FEEDLOT DESIGN AND CONSTRUCTION

44. Covered housing systems

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Introduction

Animal welfare, environmental and practical management of a feedlot all become greater issues in areas with more extreme conditions such as high rainfall or low temperatures. For example in hot, high rainfall areas, the feed gets wet and animals are heat stressed; in cold, wet and windy areas, the issues are cold stress with manure management and cleanliness of cattle (e.g. dags).

In more extreme environments, covered housing is usually adopted to control climate and minimise the effect of adverse weather conditions, and improve cleanliness and the welfare of cattle. Environmental management issues such as minimising odour and/or effluent runoff are additional secondary advantages.

The covered housing system adopted will depend upon the level of protection required and the issues being addressed, such as more ventilation against hot conditions or less ventilation against cold winds.

The main disadvantage of covered housing is the initial capital cost of constructing sheds and the ongoing costs associated with maintaining pen bedding and managing manure. The higher stocking density possible results in an increased accumulation of manure, and this also stays wet due to the shaded environment. Some form of absorbent bedding is required to hold moisture and provide an acceptable surface over the concrete floor for cattle to lie on. A slatted floor will allow urine and manure to pass through to a drainage system below. Slats should have a non-slip surface for cattle.

Design objectives

Covered housing systems should be design and constructed to

- provide a housing environment for cattle where animal welfare and protection from the environment are maximised
- provide a housing environment that maximises production performance of cattle and is functional from perspectives of feed management, livestock handling and manure management
- promote safe access for cattle to and from the feeding pens
- be structurally sound
- promote good natural ventilation
- optimise the management and removal of manure and spent bedding from the pens
- minimise ongoing maintenance costs
- provide a safe working environment for people.

Mandatory requirements

Compliance with

- Australian Animal Standards and Guidelines for Cattle (DAFF, 2013)
- National Guidelines for Beef Cattle Feedlots in Australia (MLA, 2012a)

- National Beef Cattle Feedlot Environmental Code of Practice (MLA, 2012b)
- NFAS standards (AUS-MEAT, 2011).

The building elements such as concrete footings, floor slabs and steel structures should comply with the structural provisions of the Building Code of Australia (BCA) and local building regulations and be designed in accordance with the relevant Australian standards.

Design choices

New construction or redevelopment of a covered housing facility must incorporate factors such as

- site selection and location
- shed configuration and orientation
- shed design e.g. cross section, layout
- ventilation
- insulation
- water reticulation and placement
- feed distribution
- lighting
- waste collection and management
- pen layout and design
- durability and maintenance.

Site selection and location

Selecting an appropriate site for covered housing within the overall layout of the feedlot will optimise the efficiency of operations, as covered housing facilities are permanently located.

Most site selection criteria for uncovered feedlots can be applied to covered housing systems e.g. manure storage, livestock handling, feed processing and distribution, access, topography, water storage and supply, drainage and geotechnical aspects. However, some criteria such as pen area, stocking density and topography are quite different. Site considerations are discussed in *Section 2 – Feedlot site layout*.

Shed configuration

The housing configuration depends on the issue being addressed e.g. exclusion of rainfall or cold winds.

The roof may partially (Figures 1 and 2) or fully cover the feeding pens (Figures 3 and 4). In a partially covered design, the roof would cover the feed bunk only or the bunk plus about one third of the pen area. The sides of the structure may be closed, partially closed or open. As a minimum, the feed bunk area should be covered. Fully covered pens cost more but reduce effluent control requirements as there is no pen runoff. Partially covered pens cost less, but require effluent control systems.

