Agricultural Structures & Environmental Control

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MODULE 1. Planning of Farmstead

LESSON 1. Planning of Farmstead and Farm Residence

1.1 Introduction

Farmers in India usually live in Villages located some distance away from their farms. In the past, living in villages was favoured for mutual protection, for social life, for the services of those serving the community as a whole, and for convenience in getting water supply. The fragmentation of holdings is another reason favouring living in a village. But from an agricultural point of view, this arrangement generally puts a farmer away from his land, thus reducing the supervision and attention he can give to his crops. More time is required to go to and from the fields and the trouble of taking animals and implements back and forth is increased. Moreover, the reasons which favoured living in villages in the past are not important now, with the more secured social life.

1.1.1 Location of Farmstead

A farmstead is satisfactory, if it is on a suitable site, if the individual buildings are properly designed for the functions they serve, and if their grouping is properly planned. The primary objectives of good planning are sanitation and well-being of the human beings and animals, economy in labour management, economy in initial cost and low cost of maintenance. The most convenient location from the management, sanitation, and other convenience point of view may be decided as indicated below.

1. From the management point of view, the farmstead should be located near the centre of the farm or in the middle of the long side. However, this arrangement is possible only in large farms where the farm labourers also live near the farmstead, as otherwise the farmstead becomes very much isolated.

2. Location at one side or even at a corner near a road is always helpful in procuring the farm supplies and in disposing of farm produce. This will facilitate better social life and protection, common water supply arrangement and other conveniences.

3. A site having high elevation and good natural drainage should be selected.

4. The farmstead should be located near a source of permanent water supply. Advantage of an existing well can be taken while deciding the farmstead location.

5. Sites which have trees around will provide protection against high wind velocities and dust storms, and will provide shade for human beings and animals.

1.1.2 Size and Arrangement of the Farmstead

The farmstead area is occupied by residential buildings, storage buildings, dairy barn, bullock shed, poultry houses, other service buildings, threshing yard, roads, etc. and this area usually varies from 3 to 5 per cent of the farm area.

Residential buildings should be located away from the cattle shed and other buildings. This will ensure privacy and reduce the nuisance of flies and smell coming from the dairy barn.

Residences and animals houses should be so located that the prevailing wind will not blow from the animal houses to the residences. Various buildings are arranged to provide the minimum of walking from one to the other in doing the required work. The silo pits and feed storages should be located near the animal shelters. The milk room or milk house is generally placed about 6m away from the barn.

The layout of the farmstead should allow for possible future extension of buildings. Care should be given, in designing the buildings to get maximum convenience without much additional cost of construction. Unnecessary ornamentation or carving on the buildings does not add to the convenience, and on the other hand involves extra expenditure.

1.2 Planning of Farm Residence

The residential building on a farm is the heart of the farmstead. It should be so designed and constructed that the owner has the satisfaction of staying in a most comfortable and attractive place. A residence is not merely a shelter alone, but is the centre of a social life, a place of health, comfort and happiness of the entire family in all stages and walks of life. It must provide conveniences for all the life activities. There must be places for cooking, dining, sleeping, study, guests, and other special requirements, to take maximum advantage of the sun light, the residence should face south or north. Facing the residence onto the main road and rivers or streams in another desirable feature.

However, the traditional designs of village houses have the following defects :

1. Construction is unsatisfactory and not water proof.
2. Windows are too small
3. Rooms are too small
4. Kitchen are not properly constructed to remove the smoke
5. Animals are also kept in or around the house
6. Surroundings are often used as a waste disposal place.

Hence, a good house should have the following facilities:

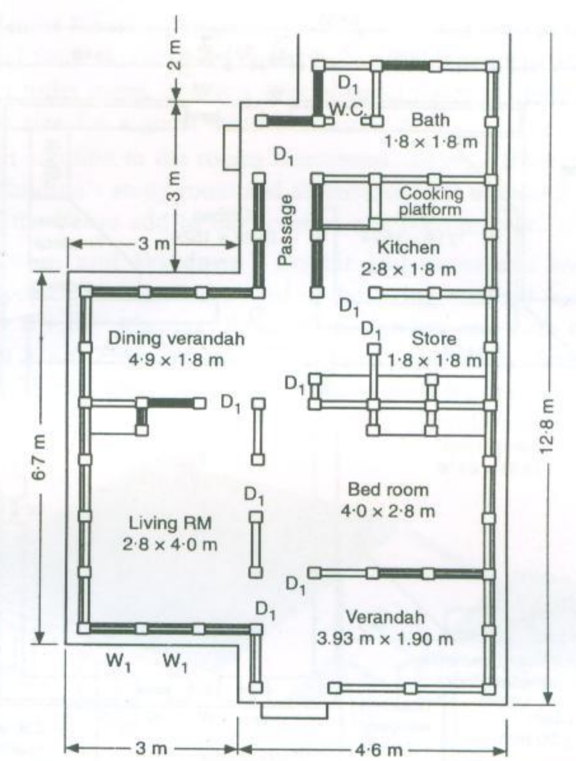
1. Bedrooms-the number depends on the size of the family.
2. Verandahs both for sitting out and house work.
3. A Kitchen with good ventilation
4. Food grain store
5. Fuel wood store
6. Animal shelter
7. Animal fodder store
8. Latrine cum urinal and a bathing place

9. Sitting room cum DALAN
10. Open space inside or outside the house well enclosed for social gatherings.
11. Space for biogas plant and slurry dump
12. Space for kitchen garden
13. Space for washing purposes
14. Space for farm tools and machinery storage

1.3 Improved Farm House Design

A farm house should be designed to provide maximum utility and comfort. The various rooms should be so located as to provide adequate comfort and minimum time and energy wastage in going from one to the other.

Planning of Farmstead and Farm Residence 5'

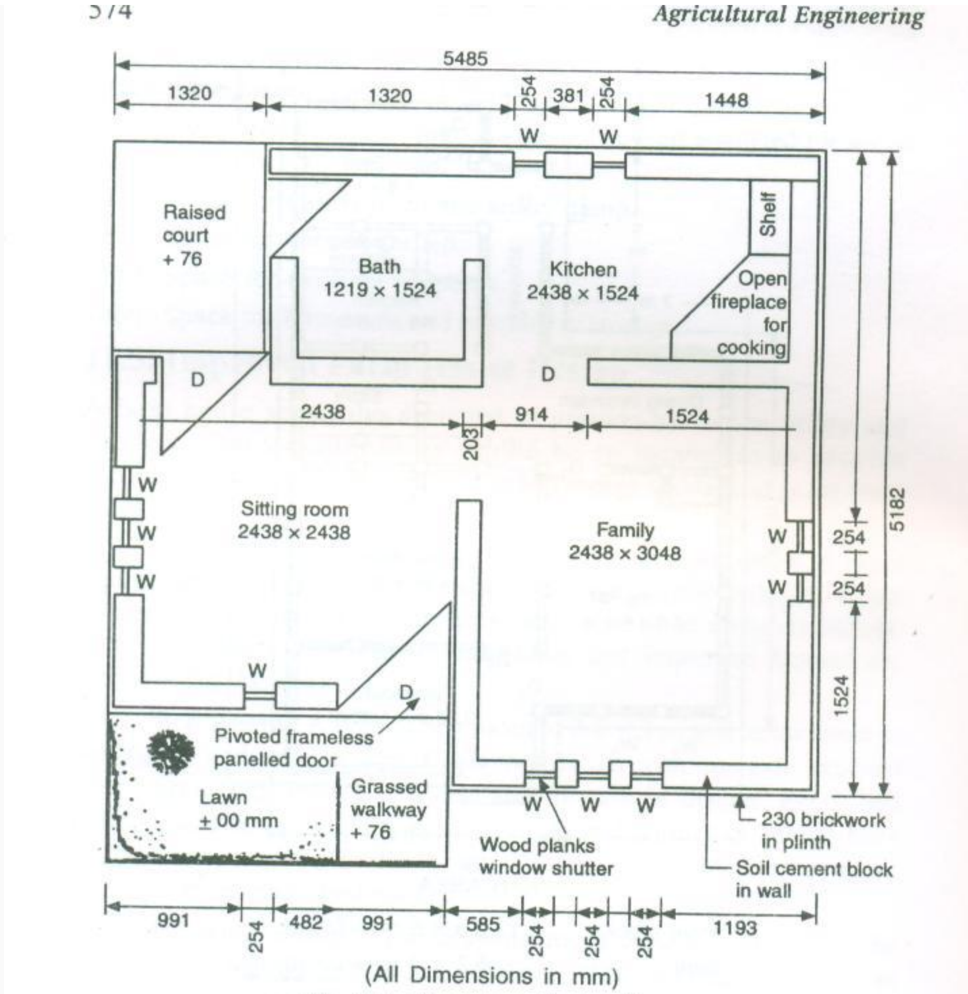


PLINTH AREA

Main block	:	12.8 × 4.6 m =	59 sq. m
Side	:	6.7 × 3 m =	20 sq. m
Total	:		79 sq. m
Deduct	:	1 × 2.1 m =	2 sq. m
Total	:		77 sq. m

Fig.11.1. Floor plan of a farm house

light. Availabilities of LPG in rural areas have made considerab



The two floor plans (Fig. 1.1 and 1.2) presented in these figures are meant for small family sizes living in the villages. These houses are sufficient to provide necessary facilities to a modern farmer. Two conceptual drawings of traditional and improved houses are shown in Fig. 1.2 (a).

1.3.1 Bed Room : A typical be room of 3.6 x 3m will accommodate two single beds of 1 x 2 m. Cross ventilation with one side exposed to the prevailing breeze is a desirable feature in desing. Every bed room should be provided with attached toilet facilities or should have an independent access to the common toilet room. Some storage space is essential in every bed room.

1.3.2 Drawing Room : The drawing room generally serves as the room for recreation and social gathering. The minimum size of the drawing room is 4.5 x 3.6 m but some people prefer to have one large room of about 6 x 4.5 m to serve as a drawing room cum dining room. The drawing room is best suited to be on one side of the house, and should generally open into the front porch, kitchen, and bed room. Wall space in the drawing room should have plenty of provision for natural light and ventilation.

1.3.3 Kitchen : The kitchen is preferably place near the living room but away from the bed rooms. It should be equipped with a sink and many built-in-racks for storage of utensils and supplies. Floor space of kitchens usually varies form 9.3 to 14 sq. m. Store rooms and fuel storage space should be attached to the kitchen. Besides a large size chimney to carry out the smoke from the built-in-cook stove, the kitchen should have cross ventilation. One of the windows and a door must directly open to the kitchen garden. The kitchen must have an eastern location if possible, so that the rays of morning sun can provide adequate light. Availabilities of LPG in rural areas have made considerable difference in the design and layout of kitchen in villages. Where gas stoves are not being used, improved fire wood CHULHAS are being introduced.

1.3.4 Toilet Rooms : For Indian families, bath room and lavatory should usually be separated. In the bath room, provision should be made for both a shower and a direct tap bath. If the water supply is not maintained throughout the day and night, a small water reservoir may be a part of the bath room. A hanger fro towels and a rack for soap, etc., are very useful. For the lavatory, a flush arrangement is essential.

MODULE 2. Physiological Reactions of Livestock

LESSON 2. Reactions of Animals to Thermal & Other environmental factors

1.1 Introduction

Functions of all organs and systems ultimately depend upon absorption and nutrition. The food taken in by the animal is used in constructing new tissue while some is broken down that ie., oxidized by tissue cells to produce heat and energy. The heat produced by oxidation processes can be measured which will determine the metabolic rate. The metabolic rate of animals is an therefore indicator of their nutritive and productive status. It is also verymuch influenced by the environmental variables such as temperature humidity air velocity and radiation. The heat and moisture released through respiration are simples and his heat must be dissipated out.

1.2 Homeostasis

Homeo – like or similar

Stasis - standing

Preventing changes or keeping things the same. It refers to the maintenance of a fixed internal environment in animals through dynamic, self – regulating processes, operating on the feedback principle. Many internal factors are maintained constant. These include body temperature, mature body weight, blood pressure, respiration, body fluid, hormones and movement.

Homeothermy:

Maintenance of appropriate internal body temperature is an excellent example of homeostasis, sometimes called homeothermy.

The regulation of internal temperature is carried out through several sets of feedback mechanisms. Mammals and birds are homeotherms and they are equipped with peripheral receptors in the skin and central receptors in the brain. There exists for each species a range of environmental temperature that is optimal in terms of minimum action by the regulating mechanisms. This range is the thermoneutral condition. When the environment cools below this range, the condition is sensed peripherally and transmitted to a specific part of the brain, (the posterior hypothalamus), which activates a set of protective actions. These include increase in appetite and rate of heat production, decrease in blood flow to the periphery, and change in posture of hair coat or feathers. With continued decrease in external temperature shivering is initiated. Shivering is involuntary muscle contractions that increase the rate of heat production.

When external temperature rises above the optimal, another set of protection devices is activated. The surface blood vessels dilate, appetite decreases, rate of moisture evaporation increases, respiration rate increases, in humans, profuse sweating occurs. These actions are involuntary and are mainly controlled by the anterior hypothalamus in response to blood temperature changes. Increase in appetite increases metabolic rate, the other actions serve to increase rate of heat loss to the environment.

Thermonentrality occurs within a range of environmental temperatures in which the body's homeothering mechanism maintain, a balance between heat loss and heat production without stress. Within this range the thermal regulation is minimal – neither heat nor cold in felt. In these terms, thermonentrality defines a "comfort" zone. The overall objective in animal housing systems design thus is to create environments in which the animals approach thermonentrality, but with appropriate balance between the productive value of thermonentrality and the cost of systems to maintain it.

Animal Reactions

The reactions of animals to environmental factors can be arbitrarily divided into two classes Productive and physiological. The distinction is artificial rather than real, but has value to an engineer to whom the productive factors are more useful. The physiological reactions are body temp, pulse rate, and respiration rate.

(i) Temperature:

This is the most significant parameter Environmental temperature is the integrated total of all temperatures surrounding the animal is 4пsr (steradions). If the walls, ceiling, floor and air temperatures are identical, then the environmental temperature is simply the air temperature. But this is a rare case. The more usual case is that surfaces and air are at different temperatures and adjoining A THI of 75 is a critical value for even the low producers while the higher producers are already affected at this THI. Hence THI should be between 72-75 for normal cows.

Light

The seasonal variations in physiology of farm animals are related to light, including both duration and dimate. It appears that length of day, or rate of change of day length, have marked effects on hair coat of cattle andwool growth and breeding behaviours of sheep.

Air movement:

Animal heat loss is influenced by air velocity, which is important at both low and high temperatures. Under confinement conditions the air velocity can usually be regulated by fans. In the case of dairy cattle held at 95°F air temperature an increase in air flow rate from 0.5 to 10 mph (mily per hour) tended to reduce production losses normally experienced at such high temperatures. However, 10mph is a rather high velocity inside a building and would be particularly annoying if conditions happened to be dusty. The favorable effect of increased air flow at high temperatures is due to the increase in evaporative heat loss. The daily weight gains of beef cattle in summer are considerably less at 0.5 mph compared to 4mph. Increasing air velocity above the latter figure, however gives no further advantage.

LESSON 3. Physiological Reactions of Farm Animals

Introduction

Since the major purpose of environmental control in buildings for housing livestock is for comfort of the animals, it should be fairly obvious that the physiological reactions of the animals are of extreme importance in determining design conditions. Warm-blooded animals, such as cattle, swine, sheep, and poultry, give off heat and moisture during normal living processes. The rate at which these are expelled will vary with environmental conditions. Unfortunately, complete information is not available on the reactions of all animals under all conditions. Research is under way at various stations in the United States to determine this information where such information are based on practical experience.

Dairy Cattle: The first approach to presenting information on the heat and moisture production of dairy cows was made in 1921 by Armsby, who presented a method of computing the heat production of dairy cows. Based on Armsby's method, together with research information on steers presented by various works, Strahan suggested basic information to be used in design of insulation and ventilation for dairy barns. [1] This information is shown in Figure 14.4. Curve A shows the effect of environmental temperature on the percentage of total heat in latent form. Latent heat is that heat contained in the vaporized moisture expelled by the animal. As the temperature increases, more moisture is given off by the animal, carrying with it moreheat in latent form to regulate the body temperature of the animal. Curves B and C show the reduction in sensible-heat production with increasing temperature; Fig. 14.4. Effect of temperature on heat and moisture production of dairy cattle. (From J. L. Strahan, A method for Designing Insulation and ventilation for Animal Shelter Buildings, Agr. Engg.)

[1]Samuel Brody, Physiological Backgrounds, Ho. Agr. Fept. Sta. Research Bull, 423, September, 1948.

