

AGE 507: Farm Structures (3 Units)

Farmstead planning and layout. Integrated study of farm housing – family housing, livestock housing, farm products and food storage structures. Environmental control and structural requirements of crops and livestock. Design of structural members of wood, steel, plain and reinforced concrete and local materials. Design of farm structures, columns, beams nailed and local bolted connections of timbers.

1.0 FARM STEAD PLANNING

Planning is an important activity which determines the success of any endeavor. It is often said that “without plans, purposes are frustrated”.

Planning is the first and most important step in designing a farm stead. The cost of changing a plan on paper is very low when compared with an alteration to a completed building; also, an ill-conceived arrangement of buildings can diminish profits on a long term. At the planning stage, it beneficial to evaluate all necessary factors that must be considered and reasonable compromises made. For example, the distance between each building in a farm stead is important, convenience and efficiency might indicate very close proximity, while fire safety may dictate a minimum distance of 30m. Offensive odours might inform distance of over 100m apart from dwellings. Careful planning with adequate information will help to attain desirable compromises.

1.1 SITE SELECTION

A number of factors necessary for consideration for site selection for a farm stead are outlined below:

- (A) **Drainage:** - Adequate surface and sub-surface drainage will ensure that foundations of structures are dry and will prevent local flooding. Well drained soil is necessary for the operation of Septic tank and for the removal of feed lot runoff and other wastes.
- (B) **Waste Management:** - The ability to handle waste without problems is very important. This is particularly so if the farmstead will house a major livestock enterprise. The site must conform to all state and local environmental regulations; the topography must be satisfactory for the required storage and drainage of manure and other effluents; prevailing wind direction is required to prevent pollution or dust from mills etc.
- (C) **Water:** - Availability of good quality of water for the farm is very important, almost all activities on the farm require water and it must be available in adequate quantity.

- (D) **Utilities and Services:** - These include telephone, electrical services, school bus, product delivery and pick up, access drives etc. The soil should be well drained and rich enough to provide landscaping gardens, play areas etc.
- (E) **Orientation:** - Air drainage and maximum sunshine may require orientation on a gentle southerly slope. Prevailing winds must be considered and natural barriers used where possible.
- (F) **Expansion:** - Adequate provision for future expansion must be provided for. Growth in this farm stead enterprises should be anticipated and the layout should facilitate expansion of buildings and services. It is pertinent to also provide for expansion of all facilities such as machineries, utilities etc. It is wise to look for twice as much area as that required initially, because of the impact of increasing production volume in future

1.2 BUILDING ARRANGEMENT

The arrangement of facilities for maximum efficiency of operation should be a prime concern. Proper arrangement increases efficiency by reducing walking distance to a minimum and providing adequate drive ways and turn around. It is important to note that fire protection, safety and security and all influenced by the farmstead planning.

When a site has been selected, it is then needful to draw a map which will show major details. There should be contour lines, the direction of the north, direction of prevailing wind and general slopes, existing roads, natural wind barriers and water ways. The arrangement and rearrangement of buildings should then follow till a satisfactory layout is designed. An operation center should be located first, this will often be the farm house; the farm house should be sited such that it can be accessed from any direction in the farm stead, in general cases, it should be centrally located since the entire farm is administered from the farm house. The remaining buildings can then be arranged in relation to the operating center.

Building arrangement requires the consideration of some environmental factors such as slope, prevailing wind, sun etc. buildings should be located on relatively high ground with surface drainage directed away from foundations. Buildings should be arranged to take advantage of natural conditions; winds can blow in all direction but the prevailing direction is important, winds carry odours, dust, and noise, proper arrangement of buildings will use the wind to carry these away from the living center. Livestock yards and buildings should be located down wind (wind ward) from farm home and from neighbours. Buildings lined up at right angles to the wind rather than parallel are less subject to the spread of fire. Also, open front buildings, stockyards and solar heated facilities should be arranged so

that during cold season they receive the full benefit of sunlight. Tall buildings, such as tower Silos, should be located so they do not cast shadow on feed lots.

Labour efficiency is improved by reducing travel to a minimum; buildings which will require frequent movement of workers should be sited close. Arrange buildings in relation to drive and yard to allow easy maneuvering of large vehicles and equipment

1.3 PLANNING OF FARM BUILDINGS

Farm buildings represent a production or storage cost. Every enterprise requires a return on every investment made hence a return on feed and labour cost is expected. In view of this, a benefit from a building investment should also be anticipated. Some of the benefits derivable from a farm building include: -

- Provide facilities for efficient operations
- An environment providing conducive and sanitary conditions.
- Provide desirable condition suitable for production
- Provide comfortable surroundings for both livestock and workers.
- Provide safe conditions for both livestock and workers.

It should be noted that a number of design factors must be considered in planning a building to obtain the greatest number of benefits at a reasonable cost, some of these factors includes:

1. The functional requirement for the enterprise such as space, temperature, light, safety, sanitation, physical protection etc.
2. Efficiency of system, including centralized operation, bulk material handling etc.
3. Adequate structural design for the loads to which the building will be subjected to.
4. Suitability of materials with respect to characteristics like durability, cost, fire resistance, ease of cleaning etc.
5. Economy of construction, costs are reduced by choosing prefabricated assemblies, standard size materials and components etc.
6. Flexibility of design that will allow proposed enterprise to be altered or a new enterprise to be established with minimum expense and effort.

2.0 DESIGN OF FARM STRUCTURES

Farm structures are different from urban structures, mainly due to the nature of load they carry and the purpose for their use. These two factors and others are very important for consideration in any design of farm buildings.

2.10 LOAD CONSIDERATION FOR BUILDINGS

Every building must be designed with adequate strength characteristics, the load to which it will be subjected must be determined. It is pertinent for the engineer to understand the nature and significance of the various types of loads that act on farm buildings and then relate this information to all decisions on design, materials and construction methods.

2.11 CLASSIFICATION OF LOADS

Loads on buildings can be generally classified as dead loads, live loads, snow and wind load, combined loads.

A. Dead loads:

These include the weight of all the materials used in constructing the building, Such as concrete in footings and foundations, timber and other material used in the frame and roof. Dead loads are usually an integral part of the structure, permanent and stationary. It is estimated by making a bill of materials and then determining the force by using standard values of individual components such as concrete, steel, brick walls, aluminum, etc. Standard weights can be found in the book of standards e.g. ASABE, NIAE.

B. Live loads:

These types of loads include the weight of stored products, equipment, livestock and vehicles. These are difficult to estimate because of their intermittent nature and may cause stresses to be applied in an unpredictable manner. Live loads also include the forces of nature such as snow load, wind and earthquake, although they are generally treated separately. Refer to book of standards for values of different types of live loads.