Fully covered double row housing system

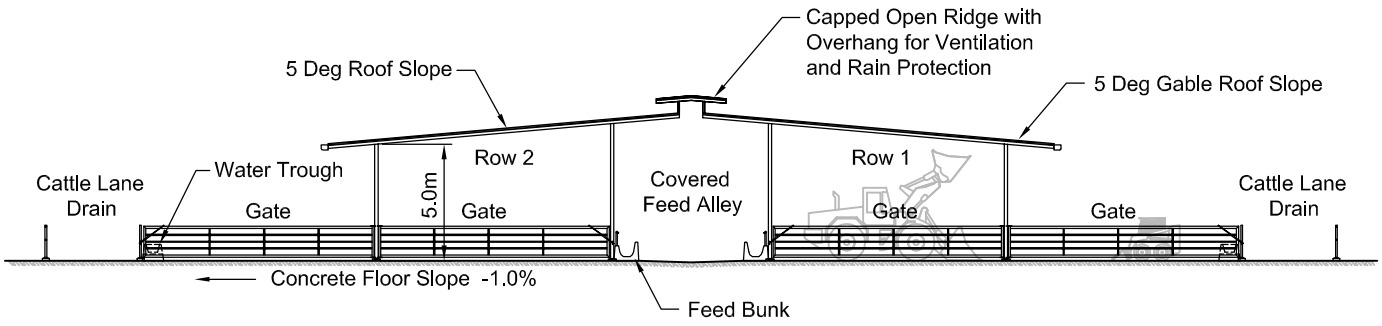

Figure 1. Typical end elevation – partially covered double row shed

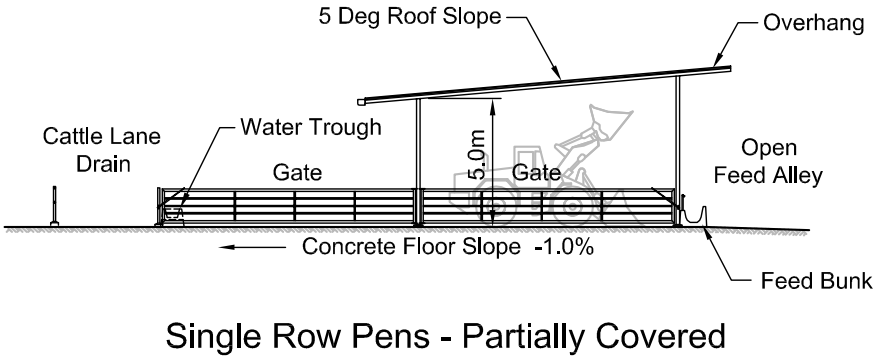

Figure 2. Typical end elevation – partially covered single row shed

Gable roof with centre ridge vent – no end or side walls and a high ceiling height promote good ventilation.

The small concrete end walls enable pen cleaning equipment to pick up spent bedding.

Orientation

The orientation of the shed depends on the environmental issue being addressed. An east-west orientation of open-sided sheds will result in less direct sunlight penetrating underneath the roof or awning during daylight hours. A north-south orientation will allow sunlight into the pens during the morning and afternoon to promote the drying of bedding material.

If protection from cold, wet and windy conditions is required, the open side of the shed should be away from prevailing wind direction and preferably north facing.

Shed spacing

Multiple sheds should be spaced apart a distance of three to five times the eave height for adequate natural ventilation and for fire safety considerations (Figure 5).

Shed design

The main purpose of a shed design is to protect cattle from cold wind, rain and/or extremely high or low temperature. Uninsulated, open, naturally ventilated housing is recommended over fully enclosed environmentally controlled systems.

Environmentally controlled systems need to be heavily insulated and supplemented with additional cooling or heating methods if required. The shed will also require a controlled mechanical

ventilation system that maintains a satisfactory air quality within the structure. Apart from the cost element, environmentally controlled systems are less practical from a feed delivery, animal movement and manure management perspective for beef cattle.

The shed design may be a single row of pens under cover (Figure 3) or a duplicate row of pens on either side of a central feed alley (Figure 4). Sheds should be designed with high eaves, open sides and open ridge caps to promote ventilation. If cold winds are to be excluded, wall sheeting will be required to partially or fully close in the appropriate sides. Mechanical ventilation may be required to ensure adequate air circulation and ventilation. Ridge caps must allow sufficient overhang to prevent wind-driven rain passing through the gap. Sheds must allow easy access for machinery to deliver feed and clean pens.

The depth of the shed increases the level of wind protection for cattle.