One of the first important considerations is the effect of temperature on milk production. Data from the Missouri study on the influence of ambient temperatures from 4 to 95°F on the milk production of Jersey and Holstein cows indicate the following:1

1. Lowering the temperature from 50 to 4°F depressed the milk production. Effects of sudden lowering of temperature from 50 to 4°F were much more striking on unacclimatized cows than on acclimatized cows.

2. The optimal temperature zone for milk production appeared to be not far from 50°F. Critical high temperature was apparently 80°F, whereas no critical low temperature was evident.

3. Rising temperatures were more detrimental to the Holsteins, and declining temperatures more detrimental to the Jerseys. The effect of lowering temperatures below 50°F was much less for both breeds than rising temperatures above 50°F.

Date on the influence of ambient temperature on moisture given off by Jersey and Holstein cattle indicate the following:[2]

At 0°F, about 8 percent of the total heat given off by the animals was dissipated by evaporative losses; at about 102°F all of the heat produced was dissipated by moisture vaporization.

1. Between 90 and 100°F, the cows vaporized about 2 pounds of moisture per hour.
2. At other temperatures, data presented showed the following ranges of moisture vaporization per 1000-pound animal unit.

0-20°F 0.3-0.4 pound per hour

20-40°F 0.4-0.6 pound per hour

40-60°F 0.6-0.8 pound per hour

60-80°F 0.8-1.7 pounds per hour

When computed to a comparable basis, these figures are higher than those proposed by Strahan.

Data on the effect of ambient temperature on heat production of Holstein and Jersey cows indicated the following:[2]

[1]A.G.Ragsdale, D.M. Worstell, H.J. Thompson, and Samuel Brody, Influence of Temperature, 50° to 0°F and 50° to 95°F, on Milk Production, Feed and Water Consumption and Body Weight in Jersey and Holstein Cows, Mo. Agr. Expl. Sta. Research Bull. 449, September, 1949.

[2]H. J. Ragsdale, D.M. Worstell, H.J. Thompson, and Samuel Brody, Influence of Ambient Temperature, 0° to 105°F, on Insensible Weight Loss and Moisture Vaporization in Hostein and Jersey Cattle, Mo. Agr. Expt. Sta. Research Bul, 451, October, 1949.

[3]H. H. Kibler and Samuel Brody, Influence of Temperature, 50° to 5°F and 50° to 95°F, on Heat Production and Cardiorespiratory Activities of Dairy Cattle, Mo. Agr. Expt. Sta. Research Bull, 450, October, 1949.

1. An increase in heat production of 30 to 3 percent in lactating Jerseys and of 20 to 30 per cent in lactating Folsteins for gradually decreasing temperatures from 50 to 5°F.

2. A decrease in heat production by both breads of 20 to 30 per cent above 70 to 80°F with gradually increasing temperatures from 50 to 100°F.

Actual values of heat production in the data around the 50°F range did not differ greatly from the figures proposed by Strahan.

Poultry. Studies of the physiological reation of poultry to environmental conditions are under way at Beltsville, Mayland, by the Division of Farm Bujildings and Rural Housing, Bureau of Plant Industry, Soils, and Agricultural Engineering, USDA. Although these studies have not been completed, some information has been reported which can be used as tentative considerations for design procedure.[1] Results of this study to date are shown graphically in Figure 14.5. All data re converted to a single basis of 5-pound Rhode Island Red hens. Results shown on the lower chart would indicate that the optimal temperature range for egg production lies in the neighborhood of 50 to 55°F. Temperatures as low as 45° and as high as 65° do not seem seriously affect egg production.

The upper chart shows a reduction in total heat and sensible heat and an increase in latent heat with increasing temperature. The amount of moisture produced can be estimated from the latent-heat production. It takes approximately 1070 But to change I pound of water to vapor at 40°F and about 1040 at 90°F. Considering that the latent-heat production is about 22 But per hour at 50°F and 1065 But are required to evaporate water at this temperature, then the equivalent moisture vapor produced could be computed as follows:

$\frac{22x24}{1065} = 0.495$ pound of moisture produced per day by a 5 lb hen at 50°F

This value is higher than estimates made by previous workers. The authors of the report emphasize that the work must be considered as preliminary since it was based on a limited number of hens. Further work should produce valuable design information for poultry laying houses.

When baby chicks are first hatched, they do not have the facility to produce heat. Hence the beat must be supplied artificially. It has long been accepted practice to start day-old chicks at a temperature of 95°F and drop the temperature 5°F each week until 70 is reached.

Considerable interest is being shown in the broading of chicks at lower.

[1]Hajime Ota, H. L. Garver, and Wallace Ashby, Heat and Moisture Production of Laying Hens, Agr. Eng. 34:163-167, March, 1953.

FrG. 14.5. Effect of temperature on heat and egg production of poultry. (From Hajime Ola, h.L. Garver, and Wallace Ashby, Heat and Moisture Production of laying Hens, Agr. Engg. 34:163-167, march 1953.)

Temperatures under infrared lamps. Experimental work on this method has been reported by Baker and Bywaters.[1] More information is needed than is available at the time of this writing before specific recommendations can be made.

[1]vernon Baker and James Bywaters, Boording Poultry with Infrared Energy, Agr. Eng., part, 32:316-320, June, 1951, and part II, 33:15-18, January, 1952.

Swine, Studeis of the effects of environmental conditions on the Physiological reactions of swine are being made at the University of California at Davis jointly with the U.S. Dep[artment of Agriculture. A report on heat and moisture production based on preliminary studies has been made by Bond et al.[1]

FIG. 14.6 Effect of environmental temperature on heat and moisture production of hogs. (from T.E. Bond, C.G. Kelly, and Hubert Heitman, Jr., Heat and Moisture Losses from swine, Agr. Eng., 33:148-154, march, 1952.)

Some of the data collected by these workers are shown in Figure 14.6. Based on these data, the reactions of a 100-pound hog could be determined as follows. In Figure 14.6b, such a hog would produce about 350 Btu per hour sensible heat and about 410 Btu per hour total heat at 60°. This means that 60 But per hour is produced in moisture. It 1060 Btu is required to evaporate a pound of moisture, the hog would be roducing approximately 0.06 pound of water vapor per hour.

[1]T.E. bond, C.G. Kelly, and Hubert Heitman, Jr., Heat and Moisture Loss from Swine, Agr. Eng., 33:148-154, March, 1952.

MODULE 3. Farm Structures

LESSON 4. Composting Process and Techniques

Composting is the natural process of 'rotting' or decomposition of organic matter by microorganisms under controlled conditions. Raw organic materials such as crop residues, animal wastes, food garbage, some municipal wastes and suitable industrial wastes, enhance their suitability for application to the soil as a fertilizing resource, after having undergone composting.

Compost is a rich source of organic matter. Soil organic matter plays an important role in sustaining soil fertility, and hence in sustainable agricultural production. In addition to being a source of plant nutrient, it improves the physico-chemical and biological properties of the soil. As a result of these improvements, the soil: (i) becomes more resistant to stresses such as drought, diseases and toxicity; (ii) helps the crop in improved uptake of plant nutrients; and (iii) possesses an active nutrient cycling capacity because of vigorous microbial activity. These advantages manifest themselves in reduced cropping risks, higher yields and lower outlays on inorganic fertilizers for farmers.

Types of composting

Composting may be divided into two categories by the nature of the decomposition process. In anaerobic composting, decomposition occurs where oxygen (O) is absent or in limited supply. Under this method, anaerobic micro-organisms dominate and develop intermediate compounds including methane, organic acids, hydrogen sulphide and other substances. In the absence of O, these compounds accumulate and are not metabolized further. Many of these compounds have strong odours and some present phytotoxicity. As anaerobic composting is a low-temperature process, it leaves weed seeds and pathogens intact. Moreover, the process usually takes longer than aerobic composting. These drawbacks often offset the merits of this process, viz. little work involved and fewer nutrients lost during the process.

Aerobic composting takes place in the presence of ample O. In this process, aerobic microorganisms break down organic matter and produce carbon dioxide (CO_2), ammonia, water, heat and humus, the relatively stable organic end product. Although aerobic composting may produce intermediate compounds such as organic acids, aerobic micro-organisms decompose them further. The resultant compost, with its relatively unstable form of organic matter, has little risk of phytotoxicity. The heat generated accelerates the breakdown of proteins, fats and complex carbohydrates such as cellulose and hemi-cellulose. Hence, the processing time is shorter. Moreover, this process destroys many micro-organisms that are human or plant pathogens, as well as weed seeds, provided it undergoes sufficiently high temperature. Although more nutrients are lost from the materials by aerobic composting, it is considered more efficient and useful than anaerobic composting for agricultural production. Most of this publication focuses on aerobic composting.

Composting objectives may also be achieved through the enzymatic degradation of organic materials as they pass through the digestive system of earthworms. This process is termed vermicomposting.

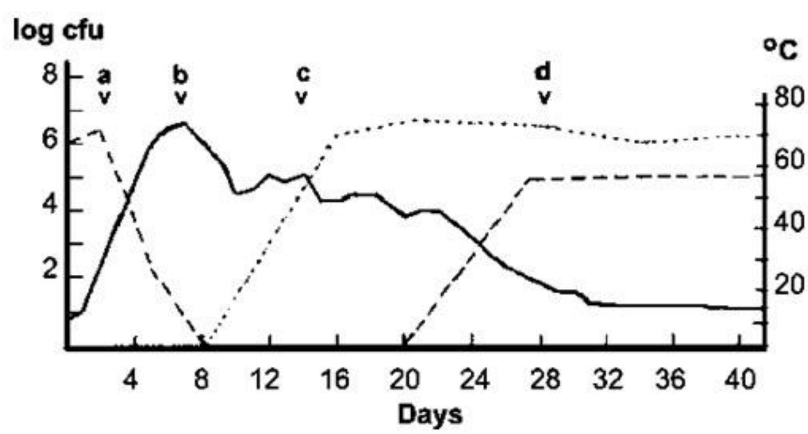
The aerobic composting process

The aerobic composting process starts with the formation of the pile. In many cases, the temperature rises rapidly to 70-80 °C within the first couple of days. First, mesophilic organisms (optimum growth temperature range = 20-45 °C) multiply rapidly on the readily available sugars and amino acids (Figure 1). They generate heat by their own metabolism and raise the temperature to a point where their own activities become suppressed. Then a few thermophilic fungi and several thermophilic bacteria (optimum growth temperature range = 50-70 °C or more) continue the process, raising the temperature of the material to 65 °C or higher. This peak heating phase is important for the quality of the compost as the heat kills pathogens and weed seeds.

The active composting stage is followed by a curing stage, and the pile temperature decreases gradually. The start of this phase is identified when turning no longer reheats the pile. At this stage, another group of thermophilic fungi starts to grow. These fungi bring about a major phase of decomposition of plant cell-wall materials such as cellulose and hemi-cellulose. Curing of the compost provides a safety net against the risks of using immature compost such as nitrogen (N) hunger, O deficiency, and toxic effects of organic acids on plants.

Eventually, the temperature declines to ambient temperature. By the time composting is completed, the pile becomes more uniform and less active biologically although mesophilic organisms recolonize the compost. The material becomes dark brown to black in colour. The particles reduce in size and become consistent and soil-like in texture. In the process, the amount of humus increases, the ratio of carbon to nitrogen (C:N) decreases, pH neutralizes, and the exchange capacity of the material increases.

FIGURE 1
Temperature changes and fungi populations in wheat straw compost



Note:
Solid line = temperature; broken line = mesophilic fungi population; dotted line = thermophilic fungi population; left y-axis = fungal populations (logarithm of colony forming units (cfu) per gram of compost plated onto agar); right y-axis = temperature in centre of compost. a, b, c and d = heating phases.

Factors affecting aerobic composting

Aeration

Aerobic composting requires large amounts of O, particularly at the initial stage. Aeration is the source of O, and, thus, indispensable for aerobic composting. Where the supply of O is not sufficient, the growth of aerobic micro-organisms is limited, resulting in slower decomposition. Moreover, aeration removes excessive heat, water vapour and other gases trapped in the pile. Heat removal is particularly important in warm climates as the risk of overheating and fire is higher. Therefore, good aeration is indispensable for efficient composting. It may be achieved by controlling the physical quality of the materials (particle size and moisture content), pile size and ventilation and by ensuring adequate frequency of turning.

Moisture

Moisture is necessary to support the metabolic activity of the micro-organisms. Composting materials should maintain a moisture content of 40-65 percent. Where the pile is too dry, composting occurs more slowly, while a moisture content in excess of 65 percent develops anaerobic conditions. In practice, it is advisable to start the pile with a moisture content of 50-60 percent, finishing at about 30 percent.

Nutrients

Micro-organisms require C, N, phosphorus (P) and potassium (K) as the primary nutrients. Of particular importance is the C:N ratio of raw materials. The optimal C:N ratio of raw materials is between 25:1 and 30:1 although ratios between 20:1 and 40:1 are also acceptable. Where the ratio is higher than 40:1, the growth of micro-organisms is limited, resulting in a longer composting time. A C:N ratio of less than 20:1 leads to underutilization of N and the excess may be lost to the atmosphere as ammonia or nitrous oxide, and odour can be a problem. The C:N ratio of the final product should be between about 10:1 and 15:1.

Temperature

The process of composting involves two temperature ranges: mesophilic and thermophilic. While the ideal temperature for the initial composting stage is 20-45 °C, at subsequent stages with the thermophilic organisms taking over, a temperature range of 50-70 °C may be ideal. High temperatures characterize the aerobic composting process and serve as signs of vigorous microbial activities. Pathogens are normally destroyed at 55 °C and above, while the critical point for elimination of weed seeds is 62 °C. Turnings and aeration can be used to regulate temperature.

Lignin content

Lignin is one of the main constituents of plant cell walls, and its complex chemical structure makes it highly resistant to microbial degradation (Richard, 1996). This nature of lignin has two implications. One is that lignin reduces the bioavailability of the other cell-wall constituents, making the actual C:N ratio (viz. ratio of biodegradable C to N) lower than the one normally cited. The other is that lignin serves as a porosity enhancer, which creates favourable conditions for aerobic composting. Therefore, while the addition of lignin-decomposing fungi may in some cases increase available C, accelerate composting and reduce N loss, in other cases it may result in a higher actual C:N ratio and poor porosity, both of which prolong composting time.

Polyphenols

Polyphenols include hydrolysable and condensed tannins (Schorth, 2003). Insoluble condensed tannins bind the cell walls and proteins and make them physically or chemically less accessible to decomposers. Soluble condensed and hydrolysable tannins react with proteins and reduce their microbial degradation and thus N release. Polyphenols and lignin are attracting more attention as inhibiting factors. Palm *et al*. (2001) suggest that the contents of these two substances be used to classify organic materials for more efficient on-farm natural resource utilization, including composting.

pH value

Although the natural buffering effect of the composting process lends itself to accepting material with a wide range of pH, the pH level should not exceed eight. At higher pH levels, more ammonia gas is generated and may be lost to the atmosphere.

Techniques for effective aerobic composting

Simple replication of composting practices does not always give the right answer to potential composters. This is because composting takes place at various locations and under diverse climates, using different materials with dissimilar physical, chemical and biological properties. An understanding of the principles and technical options and their appropriate application may be helpful in providing the optimal environment to the compost pile.

Improved aeration

In order to obtain the end product of uniform quality, the whole of the pile should receive a sufficient amount of O so that aerobic micro-organisms flourish uniformly. The methodologies deliberated in this publication made use of the techniques as presented below.

Pile size and porosity of the material

The size of the pile is of great significance and finds mention in the sections on passive composting of manure piles (Chapter 2) and turned wind-rows (Chapter 3). Where the pile or wind-row is too large, anaerobic zones occur near its centre, which slows the process in these zones. On the other hand, piles or wind-rows that are too small lose heat quickly and may not achieve a temperature high enough to evaporate moisture and kill pathogens and weed seeds. The optimal size of the piles and wind-rows should also consider such parameters as the physical property (porosity) of the materials and the way of forming the pile. While more porous materials allow bigger piles, heavy weights should not be put on top and materials should be kept as loose as possible. Climate is also a factor. With a view to minimizing heat loss, larger piles are suitable for cold weather. However, in a warmer climate, the same piles may overheat and in some extreme cases (75 °C and above) catch fire.

