Computational Fluid Dynamics (CFD) Study on the Interference Effect of Surrounding Buildings on Pressure Distribution on a Naturally Ventilated Finishing Pig Building

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Outline

➢ **What is the problem and the motivation driving the study?**

➢ **Objectives of present study and benefits**

➢ **Study methodology**

➢ **Simulation results and discussion**

➢ **Conclusions and what next?**

What is the Problem?

❑ **Natural ventilation(NV):**

Natural ventilation is regarded a potential alternative to mechanically ventilated pig building due to;

- **Rising cost of energy**
- **Growing requirements for environmental and animal welfare friendly pig production**

❑ **Currently no standard NV building design models compared to MV buildings because:**

- **several factors affect natural ventilation which are not well understood**

❑ **Interference effect of surrounding buildings/obstacles:**

- **Most experimental studies are carried out on stand alone buildings**

✓ **Motivation:**

- **Limited studies on the influence of surrounding buildings and obstacles on natural ventilation performance in livestock buildings**

The Need for CFD Studies

- ❑ **Experimental studies remains an important source of information on NV building designs, they however inherently have the following limitations:**

  - o **Time consuming and expensive**
  - o **High Potentials of experimental errors**
  - o **Over -simplification of building geometries and or assumptions**
  - o **Limited range of applications**
  - o **Limited access or low resolution measurements of natural ventilation performance parameters**

Source:http://www.mcr.unibas.ch/Projects/BUBBLE/textpages/md_windtunnel.en.htm

- ❑ **Alternative modelling tools needed**

Computational Fluid Dynamics (CFD)

❑ **Computer based simulation tool for the analysis of systems involving fluid flow and heat transfer by solving the basic conservation equations**

❑ **CFD cannot totally replace experimental modelling, it however offers numerous advantages compared to experimental modelling:**
  o **Cheap**
  o **No need for scaling up**
  o **Presents simulated results that cannot be measured experimentally**
  o **High resolution flow fields can be visualised**

❑ **Validation and verification of CFD models is required before they can be trusted**

Research Objective and Benefits

➢ **Objective:**

To numerically investigate the interference effect of surrounding buildings/obstacles on the pressure distribution on a naturally ventilated finishing pig building at Harper Adams University pig farm.

➢ **Benefits:**

Results from current study would be used as input to numerically optimise natural ventilation designs of pig buildings in a dense farm layout by suggesting optimal separation distance, layout arrangement and retrofit building designs in existing dense layouts.

Overall Approach

❑ **Test the robustness of CFD from literature review for:**

- Full scale experimental measurements of surface pressure coefficient from Robertson et al. (1988).
- Wind tunnel experimental measurement of indoor air velocities by De Paepe et al. (2012).

❑ **Field measurement of air velocity at Harper Adams University (HAU) pig farm for validation purposes**

