

Design and performance of a swine finishing barn for production and manure research

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Campbell, A.J., Van Lunen, T.A., MacLeod, J.A., Hurnik, D. and Linkletter, G. 2003. **Design and performance of a swine finishing barn for production and manure research.** Canadian Biosystems Engineering/Le génie des biosystèmes au Canada **45**: 5.1-5.6. The objective of this paper is to describe the 1000 head grower/finisher swine research unit and how it addresses the research needs associated with the growing and finishing phases of pork production, including integration of manure studies with studies of other production variables. The facility utilizes an all in/all out production system, cycling approximately every four months. The design of the facility allows for manure collection and feed delivery on an individual pen basis. Feed is delivered via a cart utilizing electronic scales to measure feed allocation to each pen. In the slatted portion of the barn, a separate manure cell is located under each pen. In the deep bedded portion of the barn, solid manure can be collected from each pen using a front end loader. Results to-date indicate that the design and location of the barn facilitates research into aspects of nutrition and manure management in pork production.

L'objectif de cet article est de décrire une unité de recherche porcine d'une capacité de 1000 têtes en croissance/finition et de présenter comment cette unité répond aux besoins de recherche associés aux phases de production croissance et engrangement, incluant l'intégration d'études sur la gestion des lisiers et fumiers ainsi que des études sur d'autres variables touchant la production porcine. L'unité utilise la technique de production tout plein tout vide, avec des cycles de production d'une fréquence de quatre mois. Le design des installations permet l'accumulation du lisier ou du fumier et la livraison d'aliments individuellement à chacun des parcs. Les aliments sont livrés par un chariot muni de balances électroniques pour mesurer la quantité d'aliment fournie à chaque parc. La partie de la porcherie sous caillebotis est dotée de dallots indépendants situés sous chaque parc. Dans la portion de la porcherie sous litière profonde, le fumier solide peut être repris dans chaque parc à l'aide d'un chargeur frontal. Les résultats obtenus jusqu'à maintenant indiquent que le design et la localisation de la porcherie facilitent les travaux de recherche portant sur différents aspects de la nutrition et de la gestion des lisiers/fumiers en production porcine.

INTRODUCTION

Recently, the North American pork industry has changed from a predominantly farrow to finish system to a multi-site production system where pigs are weaned and moved to a location away from the breeding herd. Several weeks later, they

are moved again to a third site for growing to market weight. This results in two breaks wherein disease transmission can be reduced or eliminated.

Traditional grower/finisher units have been based on liquid manure handling systems. Problems with such systems are well documented. They include objectionable odours during collection, storage and application, low manure nutrient density, and the risk of pollution from improper land application or storage failure. On the positive side, liquid manure systems have a low labour component, resulting in reasonably clean pigs, and allowing for an efficient handling system using various combinations of pumps, tankers, irrigation piping, and drag hoses (Barrington and Cap 1991).

Before liquid manure systems became popular, pigs were housed on bedding or solid manure systems. Pens had solid floors and required daily scraping and the addition of new bedding. As barn size increased, the labour requirement became excessive and liquid manure systems became the norm. For an all in/all out production system, producers are now experimenting with modern bedding systems which require only periodic cleaning and bedding additions with a total barn clean out at the end of each production cycle. One such system is the high-rise swine finishing building under test in West Central Ohio (Mescher et al. 1999). In this case, solid manure was collected on a bulking agent under a fully slatted floor. Solid manure systems offer such advantages as higher nutrient density (thus reduced transportation costs), inexpensive storage in piles, and fewer objectionable odours. Manure removed from our barn is already partially composted. Bedding must still be obtained and stored and labour is required to add and remove it from the barn.

