Poultry Housing Design

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The economical growing of chickens starts from the correct and adequate design of the building for the appropriate breed and the environment of the location. The designs of the poultry house for hens or broilers in some countries dose not always based on engineering and scientific foundation, but on some incorrect information, and practices or lack of accurate information. For these reasons and others there is a high mortality rate.
In absence of scientific and engineering aspects and rules in poultry housing design that led to different sizes and many non-standard types of sheds. In many situations it is not adequate for large production, or using standard mechanization (feeding, drinking systems) for poultry production. Selecting the correct dimensions for the poultry house helps in use of standard mechanization and adequate design of the ventilation system. Not using scientific rules in poultry building design could create production problems, high production cost, lower returns, and wastage of different types of energy.
There are three types of House

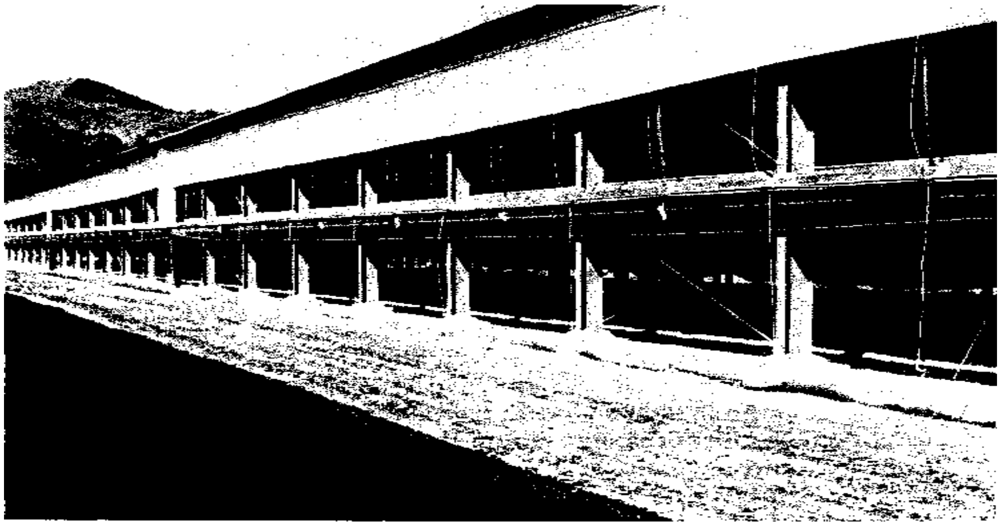
1. Open-side Poultry house
2. Front and Back sides
3. Controlled Environment house

OPEN-SIDED POULTRY HOUSE

Most of the poultry houses in the world are conventional or open-sided (see Figure 1); that is, they rely on the free flow of air through the house for ventilation. Certain requirements must be met if such a ventilated house is to provide an adequate environment. Care in following these rules during the course of construction will avoid pitfalls later.

Width of house. The width of the open-sided poultry house should be about 30 ft (9.8 m) and no more than 40 ft (12.2 m) wide. Houses that are wider will not provide ample ventilation during hot weather. Wide houses also require additional interior supports that may interfere with equipment or manure removal. This width recommendation is basic for growing birds, broilers, and laying hens.

Figure 1. An open-sided high-rise cage house with side curtains.



Height of house*.* Most open-sided houses have a stud that is 8 ft (2.4 m) long. The stud represents the distance from the foundation to the roofline. In areas where the temperature is exceptionally high throughout the year, the stud length should be increased to 10 ft (3 m). High-rise houses, with manure storage areas below the cages or slats, should be as high as 14 ft (4.3 m) or more at the eaves.

Length of house*.* Poultry houses may be almost any convenient length. The terrain on which they are to be built often determines the length; rolling land means more grading before construction can start. Because automatic feeding equipment will limit the length of the poultry house, the equipment manufacturer should be consulted about the optimum length of the feeding system. Many times the feed hopper is placed in the center of long houses to provide better use of automatic feeders.