Ventilation

Provision of ventilation complements efforts to optimize pile size. Ventilation methods are varied. The simplest method is to punch holes in the pile at several points. The high temperature compost method of Chinese rural composting (Chapter 2) involves inserting a number of bamboo poles deep into the pile and withdrawing them a day later, leaving the pile with ventilation holes. Aeration is improved by supplying more air to the base of the pile where O deficiency occurs most often. In addition to the above-mentioned vertical poles, Ecuador on-farm composting (Chapter 2) uses a lattice of old branches at the base to allow more pile surface to come into contact with the air, and the composting period is reduced to two to three months in warm seasons. This technique is also practised in the rapid composting method developed by the Institute of Biological Sciences (IBS) in the Philippines (Chapter 2), where the platform should be 30 cm above the ground. The passively aerated wind-rows method (Chapter 3) uses a more sophisticated technique. It entails embedding perforated pipes throughout the pile. As the pipe ends are open, air flow is induced and O is supplied to the pile continuously. The aerated static pile method (Chapter 3) takes this aeration system a step further; a blower generates air flow to create negative pressure (suction) in the pile and fresh air is supplied from outside.

Turning

Once the pile is formed and decomposition starts, the only technique for improving aeration is turning. As Table 1 shows, frequency of turning is crucial for composting time. While the Indian Bangalore method (Chapter 2) requires six to eight months to mature, the Indian Coimbatore method (Chapter 2) (turning once) reduces the time to four months, and the Chinese rural composting pit method (turning three times) reduces the time to three months. An extreme example is the Berkley rapid composting method (Chapter 2), which employs daily turning to complete the process in two weeks. In some cases, turning not only distributes air throughout the pile, it also prevents overheating as it kills all the microbes in the pile and terminates decomposition. However, turning too frequently might result in a lower temperature.

Inoculation

While some composters find improved aeration enough for enhanced microbial activities, others may need inoculation of micro-organisms. Inoculum organisms utilized for composting are mainly fungi such as Trichoderma sp. (IBS rapid composting and composting weeds (Chapter 2)) and Pleurotus sp. (composting Coir Pith (Chapter 2) and composting weeds). This publication also features 'effective micro-organisms' (EMs) (EM-based quick compost production process (Chapter 2)). The inoculums are an affordable choice for those with access to the market and also for resource-poor farmers. The production cost could be reduced by using inoculums taken from compost pits (pit method of the Indian Indore method (Chapter 2)), by purchasing the commercial product and multiplying it on the farm (EM-based quick compost production process), and by utilizing native inoculums derived from soils or plant leaves.

Supplemental nutrition

The techniques mentioned above often need to be complemented by the provision of nutrients. One of the most common practices is to add inorganic fertilizers, particularly N, in order to modify a high C:N ratio. Similarly, P is sometimes applied as the C:P ratio of the material mix is also considered important (the ratio should be between 75:1 and 150:1). When micro-organisms are inoculated, they require sugar and amino acids in order to boost their initial activities; molasses is often added for this purpose.

Table 1 Salient features of selected small-scale aerobic composting techniques

Method	Salient features					Duration
	Substrate size reduction	Turnings at intervals of (days)	Added aeration provision	Microbial inoculation	Supporting microbial nutrition	
Indore pit		+15, +30, +60		Inoculum from old pit		4 months
Indore heap	Shredded	+42, +84				4 months
Chinese pit		+30, +60, +75			Superphosphate	3 months
Chinese high temperature compost	Shredded	+15	Aeration holes in heap through bamboo poles/maize stalks		Superphosphate	2 months
Ecuador on-farm composting		+21	Lattice of old branches/poles at heap base			2-3 months in summer; 5-6 months in winter
Berkley rapid composting	Shredded to small size	Daily or alternate day turning				2 weeks with daily turning & 3 weeks with alternate day turning
North	Shredded	+3 or +4	4-5 holes punched		0.12 kg N per 90	4-6

Dakota State University hot composting			in centre of pile		cm dry matter	weeks
EM-based quick composting		+14, +21		EM	Molasses	4-5 weeks
IBS rapid composting	Shredded	+7, +14, then every 2 weeks	Raised platform ground/perforated bamboo trunks	*Trichoderma* sp.		3-7 weeks

Shredding

Downsizing, or chopping up the materials, is a sound and widely-practised technique. It increases the surface area available for microbial action and provides better aeration. This technique is particularly effective and necessary for harder materials such as wood.

Other measures

An example of other measures mentioned in this publication is the practice of adding lime. Lime is thought to weaken the lignin structure of the plant materials and enhance the microbial population. However, in some cases, liming is not recommended as the pile may become too alkaline, resulting in significant N loss.

LESSON 5. Design and construction of Fodder Silo

1 Introduction

It is need to store animal fodder and feeds, fertilizers, seeds, vegetables, milk and milk products, farm machineries etc., in a variety of storage structures.

1.1 The Silo

Silo is a farm structure which stores and products the animal fodder providing an ideal condition. The fodder is cut and packed in the silo in an air tight condition to favor for partial fermentation. The stored fodder is known is known as silage. Silage can be made from any green crop with moderately tough stalk. e.g. Grass, Sugarcane, legumes, etc.

Silage is more nutritive then dries stalk. But when compared to green fodder, there is some loss of nutritive value in silage, because the sugar is converted into lactic acid giving a sour taste. Losses are also occurring due to surface spoilage, fermentation and seepage. Loading of tower silos is difficult. It heeds a mechanical loader or a large capacity blower for elevating the cut fodder. The wall should be smooth, circular and strong enough to avoid cracking due to lateral pressure. Hence, a heavy reinforcement is a must.

The only advantage is if the water table is very close to the ground level, tower silos are preferred. The cost of constructing these silos is comparatively much higher than that of horizontal types.

1.2 Horizontal silos

Horizontal surface silos are really used for storing silage. These silos are readily and cheaper made at any time and they can be easily filled and unloaded without any equipment. They are successful in areas having a deep water tale. The dry matter losses ranges from 20-30% while filling either trench or pit site. Chopped silage should be spread, leveled and packed. They are filled, till the silage reaches the above G.L. They should be covers with dry paddy straw or plastic covers. Well packed silage weighs 480-800 g per m^3. Area=650 kg/$m^{3.}$

1.2.1 Pit silos

It is a circular deep well which is lined all along the side and bottom to prevent the water entering it. They can be made of bricks or stores or concrete with either lime or cement. Up to a depth of 15m a 22.5m wall is provided with plastering the entire inner surface. A simple roof over the silo can be provided to protect the silage from sun and rain. Generally a cow is feed about 1.4kg of silage per 45kg of her body weight per day. i.e. 1.4 kg/45 kg /day or 3 kg/100 kg of body weight.

Diameter of the silo is determined by the quantity of silage feed daily. The rate removal should at the rate of 10cm/day. The diameter is limited to 6 m and its depth is kept 2-3 times the diameter.

Design criteria

1. Rate of removal - 10 cm/day
2. Silage fed per day - 3 kg/100kg of body weight
3. Maximum diameter - 6 m
4. Depth - 2-3 times diameter
5. $1m^3$ of silage - 650 kg

Problem: Work out the economical diameter and depth of a silo to store sufficient quantity of silage for a herd of 300 dairy cows having an average body weight of 450 kg each. The cows fed with silage for 200 days /year.

Given :

No. cows - 300

Body weight - 450 kg

No of days per year - 200 days /year.

Solution:

Let i) $1m^3$ of silage = 650kg.

ii) Thickness of silage fed per day = 10 cm/day.

iii) Let each cow I fed 3kg of silage per 100 kg of the body weight.

Weight of silage required for each cow = (3/100) X 450

= 13.5 kg / day

Weight of silage required for 300 cows =13.5 X 300

= 4050 kg / day

Volume of silage required to be stored =4050/650

= 6.23 m^3 ------------------ (1)

Allowing 20 % loss, Actual volume of silage = 6.23 + 0.2x6.23 = 7.476 m^3

Volume of pit for a daily withdrawal depth of 10 cm = $\frac{\pi}{4}d^2 \times 0.1 \, m^3$ -------------- (2)

Equating (1) & (2) $\frac{\pi}{4}d^2 \times 0.1$ = 7.476

$$d^2 = \frac{4 \times 7.476}{\pi \times 0.1}$$

$$d = 9.756 \approx 10 \text{ m}$$

Depth of the silo = daily depth x no. of days = 0.1 x 200 = 20 m

1.2.2 Trench silos

It can be either lined one or unlined one. Unlined silo is easy to construct but give more spoilage of silage and caving in of sides due to rain. A lined trench silo is advantageous and the lining can be made with brick concrete or cement plaster with reinforcing wire mesh. Filling packing and sealing are similar to pit silo. The drainage water should not be allowed to collect near the trench and so drains should be made around the trench. The cross section depends on number of animals to be fed and the length is determined by the number of days, the silage is fed in a year.

Problem: Design a trench silo for a small farm having 140 buffaloes weighing 680 kg each and has to be fed at the rate of 4 kg/100 kg of its weight. The silage is fed 160 days in a year.

Given Data:

No. of animals = 140

Wt. of each animal = 680 kg

Feeding rate = 4 kg / 100 kg of body weight

No. of days of feeding = 160 days

Solution:

Let the depth of silo be 2.5 m

Length of feed per day be 15 cm

Side Slope be 1 : 2

Wt. of silage required per day = feeding rate x wt. of each animal x no. of animals

$= \frac{4}{100} \times 680 \times 140 = 3808$ kg / day

Let 1 m^3 of silage = 650 kg/ m^3

Volume of silage required per day $= \frac{3808}{650} = 5.858$ m^3/ day -------------- (1)

Volume of silage stored per day $= \frac{1}{2}(w + w + d) \times d \times 0.15$ ------------- (2)

Equating (1) & (2)

$$\frac{1}{2}(w + w + d) \times d \times 0.15 = 5.858$$

Bottom width, w = 14.37

Top width = w + d = 14.37 + 2.5

= 16.87 m

Length of the silo = length of silage withdrawn/day x no. of days the feed is given /yr

= 0.15 x 160 = 24 m.

With 20% loss, the Length = 28.8 m.

Result:

Top width of silo = 16.87 m

Bottom width of silo = 14.37 m

Depth of silo = 24.0 m

Length of silo = 28.8 m.

LESSON 6. Construction of Farm Fencing

1.1 Introduction

For a farm, fencing is adopted to enclose the farm to distinguish the boundaries and to prevent trees passing of animals etc. It is also used for open yards to keep the animals confined in it. Live hedges, compound walls, wire fencing etc., are ordinarily adopted in India. The compound wall construction is costlier when compared to the wire fencing.

In wire fencing upright posts made of wood, angle iron or concrete are used and to these barbed wires, plane wires or mesh wires are attached. Mesh wire are generally convenient for cattle sheds and poultry houses whereas barbed wire is used for demarcating the boundaries.

Upright posts:

Upright posts made of wood are cheaper but does not last long. They become uneconomical due to painting of them year after a year and renewing owing to white ants, rot and deterioration. Next in order of present day popularity for fence post is iron, which also has to be continuously painted and guarded against rust, which is the ever present enemy of iron material. The concrete posts are better than both wooden and iron ones and durable though the cost is slightly more than other two.

The concrete posts can be manufactured on the farm itself. They are made as square posts, square tapered posts or as posts with triangular coping. Concrete posts are easy to construct. The posts are usually made for 1.8 m to 2.1 m (6 ft. to 7 ft.) length and the size of the posts being 12.5 cm square (5 inches) square or 12.5 cm square (5 inches square) bottom and 7.5 cm square (3 inches square) at top. These posts are made on the form by using rectangular wooden moulds without top or bottom. The moulds are placed over a platform and reinforcement bars (steel rods) are placed in position leaving a cover of 1.9 cm to 2.5 cm (3/4 inch to 1 inch) alround by propping. The size of rods adopted for reinforcements may be of 6 mm or 10 mm (1/4 inche or 3/8 inch). The smaller diameter rods are adopted for ordinary posts, but when heavy usage is expected and a bigger post is therefore necessary, larger diameter may be used. As a fence post has usually to resist lateral or bending pressure and it is difficult to determine from which direction the pressure acts, it is safe to reinforce all the four sides.

The rods are laid lengthwise, the ends built up at right angles to exclude any change of the concrete pulling away from the steel. The rod should be kept apart by 3 mm (1/8") wire wound round in the form of spirals at 30 cm (12 inches) apcing.

Casting posts :

The concrete is prepared by mixing broken stones 1.9 cm (3/4 inches gauge with sand and cement in the proportion of 4:2:1 or 3: 1.5:1 by volume. This is mixed well by adding clean water at the rate of not more than (5 gallons) pr bag of cement. The mixture after the water is added should be of medium wetness and thoroughly plastic, but not too slopy. Before concrete is placed in the mould ; the latter should be lightly greased or rubbed with oil or soft soap. Instead, they can be thoroughly wetted by pouring water. The concrete should be placed within the mould as soon as mixing is completed as the concrete sets within 30 minutes. The mixture filled in thin layer should be tamped well to ensure complete filling of the space without any voids. The top surface should be trowelled to level the surf ace and left to settle.

If holes are to be provided for inserting the wires or to be tied, rods should be inserted through the holes provided in the side of the boxes before the concrete is placed. These rods should be withdrawn after the concrete has set sufficiently to retain its shape which varies from 4 to 6 hours.

The castings should be left in the mould for 24 hours after which time the mould can be dismantled are reused. Then the post should be cured on the platform itself for 4 days by covering it wetted sand. It is then lifted from the platform and put in a water tub or pond for curing. If no pond is available it can be placed over a bed of wet sand and water sprinkled on it. The curing should be done for two or three weeks. The posts should be used preferably after 3 months period after casting but in no case it should be used before 30 days.

Spacing of posts:

The life of fence and maintenance cost is dependant upon the size of spacing of fencing posts. usually a spacing of 2.4 m to 3.0m (8 ft. to 10 ft.) is better for wire fences. The corner posts and straining posts should be heavier than the line posts and must be supported by struts. For this a mortise is made near the top of the post. The struts are made to 7.5 cm x 7.5 cm(3″ x 2″) and reinforced with four 6mm (1/4″) diameter rods. The struts are placed into the ground and covered by concrete.

Erecting fence posts and wire:

The posts should be set in the ground for 52.5 cm (1.75 ft.) or 60 cm (2 ft.) depth and should be concreted with a mix of 1:2.5:5. The wires are fastened to the posts and stretched well. The different methods of fastening the wires to the posts are given in fig.

The selection of wires depends on the purpose for which it is used. Barbed wire is effective for fencing the boundaries to prevent animal trespassing. But it is not suitable for poultry yards. Plain wires are best suited for cattle yard with or without barbed wire. Wire mesh is suitable for poultry yards. In fencing with barbed wire, plain wire or wire mesh, the arrangement of horizontal wires at the bottom should be closer than at the top.

Farm gates :

Gate and position should be selected so that unnecessary travel distance should be reduced. The gate way should be wide enough to give access to easy traffic. The gates provided should be strong and durable. For farm gates separate gate pillars of heavier sections should be provided to bear the weight of gates. The gates may be wooden, or iron with necessary locking arrangements. Some of the simple type of gates that can be made in the farm itself is given in figure.

LESSON 7. Machinery and Implements Shed

1.1 Introduction

Farm implements and machineries vary from to farm. Any a common storage shed for these are essential to protect them from weathering action. The sheds Need no enclosure no all sides. Hence angle iron posts or masonry pillars may be provided for supporting the corrugated sheet roofing. A lean to roof with a rear end enclosures or gabled roof with only end enclosures to support the Roof may also be adopted.

A raised ground itself serves serves as satisfactory flooring. But for cleanliness well packed gravel flooring will be sufficient. Ramps should be provided to allow movement of machineries over the floor. Where a separate workshop is not provided on a farm, necessary platforms, benches etc., may be provided in the machinery shed itself to facilitate cleaning. Servicing and repair works of the farm machineries.

Fig.6.1. implements shed for the smaller farm

Table.6.1. average space requirements of farm implements and machinery.

Tractors	so.m.
Medium powered wheel tractor	6.50
Track-laying tractor	5.57
Single furrow plough	2.60
One furrow one way tractor trailer plough	5.57
Tow furrow tractor trailer plough	5.12
Three furrow tractor trailer plough	6.50
Four furrow tractor trailer plough	8.83
Six furrow tractor trailer plough	12.55
One furrow mounted plough	1.86
Tow furrow mounted plough	2.33
There furrow mounted plough	3.26
Four disc plough	7.90
Fertilizer distributor	6.50
Farm yard manure loader	7.43
Farm yard manure spreader	9.29
Transport Equipment:	
Two wheel tractor trailer	7.43
Four wheel tractor trailer	9.29
Cart	6.50
Lorry	11.15
Van	7.43

HEIGHT REQUIREMENT OF LARGE TYPES IMPLEMENTS MACHINERIES AND TRACTORS:

Medium power wheel tractors 2.4 m (8 ft.) over exhaust and air intake pipe. Tract sugar beet equipment 2.1 m over exhaust and air intake pipe.