Partially covered single row housing system

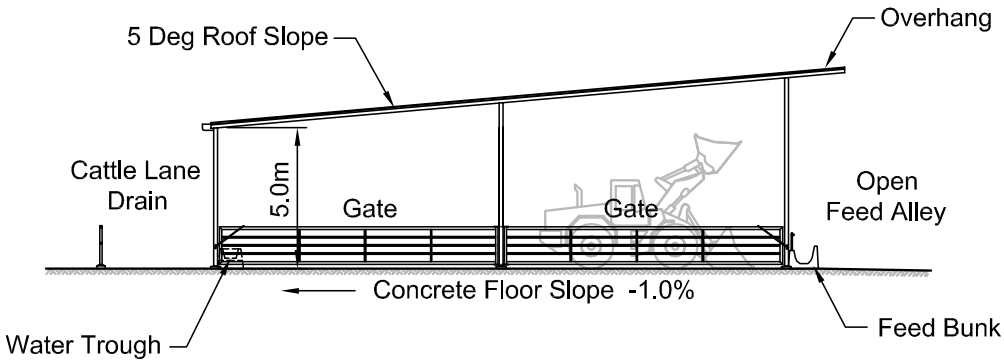

Figure 3. Typical end elevation – fully covered single row shed

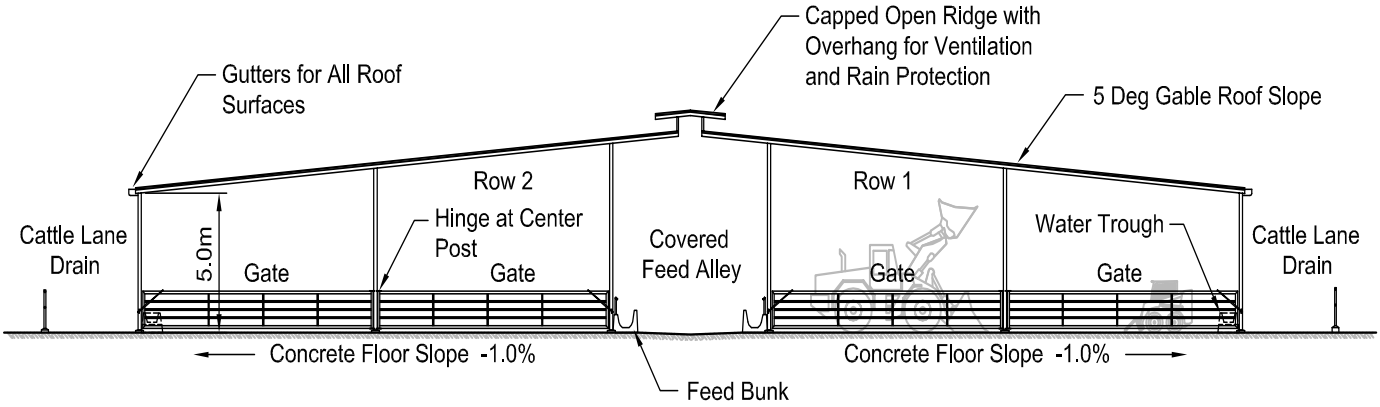

Figure 4. Typical end elevation – fully covered double row shed

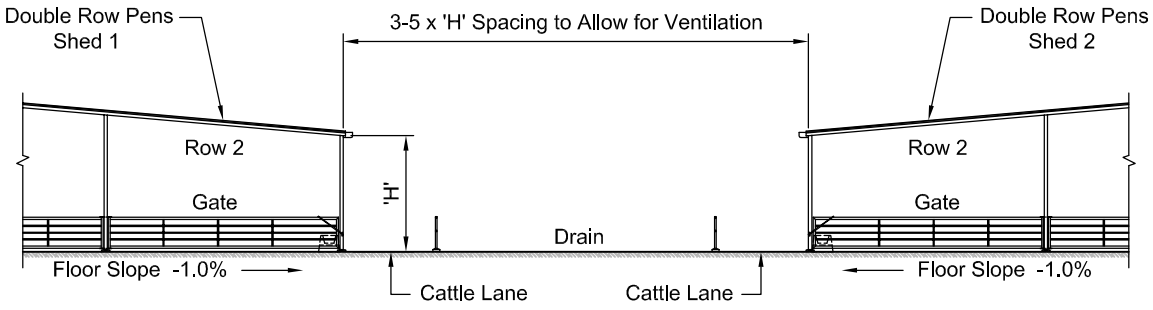

Figure 5. Typical end elevation – fully covered single row shed

Single row gabled roof system with uncovered feed bunk

Gable, trussed roof with sheeted end wall

Eave height

The type and working height of machinery that will be used, combined with a suitable clearance (600 mm minimum) to overhead structural elements such as beams and roof sheets, will determine the minimum eave height. Typically, the minimum eave height will be about 3.5 m.

