Chapter 4

Poultry Housing and Equipment

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Abstract

Basic functions of housing are facilitation in managemental practices (bio-security, feeding, watering, stocking density, predator protection and weather protection) and provision of physical environment (temperature, humidity, ventilation and lighting) which are responsible for optimum production performance of poultry birds. For efficient production performance, housing systems like free range, semi intensive and intensive have been used for rearing poultry birds. However, intensive system is found most efficient one. Two main types of intensive housing system are open sided and environment controlled houses. These poultry houses are further classified into deep litter system, all slat system, slat and litter house, wire system, slat and wire system, deep-pit system and cage system. Cage system is mostly used for layer birds; various types of cages include reverse cages (Stair-step), flat deck cages and combi-cage system. Environment controlled poultry housing system is the most efficient type of housing, because in this system all the environmental factors are provided by artificial means and their range is precisely controlled according to requirements of poultry birds. Bird's requirements in terms of environment based upon its type, age, weight, feed and production status. Protection of birds from extremes of climate and precise control of environment is only possible in environment controlled housing system. For construction of such houses, selection of site and selection of appropriate equipments are also important. Site should be selected keeping in view availability of transportation, labor, electricity and water. Whereas, equipments selection according to performance, durability and economics.

Keywords: Poultry Housing, Housing systems, Open Sided Houses, Environment controlled Houses, House location, Construction, Insulation, Light, Gas, Water,

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Heating systems, Cooling systems, Ventilation system, Brooding, Rearing, Laying, Equipments, Economics.

4.1 Introduction

In poultry business capital investment is needed for housing poultry birds. It plays an important role for successful poultry farming. Two basic function of housing are facilitation in managemental practices and provision of physical environment (Austic and Nesheim 1990). Both factors are responsible for the optimum production performance of poultry birds.

4.1.1 Managemental Practices

Managemental practices associated with housing are:

4.1.1.1 Bio-Security

Bio-security practices like washing, cleaning, disinfection, fumigation, proper drainage, dead bird disposal pit and dipping pads for humans and transports are associated with designing and construction of poultry houses. A poorly constructed house may not facilitate intensive washing or fumigation or bio-security program.

4.1.1.2 Feeding

It includes provision of appropriate feeding space and application of manual as well as automatic feeding equipments to improve feed conversion ratio. Feeding cost is 60-70% of total cost of production in poultry farming and proper feeding requires appropriate housing. Installation of modern feeding equipments with housing modifications decreases feeding space associated with width of housing and number of feeding lines.

4.1.1.3 Watering

Selection of site having good quality water and implementation of manual as well as automatic drinking systems plays key role in successful poultry farming.

4.1.1.4 Stocking Density

Number of birds per square foot has a great impact on production performance and behavior of birds. Whereas, stocking density depends on type of birds and housing type. More number of birds can be kept per square foot in environmentally controlled poultry houses as compared to open sided poultry houses.

4.1.1.5 Predator Protection

A better constructed house and appropriate fencing helps to protect poultry bird from predators like dogs, cats, rat and disease spreading birds.

4.1.1.6 Weather Protection

Weather extremes adversely affect bird's performance which can be managed by appropriate housing (house which protect birds from rain, sunlight and cold wind).

4.1.2 Provision of Physical Environment

Physical environment related to poultry housing include house temperature, humidity, ventilation and lighting.

4.1.2.1 Temperature

Ambient temperature is an important factor which not only affects process of thermoregulation in birds but also affects feed consumption, weight gain and feed conversion ratio (Van Kampen 1981). Heat stress due to mismanagement of temperature results in increased respiratory rate, reduced feed consumption, low eggshell quality, reduced egg production and increased mortality (Reece *et al.* 1972; Scott and Balnave 1988). Comfortable temperature at which bird is not using any energy for the gain or loss of heat is called thermo neutral zone. For adult chicken thermo neutral zone is between 18°C to 23.9°C (Sturkie 1965), while for adult broiler it is 26°C to 27°C (Hel *et al*. 1991). Maintaining thermoneutral zone is conducive for optimum production performance. During 1st week temperature requirement is 95°F, which decreases by 5°F weekly until it reaches 75°F.

4.1.2.2 Humidity

Increased humidity level in poultry house aggravates adverse effect of temperature on birds performance. Humidity level in poultry house should range between 60 to 65%. Low humidity may cause dry, dusty litter leads toward respiratory problems. High humidity causes growth of fungus and protozoa (Haq and Akhtar 2004).

4.1.2.3 Ventilation

Function of ventilation is to control temperature in shed, removal of moisture, provision of oxygen, removal of toxic gases (practical limit of carbon-dioxide, methane, hydrogen sulfide and ammonia in shed is above 1.0, 5.0, 0.004 and 0.0025%). All physiological factors affected by temperature and humidity are indirectly linked with ventilation management (Bell and Weaver 2007).

4.1.2.4 Lighting

Lighting is associated with reproductive system of poultry birds. Lighting requirements vary with type and age of birds. For appropriate control of light in environment controlled poultry houses light trap/baffles are used.

4.2 Poultry Housing Systems

Poultry housing system are classified as free range, semi intensive and intensive housing systems. Intensive system is further divided into open sided, environment controlled, semi- environment controlled and prefabricated poultry houses.

4.2.1 Free Range System

In free range system poultry birds are kept in field areas so that they can consume herbaceous seeds, insects, crop waists and green forage etc. In this system protection from predators, infectious diseases and parasitic infestations is provided

to the birds. Poultry birds mostly kept in free range system are chicken, duck, turkey and ostrich. Shelter is usually provided by temporary roofing. Stocking density in range system is depending upon type of birds and field conditions. However, average stocking density of adult birds in this system is about 250birds per hectare (Jadhave and Siddiqui 2007).

4.2.2 Semi Intensive System

In this system, both range and housing facilities are provided to birds. Birds are kept in house for night or during hot period of day; they are provided access to open field. This system is mostly used for duck, turkey and ostrich rearing. Stocking density in this system is about 750 birds per hectare depending upon type of bird (Jadhave and Siddiqui 2007). Application of scientific managemental practices is not possible in this system which resulted into reduced performance of poultry birds in terms of weight gain or egg production. However, with increasing demands of organic poultry and pasture raised poultry birds this system is regaining its popularity. Due to increased price of pasture raised birds this system is now used for commercial poultry farming in several regions of world.

4.2.3 Intensive System

In this system birds are confined in house throughout their production period. Such types of housing system facilitate organization and concentration of flock into a manageable unit. Practices regarding provision of temperature, humidity, ventilation and lighting can easily be performed in intensive housing system. However, managemental practices are dependent upon housing type in this system. There are about three types of houses constructed under intensive housing system i.e. conventional houses, semi-environment controlled houses and environment controlled houses. Stocking density in such type of houses is range from 10000 to 25000 birds per hectare (Jadhave and Siddiqui 2007). Birds kept under this system perform better than those kept under range or semi- intensive housing system. Intensive housing system is widely used all over the world for commercial poultry farming due to its unique advantages like less land required, easy management, economical production, can be installed near market, sick birds easily detected and treated, maximum protection against rodents and climatic fluctuations.