Complete harvester	3 m
Grass equipment	**In metres**
Pick up baler	2.4
Stationary baler	3.0
Green crop loader	3.6
Elevator (folded)	2.4

LESSON 8. Animal Shed or Shelters Dairy Barn

In India, the need for expanding the supplementary and subsidiary foods especially proteins has been increasingly realized in recent years. The demand for these articles has specially increased and with the rise in income it is likely to increase more rapidly in future. The prospects of augmenting the supply of milk and milk products, table birds, eggs etc depends on the development of dairy farming and poultry keeping which are an integral part of a sound system of diversified agriculture. Therefore special emphasis is laid on mixed farming, in which crop production and animal husbandry are dovetailed for efficient and economic utilization of land laboures and capital. The integration of farming with animal husbandry is essential for the fuller utilization of farm by products maintenance of soil fertility fuller employment ofr agriculturists throughout the year and increase in rural incomes. Hence for better management and breeding of the farm animals in healthy condition animal shelters are inevitable.

The kindof shelter required for an animal depends upon the kind of animal and the climate condition of the region. The rapid increase in temperature and extreme temperatures affects the animals. So to maintain the in properly, a shed is to be provided with a roof. The space available for each animal should be sufficient to allow free movement so as to maximize the ability to adjust to the environments. In the case of high velocity wind also, animals are affected and hence to protect them from wind droughts, enclosures is of provided. The sheds for housing the clarity cows and poultry hers are dealt in detail.

Dairy Barns

When planning a new dairy form, the size and location of barn with relation to the entire farm, the fields, roads, drainage channels, prevailing winds and landscaping are of importance are of importance and should be considered. The requirements of the dairy cows and calves should also be considered before any construction work is undertaken. The location of the fodder and feeder storage buildings should be included in the plan.

Milk straining, weighing, cooling and cleaning of the milk utensils require significant of labour and therefore the location of a well planned milk house should be carefully chosen. Before a new dairy barn is planned the future expansion of the business should also be considered. The size of the hard is usually determined on the basis of the total quantity of fodder the farm is capable of producing annually. Generally, it is economical to produce fodder on the farm and to buy concentrates from the market, and thus are can afford to have a large size hard than if its farm itself had to provide all the feed stuffs.

The dairy barn, when properly located should have a good approach from the highway, as well as from the farm house. The milk house is best located on a clean, well drained site near the barn, but separated from it by a 6 m long paved passage. It should face the road and be provided with doors fixed with wire mesh to keep off the flies. In tropical countries like India, it is better to have enclosed becomes facing in the east west direction. The location of the feed and fodder stores w.r.r barn should be planned so that the minimum time is spent in taking the supplies to the barn. The topography of the barn site determines the drainage pattern required. Drainage should be diverted around the barn by proper grading of the surrounding land.

Besides the natural rainwater, water used in grooming the cows, and cleaning the barn and dairy utensils has to be disposed off. It is desirable to have paved approaches to the dairy barn, since this prevents stagnation of water and mud formation. Under these conditions, it is not possible to transport the cow dung from the barn daily, it is desirable to fence an area near the barn of storage of manure.

Types of Dairy Barn

There are three general types of barns.

i) Stanchion barn

ii) The loose housing barn with milking room and

iii) The open air barn

In the stanchion barn the cows are housed and milled in the some building. It is also called the general purpose barn of the cow. The loose housing barn is one in which the cows are housed in a covered or partially covered yard, but they are milked in batches in a special milking house called the milking barlour. This system is also called the milking house system. the open air barn does not have any coves. The cows live in field and they are fed and milked there. The system is also known as the leafing barn system and is not common on a well established dairy barn.

Stanchion barn is one is which the cow is kept tied in separate stalls and provided with feed. Each stall consists of a bedding place and feed place so that the cow can be kept in the stall itself at all times. Stanchion is a frame work made up of pipe or angle iron with an oval shaped adjustable ring kept one end hanging from the frame and the other hinged to the floor. It shoul0d be wide enough to pin it on easily to the neck to the animal and to lock it. It should also give facility for the animal to rest and move its neck side ways to reach feed l./ and water. Instead of using oval shaped ring chains are also used to fasten the animals to the stanchion. For this a strap is around the neck of each animal.

The animals are arranged in rows according to the members to be housed. In enclosed shelters for more than 8 cows two rows is preferable. The rows can be arranged so that they may be facing each other known as 'face in' arrangement of is the opposite direction known as 'face out' arrangement. Face in type arrangements will reduce the floor area give facility for cleaning manure to the open sides an is suited mostly for unenclosed barns or for bullodes. The stalls are separated by a small partition wall usually of concrete to 12.5cm height, with a bent pipe fixed equal to the length of stall for efficiency of management the length of rows should be restricted to have maximum of 10 cows in a row. If the limit is exuded.

Stall size: The size of stall depend upon the size and age of animals. Narrow and cramped stall should be avoided, as it restricts the movement of animal resulting in discomfort and even injury to the animal which will affect the milk yield. As the size old cow varies with different breeds, a general space requirement of each type of the basis of its weight is given in the following table

Table . Dimensions of cow stall

Weight of cow		Girth (per meter)		Stall width		Stall length	
Kg	lb	cm	inch	cm	feet	cm	feet
363	800	162.5	65.0	100.0	3′4″	135	4′6″
454	1000	176.25	70.5	110.0	3′8″	140	4′8″
544	1200	187.50	75.0	120.0	4′0″	150	5′0″
634	1400	198.75	79.5	130.0	4′4″	160	5′4″
723	1600	210.0	84.0	140.0	4′8″	170	5′8″

Mangers : are feeding structures for the animals. The size of the mangers should be sufficient to hold the feed. It should, be sufficient to hold the feed. It should be shaped in a curved form so that no wastage of feed is allowed. The two usual types of mangers adopted are shown in figures.

The low manger known as "sweep in" is simple and easy to construct and it affords facility for quick feeding. The waste thrown by the animal away from the manger can easily be swept back. The high front manger, though a bit difficult and costlier in construction, is still adopted of less wastage by throwing the feet out of mangers. The usual width of manger varies from 60 cm to 90 cm. The back of low manger is flush with feeder alley and the back of height front manger is about 70 cm above the feeder alley.

At the foot of manger a stanchion curb of height 12.5 cm is provided to prevent the animal from dragging the feed into the stall. This curb separate the manger and the stall and provides support for the bottom of stanchion.

Cement concrete tubes of 150-200 liter capacity are provided in between two cows.

Space for pathways: To increase the efficiency of diary management enough space for pathways should be provided for conveying feed to the manger, milking the cows and removing the manure waste etc. The pathways provided in a stanchion barn are feed alleys and litter alleys. Feed alleys are pathways provided between two rows of mangers in case of face in system or pathways between the mangers and side wall in the case of face out system. the usual space left is 1.2 m so as to allow the conveyance of feed in a push cart. In the case of big dairy barns the should be wide enough for a farm cart drawn by bullocks or farm tractor. In the case of face in arrangement no separate litter alley is provided as the sides are not enclosed. But in face ant arrangement litter alleys are provided for a width of 1.8m to 2.4 m for facility of milking and taking out animals. Cross alleys are also provided where the number of animal are more to have access from one side to the other without back tracking.

Cutters: these are provided to convey the animal waste and to drain urine and wash-water to manure pits provided out side the dairy barn. These are provided by the side of litter alleys and their width varies from 40cm to 45cm and the depth is 15 cm. A minimum bed slope of 2% should be given for the gutters to drain without any stagnation.

Flooring: The flooring for dairy barns may be laid either with cement or lime concrete as sub grade, with a meet rough finish on top with c.m. The stall platforms should be sloped well for maintaining the clean liners. The top surface of the flooring should not be left smooth as it may cause slipping of animals. Thread linings. Made on the floor renders grip to the animals. A toe hold known as toe drain provided at the front of the stall for 1/3 length helps the animals to sit or stand without slipping.

Walls : Brick or rubble mesory in lime or cement marker can be adopted for enclosing the barn. The length should be a minimum of 2.4m. ventilators or opening of 0.37 sqm (4 sq ft) per each cow should be provided to give natural lighting & air. It climate and environment do not call for enclosures, pillars at 2.4m to 3m apart (8 to 10 ft) can be had to support the roof.

Roofing: In not regions, tiled roofing can be advantage adopted rather than A.C. sheet or other corrugated sheet roofing, be cause of its less heat radiation. A.C. sheet can be adopted where the temp is moderate. Concrete roofing is the best, if the investment in justifiable. In the case of two rows. Barns, roof trusses of iron or timber should be used, since the width will be more than gm.

Loose housing system : In this system of housing the milking, feeding and bedding operations are arranged in separate places. An open exercising yard is also provided in this system. the labour requirement is less and efficiency of management is more since the milking is done in a small enclosed area and he manure allowed to accumulate in the bedding area to cleared once or twice is an year. The success of this method is related to the allotment of enough space and shelter.

Feeding shed This is a covered shed to protect the feed from rain and an area of 3.7 sqm (40 sqft) is recorded for each cow. Pavement with mangers is betters for keeping the feeding area clean. The space of manger for each cow varies from 67.5 cm to 75 cm. and the depth should be sufficient to prevent wastage by dragging out of the mangers. Water tub of 300 litres capacity are provided for every 15 cows in the feeding room. For feeding shed a lean to root shed with no enclosure on are side is economical and suitable.

Bedding area: This is also a covered area with an ample space of 6.4 sqm per cow. The shed room should be a min. of 3m to allow piling up of manure for 0.9m height. The bedding area should include separate place for caves at the rate of 2.8 sqm (30 sqft) per cow.

Exercising yard: This is an open enclosed space to afford free movement of animals to get fresh air and exercise. The space required for each cow is 9.2 sqm (100 sqft). This is provided adjoining the bedding area. The yard should have a slope of 1 in 6 for the first 1.0m width and then 2% slope away from the bedding ara for draining water.

Milking rooms : The milking room is provided separately where facilities are made for milking a few cows at a time. This is constructed adjoining the feed room so that other animals can be kept there awaiting their turn to be led to milking. For providing facility for milking, stalls should be constructed to keep the animals at the floor level or raise above the floor where the operator works. The level floor stall arrangements are similar to stall barns with space for litter and feeder alleys. The room is covered on the sides and top to keep it clean.

Stall systems are either floor level, with the platforms at the same level as he floor on which the operator works or elevated with the cow platform from 30" to 36" above the operators (fig) floor level stalls are usually arranged abreast like the stalls in a stall barn.

The cows may walk thro after milking or back at F or one operator the most convenient number of stalls in this arrangement see was to be 6 to 1, for two operators, 8 to 12 or 16 stalls should be provided.

The elevated stall system places to cows at a more convenient and comfortable work height for the operator. If milk is carried from milking room to milk house, the operators floor should be at the same level as the milk house floor. The stalls are the a elevate and suitable ramps provided for the cows.

Chute: There are a no of arrangements of stalls suited to the elevated stall system. the chute type stalls are probably the least expensive to construct, because no wall fot eh cows is necessary and fewer gates need be provided for handing the cows. However all the cows, in one line must be let in and released at one time. A slow milker may hold up the line and cause lost time. Feed boxes that slide out into 1 operators ara permit clean. Passage for the cows to move thro. The chute arrangement can be built force single row or two rows of cows. Feed in tube is filled with feed with the help of chute pipe from an elevated feed storage hub.

Tandem type: The tandem type of arrangement permit cows to enter and be released individually. However a wale for the cows must be provided along the side. Gate must be provided on each stall, one for entrance and one for exit. The tandem arrangement man be built for one or two cows of cows.

U Type: or square type of arrangements are modifications of the tandem arrangement. In both the cows can be brought in and released individually. These arrangements may centralize the milking operation more than other types.

Montana: It is an abreast arrangement with elevated stall. For one operator, one working area and two stalls are provided for two operators, two working areas and four stalls are provided.

Dairy Cattle Housing

Stall systems for the milking room. Stall systems are another floor-level, with the platforms at the same level as the floor on which the operator works, or elevated, with the cow platform from 30 to 36 inches above the operator floor (See Figure 16.14). Floor level stalls are usually arranged abreast like the stalls in a stall barn (Figure 16.15)

The cows may walk through after milking or back out. For one operator, the most convenient number of stalls in this arrangement seems to be 6 to 1; for two operators, 8 to 12 or 16 stalls should be provided.

The elevated-stall system places the cows at a more convenient and comfortable work height for the operator (Figure 16.16). If milk is carried from milking room to milk house, the operator floor should be at the same level as the level as the milk-house floor. The stalls are then elevated, and suitable range provided for the cows. With the pipeline milker, the operator may be in a pit, and the cows at the same level as the holding area.

Chute. There are a number of arrangements of stalls sited to the elevated-stall system. The chute-type stalls are probably the lest expensive to construct, because no walk for the cows is necessary, and fewer gates need to provided for handling the cows. However, all the cows in one line must be let in and released at one time. A slow milker may hold up the line and cause lost time. Fed boxes that slide out into the operators area permit clear passage for the cows to move through. The chute arrangement can be built for a single row or two rows of cows.

Tandem. The tandem type of arrangement permits cows to enter and be released individually. However, a walk for the cows must be provided along the side. Gates must be provided on each stall, one for entrance and one for exit. Ropes over pulleys from the gates to the operator's area facilitate the handling of the cows. The tandem arrangement can be built for one or two rows of cows.

U type. The U-type and square-type arrangements are moderations of the tandem arrangement. In both, the cows can be brought in and released individually. These arrangements may centralize the milking operation more than other types. In the square-type arrangement the pipeline milker is essential, because the operator has no exit through which to carry the milk when the cows are in the stalls.

Montana. The Montana-type milking room is an abreast arrangement with elevated stalls. For one operator, one working area and two stalls are provided for two operators, two working areas and four stalls are provided.

Since concentrate grain is normally fed in the milking room, an adequate supply should be readily available at milking time. This can be provided by overhead storage with chutes, or by storage in a large container in the operation's area.

In some regions of mild climate, where little or no housing is required for dairy animal, the milking area is a separate milking barn. This milking barn is similar in arrangement to the loose housing milking area.

Arrangement for efficiency. For maximum efficiency in operating the loose housing system. it is essential that he various units be correctly located with respect to one another. Such an efficient layout incorporating the ideas already discussed is shown in

Space Requirements of Dairy Animals and Layouts of Dairy Farms

All animals require shelter for protection and comfort. They can perform better under favourable environmental conditions. Housing of animals need initial capital to the extent the dairy farmers can afford. The animals are to be protected from high and low temperature, strong sunlight, heavy rainfall, high humidity, frost, snowfall, strong winds, ecto-parasite and endo-parasites. The comfortable temperature range for dairy breeds of cattle, buffaloes and goats is 150C to 270C. Climatic stress occurs when the temperature goes 50C below or above this range.

High humidity combined with high temperature causes more stress to animals in tropics. Rainfall in cold climate also causes stress in temperate zone. Strong winds further aggravate the conditions both in tropics and temperate climate. Several techniques are available to provide relief from hot weather conditions for lactating dairy cows. In tropical and sub-tropical climates, well-ventilated shed is a necessity at points of high heat stress, such as feed barns, loafing areas, and in holding areas. It is important to provide a sufficient flow of air through the building in which the animals are kept to ensure optimum thermal conditions for dairy animals.

The space requirements of dairy animals as per Bureau of Indian Standards (BIS) are given in table belo

Floor, feeding manger and watering space requirements of dairy animals

SR. NO	TYPE OF ANIMAL	FLOOR SPACE) PER ANIMAL (M^2)		FEEDING (MANGER) SPACE PER ANIMAL (CM)	WATER TROUGH SPACE/ ANIMAL (CM)	MODE OF HOUSING
		COVERED AREA	OPEN AREA			
1	Young calves (< 8 weeks)	1.0	2.0	40- 50	10-15	Individual or in groups of below 5
2	Older calves (> 8 wks)	2.0	4.0	40-50	10-15	Groups of below 15
3	Heifers	2.0	4.0-5.0	45-60	30-45	Groups of below 25
4	Adult cows	3.5	7.0	60-75	45-60	Groups of below 25
5	Adult Buffaloes	4.0	8.0	60-75	60-75	Groups of below 25-30
6	Down calvers	12.0	20-25	60-75	60-75	Individual
7	Bulls	12.0	120.0	60-75	60-75	Individual
8	Bullocks	3.5	7.0	60-75	60-75	Pairs

* Based on ISI Standards for housing in India.
** The actual length and width of water trough may be decided as per the strength of group and size of the paddock.

Model Layouts of Dairy Farms of Various Sizes

Model layouts for the construction of various farm buildings have been prepared under loose system of housing. The loose system of housing dairy animals has been recommended for most of the agroclimatic zones of the country with minor modifications except in heavy rainfall regions and the high altitude regions where winters are very harsh. The dairy animals under lose system of housing are grouped together based on their age in case of growing animals and based on their physiological condition when they are adults. The various categories of dairy animals may be formed such as milking cows, dry and pregnant cows, down-calvers, bulls, heifers and the calves. All these animals need to be housed in separate sheds and the provision in the layout has to be made accordingly.