Ventilation

Proper ventilation of covered housing systems is of paramount importance for people working in the facility as well as for animal health and performance. Proper ventilation consists of exchanging air inside the structure with fresh air from outside uniformly throughout the structure. The required rate of air exchange depends on a number of variables including the conditions of the outside air (temperature and moisture level), cattle population and stocking density.

High moisture, manure emissions (particularly ammonia), pathogens and dust concentrations in poorly ventilated or unventilated housing provide an adverse environment for cattle and employees. For example, ongoing levels of high humidity can be a contributing factor to lung infection and respiratory disease in cattle.

Air intake and exhaust openings should be provided (Figure 4) when localised winds do not provide adequate ventilation. Sidewall openings can provide air intake. Air exhaust vents should be located in the peak or apex of a gabled shed and should extend the length of the roof line (Figure 4). The amount of rain that can enter the shed through this vent should be minimised by adequate capping along the length of the roof line.

Mechanical ventilation such as fans or blowers should not be required if the shed is designed and located properly. If mechanical ventilation is required, fans should exhaust air from the structure and be mounted such that pen cleaning machinery is not obstructed.

Lighting

Artificial lightning should not be required in open, naturally ventilated housing. In fully enclosed sheds, skylights should be considered or the installation of artificial lighting.

Support columns

Where possible, clear span structures are preferred. Columns should not be placed inside pens other than in line with fences. No columns should be placed on the alley side of feed aprons or troughs. Columns should be encased in concrete to a height of approximately one metre (1m) to prevent corrosion around their bases and damage from pen cleaning equipment.

The support column spacing will be determined by the pen shape and size.

Roofing

For single row shed design, a mono-slope roof is adequate. Mono-slopes are most identifiable by their sloped roof or truss. The pitch of the roof has an effect on ventilation, water carrying capacity of the roof area and lifespan. Typically with a steeper roof, more debris is washed off the surface during rain events, improving its effective lifespan.

Typical roof pitches are in the order of 2° to 18° but a minimum roof slope of 5° (1V:12H) is recommended. As the pitch of a roof line increases, the overhang on the high side also needs to increase so that rain does not enter the shed; similarly, less overhang is required on the low side. Figure 3 illustrates a mono-slope roof shed.

For sheds with double row layouts and a central feed alley, a gable building with a central roof vent will be required (Figure 4). Roof pitches should be steep and high enough to promote good natural ventilation and rainfall runoff with a minimum roof slope of 5° (1V:12Hd).

All roof runoff should be collected in gutters and diverted away from the controlled drainage area of the feedlot. As the runoff is not contaminated it may be directed to storage ponds for later use.

Roofing is most commonly metal sheeting of various profiles. A wider profile (e.g. trim deck) has a larger water carrying capacity than a closer or corrugated profile.

Roof water collection system

Bedding storage

A supply of bedding will need to be stored under cover in or near the building/s to reduce hauling costs. Storage space depends on the number of cattle, stocking density, bedding density and frequency of replenishment. Bulk density will be primarily influenced by moisture content.

Table 1. Bulk densities of bedding materials

Bedding material	Bulk density kg/m^3
Sawdust	250–400
Whole, unground rice hulls	110
Sand	1200
Cereal straw	100–180
Wood chips	350–500

Pen layout and design

A good pen layout promotes quiet and safe cattle movement, good access to feed and water, efficient removal of manure and spent bedding and free drainage. The following factors should be considered when designing the pens for covered housing systems.

