Natural Ventilation

Frank Mills Chartered Engineer, MASHRAE, FICBSE MIMechE

Technical Director

Low Carbon Design Consultants

OVERVIEW

- Historical background
- Modern Nat Vent – aims and objectives
- Design Strategies
- Ventilation components, systems integration
- Design Calculations
- Modelling techniques
- Current thinking

UK – Temperate climate

Me in the Pennines

The Lake District

Albert square Manchester

Liverpool city centre

The graces – Cunard, Liver, Titanic,

Stanley Dock tobacco warehouse

Tall buildings

Sealed facades

London ‘Gherkin’ is (supposed to be) naturally ventilated using double skin facade

HISTORICAL BACKGROUND

- Natural ventilation was traditional method of ventilating and cooling buildings
- Before Mech Vent and Air Con, architects used building features to drive NatVent – the building that breathes concept
- Victorian designs used Nat Vent – see Boyle's book for methods and components
- Modern Nat Vent uses same principles but with automatic controls to achieve better IEQ.

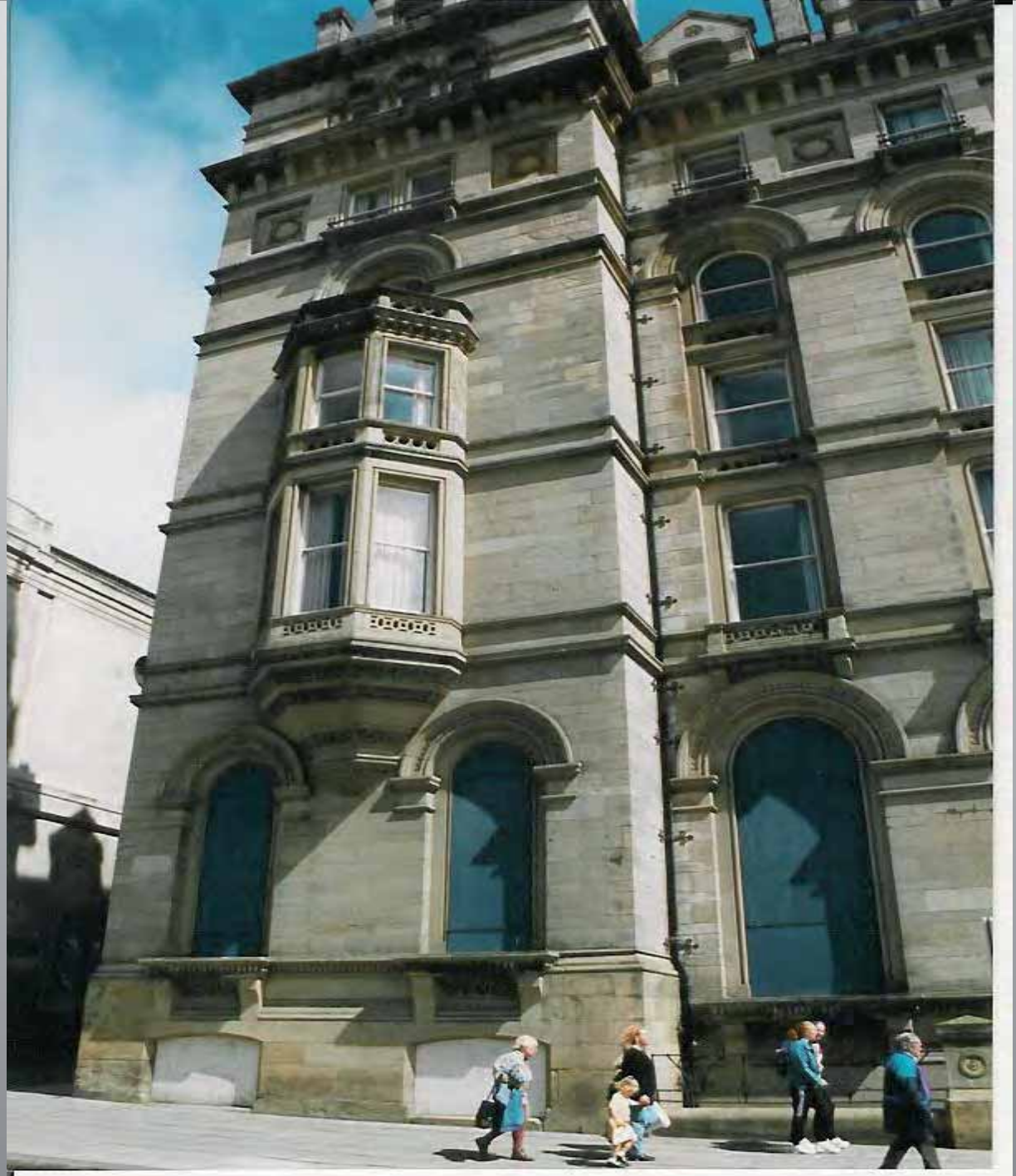