Intensive housing system can be subdivided into various systems as given below.

a. Deep litter system
b. All slat system
c. Slat and litter house
d. Wire system
e. Slat and wire system
f. Deep-pit system
g. Cage or battery system

4.2.3.1 Deep litter system

In this system of housing birds are kept on floor. Both in the open sided or environment controlled houses, floor is covered with litter material such as rice

husk, wood shaving and sawdust. Depth of litter may vary from 4-5 inches in case of deep litter system. For chicks, the depth is kept about 2 inches which is further increases according to age and type of birds. Litter material gets decomposed after the mixing of dropping and bacterial action, at this stage this is also called built-up litter. Such litter carries some use full growth factors. With excessive mixing of dropping this built-up–litter is further converted into fertile manure. Manure is removed from house after disposal of flock which is 1.5 month in case of broilers, 6 months in case of grower and about one year in case of layer or breeder. However, this duration depends upon housing type and litter condition. In case of excessive moisture and disease outbreak due to dampness of litter, it can be partially or completely replacing at any time.

4.2.3.2 All Slat System

In this system of housing birds are kept on floor without provision of litter material. Slated floor is designed to accumulate droppings in pit under the floor. This system required less floor space as compare to deep litter system. Hen requires 1.0 foot^2 floor space in all- slat system as compared to deep litter system which is 1.75 feet^2/bird.

4.2.3.3 Slat-and-Litter House

In such type of houses both the litter and slat system are applied together. These houses are developed mostly for layer and meat type breeder birds. Birds kept in slat and litter house produce more eggs, required less labor and showed more fertility than those kept in all slat houses. Whereas, floor space requirements per birds are less than deep litter house but with higher initial investment than deep litter house.

4.2.3.4 Wire System

In such type of poultry housing systems, sloping floor is built with wire fabric. Both A shape or V shape floor are developed for directing eggs towards side walls or in the center of poultry house. Floor slope is kept about 1.5 inches per running 12 inches. Egg nests are provided to birds, whereas sloppy floor facilitate collection of eggs. Mesh size is usually kept 1 inch by 2 inches. However, smaller mesh size reduces incidence of sore feet in birds.

4.2.3.5 Slat and Wire System

In such type of housing system both slat and wire system are combined, just like combining deep litter and slat system. Ratio of slat and wire floor will be kept 60% and 40%, respectively. Slat is usually kept 1 to 2 inches wide and 1 inch apart. Whereas, welded wire mesh size is kept 1 inch by 2 inches. Slat and wire floor are constructed in sections to facilitate cleaning and removal of droppings. Slat is kept about 30 inches above floor.

4.2.3.6 Deep-Pit System (High-Rise Houses)

Manure handling in poultry houses is an important aspect to be considered while designing poultry housing systems. On an average a layer bird produces about 41 to 45 kilos of fresh droppings during 52 weeks of age while consuming about 42 kg of

feed. Fresh dropping contains about 75 to 80 % moisture. To overcome problems of manure handling, deep-pit housing system is a better option, because it provides drying and protected accumulation of dropping for a long period.

In this system, double story sheds are constructed. In upper portion, birds are kept in cage or on slate floor whereas; lower portion is kept for accumulation of manure. Ventilation system is installed in lower portion for ventilation as well as drying manure in case of environment controlled houses.

4.2.3.7 Cage System or Battery System

Cage system is advance shape of wire net floor system. In this system cages are developed with straight or sloppy floors and these cages are fixed on each another. Sloppy floor is developed for layer birds, whereas, smooth floor is kept for broiler birds. Cages are also equipped with automatic feeding and drinking system. For layer birds, mechanical egg collection system is also installed with cages. In case of manual cage system, manual feeders, drinkers, and manure collection trays are installed with cages instead of automatic manure removal belts. Floor space requirements are three time less in cage housing system as compares to deep litter system. In automatic cage system in environment controlled house the space provided per layer is 0.60 ft^2.

4.2.3.8 Types of Cage System

a. Reverse Cages (Stair-Step)

These cages also called as California cages, because these are first developed in California. In this system, manual feeders and drinkers are attached outside cage and cages are arranged step-wise in two or three tiers on a stand. In this system about two times more birds are kept in a house as compare to deep litter housing system. Proppings directly fall on ground and manually removed from shed.

b. Flat Deck Cages

Flat deck cages are of two types one is called single tier flat deck, this type is usually used for chicks up to 8 weeks of age. Sometimes such cages are also equipped with automatic heating system along with 3/4 of cage roof and side walls in each block covered with metal sheet to provide brooding area. Trough feeders and drinkers are attached in each block. Second type of flat deck cages is multi-tier cage system. In this system, each compartment of cage is equipped with manure collection system and cages are installed on the top of each other. However, in both single tier and multi-tier flat deck cages birds are kept for eight week of age, this system is also used for rearing of quails after little adjustment of feeding, drinking systems and changing mesh size of cage netting.

c. Combi Cage System

In this type of cage housing system birds can be raised from day one to the end of their production cycle. Such systems are available for broiler and layer birds. In this type of cages adjustable feeding and drinking system are installed with cages. Additional wire net frames for side walls and floor are provided. The farmer can manage flock in same cage during different stages, instead of developing, brooding,

growing and laying houses separately. Such type of cages could be single or multi tiers depending upon their degree of automation and housing types. For example, in an environment control house, a cage system equipped with automatic feeding, drinking, manure handling and egg collection system could be of six to eight tier. However, special care is required for designing of ventilation system of such house.

4.2.3.9 Advantages of Cage Housing System

Advantages of cage housing are more birds in less space, in combi cage system brooding, growing and laying can be done in same house, reduces labour cost, facilitates managemental practices, easy medication and vaccination, prevents egg eating, reduces egg contamination, reduces chances of egg breakage, reduces chances of diseases related to litter contamination like coccidiosis and worm infestation and improves feed efficiency.

4.3 Open Sided and Environmentally Controlled Housing

4.3.1 Open Sided Poultry House

Open sided poultry house based on natural ventilation and lighting. Light supplementation during night is supplied through artificial light sources. Open sided house is not efficient to achieve optimum genetic potential of birds. However, its performance can be enhanced if it is constructed under following rules.

4.3.1.1 Selection of Site

Open sided poultry house should be constructed in areas where weather conditions are not too hot neither too cold, because such type of house cannot cope with extreme of climatic conditions.

4.3.1.2 Direction of House

Direction of open sided poultry house is kept East to West in hot areas and North to South in case of cold areas. This helps to avoid penetration of heat in shed in hot areas. Whereas, sunlight in cold areas should be used to warm up the shed.

4.3.1.3 Width of House

Width of open sided poultry house should be 30 to 35 feet. Exceeding width may result into poor ventilation conditions in poultry house.

4.3.1.4 Height of House

In cold areas height of poultry house should be 8 feet. Whereas, in hot area height of ceiling from the floor should be 12 feet.

4.3.1.5 Length of House

Length of open sided poultry house may range from 100 to 200 feet. It is also depending upon the availability of land and type of equipments to be used. In case

of installing automatic chain feeding system in open sided poultry houses farmer should consult with equipment manufacturer regarding house length.

4.3.1.6 Roof Shape and Insulation

Open sided poultry house roof should be kept sloppy with about one feet extension from external walls for proper drainage of rain water. Furthermore, roof of house should be properly insulated both for cold and hot climatic conditions, because in cold weather insulation helps to maintain internal house temperature and in hot weather it protects the penetration of heat in the shed.

4.3.1.7 Foundation

Foundation should be strong enough, so that it can support structure adequately. While constructing foundations for shed, type of soil and further construction plans should be kept in mind.

4.3.1.8 Floor

Type of floor depends upon type of soil; in case of saline soil concrete floor is recommended. Whereas, in sandy soil birds can be raised without concrete floor. However, for proper disease control and bio-security implementation concrete floor is the best choice.

4.3.1.9 Door

Door of open sided house could be installed on either end of house. Door should be made of metal frame with wire mesh so that they can facilitate ventilation.

4.3.1.10 Side Walls

In open sided house about ¾ of side walls are kept open. Requirements for opening of side walls depend upon type of birds, age of bird and climatic conditions. For appropriate provision of open area side walls should be equipped with some durable curtains. These curtains could be equipped with wench and pulley system, so that size of open area could be adjusted according to requirements.

Open sided houses work well only if outside environmental conditions remain favorable. Whereas, in case of adverse climate, such type of houses fails to protect birds. Especially in case of ceasing of natural air flow resulted into increased house temperature, suffocation and increased ammonia level in the shed, which ultimately led towards the onset of stress in birds. Similarly, in hot weather conditions direct flow of hot air over birds causes discomfort or even mortality in birds kept under open sided poultry house. To avoid such problems semi environment controlled house is supposed to be best option instead of conventional open sided houses.

4.3.2 Semi Environment Controlled House

Semi environment controlled house based upon the installation of lighting system, fans, pads, foggers and mechanical curtains. This house is designed to get maximum advantage of natural environmental conditions to save electricity during mild weather conditions. However, in hot climate such house can be converted into environment controlled house from open sided house by closing the open sides with

well insulated light proof curtains. After conversion, artificial lighting and ventilation systems start working to provide desired light and ventilation to birds. Building construction of semi environment controlled house is kept similar to open sided house regarding length, width, height, opening of sides. However, doors in such house are installed in side walls whereas fan and pads at front and back sides of house.

4.3.3 Environment Controlled Houses

Environment controlled houses are designed to provide physical environment through artificial resources in order to provide of precise environmental conditions in terms of temperature, humidity, ventilation and lighting, which are conducive for optimum production performance. Another reason for developing environment controlled houses is to organize large number of birds in a minimum space, so that managemental practices can be performed easily and efficiently. Environment controlled houses are constructed without windows; there ventilation system is based on exhaust fans, air inlets and cooling pads and environment controllers. Temperature in such houses is maintained by electronically controlled brooders. Lighting in such houses is provided by artificial light sources like, incandescent, fluorescent, compact fluorescent or light emitting diode. Intensity and duration of light hours is controlled by lux meter, electronic timers and computerized light management systems. Various types of rearing systems are practices in environment controlled houses like deep litter system, cage system and slat system. Automatic feeding and drinking system reduce cost of labor and enhance feeding and water efficiency. Initial cost of construction is higher in such houses as compared to open sided and semi environment controlled houses; however, overall profitability by keeping the birds in environment controlled houses is higher than conventional houses.

4.3.4 Prefabricated Environment Controlled Houses

Prefabricated or factory-built housing system is getting popular in poultry farmers, companies provide complete setup of housing and equipments. Lots of problems related to housing construction and synchronization of equipments with locally developed houses can be solved with prefabricated houses.

Provision of accurate insulation, appropriate static pressure, suitable ventilation, feeding, drinking and lighting system remains the responsibility of a single supplier, which makes it easier to claim the guarantee if something goes wrong within guarantee period. Installation of factory build houses is easier than houses developed by local contractor. Furthermore, these houses can be replaced at any other destination if farmer faces any topographic or social change in surrounding. Pre-estimation of housing and equipments is more accurate in factory build housing as compare to a contractor's estimate.

4.4 Selection of Site for Poultry Housing

Selection of site for poultry housing is an important factor, which has a great impact on overall success of poultry farming. Various important points are discussed below for selecting a suitable place for poultry farm business.

4.4.1 Water quality

Water is required for drinking, sanitation, disinfection, vaccination, and evaporative cooling system. In bird's body water is vital for digestion, execration, circulatory system, thermoregulation and vision, therefore, most important point for site selection is availability of suitable water. Site selected with bad water quality needs installation of water purification plants which increases production cost and reduces profit margin. Poor quality water may cause total failure of poultry business.

4.4.2 Better Soil Quality

Soil quality is important from construction point of view, saline and sandy soil is not good for construction of poultry farm building. Soil should be compact enough that it can give strength to foundations and reduces chances of dampness in building after construction.

4.4.3 High from Surrounding Areas

Level of land selected for poultry farming should be high from surrounding area. This will reduce damages chances by rain and flood. Furthermore, farm land height from surrounding areas will also facilitate construction of proper drainage system.

4.4.4 Having Good Drainage System

One of the most important factors for selection of site is availability of proper drainage facility in area. During washing and disinfection, lots of chemical are being applied in process. Drainage of water with such toxic substances in surroundings not only causes social issue but also is a threat to farm bio-security.

4.4.5 Availability of Electricity

Electricity is an important component of poultry farming epically in case of environment controlled housing. Selection of site without electricity facility could be an extra burden for farmer. This will increase fixed cost along with running cost of poultry farm operations.

4.4.6 Away from other poultry farms

Distance between two poultry farms should be at least one kilometer. Therefore, during selection of site for poultry farm one should visit surrounding area to find out any other poultry farm. Such site should not be selected where other poultry farms are already constructed.

4.4.7 Away from Urban Areas

Distance from urban area is impotent from social and bio-security point of view. Although government did not allowed construction of poultry sheds near to urban areas. However, expansion of cities sometime resulted into reduction of gap between human population and poultry farms. In such circumstances, farmer should be aware of cities expansion trend to avoid any current or future collapse.

4.4.8 Availability of Road / Easy Access

Availability of road and easy access is important issue for selection of site. Constant supply of feed, marketing of egg and meat, easy approach for labour and other technical staff are linked with easy approach to the farm. Therefore, farmer should select site close to road. Never buy land for farm if the road is not easily accessible or you need to barrow land from another owner to reach at your farm, this may end up in deserter.

4.4.9 Availability of Gas

Some poultry installations required gas supplies like, electric generators, dead bird disposal system and gas brooder etc. Therefore, availability of gas connection at the site is a better option to avail.

4.4.10 Near to Market

Site for poultry farm should be close to poultry markets, so that farmer could have an easy access to feed source, poultry egg and meat market, medicine market, equipment market and technical backup like doctors, electricians, debeakers, vaccinators and bio- security providing companies. This will not only reduce cost of availing such facilities but also will allow him a quick and easy backup.

4.5 Construction of Poultry Farm Building

Basic tips for construction of open sided poultry house have already been discussed in this chapter. However, with increasing trends towards environment controlled housing system, some important considerations for construction of poultry farm building are given below.

4.5.1 Land

Land requirement for an environment control house based upon space requirement of birds and the space required for the various supporting components of a poultry farm. Space requirement for birds is further based upon the type of bird (layer, broiler or breeder) as well as system of housing (deep litter system, slat system, manual cage system or automatic cage system). On an average about 1.5 Acre land is required for a single story environment control house along with all its supporting structures. On the same space a double story poultry house could also be constructed, where farmer can raise 30000 to 60000 broiler or layer birds.

However, purchase of three Acres land is be a better option for the start of an environment control poultry farm. On this land a farmer can raise about 120000 to 180000 broiler or layer birds, depending upon extent of automation and system of rearing. Space requirement for breeder stock are more than broiler or layer birds, breeder stock is mostly raised in deep litter system. Therefore, about 72000 layer breeders and 35000 broiler breeder could be raised in same area. Farmer should always keep in mind farm extension while purchasing land.

4.5.2 Direction of House

Direction of environment controlled poultry houses depends upon climatic conditions and direction of air flow. In hot areas, east-west direction could be more beneficial. Because roof insulation is comparatively easier and economical as compare to insulating the walls. However, in cold areas, environmentally controlled houses can be erected in any direction. Another important consideration regarding direction of environment controlled house is the direction of wind flow. Direction of fans installed in house should not be against direction of natural air flow. This reduces fans efficiency and increases ventilation cost.