Stocking density

The stocking density describes how much area is allowed for each animal in the pen. Refer to *Section 9 - Overall pen layout* for further information on stocking density with the stocking density selected on the size of animals to be fed and the type of housing intended. Densities in the range between 2.5 m^2 and 6.0 m^2 per head are recommended for fully covered pens, while 5.0 m^2 to 9.0 m^2 per head is adequate for partially covered pens. The higher stocking density and associated heavier moisture (in manure) accumulation rate requires some form of absorbent bedding.

Double row housing feed bunk

Single row housing with delivery of feed by gantry system running on fixed rails and connected to conveyor belt.

Bunk space per head

The feed pen must ensure cattle free access to feed. The feed apron or trough should run along the full length of the front of the pen, while the water trough should be located at the rear of the pen. A minimum of 180 mm of feed trough space should be allocated for each animal in the pen. See *Section 19 – Feeding systems* for further detail on feed bunks.

Pen slope

A gradual slope from the feed apron or trough to the rear of the pen is necessary to drain any moisture that is not absorbed by the bedding. Slopes should be between 0.5% and 1.5% for covered pen surfaces and between 1% and 2% for uncovered pen surfaces. A sufficient grade on the pen will also help shed water during the construction phase.

Pen capacity

The pen capacity should be aligned with the expected consignment numbers or multiples thereof of cattle entering or leaving the feedlot. Often this will match the number of cattle that can be transported on a single deck of a standard livestock transport vehicle (see *Section 22 – Receival and dispatch*).

Dimensions

The dimensions of a feed pen depend on the holding capacity of the pen, stocking density and the amount of feed trough space required. Figure 6 shows how stocking density (SD), trough length (TL) and pen capacity relate to the dimensions of a typical feeding pen. Where shed structures require columns within the pen area, pen dimensions may be also be determined by the spacing of the shed frames to ensure that fences are in line with columns.

A pen depth twice the width allows gates to be installed in the fenceline which can be swung across the face of the pen to temporarily pen the cattle either against the rear of the pen or feed bunk, to allow pen cleaning to occur without removing the cattle from the pen. In this arrangement, the entire row of pens can be cleaned along one side simultaneously. The cattle can then be moved to the opposite side of each pen by swinging the second gate across the face of the other half of the pen, enabling the row of pens to be cleaned.