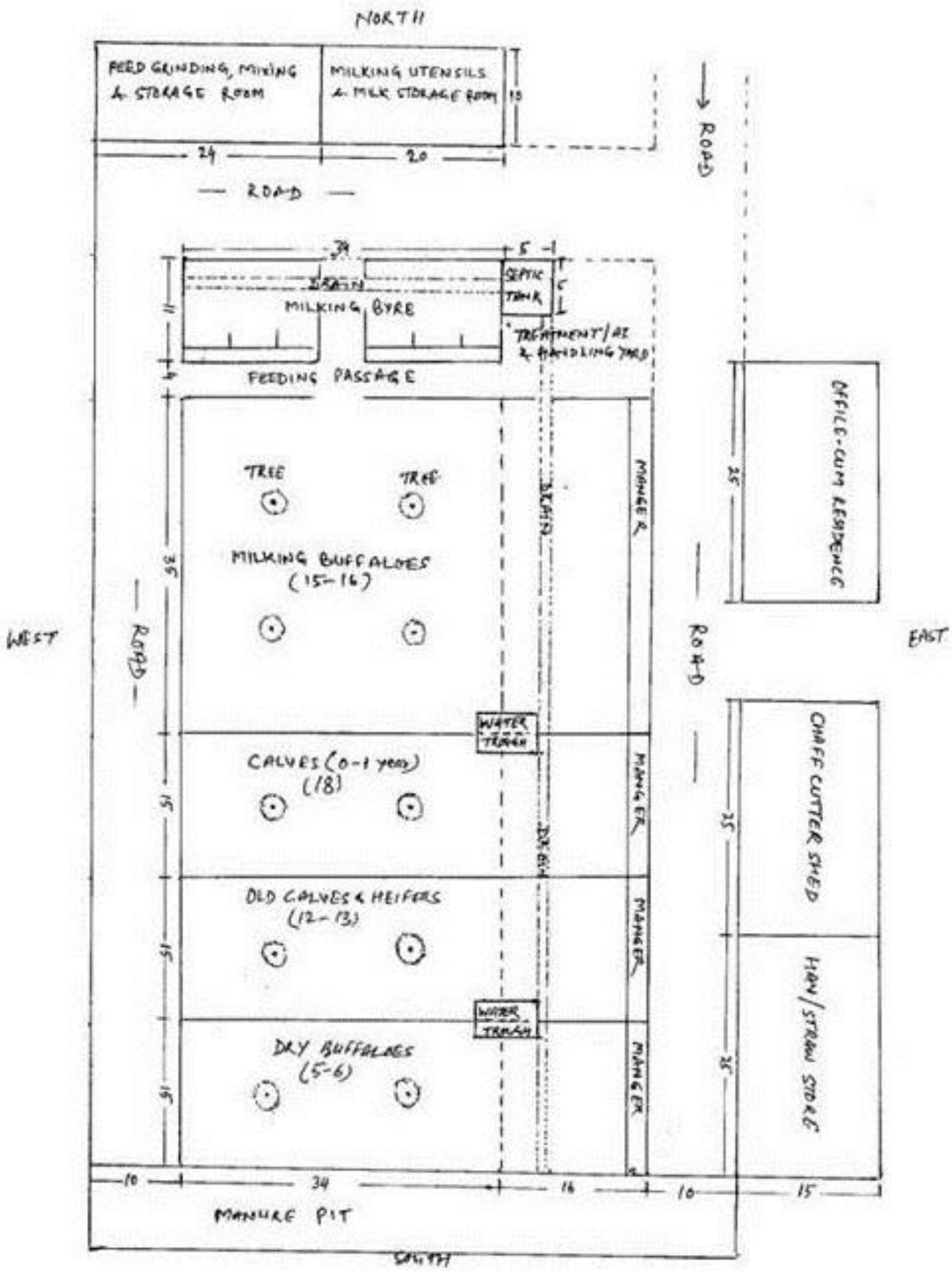
Apart from the animal sheds the certain other ancillary buildings/structures are also required to be constructed such as chaff cutter shed, feed store, implements store, straw store, milking parlour, milk room, silo pits and manure pits apart from the office, lawns. The large sized dairy farms may also need overhead water storage tank, a small sized workshop and parking space. The farm building may be arranged in such a manner that they result in higher animal productivity and labour efficiency with minimum movement of people and the animals. For example, the milking parlour may be situated close to the milking cows shed; the milk room may be adjacent to the milking parlour, the feed storage room also should be close to the milking parlour as the compound feed in mostly fed in the milking parlour during milking. The calf shed should be cloase to the milking cows shed if weaning of calves is practiced. The farm building should be constructed using cheaper locally availbale construction materials so that the construction cost is minimized.

Given under are some model layouts of dairy farms of various sizes for the setting up of commercial dairy farms.

Layout od Dairy Farm for 20 Cow/Buffalo Unit

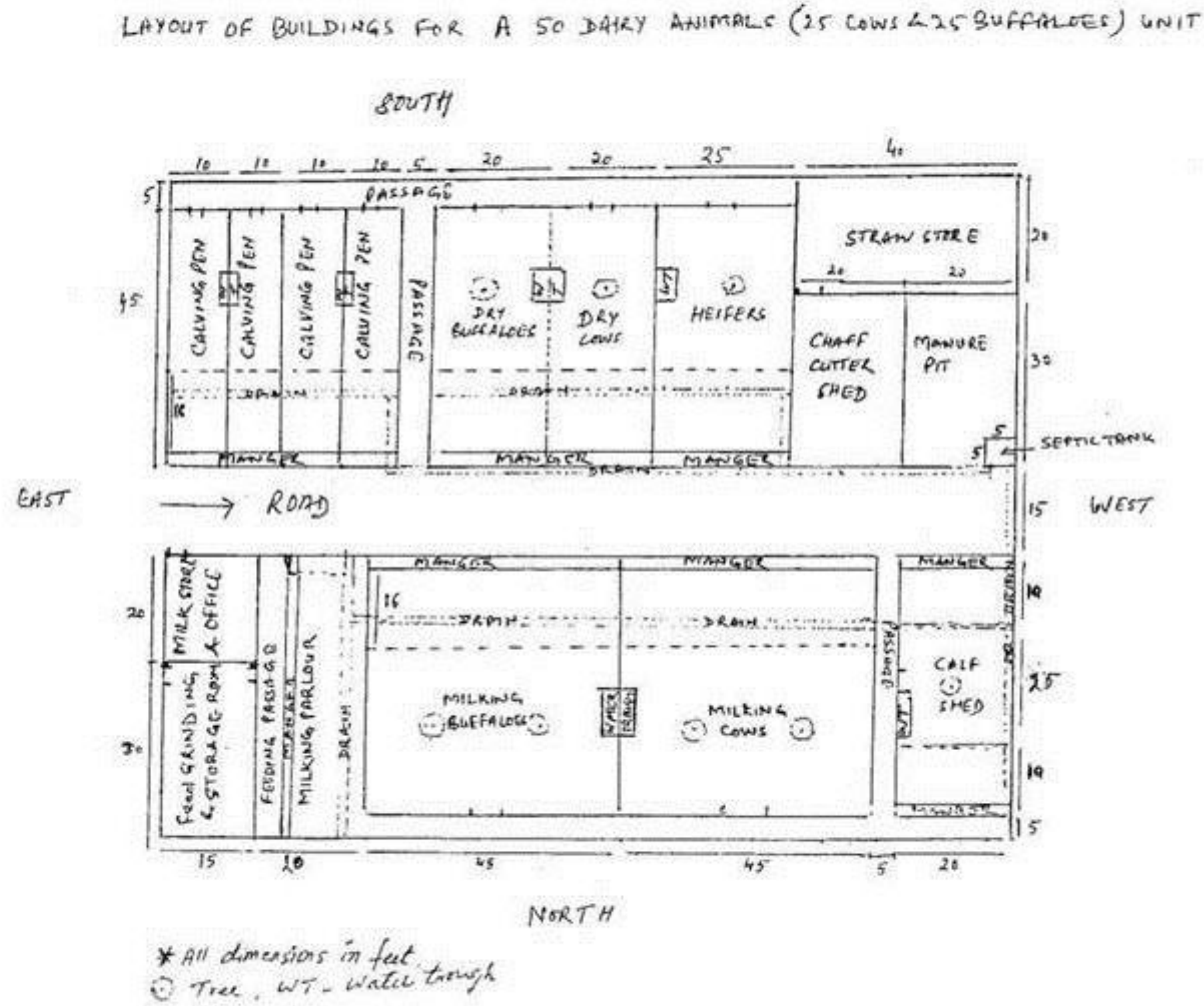
As prepared by Dr. M.L.Kamboj (NDRI, Karnal)

LAYOUT OF BUILDINGS FOR A 20 BUFFLOES BASED DAIRY UNIT



Layout of Dairy Farm for 50 Cow/Buffalo Unit

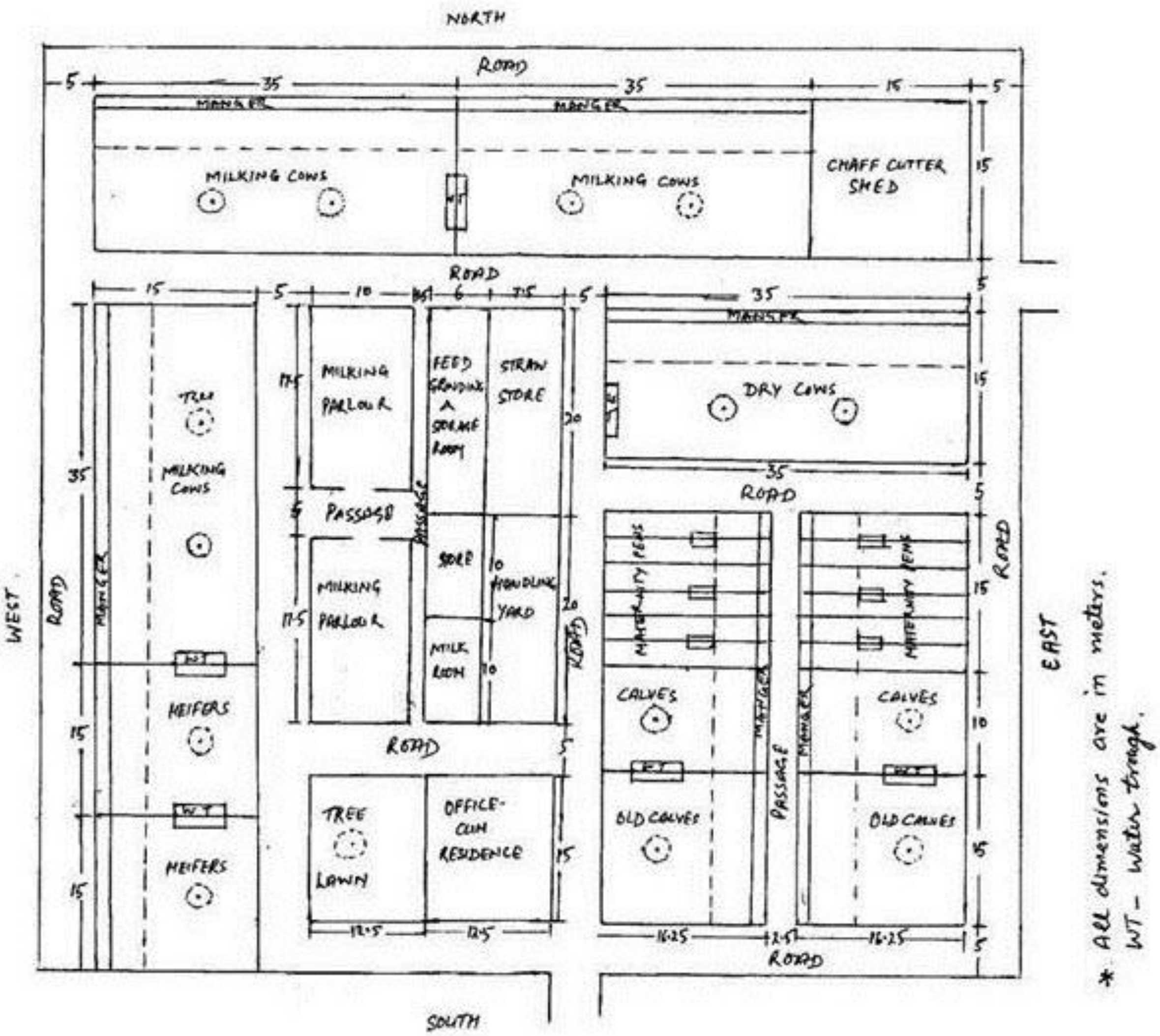
As prepared by Dr. M.L. Kamboj (NDRI, Karnal)



Layout of Dairy Farm for 200 Cow/Buffalo Unit

As prepared by Dr. M.L. Kamboj (NDRI, Karnal)

LAYOUT OF BUILDINGS FOR 200 COWS BASED DAIRY FARM



LESSON 9. Fundamental Requirements of a Poultry house

1.1 Environmental Temperature / ambient temp.

The optional temperature range for egg production lies in the range of 50-55°F. But temperature as low as 45° and, as high as 65° also do not affect egg production. When the baby chicks are first hatched, they do not have the facility to produce heat. Hence heat must be supplied artificially. It is an accepted practice to keep one day – old chicks at a temperature of 95°F and drop the temperature at 5°F each week until 70 is reached.

1.2 Humidity

When the temperature is between 32 and 45°F, the humidity should be kept below 85%. For higher temperatures the humidity should be kept below 75%. High humidities at high temperatures create undesirable conditions for the hens and result in excessive condensation in the building.

1.3 Air and its movement

A properly designed ventilation system should provide an adequate supply of fresh air for the birds and remove the products of respiration, the excess heat produced and the moisture from the breath and litter, all without causing undesirable drafts. A laying hen will produce 40-50 BTU total heat per hour of which 25-30 BTU will be sensible heat. The moisture which must be removed by ventilation will amount to @ 1/3rd lb of water per less in a day. The ventilation rate and amount of insulation should be balanced in design. An average of 2/3rd cubic foot of air/min. for each sq. feet of floor area is required. The exhaust duct size or fan capacity can be easily determined from the computed ventilation rate. Various types of ventilation in inlets have been used successfully in poultry laying houses. No inlet should be placed closer to any flue or exhaust fan.

1.4 Light

Natural delight well distributed throughout the house provides the necessary lighting for chores and for the hens to feed. The recommended window area ranges from 6-25% of the floor area for ordinary window glass. This area can be considerably increased in solar-oriented houses with insulating glass. The windows should be so distributed that 75% of the window area extends continuously across the front of the house. Artificial lighting is new commercially used during the winter season to extend the length of day for increased egg production. A 12-14 hours length of day is recommended. The light requirement is the equivalent of the 40 watt lamp hung at 6 feet above each 200 sq. feet of floor area.

1.5 Heat and moisture production inside poultry

Excessive moisture in farm buildings can cause considerable damage. Apart from spoiling the appearance where moisture collects on walls and leaves stains, considerable damage can result from rotting of wood members by moisture; moisture in walls reduces insulation value.

One of the primary sources of moisture in a building for housing poultry is that which has been given off to the air in the form of vapour by the birds.

Condensation: The most obvious moisture is that which condenses on the inside surfaces of the walls or windows because it is visible. Condensation will occur on any surface which in below the dew point temperature of the air surrounding it. The air in close contact with the surface is cooled, thus increasing its relative humidity. When cooled to the saturation point, any further cooling results in condensation.

The inside surface of walls of buildings are cooler than the inside air whenever the outside of the wall is exposed to a lower outside temperature. To determine whether the condensation will occur, the inside surface temperature must be computed to determine whether it is below the dew point of the inside dir.

The temperature of the inside surface may be computed by the formula.

$$t_s = t_i - \frac{u}{f_i}(t_i - t_o)$$

Where t_s = inside surface temperature

t_i, t_o = inside and outside temperature respectively.

Sanitation for Poultry

Cleanliness and sanitation are of extreme importance in carrying for poultry. Hens are subject to numerous diseases and insect infestations. Although sanitation is principally a management consideration, certain structural practices can facilitate the maintenance of sanitary conditions. Providing a suitable environment and cleaning the litter inside the house leed to sanitation.

The construction of the house with smooth surfaces can reduce the accumulation of dirt and facilitate cleaning and disinfecting. Equipments used in the poultry house, such as waterers, nests and feeders, should be of a type that can easily be cleaned out and disinfected.