Shape of roof*.* Practically all poultry houses built today have a gable roof, the pitch varying from one-quarter to one-third. A good overhang should be provided to protect the inside from driving rains and to afford interior shade.

Roof exhausts*.* Houses should be equipped with a covered exhaust area at the peak of the roof to allow excess heat to escape. Various systems are available to close the exhaust during the colder months in order to conserve heat.

Insulation*.* Even with the conventional poultry house, it is well to provide some type of insulation. The roof may be insulated, using special products for this purpose, or an attic, or partial attic, may be installed. Attics should be ventilated with suction cupolas, or by vents.

Building materials and construction*.* Open-sided and environmentally controlled houses use a variety of building materials. The choice is dependent on the structural strength required, the insulative characteristics of the material, material availability, and material cost. Galvanized steel or aluminum are most commonly used for roofing and siding. Framing is usually done with wood or steel and some houses constructed recently have used the tilt-up concrete wall method of construction. Cages and other equipment can be supported either from the roof trusses or from the ground. However, most of the newer multiple-deck cage units are supported from the ground because of their weight.

Foundation*.* A solid and adequate foundation should support the building. Concrete, concrete blocks, bricks, or other permanent and termite-proof material should be used. Evenness of the foundation is important, for it will determine the evenness of the completed structure.

Floor. With certain disease-control programs, a concrete or similar floor is mandatory. It is also necessary when the soil is very dense and can absorb and transfer moisture from lower subsoil, but in certain areas, where the soil is sandy, and where commercial broilers or commercial layers or breeders are kept, a concrete slab is not used when birds are placed on the floor. Cage houses usually have concrete walks to facilitate the movement of hand egg collection carts and mobile feed carts. The area beneath the cages may or may not be paved depending on the manure removal program and method.

Doors. Doors at the end of the house should be large enough for a truck, tractor, or manure-handling equipment to pass through. Such equipment will be used

when the house is cleaned.
Orientation. Houses must be oriented in a direction to take advantage of prevailing airflow patterns. Orientation must also be considered relative to solar heat transfer into the building from exposed roofs or sidewalls. Pullet-rearing areas should always be located upwind from adult birds.

Open front and back Sides

With this type of house most of the side areas are open. The height of the opening will be determined by climatic conditions, and by the type of bird being housed, as follows:

Broilers and young chicks. From one-half to two-thirds of each side is left open, the exact amount being determined by summer and winter temperatures. When both heat and cold are to be dealt with, the size of the opening should be medium. Where heat is continuous, the opening should be larger; sometimes almost all of the side is left open.

Growing birds and layers. The opening size is greater for older birds. They should be provided with more air because bird density is greater and more ventilation is necessary.

Cage houses. Houses equipped with cages necessitate the greatest amount of air movement. The bird density is the greatest of any type of flock. Sides should be almost completely open.

Curtains during cold weather. Young chicks and older birds should be given some protection during periods of cold weather and extreme winds. Curtains made of some durable and plasticlike material usually provide this protection. They are installed down the length of the building and hung so that the entire curtain may be rolled up or down by cables and a winch located at one end of the building or by thermostatically controlled automatic winches. This construction makes it easy to regulate the size of the opening according to weather conditions—an almost indispensable provision.

Controlled environment house

A controlled-environment house is one in which inside conditions are maintained as near as possible to the bird's optimum requirements. Doing so usually necessitates a completely enclosed insulated house with no windows. Air is removed from the house by exhaust fans and fresh air is brought in through intake openings. Artificial light, rather than natural daylight, is used to illuminate the interior. Where high outside temperatures are involved, some method of controlling the temperature inside of the house is provided. The houses are not heated except for brooders. The heat from the birds is used to keep inside temperature within the range required for maximum feed efficiencies.
Much of the structural makeup of the environmentally controlled poultry house is similar to that of the house with open sides. It should have a good foundation and a gable roof. Insulation is a must; both the sides and the top should be given protection. The overhang of the roof need not be as great because the sides are completely covered. But ventilating a completely enclosed house is difficult. Details must be worked out so that air movement is adequate and evenly distributed during both hot and cold weather, a complicated procedure.