C. Snow loads:

This load is applicable only in temperate regions of the world and like wind load must be estimated on the basis of meteorological records for the area. Probability of occurrence of snow of a given intensity

is used as a basis of design. Because of the probable nature of snow and wind, a factor of safety > 2.5 is usually used for building materials and connections.

D. **Wind loads:**

Wind forces may often prove to be the most critical load imposed on Agricultural buildings, especially in areas where high winds occur frequently. When the wind strikes buildings, it exerts a considerable force on both the wall and roof surfaces which must be withstood by the frame of the building. Adequate bracing and the uses of strong fasteners or anchors at critical joints is a necessary precaution against wind damage. It should be noted that many forces imposed by the wind are negative, or lifting forces and these must be resisted by solid foundations, and use of wind breaks.

E. **Pressures Exerted By Fluids**

A liquid exerts a force against any surface with which it is in contact. This force per unit area is known as pressure, in an open tank for example, pressure increases uniformly from the top of the liquid to the bottom. The pressure exerted at a given level will be equal in all directions and normal to all surfaces. The equation for calculating pressure exerted by a liquid is given as:

$$P = \rho h \text{ or } P = \ell h$$

i.e. Pressure = density of liquid X depth of liquid (kg/m^2).

3.0 **BUILDING FOUNDATION AND FLOORS**

A well designed and constructed foundation is essential for the structural stability of a building. The foundation must resist and distribute the forces acting on it so that any movement will be small and uniform. Well built footings and foundation keep buildings plumb, free of cracks and free of leaks. For the purpose of designing footing foundations, the following forces must be considered: -

- (1) The dead weight of the building, content of the building, which acts in a vertical direction.
- (2) Wind loads that impact lateral or lifting forces.
- (3) Horizontal forces from soil, water or stored products.
- (4) Uneven soil forces caused by non uniform and variable moisture levels.

3.1 FOUNDATION FOOTINGS

A footing is the enlarged base for a foundation. It increases the area between the foundation and the underlying soil, thus reducing the unit pressure to a safe level. By implication, the size of the footing depends on the weight of the building and the safe bearing capacity of the soil. The soil on which a footing is installed should be undisturbed, level and smooth. The bearing capacity of soils varies with types of soil and moisture content.

Regardless of the material used for a foundation, a continuous cast of concrete is desirable. The width of the footing depends on the soil bearing capacity and the load it will carry. After determining the width of the footing by dividing the load per unit of length by the soil bearing capacity, the thickness of the footing for a wall or pier can be found as shown in the figure below: -

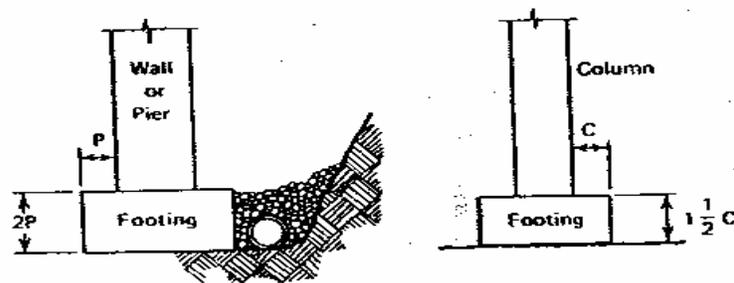


Figure 1: foundation footing proportion

It should be noted that all, foundations, piers and columns should be loaded as nearly as possible along their central axis to prevent any tipping action. If a building is constructed on sloping land, the footing may need to be stepped down with the grade. In this case, the horizontal length of each step should be at least double the height of the step and each section of footing should be tied to the adjacent wall with reinforcing rods. It should also be emphasized that each section of the footing should be bearing on ground that is carefully leveled.

3.2 TYPES OF FOUNDATION

Floating Slab foundation: - This type of foundation is conducive for areas subject to little or no ground frost, it consists of a concrete floor in which the outer 150mm is thickened to at least 300mm below grade, it is simple and economical to construct for small buildings.

Curtain wall foundation: This is commonly used for Agricultural buildings. The soil is filled against both sides of the foundation as shown below; the typical wall is built 8" – 10" thick without

reinforcing. A much thinner wall could easily support the vertical load but would need reinforcement near the top and bottom with No 4 bars.

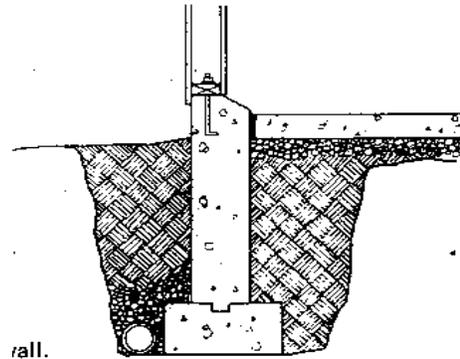


Figure 2: concrete curtain wall

Masonry blocks foundation: - Blocks of 9", 10", and 12" width may be used for a foundation, they are however not as strong nor as watertight as poured concrete foundations. While the labour and material for form work are saved, the cost of blocks and the labour of placing them often equal or even exceed the cost of a concrete wall. This is the most common type of foundation in Nigeria; it should be noted that, whenever a block foundation is chosen, the first course should be set in a full bed of mortar on a concrete footing. This is also known as strip foundation in civil engineering construction.

Treated wood foundation: -

This type of foundation is more common in America and Europe and is used mainly for barns and in some cases, living quarters. The wood to be used is treated with preservatives to prevent decay. During installation, crushed stone may be used as base on which the studs are installed above the footing plate.

Other types of foundation include pad foundation for factory buildings, pile foundation for water logged areas and raft foundation for soils with very poor bearing capacity.

4.0 DESIGN OF BEAMS AND COLUMNS

Beams and Columns are the structural members of a building frame. They must be carefully designed to carry the loads to which they will be subjected. A beam is subjected to loads that are perpendicular

to the long axis. Beams such as floor joists are installed horizontally, but they may be inclined as in case of a rafter. A column on the other side is subjected to loads that are parallel to the long axis. They are usually installed vertically, such as a post under a beam. It should be noted that structural members subjected to similar compressive forces are also found at various angles in trusses and other structures. Structural members are subjected to the loads of snow, wind, stored products or equipment and other component of the building. The forces that resist the loads are called REACTIONS. If the reaction just balance the loads, the structural members is said to be in static equilibrium.