MODULE 4. Rural Living and Development

LESSON 10. Types of Rural Roads and Their Construction

1.1 Introduction

In India many farms do not have roads and even the existing pathways or lanes are so narrow that it will suit only the bullock drawn carts. With the advances made in farm machineries, the problems of forming roads have now engaged the farmers. Farm road is an essential means of transportation of farm produce and farm requirements. To facilitate easy and speedy transportation and to suit the fast moving vehicles the old type of roads are to be renewed and improved so that it may add to the advancement of trade of agricultural output and to increase the life time of the farm machineries. Hence some knowledge of basic principles of road making will be of help to the farmers to ensure the most suitable and economical type of road for the job and to execute the work efficiently.

1.2 TYPE OF FARM ROADS:

From the service point of view the farm roads shall be grouped into the following two classes.

1. The road serving farm stead and
2. The road serving fields

According to the construction and materials used the roads may be grouped into two types;

1. The flexible road made up of layes of various materials such as lime stone, gravel, kanker, red earth etc.
2. The rigid road made up of cement concrete.

FARM STEAD ROAD :

The farmstead road generally carries traffic of greater weight and density than the field road. Therefore it should have a smooth, hard surface requiring minimum maintenance and easy cleaning. For this, the concrete is most suitable. If any existing flexible road is to be made use of, then it should be reconditioned with a wearing surface.

FIELD ROAD

Field road should have sufficient hardness and not necessarily smoothness. Hence all that is required is a good hard base with a surface of gravel of broken stone. The base may be constructed using rubble, broken brick, late rite or any other cheap material available in the locality.

1.3 THE REQUIREMENTS OF A GOOD ROAD:

An ideal road should be perfectly straight, level, smooth hard and dry. Such perfection can of course be rarely reached and hence in practice a compromise of all the above requirements is to be made.

STRAIGHTNESS :

Straight road will facilitate easy plying of vehicles and good visibility to avoid accident. Wherever curves occur they should be smooth and easy. When vehicles are moving along curves of a rod, a side thrust is created and it tends to dislodge the vehicle from the road causing slipping or skidding and overturning. To avoid this and maintain equilibrium of the vehicle moving on a curve, the outside edge of the road is kept at a higher level to counter act the centrifugal force. This rise is known as super elevation. Super elevation is the inclination given to the cross section of road on curves in order to reduce the centrifugal force on a running vehicle. It is expressed as a fraction of the difference in level between the outer and the inner edges of the road to its width.

The generally adopted super elevation for the various kind of roads are given in the table. Table showing the super elevation for various kinds of roads.

Kind of roads	Super elevation
Water bound macadam road	1 in 48
Tar macadam	1 in 60
Cement concrete	1 to 72

LEVELNESS :

The road should be level or flat as far as possible to give maximum efficiency of the vehicles. In forming new roads easy gradients are to be maintained so that the road is suitable for all kinds of vehicle and to achieve this, much cutting and embankment may be necessary. But, for the sake of economy, the amount of cutting and filling should be equal. This must be achieved without sacrificing the gradient. The importance of work and the reasonable expenditure that can be incurred will be the main factor in deciding the gradient.

Gradient is the slope (rise or fall) of a road along its longitudinal section. It is expressed as a ratio of the difference in level between two points to their longitudinal distance. It is also expressed as a percentage of slope (i.e.) the rise or fall for 100 meters (100 ft.) distance. As the steepness of roads beyond a certain limit will make it difficult for vehicular traffic, a gradient practically found useful called ruling gradient is adopted in road construction. The ruling gradient adopted for roads in plains is 1 in 40, where as in hilly tracts it is 1 in 20, In road making, a level road would be ideal from the attractive and efficiency point of view. In practice it is often impracticable due to unevenness of ground. Further, roads with appreciable gradient will help the drainage.

SMOOTHNESS :

It is important for two reason. In the case of smooth roads the wear and tear on vehicles in greatly reduced. Secondly, it helps to drain off water since on smooth water proof surface water will not stick but will be shed to ditches at the sides. Otherwise the road will never be satisfactory and maintenance cost will be heavy.

HARDNESS :

The necessity for hardness is self evident, since its resistance to wear and tear and durability depends on the hardness of road itself.

DRYNESS :

It is the native soil that really supports the weight of the traffic, and that, while the soil is preserved dry, it will carry any weight without sinking. Hence the removal of excess water falling on the finished surface by providing chamber, intercepting water from the adjoining land which drains naturally across th3e road and removing sub soil water by providing drains is essential. To effect drainage on the surface, the roads are constructed with sufficient camber. Camber is the rise of the center of roads with reference to the edge.

The camber adopted for different kinds of roads are given in the table. The tables shows the camber for different kinds of roads.

Kind of roads	Camber
Earthen roads	1 in 20 to 1 in 24
Water bound macadam road	1 in 30 to 1 in 48
Tar or bitmin	1 in 36 to 1 in 48
Cement concrete	1 in 60 to 1 in 72

Camber should be suitably adopted so as to facilitate easy traffic, since steep camber causes slipping of high speed vehicles and erosion on berms. The usual shape of camber adopted for roads is a curved contour flat at the central half and slightly steeper at the sides.

LOCATION OF ROADS :

The location and setting out the road is the first problem in road making. While determining the location it is essential to be clear as to the purpose of the road and the points it has to serve. A rod in a farm should serve as may economical one. The topography of the land, the existing obstacles requiring road crossing and the nature of the soil underlying are all factors to be examined. Too many crossing of waterways will increase the cost. Heavy cutting and embankments should generally be avoided. The location of firm soil underneath will to reduce the cost of construction and maintenance. Existing lanes may also be considered.

After making a reconnaissance survey, the alignment of the road is roughly fixed. Then a detailed survey should be conducted to prepare a plan showing a strip of sufficient width of either side of the proposed alignment to judge the deviations etc. In this plan, the alignment, sites of culvert and crossings are marked. The levels in the centre line at regular intervals together with cross sections should be taken and the levels are noted on the plan. On studying the levels and taking into consideration the various factors given under the requirement of a farm road, the centre line of the road is suitably altered and marked on the plant to effect economy.

With the aid of the detailed plan, the alignment on ground is peg marked at regular intervals for taking again the longitudinal and cross section levels to design and prepare the estimate. The formation level of road must be at least 30 cm (1 ft.) above the level of land, so that the road may be fit for traffic even during rains and the road surface may not be eroded.

WIDTH OF ROADS:

If passing places or berms known as shoulders are provided 2.4 m to 3.0 m (8 ft. to 10 ft.) wide roads are sufficient for running through fields. However, ner the farmstead still wider roads are necessary, since vehicles are housed here and the traffic will be denser. For long vehicles and trailers, the width should be increased on curves to negotiate. The increase in width depends on the radius of curves; 1 m (3.5 ft.) for 30 m radius and 2.5 m (8.5 ft.) for 18 m. radius.

Fig. 5.1. Cross section of a farm road.

The berm is the space available from the road edge to the edge of the drain and it should be a minimum of 1.2m (4 ft.). Hence the width of roads including the drains wil come to a minimum of 7.2 m to 9.0 m (24 ft. to 30 ft.) for ordinary roads.

1.4 DESIGN OF ROAD:

The expected strength of the road is determined primarily by the nature or frequency of traffic expected, the stability of the sub soil and the designed life time of the road. The design is also influenced by the available facilities for maintenance. For low maintenance the strength should be more an vice versa.

Table 5.1. Dimensions of various structures of a farm road for different traffic in different soils

Type of soil	Heavy (traffic including a high proportion of heavy lorries pay load exceeding 3 tons or traffic the maximum load of which is 4 tons)		
	Sub base	Base	Surfacing
Soft soil (loam, soft clay; new unconsolidated embankments	15 cm (6″ gravel or kunker	22.5 cm (9″) hardoore or stone pitching or 15-20 cm (6 to 8 in 1:2:4 cement concrete	Bituminous surfacing
Medium soil (sand, stiff clay, lime stone, gravel or rock embankments or old consolidated embankments)	Hard 7.5 cm (3″) gravel or kunker	15 cm (6″) hard core or stone pitching or 12.5 cm (5″) 1:2:4 cement concrete	7.5 cm (3″) gravel or Bituminous surfacing
Hard soil, gravel, kunker rock.	7.5 cm (3″) gravel or kunker	15 cm (6″) hard core or stone pitching or 12.5 cm (5″) 1:2:4 cement concrete	7.5 cm (3″) gravel or Bituminous surfacing

Table 5.2 Dimensions of various structures of a farm road for different traffic in different soils.

Type of soil	Medium (traffic consisting of mainly of medium weight lorries pay load not exceeding 3 tons or traffic the maximum wheel load of which is 2 tons)		
	Sub base	Base	Surfacing
Soft soil (loam, soft clay; new unconsolidated embankments	15 cm (6″ gravel or kunker	15 to 2.5 cm (6 to 9″) hard core or stone pitching or 12.5 to 15 cm (5 to 6 in 1:2:4 cement concrete	Bituminous surfacing
Medium soil (sand, stiff clay, lime stone, gravel or rock embankments or old consolidated embankments)	7.5 to 15 cm (3 to 6″) gravel or kunker	15 cm (6″) hard core or stone pitching or 12.5 cm (5 in 1:2:4 cement concrete	7.5 cm (3″) gravel or Bituminous surfacing
Hard soil, gravel, kunker rock	2.5 cm (1″) sand to 7.5 cm (3″) gravel or kunker	7.5 cm (3″) gravel or kunker to 15 cm (6″) hard core or stone pitching or 12.5 cm (5″) 1:2:4 cement concrete	7.5 cm (3″) gravel or bituminous surfacing

Table 5.3. Dimensions of various structures of a farm road for different traffic in different soils

Type of soil	Light (traffic consisting of mainly of cars and light vans or traffic the maximum wheel load of which is ½ ton)		
	Sub base	Base	Surfacing
Soft soil (loam, soft clay; new unconsolidated embankments	15 cm (in) gravel or kunker	15 cm (6") hard core or stone pitching or 12.5 cm (5") 1:2:4 cement concrete	7.5 cm (3") gravel or Bituminous suffering
Medium soil (sand, stiff clay, lime stone, gravel or rock embankments or old consolidated embankments)	7.5 cm (3") gravel or kunker	15 cm (6") hard core or stone pitching or 12.5 cm (5") 1:2:4 cement concrete	7.5 cm (3") gravel or Bituminous surfacing
Hard soil, gravel, kunker rock	0 to 7.5 cm (0 to 3") sand.	0 to 7.5 cm (0 to 3") gravel or kunker	7.5 cm (3") gravel or bituminous surfacing.

The table 5.1, 5.2, 5.3 show the approximate sizes of the structure of a road worked out based on the subsoil and type of traffic.

1.5 PARTS OF ROAD STRUCTURES:

The road is a structure composed of the following layers :

1. Sub-soil or road bed
2. Sub grade
3. Foundation course
4. Base course and
5. Wearing course or surface

Where natural conditions are favourable the sub soil and sub grade may be combined into one so also the base and foundation courses.

SUB SOIL:

It is the ground underlying the road after the removal of top soil. This may be natural or prepared bed on which to lay the road. This should be sufficiently strong so as to offer resistance to the movement and distortion caused by the vehicles.

SUB GRADE :

Sub grade is the formation which supports the foundation and helps to keep the foundation at the designed level. This is a compacted layer of granular permeable material covering the road bed so as to prevent the entry of water into the road foundation.

FOUNDATION COURSE:

This is a layer laid over the sub grade to distribute the load coming over the road uniformly over a sufficient area of sub grade. This is also known as 'soling' or 'bottoming'. This should be rigid and should offer resistance to the movement or distortion due to moving loads to a maximum extent.

BASE COURSE:

This is the layer providing the main supporting strength of the road structure. This consists of a minimum depth of consolidated material which resist the distortion and helps to distribute the load to the foundation. This should afford good bond to the wearing course.

WEARING COURSE:

The main functions of the wearing course are to provide a smooth running surface and to protect the base from abrasion and from the effects of rain. Hard base cannot be rolled to true surface and this has not resistance to wear and tear. Therefore, they require some surfacing. The flexible roads require simplest form of surfacing whereas rigid roads require water proof surfacing either by i. water binding or ii. Applying tar or bitumen.

DRAINAGE:

Water stagnation on the surface of earthern roads often the road, leads to formation of ruts and pot holes and finally to erosion of the surface. The stagnation on paved road is also not desirable, since it hastens the erosion by traffic and makes it unpleasant. In the case of roads having the water table very near to the formation level, the increase in water table results in wetting the soil and thereby reducing the stability of the road surface. Hence for the removal of both surface and subsurface water and to intercept water from the adjoining lands, side ditches are essential on either side of the road or on one side as the topography permits. The drains should be located at a suitable distance not less than 1.2 m (4 ft.) from the edge of the road and to a depth of about 0.3m (1 ft.) below the formation. The verge should fall from the road to the ditch. The ditches should have sufficient cross sectional area to discharge the entire water collected in them.

CULVERTS:

At such places as field gateways and road junctions, culverts are to be provided for discharging the drain water through pipes. The length of pipes depends on the length of road and atmount of water to be discharged. The minimum diameter of the pipe should be 22.5 cm (9 inches). Culverts are also provided to enable passage over roads running across narrow streams, drains or small waterways.

1.6 CLASSIFICATION OF ROADS:

According to the materials used for construction, roads may be classified as

1.Earthen roads

2. Gravel roads

3. Water bond macadam roads

4. Tar or bitumin roads and

5. Cement concrete roads

Earthen roads are temporary roads up of earth available in the locality. They are suitable for low speed vehicles such as bullock drawn carts. Gravel roads are better than earthen roads and are stable for light traffic. Water bound macadam roads are still better, and suited for heavy traffic of low speed vehicles. Bitumen or tar roads are roads that are coated with bitumen or tar and they are suitable for rubber tyred vehicles of both slow and high speed. Cement concrete roads are stable and suited for all kinds of traffic. Each of the roads has its own qualities which influence the choice and design. The choice of road depends mainly on the traffic, finance and local conditions.

EARTH WORK FOR ROADS:

For all type of roads, earth work is a preliminary work to be carried out. The earth work may be cutting or forming embankment. Further, even where the ground level itself becomes the formation level, the top surface should be cleared of the bushes, vegetation, prickly pear etc. Hence the earth work is essential for the entire length of the road. The operation involved in earthwork are:

1. Clearing the road way
2. Excavation and
3. Embankment

1. Clearing the road way

The roadway is cleared of the vegetations, shrubs and interrupting trees etc., so that the natural, compact surface is obtained to act as a key to the materials laid over it. In removing the shrubs and trees care must be taken to seed that they are routed out completely without leaving any trace of the roots under ground.

2. Excavation

When the ground level is higher than the formation level extra earth is to be removed and transported to the low lying areas to forman embankments. This can be done by employing manual labour or using bullocks drawn scrappers or farm machineries such as bulldozers.

The cross section of the road as designed is peg marked on the ground. The centre line of the road, edges of the formations or cuttings are marked on ground with pegs. The slopes to be adopted will depend on the angle of repose of the soil. For shallow depths a vertical cut is made and then the sides are cut to the required slope. But in deep cuttings, the excavation is done step by step, the top vertical cut being wider and the width decreases towards the bottom. The sides are then trimmed by dressing the steps. The earth so excavated is transported to the places of embankments by carts, lorries or trailers. If it is not economical or the soil is unsuitable for forming embankments, they are used for forming spoil banks leaving a marging from the edge of cutting known as berm.

4. Embankment

Embankment are formed when the ground level is lower than the formation level. The soil or earth used for forming embankment should be clay, sandy loam or gravel. The top surface of the roady way si clared of vegetations etc., then the surface is scraped and the soil laid and spread evenly to the full width in layers of 15 cm (6 inches) thick. Each layer is rolled and consolidated if necessary by adding water when the soil is not wet. The embankment is brought up to the formation level giving due allowance for settlement. This sides are then neatly trimmed to the required slops.

When excavation of the roadway at places of cutting does not provide adequate material for embankments, the exra eath to make up the deficiency is obtained by excavating pits brown as 'borrow pits'. The borrow pits are selected in the vicinity of embankment to reduce the cost of transport. The borrow pits are of rectangular shaped. In between borrow pits a space of 0.9 m to 1.2 m (3 ft. to 4 ft.) is left to enable the workman to go over it.

LESSON 11. Cost Estimation, Repair and Maintenance of Roads

1. ROAD CONSTRUCTION

1.1 EARTHEN ROAD

The roadway after peg marking is first cleared of all the vegetations by removing the top, loose soil. The soil excavated nerby or brought from borrow pits in spread over uniformly to the required width in layers not exceeding 15 cm (6 inch) thick. All the clods and lumps should be crushed and spread. Red earth or clayey soil width sand mixed in a suitable proportion can be better adopted for earthen roads. The soil spread in layers is consolidated by rolling with a 6 ton roller, adding sufficient quantity of water. Excess water will make the surface slushy and the rolling difficult, since the wet soil will stick to the wheels and the consolidation will not be effective. A camber of 1 in 24 is given for earthen roads.