North Western Halls Liverpool

- Head of steam pub and restaurant on ground floor

HEAD OF STEAM PUB, LIVERPOOL, IN THE NORTH WESTERN HOTEL AT LIVERPOOL STATION

AIR INLETS THROUGH BUILDING FABRIC NORTH WESTERN HOTEL, LIVERPOOL

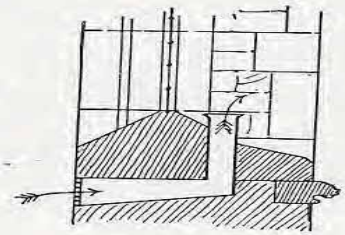
AIR INLETS THROUGH BUILDING FABRIC – INTERNAL GRILLES IN WINDOW REVEALS



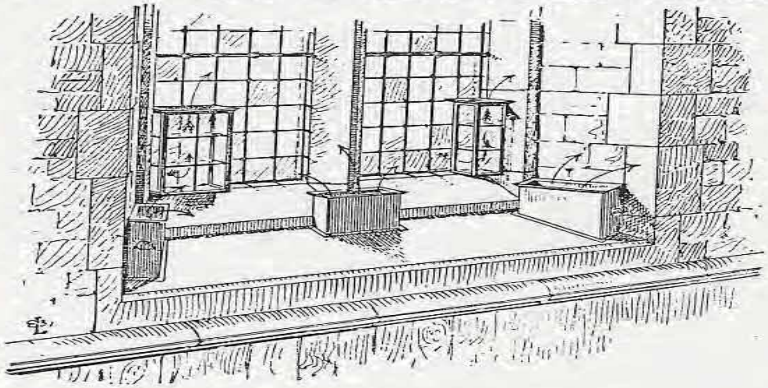

CASTILLONS
PHILLIPS
STROUD BREWERY

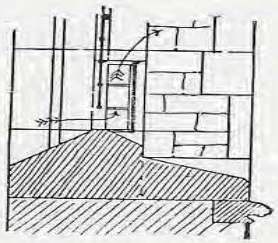
BOYLE'S AIR-INLET TUBES.
FOR FITTING TO WINDOW SILLS.

THESE TUBES ARE USUALLY EMPLOYED WHERE THERE IS AN OBJECTION TO HOLES BEING MADE THROUGH THE WALLS.



Section.



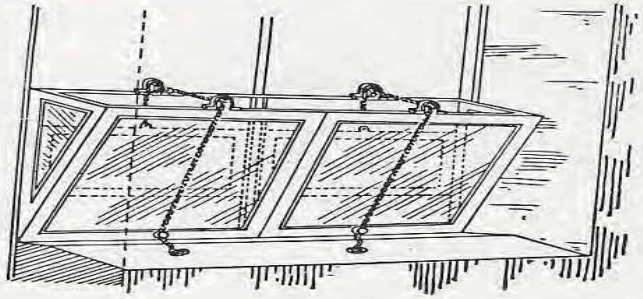


Section.

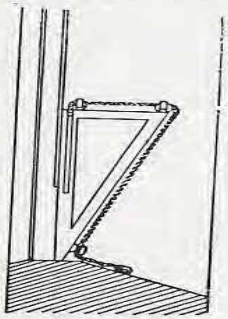
№401. №402. №403. №404. №405.

BOYLE'S AIR-INLET WINDOW HOPPERS.

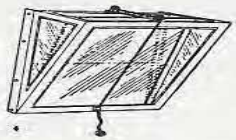
WINDOW HOPPERS SHOULD BE FITTED AT THE LOWER PART OF A WINDOW, NOT THE UPPER, AS IS USUALLY DONE, WHEN A DOWNDRAUGHT GENERALLY RESULTS.



№406.

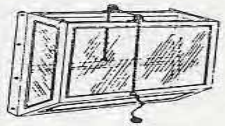


Section.



№407.

№408.

