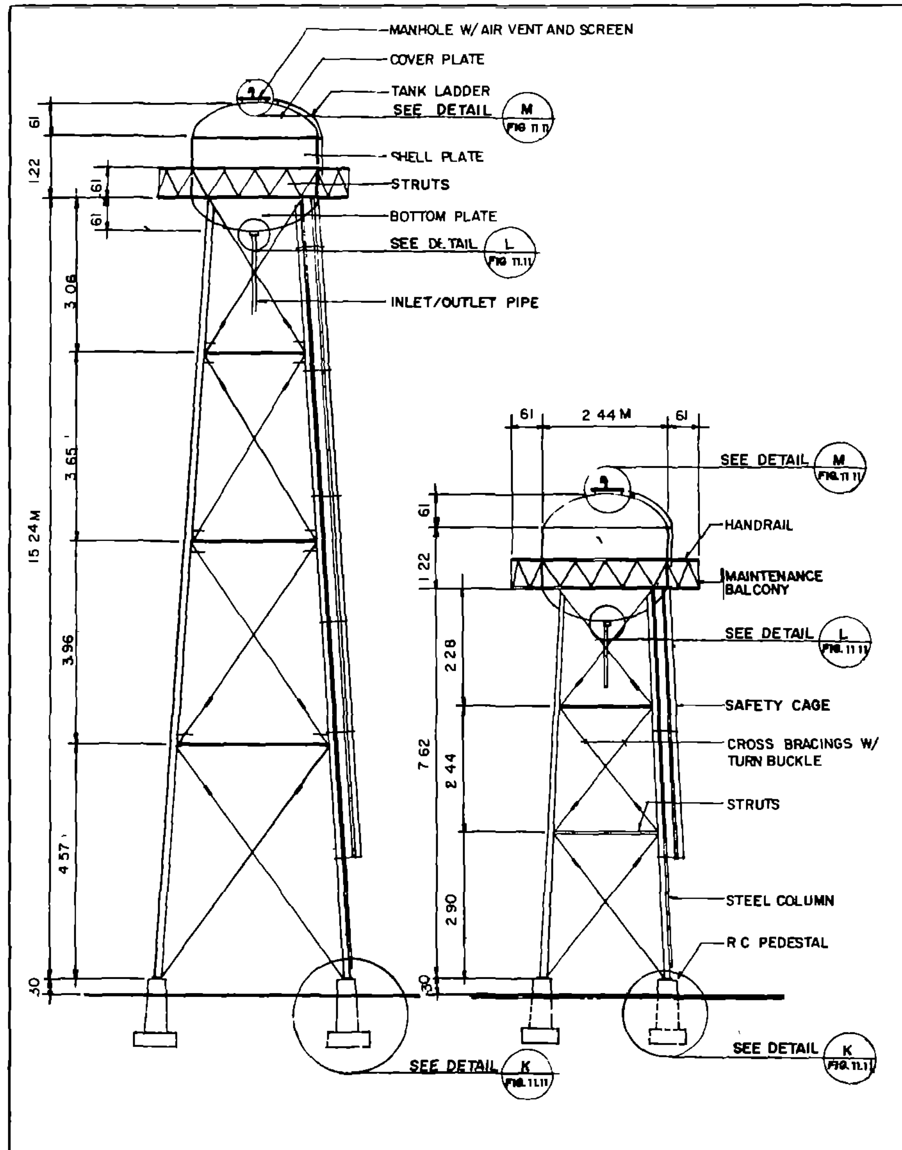


FIGURE 11 15

ELEVATED STEEL TANK
CAPACITY = 7,570 LITERS (2,000 GALLONS)

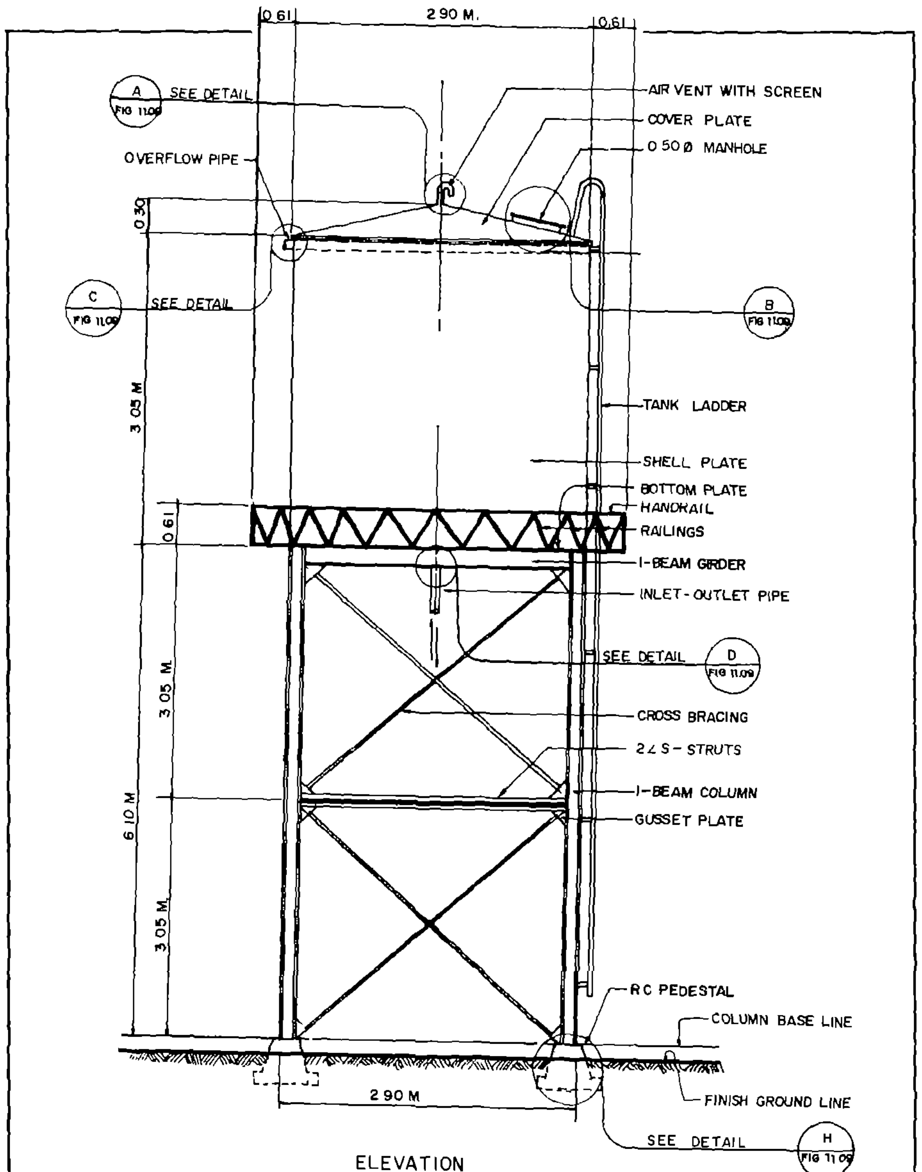


FIGURE 11.16

ELEVATED STEEL TANK
CAPACITY = 18,925 LITERS (5,000 GALLONS)

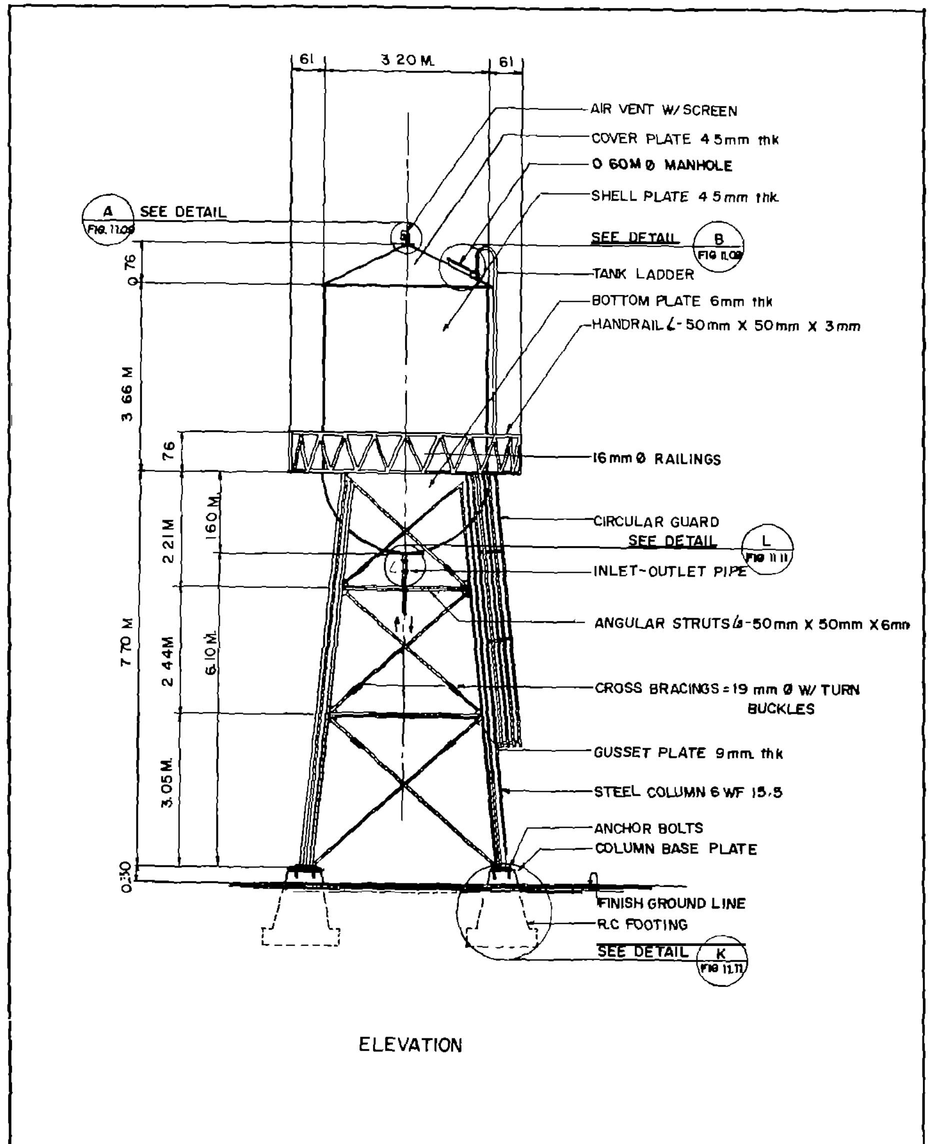


FIGURE 11.17

ELEVATED STEEL TANK
CAPACITY = 37,850 LITERS (10,000 GALLONS)

The technology for the construction of ferrocement tank is still at its infant stage. Studies conducted reveal that ferrocement structures possess comparable mechnical properties or better as compared to reinforced concrete. This could be attributed to the addition of closely spaced steel reinforcement or wire mesh which has substantially larger surface area where the concrete could be bonded. Also, these studies indicate that the construction of ferrocement structures requires relatively low material cost, however, it requires fairly high labor cost for there is an extensive hand work involved.

B. **Technical Specifications for the Construction of Skeletal Framework.**

1. Materials

a. **Wire Mesh** – The wire mesh reinforcement may be either galvanized welded or woven square mesh, or hexagonal mesh or chicken wire. The diameter of the wire should be limited within the range from 0.5 mm (0.02 in) to 1.5 mm (0.06 in.) and size of mesh opening from 5 mm (0.2 in.) to 25 mm (1 in.).

b. **Reinforcing Steel Bars** – Reinforcing steel bars placed along side with mesh reinforcement is necessary to improve the strength and deformability of ferrocement structure. Steel bars prescribed either by ASTM A-615 and A-616 may be used

c. **Concrete Spacers** – Concrete spacers are precast concrete with composition or mix design similar to the ferrocement material used in making the body of the tank. It has the dimension of 25 mm x 25 mm x 6 mm (1" x 1" x 1/4"). Concrete spacers are employed to make a spacing between the floor and the bottom of the steel frameworks.

2. Thickness of Ferrocement Structures

The thickness of ferrocement structures are determined by the number of layers of wire mesh and steel reinforcements, and the thickness of concrete cover.

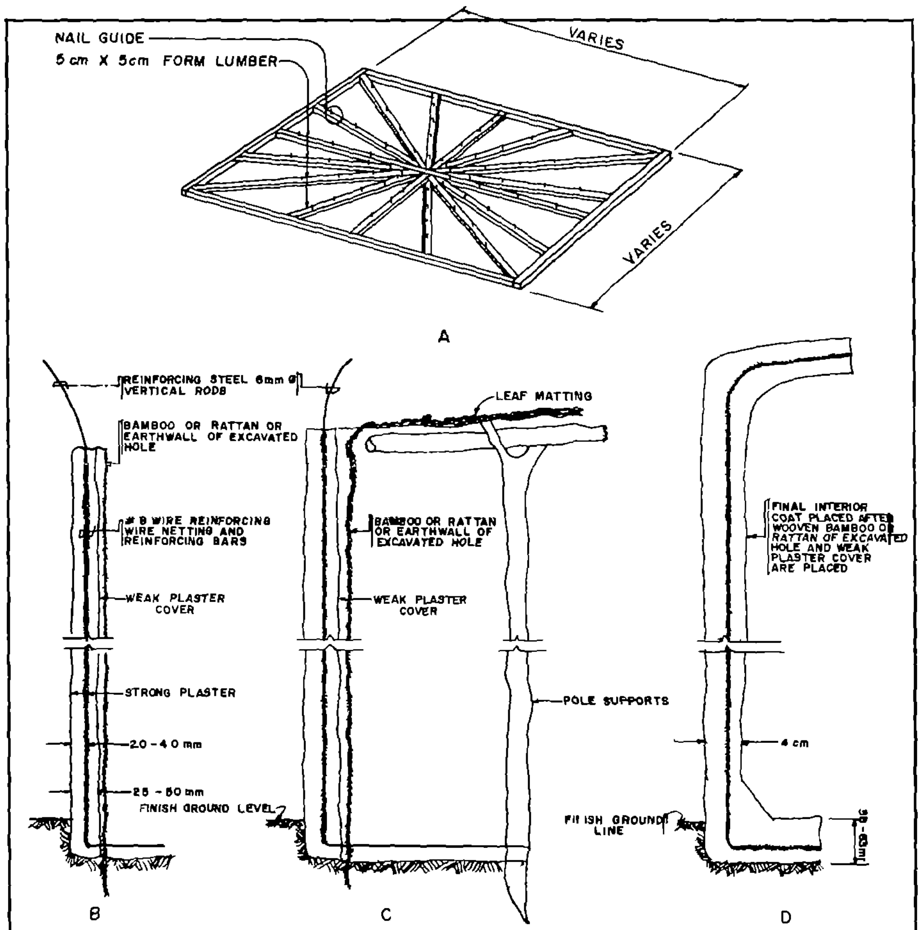
a. For a cylindrical wall, the thickness per wire mesh layer should be limited within the range of 25 mm to 40 mm (Figures 11.18B and 11.19B).

b. For the reservoir base, the thickness per wiremesh layer should be limited within the range of 38 mm to 63 mm (Figures 11.18D and 11.19B).

c. For the protection of reinforcements, a concrete cover with thickness limited to within the range of 2.0 mm (1/12") to 4.0 mm (1/6") should be provided. It is not recommended that concrete cover be more than the prescribed maximum because it may cause cracks which will expose the reinforcements to the corrosive environment.

3. Splicing

Jointing of wire mesh is accomplished by lap splicing with the length



A PREPARATION OF FORM LUMBER TO BE USED IN MOLDING CIRCULAR REINFORCING STEEL BARS

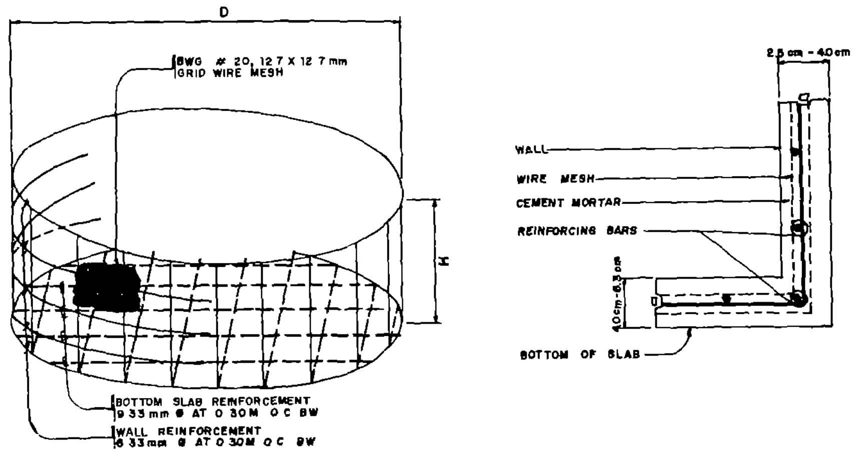
B CONSTRUCTION OF THE FERROCEMENT WALL

C CONSTRUCTION OF THE SKELETAL FRAMEWORK AND FORMWORK OF COVER

D SECTION OF FINISHED COVER, WALL AND FLOOR.

FIGURE 11 18

CONSTRUCTION STAGES OF FERROCEMENT RESERVOIR



A SKELETAL FRAMEWORK

B PART WALL AND PART BOTTOM SLAB SECTION

TABLE OF DIMENSIONS

VOLUME CU M	DIMENSIONS IN METERS		THICKNESSES IN mm		NO OF WIREMESH LAYER	
	D	H	BOTTOM SLAB	WALL	BOTTOM SLAB	WALL
2	1 60	1 20	38 1	19 05	3	2
3	2 00	1 20	38 1	19 05	3	3
4	2 00	1.50	50 0	25 4	3	3
5	2 25	1 50	50 0	25 4	3	4

NOTES

1 WIRE MESH SHALL BE BWG # 20 (0 889mm Ø) WITH 12 7 X 127mm SQUARE GRID

2 REINFORCEMENT FOR BOTTOM SLAB SHALL BE 9 53mm Ø AT 0 30M O C BW AND 6 3 mm Ø AT 0 30M O C BW FOR WALLS

3 PROVIDE SPACER BETWEEN WIRE MESH

FIGURE 11 19

TYPICAL SKELETAL FRAMEWORK OF FERROCEMENT TANKS of overlap not less than 10 cm (4"). In cases where the thickness of wall or floor requires two or more layers of wire mesh reinforcements, the joint of one layer should be staggered or displaced relative to the joints of the other layers. With respect to the splicing of reinforcing bars, refer to section 10.02.

4. Fabrication of the Skeletal Framework with Reinforcing Bars

   a. Measure, cut and bend the reinforcing steel bar to the desired shape as shown in the plans. For circular structures, a steel pattern illustrated in Figure 11.18A could be employed.

   b. Form the steel framework as specified in the plans. With respect to the procedure of splicing, refer to Chapter 10.

   c. Measure the required dimension of wire mesh, mark it and then cut it on the mark line. The length cut should be equivalent to the diameter of the reservoir plus an allowance for overlapping which should not be less than 10 cm (4 in.).

C. **Mortar Preparation**

1. Materials

   a. **Cement** – Portland cement conforming to ASTM C-150 is employed in mortar preparation. This portland cement may be the ordinary type or the Hi-Early or Rapid hardening type.

   b. **Fine Aggregates** – The aggregates to be used for mortar preparation should pass sieve no. 8 and retained in sieve no. 100 or have the particle size range of 0.149 mm to 2.38 mm.

   c. **Admixture** – Admixtures may be used for meeting special needs such as for improving the workability of the mix, for accelerating or retarding the setting time, and for increasing the resistance to sulfate attack. Presented in Table 8.01 are the different types of admixtures and their usage.

   d. **Water** – Water should be clean, fresh and free from injurious amounts of oil, acids, alkalies, salts, organic materials and other substances deleterious to concrete and steel.

2. Mortar Mix Proportion

The selection of mortar mix proportion depends primarily on the strength of the required mortar. For ferrocement structures, it is recommended that cement/sand ratio by weight be within the range of 2 to 3 and the water/cement ratio be within the range of 0.35 to 0.65. It should be pointed out that water/cement ratio is one of the important factors which determine the strength of the ferrocement structure, hence, it should be properly regulated. This could be accomplished by proper estimation of the moisture content of sand and the amount of water to be added.

3. Mixing

Mixing of mortar should be done properly for if it is not done satisfactorily, shrinkage and eventually cracking may result. Mixing of mortar is usually accomplished in rural areas by hand mixing. However, for bigger projects or for a number of small projects, it is suggested that a paddle type mixer designed especially for mortar mixing by purchased be the water agency concern.

D. **Plastering of Mortar**

1. Plastering with Formworks

This type of classification is often employed in the construction of underground reservoirs and to a lesser extent in the construction of above ground structures.