Soils which contain not more than 30 percent of sand and 70 percent of clay make a first class unmetalled road if properly maintained. Besides its cheapness, the road has got a better resilience than many of the roads. But the surface is easily disturbed by the downpour of rain and under iron tyred traffic. Hence the maintenance should be carried out often and the ruts and pot holes wherever formed should be attended to immediately by plugging and rolling them then and there.

1.2 GRAVEL ROAD:

Gravel road is an improved type of earthen road in which gravel is used instead of earth. The gravel used should be well graded and may vary from 5 cm to 2 cm. (2″ to ¾″) in size. Gravel together with soil is useful for road making as the soil will act as a binding material.

On a prepared sub grade a uniform layer of gravel for 7.5 cm to 10.0 cm (3 inch to 4 inch) thickness is spread over to the full width and it is consolidated using a 3 to 5 to roller. A moderate sprinkling of water will be of help to aid compaction. If the thickness is to be increased another layer may be spread over the first one and consolidated in the same manner. The camber given for gravel road is 1 in 28 to 1 in 32.

A gravel road has got the following advantages over an earthen road.

1. A good gravel road is economical and suits all weather
2. The construction is easy
3. The surface is smooth and it easy for driving on the road and
4. It is suited even for heavy traffic when the thickness is suitably designed.

1.3 WATER BOUND MACADAM ROAD

The water bound macadam road of metalled road is the most common type of road in India. The rod way after being bared of the vegetations etc., is shaped to the designed sections to the full width giving side slope or fall on either side. On this a layer of sand for the designed thickness to a maximum of 10 cm (4 inch) is spread evenly and consolidated well. Over the sand blanket soling stones are laid. The soiling stones may be broken brick bats, boulders of granite, laterite and kunker and they should be round shaped. The stores shold be laid on their broad base with undulations upward. They are hand packed to the full width of road taking care to stagger the joints. A binding material such as gravel is spread over the sling stones and the dry surface is rolled with a roller. The road may be even opened for traffic for a short period.

When the sub grade itself is hard, the provision of soling stones may not be essential. The metalling (wearing) can be proceeded with straight away on the sub grade formed with sand or gravel.

METALLING

The broken metal generally of 3.75 cm to 2.0 cm (1.5" to ¾") size is spread to the required thickness to the full width, with sufficient camber. The metal spread is hand packed so as to leave no hollow space. It is then rolled dry starting from the edges and proceeding towards the centre so that in each successive run, half the width of the previous rolling is again rolled. When the surface is compacted watering is done and it is again rolled to compaction. The rolling before and after addition of water shall be ordinarily 2 to 3 times.

Over the surface of the road, red earth or screened dust from the metal or gravel is spread to 1.25 cm (½ inch) thickness and it is rolled about 10 to 16 times or until a loaded country cart makes no impression on the surface. Gravel or red earth acts as a blining material and hence this is known as 'blinding'. During the rolling, the surface in watered and the slurry comes to the surface and is evenly spread with brooms. The final top dressing layer of sand to 6 cm (¼ inch) thicknessis spread evenly and finished with a final rolling. The road surface thus finished is kept moist for about a fortnight after opening to traffic.

When compared to the earth and gravel roads, the water bound macadam roads are smooth and some what more resilient. The traction oven them is good. They afford better hold for wheels so that slipping or skidding of vehicles is avoided. They are not slippery even when they are wet.

1.4. POT HOLE REPAIRS

Wherever holes or ruts appear they shall be atonce repaised by cutting out to the full depth of the metal in a rectangular form and filling it with fresh material. The filling is similar to the new road construction. Where the pot holes are too many, it is better to relay the whole surface.

1.5. RELAYING OF WEARING COAT

While commencing the relaying, the first thing to be done is picking the old metalled surface to 5 cm to 10 cm (2 inch to 4 inch) depth. The picking is done to make the surface even and to have a proper bedding for the new materials. The relaying of metal in also similar to the construction of new metalled roads.

1.6. BITUMIN ROAD

Bitumin or tar roads having their top surface finished with broken metal binded by bitumen or tar. An old surface with a sufficiently strong crust of water bound macadam serves as an excellent foundation for the bitumen or tar surfacing.

The material used for bitumen roads are hard broken stone and bitumen. The broken stones should be durable, the size varying from 19 mm to 13 mm (¾" to ½"). The granite broken stones are best suited for bitumen roads. Bitumen is the binding material used to coat the aggregates and to provide adhesive property that is necessary to prevent disintegration and protecting the water contact.

CONSTRUCTION

All bituminous types of surface belong to either of the two groups depending on whether the binder is tar or bitumen

The water bound macadam road to be treated with bitumen or tar should be smooth, dry and free from pot holes or unevenness. Immediately proceeding the surface treatment, it should be swept clen and kept free from dust. Bituminous material is then applied to the cleaning surface from sprayers at the rate of 1 kg per 1 sq.m. (20 lit/100 sq. ft.) area. The careened, dust free, dry, hard broken stone is mixed with bituminous material at the rate of 124 kg per 1 cu.m. of stones (31/2 1b/1 cuft. of stone) in the mixture and placed on the surface and spread evenly so the specified thickness. The surface is then hadn picked to avoid.

Prepare a detailed estimate for the construction of a view state Highway for 1km length. The formation width of road is 10m, average height of bank is 1 metre and side slope 2:1. The metalled width is 3.70m and three coats of metalling are to be provided as per c/s. The surface shall be finished with two coats of painting. Assume other data and suitable rates.

Details of measurements and calculations of quantities

1.	Surveying, dag belling etc.	1	1 km			1 km
2	Land acquisition permanent	1	1000 km	30m	-	3000 sqm
3	Land acquisition temporary	$\frac{\text{Quantity of earthwork in embankment}}{\text{Depth of borrowpit}}$ $=\frac{12000}{0.3}=4000\,sqm$ Quantity of earthwork same as item(4 Depth of borrow pit = 30 cm				
4	Earthwork in embankment	-(Bd+sd²) = (10x1+2x1²) x 1000 = 12000 cum				
5	Plantation of grasses on the side slope	1	$1000\times 2\sqrt{2^2+1}$			4500 sqm.
	Sloping bread	$d=\sqrt{2^2+1}$				
	METALLING					
6	Preparation of sub grade (dressing to camber)	1	1000	4.00	-	4000 sqm (30 cm wider)
7	Soling coat i) Stone boulders 15cm size ii) Laying & consolidation of boulders including bending with local sandy soil	1 Same as above	1000	4.0	0.15	600 cum. 600 cum.
8	Inter coat i) stone ballet 50mm gauge	1 Same	1000	3.70	0.12	444 cum.

	ii) Laying and consolidation of ballest including blinding with local sandy soil	as above				444 cum.
9	Top coat i) Stone bullet 40 mm gauge ii) Laying & consolidation of stone ballets including blanding with local sand soil	1 Same as above	1000	3.70	0.12	444 cum. 444 cum.
10	Bearn or patridressing	1	1 km	-	-	1 km
11	Binting or black top surfacing					
	Road tax no. 3 i) Stone grit 20mm gauge @ 1.35 cum % sqm.	1	$1000 \times 3.70 \times \frac{1.35}{100}$			50 cum
	ii) Paint or binding road Tan no.3 @ 220 kg % sqm	1	$1000 \times 3.70 \times \frac{220}{100}$			8140 kg
	iii) Laying	1	1000 x 3.70		-	3700 sqm.
12	Painting 2nd coat with asphalt					
	i) Stone grit 12mm gauge @ 0.75 cum % sqm.	1	$1000 \times 3.70 \times \frac{0.75}{100}$			27.75 29 cum.
	ii) Paint or binder asphalt @ 120 kg % sqm.	1	$1000 \times 3.70 \times \frac{120}{100}$			4440kg.
	iii) Laying	1	1000 x 3.7			3700 sqm.
13	Brick edging on both sides including bricks and labour	1	1km	-	-	1 km
14	Bridges (minor) and culvert	1	1km	-	-	1 km
15	Km half km and boundary 5 tones	1	1 km	-	-	1 km
16	Formation level pillars	1	1 km	-	-	1 km
17	Road direction posts caution signs etc.	1	1 km	-	-	1 km
18	Traffic diversion service road etc.	1	1 km	-	-	1 km
19	Arboriculture	1	1 km	-	-	1 km
	(Formation level pillar (item 16) are requd only for high banking)					

Item no.	Particulars of items of work	qty	Unit	Rate	Per	Sqm.
1	Surveying, dagbelling etc.	1	1km	300.00	km	300
2	Land acquisition permanent	3.0	hectare	3000.00	hec.	9000.00
3	Land acquisition temporary	4.00	hec.	700.00	hec.	2800.00
4	Earthwork in embankment	12000	cum	275.00	% cum	33000.00
5	Plantation of grasses on the side slopes	4500	sqm	1.00	sqm	4500.00
	METALLING					
6	Preparation of sub grade	4000	sqm	0.50	sqm	2000.00
7	Soling coat					
i)	Stone boulders 15 cm size	600	Cum	100.00	Cum	1080.00
ii)	Laying & consolidation of boulders including blinding with sandy soil	600	cum	18.00	cum	66600.00
8	Inter coat					
i)	Stone ballert 50mm gauge (supply)	444	cum	150.00	cum	8800.00
ii)	Laying & consolidation of balest including blinding with sandy soil	444	cm	20.00	cum	8800.00
9	Top coat					
i)	Stone ballet 40mm gauge (supply)	444	Cum	155.00	Cum	68820.00
ii)	Laying & consolidation of ballest including blinding with sandy soil	444	cum	20.00	cum	8880.00
10	Berm or patridressing (twice)	1	1km	1500.00	km	1500.00
11	Painting or black top surfacing Painting 1st coat with road tax no.3					
i)	Stone grit 20mm gauge (supply)	50.00	Cum	220.0	cum	11000.00

ii)	Paint or binder, road tan no. 3 (supply)	8.14	tonne	600.00	tonne	4884.00
iii)	Laying	3700	Sqm.	0.90	Sqm.	3330.00
12	Painting 2nd coat with asphalt					
i)	Stone grit 12mm gauge (supply)28.00	28.00	cum	220.00	cum	6160.00
ii)	Paint or binding asphalt (supply)	4.44	tonne	600.00	tonne	2664.00
iii)	Laying	3700	sqm	0.45	sqm	1665.0
13	Brick edging on both sides with brick & labour complete	1	km	3500.00	km	3500.00
	Total					310283.00
	Add 3% for contingencies					9308.50
	Add 2% for work changed establishment					6205.66
						325797.16
	Estimated cost comes to say Rs.3,25,79/- per km					

MODULE 5. Water Supply

LESSON 12. Sources of Water Supply

Introduction

For any living being water, air, food, shelter, etc, are primary needs. Of these needs, water is the most important need. Water is used for various purposes like

1. Drinking & Cooking.
2. Bathing and washing
3. Watering of lawns & garden.
4. Heating and air-conditioning systems.
5. Growing of crops.
6. Street washing
7. Fire fighting
8. Recreation in swimming pools, fountains & case.
9. Steam power & various industrial processes.

Quantity of water:

In order to design the water supply scheme in a town or city, it is necessary to find out the total of water required. Therefore the demand of the town has to be determined. Then a suitable water supply scheme is to be found out to meet net water demand. But it is difficult to determine the actual demand to the variable factors affecting it. Hence a thumb rule or an example formula is issued to assess the demand of the town.

The various types of demands of a city or town are

1. Domestic water demand
2. Commercial and industrial demand.
3. Fire-demand.
4. Demand for public Use.
5. Compensate losses.

i) Domestic water demand:

It includes the quantity of water required in the houses for drinking, bathing, cooking, washing, etc. This demand mainly depends upon the habits, serial status, climatic conditions and customs of the people. In India, on an average, the domestic consumption of water under normal conditions is @ 135 ht/day/capita. But in developed countries the figure may go upto 350 lit/day/captia. This 135 liters will cater the following needs.

Drinking	-	5 lit
Cooking	-	5 lit
Bathing	-	55 lit
Clothes washing	-	20 lit
Utensils washing	-	10 lit
House waster	-	10 lit
Flushing of latrines	-	30 lit
Total	-	135 lit/day/capita

ii) Commercial and Industrial Demand:

Various commercial buildings and commercial centres are office buildings, warehouses, stores, hotels, shopping centres, health centres, schools, temples, cinema houses, railway & bus stations. The water requirement of commercial and public places varies between 4.5 lit/day/capita to 450 lit/day/capita. An average of 20-25% of total water consumption may be considered for the design purpose.

iii) Fire Demand:

During outbreak of fine in a city, of water is required for throwing it over the fire extinguish it. For this purpose, or provision should be made in the water work to supply sufficient quantity of water. The quantity of water required for fine fighting is given the following empirical formula. National Board of Fire underwriters Formula is given by,

$$Q = 4640 \sqrt{p}\ (1\text{-}0,\ 01 \sqrt{p})$$

Where Q = Quantity of water required in lit

P = population of the town in thousands

This formula is used when population is upto 2l.

1. Free man formula :

   $Q = 1135.5\left[\frac{p}{10} + 10\right]$ Q = Quanty in lits/minutes

   P – population in thousands.

2. Krichling's formula

   $Q = 3182\sqrt{p}$ Q = Quanty in lits/minutes

   P – population in thousands

3. Buston's formula

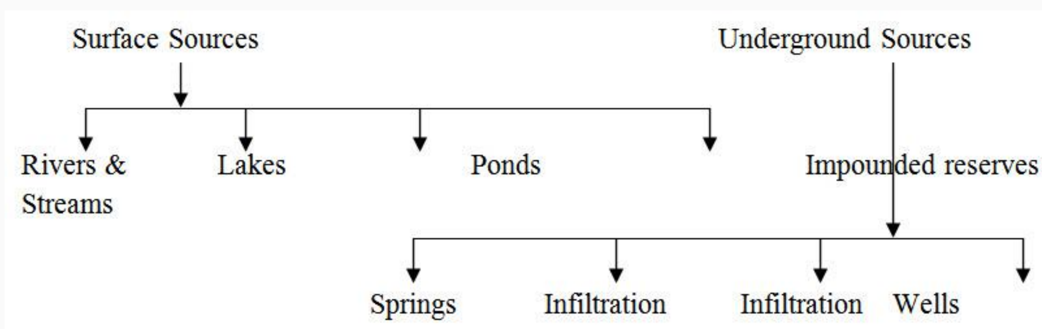
   $Q = 5663\sqrt{p}$ Q = Quanty in lits/minutes

   P = Population in thousands

iv) Demand for public Use:

This demand include, water required for washing & sprinkling on roads, cleaning of Watering of parks, garden, foundation etc.

Sources of water can be broadly classified as follows:



Surface Sources

The surface sources are rivers, lakes, ponds & impounded reservoirs. The water yield of the surface sources vary from season to season.

Streams

In mountainous region streams are formed by the runoff. Small streams are useful as a source of water, only for small villages. Large and perennial stream may be used as sources of water supplied by providing storage reservoirs across them. The streams feed their water to the lakes or rivers.

Rivers

They are the most important sources of water for public water supply schemes. Rivers may be perennial or non-perennial. Perennial rivers have water throughout the year. They are fed by rains during rainy season and by snow during summer season.

QUALITY OF WATER

Absolutely pure water is never found in nature. It is 2 molecules of hydrogen and 1 molecule of oxygen. Water may contain impurities, some of which are harmful for consumption while some of them are useful for public use. Hence, the impurities should be removed only upto certain extent so that, it may not be harmful to public health. So, a water which is not chemically pure but does not contain anything harmful to human health is called 'Wholesome water'.

The impurities of water can be listed broadly as follows :

1) Suspended impurities

These impurities are solid particles that are large enough to be removed by filtration or if they are heavier they will settle down. The suspended impurities are macroscopic in size and cause turbidity in water. Suspended impurities are algae, fungi, protozoa, bacteria, clay silt, etc.

2) Dissolved impurities

Some impurities in the form of solid, liquid & gas are dissolved in water when it moves over the rocks, soils etc. These may contain Organic compounds, inorganic salts and gases etc. The concentration of total dissolved solids is expressed in ppm & is obtained by weighing the residue after evaporating the filtered water sample. They may be Ca, Mg, Na of HCO_3, CO_3, SO_4, F, Cl_2 metals & gases.

3) Organic impurities

Again these organic impurities may be either suspended organic impurities or dissolved organic impurities. Mostly all the colloidal impurities are associated with organic matter containing bacteria. These are the chief source of epidemics. These organic impurities are either suspended or dissolved vegetable or animal matters.