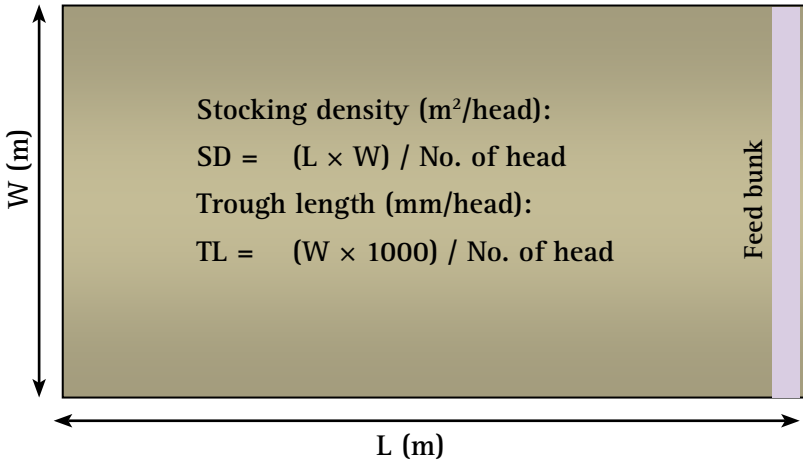

Figure 6. Dimensions of a single pen

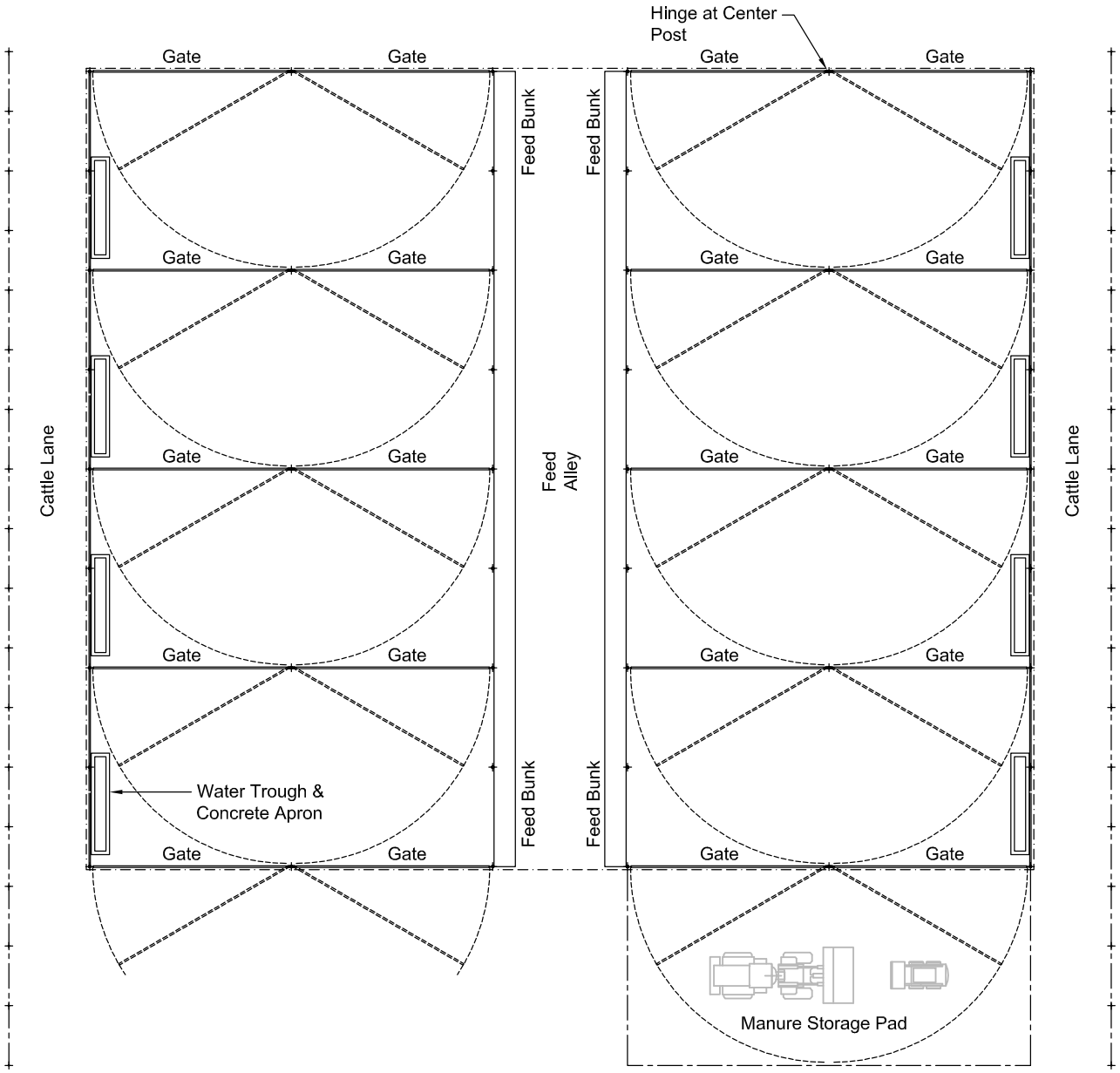

Figure 7. Plan view of a double row of pens with a central feeding alley

Gates and fencing

Gates and fencing provide a way of safely moving cattle around the feedlot in a controlled way, in all weather conditions and with minimal disruption to other feedlot operations. The design criteria for gates and fencing in a covered housing feedlot are similar to an uncovered feedlot. These considerations for gates and fencing are discussed in *Section 15 – Fences, gates and lanes*. The following additional factors should be considered when designing gates and fencing for covered housing systems.

