Chapter 4: Physical Plant

Sound animal care depends on a well-planned and properly maintained animal facility. The efficiency, economy, and functionality of the facility are influenced greatly by the design, maintenance, and operation of the structure and its equipment. The scope and types of planned agricultural research and teaching activities have an important impact on the size and design of a facility. Factors include the physical relationship of the facility to the institution or firm, animal species to be accommodated, and geographic location.

An agricultural engineer, professionally registered or eligible to be registered and with training and experience with agricultural animal facilities, should provide input on major construction and remodeling projects to design a workable and efficient physical plant. Animal scientists and veterinarians should also contribute to the design process. An agricultural engineer should be available for advice on maintenance and operation of the physical facilities.

Agricultural animal facilities should conform to applicable building codes unless deviations and variances are justified for research and teaching.

Security should be provided to protect facilities against break-ins by people and break-outs by animals. In addition, security alarms are needed to protect animals against equipment failures, power outages, and threatening environmental conditions such as smoke or temperature extremes.

LOCATION OF FACILITIES

Where agricultural animals are housed in fully enclosed buildings and there is need for nearby personnel facilities (e.g., offices, conference room, or preparation laboratory), animal houses and personnel facilities should be separated for expansion space and odor and pest control. Where agricultural animals are confined using fences or open shelters, enclosed buildings for staff and students may not be needed. Regardless of the degree of animal housing and environmental modification used, animal facilities should be designed to provide sound animal husbandry, maximal safety for animal care personnel, and efficient animal care. Vehicle access, feed and water supply, utility services, drainage, manure containment, expansion space, and aesthetics are other important considerations in locating facilities (MWPS, 1983).

FUNCTIONAL AREAS

Most research and teaching uses of agricultural animals require space for the animals to eat, drink, rest, sleep, and move about. In addition, space should be sufficient for the staff and equipment necessary for feeding and watering, waste removal, medical treatment, and other husbandry procedures. Provisions should be made for maintenance and repair of the equipment used for effective husbandry. Planning should also include provisions for delivering necessary husbandry services (e.g., feed, water, and waste removal) on a temporary basis when the regular equipment fails or is shut down for repair.

Some functional areas needed for the care of agricultural animals may be used only periodically for their designed function, but, at other times, may be part of a multipurpose area. Additionally, some situations do not require space for all possible operations. Professional judgment should be used when facilities are being designed to provide the appropriate functional areas or their substitutes. Nonetheless, agricultural animal operations generally require space for the following:

- animals (fenced, penned, or enclosed areas with waterers and feeders);
- water supply (animal, sanitation, fire, and emergency);
- feed storage between deliveries;
- electrical service (including an emergency generator);
- waste storage (excreta and contaminated drainage water);
- animal shelter (from excessive solar radiation, wind, rain, and snow);
- storage of equipment to handle feed and waste;
- storage of small tools and repair of equipment;
- veterinary examination, treatment (including surgery and necropsy), and supply storage;
- quarantine of animals;
- handling, sorting, weighing, loading, and unloading animals;
- research activities (instruments, laboratory, office, record keeping, and specific protocol needs);
- teaching activities (observing, individual handling, and discussion); and
- young animals.

In some facilities, space may also be needed for the following:

- bedding storage;
- storage of toxic materials and hazardous substances;
- semen collection, storage, and artificial insemination;
- experimental surgery (including preoperative preparation and postoperative recovery);
- chick hatching;
- work animals (e.g., horses and dogs);
- maternity care;

- species separation;
- sick and injured animals;
- slaughter and processing facilities; and
- carcass composting.

Additional functional areas may be needed when the teaching and research facility is remote, when required by local codes, or when needed for institutional efficiency. Such areas may include administrative offices and reception area; toilets, showers, and lockers; lunch room; animal or equipment cleaning; feed processing; hazardous waste storage; supplies receiving and shipping; and vehicle parking.