In analyzing the stresses in objects, it is convenient to use free-body diagrams. This diagram shows all the forces acting on a body or member. If a body as a whole is in equilibrium, then it may be assumed that a cut at any desired point in the body will result in two members that are still in equilibrium.

Examples of free body diagrams are shown below:

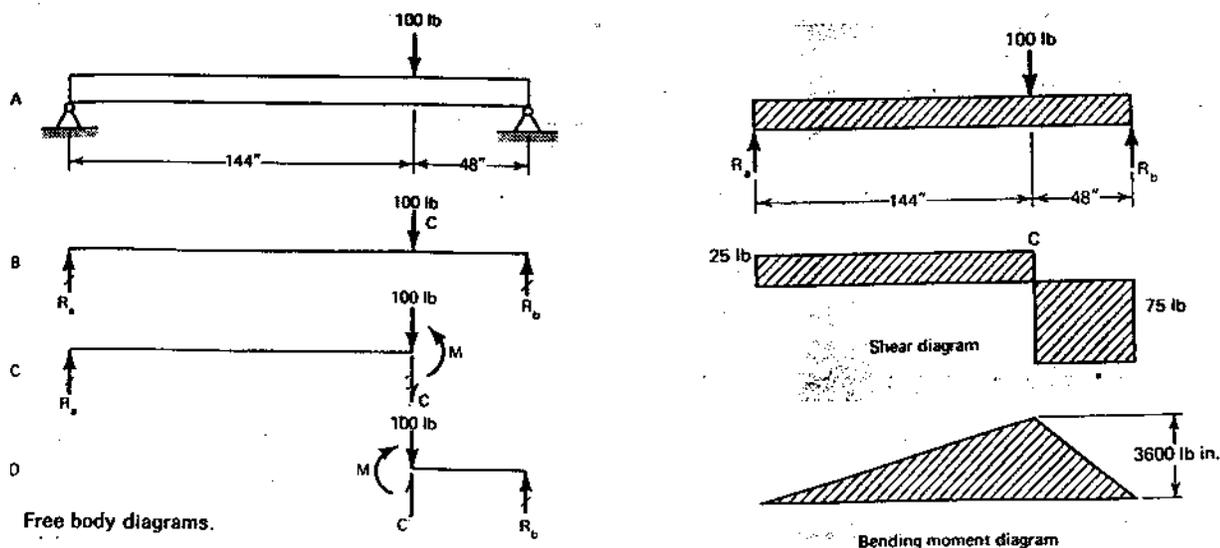


Figure 3: Important diagrams for Beam and Column design

4.1 MAXIMUM BENDING MOMENT

The external forces acting on a beam that tend to bend or break that beam produce a bending moment. Although the magnitude of the moment varies along the length of the beam, it is the maximum Bending Moment (BM) that must be considered in designing a beam to safely resist the bending forces to which it is subjected. The following steps are usually followed in finding the maximum bending moment: -

- Determine the Reactions at the supports.
- Draw a shear force diagram to locate the maximum bending moment
- Calculate the MBM

The shear force diagram consists of a base line which represents both the length of the beam and the axis of zero shear. The shear force at any point is determined by the algebraic sum of all of the forces to the left of that point. Starting at the left end, the reactions and load forces are drawn in proper direction and magnitude.

The point at which the shear line crosses the zero axis will indicate the point on the length of the beam at which the maximum bending moment occurs, the bending moment is then calculated for that location.

* **Example**

When designing the beams for Agricultural buildings, it is often necessary to make an assumption about the type of loading to which a beam will be subjected to. Some common assumptions are given below:

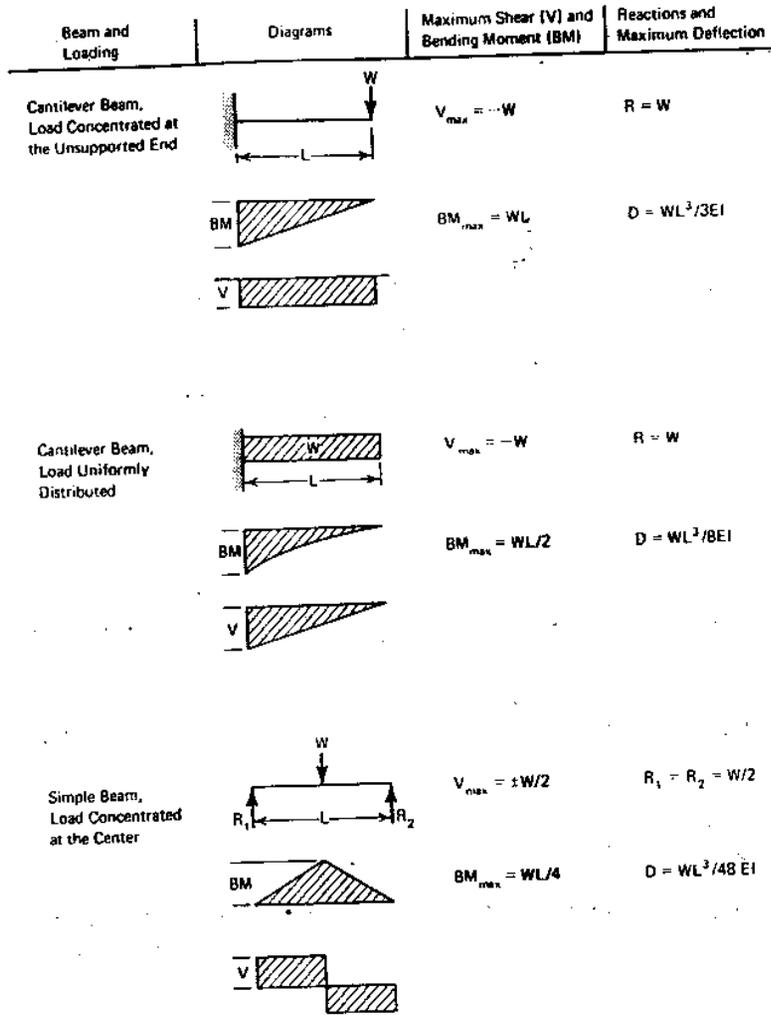


Figure 11-6. Beam equations.