4.5.3 Length

Length of environment control house may vary from 400 to 560 feet. Important thing needs to consider for adjustment of length, is the type of equipments going to be installed in the building. Mostly equipment companies have a standard length for feeding and drinking systems, which is calculated on the base of number of birds, type of birds and maximum operational capacity of electric motors and pressure controllers. Similarly, types of inlets vary in size and they required a specific distance for installation which may affect length of house. It is, therefore, recommended that farmer should consider type of birds, number of birds and equipment specifications for estimation of poultry house length.

4.5.4 Width

Width of environment controlled poultry house ranges from 40 to 65 feet. In an environment control house width is depending upon number of fans and pads, which are adjusted width wise. Whereas, fans and pads number are calculated based on type of birds and number of birds in the shed. Second consideration for adjustment of width is number of feed and water lines or the type and lines of cage system going to be installed in the shed.

4.5.5 Height

Height of environment controlled house in case of deep litter system is kept about 7.5 to 8.0 feet. However, in case of cage rearing, house height is adjusted according to cage height, which may vary from 8 to 24 feet. In case of manual cages, height is kept about 8 feet, whereas, in case of automatic multi deck cages, height of shed may vary from 12 to 20 feet or more.

4.5.6 Foundation

Environment control houses may be single story or double story which required different strength of foundations. However, foundation must be solid enough that it could bear structural load and avoid dampness.

4.5.7 Floor

Floor type in case of deep litter system should be moisture proof and easy to clean. Plain concrete floor are recommended for environment control houses. However, slat floor in case of deep-pit system and raised floor in the form of platform are also developed in case of two or three tier cages. Under slat and between raised floors, sub- floor is developed for accumulation of manure. Sub-floor needs more strength, because it needs periodic washing and disinfection. In case of multi-tier cage system, floor should be solid enough, so that frame structure of cage system can easily be grounded, epically towards manure disposal end. A deep pit is developed in floor, at manure collection side of automatic cage system for installation of manure collection belts. This pit should be two feet away from fans wall and right underneath projection of manure belt, so that dropping could easily be collected and removed from shed. Although cage system is equipped with level adjustment system, even than floor for cage house be smooth and leveled.

4.5.8 Roof

Roof of environment control house should be well insulated, solid and leak proof. Over hanged roof is not required in case of environment controlled house, because side walls are kept completely closed. However, an appropriate slope on the roof is required for drainage of rain water.

4.5.9 Walls

Various construction patterns are applied in poultry house construction. In case of single story house, bricks walls are developed, in this case the walls should properly leveled, straight and solid enough to support the roof. A frame work structure is recommended in case of double story poultry house. In this system, main structure is based on solid concrete pillars, whereas bricks walls are developed between pillars. Catching windows or emergency ventilation windows may also be installed in side walls. Windows should be air tight and well insulated.

4.5.10 Air Inlets (Ventilator)

Air inlets and exhaust fans (36 inches diameter) are installed on the side walls of environment control houses length wise for the provision of ventilation during cold weather. Inlets are located one foot below the roof where the shed height is about 8 feet. In case cage system, special inlets with two directional air flow system may be adjusted in the middle of walls. Distance between the inlets depends upon the number of inlets calculated for a specific flock.

4.5.11 Fan and pad

Fan and pads are installed on front and rare walls of environment control house for tunnel ventilation during hot weather. Number of fans and pads needed to be mounted, depends upon ventilation requirements of a specific flock, fan and pads specifications regarding their operational capacity. It is therefore, recommended that both front and rare walls should be constructed with the provision of open space required for pad and fan installation.

4.5.12 Doors

Door of environment controlled house should be well insulated and air tight. About three to four doors are recommended in side walls of a poultry house. Doors should be sized keeping in mind handling of equipment and birds (catching / transportation).

4.5.13 Insulation

Insulation is the most important factor in environment controlled housing. Insulation of roof, ceiling, walls, windows and doors play an important role both in hot and cold climatic conditions. Insulation value of house is estimated based on environmental temperature, bird's heat production, area of house for heat loss per bird and rate of air exchange.

4.5.14 Supporting Structures

One of the most important things needed to be considered is appropriate estimation of supporting structures including feed store, drainage, passages, dipping pits, generator room, spare parts store, administration offices, labour colony, kitchen, wash room, weighing bridge, disposal pit and boundary walls, etc. Feed stores should be big enough to store feed for a desired storage period. For construction point of view feed store should be damp proof and well ventilated. All components of farm building should be high enough from ground level and attached with well-defined drainage system. Appropriate passages should connect the various component of farm, so that farm operation could be carried out properly in rainy season. Dipping pits should be constructed at the main entrance for vehicles and visitors. Dipping pits should also be constructed at the entrance of each shed. Generator room should be far enough from the production shed, so that entrance of smoke and noise could be reduced. Negative pressurized system is used in environmental control houses; it is therefore, recommended that generator room should be constructed in front of exhaust fans to throw away the toxic fumes away from shed. A small workshop along with a store for spare parts should be constructed at farm for repair and maintenance of farm's equipments. Weighing bridge and dead bird disposal pit are also important component of poultry farm. Weighing ridges are installed near the main entrance after the dipping pits for vehicles. Administration offices, labor colony, washroom and kitchen should be arranged according to the size of farm operations and staff's requirements. Boundary wall is important from bio-security point of view; it should be strong and

high enough that it can prevent the entry of rodents and predators along with entrance of unauthorized persons. Another important thing is distance between boundary wall and front/rare walls of shed should be 15 to 20 feet, in order to facilitate ventilation system.

4.5.15 Layout Plan for Poultry Farm Building

For an efficient lay out plan of poultry farm building, boundary walls should not be close to front or rare walls, administrative block, labor colony, kitchen and main feed store should be kept away from sheds to avoid direct contact of visitors and vehicles with birds and there should be two entrances for washroom, one towards main entrance and other towards shed's side. Dipping pit for vehicles should be close to main entrance, small feed delivery room (with feed bin or underground hopper) should be constructed near the front or rare walls of shed and generator room along with control panel room should be towards fans side of the shed. Distance between two sheds should be 100 feet and avoid developing brooding, growing and laying sheds at same farm. Always keep direction and distance between sheds in a way that ventilation system should not scramble with each another. All components of poultry farm including sheds should be high from ground level, well connected to drainage system and attached with each other through washable passages.

4.6 Role of Insulation in Environment Controlled Housing

Major function of an environment controlled house is to provide environmental conditions (epically house temperature) close to optimum requirements of poultry birds. Such houses are developed both for hot and cold climatic conditions. During cold weather insulation protects the heat lost from the shed during brooding and improves the brooder's efficiency. Whereas, in case of adult birds, insulation helps to maintain house temperature through heat produced by bird's body. With proper insulation, a farmer can maintain house temperature close to 75°F even the outside temperature is -20°F. During hot climate insulation reduces penetration of heat inside shed. This reduces increase of house temperature and facilitates cooling system to perform better. Hence, we can say that insulation of roof, ceiling, side walls and end walls is essential. In case of environment controlled houses, insulation of doors and catching windows is also recommended.

Insulation is measured in terms of R-value, which is ability to resist transfer of heat through a material. To be a good insulator a material must contain a large number of small, isolate dead air spaces present in its each cubic inch. Moisture acts as a conductor of heat and it adversely affect R-value of insulating material. Therefore, better insulator material should not absorb moisture. Insulating materials like polystyrenes and polyurethanes do not absorb moisture. Whereas, materials such as cellulose, fiberglass and various wool products absorb moisture. In case of moisture absorbing insulating materials, additional sheets of vapor barrier (materials which resist the moisture absorption) should apply. Materials such as aluminum foil and

various types of polyethylene films are adequate vapor resisting materials. Other materials such as plywood and general framing lumber, bricks, concrete, and masonry blocks not considered as good vapor barrier. Vapor barrier must install towards warm side of insulation because low temperature cause condensation of air moisture, which cause wetting of insulation and reduces its R-value.