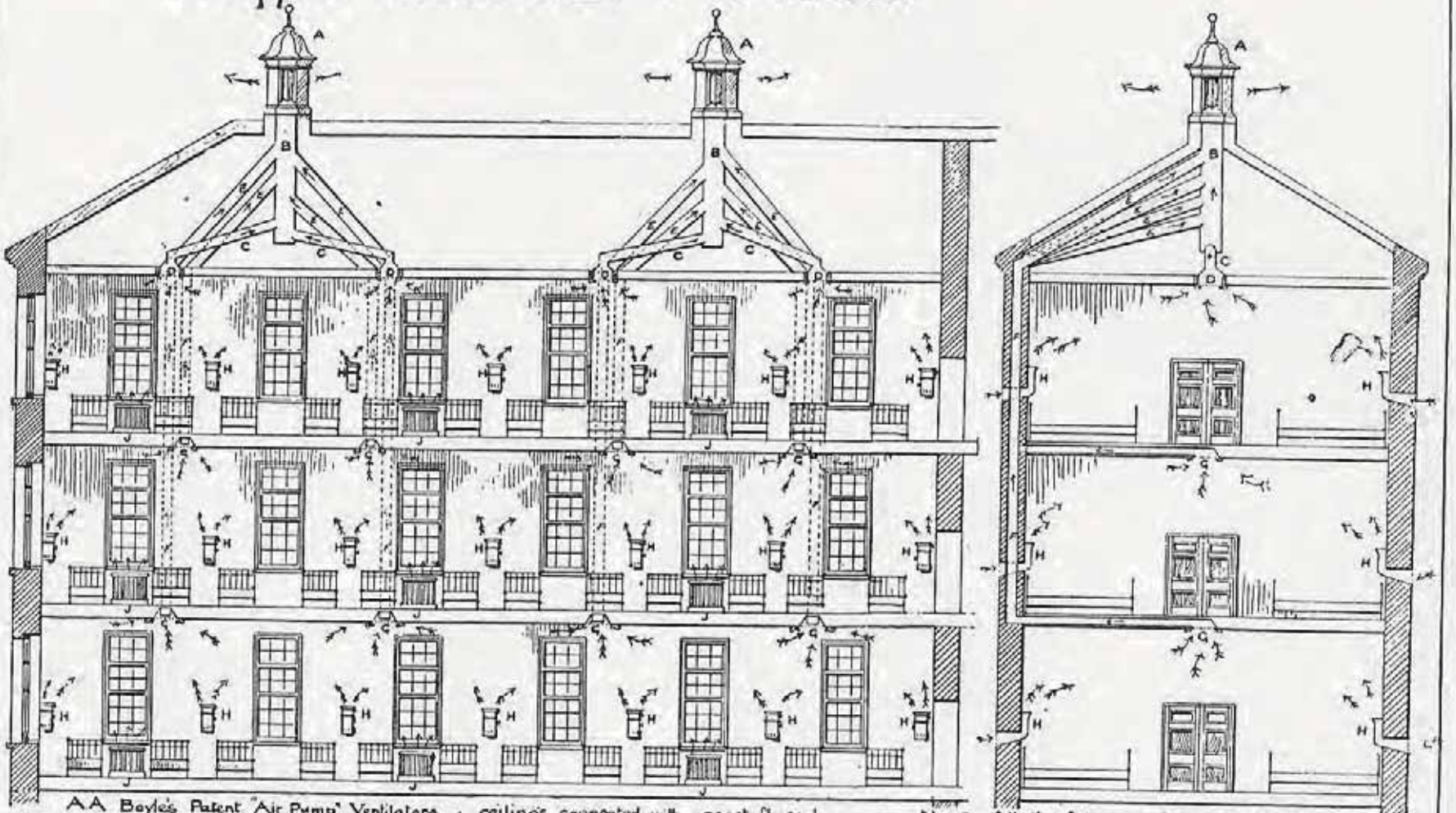


№409.

Prices quoted.

THE "BOYLE" SYSTEM OF VENTILATION

As applied to HOSPITALS & ASYLUMS



AA Boyle's Patent "Air Pump" Ventilators
B.B. Main Extraction Shafts.
C.C. Branch Extraction Shafts connected direct with Foul Air Exit openings D.D.
E.E. Branch Extraction Shafts connected with Upcast Flues F.F. constructed in walls
G.G Foul Air Exit openings in centre of ceilings connected with upcast flues by shafts between joists in channels formed in concrete floor
H.H. Boyles Air Inlet Brackets for admitting screened purified Air; may be fitted with Air-warmers or Disinfecting Chambers.
J.J. Boyle's Ventilating Radiators, admitting warmed, screened, and purified Air.

NOTE: All the Inlets are fitted with Regulating Valves, for controlling the Air Supply, which passes direct from the outside into the Building.

ROBERT BOYLE & SON, LTD
Ventilating Engineers,
LONDON & GLASGOW.

"The ventilation seems to be perfect."—LORD CLIFFORD (*Member of the House of Lords Committee on Hospitals*) on the "Boyle" System of

Open Window Ventilation.

"*Any method of ventilation which permits of a down-draught of cold air is injurious to health.*"—DE CHAUMONT.

In warm weather open windows may freely be resorted to as an aid to ventilation.

In cold weather, particularly when the heating arrangements are in operation, windows should seldom be opened in Churches, Halls, Schools, and other such buildings except when they are unoccupied. In Hospitals windows should never be opened at all in winter, on account of the dangerous down-draughts which proceed from them.

When a window is open at the top in cool weather, a stream of cold air passes into the room, spreads, and descends in a cold shower cooling and pressing down the ascending vitiated air to be rebreathed, along with the poisonous products of combustion, and the dust and dirt with which the incoming air may be charged.

It is in cold weather that special ventilating arrangements, that will change the air without draught and at the same time purify it, are absolutely necessary. In warm weather, when windows can safely be kept open—there being then not the same danger from draughts as in winter—they are not so essential so far as the air-supply is concerned.