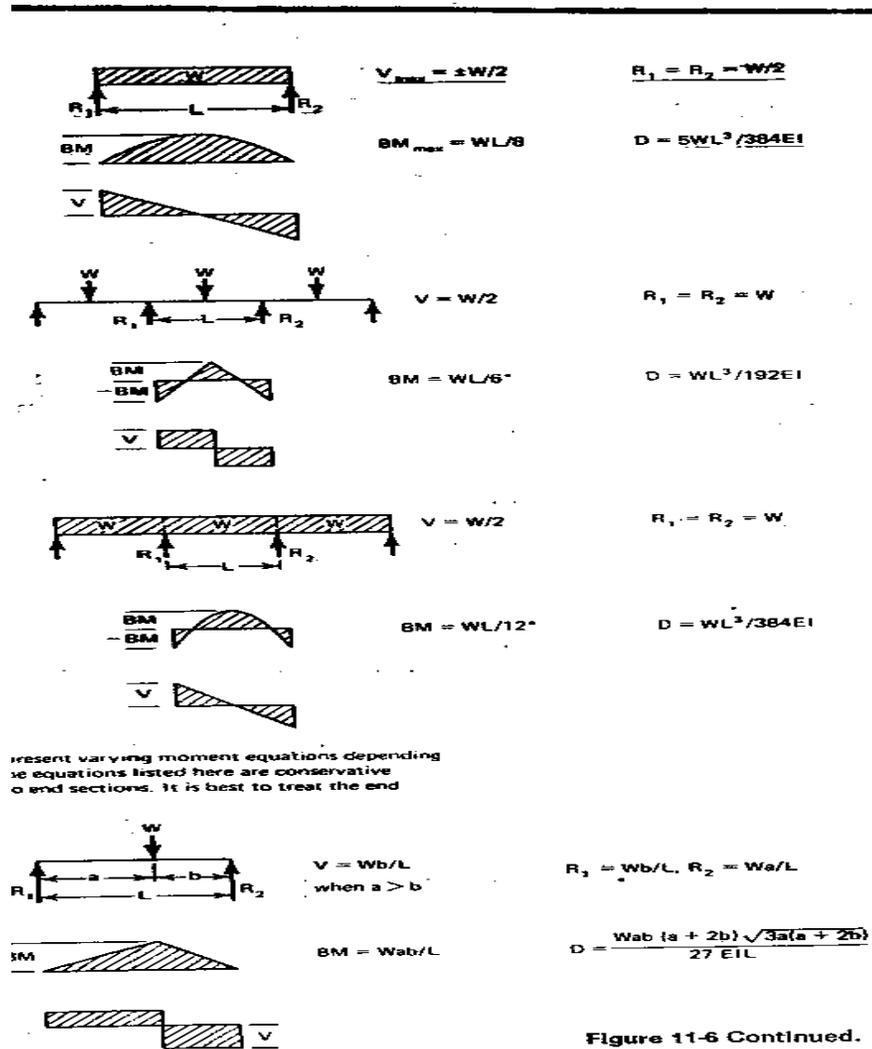


Figure 11-6 Continued.

Figure 4: Beam Equations

4.2 FIBRE STRESS

Beams and columns are subject to failure in one or more ways, depending on the material and the type of load they carry. The unit force within a body which tends to resist deformation is called stress. It may be tensile, compressive, shearing or flexural. The safe fibre stress of a material is a measure of the strength characteristics of the material that resist failure.

4.3 SECTION MODULUS

The ability of a beam to resist a bending moment depends not only on its safe fibre stress but also its Section Modulus (S) which is a cubic measurement based on shape, dimensions and position of installation. The Section Modulus and moment of inertia of some shape are given below:

4.4 DEFLECTION IN MEMBERS

Most Agricultural buildings are designed to be safe from failure due to expected loading; however, there are cases, such as farm homes, where maximum deflection (elastic bending) of members becomes an additional factor. Excessive deflection can cause uneven floors, cracks in wall and ceiling panels etc. The two factors that are normally used to determine deflection are Modulus of elasticity and moment of inertia.

4.5 COLUMNS

The formulas used for determining the safe loads on solid wood columns are based on pin-end (hinged) conditions. This may also be applied to square-end condition; one of the factors affecting the design of columns is the slenderness ratio (L/d), where L is the unsupported length of the column.

4.6 REINFORCED CONCRETE

Ordinary concrete has very little tensile strength; it is necessary to use steel reinforcing embedded in that portion of a beam, slab or column that will be subjected to a high tensile force. Reinforcing steel consists of either deformed (rough surface) bars or welded wire mesh. Specification for standard reinforcing steel can be found in structural design text books and hand books. It should be noted that reinforcing steel should be clean and free from both rust and oil.

Good quality concrete with the correct size aggregate is essential for constructing reinforced structures usually not more than about 21 liters of water per sack of cement are used with enough aggregate to produce a medium slump concrete. Maximum aggregate size may be limited by the spacing of the reinforcing bars.

Beams have their main reinforcing in one direction in order to resist the bending moment. One-way slabs are similar to shallow beams, although they will carry cross reinforcing to distribute the effects of temperature changes and non uniform loads. They will ordinarily be supported continuously along the sides that are perpendicular to the main reinforcing.

Two-way slabs, either square or rectangular in shape, have reinforcing designed to withstanding bending moments in both directions. They will ordinarily be supported on all four sides.

4.61 Concrete Floors:

Concrete Floors are commonly used in farm buildings; they are hard, strong and durable and make an effective barrier against rodents and water. The type of construction varies with use; if the building is for grain storage, there is need for protection from ground moisture only, while other floors need to be well insulated to prevent heat loss as in the case of a farrowing house. Other buildings such as machinery sheds need only a smooth, durable surface.

4.62 Concrete Columns

Reinforced concrete columns are not often required in Agricultural construction unless a high degree of fire resistance is needed. Piers of lengths up to four times the least diameter do not require reinforcing. Columns of lengths up to 11 times the least dimension can be reinforced with a bar in each corner embedded at least 38mm from each surface. The corner bars are held in place with No. 3 bars formed into squares and installed 305mm on centre.