EFFECTS OF VARIOUS IMPURITIES

	IMPURITIES		EFFECT
Suspended :	Bacterias	-	Cause disease
	Algae, Protozoa	-	Cause odour, turbidity & colour
	Clay, Silt	-	Cause turbidity
Dissolved :	Ca & Mg – Bicarbonate	-	Cause hardness, alkalinity & softening
	Carbonate	-	Cause hardness, alkalinity & softening
	Sulphate	-	Cause hardness

	Na – Fluroides	-	Cause mottle enamel of teeth
	Chloride Manganese	-	Imparts taste
			black or brown colour the water
	Iron oxide	-	taste, corrosiveness, hardness & red colour.
			Lead poisoning
	Metals – Lead	-	Poisoning
	- Arsenic	-	
	Gases - Oxygen	-	Corrode the metals
	Co_2 – Carbon-di-oxide	-	Cause acidity & Corrode metal
	H_2S - Hydrogen Sulphide		
		-	Cause rotten egg odour, Corrode metal, acidity
Organid Impurities:	Suspended – Vegetable	-	Cause objectionable colour, taste & acidity.
			Produce harmful disease germs.
	Animal (live)	-	Produce bacteria
	Dissolved – Vegetable	-	Cause pollution of water and produce disease germs.
	Animal (dead)		

LESSON 13. Water treatment suitable to rural community

The various methods which may be adopted for purifying the public water supplies are,

(i) Screening

(ii) Plain Sedimentation

(iii) Sedimentation aided with Coagulation

(iv) Filtration

(v) Disinfection

(vi) Aeration

(vii) Softening

(viii) Miscellaneous treatments such as fluoridation, recarbonation, liming, desalination etc.

Among the above processes screening, plain sedimentation and filtration are suitable to rural community

Screening : Screens are generally provided in front of the pumps or intake works

They remove the large sized particles like debris, branches, bushes, ice etc.

Coarse and fine screens may be provided. Coarse screens are parallel iron rods which are placed vertically or at an angle to the horizontal at 30º – 60º at 2-10 cm centre to centre. Fine screens are made of fine wires or perforated metal with openings less than 1 cm wide. The velocity through the screen should not be more than 0.8 to 1 m/sec.

Plain Sedimentation : Most of the suspended impurities present in water have a specific gravity more than that of water (1.0). These impurities will remain in suspension in flowing water (turbulence). If the water is made to stand still, the impurities will settle down under gravity. Hence, if the turbulence is retarded, i.e. if the water is made to stand still or stored, these impurities tend to settle down at the bottom of the tank. This is the principle behind sedimentation. The basin in which the flow of water is retarded is called settling tank or sedimentation tank or sedimentation basin or clarifier. The theoretical average time for which the water is detained in the tank is called the detention period.

Sedimentation tank :

They are made of RCC structure and may be either rectangular or circular

Rectangular tank	Circular tank
Long narrow rectangular tanks with horizontal flow	Circular tanks with radial or spiral flow

Also they may function intermittently or continuously.

Intermittent Function	Continuous Function
Simple settling basin keeps the raw water for certain periods at rest. After @ 24 hrs, the clear water is drained off & the tank is cleaned to remove the settled silt	Here only the flow velocity is decreased water is not brought to complete rest. Here water enters from one end and comes out from other end.

Design of Continuous Flow Type Sedimentation Tank

It is assumed that the sediment is uniformly distributed as the water enters the basin. If q is the discharge entering the basin, with a uniform flow velocity V, then V is given by

$$V = \frac{Q}{BH}$$

B – width of the basin &

H – Depth of water in the basin.

Let the sediment particle move with a horizontal velocity V and a downward vertical velocity Vs. The resultant path of the particle is given by the vector sum of its flow velocity V and settling velocity Vs.

Now By geometric considerations

$$\frac{V}{Vs} = \frac{L}{H} \quad \text{or} \quad Vs = \frac{V.H}{L} \qquad \text{But, } V = \frac{Q}{BH}$$

$$Vs = \frac{Q}{BH} \times \frac{H}{L} \qquad Vs = \frac{Q}{BL}$$

Hence, all the particles with a settling velocity Vs $\geq \frac{Q}{BL}$ will settle down

Hence $\frac{Q}{BL}$ i.e. the discharge per unit plan area is known as Overflow velocity and $\frac{Q}{BL} = \frac{overflowrate}{surfaceloading}$

Its value for plain sedimentation tank is 500 – 750 lit/hr./m² and for coagulation sedimentation tank is 1000 – 1250 lit/hr./m² of plan area.

Depth of water ranges between 1.8 m to 6 m. Usually it can be taken as 3.0 to 4.5m. Detention period is the average theoretical time for which the water is detained in the tank (or) is the average theoretical time required for the water to flow through the tank.

$$\text{Detention time} = \frac{\text{Volome of the tank}}{\text{Rate of flow}}$$

$$= \frac{BLH}{Q} \quad \text{- (Rectangular tank)}$$

$$= \frac{d^2(0.011d + 0.785H)}{Q} \quad \text{– Circular tank}$$

t = 4-8 hrs. for plain ST.

= 2-4 hrs. for coagulation ST.

- Width of the tank B ranges between 10 m & 12 m.

- Length of the tank is not allowed to exceed 4 times width.

- Maximum limit is L should not be more than 1 – 6 times width.

- Horizontal flow velocity V ranges between 0.15 – 0.9m/min. & it is normally = 0.3 m/min.

- Total amount of flow from the tank within 24 hrs is equal to the maximum daily demand of water.

Flowing through period: It is the actual average time taken by the water to pass through a settling tank. This will be the case when there is a short circuiting. i.e. passing of a substantial portion of water directly through the tank without being detained for the intended time. The ratio of flow through period to detention period is called the displacement efficiency.

$$\text{Displacement efficiency} = \frac{\text{Flow through period}}{\text{Detention period}}$$

It generally varies between 0.25 to 0.50

By sedimentation tank, 70% of suspended impurities is removed.

Problem: A circular sedimentation tank fitted with standard mechanical sludge removal equipment is to handle 3.5 million litres per day of raw water. If the detention period of the tank is 5 hours, and the depth of the tank is 3 m, what should be the diameter of the tank?

Quantity of raw water to be treated per day = 3.5×10^6 lit.

Quantity of water to be treated during detention period = Capacity of the tank

= 3.5×10^6 5/24

= 728×10^3 lit.

= 728 cu. m. -------- (1)

The capacity of a circular tank of depth H & dia d is given by =

= $d^2(0.011\, d + 0.785\, H)$

= $d^2(0.011\, d + 0.785 x3)$ – (2)

Equating (1) + (2), $d^2(0.011d + 0.785 \times 3) = 728$

RHS = 2465

By trial and error, d = 20, RHS = 1030

d = 15, RHS = 507

d = 17, RHS = 734.64

d = 16.8, RHS = 716.83

d = 16.9m, RHS = 725.71

Filtration

The water after the treatment of screening, sedimentation & coagulation sedimentation also may contain very fine suspended particles and bacteria in it. In order to remove the remaining impurities, the water is passed through the beds of fine granular material like sand etc. The process of passing the water through beds of granular materials is known as filtration. Filtration helps in removing colour, odour, turbidity & Pathogenic bacteria from water.

Filter materials :

Either fine sand or coarse sand is used as filter media. The layers of sand is supported on gravel and this layer permits the filtered water to move freely to the bottom.

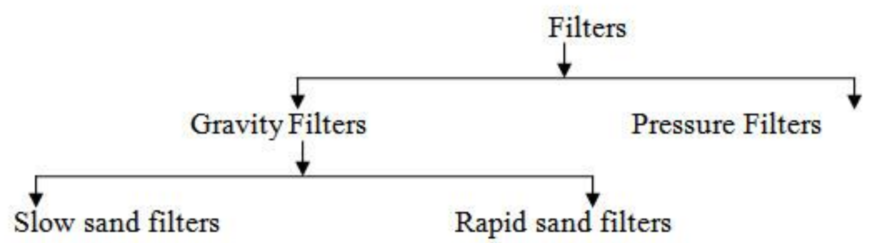
Sand :

The filter sand should be obtained from rocks like quartzite & should be (i) free from dirt & other impurities (ii) uniform in nature & size (iii) hard and resistant (iv) should not loose greater than 5% of its weight after being placed in HCl for 24 hours. Effective size i.e D_{10} is defined as the size of sieve in mm through which 10% of the sample of sand by weight will pass through. Uniformity coefficient D_{60}/D_{10} is defined as the ratio of the sieve size in mm through which 60% of the sample will pass to the effective size of sand.

Gravel :

The gravel which is used below the sand should be hard, durable, free from impurities, properly rounded and should have a density of @ 1600km/m^3.

Types of Filters:



Slow sand filters :

The various parts of this filter are discussed below.

(i) Enclosure tank :

It is an open water tight rectangular tank made of masonry or concrete. The bed slope is 1 in 100 towards central drain. Depth varies between 2.5 and 3.5 cm and the plan area is 100 - 2000 m^2.

(ii) Filter Media :

A sand layer of 90-110 cm depth is used. It is placed over a gravel support. The effective size of sand, D_{10} is 0.2 to 0.4 mm. Uniformity coefficient (D_{60}/D_{10}) varies from 1.8 to 2.5. Finer variety of sand should be kept at the top. If different grades of sand are used then coarse layer is kept near the bottom and the finest towards the top. The finer the sand used, the purer will be the obtained water.

(iii) Base Material:

It is gravel & it supports the sand. It depth varies between 30-75 cm.

(iv) Under drainage system:

The gravel support is laid on the top of an under drainage system. It contains central drain and lateral drain. Lateral drains are open jointed pipe drains or porous pipes and they are placed 3.5 cm apart.

(v) Inlet & outlet arrangements:

Inlet chamber is provided which admits water without disturbing the sand layers of the filter. A filtered water well acts as outlet. To maintain a constant discharge through the filter, an adjustable telescopic tube is generally used.

Operation:

The influent water enters the inlet chamber & gets distributed uniformly over the filter bed. The water passes through the filter media & gets purified. Then, it passes through the gravel and gets collected in laterals through open joints and discharges into filtered water well. The depth of water on the filter media should not be too large or too small. Depth of water is equal to depth of filter sand

Filter head: When water passes through the sand, gravel etc. there will be loss of head which is caused by the resistance offered by the sand grains to the flow of water. This loss of head is called filter head or filtering head. Filter head is the difference of water level in the filter tank and the filtered water well. Generally filter head is more than 0.7 to 1.2 m. But if filter head reaches a value nearer to this limit, the filter unit should be cleaned.

Cleaning:

It is done by scrapping & removing the 1.5 to 3 cm of top sand layer. The top surface is then cleaned & washed with good water. The quantity of water required is in the order of 0.2-0.6% of total water filtered. Cleaning can be done up to a depth of 40 cm. Then more sand is added. After each cleaning, the filter can be used & the effluents are used only after 24 to36 hours. Rate of filtration or rate of loading should be at the rate of 100-200 lit./ml. of plan area.

Efficiency:

The extent of bacteria removal is up to 98-99%

Problem: Design six slow sand filter beds from the following data :

Population to be served	-	50,000 persons
Per Capita demand	-	150 lit/head/day
Rate of filtration	-	180 lit/head/sq.m.
Length of each bed	-	2 x breadth

Assume maximum demand as 1.8 times the average daily demand.

Also, assume that one unit, out of six, will be kept as stand by.

Rapid Sand Filters:

These filters employ coarse sand, with effective size as 0.5 mm or so. Yield by this filter is 30 times that of slow sand filter. Water from coagulation sedimentation tank is used in these filters.

Construction:

Enclosure tank : Open water tight rectangular tank made of masonry or concrete is used. Depth is varied from 2.5 to 3.5m. Area of filter unit is 10 to 80 m^2. N = 1.22 ÖQ where Q - Plant capacity in Ml/d and N – Number of filters.

Filter Media : A sand layer of 60-90 cm depth is used over gravel support. Effective size D_{10} of sand is 0.35 to 0.55 m and uniformity coefficient D_{60}/D_{10} is 1.2-1.8.

Base Material : It supports the sand and also distributes the wash water. Depth is 60-90 cm and arranged in 4 to 6 layers. Critical function of the gravel layer is the distribution of wash water.

Under – drainage system : In slow sand filters, the under drainage system was provided only to receive and deliver the filtered water, whereas, in rapid gravity filters, the under drainage system serves two purposes : viz (i) to receive and collect the filtered water, and (ii) to allow the back washing for cleaning of filter. In addition to collecting the filtered water during its downward journey it should be capable of passing the wash water upward at a high rate of 300-900 lit/min/sq.m. of floor area. Since the rate of application of wash water is greater than the rate of filtration (6-16 time) (50-100 lit/min/m^2) the design of under drainage system should be done in such a way that there is even and uniform distribution of wash water. Forms of under drainage systems are

(i) Manifold & lateral system.

(ii) Wheeler bottom

(iii) Porous plate bottom etc.

Manifold & lateral system:The laterals may be either (i) Perforated Pipe type system and

(i) Perforated Pipe type system :The lateral drains are provided with holes at the bottom side. The holes are 6-13 cm in diameter & make an angle of 30^0 with vertical. Brass bushings are inserted in these holes to avoid the rusting of the surfaces of the holes. Laterals are supported over 40-50mm thick concrete blocky which are placed on the floor of the filter.

(ii) Pipe & Strainer type : Here, holes are not drilled into the laterals. But strainers are placed on the lateral drains. A strainer is a small brass pipe closed at its top by a perforated cap.

Factors to be considered during designing the sizes of pipes to be used in the above system are

- The total cross-sectional area of perforations should be @ 0.2% the total filter area.

- Cross-sectional area of each lateral = 2 - 4 times the total cross-sectional area of perforations for 13 mm to 6 mm diameter lateral.

- Cross-sectional area of the manifold central drain = 2 x cross-sectional area of laterals.

- Length of each lateral/Diameter of the lateral should not be more than 60.

- Maximum permissible velocity in manifold to provide required amount of wash water = 1.8 – 2.4 m/sec.

Other appurtenances:

(i) Wash water troughs : The dirty wash water which comes out of the filter after cleaning it, is collected in wash water troughs / gutters and carried to the main gutter. These gutters may be square, V-Shaped or semi-circular. They may be of cast iron, concrete, steel or wrought iron. The troughs are usually spaced at @ 1.5 – 2.0 m apart.

(ii) Air compressor : During back washing the filter, the sand grains are agitated either by water jet or by compressed air or by mechanical rates. When compressed air is used, air compressor unit having the required capacity, must be installed. The compressor should supply compressed air for about 4 minutes at a rate of about 600-800 lit/min/m^2.

(iii) Rate controller : In order to automatically obtain a uniform rate of filtration irrespective of the head loss through the filter, rate controllers are required to be fitted at the outlet end of each filter unit.

(iv) Head loss indicator:

It is a differential type of a mercury gauge, one end of which is connected to the water resting on the sand bed and the other end to the effluents coming from the filter.

Working and Cleaning Operation:

Filtering:

1. Valve (1) is opened – water enters the inlet clumber & the filter.
2. Valve (4) is opened after filtering, and the filtered water is taken out.

Back Washing : When sand becomes dirty, (indicated by excessive loss of head) the filter must be cleaned & washed. For this purpose, wash water is sent bach upward through the filter beds. This forced upward movement of wash water & compressed air, will agitate the sand particles & removes the suspended impurities from it. Valves (1) & (4) are closed. Valves (5) & (6) are opened. Wash water & compressed air are forced upward from the under drainage. Valve (5) is closed after supplying the required amount of air. The dirty water resulting from washing over flows into the wash water troughs. Valve (2) is opened & the dirty water is removed into the wash water gutter. Washing is done for 3-5 minutes. After the washing is completed, valves (2) & (3) will be closed and valves (1) & (3) are opened out. The filtered water is not collected & washed for a few minutes through valve (3) to the gutter.

Then (3) is closed & (4) is opened.

Design of Slow Sand Filters

1. Design six slow sand filter beds from the following data :

Population to be served = 50,000

Per capital demand = 150 lit/head/day

Rate of filtration = 180 lit/head/sq.m.

Length of each bed = Twice the breadth

Assume maximum demand as 1.8 times the average daily demand. Also assume that one unit, out of six will be kept as stand by.

2. Design slow sand filter for the following data.

Population = 1 lakh

Per capacity demand = 140 lit/day

Total Maximum demand = 1.5 times average

Indicate general arrangement of filter beds.

3. Design six slow sand filter beds from the following data & show the arrangements of bed in plan.

Pop. to be served = 75,000

Quality of water to be supplied = 200 lit./head/day

Fate of filteration = 300 lit/sq.m./day

Length of each bed is twice the breadth