There are many aspects of pork production for which the producer and the consumer must be concerned. Some of these aspects are profitability (cost of production versus market price), animal nutrition and health, impacts on the environment, and animal welfare, as well as meat quality and safety. An integrated research team approach and special facilities are required to address the complex issues in a production system. To address these issues, a 1000-head grower/finisher barn was developed as an experimental unit. The unit incorporated liquid

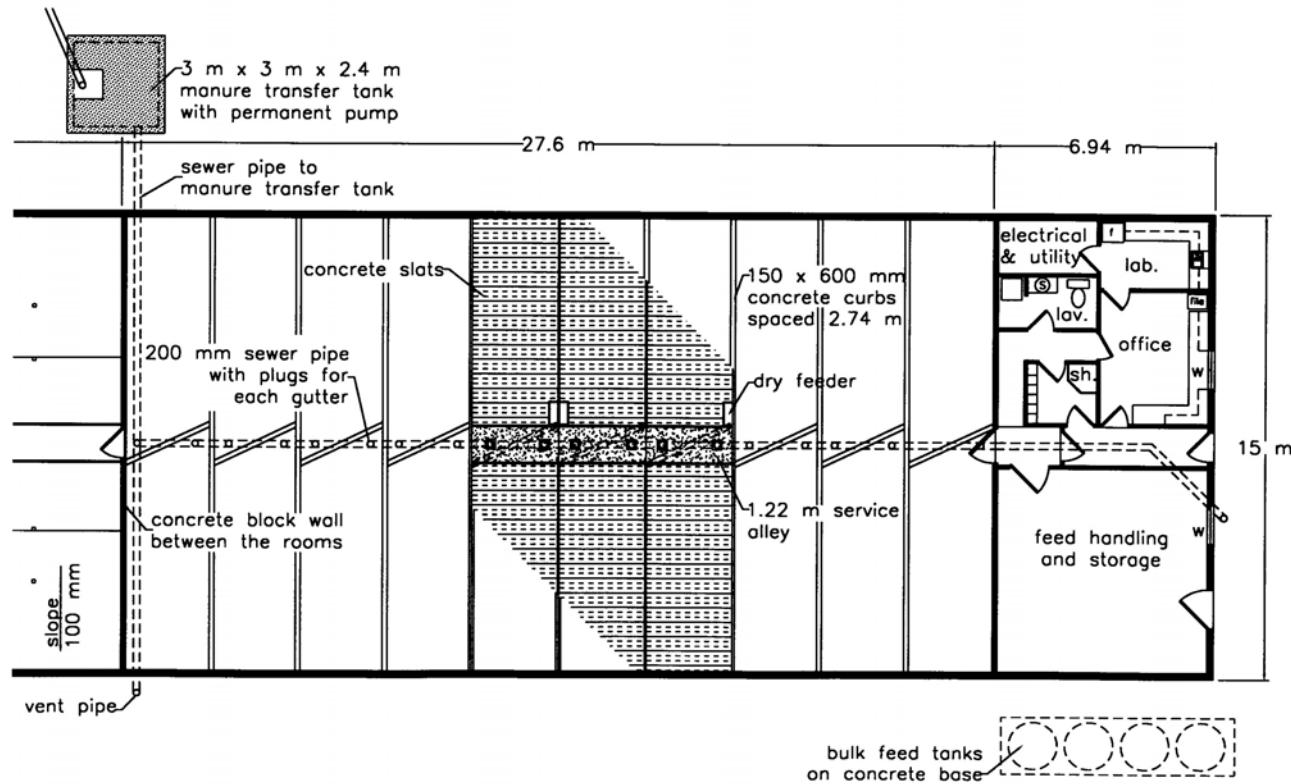


Fig. 1. Plan view of slatted floor manure system, barn office, laboratory, and feed room.

and solid manure systems and the ability to address the research needs associated with the growing and finishing phases of pork production.

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DESCRIPTION

Basic design

The general concept was to design a commercial grower/finisher swine barn with research capabilities. A design team was put in place with personnel from the Atlantic Veterinary College (AVC); Agriculture and Agri-Food Canada (AAFC), Crops and Livestock Research Centre; AVC Incorporated (AVC Inc.), Lankshire Farms Ltd., and Linkletter Engineering Inc.

The barn was designed as a 1000 head swine grower/finisher unit. The unit receives 1000 pigs of similar age and weight every four months. All animals are marketed and the barn is cleaned and disinfected prior to the arrival of more pigs. This allows for three batches of pigs to be finished each year, or in the case of research, three sets of projects or time replications to be conducted. Office space, laboratory, feed, wash, shower, and utility rooms are all located at one end of the building (Fig. 1).