Insulation requirement for a poultry house depends upon the environment condition of its location. Farmer should be aware of natural climatic conditions before construction of poultry house, so that insulation requirement could be properly addressed during construction of sheds. Insulation requirements during different climatic conditions are given in Table 4.1.

Table 4.1. Insulation requirements under different climatic conditions.

Climate Type	R-Value	
	Ceiling	Side walls
Hot ($\Delta t < 30°F / 17°C$)*	9.0	6.0
Medium (Δt 30-50°F / 17-28°C)*	12.0	8.0
Cold ($\Delta t > 50°F / 28°C$)*	20.0	14.0

*Δ = *difference between inside and lowest outside temperature.*
Source: Bell and Weaver (2007)

Factors other than the environmental temperature, involved in estimation of R-value are type of birds and their heat production, size of flock (depend upon number of birds in same house) and ventilation rate.

4.7 Light (Electric), Gas and Water Fitting in Poultry Houses

Automation in feeding, ventilation, manure removal and egg collection has increased the use of electro- mechanical equipments in poultry farming. Electricity supply is highly important to run automatic equipments at farm.

4.7.1 Electricity at Farm

Uninterrupted electric supply for 24 hours is needed for environment controlled poultry farms. Any mistake to calculate electricity load may cause short circuit in electric wiring which may cause an electric failure for entire system. With the high density cage housing system a shed may have 100,000 to 180,000 layer birds in it. Under these circumstance failure of ventilation system even for a half hour may cause high mortality rates. To regulate electricity and automation special electronic control panels are used along with two generators of good quality. Electric load required at farm by adding up watts of all electric equipments installed at farm. This will help to arrange electric wiring, for example single phase wiring for equipments works on single phase current and three phase wiring for its respective equipments. This will help to calculate generator capacity for backup electric supply. Buy generator having 10% additional capacity of actual requirement.

4.7.2 Light Fitting at Farm

After electricity arrangement for farm equipments, installation of lighting is next important step. To estimate lighting requirements and electric wiring for lighting, terminology related to lighting management is given below.

1. Foot candle: If one watt incandescent bulb hangs on a height of 7 feet and its light falls on 4 square feet area, the light intensity on each square foot will be one foot candle. One foot-candle equals 10.76 lux.
2. Lux: A lux of light intensity is equal to one lumen per square meter. One lux is equal to 0.0929 feet candle.
3. Lumen: A lumen is a standard of measurement of light intensity from electric bulbs of various types and sizes from a specific distance on a specific area.

Lumens per Watt

Lumens of light produced per watt of power are as follows:

Incandescent	20 lumens per watt
Mercury Vapor	55 lumens per watt
Fluorescent	65 lumens per watt

Although watts of required illumination at farm can be calculated from above definitions, better way to calculate electric requirements for lighting is to use lux meter, because different sources of light produces different lumens per watt.

4.7.3 Gas Fitting at Farm

Gas is mostly used for brooding or to produce electricity at the farm. Before applying gas connection for farm one should calculate gas requirements. To calculate gas requirements at farm, add gas requirement for kitchen, offices, gas brooders and gas operated electric generators. Just like the generator back up for electric supply, farmer may arrange portable gas cylinders to store gas at farm in case of emergencies. While dealing with gas fitting at farm, one should be careful about pressure of gas required by different equipments. Use of pressure regulators with gas brooders and gas operated electric generators enhances equipment efficiency and reduces chances of and misshape. Always keeps fire extinguishing at farm while having gas operated equipments.

4.7.4 Water Fitting at Farm

Calculation of water requirement is important before installing water system at farm. For this purpose, the farmer should consider the water requirements of flock at adult stage, emergency storage capacity and water required for cooling system. Water fitting includes water pumps, water lines and storage tanks. Always keep spare water pumps at farm. Underground fitting of water lines reduces change of water temperature due to hot or cold climatic conditions. Water tank is to maintain water temperature.

4.8 Heating and Cooling Systems

4.8.1 Heating Systems

Heating systems at farm are used for brooding purpose. Various type of brooders (heating systems) are available for heating the poultry house like electric brooder, gas brooder, coal brooder, diesel brooder and wood brooder.

1. Electric brooder: Electric brooders are based on electric heater, electric fans and thermostats. Electric brooder may be radiant brooder if fan is not installed in it and electric heater is controlled by manual or digital thermostat. If fan is also installed in an electric brooder, both fan and heaters are controlled by electronic thermostat, then brooder is called hot air electric brooder.
2. Gas brooder: In gas brooders heat is generated by gas heaters (gas burners) and provision of gas in theses heaters is controlled by electric gas valves. Electric gas valves are further controlled by electronic thermostats. Various types of gas brooders include radiant gas brooder, direct air brooder or indirect air brooders. Radiant gas brooders based on radiant gas heaters, electric gas valves, auto ignition switches, flame sensors and electronic thermostats. In direct air gas brooding system heat is produced by gas heater and fan is used to throw hot air in shed directly or by ducts. Gas valves are used to control gas pressure in the heater, whereas electronic thermostat is used to operate gas valves and fan operation according to required temperature. In indirect hot air gas brooding system, gas heaters is used to heat metallic pipes installed and air move inside hot pipes and thrown in shed through fan, so that no direct fumes enter in shed, rest mechanism of this system is similar to direct air brooder.
3. Diesel brooder: Diesel and kerosene oil brooders are also available in market. In such brooders, oil injection pumps are used to supply fuel to burners. In such type of brooders, in direct hot air brooding system is applied. Diesel or kerosene oil burner is used to heat metallic pipes or drum, whereas, fan is used to drive hot air in shed through polythene ducts or metal pipes. Sensors are installed in shed. Fuel injection pump and fan are controlled through electronic thermostat to maintain shed temperature.
4. Coal or wood brooder: In coal or wood brooding, indirect hot air brooding system is used; these brooders are usually installed outside shed. Coal or wood is burned up in a furnace to heat the metallic pipes installed on upper side of furnace. Fumes are drive out through a chimney at about 20 feet high in the air. Electric fan is used to drive air through the hot pipes into shed. Electronic heat controlling system is adjusted with coal or wood brooder; heat sensors are installed in shed at different locations. Operation of hot air delivering fan and blower fan (fan fixed with furnace) is controlled through electronic temperature controller based upon the temperature requirement and response of heat sensors installed in shed. However, coal or wood is manually loaded in furnace. Operational cost of coal or wood is comparatively lower than other heating systems.

4.8.2 Cooling Systems

There are two common systems used for cooling in poultry house. One is fogging system and other is fan and pad system. In both cases, evaporative cooling mechanism is used. In fogging system, a fine mist of water is produces by forcing water through fine jets. Fine mist is directly employed over birds, which keep birds wet and helps keep them cool. Foggers do not lower temperature in house unless they are used with fans. Use of high speed fans with foggers helps reducing house temperature. While using fan and fog system for cooling the house, one should be careful about the relative humidity in atmosphere. Fan and fog system did not work well in case of high humidity. Fog and fan cooling system is mostly used in conventional open sided and semi-environment controlled poultry houses.