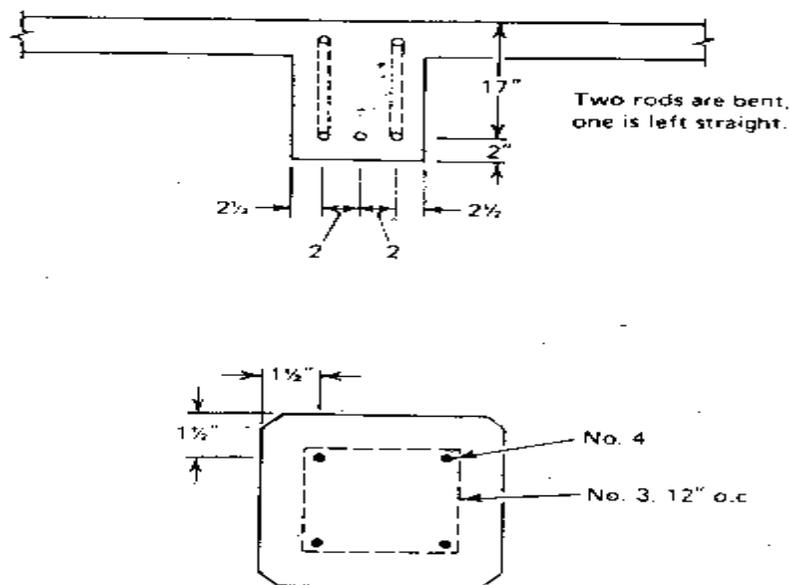


Figure 5: Reinforcement in Beams and Columns

4.63 Concrete Masonry

Walls constructed with stones, bricks, tiles, blocks, or concrete blocks bonded together with cement mortar are described as masonry construction. This type of construction is popular because it is durable, fire resistance, low in maintenance and attractive in appearance. It is not affected by high humidity, termites and most agricultural products and wastes. However because it is more porous and more subject to cracking than concrete, it is difficult to make it water tight. Out of the aforementioned masonry units, the concrete block is the most common for Agricultural use; these block come in number of different shapes and sizes.

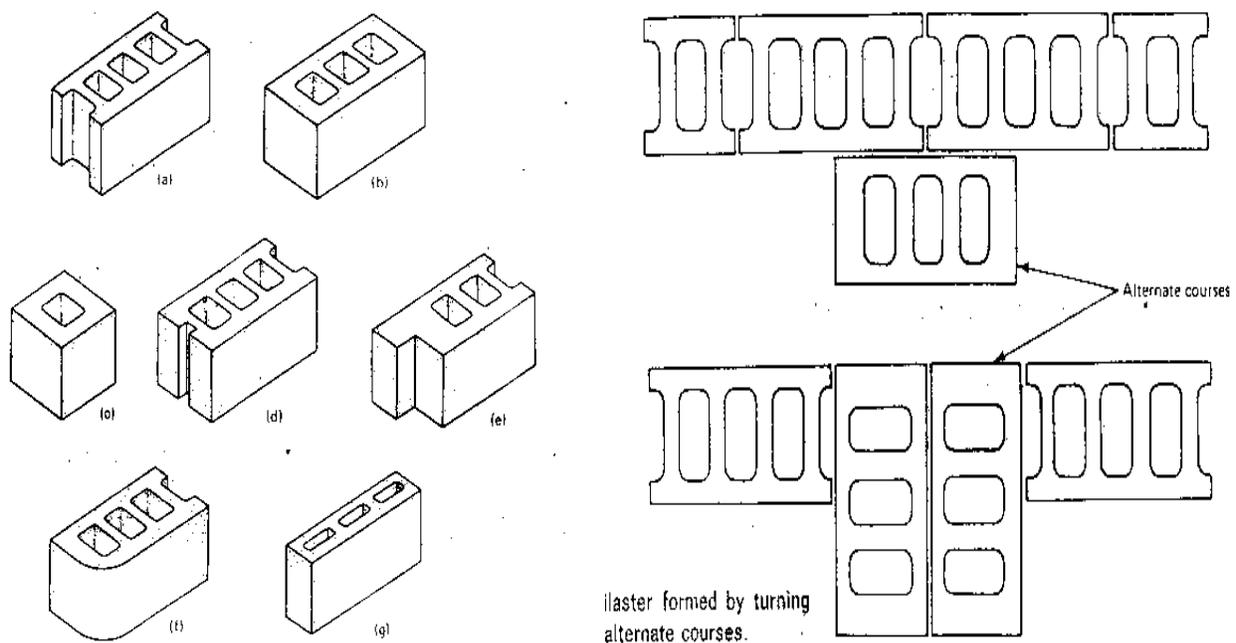


Figure 6: Shapes of concrete blocks and arrangements

4.6.3.1. Dimensioning BLOCK WALLS:

In designing a building to be constructed of concrete masonry units, it is desirable to make all dimensions divisible by 200 mm (8''). This will allow construction without the need to cut blocks, an economy of both materials and labour. Cut pieces of block also detract from the appearance of the wall. Block walls have limited lateral strength which determines the recommended unsupported length and height. 8'' (200mm) blocks may be used in walls up to 12' (3.6m) high if no more than 7' (2m) is below

grade in well-drained soil. Higher walls should be constructed with 12” (300mm) blocks although the top 12’ (3.6m) may be of 8” (200mm) units. No block wall should be more than 35’ (10m) high.

5.0 LINTELS AND SILLS.

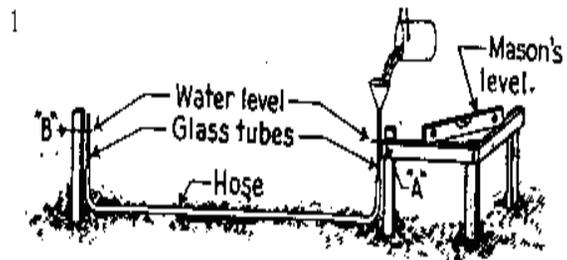
Lintels are reinforced concrete beams used over doors, windows and other openings. Concrete sills below windows prevent water from seeping into the cores of the blocks. Water running off the windows is directed away from the wall to prevent streaking. Sills may be precast or cast on the site.

6.0 ROOF ANCHORAGE:

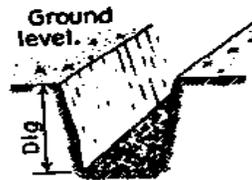
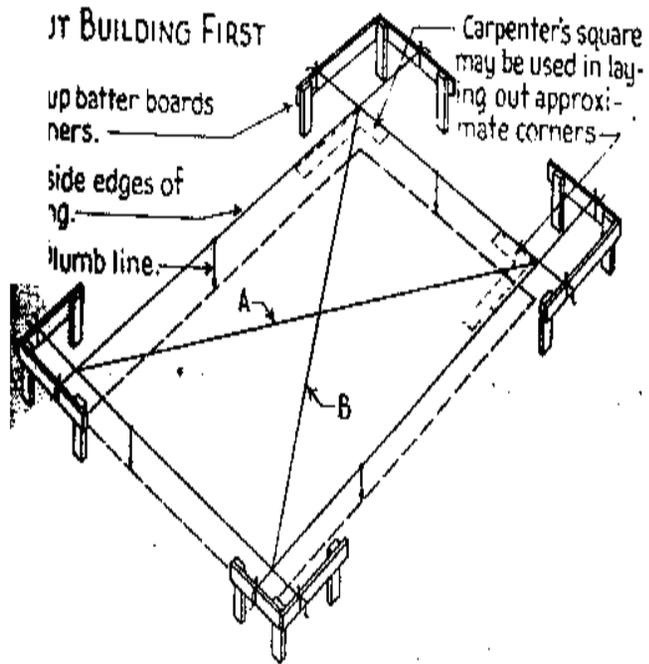
This is where the roof is anchored to the wall, this joint is subject to severe strain during high winds. A rigid connection between the roof and the wall furnishes lateral support to the walls and prevents high winds from lifting off the roof. It is common nowadays to have a head coach with 10mm steel rods inserted at regular intervals and used to hold down the rafters and trusses. In developed countries, it is common to use bolts to fasten the roof to the walls. The bolts are inserted into the core of every third block, extending down through two courses. The core area containing the bolts is filled with concrete to ensure good anchorage. After the concrete has hardened, the roof plate is placed and fastened securely to the wall. Rafters and trusses can then be attached to the plate with framing anchors.