Procedure:

a. **Prepare the Formworks.** For underground reservoirs, the surrounding earth wall of the excavated hole may be serve as the form. For above ground reservoirs, weave a circular wall from pitpit, wildcane or bamboo.

b. Apply a thin coat of mortar prepared by mixing one part of cement to 6 parts of sand to give the rough formwork a smooth finish. The plastering should be accomplished in tiers of 60 cm - 100 cm starting from the bottom advancing upwards.

c. Allow the applied mortar to stiffen for 1 to 2 hours.

d. Apply 2.0 cm to 4.0 cm thick layer of mortar prepared by mixing a part of cement to 3 parts of sand. This should be done in tiers of 0.6 M to 1.0 M from the bottom progressing upwards.

e. Allow it to stiffen for 2 to 3 days.

f. Place the skeletal framework as indicated in the plans.

g. Continue plastering using the mortar with mix ratio of 1:3 until the desired thickness is reached or until the point where the second wire mesh should be placed (Figure 11.18B).

2. Plastering Without Formworks

This type of plastering procedure is usually employed in the construction of above-ground reservoir.

a. Prepare the skeletal structure of the reservoir as indicated in the plans or as illustrated in Figures 11.18 and 11.19.

b. Prepare a mortar mix by mixing one part cement to three parts sand with sufficient water to make a consistency of a thick paste.

c. Start the plastering of mortar. The application of mortar is accomplished manually using a trowel and in tiers of 0.6 to 1.0 M.

The process consists of forcing the mortar from the outside to the inside where it can be finished off to a smooth surface. Under no circumstances should the inside mortar be applied until the outside has fully penetrated the wire as this will result in the entrapping of air between layers. Also, the plastering from both sides should never be done as this will yield the same defects.

d. Apply the finishing coat. The final coat should be applied before the initial set of the main plaster has taken place.

3. Plastering at the Construction Joints

Plastering operation should be completed if possible in one day to avoid construction joints. However, if it is not possible, the following plastering technique is recommended.

a. Remove laitance before the mortar has finally set. This can be accomplished by spraying the exposed edge of the mortar with fine jet of water. This is usually done six to ten hours after the placement depending upon the temperature. The removal of the laitance will provide a relatively rough surface of exposed sand grains.

b. Prepare a portland cement grout by mixing one part cement to three parts sand with sufficient water to provide a creamy consistency.

c. Place the mortar on the construction joints. Alternately, apply epoxy resin glues to the joints to ensure perfect jointing.

E. **Curing**

Cure the structure continuously by spraying of water for the first seven days after placement if the cement used is the ordinary type and 3 days if the cement used is the Hi-Early type. For detail of the curing procedure, refer to section 8.12.

F. **Installation of Appurtenances**

Install all appurtenances as shown in the plans. This is accomplished by chipping off with the use of the chisel the area where a certain appurtenance is to be placed, placement of the appurtenance, and the sealing of the construction joints between the concrete and appurtenant structure.

G. **Finishing of Concrete Structure**

Check the surfaces for defects and then patch it using a concrete mortar. The composition of mortar for this purpose should be similar to that used in making the body of the reservoir.

H. **Waterproofing**

After finishing, the contractor should see to it that the reservoir is watertight. This could be accomplished by the addition of appropriate waterproofing materials.

I. Procedure for the Construction of Underground Reservoir

1. Foundation work

   a. Excavate a hole of dimensions specified in the plans.

   b. Construct the underdrain of the reservoir as shown in Figure 11.20 and detail E/11.03.

2. Construction of the Base of Reservoir.

   The base of the reservoir may be a reinforced concrete slab or ferrocement concrete structure. In this manual, we are recommending a reinforced concrete base.

3. Construction of the Reservoir Walls

   The ferrocement concrete wall could be constructed using the procedure outlined in section 11.05D.1. Plastering of mortar with form work.

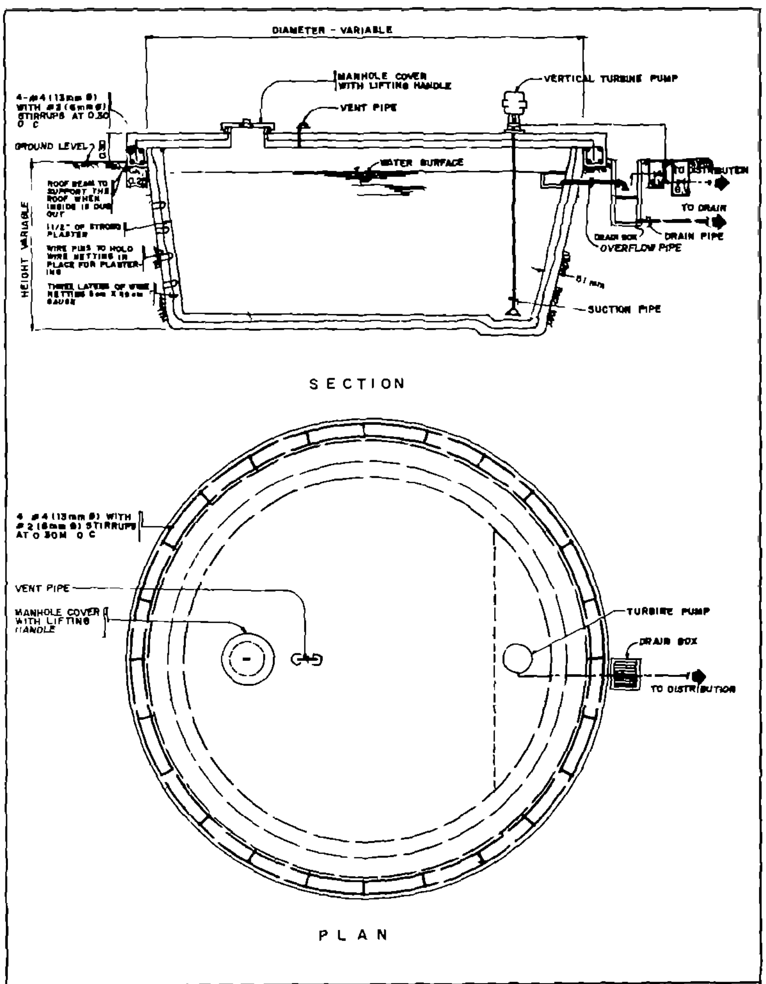


FIGURE 11.20

UNDERGROUND FERROCEMENT TANK

4. Construction of the Reservoir Cover

   a. Bend the reinforcing bars as illustrated in Figure 11.18C.

   b. Construct the form which will support the cover to be casted. A typical form is illustrated in Figure 11.18C.

   c. Apply a thin coat of weak mortar prepared by mixing one part of cement with 6 parts of sand to give the rough formwork and a smooth finish. Allow it to harden for 1 to 2 hours.

   d. Prepare the skeletal framework of the reservoir as shown in the plan.

   e. Apply mortar until the desired thickness is reached.

5. Sealing of Construction Joints.

   The sealing procedure is outlined in section 11.05D.3.

6. Cure the concrete structure, install the appurtenances, repair the surface defects detected and apply waterproofing materials.

J. **Procedure for the Construction of Above-Ground Reservoir**

1. Excavate a hole of dimensions specified in the plans and construct the underdrain of the proposed reservoir as shown in Figure 11.02 and detail (E/11.05).

2. Construct the reinforced concrete base of the reservoir.

3. Construct the ferrocement concrete walls. The construction procedure is outlined in section 11.05.D.2: Plastering of Mortar Without Form work.

4. Construct the reservoir cover according to the procedure outlined in section 11.05.1.4: Construction of Reservoir Cover for Underground Reservoir.

5. Seal the construction joints according to the procedure outlined in section 11.05.D.3.

6. Cure the concrete structure, install the appurtenances, repair the surface defects detected and apply waterproofing materials.

11.06 HYDROPNEUMATIC PRESSURE TANKS

Hydropneumatic pressure tank can be bought in the market by package deal. The package consists of a steel tank either horizontally or vertically mounted, pressure regulator, pumps, valves and other minor appurtenant structures. Shown in Figure 11.21 are typical installations of hydropneumatic pressure tanks.

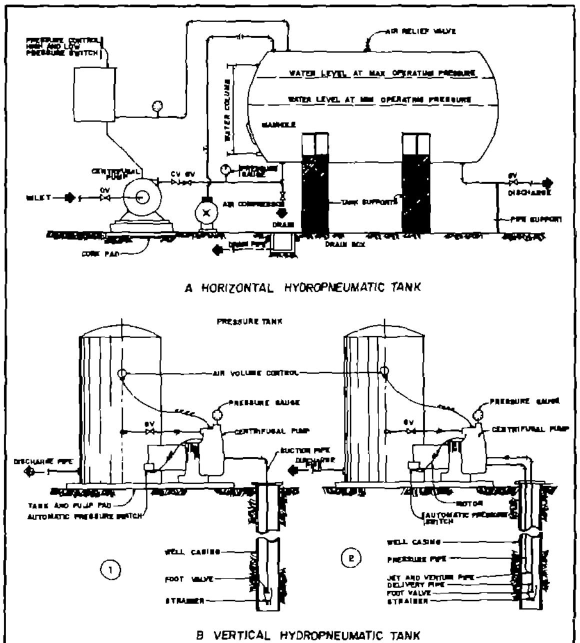


FIGURE 11.21 SCHEMATIC DIAGRAM OF HYDROPNEUMATIC STORAGE TANKS

11.07 WATERPROOFING OF RESERVOIRS

Reservoirs could be made watertight by adding or application of water-proofing materials. These materials are available in the market today under various trade names. Generally, waterproofing materials could be classified into three general categories, namely admixtures, membranes and coatings.

A. Admixtures

Waterproofing admixtures are prepared by mixing water repellant and dispensing compounds. It is applied by blending it with the concrete mix. Its incorporation creates a chemical change wherein a non-wettable lining is formed on the side walls of all pores and voids in the concrete making them water repellant. Also, the addition of the admixture resulted to the formation of a dense, hard and impermeable concrete structure. For details of the application procedure, it is recommended that the contractor consult the brochure which always accompany the purchased product.

B. Membranes

Membranes are very thin plastics used to form a barrier between water and the concrete structure. It is applied by pasting it to the concrete surfaces to be waterproofed. For details of the application procedure, refer to the product brochure.

C. Coating

The principle in making a reservoir watertight using coating materials is similar to the principle in making a reservoir watertight using membranes. Coating materials are derivatives of silica and cement. They are applied by use of steel trowels. For detail of the application procedure, it is recommended that the user will refer manufacturer's manual of the product selected.

CHAPTER 12

CONSTRUCTION OF SLOW SAND FILTRATION SYSTEM

12.01 GENERAL

The slow sand filter is considered as one of the cheapest means of purifying surface water. For treatment of rural water supplies, it is usually selected not only because it is simple to operate but also because it can be constructed using indigenous materials.

The slow sand filtration system is composed of four main parts, namely: surface water intake structure, pumping or water conveying system, filter system and storage.

12.02 SURFACE WATER INTAKE STRUCTURE

Illustrated in Figure 12.01 is a typical surface water intake structure. The installation consists of a delivery pipe and well. The delivery pipe is equipped by a float and perforated pipe which serves as the water inlet. The well on the other hand may be equipped with a pump depending on its elevation relative to the filter.

Construction Procedure:

1. Construct a hand dug well approximately, 2-4 meters from the stream or river (Figure 12.02A). The well may be made of reinforced concrete pipe. For the construction procedure, refer to Chapter 6.
2. Cut a trench as shown in Figure 12.02B.
3. Drive a metal pipe from the bank of the river towards the constructed well, (Figure 12.02C). For the pipe driving procedure, refer to section 5.03.
4. Install the float intake structure (Figure 12.02D).
5. Backfill the excavated trench with earth and then line the bank with stones grouted with cement mortar. This is necessary to prevent soil erosion.
6. Deepen the well further to increase its water holding capacity.

12.03 FILTER BED

The purification process takes place in the filter bed. Organic and inorganic matter found in raw water are removed as it passes through the bed. The filter bed consists of the following parts; namely: filter box, sand and gravel bed, and underdrains.

A. **Filter Box**

The filter box houses the underdrains, sand and gravel bed and the supernatant water reservoir. The height of the box usually ranges from 2.5 to 4.0 meters.

Filter boxes may be circular, rectangular or any shape depending on the configuration of the ground available and may be made of reinforced concrete, concrete hollow blocks or ferrocement. The sides or walls may be

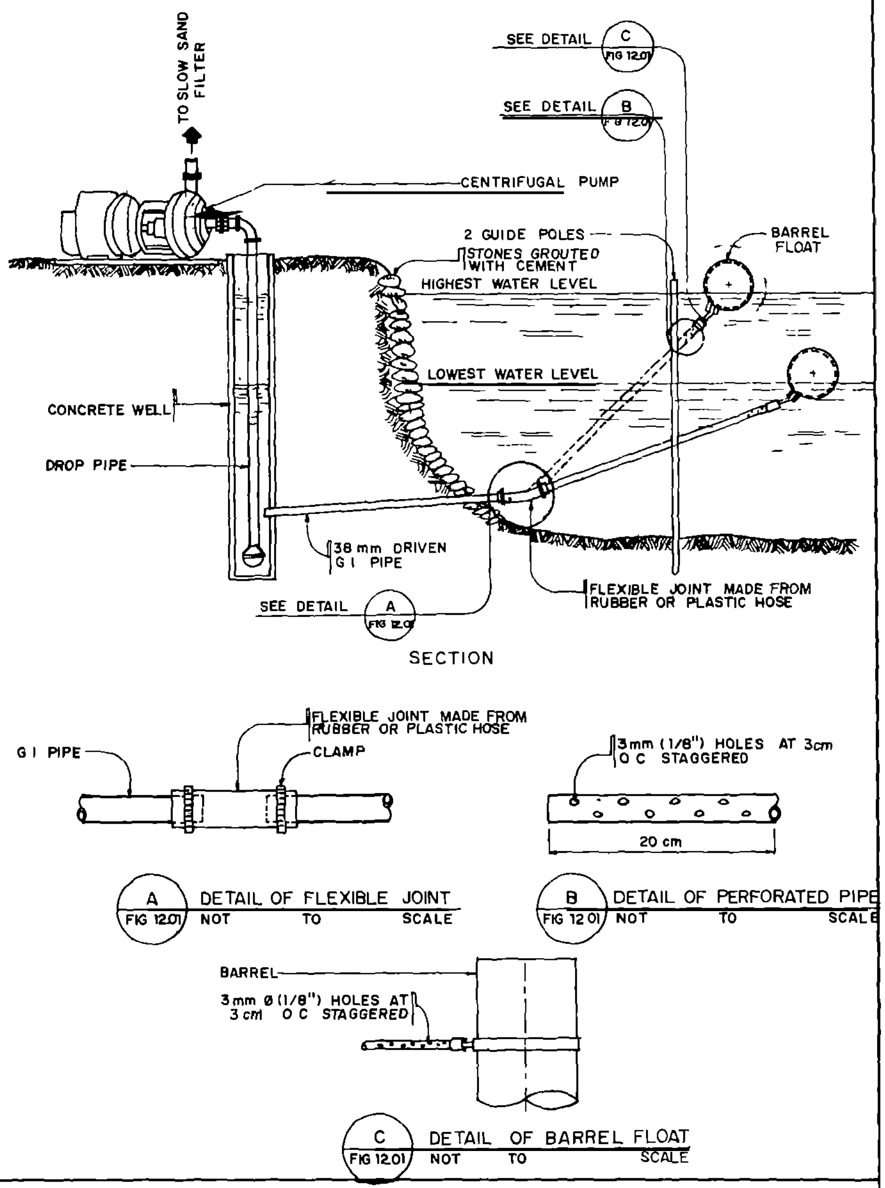


FIGURE 12 01

SURFACE WATER INTAKE STRUCTURE

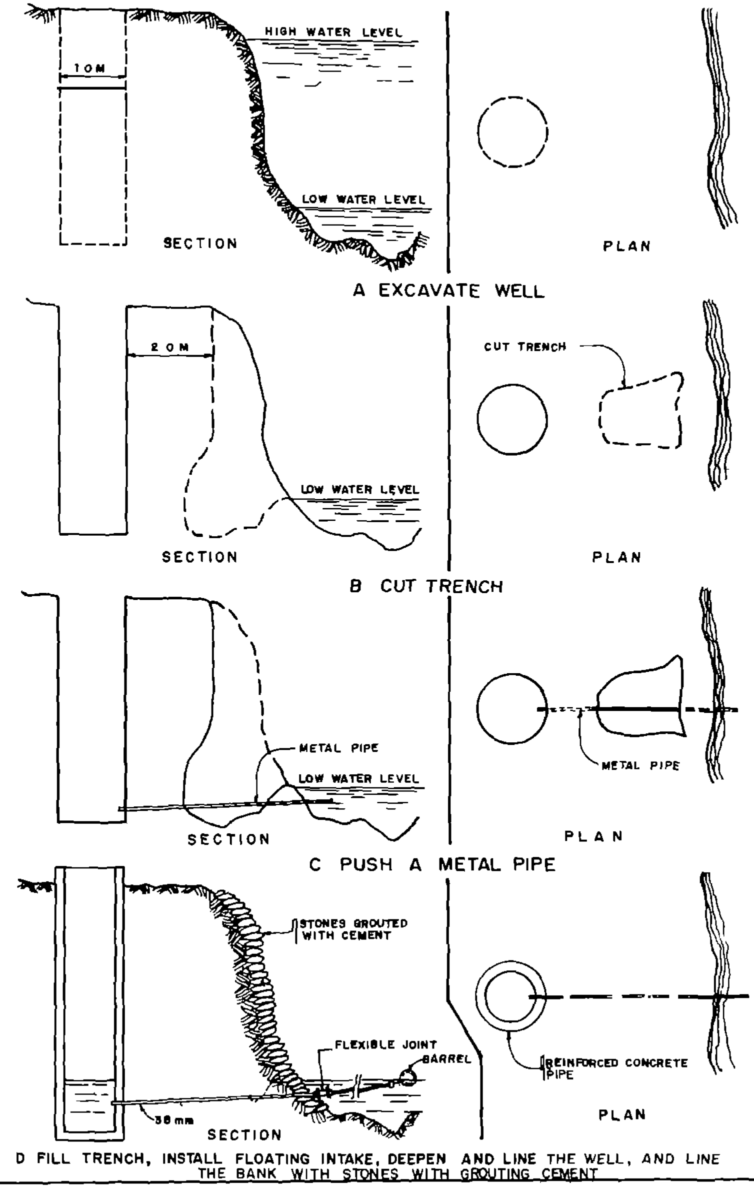


FIGURE 12 02

CONSTRUCTION OF INTAKE

vertical or sloping depending on the bearing capacity of soil and available space.

1. Vertical Walls

   Shown in Figure 12.03A and B are typical vertical filter box walls. Illustrated in Figure 12.03B is a wall shaped like a ladder step. This second type of vertical wall is constructed with provisions against short circuiting or the passing of water round the edges instead of through the sand bed. Short circuiting may occur if the sand bed shrinks away from a vertical wall.

2. Sloping Walls

   Illustrated in Figure 12.03C and D are typical sloping walls for filter boxes. Figure 12.03C shows a wall made of reinforced concrete while Figure 12.03D shows a wall made of ferrocement. The construction of sloping sides is usually cheaper than the vertical sides since the ground takes the thrust of the water pressure and the wall functions only as a lining material required for water tightness and not for structural strength, hence, the wall thickness is minimum. However, when this type of wall is employed, provisions should be made against unequal settlement. Furthermore, this type of box requires more space since the critical area is the top of the filter surface.

B. Underdrain

The underdrain serves as support of the filter media and provides outlet for the filtered water. It may be constructed by laying bricks on edge (Figure 12.04A), using bridge-shape porous concrete blocks (Figure 12.04B), using perforated half round tiles (Fig. 12.04C) or using perforated pipes (Figure 12.04D). The underdrain may have a height ranging from 15-20 cm., depending on the type of materials selected.

C. Placement of Filter Materials

1. Materials Specifications

   a. **Filter Gravel** — Gravel for use in slow sand filter should consist of hard round stones having a diameter ranging from 2.4-19 mm. and specific gravity not less than 2.5 and should be visually free from shale, sand, silt, clay, dirt and other organic or inorganic impurities.

   b. **Filter Sand** — Sand to be used as filter should consist of hard durable grains of siliceous materials with effective size ranging from 0.25 to 0.35 mm, with uniformity coefficient ranging from 2.0 - 3.0 and should be free from dirt, loam, clay and other organic materials. Effective size is defined as the sieve opening through which 10 per cent of the material will just pass while the uniformity coefficient defines the size distribution of sand particles and is the ratio of the sieve opening which allows 60 per cent of the materials to pass to the effective size.