Shard, London

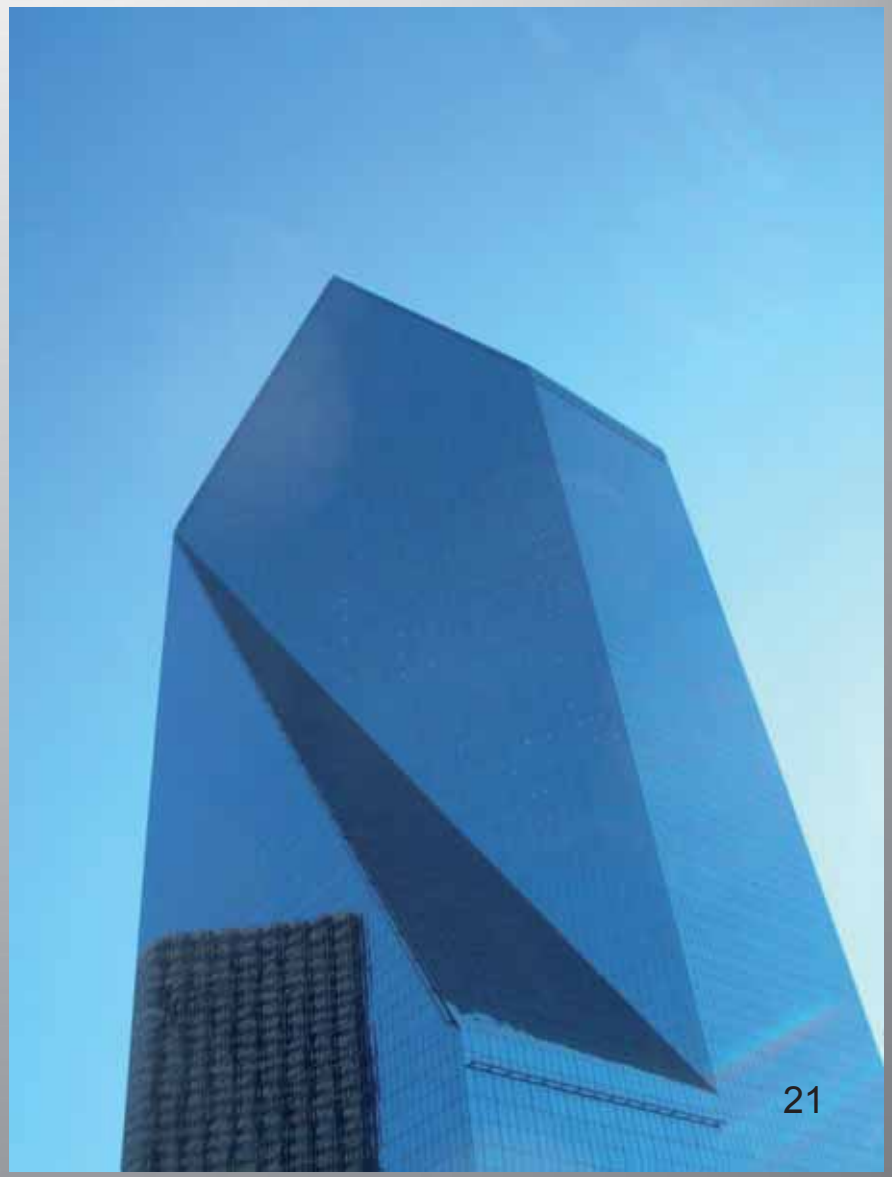
Fully glazed - air conditioned

Air conditioned facades

Solar control glass

Reflective, flush, sealed up

AIR CONDITIONED BUILDING, DALLAS
NO OPENING WINDOWS, HVAC PLANT



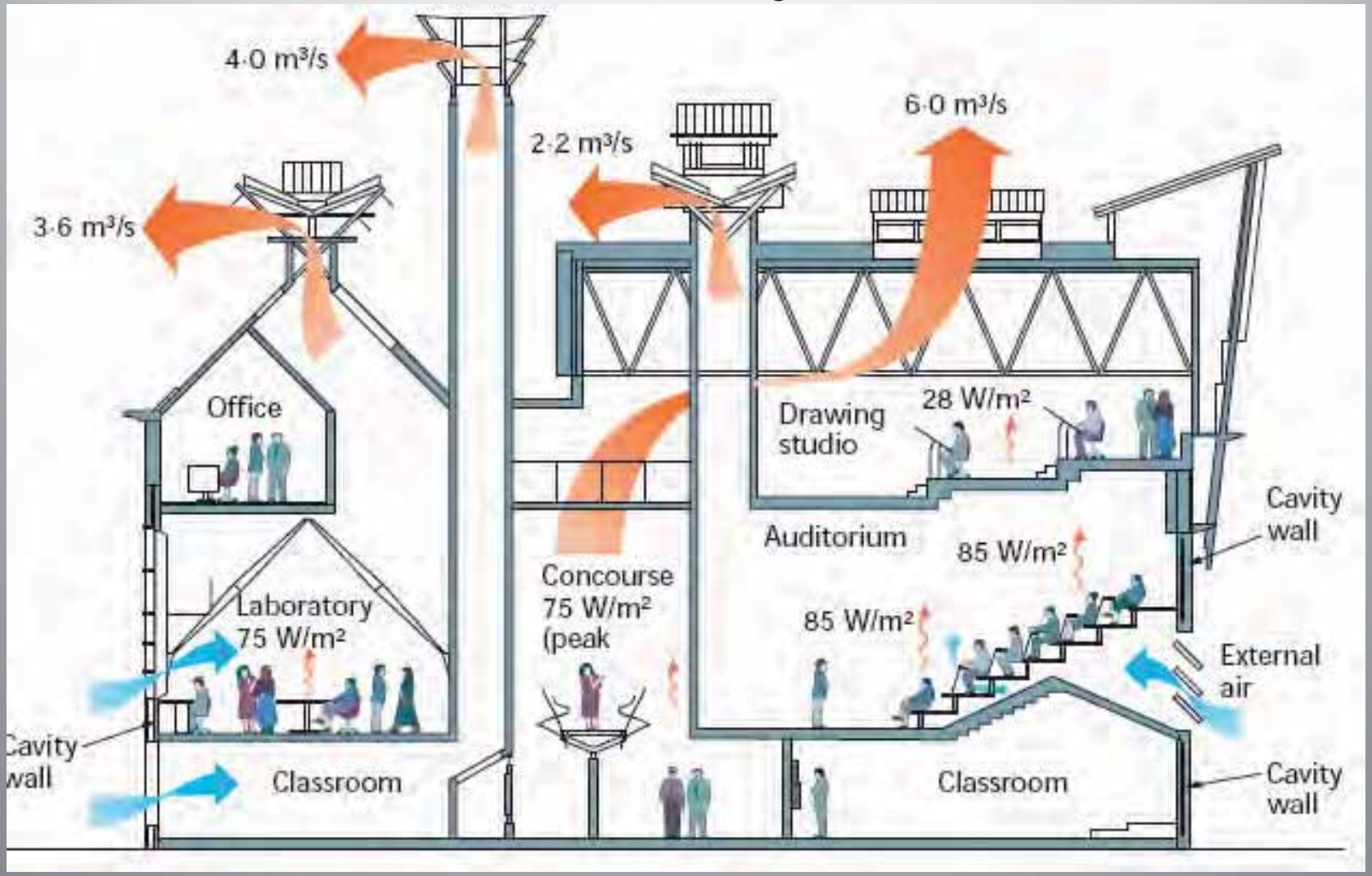
COOLING PLANT IS A FEATURE OUTSIDE MAIN ENTRANCE