Another system of cooling is fan and pad. This system is used in environment controlled poultry houses. In this system, slow speed exhaust fans are installed on one end of poultry house and cooling pads are places on another end of shed. A negative air pressure is generated in the shed through exhausted fans. Air can enter in the shed through cooling pads. Water is sprinkled on the cooling pads for evaporation. Evaporation causes the pads to become cool which reduces the air temperature passes through it. Electronic controller with temperature and humidity sensor is used to operate fans and water flow on pads, to maintain temperature and humidity in house.

4.9 Ventilation System

Ventilation is the most important managemental factor in poultry farming. A main function of ventilation in poultry house is provision of oxygen, removal of toxic gases and removal of moisture and maintenance of environmental temperature. Oxygen and level in the shed should not be less than 19.6%, carbon dioxide should be less than 0.3% and level of ammonia should not be more than 10 ppm. Whereas, moisture level in shed should be 55 to 65 %. Ventilation requirements for a poultry house depends upon age of bird, number of birds, weight of bird, type of bird, type of insulation, environmental moisture and temperature.

Ventilation in open sided poultry house is conducted by keeping width of shed less than 35 feet. In case of semi-environment controlled houses. High speed fans or desert coolers are used for ventilation. Whereas, in case of environment controlled houses, ventilation is mostly done through negative pressurized ventilation system. There are two main systems of ventilation.

4.9.1 Positive Pressure Ventilation System

In this system of ventilation fans or evaporative coolers (desert coolers) are placed inside walls, these fans force air into poultry house. Openings are provided through which air is exhausted from house. Air openings are regulated to generate a positive pressure. Positive pressure distributes air homogeneously in shed.

4.9.2 Negative Pressure Ventilation System

Negative pressurized system is further divided into three ventilation systems

4.9.2.1 Tunnel Ventilation System

In this system, slow speed exhaust fans are installed on one end of poultry house and evaporative pads are places on another end. After completely sealing house, air in shed is exhausted. Fresh air is allowed in shed through a specific area of cooling pads. A static pressure is maintained by adjusting amount of exhaust air and pad area. Static pressure is further applied to control air speed in house. This system is mostly used in environment controlled houses build in hot climate.

4.9.2.2 Minimum Ventilation System

In this system, exhaust fans are installed on side walls of shed and air-inlets are installed on both side walls about one foot below ceiling. Mechanical opening of air-inlets is to generate required static pressure. In this system, static pressure is controlled to regulate speed of air coming through inlets.

4.9.2.3 Transitional Ventilation System

This system is applied in mild environmental conditions, negative pressure is generated by combined opening of pad and inlet. Where, both front and side walls fans are operated as per requirement. House temperature and moisture is controlled through controlling of water pump used for wetting evaporative cooling pads.

4.9.2.4 Combi-Ventilation System

This system is basically combined installation of fans, pads, inlets and side fans in poultry house. In this system, all three types of negative pressurized systems are applied in same house. Specially designed environment controller is used in this system. This controller is joined with temperature and humidity sensors and it can control water pumps, number of fans to operate, duration of operating fans and opening of inlets. Environment controller is programmed to maintain inside house temperature both in hot, cold and moderate climatic conditions. Such system is used in poultry house developed in area of variable climatic conditions. Minimum ventilation requirements for broiler are 1.25 cfm/lb body weight. Minimum ventilation requirements for layer birds are 1.5 cfm/lb body weight (Bell and Weaver 2007). Rule of thumb is to provide 0.012 cfm/lb of body weight of chickens in house for each 1 °F of temperature.

4.9.3 Calculation of Number of Fans for Tunnel Ventilation

Birds in the shed = 30000
Type or bird = broiler
Weight of bird = 4.4 lb
Exhaust fan capacity = 21000 cfm
Number of fans = No. of birds × weight of bird (lb) × ventilation required/ lb bodyweight / capacity of exhaust fan
Number of fan = 30000 × 4.4 × 1.25 / 21000 = 7.85 or 8 fans

4.9.4 Calculation of Evaporative Cooling Pad for Tunnel Ventilation

Number of fans = 8
Area of cooling pad = 6.5 feet. × 2 ft. = 13 feet^2.
Capacity of exhaust fan = 21000 cfm
Required air speed from pad = 250 fpm
Number of cooling pads per fan = (Capacity of fan / required air speed from pad)/ area of cooling pad in ft^2= (21000 / 250)/ 13
= 84/13
= 6.5 Evaporative cooling pads per fan
Total pad required for 30000 birds shed = No. of fans× no. of pads per fan = 8 × 6.5
= 52 Evaporative cooling pads required
Calculation of fans and inlets for minimum ventilation
Rule of thumb: one square inch in let area is required for each 4 cubic feet of air.
Minimum ventilation requirement at 40°F = 48 cfm / lb body weight
Number of birds = 30000
Body weight per bird = 4.5 lb
Capacity of exhaust fan = 21000 cfm
Number of fan required = No. of birds × weight of bird (lb) × ventilation required/lb body weight/ capacity of exhaust fan
= 30000 × 4.5 × 0.48 / 21000
= 64800/ 21000
= 3 fans
Ventilation required by the flock is = 64800 cfm
Area of in let required = 64800/4 = 16200 square inches
Area of inlet = 12 inches × 24 inches = 288 square inches
Number of inlets required (1 ft × 2 feet) = Area of inlets required in square inches/ area of one inlet in square inches = 16200/ 288
Number of inlets required = 56.25 or 57

Air speed passing through inlets is controlled by static pressure. For better mixing of incoming cold air, air velocity should be about 600 feet per minute (FPM).

All the above calculations are based on a shed having length = 400 feet, width = 45 feet and height 8 feet. Total area of shed is 18000 square feet and has capacity for 30000 broiler birds @ 0.6 square feet/bird. Ventilation requirements of different type of birds in same shed can be calculated by values given in Table 4.2

Table 4.2. Floor space requirements of different types of birds.

Type of birds	Space required per bird (Cubic feet/bird)	Bird weight in lb	Birds number in shed of 18000 feet^2
Broiler (on floor)	0.60	4.40	30000
Layer (Two tier caged)	0.75	3.30	24000
Broiler breeder (on floor)	2.10	8.80	8571
Layer Breeder (on floor)	1.50	3.30	12000

Source: Daghir (2008)

Note: Average weight of birds may vary for different strains, always consult breeder manual for the precise calculation of ventilation.

In case of tunnel ventilation system number of fan may also be calculated based upon air speed requirements in shed (Daghir, 2008). Recommended air velocities in tunnel ventilated house are given in Table 4.3.

Table 4.3. Air velocities in tunnel ventilated houses.

Type of bird	Air Speed (FPM)*	Air Speed (m/s)**
Broiler	450 – 540	2.50-3.00
Pullet	315 – 405	1.75-2.25
Broiler Breeder	405 – 540	2.25-3.00
Commercial Layer	450 – 540	2.50-3.00
Turkey	450 – 540	2.50-3.00

**FPM= foot per minute*

Calculation of number of fans based upon the airs speed are given below

Length of shed = 400 feet
Width of shed = 45 feet
Height of shed = 8 feet
Air speed required in shed = 450 feet per minute
Cross section area of shed = width x height = 45 × 8 = 360 square feet
Ventilation requirement at 450 fpm air speed= 360 × 450
= 162000 cubic feet / minute
Capacity of fan = 21000 cfm
Number of fan required = 162000/ 21000 = 7.7 or 8 fans

Note: required ventilation can be provided by operating the fans through timers.