❑ **Development of CFD model for HAU pig farm**

Field Measurement-HAU Pig Farm
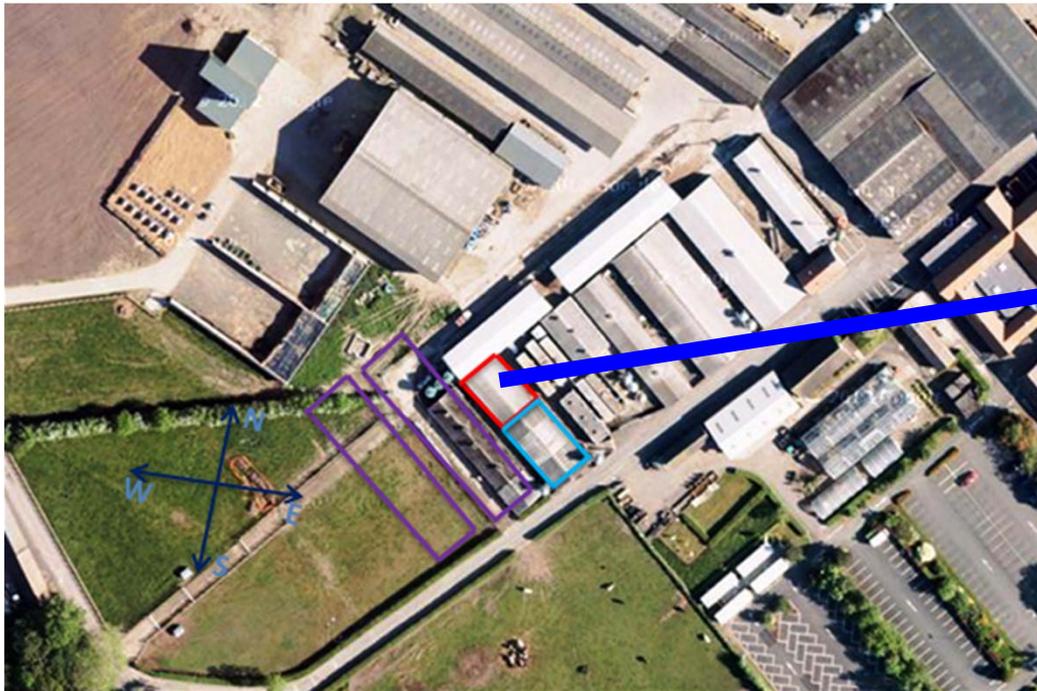
Air velocity measurement
- Ultrasonic anemometer- placed 0.7 m from sidewalls
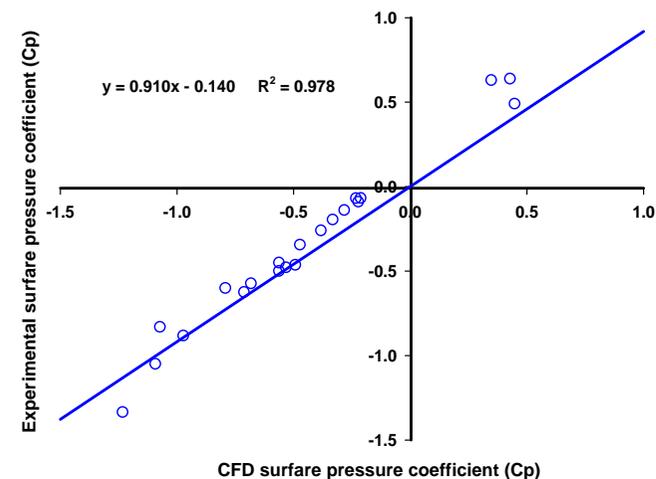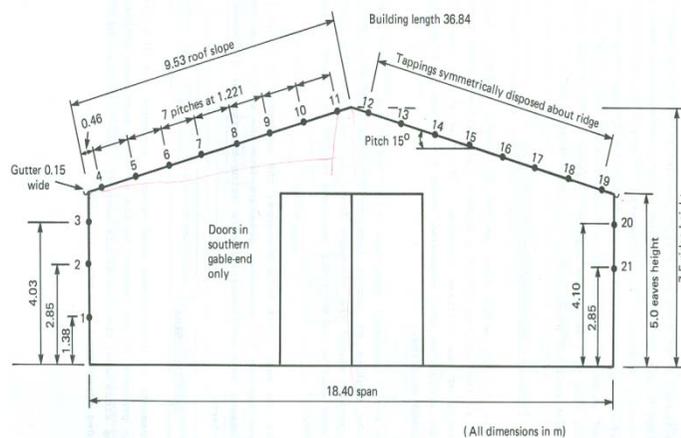- Air velocity measured at 1m and 2.3 m high simultaneously at four points from each sidewall

Dimension of the ACNV building:
- 13.85 m× 9.78 m× 2.7 m (eave height) and 3.8 (ridge height)
- Curtain opening

Test of CFD Prediction with experimental results-from literature

De Paepe et al. (2012)

$y_{Design1} = 0.866x + 0.220 \quad R^2 = 0.968$

$y_{Design2} = 0.883x + 0.109 \quad R^2 = 0.897$

$y = 0.910x - 0.140 \quad R^2 = 0.978$
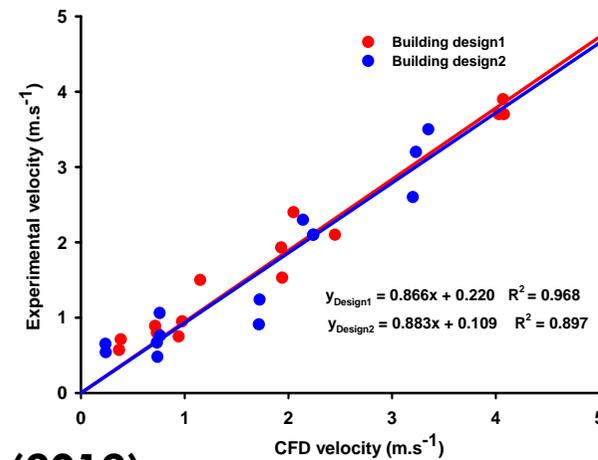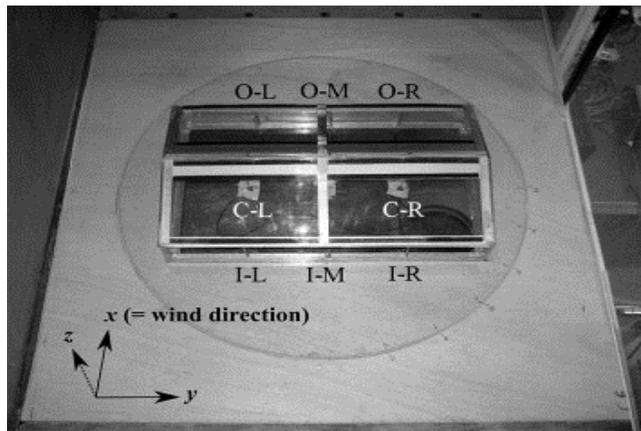
Robertson et al. (1988)