Beetham Tower Manchester – 50 storeys high – opening windows

NATURALLY VENTILATED BUILDINGS HAVE CHIMNEYS , OPENING WINDOWS,AIR INLETS AND OUTLETS


QUEENS BUILDING

De Montfort University - air flow routes



Integrated design

9 May, 2016

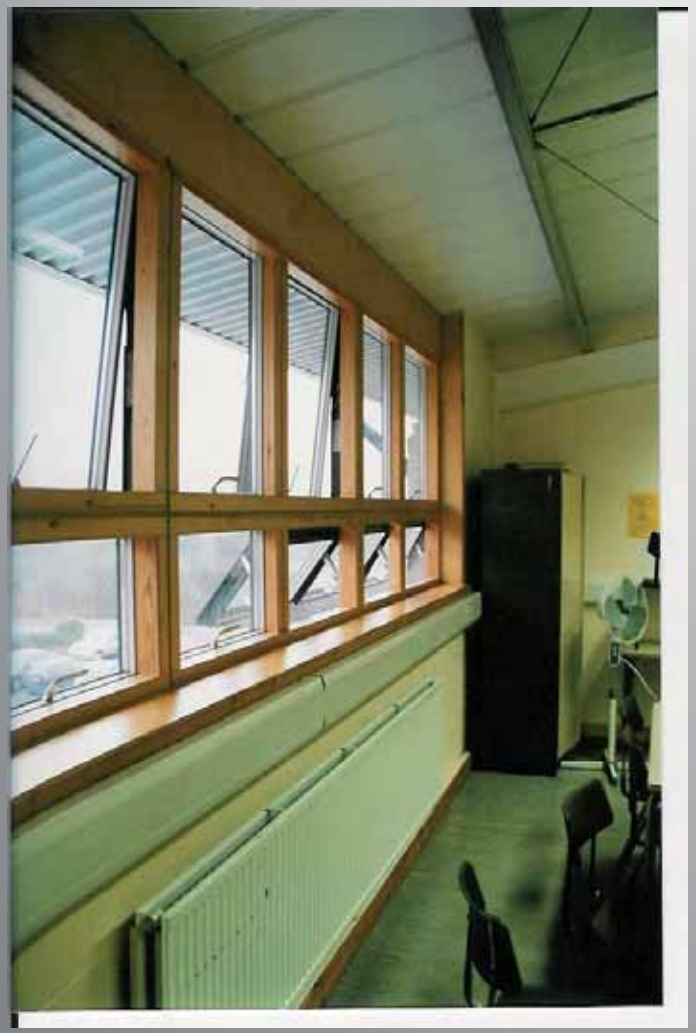
Air inlet design

Aesthetics and free area

Integrated heater VCD and grille

Windows

MANUAL OR AUTOMATIC
PISTONS
ACTUATORS
AESTHETIC DESIGN
SAFETY FEATURES – 100mm max?
SECURITY
OPERATION IN FIRE
ELECTRICAL CABLE ROUTES



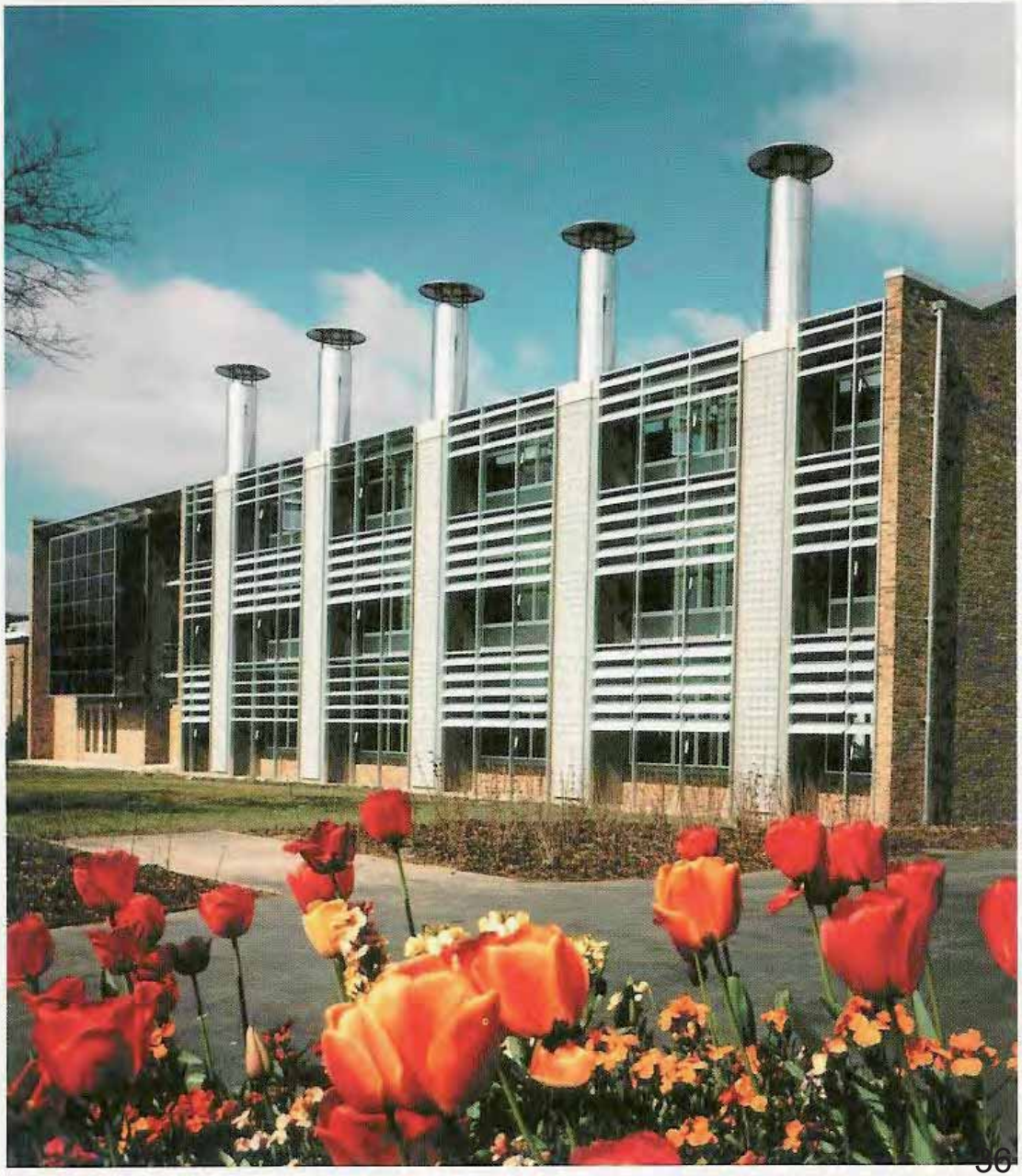
Security – window issues

ATRIUM ROOF OUTLETS

Integrated damper and louvre inlet

BRE TEST BUILDING – THEIR 'ENVIRONMENTAL OFFICE'

SOLAR CHIMNEYS TO PROMOTE AIRFLOWS.

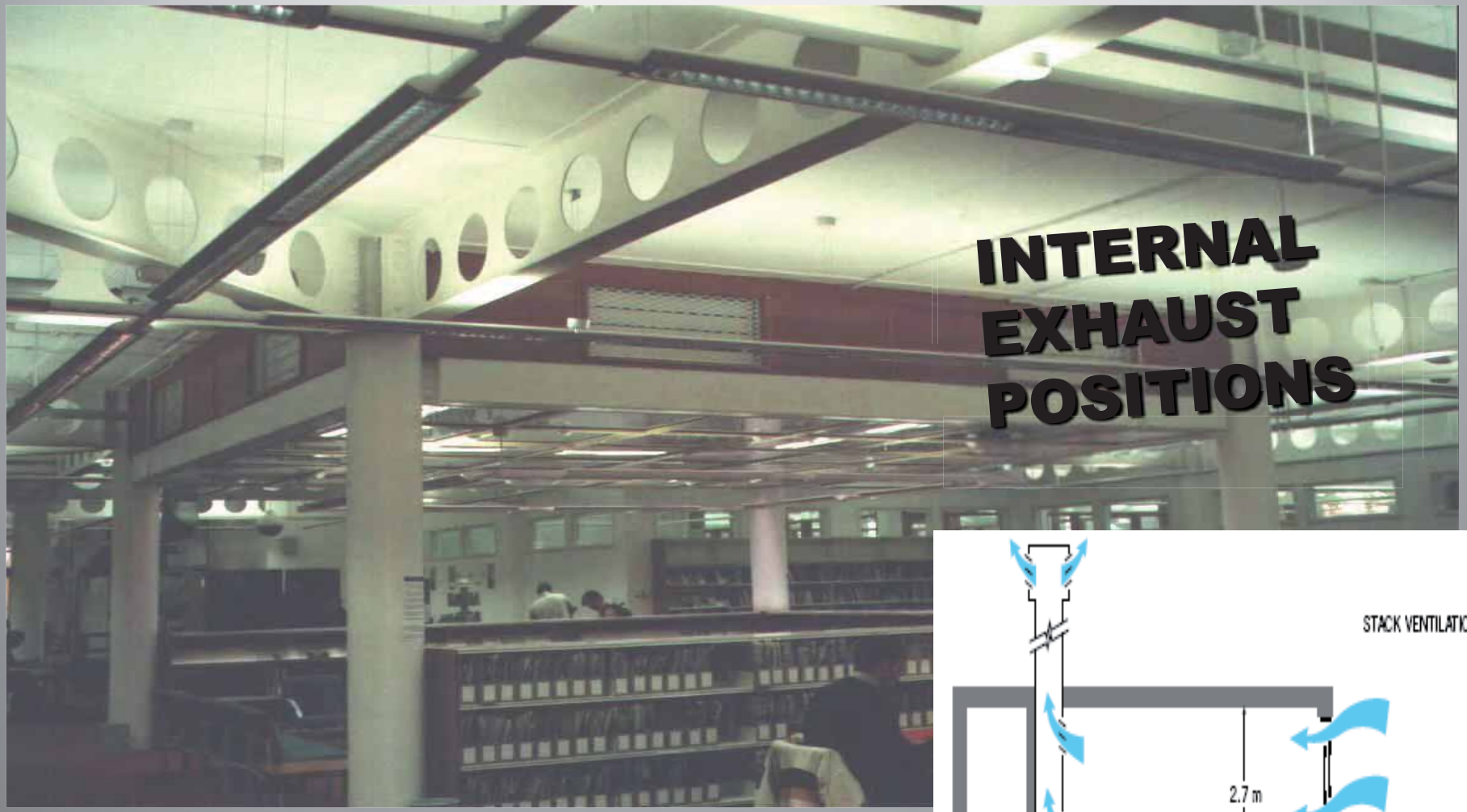


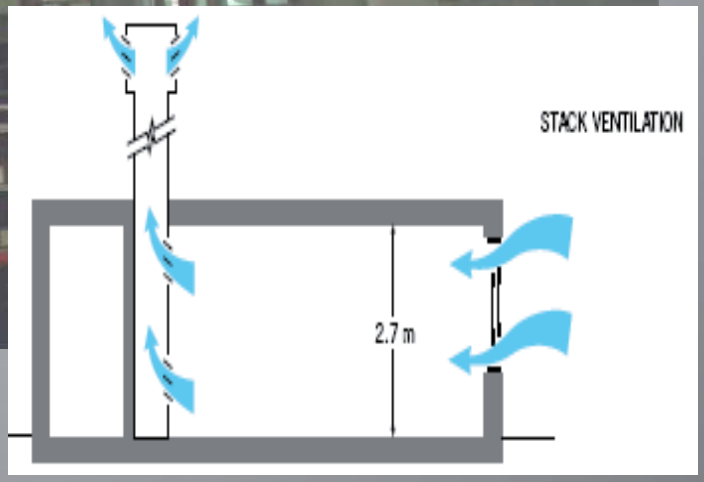
COVENTRY UNIVERSITY LIBRARY

Chimney - but no opening windows

Roof outlets over atria

LANCHESTER LIBRARY, COVENTRY





Coventry University library

Atrium Buildings

- Runshaw College Leyland. Infill all courtyards with atriums, 1993.