4.10 Brooding, Rearing and Laying Equipments

4.10.1 Brooding House Equipments:

4.10.1.1 Brooder

Brooder is used to provide heat during brooding phase. Various types of brooders are available in market based upon different types of fuels. There are two type of brooding systems used during brooding phase.

a. Colony Brooders

For colony brooding small scale electric; coal or wood brooders are used. These brooders are manually operated. Brooding capacity of such brooders ranges from 500 to 1000 birds. In this brooding system small groups of birds are raised.

b. Continuous Brooders

These brooders deliver hot air directly or by air ducts in brooding area. These brooders include gas brooder, coal brooder, wood brooder and diesel brooder. Brooding capacity of such brooders ranges from 5000 to 60000 chicks.

4.10.1.2 Chick Guard

Chick guards are used to separate chicks in different colonies and to keep them close to sources of feed, water and heat. Chick guards are 8 feet long and 1.5 feet high metallic sheets are joined together to develop a boundary wall around brooder. Chick guards are expanded/removed as soon as chicks get familiar with feed, water and heat source.

4.10.1.3 Small Feeders and Drinkers

Small round plastic feeders or trough feeders along with manual drinkers having small plats are places near heat source in case of colony brooding system. Whereas, in continuous brooding system, small plastic feeding trays are spread throughout the brooding areas and height of nipple drinkers lines are reduced to chicken level. Water lines consist of nipple drinker are attached with water pressure regulators, which maintain water pressure in nipples according to age of chicks. In automatic trough or pan drinkers, suspension valves or float valves are used to regulate water flow in drinkers. One small round feeder or drinker is for 25 chicks during brooding.

4.10.1.4 Trough Feeders

Troughs that are 3.5 feet in length, four inches wide and about 2-3 inches deep, attached with a reel over the trough to keep the chicks out of the troughs. These are mostly used during brooding in conventional or semi- environmental controlled houses. One trough feeder is used for 40 chicks during brooding.

4.10.1.5 Brooding Cages

In case of cage brooding, small trough/round feeders and nipple drinkers are used. In brooding cages, adjustable frames with small mesh size are used to keep chicks inside the cage. Along with side walls frames, plastic sheets having small mesh size are used on floor of cages to facilitate comfortable standing of chick in cages. Now a day's special cage system is available in market for broiler and layer birds, in these cages birds can raised right from brooding till end of their production cycle.

4.10.1.6 Artificial Lights

Light bulbs and light timers are used during brooding to provide a specific light intensity and duration to chicks.

4.10.1.7 Exhaust Fans

Slow speed exhaust fans are used for minimum ventilation during brooding period.

4.10.1.8 Inlets

Mechanically operated air inlets are used during brooding to provide required ventilation to chicks. During brooding sometime ventilation is conducted by using exhaust fans, and passing air through evaporative pads without wetting them.

4.10.1.9 Climate Controllers

In case of environment controlled housing, programmable climate controllers are also used during brooding to operate heating and ventilation devices. These controllers are also used for lighting management during brooding.

4.10.2 Growing/Rearing House Equipments:

Selection of equipments for growing period based upon their cost, performance and durability is important, because most of equipments used during growing may use in laying period as such or with a little adjustment. Equipments used during growing are given below:

4.10.2.1 Water Drinkers

There are different types of drinker which can be used during growing as well as laying period. These include round drinkers, bell drinkers, trough drinkers and nipple drinkers. Round drinkers have 4 to 6 litter's water capacity and are used in conventional poultry houses. There serving capacity is about 25 birds per drinker. One bell drinker is used for 100 birds. Whereas, one nipple drinker is used 10 to 15 birds. Trough drinkers are used @ one liner inch per bird. Nipple and trough drinkers are used both in deep litter system and cage system during growing and laying phases. Water meters and water proportioned pumps are also adjusted with drinking system. Water meter is used to measure water supply to flock. Whereas, water proportioned pump/ injector is used to supplement water soluble medicines, vaccines, vitamins and minerals in drinking water.

4.10.2.2 Feeders for Growing Birds

Various type of feeders used during growing period are as under:

a. **Tube feeders:** These are large tubes about 8 to 16 inches in diameter and about 1.5 to 2 ft. long, at bottom a large pan is suspended into which feed flows from tube. Tube feeders are suspended from ceiling and are used in conventional poultry houses having capacity of 25 birds per feeder.

b. **Automatic Pan or Tube Feeders:** These feeders consist of a pan and automatic feed transfer mechanism. Pan or tube feeders further attached with feed hopper through feed delivering pipes. Electric motors attached with auger system delivered feed form main feed bin to small hopper, and from small hoppers to pan feeders. Serving capacity of an automatic pan feeder is about 60 to 64 birds. Automatic trough feeders used in deep litter system is filled with chain or auger system. Whereas, trough feeders used in multi-tier cage system are filled with mechanical feed filling hoppers. These hoppers are further filled by feed bins through auger system.

c. **Trough and Chain Feeder:** Feed trough goes around poultry house in a close circuit and a feed hopper is attached with it at the end. Chain run in trough with an electric motor, which drag feed from feed hopper to trough.

d. Feed Bin: Bulk feed bin is used from brooding till end of production. Size of feed bin is based upon daily feed requirement of adult flock along with one week storage capacity of daily feed consumption**.** Actual capacity feed bin capacity is based upon feeding requirements of adult flock.

e. Feeding Time Controllers: Electronic controllers are used in mechanical feeding system. These controllers are used to atomize feeding quantity and timing by controlling operation of feed delivering motors.

4.10.2.3 Environment Controlling Equipment

In case of hot climatic conditions exhaust fans along with evaporative cooling pads and controllers are used for tunnel ventilation system during growing phase. Whereas, in case of cold climatic inlets are used with exhaust fans for ventilation.

4.10.3 Laying House Equipments

4.10.3.1 Feeders and Drinkers

Feeding and drinking house equipments are generally same as growing house equipments. However, equipments number may increase according to feeding and water space requirements of birds at different ages. In case of cage birds, feeders and drinkers are already installed on the basis of adult bird's requirement. Therefore, these feeding and drinking equipments can be used both for growing and laying stage of poultry birds.

4.10.3.2 Nest

Nest is specifically laying house equipment. Each nest is about 12 inches wide, 12 inches high and 16 inches deep along with 3-4 inches perches. For broiler breeder, slightly larger nest is used. In laying house, a combined nest having 10compartments is used for 50 birds. In case of cage housing system, cages with slope are used as roll away nests. Individual roll away nests with collection belts are also used in deep litter poultry housing system for egg collection.

4.10.3.3 Environment Controlling Equipments:

Environment related equipments like fans, inlets, evaporative pads and lighting systems are basically calculated and installed based on laying house requirements. These equipments are operated as per requirements during brooding, growing and laying stage.

4.11 General Farm Devices

Temperature controller is used to operate heating or cooling system to maintain required range of temperature within the limits. This device has alarming system to alert farmer in case of any problem of heating or cooling equipment. Moisture controller is used for controlling the operation of humidifiers and dehumidifiers in order to maintain required humidity level in shed. Light controller is used to

maintain duration and intensity of light in shed. Supplementation of artificial light along with natural light can be managed by this equipment. For manure handling and removing steel drag, trolleys, loaders, belt and loaders are used at farm. Electric devices used for electricity regulation at the farm are transformers, generators, uninterrupted power supply Units (UPS) and electric panels. There are various equipments which are used in offices or sheds. These equipments include, computers, printers, tables, chairs, racks, exhaust fans, air conditioners, refrigerators, weighing balances, automatic syringes, spray pumps, dissection box and fire extinguishers. Selection and quantity of such equipments is based on the size of flock and type of housing system.

4.12 Farm Monitoring Equipment

Farm monitoring equipment are used to evaluate performance of equipment installed at farm which includes

4.12.1 Temperature Meter

Manual or electronic thermometers are used to monitor temperature. Infrared thermometer is used to check temperature of birds, floor, walls, ceiling and electric motors. Thermometers are used to evaluate performance of heating and cooling devices and their controlling mechanisms. Temperature is monitored on daily basis in poultry houses.