Cattle access lane outside housing shed

Location

Cattle must be able to easily move into and out of the pens when being handled. Cattle lanes for access to the feeding pens should run along the bottom end (opposite the feed apron or bunk) of

Half-covered cattle lane running length of shed – roof is guttered to prevent runoff directly into cattle lane.

the pens. Laneways may be positioned inside (covered) or outside the shed. Cattle can be moved into feeding pens through gates on the back fence of pens, which open into and across the laneway. Where possible, cattle lanes should not cross any service roads as disruption to feeding and cleaning operations can occur when moving cattle. If the spacing of the sheds is adequate, cattle lanes can be shared by a row of pens on either side.

Width

Cattle lanes should be between 4 m and 5 m wide to allow free movement of cattle and machinery (if required). See *Section 15 – Fences, gates and lanes* for further information on cattle lanes.

Surface

If the cattle lanes are under the roof of the shed, they are best concreted so that cattle can be moved around the shed in any weather conditions. The surface should be stamped with a grooved pattern to prevent cattle slipping. See *Section 24 – Buildings* for further information on non-slip concrete surfaces. If the cattle lanes are not under the cover of the roof, they can be constructed of sound base material.

Slope

Cattle lanes should have a longitudinal slope of approximately 0.5 to 1% to assist drainage.

Materials

Materials are identical to those used in open-air pens. See *Section 15 – Fences, gates and lanes*.

Water troughs

Cattle must have free access to water. For fully covered pens, the water trough should be located at the rear of the pen with its length parallel with the back fenceline, rather than in the dividing fenceline between pens where it would prohibit pen to pen cleaning (Figure 7). Use Position F as shown in *Section 20*.

For partially covered pens, the water trough should not be located at the rear of the pen with its length parallel with the back fenceline as this will restrict drainage out of the pen. Use Positions A or D, not Position F, as shown in *Section 20*.

Water trough design is similar to open air pens. See *Section 20 – Water trough design and sewer systems* for further detail on water troughs.

Parallel slatted flooring

Flooring

The flooring should provide a comfortable and safe surface for cattle to move and rest on, while maintaining good pen hygiene through easy pen cleaning and good drainage.

Surface

Concrete surfaces are strongly recommended for all covered housing systems. A smooth surface under the bedding area will make cleaning easier, but with non-slip finishing for people traffic areas and where bedding is not applied. *Section 24 – Buildings* provides more information on non-slip concrete surfacing techniques.

If underground drainage is installed under the covered pen surfaces, bedding material will not be required as parallel slats will allow urine and manure to pass through the floor surface into the drainage area below. The slats should be covered in a hard plastic or hardened rubber material to ensure adequate softness for cattle and a non-slip surface.

Slatted flooring

Pen cleaning and bedding management

Bedding

The main purpose of bedding is to provide soft flooring, improve animal comfort and to absorb manure moisture. Bedding is only required in sections of the pen which are covered.

Bedding materials may be categorised as organic or inorganic. Organic materials include straw, hulls (rice/peanut) and sawdust and dry compost (Table 2). Dry bedding should be placed in the pen to a depth of approximately 200 mm and should be removed when it is unable to absorb any further moisture or manure. It is then taken to a manure storage area or directly off site.

An alternative is to install slats with a protective coating over an underground drainage system.

Pen cleaning

Pens will need to be cleaned every two to three weeks depending on the stocking density and type of bedding material used. For covered pens, cleaning involves the removal of spent bedding material along with manure and other solid wastes. An appropriate flooring/bedding system should allow material to be removed mechanically. Uncovered pens that have concrete floors may be washed clean by rainfall, although hosing may be used if necessary.

Sawdust bedding to absorb urine and improve animal comfort

The ability to clean pens practically and efficiently should be considered in the housing design and pen layout.

If a push-through system is used, a manure/spent bedding stockpile area may be needed at the end of the pen row (Figure 7).

Where parallel slats are installed over an underground drainage system, feeding pens can be cleaned regularly and the drainage system flushed as required or on demand.

Drainage and effluent collection

Runoff from contaminated areas must be directed to the effluent management system. For fully covered housing systems, this will include cattle lanes, manure stockpile areas, livestock handling facilities and feed processing areas, including silage and liquid feedstuffs storage areas. For partially covered housing systems, runoff from the open air pens will also need to be contained within the controlled drainage area.

Drainage slopes for cattle lanes will be similar to those in uncovered feedlots (see *Section 10 - Pen and drainage systems*).