HAU Pig Farm Model

To investigate the influence
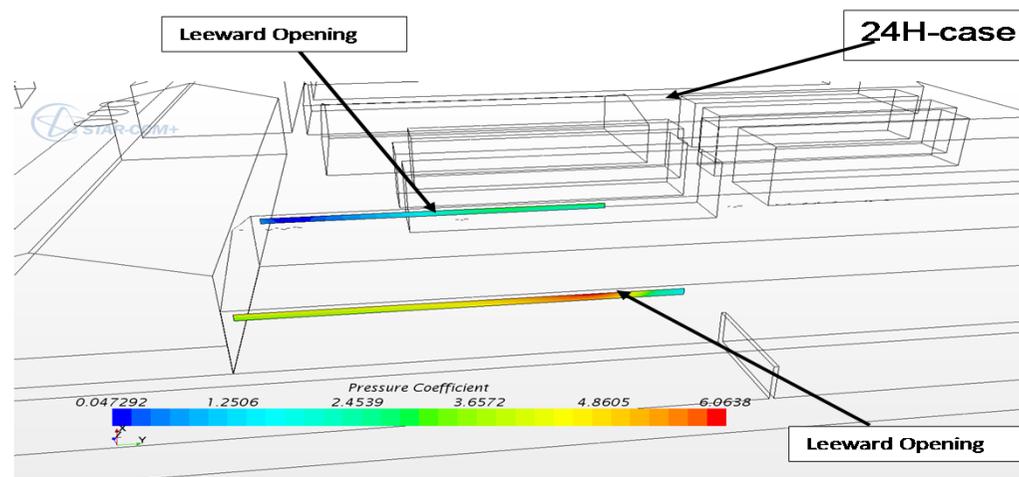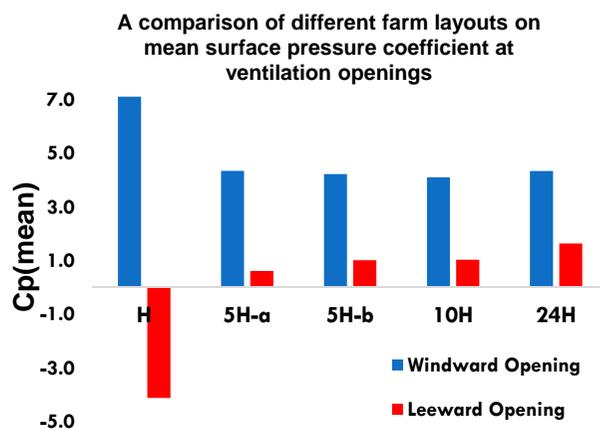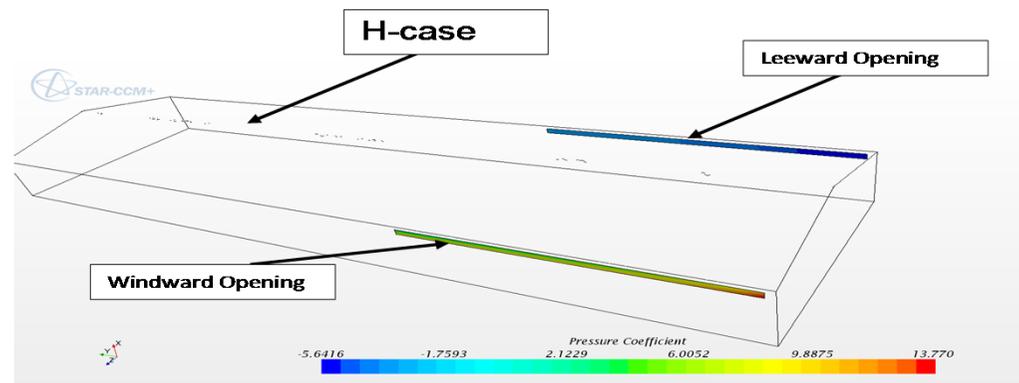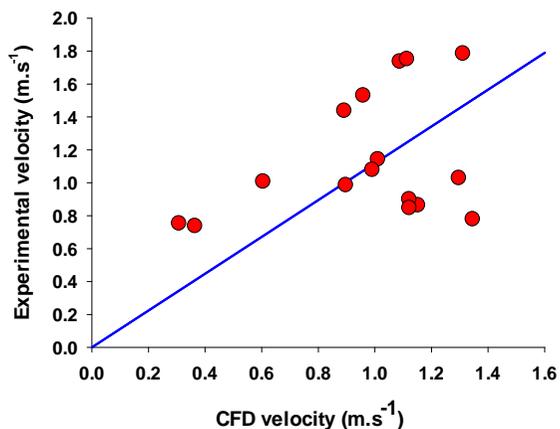Of surrounding building on pressure
distribution at the vent openings:

- Buildings are retain at a radius of; H,
  5H,10H and 24H where H is the ridge
  height (m)

- Surface pressure coefficient at
  ventilation opening is chosen as the
  measurement parameter

- Inlet wind velocity set perpendicular
  to the windward sidewall at 4.1m/s
  only
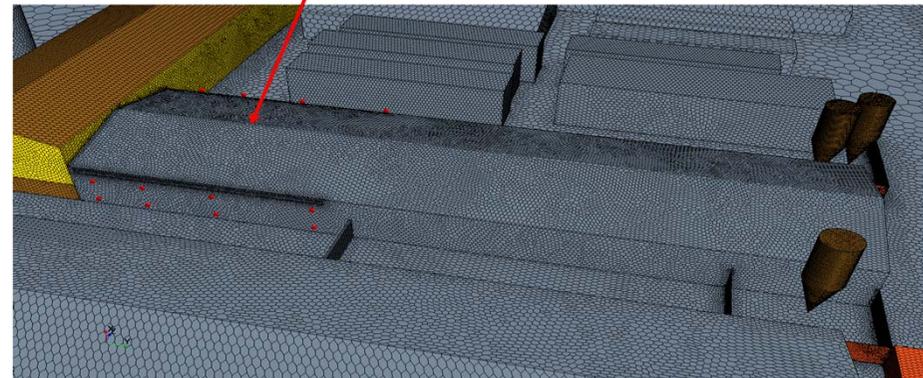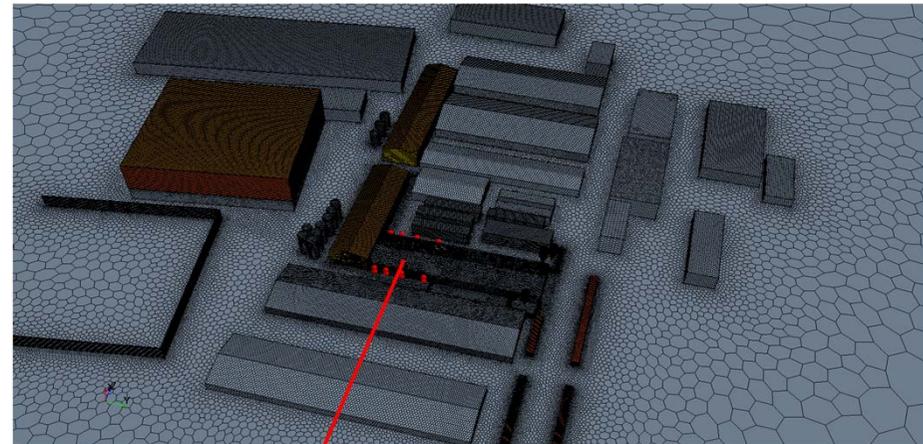
A volume mesh of farm layout

Results-HAU Pig Farm

Conclusions and What Next ?

Conclusions

CFD results showed the leeward side opening to be the most sensitive to the surrounding buildings

The presence of surrounding building resulted in positive pressure coefficient at both the windward and leeward openings, thus the typical cross flow condition in wind ventilated may not exist in the investigated building.

What next?

Numerically optimise the ventilation designs and test the effect of different surrounding building arrangements on airflow with pigs in the building

Acknowledgements

Thank you

Supervisors:
Dr Tomas Norton; Mr Alan Stewart and Mr David White

Sponsors: