Providing Adequate Natural Ventilation within Livestock Buildings

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1.0 Introduction

Inadequately ventilated livestock buildings can lead to respiratory diseases, heat stress and general poor wellbeing of the housed livestock. The knock on effect of this poor design can lead to increased upkeep costs, lower production yields and reduced price/head. Therefore, providing adequate ventilation within a livestock building is a critical factor to ensure housed stock achieve the desired level of optimum potential.

In addition to this, working conditions for stockmen can be greatly improved and environmental damage to the building structure and fabric significantly reduced, thus ensuring extended lifetime performance.

"Providing adequate ventilation in a building for livestock is probably the most important factor to be considered at the design stage of a new building….."

Source: RIDBA (Rural & Industrial Design & Building Association) The Farm Buildings Handbook

2.0 Design Principles

A well designed ventilation system provides an adequate amount of fresh air to supply oxygen, remove excess moisture and control temperature. There are two natural forces that can provide ventilation within buildings. These are:

i) Wind Effect
ii) Stack Effect (Thermal Convection)

In practice buildings can be naturally ventilated solely by using the movement of air caused by the outside wind effect. Therefore, site selection, topography, orientation and proximity of other buildings are all critical factors that need to be considered in order to get the most positive results.

However, whilst the above considerations should never be overlooked, most ventilation issues actually occur at times of still weather conditions and therefore, typical natural ventilation systems tend to ignore wind effect when calculating required performance and concentrate purely on the minimum ventilation rate that occurs under the stack effect alone.

The Stack effect (or chimney effect as it is sometimes known) operates on the principle of thermal convection. Air that is hotter than the surrounding air is less dense and experiences an up-thrust caused by 'thermal buoyancy'. This is similar in principle to heavy objects being placed in water. The object, being denser than the water will displace it forcing the water upwards.

Whenever a building contains livestock there will always be a production of energy that is available to warm the air entering from outside. Therefore, utilising the above principles on a ventilated building, warm air can be exhausted out and replaced by cooler, denser air entering from the outside. Typically this is done by allowing the cooler external air to enter at the eaves or just below (known as the inlet). When meeting the warmer air this produces an upward buoyancy force to 'push' the warmer internal

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air out via an opening at the ridge (known as the outlet). Typical wind suction across the external roof surface also helps draw this warm air out.

3.0 Factors that dictate Stack Effect Design

To calculate the minimum inlet and outlet open areas required for adequate natural ventilation during still conditions, the critical design factors governing ventilation due to stack effect are as follows:

i) Building Floor Area
ii) Difference in height between inlet and outlet
iii) Roof Pitch*
iv) Type of Livestock
v) Livestock weight
vi) Floor area/animal

* It is recommended that a minimum of 10 degrees is used.

4.0 Example Calculation

The Scottish Farm Buildings Design Unit (SFBIU) have produced formulae and graphs to assist in the necessary calculation. Highlighted below is an example calculation produced using the method they have collated:

Example:
The building is 25m wide and 50m long with a 15 degree roof pitch. 120 cows are housed in two groups of 66 cubicles on either side of the feed passage, i.e. there are 10% more cubicles than cows. The cows' average weight is 600kg.

Step 1: Calculate the total floor area/animal (A)

Total Building Area/Number of Cattle =

(25 x 50)/120 = <u>10.416m^2/Animal</u>

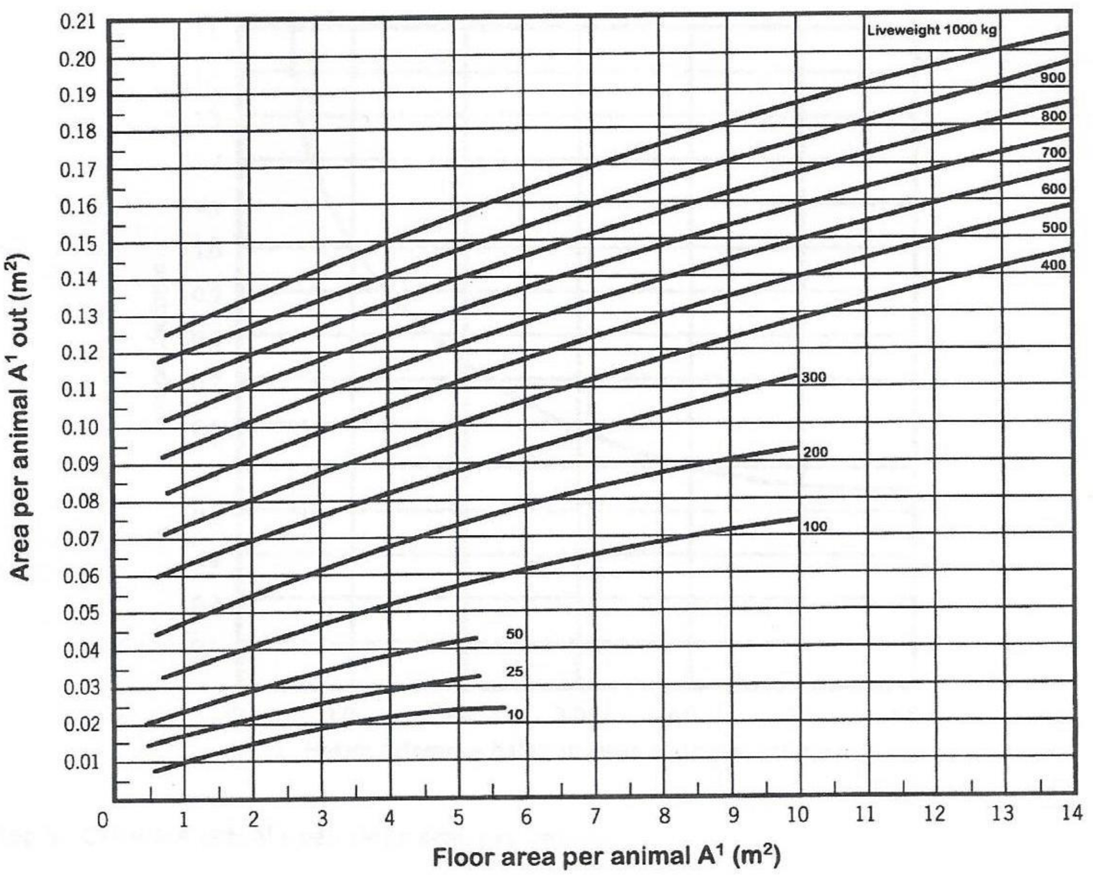
Step 2: From Graph 1, using live weight and total floor area per animal, find the outlet area (A' out).

