Engineering

Mitigating Accelerated Deterioration of Pig Buildings

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On average, Canadian swine buildings are 20 - 30 years old; over the next few years, these buildings need renovations or may be replaced with new construction. This project set out to identify potential solutions applicable to Canadian conditions to mitigate the rapid deterioration of swine buildings. A comprehensive literature search supplemented by an information survey of various stakeholder groups in the industry was carried out to compile and identify potential solutions on barn building deterioration. An information survey had a total of 46 respondents composed of producers (43%), builders (13%), materials and equipment suppliers (20%), and academic and research and development organizations (24%). Results of the literature review and survey have identified various potential solutions for farm building material degradation which were categorized based on building design, material selection and treatments, and building management and animal production practices.

INTRODUCTION

Many barns currently in use in the Canadian hog industry were built in the 1990's during the period of rapid upswing in the pig industry (Brisson, 2014); these were mainly based on the existing barn designs available at the time. Most of these barns have almost totally enclosed shell, and mechanical ventilation system composed of fans, inlets and exhaust outlets to maintain favourable conditions for the pigs year round.

During winter months, ventilation is typically turned down to a minimum level to minimize heating costs. This, however, leads to higher levels of moisture and corrosive gases, varying thermal conditions, and presence of dust and decay microorganisms. The minimum ventilation rate, combined with high prevalence of strong winds in some areas during the winter months, ultimately results in recirculation of the exhaust air back into the barn, leading to poor in-barn air quality. As a consequence, rapid deterioration of structural members (e.g. walls, eaves, ceiling, attic, plenum, etc.) is inevitable due to prolonged exposure to recirculated moisture and corrosive gases (Meyer et al., 1988). Thus, potential solutions or strategies are needed to address these issues and subsequently mitigate the accelerated degradation of swine barns.

MATERIALS AND METHODS

The overall objective of this project was to develop and evaluate measures/ strategies to mitigate accelerated deterioration of swine buildings. The main approach was to conduct a comprehensive literature review and information survey to identify potential solutions applicable to Canadian pig barns (including but not limited to alternative ventilation configurations, surface treatments, innovative building materials, etc.) to address accelerated barn deterioration.

RESULTS AND DISCUSSION

About 60% of the producers and builders had issues with rapid deterioration of barn structural components. Specifically, the structural components that they had issues with were: roofing (50% of the respondents); penning/ stalls (50%); exterior walls (40%); ceilings, trusses and/or attic, and feeding and drinking system (30%). No significant issues with accelerated deterioration have been identified in partition walls between two rooms, manure and drainage system, and barn foundations.

Table 1 summarizes the issues encountered by producers and builders related to barn deterioration and their recommendations for mitigation. The most common issue was corrosion/rusting of barn roof, penning/stalls, exterior walls, ceiling, trusses, and feeding and drinking system. Some respondents have pointed out issues related to moisture decay in trusses, and cracks in penning/stalls, and feeding and drinking system.

Mitigation Strategies

Among the solutions to improve the building life span such as surface treatments, new material, ventilation system, control and maintenance (guide information), the latest has been pointed out by the participants as the least expensive one and the easiest to adopt by producers. However, few consider maintenance improvement as the best option to improve building life span. If the cost would not be considered as a decision parameter, new building material and ventilation system improvement should be the priorities. For producers, when the cost of the technology is not considered, an adequate ventilation system, sufficient insulation and high durability wall materials are the most attractive solutions to improve building life span.

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Table 1. Summary of responses from producers, builders and their equipment suppliers on current status of pig barns in terms of barn degradation and their recommendations to mitigate them.

Structural components	Issues encountered (% reporting the issue)	Mitigation strategies
1. Roofing	• corrosion/rusting (100%)	• use of a thicker gauge of tin • better screws • application of paint on both sides of tin • modification of ventilation system so that barn air does not get in contact with the roof
2. Penning/stalls	• corrosion/rusting (86%) • cracks (29%)	• stronger support, use of heavier anchors (1/2” rather than 3/8”) • use of solid rod; avoid welds in wet areas • use of stainless steel for first 6” of post or anything that has contact with manure or the floor • use of plastic (if not costly) instead of concrete or steel
3. Exterior walls	• corrosion/rusting (100%)	• plastic walls filled with concrete • thicker tin • concrete construction • better exhaust fans; proper ventilation
4. Ceiling	• corrosion/rusting (60%)	• use of screws, not nails • application of paint • use of plastic or fiberglass products
5. Trusses	• corrosion/rusting (80%) • moisture decay (60%)	• installation of ridge ventilation • use of galvanized or stainless steel, protective coatings and insulation • better ventilation to avoid back drafting
6. Feeding and drinking system	• corrosion/rusting (40%) • cracks (40%)	• thicker PVC for drinking system • use of steel feeders • use of plastics above pig level and steel at pig level • all intake hoppers and drive units should be stainless steel

CONCLUSION

Among all the potential solutions, techniques related to appropriate ventilation, environmental control and air treatments, improvement of corrosion protection efficiency of building materials, and effective building maintenance have been identified as the most promising solutions to rapid deterioration and have high adaptability to Canadian swine production conditions. Although these strategies still need to be evaluated in an actual barn prior to their full implementation for adoption in Canadian swine barns, outcomes from this current project represent significant step toward optimizing future barn renovations and constructions as well as for possibly changing the conventional swine production practices and farm building management.

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Table 2. Summary list of potential solutions to rapid barn deterioration and their applicability to Canadian swine farms based on literature review and survey.

Category/Potential Solution	Description	Applicability
A. Building Design		
1. Wood (Durable design)	• use of timber with bigger dimensions, well-seasoned and with good detailing	Applicable
2. Metal (Durable design)	• rigid or batt insulation (e.g. 4-6 mil polyethylene) plus vapour barrier especially on truss assembly • appropriate design gap between insulation and wall or ceiling for moisture drying in the event of penetration • good vapour barrier on areas in close proximity to fasteners	Applicable
3. Ventilation (in general)	• use of stacks or discharge tubes to release exhaust air away from the animal building • extension of insulation and vapour barrier from inside the building to underside of vented overhangs • chimneys installed intermittently between trusses for ridge ventilation • separate ventilation for barn interior and the attic	Applicable; extent of current application in Canadian swine/livestock buildings not confirmed

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B. Building Material Selection and Treatments		
1. Wood	• use of naturally durable wood	
Chemical preservation	• oil-based preservatives (Creosote oil) • fixed water soluble preservatives • organic solvent preservatives	• Applicable
Impregnation of wood with polymers	• improve the physical and mechanical properties of low grade wood species • use of copolymer derived from allyl alcohol and methyl methacrylate (optimum compatibility and compressive strength perpendicular to fiber increased by approximately 100 times while water absorption was reduced by 50%; biodegradation did not occur)	• Applicable; Further investigation of effectiveness against deterioration needed
Bio-control	• wood treated with urea and ureolytic bacteria (*Proteus sp. and Bacillus sp.*) • combination of *Proteus sp.* and *Trichoderma viride* to inhibit growth and kill fungi	• Further investigation of effectiveness needed
Titanium dioxide nanoparticles	• used to prevent fungal *Hypocrea lixii* (white-rot) and *Mucor circinelloides* (brown-rot)) growth in wood • applied on surfaces by spraying or simple brushing	• Further investigation of applicability/ feasibility for use in livestock buildings needed
2. Metal		
Stainless steel	• known resistance to dry corrosion (oxidation) and attack of acidic condensates	• Applicable
G90 hot-dip galvanized (G90 HDG)	• treated with zinc phosphate • recommended by U.S Steel for metal connectors in animal housing, G90 zinc coating are typically used in Canada (G60 for US)	• Applicable
Duplex System	• e.g. G90 Duplex = G90 connector + paint and G185 Duplex = G185 connector + paint • G90 duplex or G185 connectors with vapour barrier and separate ventilation for attic space is recommended in animal buildings	• Applicable
Avoidance of galvanic corrosion	• e.g. using stainless steel nails for stainless steel hangers and galvanized nails for galvanized hangers	• Applicable
Use of other materials such as ceramic materials and polymers		• Applicable
Galvanizing	• zinc layer application on steel and iron structures	• Applicable
Coatings	• epoxy coating that is lead and chromate-free recommended for metal truss plates	• Applicable
Repair of corrosion-attacked metals	• cleaning as a de-rusting method remains the advised method over use of rust converters	• Applicable
3. Concrete		
Concrete mix composition	• use of sulphate-resistant binder-like type 50 Portland cement (equivalent to CEM IIIB concrete based on CSA A3000, 1998) as most effective among 8 concrete treatments • use of other supplementary cementing materials such as slag, fly ash and silica fume to minimize tricalcium aluminate (C3A) content of concrete mix • use of additives for concrete top layers (e.g. product "S" based on ground tuff) to increase life of concrete compared to regular sand-cement mix for top layer of animal housing flooring • also applies for protection of steel reinforcements	• Applicable; feasibility and cost analysis needed for application in livestock buildings

C. Building Management/Production Practices		
Interior cleanliness and maintenance	• proper cleaning and disinfection; high pressure washing and use of cleaners to effectively remove aggressive residues and manure on surfaces • periodic inspection for leaks through vapour barriers and corrosion on connectors and fasteners • removal of corrosive agents from the attic and additional protective coatings must be provided to connectors	• Applicable
Feeding method	• wet feeding method can make the degradation problem on barn floors worse • greater feeder-drinker distance to minimize lactic and acetic acid attack on concrete by the feed-water mix	• Applicable
Others	• putting concrete or brick bin underneath nipple drinkers • protection of concrete floor itself by fibre cement-board, metal plate, rubber sheet, or a top layer "product S"	• Applicable