Insulation

Heat loss from a building can be reduced through proper use of insulation. To better understand the value of insulation, it is important to understand how heat is transferred between a poultry structure and the outside environment.

7. Heat Loss

Heat loss refers to the movement of heat from a warm area or surface to a cold area or surface. Heat can be lost or gained from poultry structures by passing through building materials and by infiltration. Insulation itself does not completely stop the passage of heat; it merely reduces the rate of heat movement. Heat is transmitted in one of the following ways or by a combination of them: conduction, convection, and radiation.

Conduction heat movement occurs whenever there is direct contact between hot and cold areas. For example, if one surface of a material inside a poultry facility is heated, the heat will pass through the material to the colder surface; this is called conduction.

Convection occurs when air at some temperature moves across a surface having a different temperature, thus transferring heat to or from that surface. Convection depends on some medium, usually air or water, for the conveyance of heat. Ventilation air and infiltration are normal modes of convection heat transfer.

Radiation heat loss occurs when there are two separate bodies or surfaces at different temperatures. The warmer body or surface will radiate heat to the colder body or surface without heating the air between them. The heat from the sun warming the earth is an example of radiated heat. Poultry can lose heat by radiation to a colder surface such as a wall or ceiling, or similarly gain radiant heat from a hot uninsulated roof.

2. What is Insulation?

The term insulation refers to materials which have a high degree of resistance to the flow of heat and are used principally for this purpose. Most insulations are fibrous or granular materials that contain many tiny air pockets or cells. Generally, the more air pockets in a material, the better it insulates. Some building materials, such as wood, have some insulating properties, while others, like concrete, are poor insulators. Wood has approximately ten times the insulating value of the same thickness of concrete.

Another kind of insulation, reflective, consists of paper coated with metal (usually aluminum) or metallic foil. Reflective materials insulate on an entirely different principle than the fibrous or granular materials. Their effectiveness is based on the fact that smooth metallic surfaces have the ability to reflect radiated heat much like a mirror reflects light. Reflective insulating materials are effective only if there is an air space on one or both sides of the metallic surface. Hence, reflective insulation will not function if placed between sheathing and siding or imbedded in concrete.

3. Why Insulation Is Needed

Insulation is placed in poultry houses to help maintain a desirable environmental temperature and to reduce the cost of winter heating or to minimize heat gains during summer. Providing a proper environmental temperature will help assure good animal welfare and therefore, optimum production performance.

4. Where To Insulate

In general, insulation should be placed in the ceiling and walls of a poultry house. In colder climates, perimeter insulation should be used.

A large amount of the total heat loss is through the ceiling (or roof) of a poultry house. If only part of a building is to be insulated, start with the ceiling or roof first. This is true for both hot and cold climates.

Insulation in sidewalls is important and feasible in the poultry house since a controlled environment is desirable. Sometimes window insulation in the form of double glass panes or plastic is practical.

Table 1

INSULATION VALUE OF MATERIALS THAT MAY BE USED IN POULTRY STRUCTURES"