Therefore, A' out = <u>0.151m^2/Animal</u>

However, this is the outlet area for a building with a height difference of 1.0m between inlet and outlet.

THIS NEEDS TO BE CORRECTED FOR THE ACTUAL HEIGHT DIFFERENCE OF THE BUILDING.

GRAPH 1



Step 3: Calculate the actual height difference (H)

From the table below, it can be seen that a 15 degree roof pitch has a rise of 1 in 3.7.

Roof Pitch (Degrees)	10	15	22.5	30	45
Rise	1 in 5.5	1 in 3.7	1 in 2.44	1 in 1.72	1 in 1

Height Difference (H) = 0.5 x building width/3.7

= 12.5/3.7

= 3.378m

Step 4: From Graph 2, find the height correction factor (h)

For a height difference of 3.378m

Height Correction Factor (h) = 0.525

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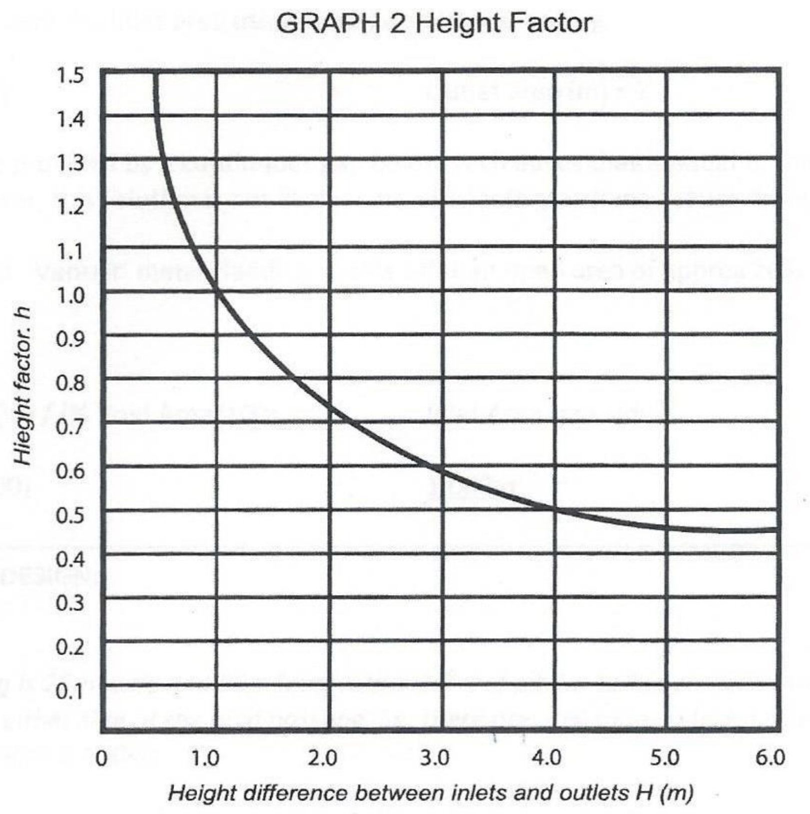

Step 5: Calculate actual open ridge area per animal

Multiply A' out by the h factor to give the corrected open ridge area per animal.

A'out x h	=	0.151 x 0.525
	=	<u>0.0868m^2/Animal</u>

Step 6: Calculate the total area of open ridge required

Open Ridge per Animal x No. of Animals Housed	=	
0.079275 x 120	=	<u>9.513m^2</u>

Step 7: Calculate the width of open ridge

Total area of open ridge/building length*	=	
9.513/(50-2)	=	0.198m
	=	<u>200mm</u>

Note:* Open ridge detail designed to start 1m from each end.

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Step 8: Calculate the inlet area using TPP Ventair Cladding

Inlet area (m)	=	Outlet area (m) x 2

This could be provided by a continuous gap below each eaves that is equal to the required open ridge. However, this solution is not likely to be satisfactory as it may cause draughts at stock level.

TPP Ventair cladding offers an open area of approx. 18% per m^2.

Therefore,

Outlet Area (m) / (% Void Area/100)	=	Inlet Area (per side)
0.200/(18/100)	=	1.111m

Ventair louvre bands must be divisible by 127.5mm. Therefore, louvre band should be 1.275m deep. This would give identical performance to 4 inch Yorkshire boarding with an inch gap between boards but without the risk of driven rain issues.

REQUIRED DESIGN:

Example:
The building is 25m wide and 50m long with a 15 degree roof pitch. 120 cows are housed in two groups of 66 cubicles on either side of the feed passage, i.e. there are 10% more cubicles than cows. The cows' average weight is 600kg.

INLET AREAS (Minimum)	=	1.275m high band of Ventair below both eaves lines
OUTLET AREA (Minimum)	=	200mm Wide Ventilated Ridge

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