4.12.2 Hygrometer

Hygrometer is used to monitor the relative humidity inside and outside shed. Moisture level in the poultry house should be checked every day.

4.12.3 Lux Meter

Lux meter is used to measure intensity of light. Light intensity in should be checked every week, because dust in the poultry house may accumulate on light source and reduces its efficiency.

4.12.4 Avometer

Avometer is used to measure speed of air in feet per minute (fpm). Some avometers also have additional functions to measure volume of air in meter per second (m/s), Kilometer per hour (Km/h) or cubic feet per minute (cfm). Damaged fan belt, fan pulley and dust on fan blades reduce its efficiency, which can be checked by using avometer. Performance of all fans installed at farm should be checked once in a month. Formula for conversion of fpm into cfm is as under

$$\text{CFM} = \text{FPM} \times \text{Area in Cubic Feet.}$$

4.12.5 Static Pressure Meter

Alteration in efficiency of fans, excessive opening of ventilators or any cracks in building results in reduction of required static pressure in building. Static pressure meter should be used at farm every time when ventilators are adjusted for a required static pressure and air speed. Reduction in static pressure is also indication of poor fan's performance. It is therefore, advised to use avometer along with static pressure meter to ventilation system precisely.

4.12.6 Volt Meter

Volt meter is used to measure voltage available at farm and availability of voltage to each of electric equipment. In case of three phase wiring there should be equal voltage on all three phases. Drop of voltage on any phase may damage electric motors. It is therefore, recommended that volt meters should be permanently installed at farm on all three phase lines. A portable volt meter should also be kept at farm to measure voltage at equipment side.

4.12.7 Ampere Meter

Ampere meter is used to check electric load of various electric equipments installed at farm. A regular checkup of feed delivering motors and exhaust fans motors is important. Over loading or malfunctioning of these equipments may result an increase of their amperes utilization. Efficiency of exhaust fan can also be checked by its electric consumption in amperes and its air delivering capacity. For example, a fan motor takes 2.5 amperes and deliver 20000 cubic feet of air per minute will be better than a fan which takes 3 amperes for the same amount of air.

4.12.8 Carbon Dioxide Meter

Carbon dioxide in shed should not exceed more than 1% or 10000 ppm. Therefore, availability of CO_2 meter especially in high density cage layer house is very important. Daily check of CO_2 level in shed is important for optimum production of layer birds kept in environment controlled cage housing system.

4.12.9 Ammonia Meter

In environment controlled deep litter housing system estimation of ammonia is important factor for managing ventilation of poultry birds. It is, advised to ckeck ammonia level in adult laying birds and broilers during finishing stage daily. Ammonia level in poultry house should be less than 0.0025% or 25 ppm.

4.12.10 Insulation Meter

Insulation meter is required to measure insulation (R-Value) of poultry house. Excessive moisture and condensation alter insulation values of poultry house. Insulation is an important factor for calculating minimum ventilation requirements of birds kept in an environment controlled poultry house. Therefore, availability of insulation meter is important for precise calculation of ventilation requirements.

4.13 Economics of Poultry Housing

Economic of poultry housing deals with estimation of cost of housing and equipments on the production of poultry bird. Over all economics of poultry bird is based upon its cost of housing, cost of equipments, cost of chick, cost of feed, cost of labour, cost of fuel and cost of medicine. For calculating cost of housing and equipments, information required is as under

4.13.1 Type of Bird and Space Requirements

Type of birds includes broiler, layer, broiler breeder or layer breeder. Floor space requirements for each type of bird is different for example, in an environment control house space requirements for broiler, layer, broiler breeder and layer breeders are 0.6, 0.75, 2.25 and 1.5 square feet / bird respectively.

4.13.2 Size of Flock:

Requirement of area and equipments is also based upon size of flock for a specific bird. Area of shed and its construction cost is calculated on basis of floor space requirement of a specific bird. However, in multi-tier cage housing system, more number of birds can be raised in same area as compared to floor housing system.

4.13.3 Various Components of Farm Building

Area specifications (length, width and height) and cost of construction per square foot area of various components of poultry farm is required to calculate total cost of construction of poultry housing. Floor space requirement for different type of birds is required only for construction of poultry sheds. Whereas, construction cost of other essential components of poultry farm building should also be included in calculation of cost of housing for a bird.

4.13.4 Annual Depreciation

Annual depreciation rate for buildings is 5% per annum and in case of equipments it is 20% per annum. For calculating cost of housing per bird, after calculating the total cost of construction, annual depreciation rate is calculated and then it is divided by total number of birds served in the house during a year to calculate cost of housing per bird. Similarly, after calculating total cost of equipments installed at farm, annual depreciation of equipments is calculated to calculate cost of equipment per bird. Dividing annual depreciation rate by number of bird's server per year will give rearing cost of bird. An example of calculating cost of housing is given in Table 4.4 and equipments are given in Table 4.5.

Table 4.4. Cost of housing per bird for a flock of 30000 broilers (Year 2015).

Type of House	Environment Controlled House			
Type of Birds	Broiler			
Floor Space Requirement	0.6 ft^2/Bird			
Flock Size	30000 birds			
Housing Specifications	Length	Width	Cost/ft^2	Cost of construction
a. Shed	400	45	400	7200000
b. Office	10	10	800	80000
c. Feed store	20	20	400	160000
d. Labour room	10	20	400	80000
e. Equipment store	10	10	400	40000
f. Wash room	6	10	800	48000
g. Generator/ Electric panel room	6	10	400	24000
h. Total cost of Construction	= (a+b+c+d+e+f+g)			7632000
i. Annual Depreciation @ 5%	= h × 5/100			381600
j. 6 flocks, 30000 birds/flock raised	= (6 × 30000)			180000
k. Housing cost/bird	= i/j			2.12

Table 4.5. Cost of equipments per bird for a flock of 30000 broiler birds.

Cost Feeding System:	Requirement (No.)	Cost of Equipment
Feeding lines	3	
Feed hopper	3	
Feed pan per line	158	
Total number of pans per house	468	
Number of birds per pan	64	
Total feeding system cost		**1250000**
Cost of nipple drinking system:		
Water lines	4	
Nipples per line	625	
Total number of nipples per house	2500	
Number of birds per nipples	12	
a. Drinking system cost		**535000**
Cost of ventilation system		
Fans required	8	
Number of pads (6.5ft*2ft*0.4inch)	52	
Number of Inlets	58	
Number of wench	2	
Control panel	1	
b. Total cost for evaporative cooling system		**977000**
Miscellaneous Equipments		
Energy savors	140	28000

Refrigerator	1	32000
Automatic syringe	1	8500
Generator	1	600000
Cost of heater	1	400000
Cost of transformer	1	300000
Wiring of electricity and water		200000
Water pump	2	15000
Lux meter	1	15000
Air velocity meter	1	10000
Infrared thermometer	1	5000
wet blub thermometer	1	1000
Office equipments, manure and feed handling equipments		200000
c. Total cost of miscellaneous equipments		**1814500**
d. Total Cost of Equipments	(a+b+c+d)	4576500
e. Depreciation of equipment	= e × 20/100	915300
f. Birds rear in one year	= 6 × 30000	180000
g. Equipment cost per bird	**= f/g**	**5.08**

Conclusion

Poultry housing layout, water quality, construction, insulation, feeding, watering systems, brooders and modern poultry instruments contributes a great in modern day poultry units. Each of these has its due importance for economic production of meat and eggs. Proper housing system and equipments quality aid in poultry production.

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