CONSTRUCTION GUIDELINES

Publications of the MWPS, the NRAES, and other organizations provide guidance on planning, specifications, cost estimation, and construction of commercial agricultural animal facilities in different parts of the United States. Appropriate local codes and zoning provide additional guidelines.

The selection of and specifications for functional and economical building materials should consider conditions of use common to various parts of the facility, including the following:

- animal impacts and behavior that may lead to structural damage (e.g., chewing, mounting, fighting, kicking, and escape attempts);
- animal traction and safety;
- contact time with wet and corrosive animal wastes, acidic silage, or cleaning solutions;
- moisture and fire resistance;
- personnel protection and safety;
- light reflectance;
- surface cleanability and sanitation;
- absence of stray voltage and proper grounding of electrical equipment;
- vermin control;
- waste handling; and
- sanitary requirements for food products (e.g., milk, meat, and eggs).

MATERIALS

Building materials should be selected to facilitate efficient and hygienic operation of agricultural animal facilities. Durable materials that are resistant to moisture and to fire are most desirable for interior surfaces. Unpainted wood is acceptable for most applications, except when treatment for structural damage and insects is not possible and the wood is in direct contact with the ground. Paints, glazes, and wood preservatives should be nontoxic, free of lead, and, where applicable, resistant to the effects of cleaning agents, scrubbing, and high pressure sprays and impacts (MWPS, 1983).

MAINTENANCE OF FACILITIES

Physical facilities that support agricultural research and teaching programs should be well-maintained. The physical plant should be in good repair, and the grounds should be free of trash, which injure animals (e.g., foot trauma or hardware disease).

CORRIDORS AND DOORS

When used, corridors should be wide enough to facilitate the movement of animals, personnel, and equipment. Doors vary in size according to the function they serve. In enclosed facilities, doors should fit tightly within their frames, and both doors and frames should prevent the entrance or harboring of vermin. Exterior doors should be equipped with locks.

FLOORS AND WASTE HANDLING

Dirt floors are acceptable in sunshades, open (run-in) sheds, pens, or shelters where climate, animal use, and management intensity permit a firm, dry, easily cleaned base support. Floors in barns should be relatively slip-free; not excessively abrasive to animals' feet; and resistant to wear, corrosion, moisture, and manure. Uniform slopes (1 to 4%) for drainage and an appropriate concrete finish should be provided for animal traffic areas. Slip-resistant grooves should be provided for ramps (sloping 5 to 15%), for concrete floors, and for other floors where slipping and falling may take place. Cleat spacing is an important factor in determining appropriate ramp slopes (Phillips et al., 1988, 1989; Grandin, 1993).

The finish of concrete floors on which animals walk is critical. Diamond grooves 1.3 cm deep × 10.2 cm (.5 in deep × 4 in) are preferred. A coarse wood float finish with the approximate texture of coarse sandpaper is acceptable. Polished steel-troweled finishes are slippery and only acceptable for dry areas (Applegate et al., 1988; MWPS, 1989a).

Waste handling systems should be considered as part of the floor design. Manure slots and gutters should be sized and spaced to prevent hoof or ankle injury of animals occupying the facility. Slotted floors and grates separate animals from their excreta and are an integral part of several acceptable and desirable waste handling systems. Other systems utilize mechanical scrapers or hydraulic flushing to clean the floors, gutters, or manure channels. Open lagoons and waste storage ponds should be surrounded by a security fence.

Solid floors used as resting or recovery areas for some species should be covered with a cushion of dry, absorbent bedding or rubber mat to reduce skin irritation from concrete, urine burn, or manure caking on the body surface. The amount and type of bedding used should be compatible with the waste-handling system.

Acid-resistant plastic overlays or ceramic tiles may be desirable for silage mangers, milking room floors, and other special areas. Resilient plastic or rubber mats are desirable for areas such as work stations, animal-holding stalls, and treatment pens.