7.0 LAYING BLOCK WALLS

Blocks should be well cured and dry before use. After delivery on the job, the blocks should be stored on a dry base, covered and not wetted prior to laying them in a wall. Cracking in the wall results from the shrinkage that occurs when damp blocks dry out. The wall should be started on a good concrete footing installed on firm, undisturbed, well-compacted soil. In laying masonry walls, mortar is placed between the ends of adjoining blocks and between the courses of adjoining blocks. The first course of blocks is laid in full mortar bedding placed on the footing. Succeeding courses are laid with face shell joints (mortar along the edges of the blocks only). All the joints should be tooled to compress the mortar, leaving it neat and compact.



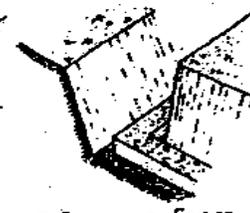
2



1. Dig trench down to firm soil below frost.
2. Make bottom of trench flat and level.

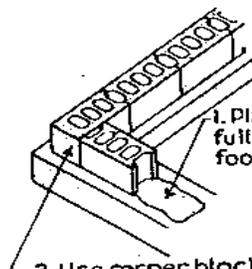


3. Forms to make footings proper size.
W = Twice masonry wall thickness.
4. Fill with 1-2 3/4 : 4 concrete.



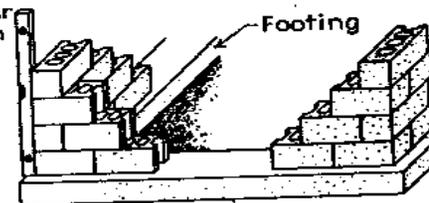
5. Remove form after concrete hardens.
6. Sweep off top of footing before laying concrete masonry.

4 START LAYING BLOCK AT CORNERS



2. Use corner block with one flat end at corners.
3. Mortar placed on face shells only for succeeding courses.

4. Make height of wall to fit concrete masonry unit. 1 block and 1 horizontal joint equal 8".



5. Build corners up using mason's level to keep plumb and straight.

5 BUILD WALL BETWEEN CORNERS

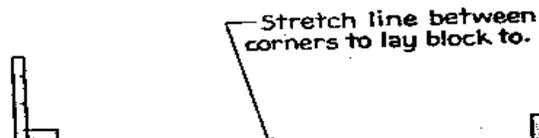


Figure 7: Steps in the building of masonry walls

8.0 ROOF FRAMING

Upon completion of block walls of buildings, the next stage is to design and construct the roof frames. Roof frames must be designed to withstand live loads expected for that locality and the dead load imposed by the framing, roof deck and roofing materials. It is pertinent to carefully fit all the joints in order to avoid reduced rigidity of the roof frame.

Roof frames differs from one another in terms of purpose of building, aesthetics and cost. Common examples of roof shapes are outlined below:

- ✚ **Flat roofs:** These are simple to construct with clear spans of 5m using roof joints. Greater spans are possible by using flat trusses. Being flat, they require a built – up asphalt or felt covering which may be expensive than others.
- ✚ **Shed roofs:** Shed roofs are inexpensive and like a flat roof, they can have a span of 5m without resorting to truss construction. A less expensive roof covering may be used.
- ✚ **Gabled roofs:** These are medium in cost, easy to construct, and the most common. Depending on the pitch, several different roof covering are satisfactory. A medium – pitch gable roof is one of the most wind resistant shapes available. Clear span of 7 – 8m are feasible with plain rafters while trusses may be used for greater widths.
- ✚ **Hip Roofs:** Hip roofs are most often chosen for their appearance. The framing and roofing are more complicated and expensive. Attic ventilation is more difficult than with a gable roof.
- ✚ **A-frame roofs:** This type of roof is just an architectural novelty, because of their shape, outside maintenance is largely restricted to roof covering while at the same time usable floor space is restricted by the sloping walls. This type of roof is not common in Nigeria.
- ✚ **Combination roofs:** Sometimes called “offset gable”, these roofs are often used on building that are open on one side. Depending on the requirements, the high side may be left open to provide maximum clearance or the low side may be left open for maximum weather protection.
- ✚ **Monitor or Semi monitor roofs:** Although more expensive to construct, these may be chosen if a considerable amount of natural light is required near the centre of the building. In widths up to 11m, ventilation is adversely affected.
- ✚ **Gambrel roofs:** Barns with gambrel roofs came into use to provide greater storage space than was easily obtainable with gable roofs. They are expensive and have uneven roof deterioration, and are subject to greater wind forces.
- ✚ **Arched roofs:** They vary in shape from semi circular to high gothic. The choice height and shape depends on the space required.