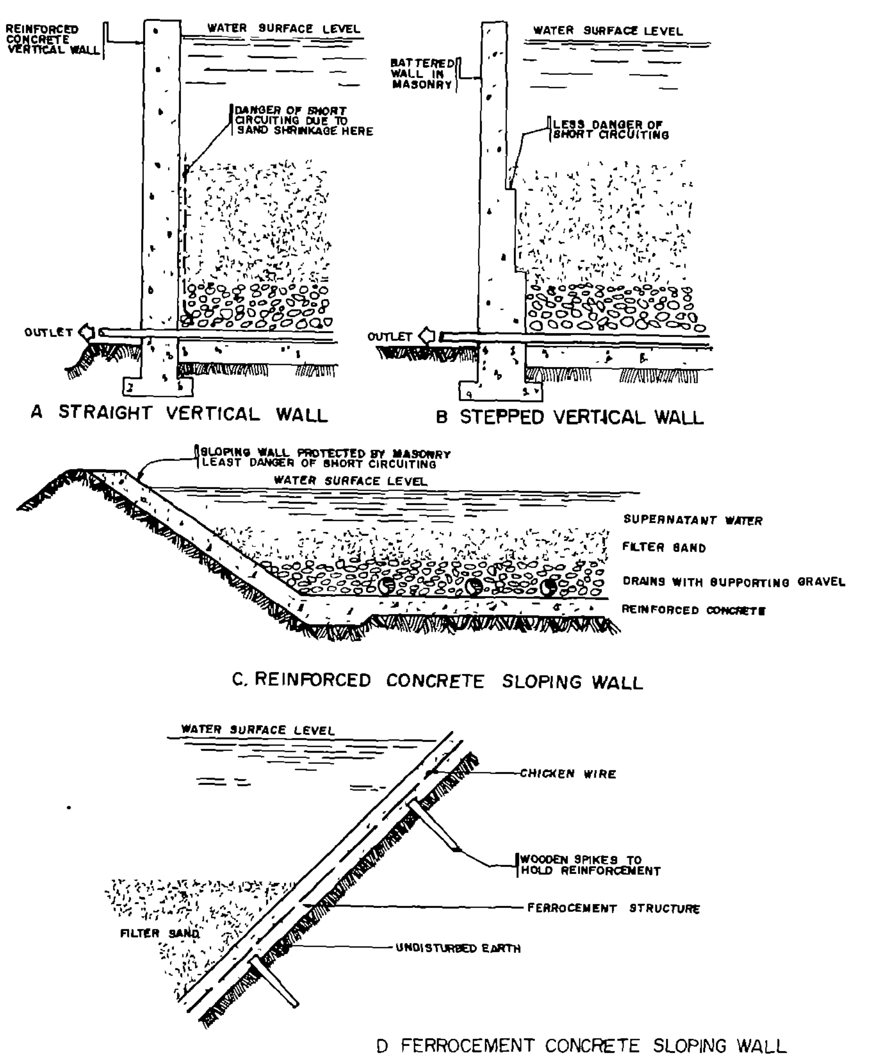


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FIGURE 12.03

TYPICAL WALLS FOR THE FILTER BOX

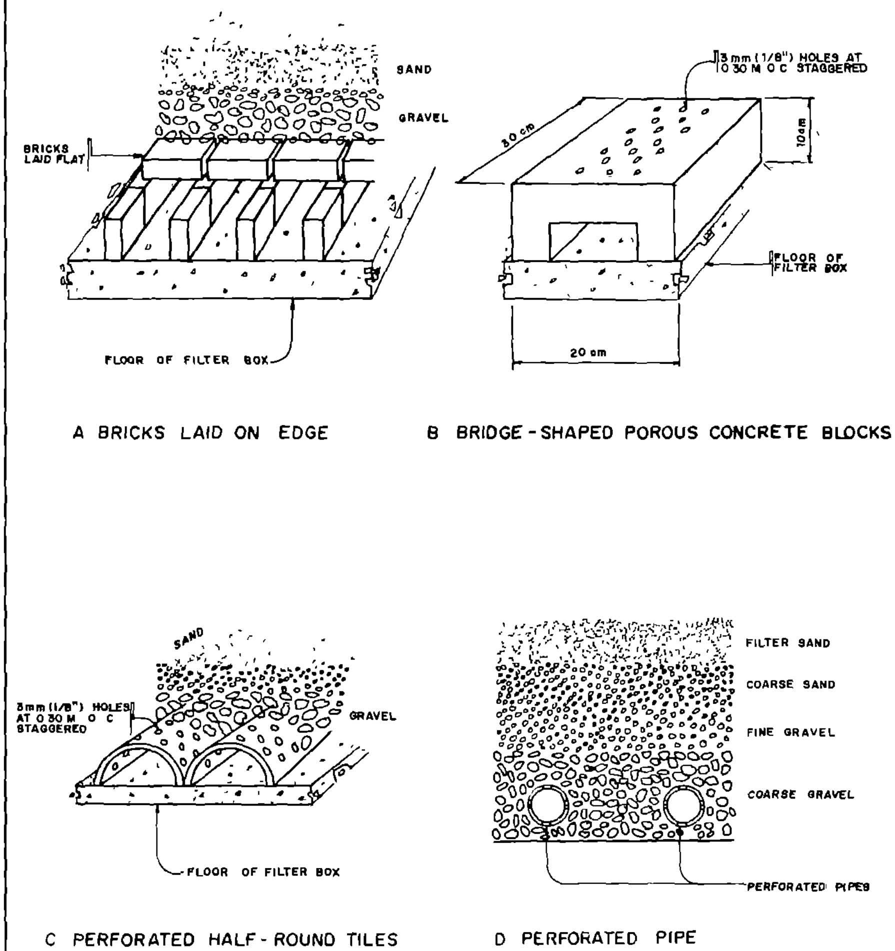


FIGURE 12.04

FILTER UNDERDRAIN STRUCTURAL VARIATIONS

2. Preparation of Filter Box

   a. Clean the filter box thoroughly from undesirable materials.

   b. Mark a continuous level line representing the top elevation of each gravel or sand layer on the inside of the box.

3. Placement of Gravel Bed

   The entrance of gravel into the underdrain and the penetration of sand into the gravel layer should be prevented as much as possible. This can be achieved by proper placement of gravel layers and the proper selection of sizes of particles for each layer. Outlined below is the procedure for placement of gravel bed.

   a. Technical specifications for the construction of gravel bed.

      i. Gravel particles within each layer should have fairly uniform sizes. Outlined below are the suggested size ranges of gravel to be placed from the underdrain to the top of gravel layer.

         i.1 38-19 mm (1 1/2" – 3/4")

         i.2 25-13 mm (1" – 1/2")

         i.3 19-9.5 mm (3/4" – 3/8")

         i.4 9.5-4.8 mm (1/2" – Sieve No. 4)

         i.5 2.4-4.8 mm (Sieve No. 4 – Sieve No. 8).

      ii. Minimum particle size of any layer should be as large as the maximum particle size in the layer above.

      iii. Within any layer, the maximum particle size should not be more than twice the minimum particle size.

   b. Procedure for the Placement of Gravel Layers

      i. Place the bottom layer carefully to avoid damaging the filter underdrain. Screen the top surface to bring it to a true level plane and check the elevation of its top surface by filling the filter box with water up to the marked level or by measuring from a straight edge laid across the top of the filter troughs.

      ii. Place the succeeding gravel layers. In placing, care should be exercised to avoid disturbing the surface of the layer beneath. Also, screen the surface of each layer placed to bring it to a true level and then check the elevations.

iii. After all filter gravel have been placed and before the filter sand is placed, wash the filter for 5 minutes at the maximum available rate but not to exceed 6 liters per square meter per second of filter area.

4. Procedure for the Placement of Sand Layers

The procedure for the placement of sand layers is similar to the placement of gravel layers. The top surface of the filter material, after initial washing, should have the height equal to the finished elevation plus the layer of sand to be removed by scraping. Furthermore, during first washing of the filter bed, it expands due to the segregation of particles. Hence, provisions should be made to take care of this expansion. It is usually accomplished by placement of sand up to a level which is approximately 10 percent of bed thickness below finished elevation. Also, to avoid the removal of an excessive amount of material by scraping which may result in a coarser filter than was intended, no material shall be placed in the filter in excess of that necessary to produce the finished surface elevation.

12.04 FILTER CONTROLS

The ideal way of operating a slow sand filter is to maintain without interruption a constant rate of flow at all times through the sand bed. The rate of flow through the bed can be controlled either by manipulating the water level above the filter bed or the outlet control structures to regulate the outflow of filtered water.

A. Water Inlet Structures

The choice of the type of inlet structure depends primarily on the elevation of filter bed with respect to the raw water source and the economy of its construction. Raw water can be conveyed from the raw water source to the filter either by gravity, if the location of water source is higher than the high water level of the slow sand filter (Figure 12.05A), or by pumping (Figure 12.05B) if it otherwise. Also, if the latter system is selected and at the same time it is desired that pump operating time is minimized and partial removal of suspended solids is necessary in intervening settling tank/reservoir should be provided (Figure 12.05C). The low water level of this reservoir should at least be at the same level of the water level in the supernatant water reservoir in the filter so that water could continually flow through the filter. With respect to the inlet controls, this could be done automatically using a float valve or manually using a gate valve.

B. Outlet Structure

Filter outlet control is employed to regulate the flow of filtered water. Allowing the outflow of water more than the design capacity of the filter will result in a poor quality filter effluent. Filter outlet control can be accomplished using a gate valve, overflow weir or by use of an adjustable overflow tubes.

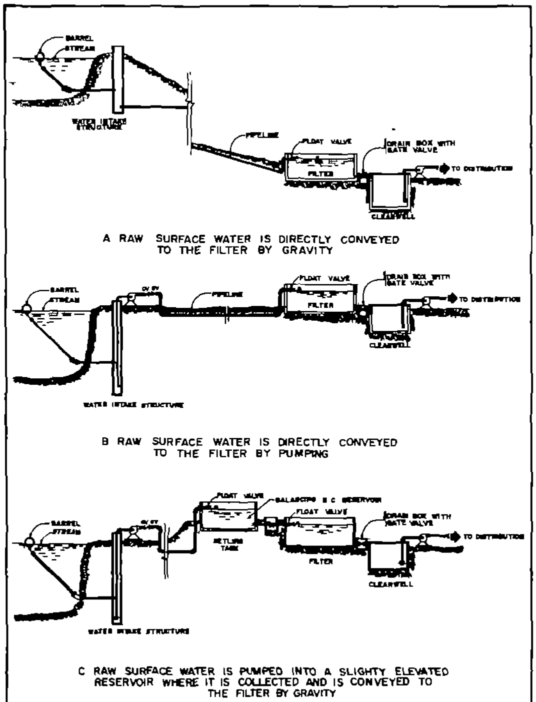


FIGURE 12 05
SLOW SAND FILTRATION SYSTEMS

12.05 CLEAR WELL

Clear well is sometimes referred to as a filtered water reservoir or pump sump. It can be constructed using reinforced concrete, concrete hollow blocks, ferro-cement and other indigenous materials. A clear well is employed to collect and store filtered water before it is conveyed to the main storage tank and/or to consumers.

12.06 TYPICAL DESIGN OF SLOW SAND FILTER

Illustrated in Figures 12.06, 1207, 12.09, 12.10 and 12.11 are different features or designs of a slow sand filters. Tabulated below are their respective characteristics.

Figure No.	Type of Wall of Filter Box	Type of Under-drain	Inlet Control	Outlet Control
12 06	Stepped vertical wall	Perforated pipe	Float valve	Gate valve with piezometer tube
12 07	Vertical wall	Perforated pipe	Gate valve with inlet weir	Gate valve with outlet weir
12 09	Sloping wall	Bricks laid on edge	Pump	Gate valve
12 10	Grouted sloping wall	Perforated half-round tiles	None	Water level in clear well
12 11	Vertical wall	Perforated pipe	Pump	Water level in clear well

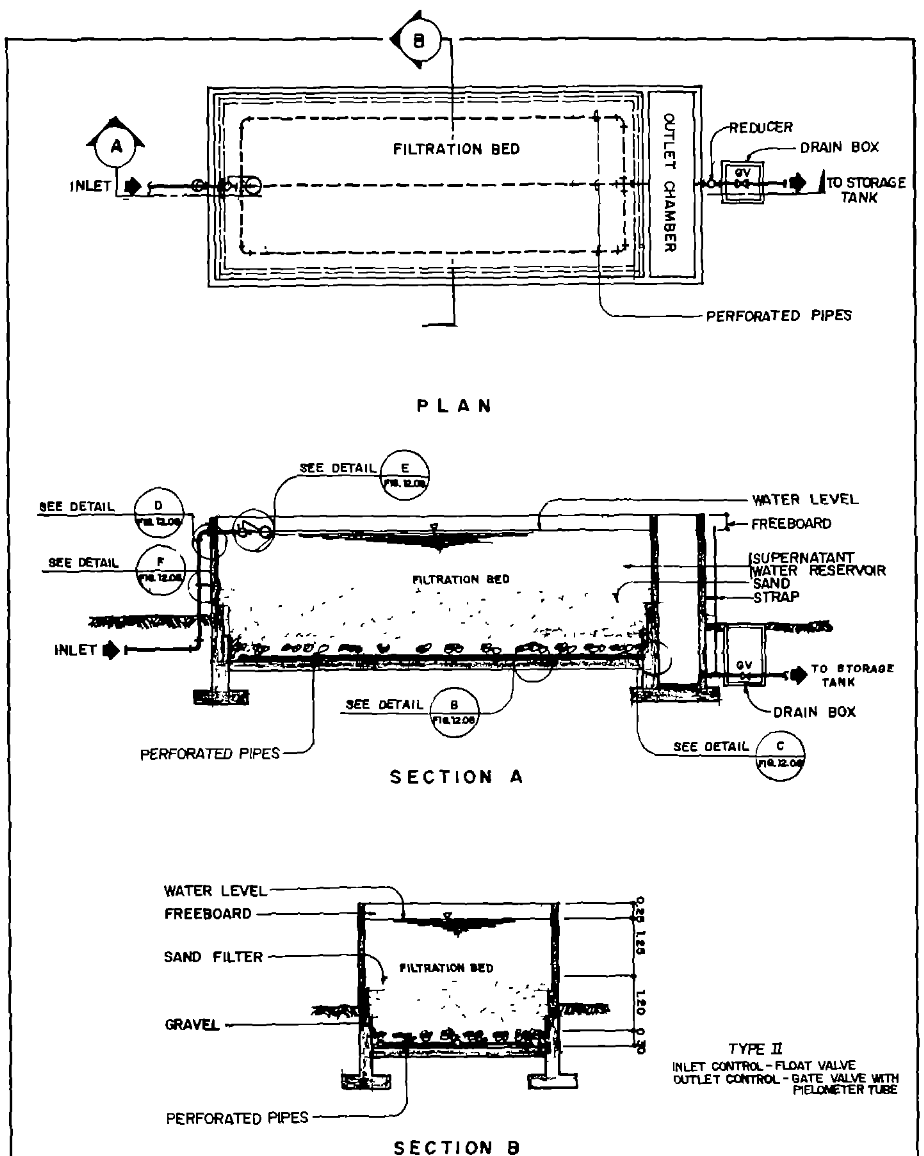


FIGURE 12 06

TYPE I SLOW SAND FILTER

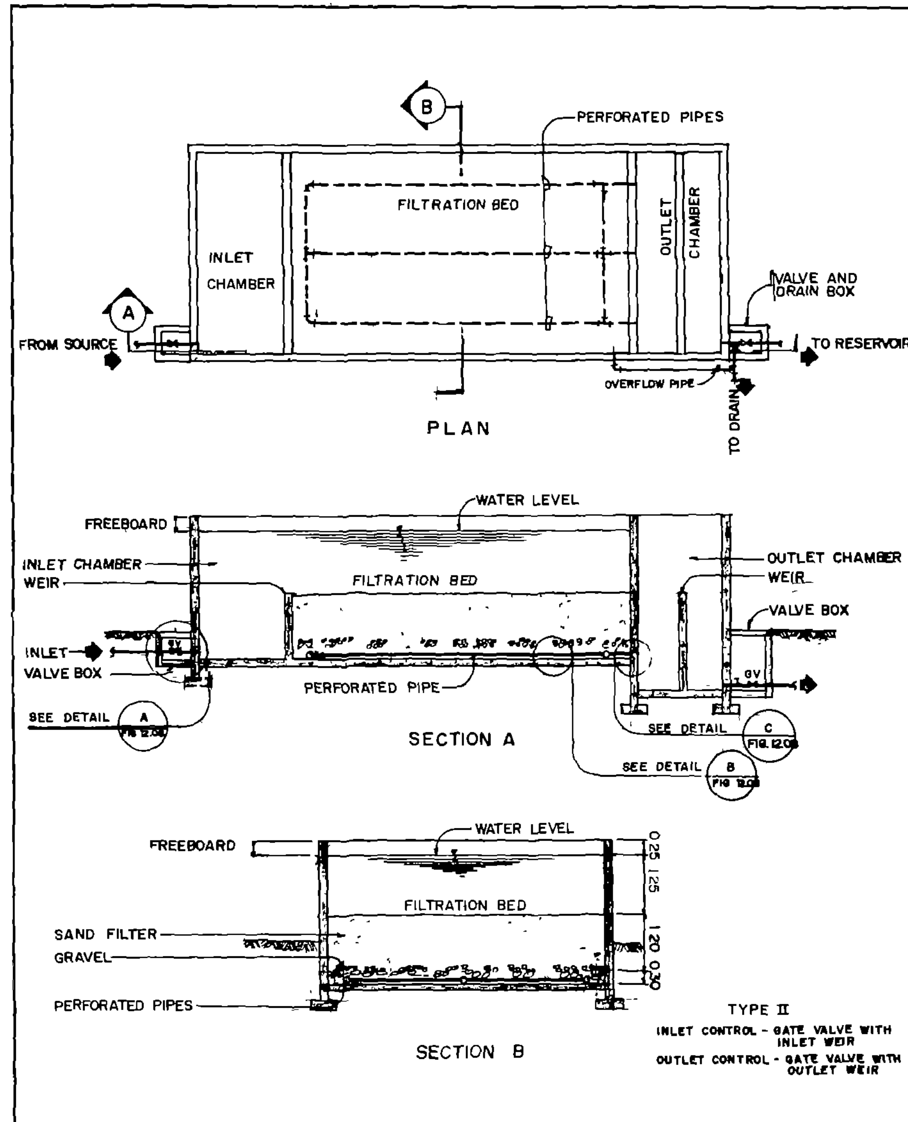
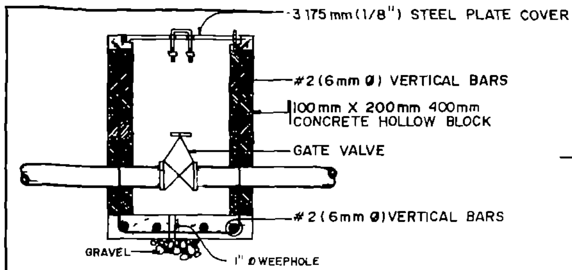
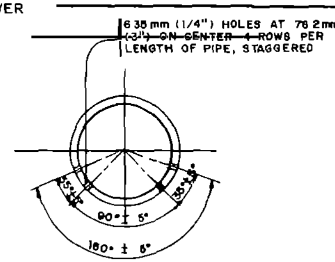


FIGURE 12 07

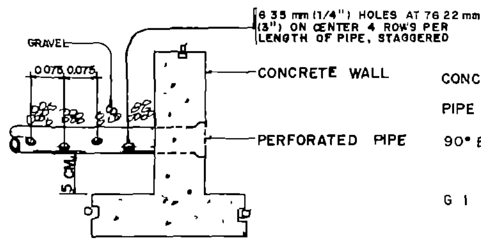
TYPE II SLOW SAND FILTER



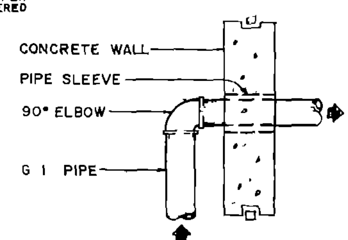
A DETAIL OF VALVE BOX
FIG 12 08 NOT TO SCALE



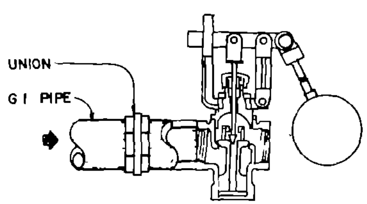
B DETAIL OF PERFORATED PIPE
FIG 12 08 NOT TO SCALE