A natural ventilation system with a cathedral type ceiling, fabric ventilation curtains on the north and south sides running the length of the barn, and eight 750 by 750 mm chimneys along the ridge line were incorporated into the design (Fig. 1). The facility is operated under the guidelines of the Prince Edward Island (PEI) Quality Swine Minimal Disease Program which

uses a strict bio-security protocol. It is located on property owned by AVC Inc. and is adjacent to the Crops and Livestock Research Centre at the Harrington Research Farm.

Research components

The barn is divided in half with a concrete block wall separating a fully slatted floor liquid manure system from a solid manure system (Figs. 1 and 2). Each half is subdivided into 20 pens 2.7 m wide x 6.7 m long, each capable of housing approximately 25 pigs. Pens are divided by solid walls of 50 mm thick PVC penning (Walbern Agri-Systems Sask (1996) Ltd., Saskatoon, SK). Each pen has a two station wet/dry feeder (Crystal Spring, Gro Master Inc., Omaha, NE) located adjacent to the centre alley. Individual feeders are filled from feed carts equipped with electronic scales and dispensing augers. Access for carts is via a 1.2 m centre alley that runs the length of the unit.

Manure from each pen is collected separately. On the slatted end, the wall under the central service alley is angled to allow for a single drainage pipe for all 20 pens (Fig. 1). Each pen is connected by a drop pipe with a bung to the central pipe (200 mm in diameter) (Fig. 3). The central pipe gravity feeds to a 3 x 3 x 2.4 m transfer tank located outside the barn. To provide access to each manure pit for cleaning and for the removal of solids, 0.61 m sections of slats may be lifted and moved. Manure may be measured and sampled in the transfer pit before it is pumped to long term storage (24.4 m diameter by 3.96 m deep concrete tank). Provisions are made to rinse the pipe and tank to prevent cross contamination if the study requires it. Alternately, manure may be pumped to a tanker from the transfer pit for direct application or removed to a separate storage facility for testing and later use in field experiments (Campbell 1998).