Material	Thickness (cm)	Resistance Rating — RSI (m^2 • °C/W)
Air space, enclosed by ordinary materials	1.91—	0.16
Air space, aluminum foil one side	[illegible]	
Air space, aluminum foil both sides	1.91—	0.38
Surface film, inside (f,). nonreflective (gen.	1.91—	0.43
val.)		0.11
Surface film, inside (f|). reflective		0.19
Surface film, outside (f,,) 24.1 km/hr		0.03
Asbestos-cement board	0.32	0.01
Gypsum board or sheet rock	0.95	0.06
Gypsum board or sheet rock	1.27	0.08
Plywood	0.64	0.05
Plywood	0.95	0.08
Plywood	2.54	0.22
Hardboard	0.32	0.02
Insulation board, sheathing, regular density	1.27	0.23
Blanket insulation, mineral (rock) wool, or glass	2.54	0.65
Loose fill insulation, wood fiber	2.54	0.59
Loose fill rock wool or glass wool	2.54	0.65
Loose fill, vermiculite expanded	2.54	0.38
Sawdust or shavings	2.54	0.39
Foam insulation, expanded polyurethane	2.54	I.IO
Foam insulation, expanded polystyrene	2.54	0.70
extruded plain	10.16	0.14
Common brick	10.16	0.03
Face brick	10.16	0.20
Clay tile	20.32	0.33
Clay tile	20.32	0.20
Concrete blocks, regular	20.32	0.35
Concrete blocks, lightweight	20.32	0.11
Concrete, regular	1.91	0.17
Sheathing or flooring, softwood	1.91	0.12
Sheathing or flooring, hardwood	2.54	0.14
Drop siding, 20.32-cm wide	1.27	0.14
Bevel siding lapped. 20.32-cm wide	1.91	0.18
Bevel siding lapped, 25.4-cm wide		0.01
Building paper		0.03
Roll roofing, asphalt	0.95	0.06
Built-up roofing	0.95	0.08
Asphalt shingles. 3 tab		0.15
Wood shingles. 19.05-cm exposure		Negligible 0.02
Metal roofing		
Window, single glass		0.27
Window, single glass with storm sash		Negligible
Polyethylene vapor barrier		Negligible
Rolled sidewall curtain		

Types of Insulation

Insulation may be purchased in several forms — loose fill, blanket, bait, board, block, reflective, and foamed in place. In poultry houses, the types most often used are loose fill, blanket, batt, and board. The form selected for a particular purpose will be determined by consideration of the following:

- ❖ How is it to be used? Is it purely for insulation or should it have structural qualities?
- ❖ How adaptable is it to the particular use?
- ❖ Can it be applied easily?
- ❖ How resistant is it to insects?
- ❖ Susceptibility to moisture loading.
- ❖ What is its relative cost? The relationship between the R-value in SI units and the
- ❖ Thickness of materials shown in Table 3 can be used to assist in making relative cost determinations.

Insulation blankets, loose fill, and batts are made of loosely matted glass or mineral fibers, plant fibers, or crinkled paper. The blankets and batts may have a vapor-resistant paper on one side or a thin metallic foil bonded to reinforce paper. They may also be purchased unfaced. Blankets and batts range in thickness from 2.54 to 15.24 cm. Blankets and batts come in widths suitable for poultry house construction. The widths may vary from 40.64 to 182.88 cm. The wider widths may not be available except by special order. Batts are fairly short in length, usually 1.2 m, but blankets come in lengths up to 30.5 m. Board-type insulation is usually made from styrene, urethane, cane, or other cellulose fibers. It usually comes in a 1.2-m width and in lengths ranging from 1.8 to 6.1 m. Insulation may be used for sheathing as well as for interior surfacing. If used for interior surfacing, take special precautions to prevent buckling and losing insulation value due to moisture accumulation. It has been noted in most broiler production areas in the U.S. that the lesser meal beetle will tunnel into some board insulations such as styrene and urethane, which if not controlled can lead to a reduction in their insulation value. If this type of insulation is used in poultry structures, efforts to control the beetle and seal the insulation from being penetrated by the beetle may help control damage.

R-values for Insulating Efficiency

The efficiency of any insulating material, or combination of materials, or type of construction, is rated by its ability to resist the transfer of heat through it. There are many materials or combinations of materials used to insulate poultry houses, and the resistance of these materials to the transfer of heat has been given a practical term known as *R-value,* or thermal resistance. These are given in Table 11-4.