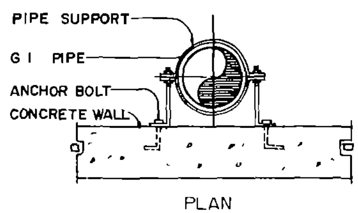


C DETAIL OF UNDERDRAIN PIPE
FIG 12 08 NOT TO SCALE



D DETAIL OF INLET PIPE
FIG 12 08 NOT TO SCALE



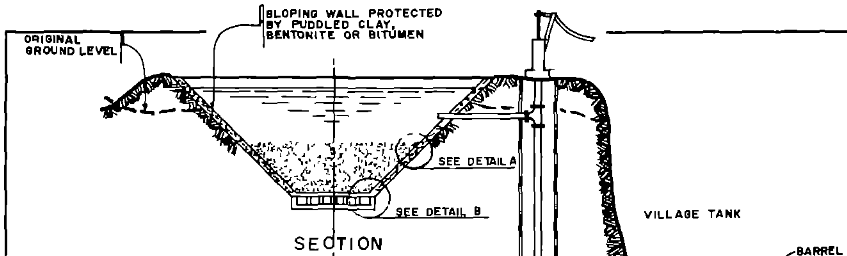


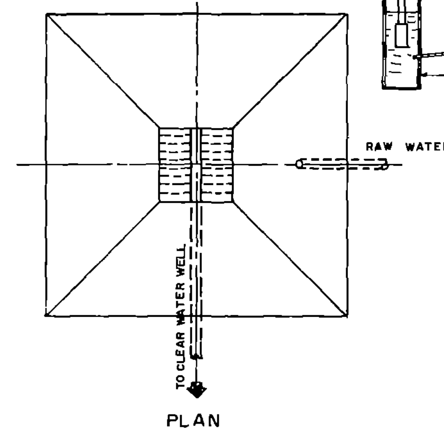
E DETAIL OF FLOAT VALVE
FIG 12 08 NOT TO SCALE

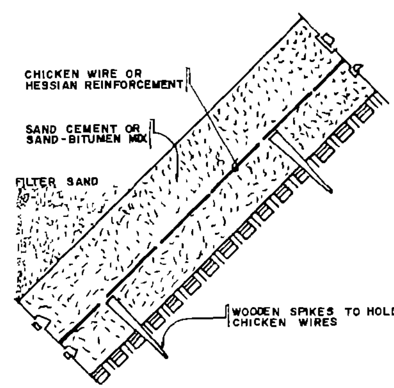
F DETAIL OF PIPE SUPPORT
FIG 12 08 NOT TO SCALE

FIGURE 12 08

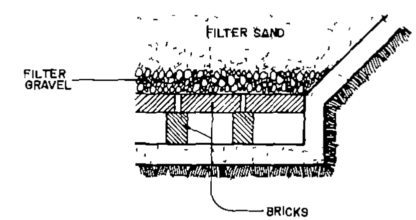
TYPICAL DETAIL OF FILTER APPURTENANCES







DETAIL A



DETAIL B

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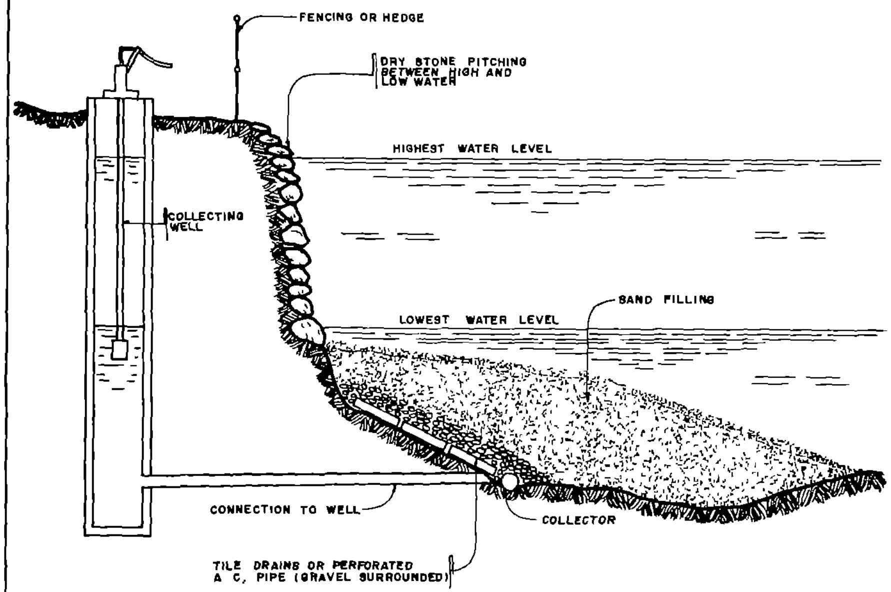
FIGURE 12 09

TYPE III SLOW SAND FILTER

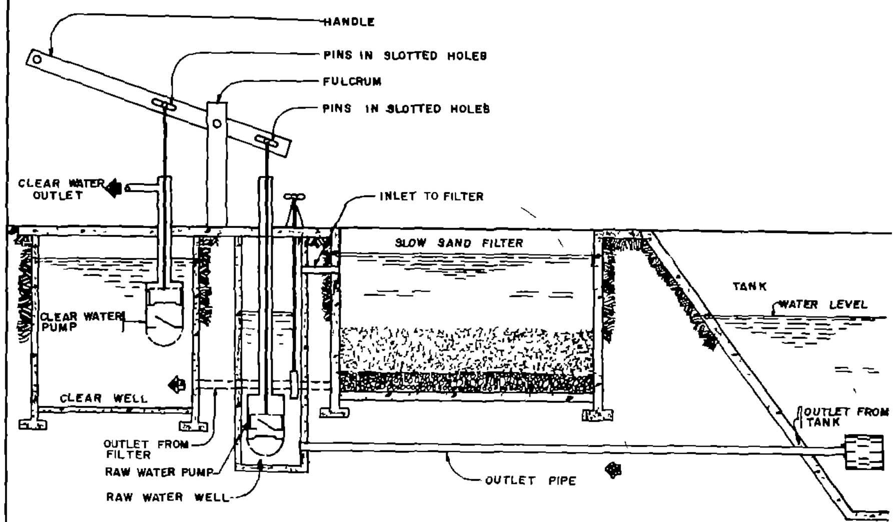


SECTION

FROM = BIOLOGICAL FILTERS, WORLD HEALTH ORGANIZATION

FIGURE 12 10

TYPE IV SLOW SAND FILTER



SECTION

FROM = BIOLOGICAL FILTERS, WORLD HEALTH ORGANIZATION

FIGURE 12 11

TYPE V SLOW SAND FILTER

CHAPTER 13

INSTALLATION OF PUMPING FACILITIES

13.01 GENERAL

Pumping equipment forms an important part in the transmission and distribution systems. It serves as the heart of the whole water supply system for it controls the amount of water to be transmitted and distributed. To properly determine the capacity and head of pumping facilities, a detailed hydraulic analysis should be conducted. The result of the analysis should then be correlated with the design and installation of the system.

Pumping facilities used for rural water supplies could be classified into two major categories, namely: well pumps and booster pumps. Well pumps are employed in pumping water from the well to the reservoir and/or directly to the distribution system and to the consumers. On the other hand, booster pumps are used to boost pressure in cases where the pressure available is below the minimum required pressure. This usually happens when the source is far from the consumers or when the elevation of the source is lower than that of the end users.

13.02 INSTALLATION OF WELL PUMPS

Installation of well pumps follows after well is completely developed and tested. In the design and installation of pumping facilities, friction losses should be minimized as much as practicable. This could be accomplished by making suction piping direct and short as possible and by proper selection of suction pipe and strainer. Usually, the selected pipe diameter for the suction line is one or two commercial pipe sizes larger than the pump suction connection. In which case, an eccentric reducer (with the pipe crown aligned) is required to eliminate the accumulation of air in the suction line which may lower the pumping efficiency. With respect to the size of the strainer, it should be 3 to 4 commercial pipe size larger than the suction line but at least one or two commercial pipe sizes smaller than the well casing.

A. Reciprocating Pumps

Shown in Figure 13.01 is a typical installation of a reciprocating pump. The assembly consists of a plunger rod holding the tubular well cylinder which is the water drawing part of the pump and the driver which composed of a flywheel driven by a motor and a handle for manual operation in case of power failure.

Installation Procedure:

1. Construct a concrete foundation as shown in Figure 13.01.
2. Install the pump arm, pivot (detail B/13.02), handle (detail A/13.02), and the motor assembly.
3. Lower the drop pipe with a strainer and foot valve attach to its bottom end using a pulley system. The final position of the strainer should

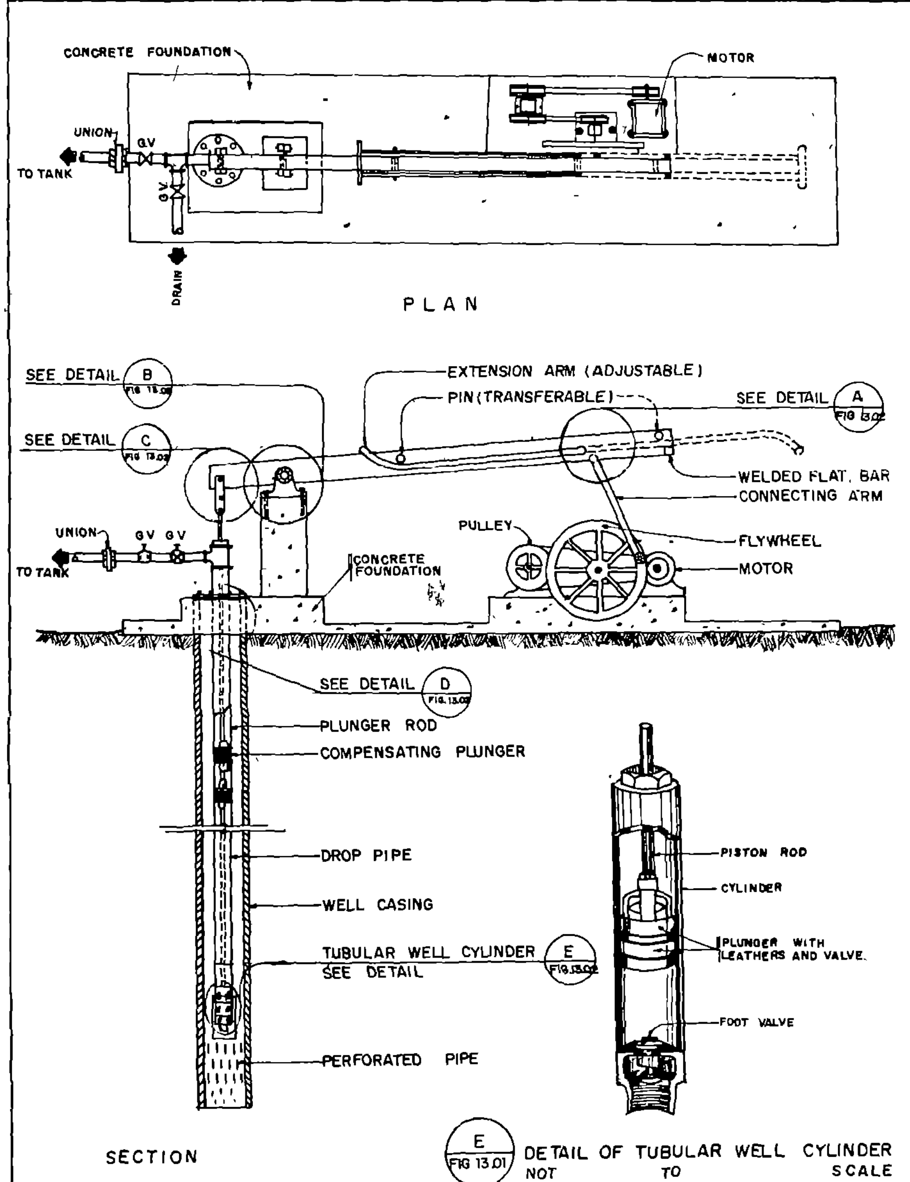


FIGURE 13 01

INSTALLATION OF RECIPROCATING PUMP

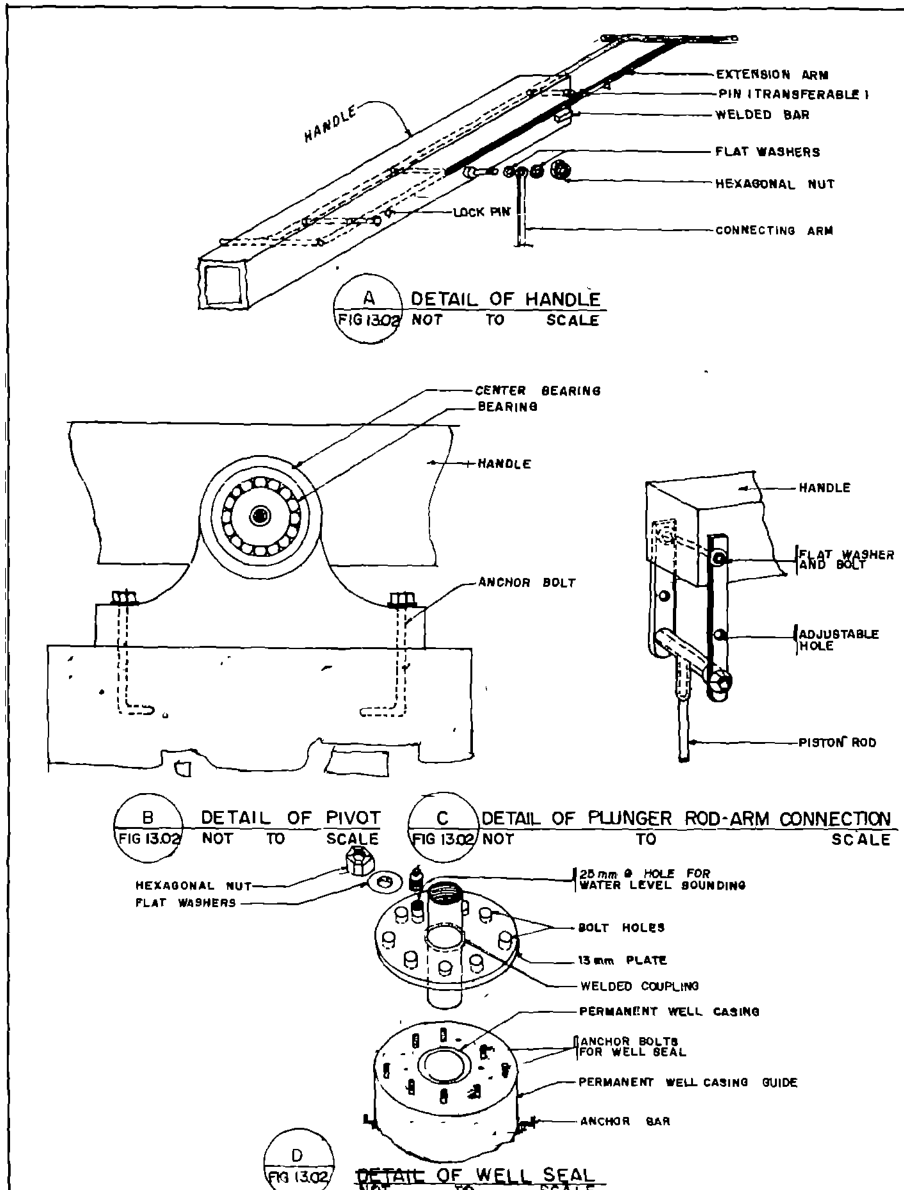


FIGURE 1302

TYPICAL DETAILS OF RECIPROCATING PUMP ASSEMBLY be at least one meter above the well screen or perforated pipe but below the pumping water level.

4. Connect the tubular well cylinder to the piston or plunger rod together with the drop pipe and then insert them into concrete casing.

5. Fix the end length of the drop pipe in the well seal (see detail D/13.02).

6. Bolt the upper end of the plunger rod to the arm (see detail C/13.02).

7. Connect the well arm to the flywheel of the motor assembly.

8. Install all the necessary valves and other appurtenances as shown in Figure 13.01.

9. Test and disinfect the newly installed assembly.

B. **Centrifugal Pumps**

Centrifugal pumps are employed in shallow well installations. It is employed only if the pumping water level is less than six meters.

Installation Procedure:

1. Construct a concrete foundation as shown in Figure 13.03 and detail (A/13.04).

2. Lower the suction line with foot valve together with the strainer attached to its lower end. The detail of foot valve and strainer is illustrated in detail C/13.04.

3. Fix the drop pipe using a well seal (see detail D/13.02).

4. Install pump and motor.

5. Connect the drop pipe to the suction of the pump as shown in Figure 13.03.

6. Install all the necessary valves and all other appurtenances as shown in Figure 13.03.

7. Test and disinfect the newly installed well pump assembly.

C. **Jet Pumps**

Jet pumps are installed in wells where the pumping water level do not exceed 20 meters. Shown in Figure 13.05 is a typical installation of a jet pump. The installation procedure is as follows:

1. Construct a concrete pump foundation and then allow a curing period of 28 days if standard Portland Cement is used or 7 days if Hi-Early Strength Portland Cement is employed.

2. Lower the drop pipe with foot valve, strainer and jetting equipment attached to it.

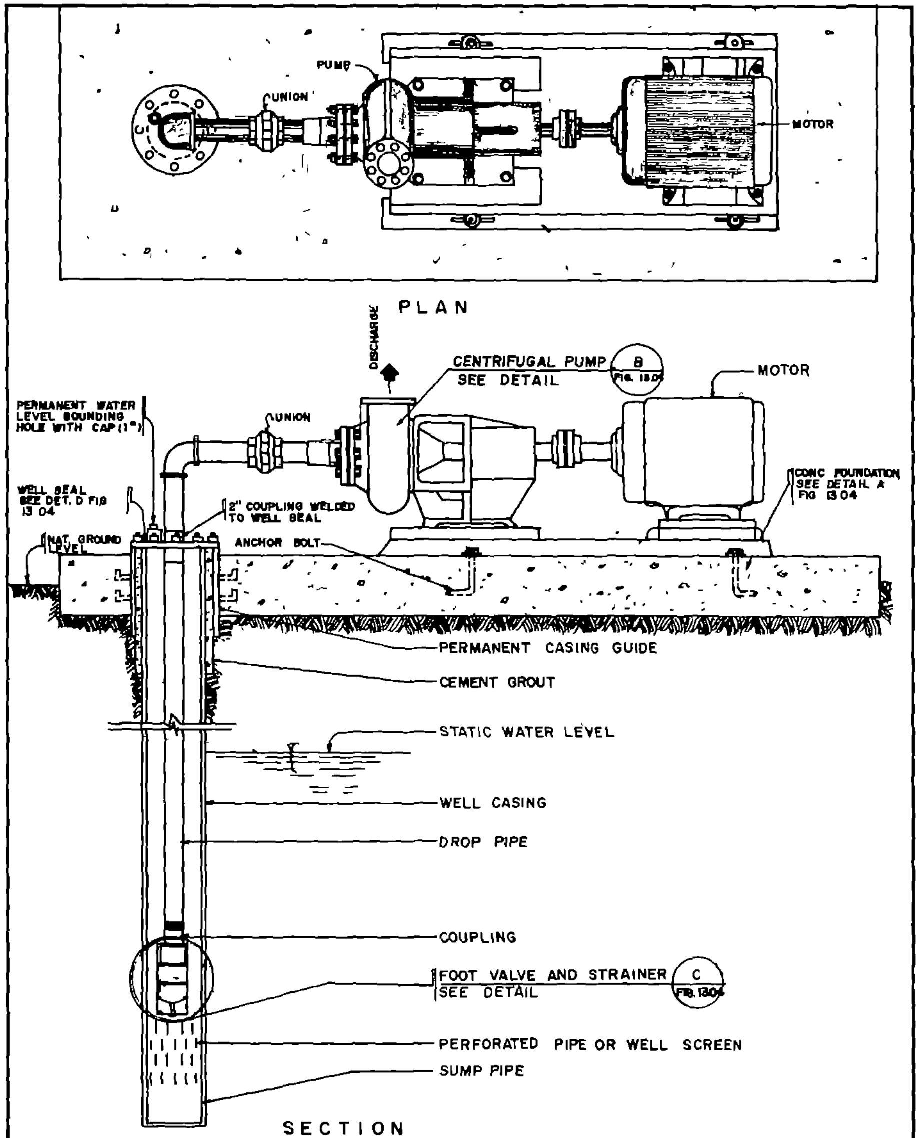


FIGURE 13.03

INSTALLATION OF CENTRIFUGAL PUMP

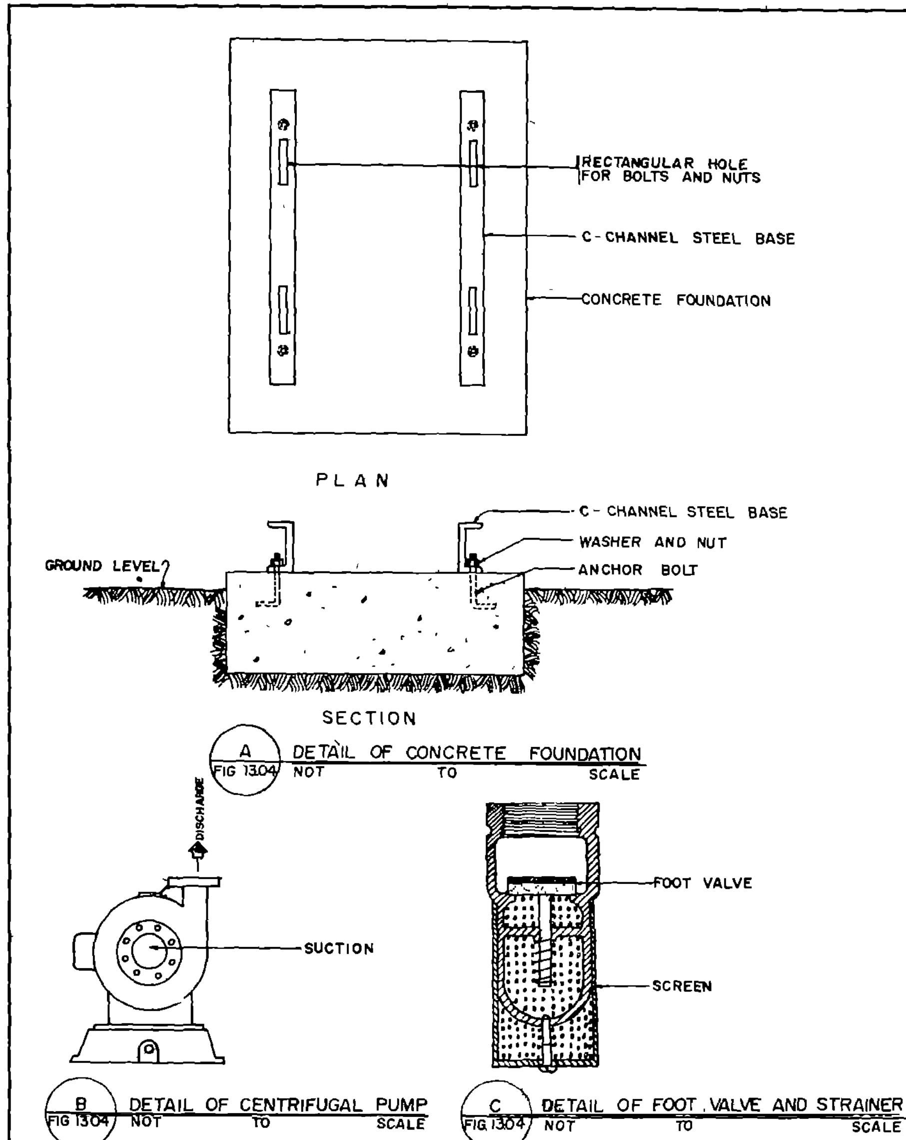


FIGURE 13.04

TYPICAL DETAILS OF CENTRIFUGAL PUMP ASSEMBLY

3. Fix the drop pipe at the mouth of the well using a well seal clamp (see detail A/13.05).

4. Install pump and motor.

5. Connect the drop pipe to the suction of the pump.

6. Install all the necessary valves, controls and other appurtenances as shown in Figure 13.05.

7. Test and disinfect the newly installed assembly.

D. **Submersible Pumps**

Submersible pumps are designed so that the pump motor and bowl are placed in the well below the water level. Shown in Figure 13.06 is a typical installation of a submersible pump in a deep well. The depth of submergence shall be such that there is sufficient net positive suction head (NPSH) available for the particular pump selected. Usually, the pump bowl is set at approximately 5-8 meters below the anticipated pumping water level.

Installation Procedure:

1. Prepare all parts and accessories of submersible pumps as indicated in Figures 13.06 and 13.07.

2. Inspect pump rotating elements. Open the pump and turn the end shaft with a screw driver to be sure that the rotating elements turn counter clockwise without binding. Replace all the dismantled parts.

3. Connect cable to the motor.

   a. Cable Connector to Motor is of screw or thread type

      i. Remove the cable guard with a screw driver and the plastic plug from motor connector socket.

      ii. Insert connector end of cable into motor connector socket.

      iii. Thread connector jam nut into motor socket to seal the cable.

   b. Cable Connector to Motor is of Splice Type

      i. Cut the cable ends in a manner that the joints will be staggered 50 mm apart. Take care to match wires by colors; that black to black, red to red, and yellow to yellow.

      ii. Trim the insulation back 13-19 mm from the end of each wire and then carefully clean off all insulating varnish from exposed copper.

      iii. Connect the cable to the motor terminals and cover the joint tightly with either No. 33 or No. 88 Scotch waterproof tape. Stretch tape and wrap each wire and joint tightly for a distance of 38 mm on each side of the joint until four lay-

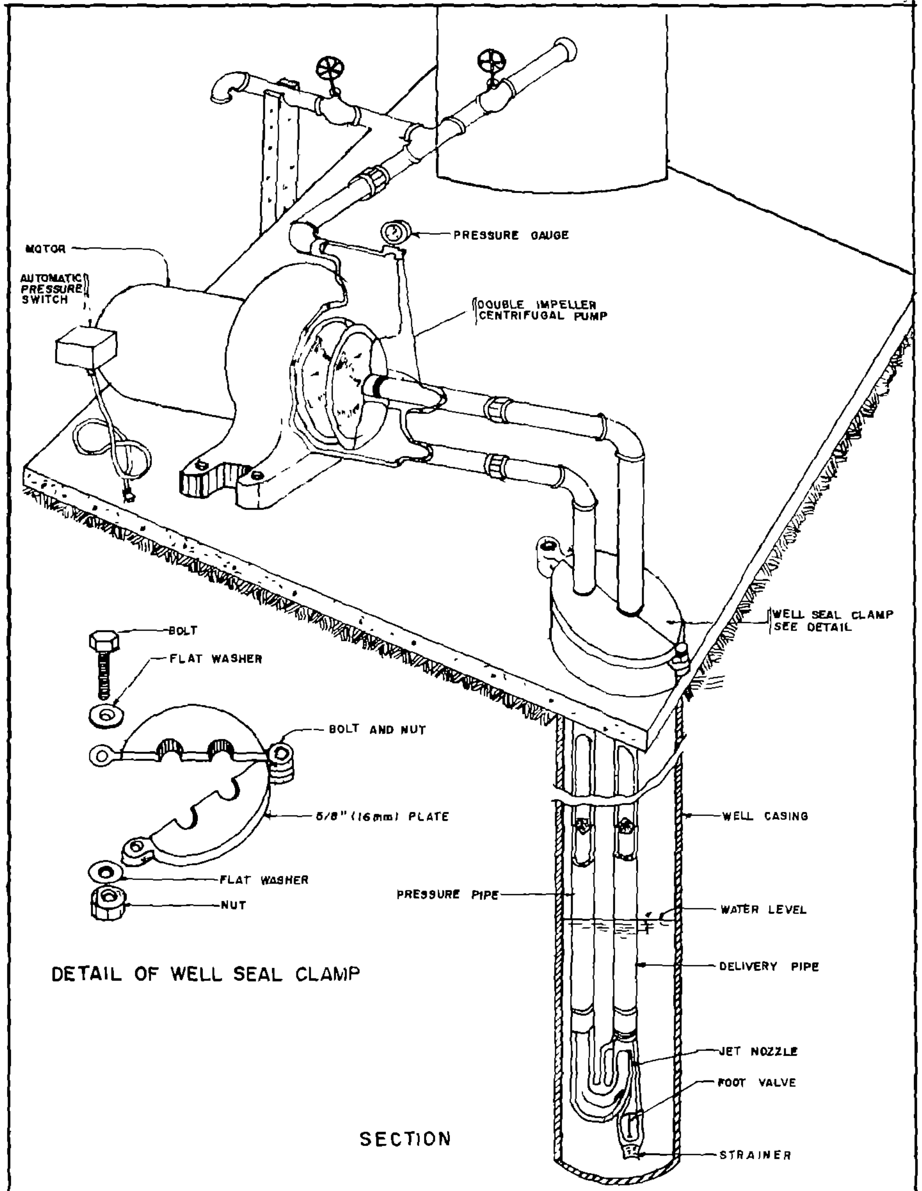


FIGURE 13 05

INSTALLATION OF JET PUMPS

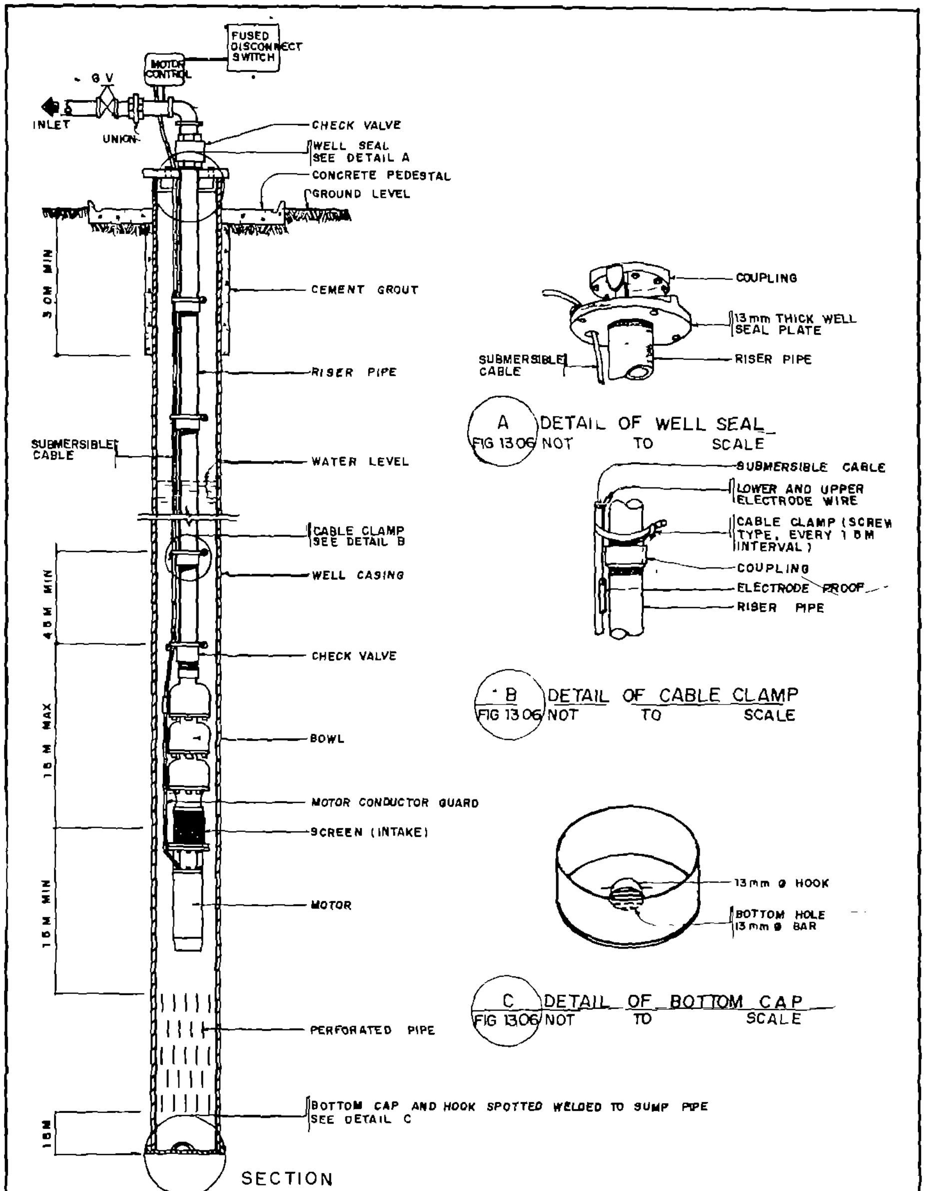


FIGURE 13 06

INSTALLATION OF SUBMERSIBLE PUMP INSIDE WELLS

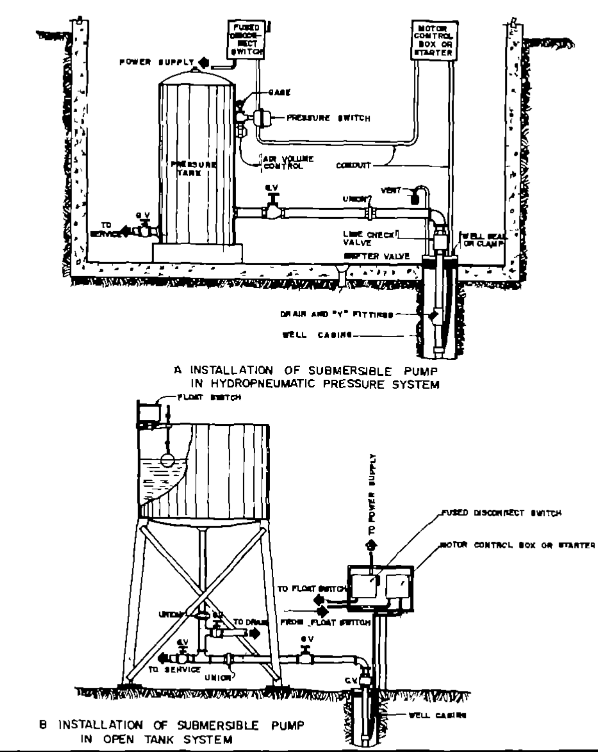


FIGURE 13 07 INSTALLATION OF SUBMERSIBLE PUMP IN PRESSURE AND NON - PRESSURE SYSTEM

ers of tape are wound tightly about the joint. The edges of the tape should be pressed down solidly onto the wire.

4. Test the motor as well as the joints by connecting the unit to power supply. During the testing, the pump and motor should be submerged by at least 10 cm in water. Also, provide a pipe connected to the pump discharge to direct pump water back into the testing tank. During the test run, do not allow pump to run dry even for a few seconds. Furthermore, to determine whether the joints are grounded or not, an ohmmeter is oftenly employed.

5. Lay cable flat against pump and install cable guard protecting cable from any sharp edges.

6. Connect the first length of riser pipe to the pump and start the lowering of the pump slowly with the aid of a tripod, pipe holder, chain block, pulley and pipe clamps. As lowering of the unit progresses, other sections are added until the unit is completely submerge in water.

   During the lowering of the pump, the cable is secured in the riser pipe at every 3 meters interval with a cable clamp. As the cable is attached to the riser pipe, examine it for insulation breaks. Any damaged spots on the cable should be cleaned carefully and sealed with a waterproof electrical tape. Also, during the lowering operation, avoid using pump cable to support the weight of the unit.

7. Repeat checking the cable for "ground" using an ohmmeter. If it is found to be grounded, check the cable joints and seal it.

8. Continue the lowering of the pump until the desired pump submergence (usually 5-8 meters below the pumping water level) in the well is reached and re-checked the assembly for "ground".

9. Fix the drop pipe at the mouth of the well casing using a well seal (see detail A/13.06).

10. Connect the cable line into the pump control box. The connection should be done in accordance to the specification of the pump manufacturer.

11. Test the unit by connecting it to the power supply and observing its discharge rate. If the rate is below the specified pump capacity, immediately stop the pump and check the electrical connection. During the test, never allow the pump to run dry even for a few seconds nor allow it to run in a reverse direction for several minutes.

12. Install all valves, controls and other appurtenances. If submersible pump is employed in hydropneumatic pressure system, install appurtenances as shown in Figure 13.07A while if it is used in open tank system, install appurtenances as shown in Figure 13.07B.

13. Install a lightning arrester on the incoming line to the control box or magnetic starter to protect the pump from lightning.

13.03 INSTALLATION OF BOOSTER PUMPS

Booster pump is employed either to increase head or pressure in the pipelines or to increase its carrying capacity or both. It is particularly useful in boosting the pressure in the transmission of water whose source is far from the consumers and where there is not enough distribution pressure or as a means of supplementing the supplies to isolated areas where the growth of consumption over a period of years has exceeded the capacity of the existing water supply system.

Boosting can be accomplished by either using an In-Line Booster Pump or Sump Pump. Booster pumps are usually operated automatically. Their operation may either be based on the rate of flow and head downstream, by time controls or by pressure if a pressure tank is employed. If the latter type of control is used, the pump is started and stopped by means of a pressure operated switch.

A. In-Line Booster Pump

Illustrated in Figure 13.08 is a typical assembly of an In-Line Booster Pump. The installation procedure are as follows:

1. Determine where the pump will be located.

2. Construct the pump concrete foundation and allow the concrete to harden.

3. Install the pump on the concrete foundation.

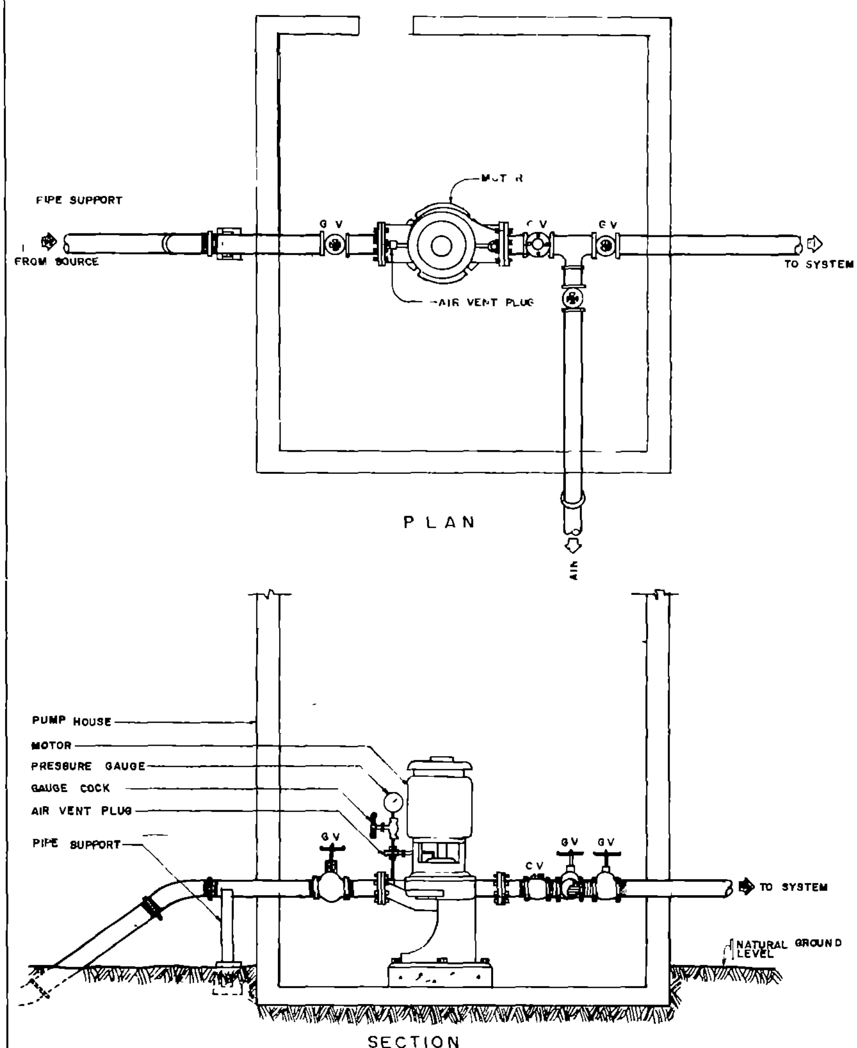


FIGURE 13 08

INSTALLATION OF IN-LINE BOOSTER PUMP

4. Connect the suction side of the pump to the water main coming from the water source and the discharge side to the water main distributing water to the consumers.