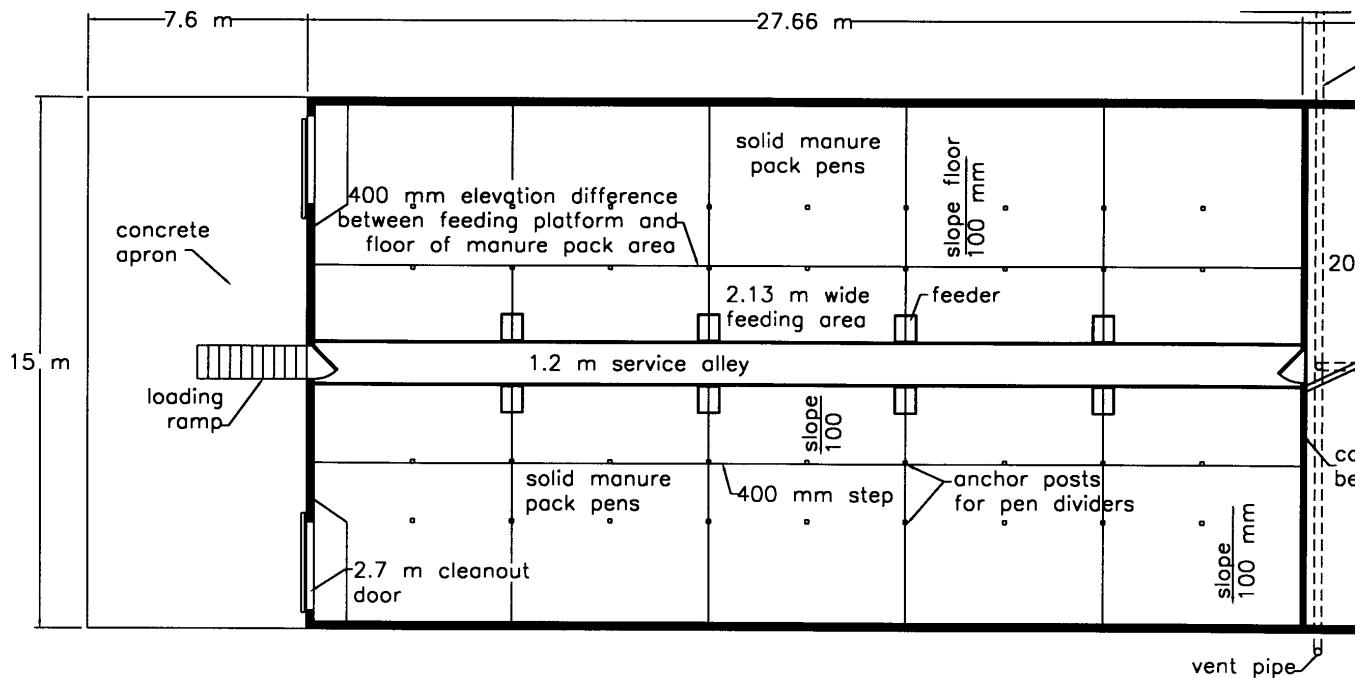


Fig. 2. Plan view of solid manure system.

In the solid end, each pen has a 2.13 x 2.7 m concrete feeding area and a 4.9 x 2.7 m bedded area (Fig. 4). The feeding area is routinely scraped. Filling with bedding and removal of manure are through two 2.7 m doors at the end of the barn (Fig. 2). Pens are filled with bedding sequentially, starting furthest from the doors. Additional bedding may be added as required.

Clean out is done in reverse order. All bedding may be weighed and sampled on the way into the barn using a Knight Model #3250 mixer wagon (Knight Mfg. Corp., Broadhead, WI) (Fig. 5). Manure exiting the barn may be weighed and sampled using the same equipment.