WALLS AND CEILINGS

Walls and ceilings enclose interior space for security and environmental modification but may be unnecessary or undesirable for some animal shelters or storage buildings. The degree of environmental modification specified by the user directly affects the thermal resistances; moisture permeabilities; surface finishes; openings for doors, windows, vents, and fans; and lighting equipment chosen by the designer for walls and ceilings. Surfaces should be easy to clean and resistant to damage from animal contact and impact where these normally occur.

ENVIRONMENTAL MODIFICATION SYSTEMS

Environmental modification systems for agricultural animal facilities range from negligible (e.g., fenced pasture with no additional shelter) to complex. The system should be appropriate for the animal species and ages and the local climatic conditions. In enclosed structures, the system should be capable of maintaining environmental conditions within an acceptable range (Chapter 2 and Chapters 5 though 11; MWPS, 1983).

There are two basic housing categories for cold weather housing of agricultural animals, cold housing and warm housing. Proper design of each is critical to provide an acceptable microenvironment. Although all species can be housed in either kind of house, certain species normally receive better husbandry in one kind than in the other in a specific climatic region. In some parts of the United States, cattle, horses, sheep, and goats are better served year-round by cold housing systems, and poultry and swine are better served by warm housing systems. Newborn animals of all species have special environmental requirements, especially during cold periods.

Cold Housing

Cold housing systems provide primary environmental modifications and are designed to protect the animals from solar radiation, wind, snow, rain, and other hot and cold weather extremes. Cold houses usually provide the animals with a microenvironmental temperature that is no more than 5°C above the outdoor temperature. Strategically placed openings throughout the shelter must be provided to ensure that ventilation is adequate to control water vapor. For hot weather operation, the shelter acts as a sunshade, and additional openings then facilitate natural air movement through the animal space. Mechanical fans are sometimes used to augment air movement in hot weather (MWPS, 1989b).

Warm Housing

Warm housing involves either mechanical ventilation with fans and controls, natural ventilation with controlled openings, or combinations of the two. Ventilation is designed to provide acceptable air quality, humidity, and thermal conditions for a specific species (MWPS, 1990).

Sensors. Sensors used to regulate an environmental modification system should be located and operated to monitor conditions representative of the animal microenvironment. Sensors should perform satisfactorily in agricultural animal environments and be calibrated and maintained regularly.

Controllers. Controllers should be staged properly for effective use of heating, ventilating, and cooling equipment. Written instructions for the proper operation and sequencing of controllers should be provided to animal care personnel and be readily available near the controllers. When the ventilation system depends on fans or power-controlled openings, a warning device is needed to alert the building operator to a power interruption. A standby, automatic electric generator or automatically opening wall ports are needed to protect animals if the warning device does not reliably reach personnel who can attend to the animals' survival. It is important that electric generators and other emergency equipment be checked regularly to ensure that they are operational.

REFERENCES

Applegate, A. L., S. E. Curtis, J. L. Groppel, J. M. McFarlane, and T. M. Widowski. 1988. Footing and gait of pigs on different concrete surfaces. J. Anim. Sci. 66:334-341.

Grandin, T., ed. 1993. Livestock Handling and Transport. CAB Int., Wallingford, Oxon, UK.

MWPS. 1983. Structures and Environment Handbook. Publ. MWPS-1. MWPS, Iowa State Univ., Ames, IA.

MWPS. 1989a. Farm and Home Concrete Handbook. Publ. MWPS-35. MWPS, Iowa State Univ., Ames, IA.

MWPS. 1989b. Natural Ventilating Systems for Livestock Housing. MWPS-33. MWPS, Iowa State Univ., Ames, IA.

MWPS. 1990. Mechanical Ventilating Systems for Livestock Housing. MWPS-32. MWPS, Iowa State Univ., Ames, IA.

Phillips, P. A., B. K. Thompson, and D. Fraser. 1988. Preference tests of ramp design for young pigs. Can. J. Anim. Sci. 68:41-48.

Phillips, P. A., B. K. Thompson, and D. Fraser. 1989. The importance of cleat spacing in ramp design for young pigs. Can. J. Anim. Sci. 69:483-486.