5. Install all the appurtenances shown in Figure 13.08.

6. Test and disinfect the assembly before commissioning.

B. **Sump Pumps**

Illustrated in Figure 13.09 is a typical installation of a sump pump. The assembly consists of a sump, flow control valves and pump controls. The sump may be constructed using reinforced concrete ferrocement or concrete hollow blocks while the pump maybe of centrifugal, vertical or submersible type. The procedure of sump pumps are as follows:

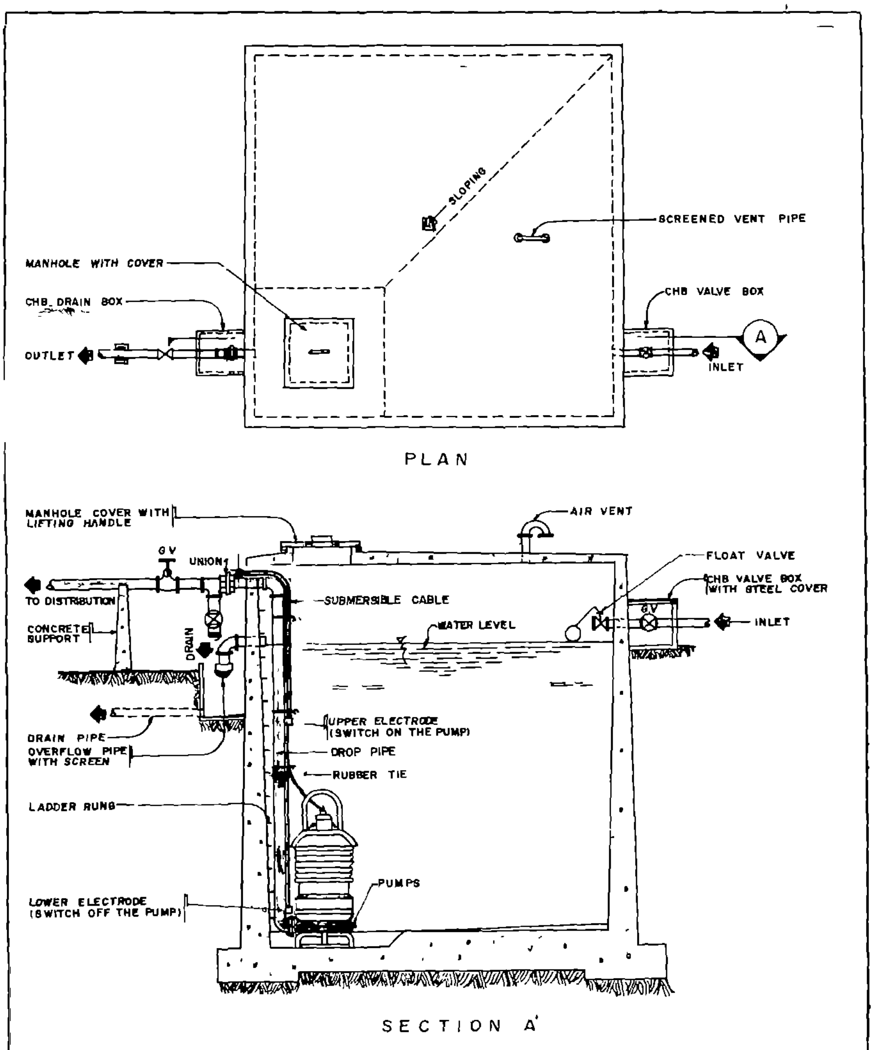


FIGURE 13.09

INSTALLATION OF SUMP PUMPS

1. Construct a Sump.

   The sump should have a volume equivalent to at least the volume of water the pump could convey in 20 minutes. Also, in designing the sump, the amount of water coming into the sump as well as the water demand of the consumers should be carefully considered.

2. Install the pump and its appurtenances as shown in Figure 13.09. The type of pump illustrated in the figure is the submersible type.

3. Test and disinfect the assembly before commissioning.

13.04 PUMP CONTROLS

Pumping facilities may be operated manually or automatically. Manual control consists of a switch which starts and stops the motor of the pump as desired. On the other hand, pumps could be operated automatically using a pressure switch or electrodes or flow switch.

A. **Electrodes**

Electrodes are installed at the minimum and maximum water level of the reservoirs. The electrode set at the minimum water level starts the pump automatically while the electrode placed at the maximum water level stops the pump motor automatically.

B. **Pressure Switch**

This type of control is used only when the pump is operated in conjunction with the hydropneumatic pressure tank. The pump meter is started when the pressure in the tank is the minimum pressure set and is stopped when the pressure is the maximum pressure set.

C. **Flow Switch**

A flow switch is installed at the discharge of each pump to cause the motor to stop automatically when flow ceases when the reservoir is already full.

13.05 CONSTRUCTION OF PUMPHOUSES

Pumphouses are primarily constructed to protect pumping facilities and to serve as the operator's quarter and office and storage for spare parts of equipment and tools for the operation and maintenance of the water supply system. Illustrated in Figure 13.10 to Figure 13.19 are plans for the construction of typical CHB pumphouse. In the selection of construction materials, indigenous materials should be given the first priority.

Construction Procedure:

1. Measure the area where the pumphouse will be located with reference to the plans and drawings, and stake it.
2. Clear and grub the proposed site of pumphouse.
3. Excavate the area that will serve as the foundation.
4. Install the reinforcing bars.
5. Construct the form for columns or posts.
6. Concrete the foundation and columns.
7. Put up the CHB walls and partitions.
8. Concrete the floor.
9. Construct the roof support structure.

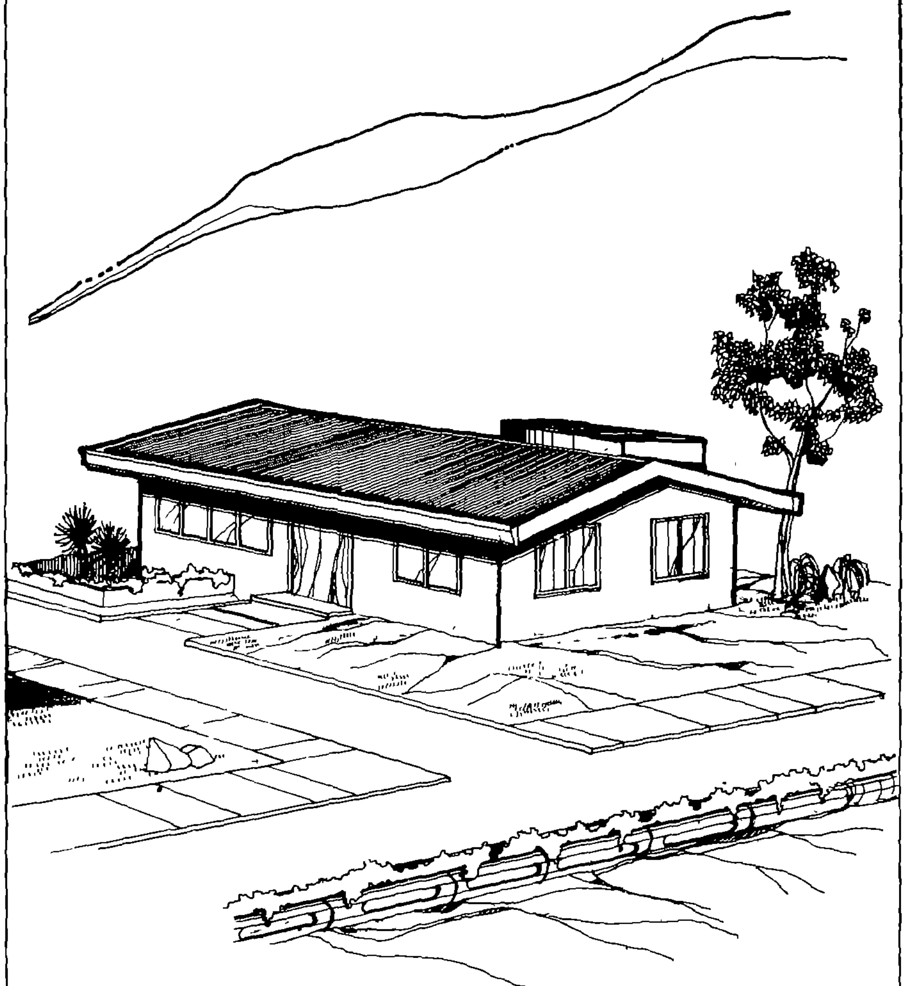


FIGURE 13 10

PERSPECTIVE OF PUMPHOUSE

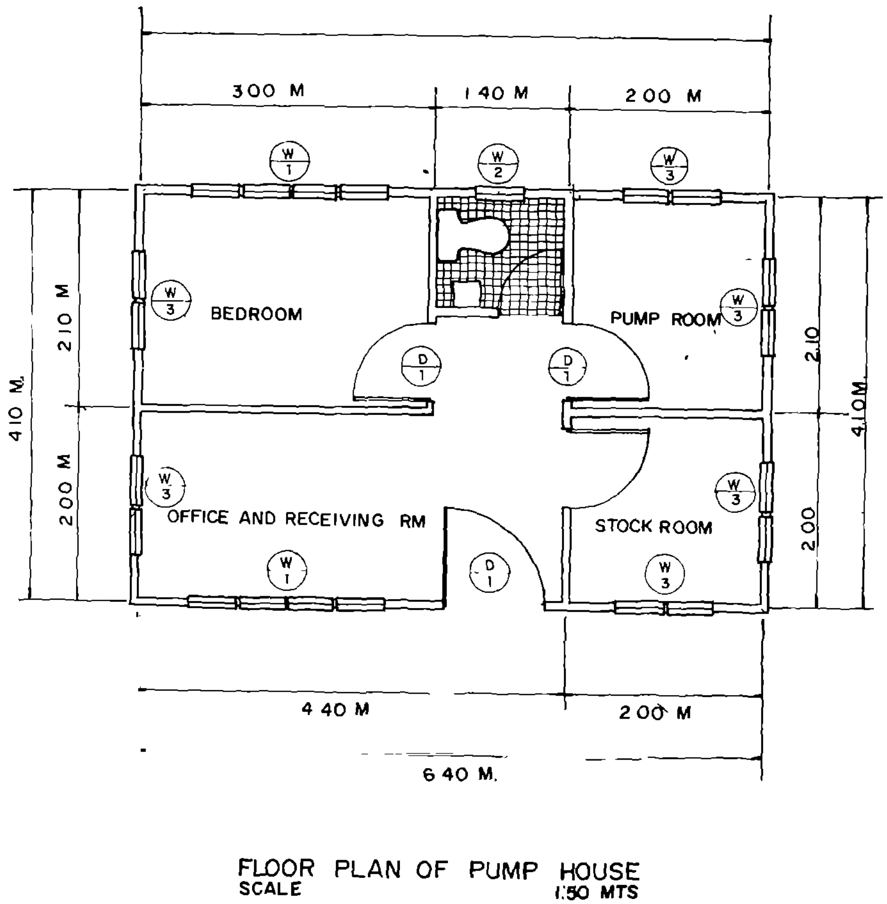
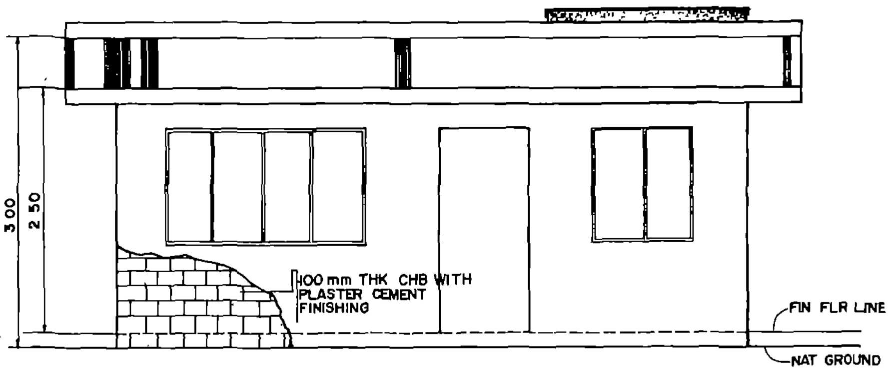
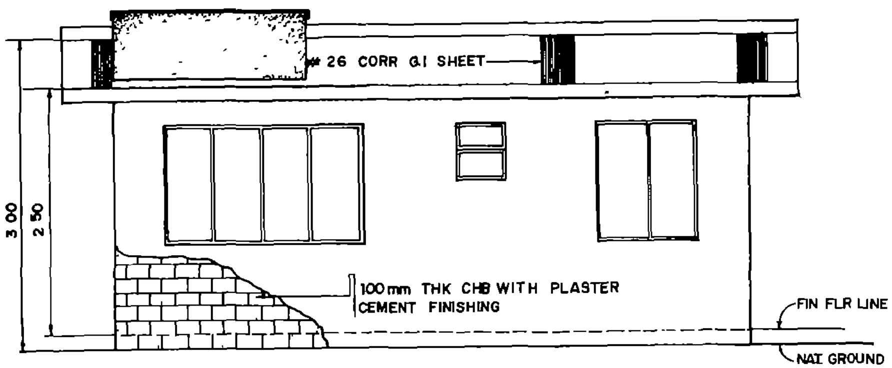


FIGURE 13 11

FLOOR PLAN OF PUMPHOUSE



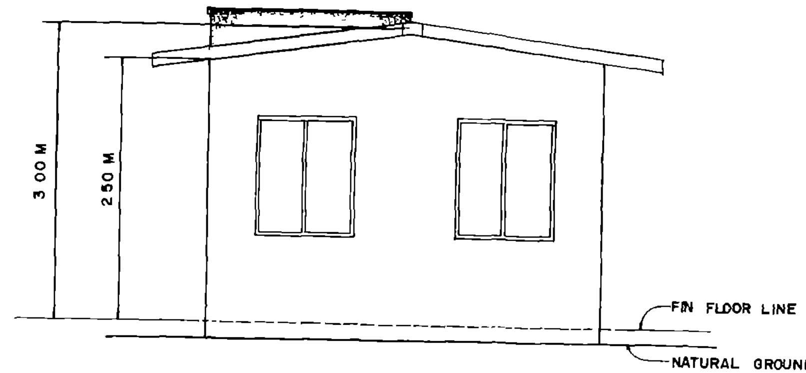
FRONT ELEVATION
SCALE 1:50 M.



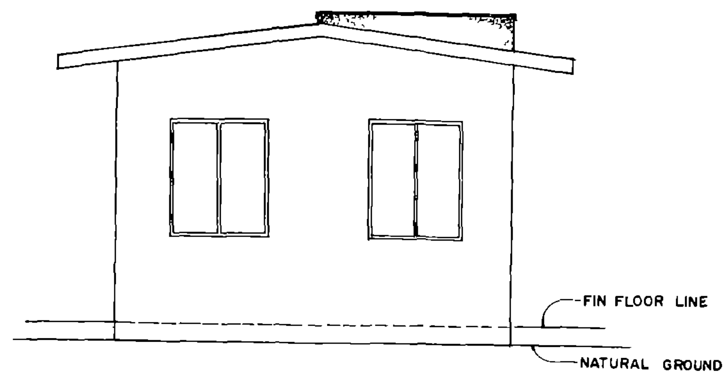
REAR ELEVATION
SCALE 1:50 M.

FIGURE 13.12

FRONT AND REAR ELEVATION OF PUMPHOUSE



LEFT SIDE ELEVATION
SCALE 1:50 M



RIGHT SIDE ELEVATION
SCALE 1:50 M

FIGURE 13.13

RIGHT AND LEFT SIDE ELEVATION OF PUMPHOUSE

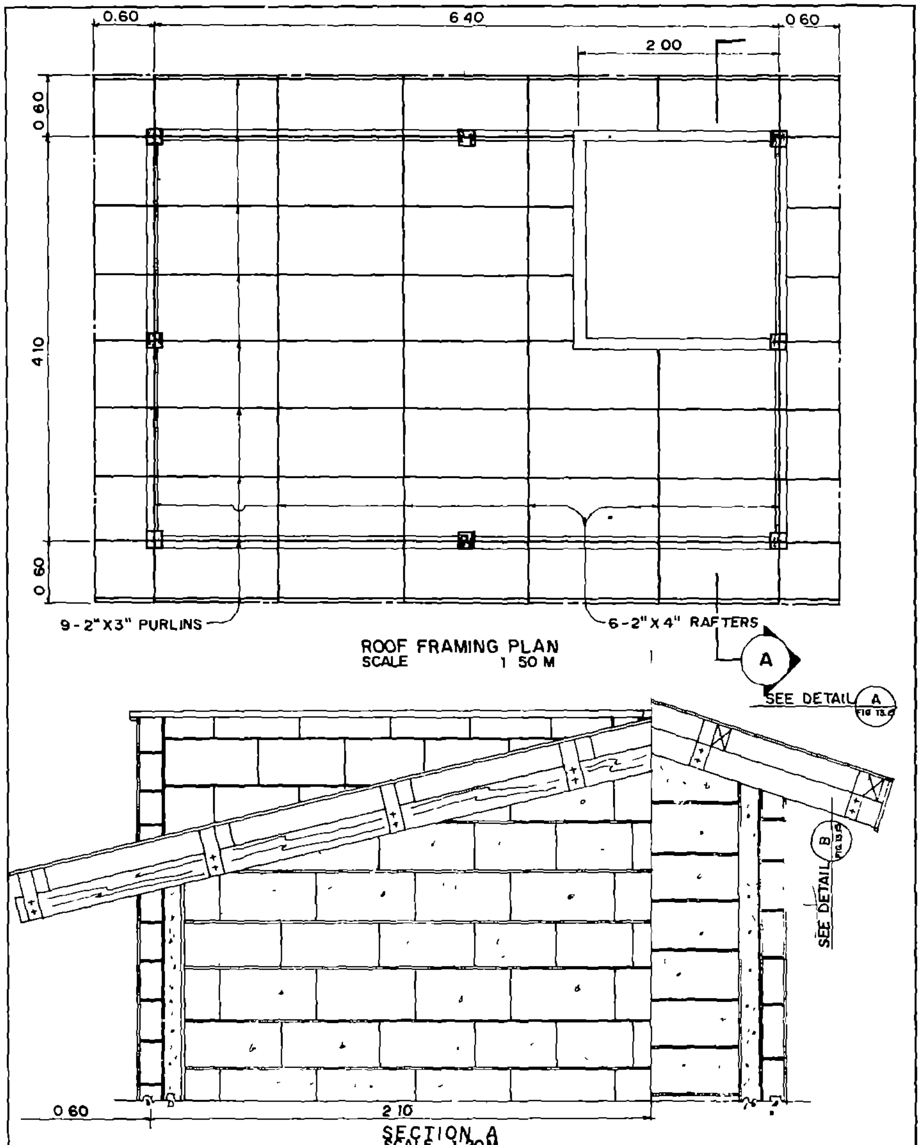


FIGURE 13.14

ROOF PLAN OF PUMPHOUSE

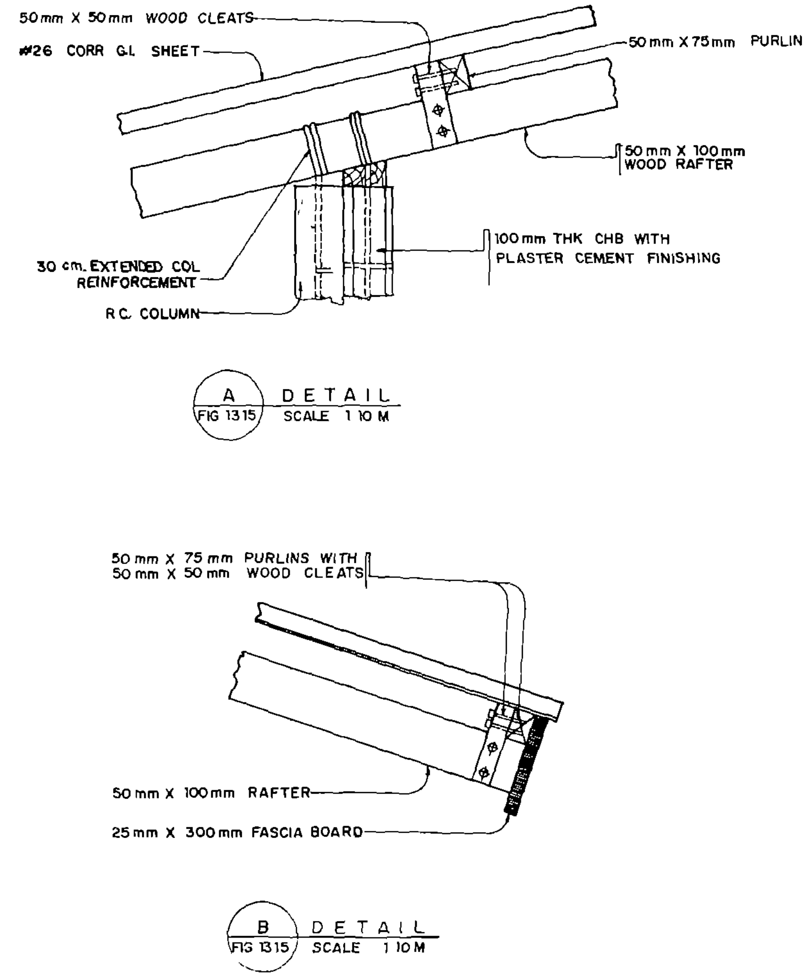


FIGURE 13.15

DETAIL OF ROOFING CONNECTION

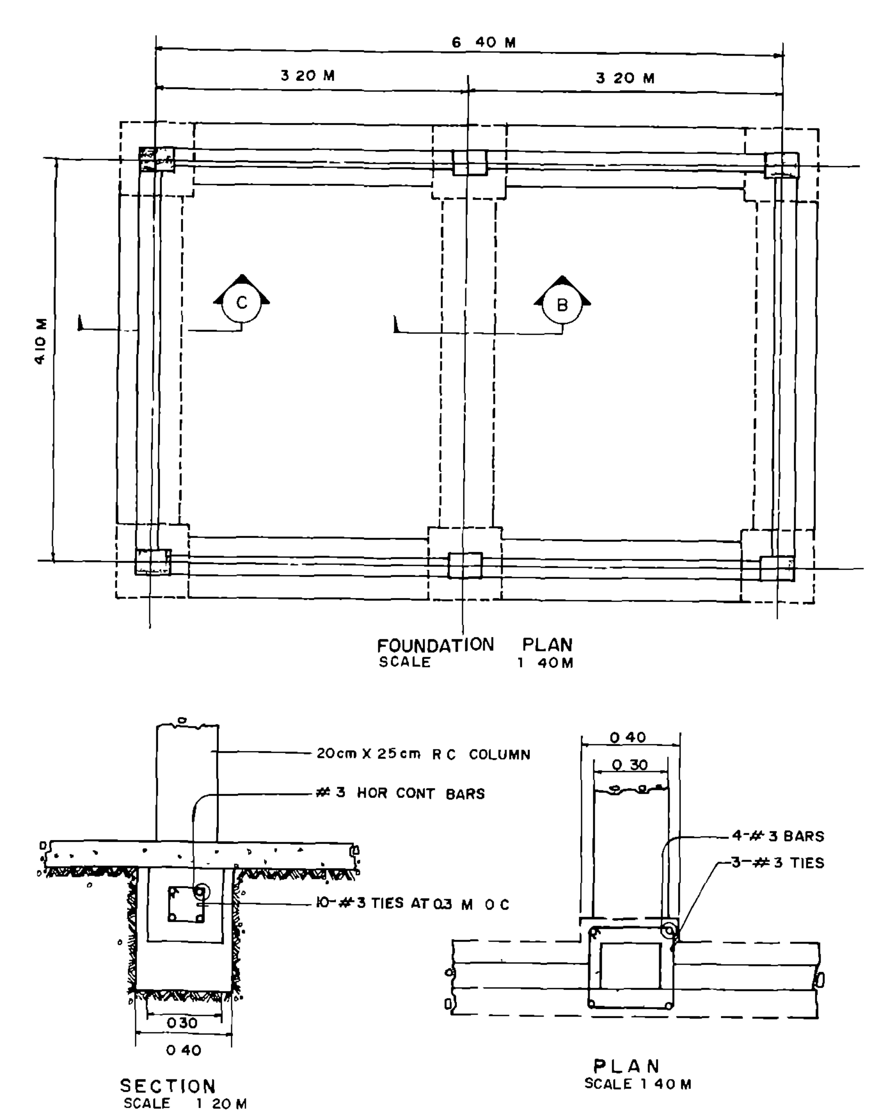


FIGURE 13 16

DETAIL OF FOUNDATION

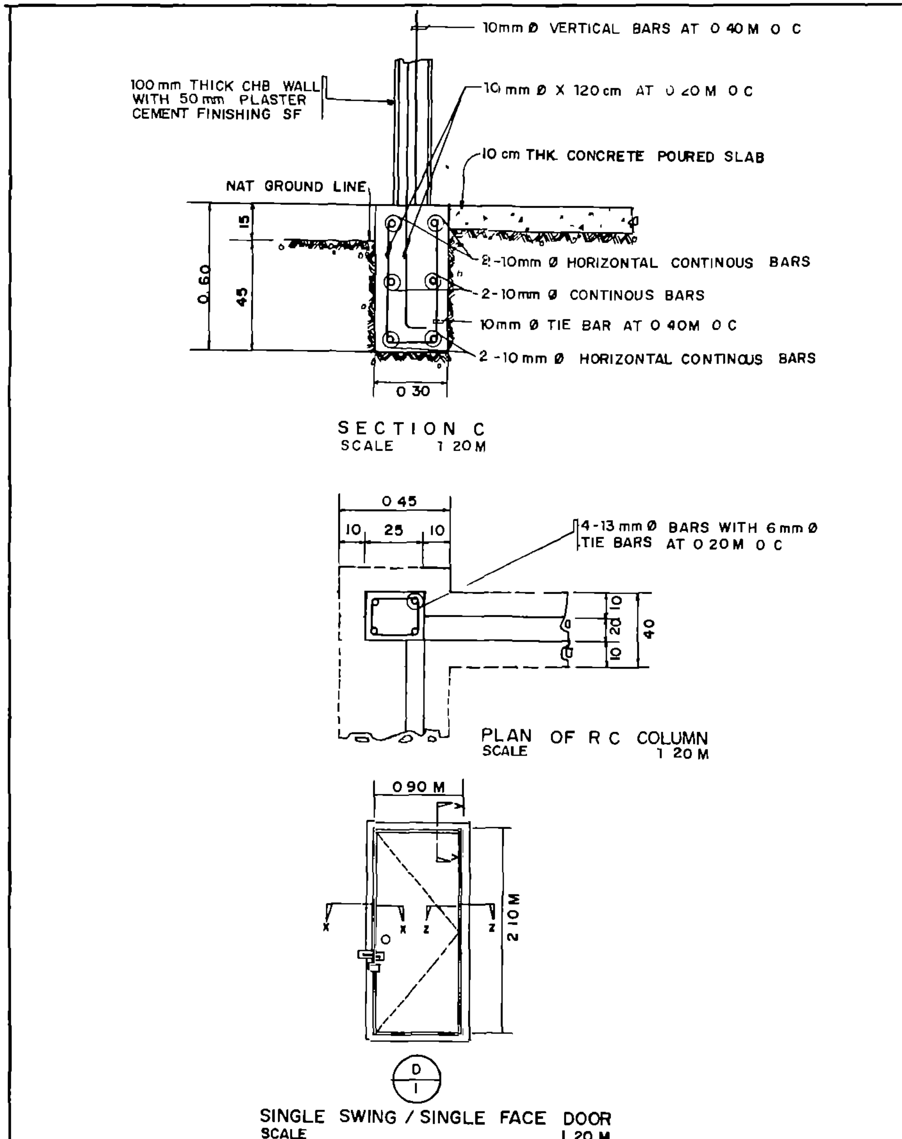


FIGURE 13 17

DETAIL OF WALL FOOTING, R C COLUMN AND DOOR

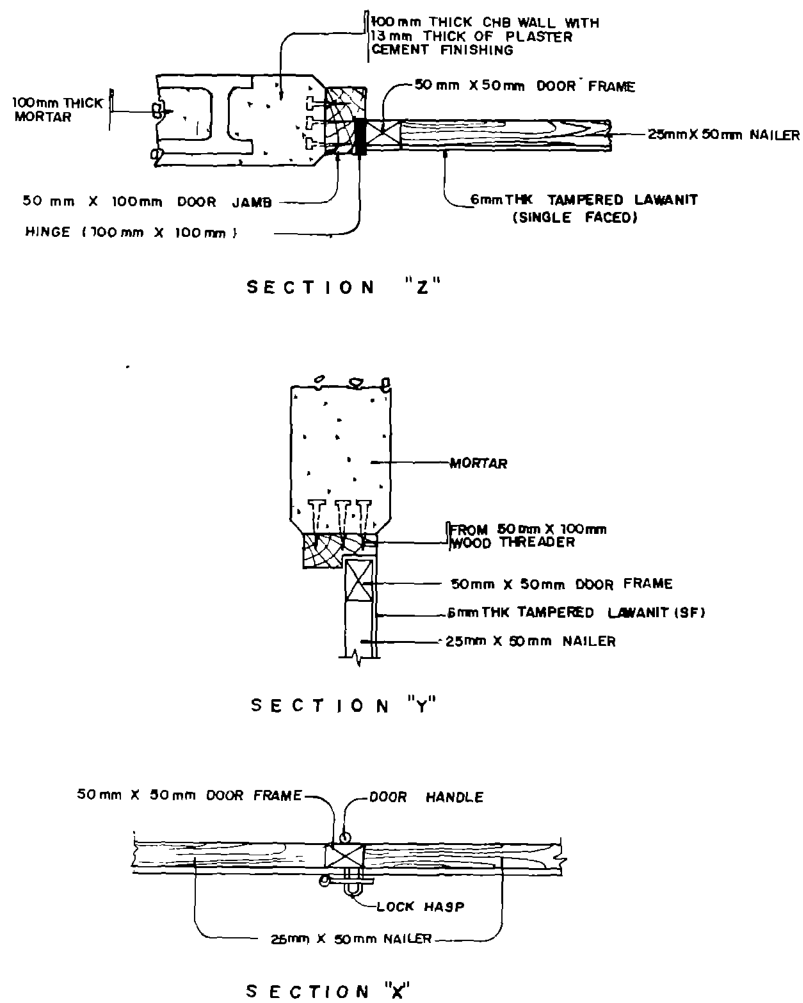


FIGURE 13 18

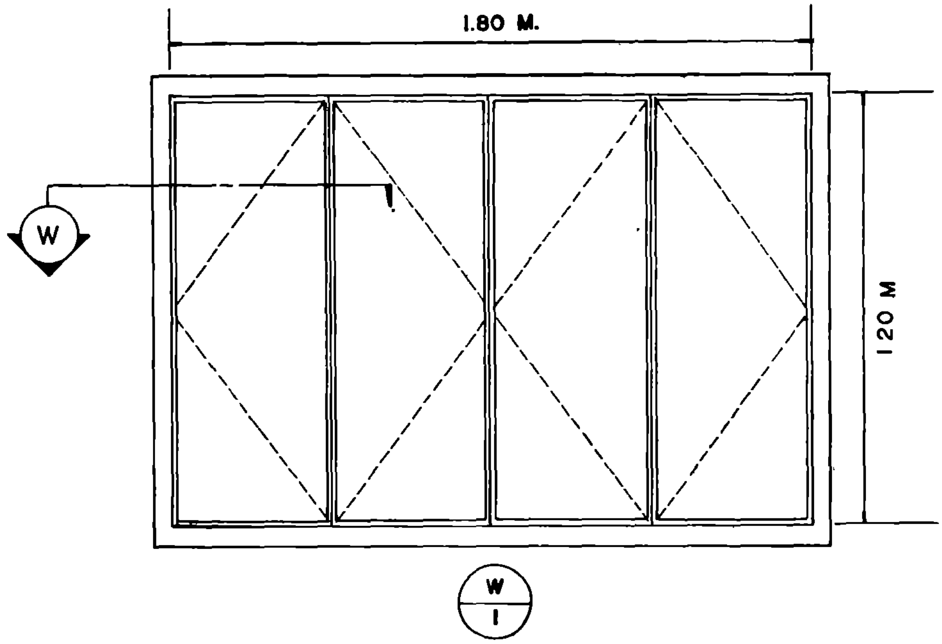
DETAIL OF DOOR

10. Fasten the corrugated G.I. sheets to the roof structure.

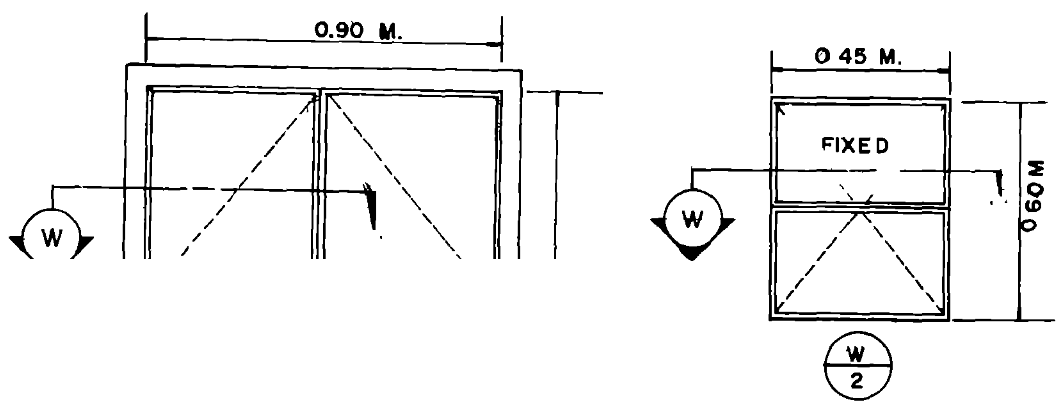
11. Proceed with the finishing operations which include the plastering of CHB walls with concrete mortar, putting up of windows, doors and other necessary items as shown in the plans.

12. Paint the pumphouse.

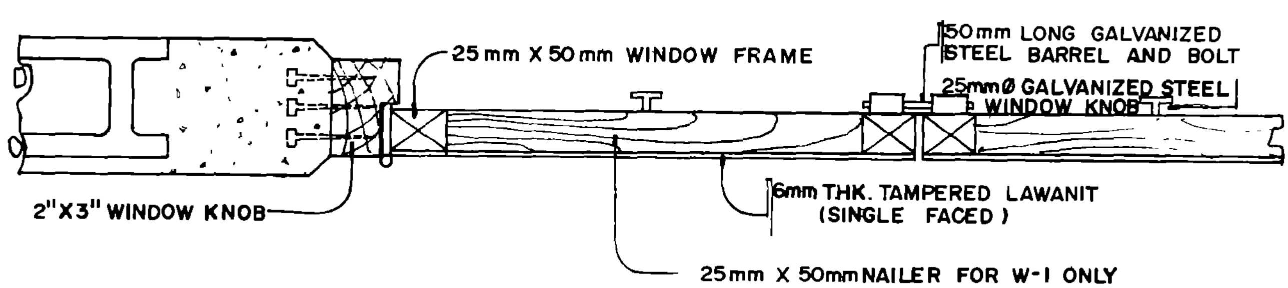
The size and finishing of pumphouse is usually dictated by the amount of funds available for its construction and the size of the water supply system. An alternate design of pumphouse is shown in Figure 13.20. It is smaller in dimension as compared to the design shown in Figure 13.10.



CASEMENT WINDOW WOOD TYPE WITH MULLION AT MIDPOINT OF OPENING PROVIDE STIFFENER.
(SET)



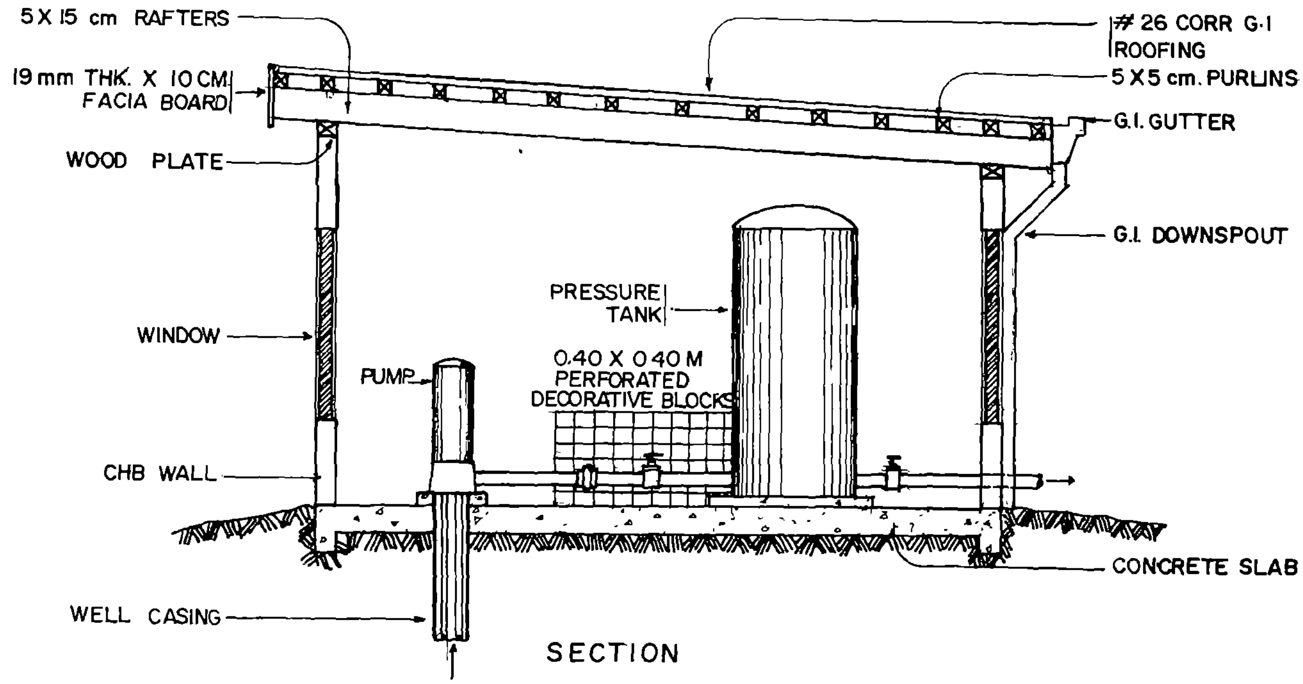
CASEMENT WINDOW WOOD TYPE WITH MULLION AT MIDPOINT OF OPENING
(SET)



SECTION "W"

FIGURE 13.19

DETAIL OF WINDOW



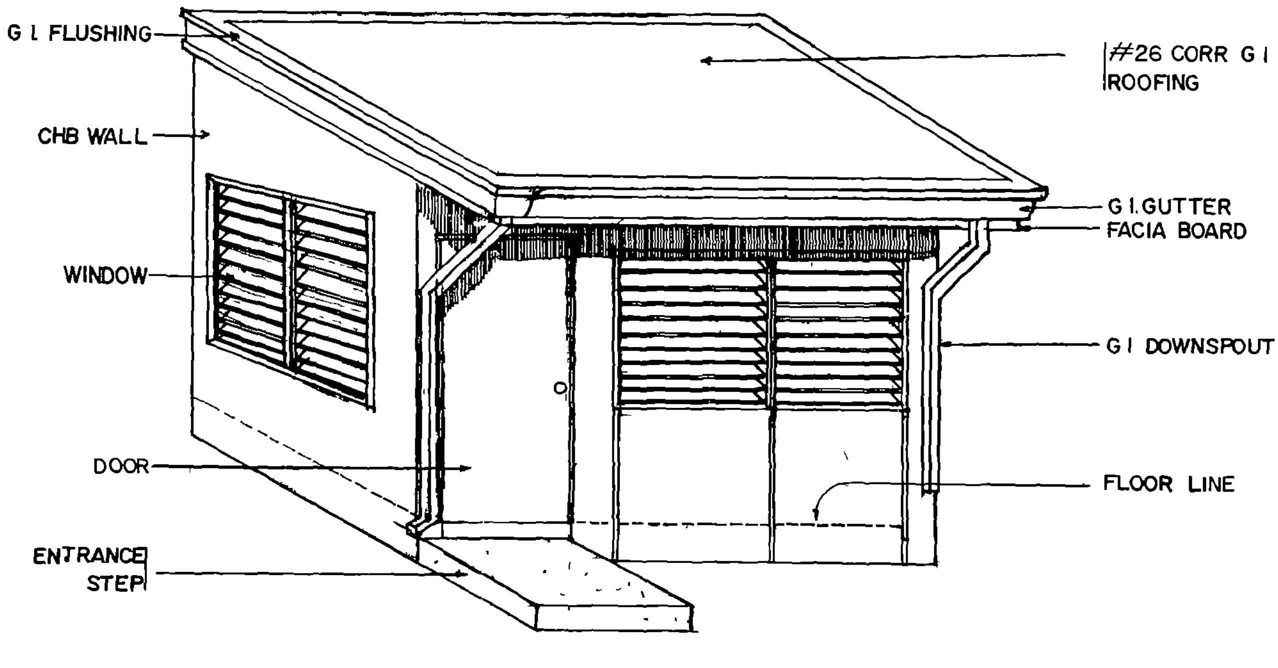


FIGURE 13.20

TYPICAL PUMPHOUSE FOR A PUMP INSTALLATION

CHAPTER 14

PAINTS AND COATINGS

14.01 GENERAL

Paints and Coatings are employed to protect the exposed surfaces of materials from immediate deterioration. For instance, painting protects the wood from the attack of termites carpenter ants and other boring insects; and metals from corrosion. Also, paints and coatings are used to improve the appearance of these materials, making them pleasant to look at.

14.02 PAINTING MATERIALS

Painting materials may be generally classified as primers and finishing paints. Primer paints are usually employed as the primary or first coat while the finishing paints are employed for the body or second coat and finishing or third coat.

A. Finishing Paints

Finishing paints may be classified according to usage and composition. Presented in Table 14.01 are the different types of paints classified according to their composition and usage. Also, paints may be classified as gloss and flat if the bases of classification is the brightness of the surfaces painted. Gloss paints produce a bright painted surface while flat paints give a dull surface.

B. Primers and Sealers

In any painting job, primers and/or sealers are usually employed as the primary or first coat to provide the body and finishing coats a good base to adhere. Also they are employed to stop surface suction, thereby reducing the amount of finishing paints to be used in the succeeding coats. Sometimes, primers/sealers are used in filling holes and dents, thereby providing a smoother surface. Presented below are some common primers/sealers:

1. Red Lead and Red Oxide Primer

   Red lead and red oxide primer are general purpose primer paints for interior and exterior used on iron and steel surfaces. They are highly recommended for use as coat primer providing metals long lasting protection against corrosion. However, they contain a very toxic pigment, hence, they are not recommended to be used in the painting of the inside surfaces of reservoirs or any other surfaces in contact with the water supply.

2. Epoxy Paint Primer

   Epoxy paint primer is non-toxic, hence, it is employed as the first coat when painting metals in contact with water supply.