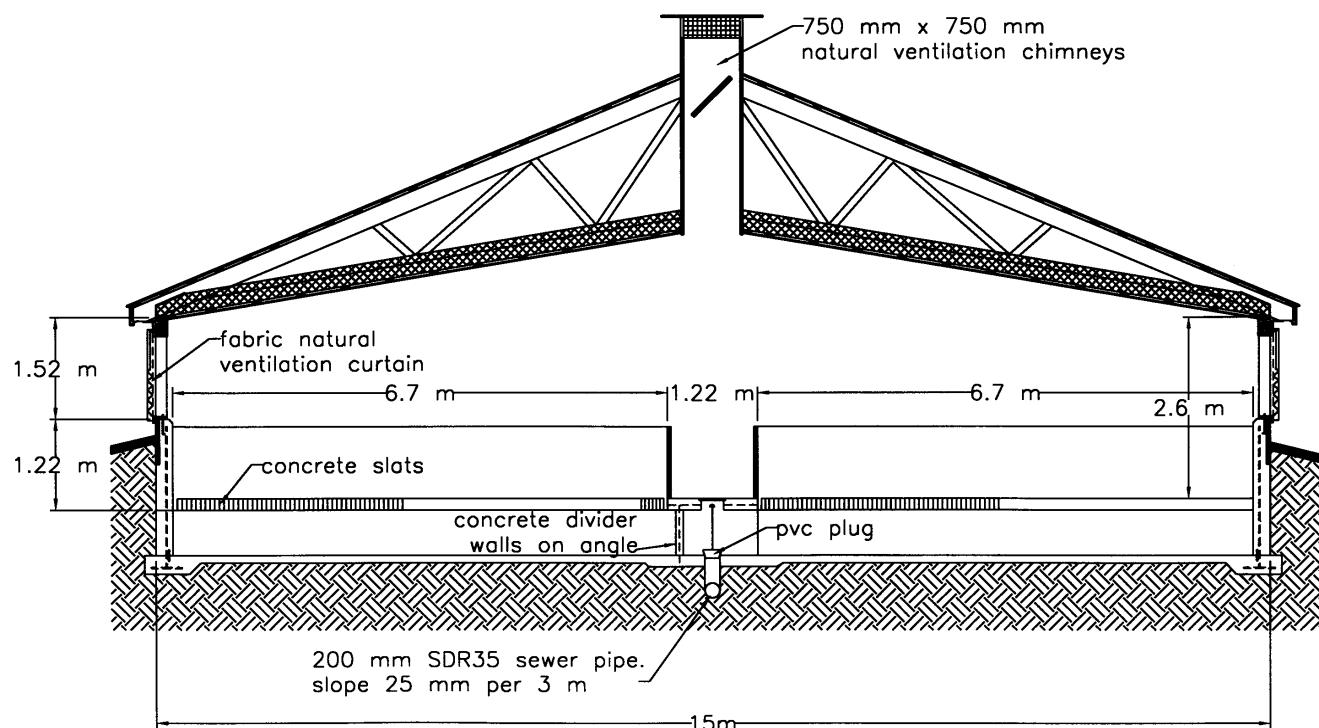


Fig. 3. Cross section of slatted floor liquid manure system.

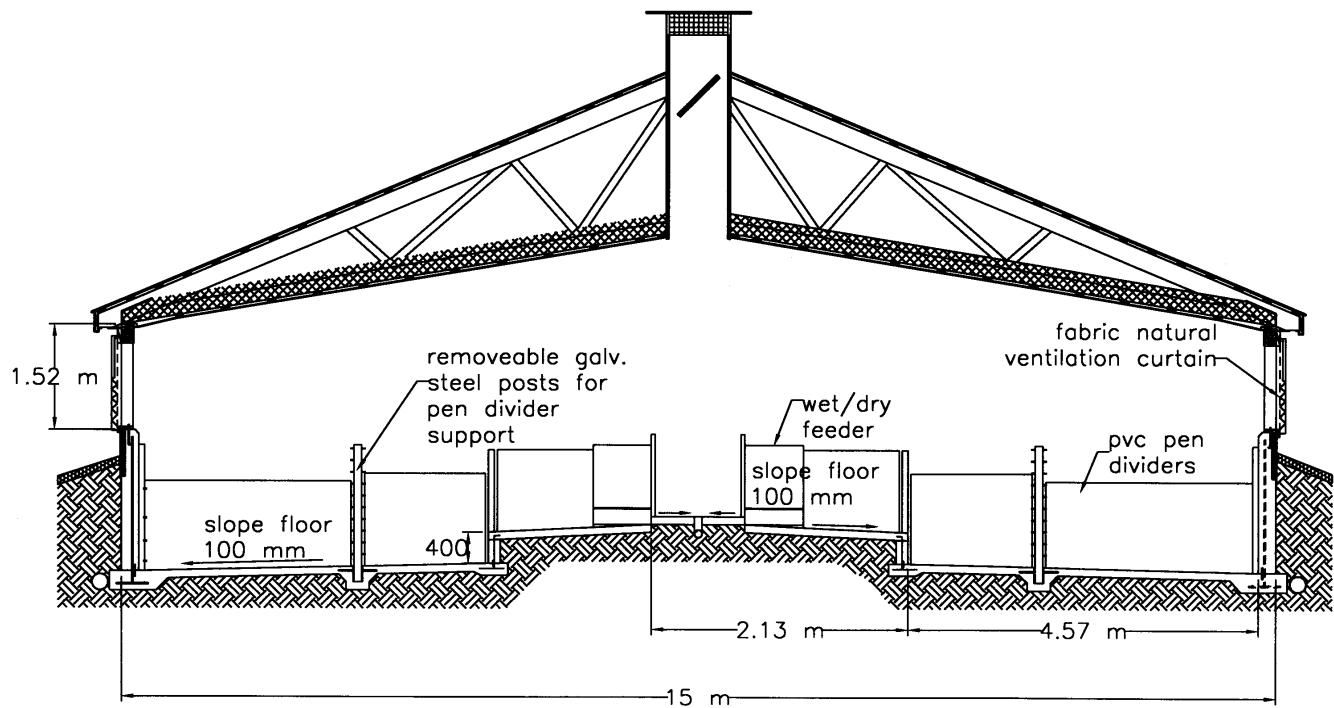


Fig. 4. Cross section of solid manure system.



Fig. 5. Knight Mixer Wagon 3250 being emptied of manure as it comes from the barn

Table 1. Mass and nutrient content of manure from slatted floor and deep bedding manure systems.