Vapor Barrier

To be effective, insulating material must be dry, since moisture can conduct both heat and cold. To prevent moisture from penetrating the outside wall or roof and wetting the insulation, a dead-air space between layers of material may be provided. This space is known as a *vapor barrier.* However, during the last few years new materials that take the place of the dead air space have come on the market. These materials are porous and do not conduct moisture. Therefore, they may be placed directly against other material, which makes them easy to install. Sometimes these insulating materials are placed on the underside of the rafters, thus leaving an air space between them and the roof sheathing or covering. Vapor barriers prevent insulation materials from becoming wet and thus losing insulation value. This is particularly critical in fibrous insulation materials. Vapor barriers without reflective surfaces do not normally have an insulating value. These barriers are often an integral part of the insulation material. The vapor barrier should always be placed on the warm or interior side of the wall. A good barrier permits $^1/_2$ perm or less of moisture vapor to pass through the material. A perm is the amount of moisture vapor, in grains, that will pass through a 929 cm^2 of material in 1 hr when the pressure difference is 2.54 cm of mercury.

How Much Insulation?

Obviously, there should be more insulation in cold climates than in warm or hot. But the average should show the following R-values:

Type of Climate	R-value for Roof and Ceiling	Walls
Hot climates	4	2
Medium climates	8	2.5
Cold climates	12-14	8-10

Determining the R-value of Walls and Roofs

Because each type of wall or roof covering has an R-value, the sum total of the R-values of the materials used will give the R-value for the wall or roof. Using Table 11-4, an example of the resistance value of a wall has been calculated as follow:

Wall Insulation Item	R-value
Outside surface	0.17
Metal siding	0.09
Vertical air space	0.91
2-in. fiberglass	7.40
1/4-in. plywood	0.32
Inside surface	0.61
Total resistance rating of wall	9.50

Types of Insulation

Each type of insulation has its advantages and disadvantages. The blanket or bat is usually made from some type of mineral, such as glass fiber. If it has a foil back be sure to install it so it is tight and there is little vapor loss. When such materials are moisture laden they lose their insulating value.

Some insulating materials are extremely flammable while others have flame retardants added to them. But even with retardants they emit a lot of smoke when burned. Most materials are tested and rated according to their flame spread and smoke development. In some locations the building code or insurance companies require a spread rating of 20 to 25, or less.

Table 2. R-values of Various Building Materials

Item	Thickness in.	Thickness cm	Resistance Rating
Insulation per 1 in. (2.5 cm) of thickness			
Blanket bat	1	2.5	3.70
Balsam wool (wood fiber blanket)	1	2.5	4.00
Cellulose fiber	1	2.5	4.16
Expanded polystyrene, molded (bead board)	1	2.5	3.50
Expanded polystyrene, extruded (Styrofoam®)	1	2.5	5.00
Urethane foam	1	2.5	6.60
Fiberglass (glass wool)	1	2.5	3.70
Palco wool (redwood fiber)	1	2.5	3.84
Rock wool (machine blown)	1	2.5	3.33
Rock wool (blanket)	1	2.5	3.33
Foam glass	1	2.5	2.50
Glass fiber blanket	1	2.5	3.33
Mineral wool	1	2.5	3.33
Insulation board	1	2.5	2.37
Vermiculite (expanded)	1	2.5	2.05
Wood fiber	1	2.5	3.33
Sawdust or shavings (dry)	1	2.5	2.22
Straw	1	2.5	1.75
Materials (thickness as indicated)			
Air space, horizontal	0.75 +	1.8 +	2.33
Air space, vertical	0.75 +	1.8 +	0.91
Asbestos cement	0.12	0.3	0.03
Building paper			0.15
Concrete	8.00	20.3	0.61
Concrete block	8.00	20.3	1.11
Hardboard	0.25	0.6	0.18
Plywood	0.25	0.6	0.32
Plywood	0.50	1.2	0.63
Surface, inside			0.61
Surface, outside			0.17
Siding, drop	0.75	1.9	0.94
Sheathing	0.75	1.9	0.92
Metal siding			0.09
Glass, single			0.61
Shingles, asbestos			0.18
Shingles, wood			0.78
Roofing (roll, 55-lb)			0.15
Vapor barrier			0.15