Sedimentation structures will be required only for partially covered pens and will be similar to those in uncovered feedlots (see *Section 11 – Sedimentation removal systems*). Design and construction of holding ponds will be identical to those in open air feedlots (see *Section 12 – Holding pond design*).

Clean runoff (from roofs and grassed areas) should be excluded from the effluent management system where possible to minimise the required system capacity, with roof runoff able to be stored for reuse

Table 2. Suitability of bedding type for Australian feedlots

Type	Absorbency	Durability	Porosity	Recyclability	Key factors that influence the suitability and uptake of bedding materials
Woodchip (screened chip)	*Avg.	Good	Avg.	Good	More durable than straw and sawdust. Porosity within a woodchip bedded area typically lasts longer than a straw or sawdust bedded area.
Woodchip (Post peeling)	Avg.	Avg.	Avg.	Poor	Larger woodchip pieces can be recycled (i.e. screened from spent bedding). Easier to handle, transport, distribute and remove from feedlot pens than straw. Sharp woodchip pieces assist in removing/wearing dags off cattle.
Corn stubble /straw	Good	Avg.	Good	Poor	Good absorbency and provides softer, more comfortable lying surface for cattle than woodchip. Longer straw particles create a stronger, more durable bedded area that allows better drainage than chopped straw.
Sawdust	Good	Poor	Poor	Poor	Good absorbency and provides softer, more comfortable lying surface for cattle than woodchip. Poor durability once wet/saturated. Longevity reduced through interaction with rainfall.
Rice hull	Poor	Poor	Good	Poor	Rice hulls have good porosity and thermal insulation properties. However, their fluffy nature reduces transport efficiency and makes them difficult to handle.
Almond hull	Avg.	Poor	Avg.	Poor	Almond hulls have average absorbency and porosity, but they may be considered palatable by cattle. Availability and uptake limited to processing locations in north western Victoria and NSW Riverina.
Composted manure	Good	Poor	Poor	Poor	Very absorptive but not considered suitable as a bedding material in Australian feedlots.
Sand	Poor	Avg.	Poor	Avg.	Low porosity reduces its effectiveness and high bulk density makes it expensive to transport. Hard to recycle (unless washed) and can be abrasive on soft hooves.
Recycled rubber chip	Poor	Poor	Avg.	Avg.	No data found on use in cattle feedlots. Potential concerns of heavy metal contaminants from the recycled tyres.
Parallel slats	Poor	Good	Poor	Avg.	Suitable over underground drainage system. Limits moisture and accumulation of spent bedding. Requires underground flushing mechanism to remove urine and manure deposits. Provides enhanced welfare outcomes as feeding pens can be clean(ed) all year round.

Solid waste management

Solid wastes are most easily handled when they are dry. Skid steer loaders are suitable for cleaning pens or sedimentation structures and can load solids into trucks, which then transport the material to storage areas.

Solid waste management systems must have enough capacity to store solids produced from the feedlot as they dry and are further processed for reuse. Reuse or removal (further value-adding or sale) of stockpiled solid wastes will reduce the required capacity of storage systems.

If odour was a reason for adopting covered housing, solid waste material must be kept as dry as possible to limit excessive odour and emissions. The stockpile area may need to be under cover in high rainfall areas.

All storage areas must be located within the controlled drainage area and provide adequate drainage to allow stockpiled solids to drain and dry in the stockpile. Drainage from the storage area must be directed into the effluent management system (see *Section 10 – Pen and drainage systems*).

Quick tips

- Partially covered pens cost less but require effluent control systems.
- The full advantages of a covered housing system are not realised unless the pen area is completely covered.
- Sheds should be designed with high eaves, open sides and open ridge caps along the apex to promote ventilation.
- Roof pitches should be steep enough to promote ventilation. A minimum roof pitch of 5° (1V:12H) is recommended.
- All roof runoff should be collected in gutters and diverted away from the effluent management system.
- A pen depth twice the width allows gates to be installed in the dividing fenceline that can be swung across the pen to temporarily hold cattle for pen cleaning or maintenance.
- Roof support columns should be placed in line with fences.

Further reading

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