	Liquid system/ slatted floors	Solid system/ deep bedding
Wet mass/pen (t)	10.30±0.99*	6.97±0.46
Dry mass/pen (t)	0.89±0.22	2.26±0.09
Dry matter (g/kg)	86±19	324±12
Nitrogen (g/pig)	1.56±0.53	1.76±0.11
Phosphorous (g/pig)	0.92±0.16	1.01±0.07
Potassium (g/pig)	1.20±0.18	1.59±0.09

*Mean and standard deviation, n=4

Measurements on manure collected may include quantities, dry matter, carbon content, macro nutrients (nitrogen, phosphorus, potash, calcium, magnesium, sulphur) and micronutrients including iron, boron, manganese, copper and zinc.

The floor plan includes office space, laboratory, feed, wash, shower, and utility rooms (Fig. 1). The barn is managed by a person with half of their time spent on general barn operation and animal care and the other half spent on research projects and data collection. Additional technical support is provided as required.

FUNCTION and PERFORMANCE

Construction began in 1998 with the first fill of pigs arriving on October 5 of that year. It has been fully operational since then with pigs arriving every four months. The initial group of pigs was used to test the facility and to develop the bedding system. The results from this group are presented here.

Comparison of manure systems

A comparison of liquid and solid manure systems was conducted. The total wet weight of manure per pen was highest in the liquid system, but the total dry matter content was higher in the solid system (Table 1). Data collected by Mescher et al. (1999) also found higher nutrient densities for a solid manure system. The solid manure system contained more nitrogen (N), phosphorus (P), and potassium (K) than did the liquid system. Although sawdust bedding was added to the solid system, it contributed little to the total amount of nutrients removed.

Growth performance and feed consumption patterns of the pigs in the two housing systems were similar (Table 2) and are considered to be very good for growing/finishing pigs housed in commercial conditions (Anonymous 2000). These results are consistent with data collected by Mescher et al. (1999).

The barn's close proximity to the AAFC Crops and Livestock Research Centre allows for field work in crop production systems using manure as a nutrient source (MacLeod et al. 2000). The design allows for comparison of manure systems integrated into cropping systems - a unique feature of this facility. Four major field experiments are presently being conducted by AAFC staff looking at potato, grain, and forage production using manure as a nutrient source. Also, data has already been published and presented (Hurnik and VanLunen 2000; VanLunen and Hurnik 2000, 2002).

Table 2. Performance results of pigs in a research unit reared on slatted floor and deep bedding manure systems.

	Liquid system/ slatted floors	Solid system/ deep bedding
Start mass (kg)	19.3±0.5*	19.6±0.5
End mass (kg)	106.8±0.6	107.1±0.05
Daily gain (g/d)	913±10.5	916±10.3
Feed conversion (kg feed/kg gain)	2.55±0.15	2.57±0.21
Mortality rate (%)	1.4	1.3
Carcass lean yield** (%)	61.2±1.6	60.5±1.4

* Mean and standard deviation, n=4

**Estimated carcass lean yield (%) = 67.23 - 0.7877 (fat depth
+ 0.1086 (lean depth) + 0.0087 (fat depth)² - 0.0004 (lean
depth)² - 0.002 (fat depth × lean depth)² [Jones et al. 1993]

In spite of some minor changes, which would improve the research capability of the barn, the present structure has already proven itself successful in terms of both commercial production and research capability. Changes would include replacing solid alleys with slatted flooring which would reduce manure build up during weighing and moving pigs. Also, the addition of an improved pig weighing facility with fixed electronic scales and sorting pens would improve animal handling.

CONCLUSIONS

The approach of modifying a commercial barn design, with additional capabilities for research, has permitted the rapid development of a research facility. The facility with 40 pens has the capacity and ability to provide for scientific and practical projects which can be replicated in space and time. Commercial performance has exceeded industry averages and several research projects have been completed. Close proximity to the AAFC Harrington farm has allowed scientists and engineers to take a nutrient cycling approach to agricultural production systems. Results to-date indicate that the design and location of the barn facilitates research into aspects of nutrition and manure management in pork production.

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