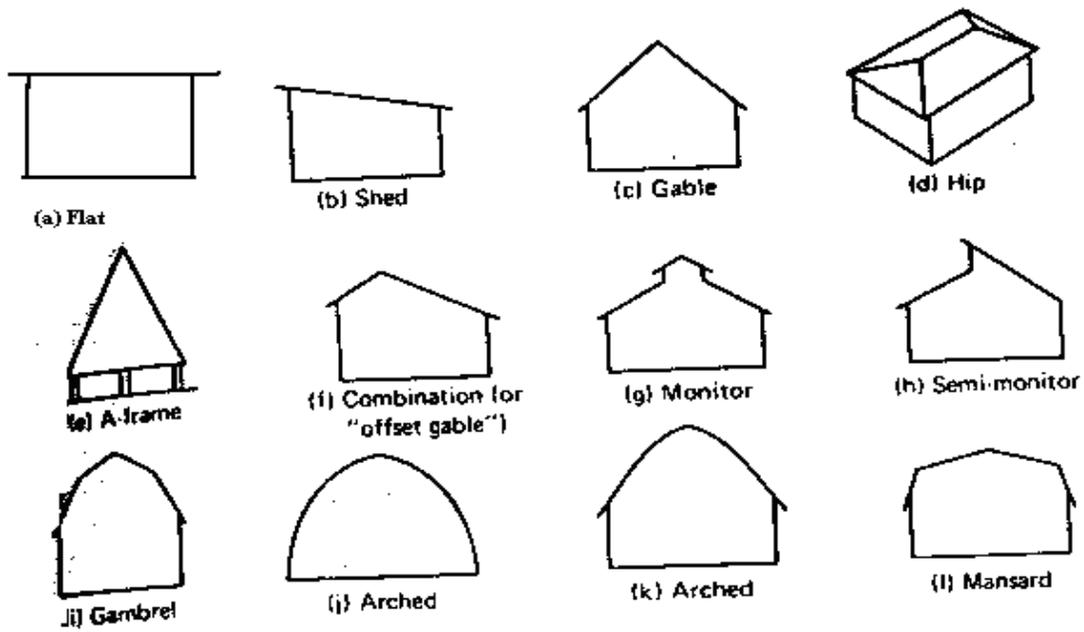


Figure 8a: Types of Roof Shapes

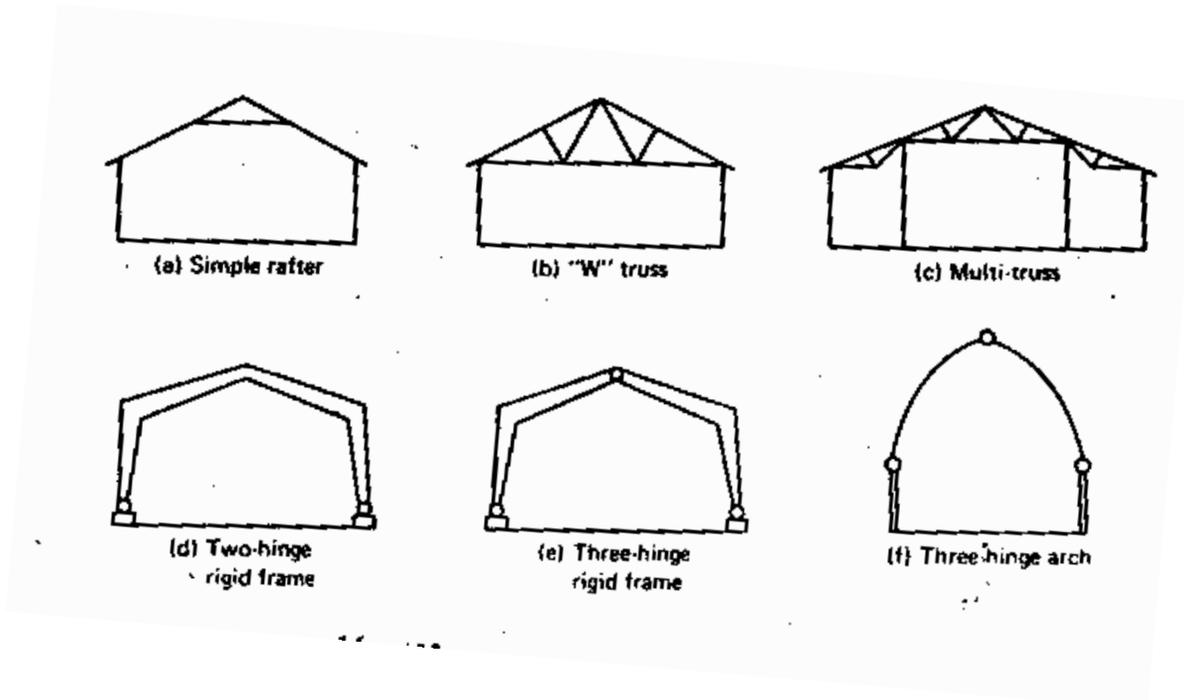


Figure 8b: Common Roof Frames

8.1 Roof Members:

The roof framing members is composed of rafters, trusses, king posts etc. after the framing is completed; a roof covering is placed on the members to protect the building from the influence of the weather. Examples of roof covering include: Corrugated iron sheets, long span aluminum sheets, asbestos roofing sheets, cement bonded roofing tiles, treated wood etc. These roof covering vary in cost and durability.

8.2 Rafters

This is a roof framing member and are usually spaced to modular dimensions. They are mostly cut from timber of adequate dimension but some times may be steel in the case of a factory. Rafters are very important in roof framing, they are influenced by length, intermediate supports, spacing and expected roof and ceiling loads.

8.3 Trusses

A truss is a structure composed of members assembled to form one or more connected triangles, thus producing a rigid frame capable of supporting a heavy load over a considerable span. The most commonly used wood trusses for agricultural construction are pitch designs with span ranging from 7 – 18m. The king post truss is simple and economical for relatively short spans. Other types of trusses are shown in the figure below.

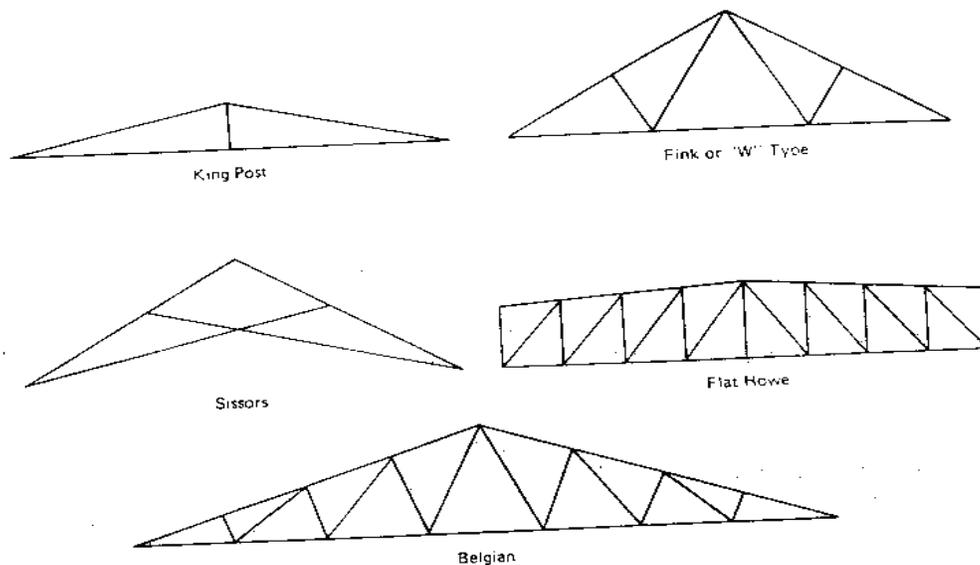


Figure 9: Types of Trusses

9.0 Agricultural Building Environment

The quality of the environment in Agricultural building is important as its influence on animal production, labour efficiency and the value of products in storage has become economically significant. The control of the moisture, temperature, light, dust and odours within buildings is essential for high production, maintenance of quality of stored produce, disease control, worker comfort, building and equipment longevity and safety from explosion. As a result of the above, it is pertinent that a knowledge of the basic factors involved in heat transfer and temperature control is necessary before a system can be designed and equipment chosen to control the environment in an Agricultural building