Table 14.01

CLASSIFICATION OF PAINTS ACCORDING TO USAGE AND COMPOSITION

Name of Paints	Classification According to Usage					
	Wood		Masonry		Metals	
	Exterior	Interior	Exterior	Interior	Exterior	Interior
1. Acrylic emulsion latex paint.	X	X	X	X		
2. Shertex textured white paint.	X	X	X	X		
3. Gloss latex white.			X	X		
4. Flat paste paints.		X		X		
5. Semi-gloss latex white.		X		X		
6. Flatwall enamel white.		X		X		
7. Exterior gloss paint.	X					
8. Quick drying enamel.	X	X			X	X
9. Semi-gloss enamel.	X	X	X	X	X	X

3. Wood Primer and Sealer

   Wood primer and sealer is a specially formulated material for use as first coat when painting wood surfaces. It possesses excellent adhesion properties and dries to a hard film, stops the surface suction, thereby, reducing to a great extent the amount of paint to be used in the succeeding coats. In addition, it is also good as a sealer.

4. Masonry Sealer

   Masonry sealer is employed as the primary coat when painting masonry and concrete surfaces. It is employed as a barrier against moisture and salt found in concrete which may cause efflorescence damage or eruptions.

C. **Accessories**

The items mentioned herein are materials used in conditioning the surfaces to be painted.

1. Concrete Neutralizer or Surface Conditioner

   Concrete neutralizer is a very reactive solution to be used on new masonry or concrete surfaces to neutralize alkalies, thus insuring good adhesion of paint to the substrate or concrete.

2. Metal Treatment Solution

   Metal treatment solution is a concentrated mixture of acids for cleaning and degreasing metal surfaces prior to application of paint system. It also acts as phosphating agent, and being acidic in nature, it functions both as an etching and a mild rust removing compound, thereby, improving adhesion of painting systems.

3. Wood Preservatives

   Wood preservatives are applied before the application of primary coat to protect the wood against fungi, moisture, rot, termites, carpenter ants, toredo worms and other boring insects.

14.03 PAINTING SCHEDULE

Materials to be painted are usually classed as architectural or non-architectural items. Unless otherwise stated or specified, painting of materials are usually accomplished in three coats, namely: first coat, primer paint; second and succeeding coats or finishing paints. Also, in selection of the color of the paint, the painter must see to it that the color of the primary coat must be lighter than the body coat and the color of the body coat must be lighter than the finished coat. Whenever it is possible, the first and body coat, should preferably have the same shade as the desired finish coat. Outlined below are the different painting schedules.

A. **Architectural Items**

In rural water supply system, architectural items may include the pump house, reservoirs, operator's room office furniture and landscapings that may be effected to improve the appearance of the system.

1. Exterior Finishes

   a. Concrete Surfaces

      i. First Coat : Masonry Sealer
      ii. Body Coat : Concrete Masonry Paint
      iii. Finishing Coat : Concrete Masonry Paint

b. Wood Surfaces

i. First Coat : Exterior Wood Primer
ii. Second Coat : Exterior Wood Paint (Enamel paint preferred).
iii. Third Coat : Exterior Wood Paint (Enamel paint preferred).

c. Unprimed Ferrous Iron Surfaces

i. First Coat : Rust inhibitive metal primer
ii. Second Coat : Exterior metal paint (enamel paint preferred).
iii. Third Coat : Exterior metal paint (enamel paint preferred).

2. Interior Finishes

a. Concrete Surfaces

i. First Coat : Masonry Sealer
ii. Second Coat : Masonry paints (enamel undercoater preferred).
iii. Third Coat : Masonry paints (interior semi-gloss enamel preferred).

b. Wood Surfaces

i. First Coat : Interior Wood Primer
ii. Second Coat : Interior Semi-gloss enamel
iii. Third Coat : Interior Semi-gloss enamel

c. Unprimed Ferrous (Iron) Surfaces

i. First Coat : Rust inhibitive metal primer
ii. Second Coat : Interior enamel paint.
iii. Third Coat : Interior enamel paint.

B. **Non-Architectural Items**

In rural water supply system, non-architectural items may include valves, pipings and equipment. In the selection of the color of paints for these items, provisions should be made so that the color selected must match the color of architectural items.

1. Galvanized Iron Pipes and Other Galvanized Metal Surfaces

a. First Coat : Galvanized metal primer
b. Second Coat : Interior semi-gloss enamel

2. Ungalvanized Metals

   a. First Coat : Rust inhibitive metal primer
   b. Second Coat : Interior semi-gloss enamel.

14.04 PREPARATION OF SURFACES TO BE PAINTED

Surfaces to be painted should be thoroughly smoothened, cleaned and dried before any painting job. This could be achieved by repairing all surface defects, levelling all the depressions and patching all cracks with plaster.

A. Preparation of Concrete and Masonry Surfaces

1. Cure all concrete and masonry surfaces for at least 30 days prior to painting.

2. Inspect the cured surfaces for defects like holes, cracks or depressions. Should any of the above-mentioned is detected, they should be neatly filled with patching plaster. Allow the plaster to dry and then smoothen with a sand paper No. 00.

3. Remove all dirt, dust, loose plaster and other deleterious matter which would prevent good paint adhesion from the rest of the surfaces to be painted.

4. Apply concrete neutralizer or masonry surface conditioner to neutralize alkalies, to remove excess oxides on new concrete and milde's from old surfaces to insure good adhesion of paint to the substrate.

5. Apply the first coat of paint.

B. Preparation of Metal Surfaces

1. Remove all dirt, scales and rusts by scraping, wire brushing or sanding.

2. Remove oil and grease with appropriate solvents.

3. Treat the surfaces with metal treatment solution or with any approved phosphoric acid etching cleaner in accordance with manufacturers' recommendation to produce a chemically clean surface.

4. Apply the first coat of paint.

C. Preparation of Wood Surfaces

1. Check the wood surfaces to be painted for cracks, depressions, knots, nail holes and other defects.

2. Fill with putty or other equivalent filler and nail holes, cracks and depressions, and clean the surfaces from knots, sap streaks and other defects.

3. Smoothen the surface of the wood to be painted using a No. 00 sandpaper.

4. Remove all dusts and dirts.

5. Apply wood preservatives and then the first coat of paint.

14.05 PREPARATION OF PAINTS

Paints available in the market today are concentrated, hence it is usually necessary to dilute it to the desired consistency prior to application. The dilution ratio depends primarily on the type of paint. It is suggested that the painter must refer to the manufacturer's recommendation before making the dilution. After the addition of paint thinner, the mixture should be stirred thorougly until it is homogenously mixed.

14,06 APPLICATION OF PAINT

The quality of the finished surfaces primarily depends upon the skillfulness of the painter handling the job, the thoroughness of the preparation of the surfaces to be painted and the climate or temperature. For instance, painting should not be done when the temperature is greater than 32°C (92°F) or when the weather is damp.

Procedure of Application:

1. Prepare the painting materials needed for the painting job with reference to the painting schedule which is presented in section 14.03.

2. Apply the primary or first coat evenly, free of laps, sags and cut sharply to the required lines using a brush or spray.

3. Allow the primer paint to dry for no less than 24 hours.

4. Sand the surfaces using a sandpaper with gauge no. 00. This is necessary so that the succeeding coat will have a good bond with the preceeding coat.

5. Apply the second or body coat evenly to have a uniform thickness.

6. Allow it to dry for at least 24 hours and then roughen the surface using a sandpaper no. 00.

7. Apply the third and final coat.

14.07 PAINT PROBLEMS, THEIR CAUSES AND REMEDIES

Outlined in Table 14.02 are the common problems which may be encountered during the performance of painting jobs.

Table 14.02

PAINT PROBLEMS, THEIR CAUSES AND REMEDIES

Problem	Causes	Remedies
1. Blistering and peeling.	Coat of paint develop bubbles with trapped water that later burst. This happens when excessive moisture in and underneath the siding is drawn out to the surface by the heat of the sun.	Check probable sources of moisture like seepage or leaks from eaves, roofs and plumbing. Seal all these sources of moisture, and provide vents for interior moisture.
		Sometimes on low weather, blistering occurs during or right after painting. Unevaporated solvent is trapped in deep surface pores. When exposed to the heat of the sun, it vaporizes and ruptures the dried surface film. This happens most often with dark color paints which absorb more heat than lighter colored ones. To minimize solvent entrapment, paint while in the shade.
2. Flaking and cracking.	Occurs when the wood swells and shrinks due to wetting and drying out.	Use well dried wood and keep wetting. Have a good surface preparation and have proper sealing.
3. Intercoat peeling.	Occurs when there is no adhesion between coats.	Sand the problem area with sand paper no. 00. Repaint with one or two coats of paint undercoater and then apply two coats of finishing paint.

4. *Alligatoring*	Due to faulty application of paint surface, coat dries faster and harder than the coats underneath. As the material under the surface film dries and hardens, it shrinks causing the already hardened surface to pucket and wrinkle. If the surface film is not elastic enough, it will crack under this tension.	Follow manufacturers' recommendation/instruction as to type and drying time of the undercoater and the spreading rates of the materials.
5. Wrinkling	Usually results when thick heavy films of paint are applied in cold weather.	Follow manufacturers' recommendations on proper spreading rates and favorable painting temperatures. When repainting over wrinkled surfaces the old surface should be sandpapered to eliminate the irregularities.
6. Suction spotting.	This is caused by inadequate priming of porous wood surfaces. This leads to abnormally high absorption of the binder by certain porous areas of the substrate. These areas will now experience excessive chalking (due to the decreased amount of binder in the film) and weather away exposing the wood surface underneath to more serious problem.	The entire job should be given another coat of finish paint. The correct use of a high quality primer or sealer especially formulated for use with its companion top coat is the best insurance against this problem.

CHAPTER 15

CLEAN UP, TESTING, DISINFECTION AND START UP

15.01 GENERAL

Following the completion of the construction and/or installation of the different elements of the water distribution system, it is necessary to condition the system prior to its full scale operation. Conditioning may include clean up or removal of undesirable materials, testing to determine whether the efficiency of operation conforms to the design efficiency before turning it to the water cooperatives and disinfection of the different components to kill all disease-causing bacteria.

After conditioning, the system is now ready for the start up. To fully understand the manner of operating the different component of the system the operator is advised to study the Volume III: Operation and Maintenance Manual.

15.02 CLEAN UP

After the systematic putting up of the different components of the system, it is now the time to remove all eye sores and to develop the site. The cleaning process consists of the hauling to the storage area all tools and excess materials, stripping of temporary makeshifts or structures used during construction, levelling of the ground and sweeping of all rubbish and dirt to the dumping site. The storage area is usually located in the pumphouse.

15.03 TESTING

Testing is a way of determining whether the different elements of the systems were installed properly. This is usually indicated by the system providing adequate volume of water to the consumers at a minimum possible operational cost.

The testing process usually consists of the testing of the different parts of the system separately and the testing of the system as a whole.

A. Pressure and Leakage Testing of Pipelines

Pressure and leakage testing is employed to determine the fitness of pipelines for the transmission or distribution of water supplies. The process consists of determining the amount of water leaking through a section of the distribution system and comparing it to the allowable leakage.

Leakage in pipeline testing is defined as the quantity of water that must be supplied into the newly laid pipe or any valved section thereof to maintain the specified leakage test pressure after air in the pipe lines has been expelled and the pipeline has been filled with water.

Testing Procedure:

1. Preparation of the Pipelines to be Tested

   a. Allow the elapse of the following curing periods before starting the test.

      i. If the pipeline is jointed with solvent cement, allow a curing period of at least 2 days to elapse.

      ii. If any section of the pipeline is provided with concrete backing or thrust blocks, allow a curing period of at least 7 days to elapse if standard portland cement was employed and 36 hours if Hi-Early Cement is utilized.

   b. Isolate the section to be tested by closing appropriate valves if available and/or by placing bulk heads at any predetermine section of the pipe-lines.

   c. Flush the pipelines with clean water.

2. Visual Determination of Leakages

   a. Fill the pipelines slowly with water at elevated points and allow the removal of air through the air vents which is usually located at all high points.

   b. Apply a slight pressure after the line or section has been completely filled. Let the system stand in that manner for at least 48 hours to allow the escape of air from air pockets and to allow the pipelines and their joints to absorb as much water as possible.

   c. Examine all exposed pipes, fittings, valves, joints and couplings for visible leaks during this 48 hours period. Should a defect was detected, repair or replace that particular part with sound material.

3. Start the pressure and leakage testing. The test pressure is 10.6 kg/sq.cm. (150 PSI) and the test duration is 2 hours.

   a. Pump water into the pipelines until the minimum pressure within the section tested is 10.6 kg/cm^2. Hold the test pressure for a minimum of two hours. Should the pressure goes down, activate the pump and start pumping water until the test pressure is restored to 10.6 kg/sq. cm. The reduction of the pressure is an indication of the presence of leakages.

   b. Measure the amount of water pumped into the pipeline within the two hours period with any suitable measuring device. The amount of water leaking through the pipeline is equivalent to the amount of water pumped to the system to restore the pressure of the system to the required test pressure.

c. Compare the amount of water the meter has registered with the allowable leakage. The allowable leakage is 1.85 liters per mm diameter of pipes per kilometer of pipelines per day.

d. Locate and repair or replace the defective pipe, fitting, joints or other appurtenances should the test of the section disclose that the leakage is greater than the allowable leakage.

e. Repeat the test until the leakage is within the permissible level.

B. **Leakage Testing of Reservoirs**

1. Elevated Reservoirs

The testing of the leakage of elevated reservoir is very simple. The procedure consists of filling up the reservoir with clean water and then visually observing the outside surfaces for the presence of leaks.

2. Ground Level or Underground Reservoirs.

There are two simple ways of checking for the presence of leakages in reservoirs which are sitting on the ground. These two methods are:

a. **Method A – Close the discharge control** valve. Fill the tank with water up to a certain level, mark the water level on the wall of the reservoir and then close the inlet control valve. After two days, check the water level. Should there be an appreciable decrease in water level, the reservoir has leaks. During the entire process, both the inlet and outlet control valves should be tightly closed.

b. **Method B** – If the tank has an underdrain, observe the discharge in the underdrains. Should there be an appreciable discharge, the tank has leaks.

15.04 DISINFECTION

Before the commissioning and the turning of the newly constructed water supply system to the owners, all of its parts which will be in contact with the water supply should be disinfected to to kill all the disease-causing bacteria.

The disinfection process consists of subjecting all the above wetted parts with 50 mg/l chlorine solution for 24 hours and the testing of the concentration of chlorine after the disinfection period. If the test results reveal that the chlorine content is lesser than 25 mg/l, the disinfection process should be repeated.

A. **Disinfection of Wells and Well Pumps**

The procedure of disinfection is as follows:

1. Pour 50 mg/l chlorine solution into the well and start the pumps. Open the nearest outlet valve and try to smell the odor of chlorine. When

chlorine odor is noticeable, close the valve and stop the pump. A more convenient procedure is to determine the amount of chlorine solution necessary to produce 50 mg/l in the well and then pour the required amount of chlorine solution into the well.

2. Allow the well to stand idle for at least 24 hours.

3. Pump water to waste until the odor of chlorine disappear. During the first 30 minutes, return the heavily chlorinated water back to the well via the space between the casing and the drop pipe to disinfect this area.

4. The well is now ready for service.

B. **Procedure of Disinfection of Reservoirs and Storage Tanks**

1. Clean the reservoir by brushing all adhering dirt particles.

2. Disinfect the tank by any of the following methods:

   a. Fill the tank with 50 mg/l chlorine solution and allow the solution to stand for 24 hours before draining it to waste. Check the concentration of chlorine in the drained solution. Should it be less than 25 mg/l, repeat the chlorination process.

   b. Alternately, prepare a thin paste by mixing bleaching powder and water in a pail or bucket. Apply the thin paste vigorously using a brush on the interior surfaces of the reservoir. Allow one hour to pass before rinsing the tank with clean water.

3. Flush the tank with clean water

When disinfecting pressure tanks, it is necessary to open the air relief valve at the highest point so that air is released and the tank should be completely filled with heavily chlorinated water.

In all cases, the test should show a distinct residual chlorine (approximately 25 mg/l in the water drained out of the tanks. This is evidenced by a very slight odor of chlorine in the water. If there is no residual chlorine, the disinfection process should be repeated.

During the disinfection process, all the working men must be equipped with breathing apparatus and full protective clothing. In case where bleaching powder solution accidentally gets in contact with the eyes, immediately wash eyes with clean water. After the disinfection job, all men involved in the work must take a bath.

C. **Disinfection of Pipelines**

The procedure for the disinfection of pipeline is as follows:

1. Introduce a 50 mg/l chlorine solution into the pipelines to be disinfected until they are full. The preferred point of application is at the

beginning of the pipeline extension or valve section or through corporation stops inserted on top of the laid pipe.

2. Allow the pipelines to stay idle for 24 hours. During this 24 hours contact period, all valves and appurtenances should be operated.

3. Drain the chlorine solution through the draw-off valves and then flushed the pipelines with clean water. After flushing, the residual chlorine should be less than 0.75 mg/l but more than 0.2 mg/l. This is measured roughly with the aid of a chlorine pumphouse residual test kit.

15.05 START UP

After making sure that the installation of the different elements of the system is sound, start up and/or the testing of the operationality of the whole system follows.

A. Start Up of the Pumping System

The mode of the start up of the pumping system depends upon the type of the pump installed. The operator is advised to refer to the manufacturers instructions on its operation or to the Operation and Maintenance Manual.

B. Start Up of the Distribution System

Allow the entrance of water to the distribution system from the source by opening the appropriate valves. Allow 10-20 minutes for the stabilization of the pressure throughout the pipelines and then observe the pressure at the pressure gage installed at the selected points. For the system to be acceptable, the pressure in all water mains should not be less than 3 meters.

C. Start Up of Slow Sand Filter

1. Introduce water at the bottom of the filter through the outlet chamber. The purpose of adding water from the bottom is to get rid of all entrained air in the sand pores and in the underdrainage system which may cause air binding. Filling should continue until water begins to show on the filter surface.

2. Level the top of the sand by ranking.

3. Continue adding water through the outlet chamber until the water level is at least 10 cm above the sand bed. The purpose of raising water up to this level is to protect the sand surface from being scoured out of level when water is introduced from above.

4. Open inlet valve and start feeding water slowly from the top until the maximum water level in the supernatant water reservoir is reached.

5. Open the outlet valve and waste the filtrate until the filter gives clear water.

6. Allow the filter to ripen for at least one or two weeks. Ripening is the process of allowing the growth of biological or slimy layer at the surface of the filter bed.

CHAPTER 16

SITE DEVELOPMENT

16.01 GENERAL

After the construction and installation of the different elements of water supply system, the construction site should be cleaned from all eye sores and be made pleasant to look at. The development process may consist of the grading or levelling of the ground, landscaping and the planting of ornamental plants.

The pumphouse or station is one of the few components of water system which will be ultimately left visible to the general public. Hence, it should be designed and constructed properly to make it attractive to look at. A little extra amount spent on its building and its surrounding is generally worthwhile and compensated by the respect and patronage of its consumers. This is because its orderliness and cleanliness reflects to a great extent the quality of the management running the system.

In general, there is no single rule to be followed in the development of the site. The extent of the development usually depend on the existing condition of the proposed site, the type of materials and equipment installed, the condition of the surrounding neighborhood and the budget for the site development.

16.02 SITE GRADING AND PAVING

Site grading and paving is the process of levelling the ground to desired grade. It consists of filling of low area with earthfill and the removal of solid from high or protruding areas to make the ground area fairly level or uniform. After levelling, all fills should be compacted. If ornamental plants is to be planted in the graded site, garden soil should then be added after compaction.

16.03 ACCESS ROADS

If pumphouse is not located along any street, access roads should be built. These access roads are necessary for the operation and maintenance of the system.

The access roads to be built should be wide enough to accommodate the passing of a cargo truck. A minimum width of 3.5 meter is recommended. Also, the access roads should be well drained and constructed of materials that do not need too much maintenance. If finances permit, access roads should be asphalted or cemented.

16.04 FENCING

Fences should be provided around pumping stations to prevent the entrance of unauthorized persons and stray animals who may destroy the equipment and other items, and/or contaminate the water supplies. To serve the above mentioned purposes, fences should therefore be unclimable and strong. Also, they should be attractive and the materials used should have a long life and requires minimum maintenance. Fences made of barbed wire or cyclone wire fixed on concrete posts may serve the purpose. To improve its appearance, hedges may be planted along the fence.

16.05 OTHER IMPROVEMENTS

Surroundings of the pumphouse could be improved by landscaping and by planting of ornamental plants. The configuration of the landscape will depend primarily on the existing configuration of constructed pumphouse and the terrain. In order that it will be effective, it should harmonize and blend with the existing structures. Also, the type of ornamental plants to be used will depend primarily on the variety which is available locally, its suitability or blending with the landscape and its cost.

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