Ventilation which involves moving air through a building either by natural convection currents or with fans will provide adequate conditions at reasonable cost for many Agricultural enterprises. In other cases, supplemental heat, refrigeration or atmosphere modification are required to maintain an optimum environment. Some examples of environmental control scenarios are presented below: -

- (1) In a free-stall dairy barn, temperature is of little consideration, a simple system using natural convection removes sufficient moisture to prevent condensation.
- (2) In a cage poultry house, wall and ceiling insulation conserves enough animal heat to maintain a warm temperature while ventilation removes excess moisture and odours.
- (3) In a farrowing house, low animal density and the need for a warm room temperature make the use of supplemental heat necessary, ventilation controls moisture and odours.
- (4) Fruits for storage are harvested earlier in the season during relatively warm weather. To provide the required storage temperatures, refrigeration systems are essential. In addition, atmosphere modification is used to achieve maximum storage periods.

9.1 Physiology Consideration

Before designing a system for environmental control, it is important to understand the physiological characteristics for the enterprise to be housed. These include heat and moisture needed as well as that produced by the animals or product.

Poultry and other farm animals are homoeothermic, i.e. they maintain relatively constant body temperature usually within $1^{\circ} - 2^{\circ}\text{C}$ range. The hypothalamus gland is the body temperature regulator and stimulates mechanisms to counter either high or low ambient temperatures. For example, increased metabolic activities and greater conversion of feed to heat energy are used to counter low

ambient temperature. In contrast, increased respiration and blood circulation in skin counter high ambient temperature. Agricultural products on the other hand have individual temperature and humidity requirements when held in storage, like animals, they also give off heat energy. See table below:

Table 1: Environmental Requirement of stored Products

Product	Temperature °C	Humidity %	Remarks
Milk room	10-30	90 max	Prevent freezing and condensation
Eggs	13	60-80	Controlled atmosphere desirable First 7-10 days Fresh and Seed use As required by processing use
Apples	-2 - +1	85-90	
Potatoes	10-16	85-90	
	4	85-90	
	7-12	85-90	
Grain	-	<14	
Hey	-	<20	

Source: Whitaker (1979)

A large proportion of automatically controlled ventilating fans are installed in well insulated buildings where the control of temperature and moisture are primary concerns. The proper selection and installation of ventilation equipment will provide the air volume required for uniform air mixing, moisture control and temperature levels

9.2 Fans and Blowers

Fans used to move air through buildings are classified as axial flow fans or centrifugal blowers. With the axial flow (propeller) type, the air is moved parallel with the fan shaft by two or more radially mounted blades. Centrifugal blowers discharge air at right angles to the squirrel cage shaft and blade assembly. The choice of a fan or blower depends on the stable pressure condition under which it must operate.

9.3 Poultry Housing Requirement

Changes in poultry housing in recent years have been rapid and dramatic. The transition from the old farm chicken coop with a few hundred birds to a modern, environmentally controlled cage house for thousands of birds represent one of the greatest advancement ever made in housing for an agricultural

enterprise. Automated equipment for feeding, watering, egg pickup, ventilating and manure removal has promoted egg production to one of the most efficient of farm operations.

9.31 Site selection and Building Design

Buildings for all phases of poultry production tend to produce considerable odour, hence, the site should be well down wind from living quarters. A well drained site is most desirable.

This is particularly true for the litter system as they may be partially below grade, foundation drains are essential to protect against wet manure problems

Temperature is the most important environmental factors in poultry housing. Young chicks need very warm surroundings to survive. Older chickens, both layers and broilers exhibit their best feed conversion efficiencies at 21 – 24⁰C; however, production drops rapidly as temperature rise above 27⁰C and temperatures above 38⁰C may be lethal.

Humidity is important in two circumstances very low humidity tends to cause objectionably dusty conditions and high humidity combined with a very high temperature interferes with the birds natural cooling mechanism and contributes to high mortality.

9.32 Housing for Breeding Flock

Breeders are usually managed using the deep litter system in either window or environmentally controlled houses. Considerable supervision is required in feeding and disease control in order to produce high quality eggs for the hatcheries. Labour efficiency is improved with automatic feeders and waterers which are often located in lines along the outside wall or on either side of a center alley for convenient egg collection.

9.33 Housing for Laying Hens

Open houses utilizing cage system is protected with only a light reflective roof and roll-up curtains on the sides. In some cases, many lightly insulated, floor managed houses, often with open fronts, are being used. Although they offer some protection from weather extremes, they do not provide either environmental conditions or the labour saving facilities for a modern and efficient laying enterprise.

A number of different cages and housing have been developed over the years; there are variation in equipment and design. Cage system may be classified by the number of levels of cages. Most of the early systems were flat deck, i.e. just one level of cages. The introduction of 2 –tier, stair – step cages greatly improved the accessibility to the birds. With the advent of controlled environment

housing, cage designs continued to be improved till 3 – and 4 – tier cage systems became popular and allowed increased bird density within a house.

9.34 Housing for Pullets Rearing and Broiler Production

Raising broilers and replacement pullets involves brooding and growing the chicks to either market age or point of – lay stage. Housing, equipment and management procedures during the first few weeks are similar. Most chicks for layer replacement or broiler production are started on the floor with either portable or centrally heated brooders.

As the chicks grow they are allowed to spread out to use a greater amount of floor area. Compared to the first week, 2 – 3 times the floor area will be required by the time they reach 7 – 8 weeks of age. Since heating and ventilating the entire building is insufficient at the start, “end room” brooding is recommended. One end of the house is closed off and used for the first 4 – 5 weeks and then the growing birds are allowed to spread out over the whole floor area.

Experience has shown that pullets grown on the floor can be put into either floor – or cage managed laying houses. However pullets grown in cages do not adapt well to floor – managed operations.