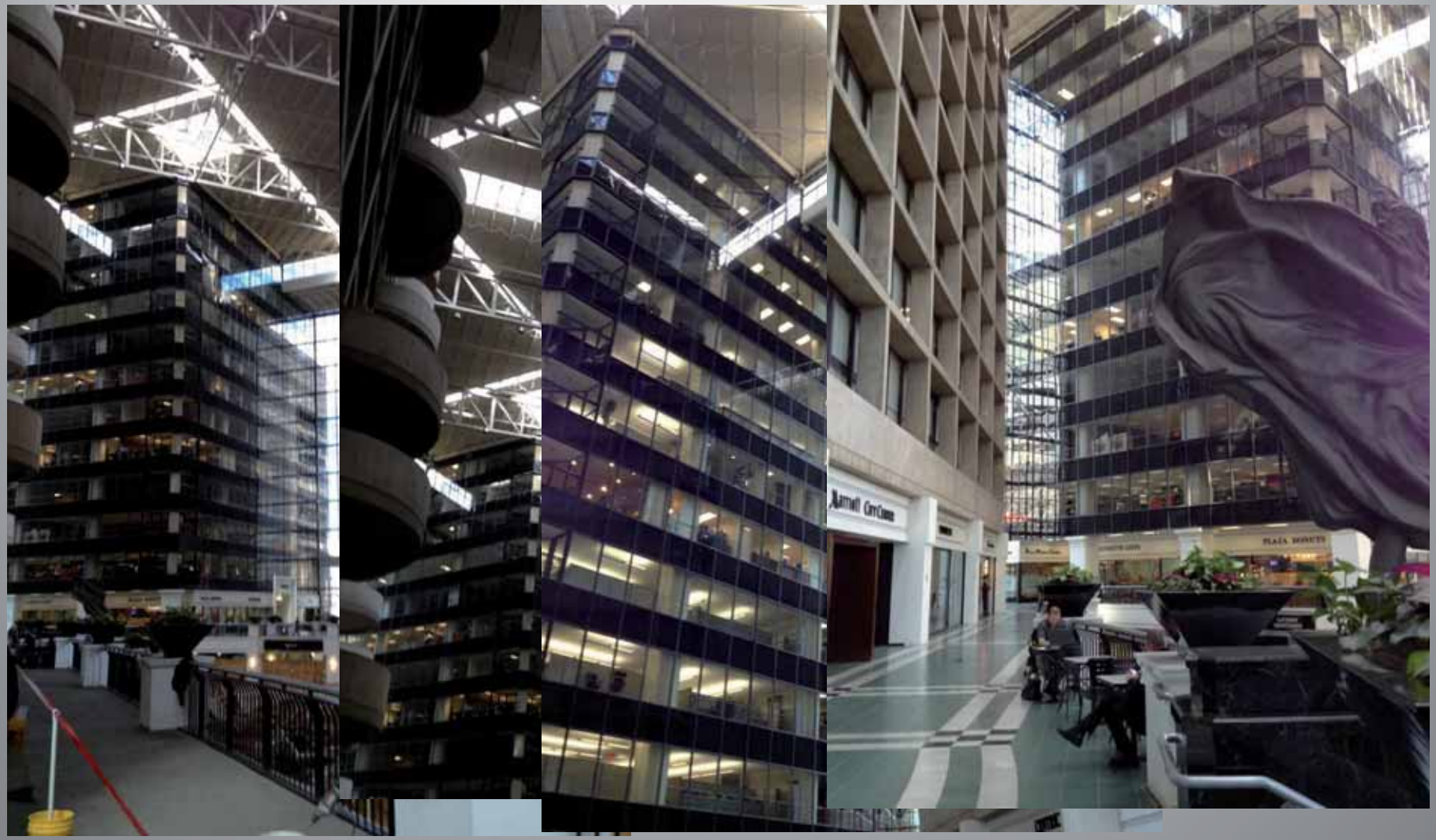
RUNSHAW COLLEGE, LEYLAND

European arcades

Royal arcade Brussels

Kings Cross station London

Atrium -a ventilation shaft



Corporate HQ offices

- EXCELLENT ECO RATING
- NATURAL VENTILATION
- LOW ENERGY OFFICE
- ATTRACTIVE ENVIRONMENT
- COMBINES USER CONTROL OF WINDOWS WITH AUTOMATIC CONTROL OF INTERNAL ENVIRONMENT
- LOW OPERATING AND MAINTENANCE COSTS

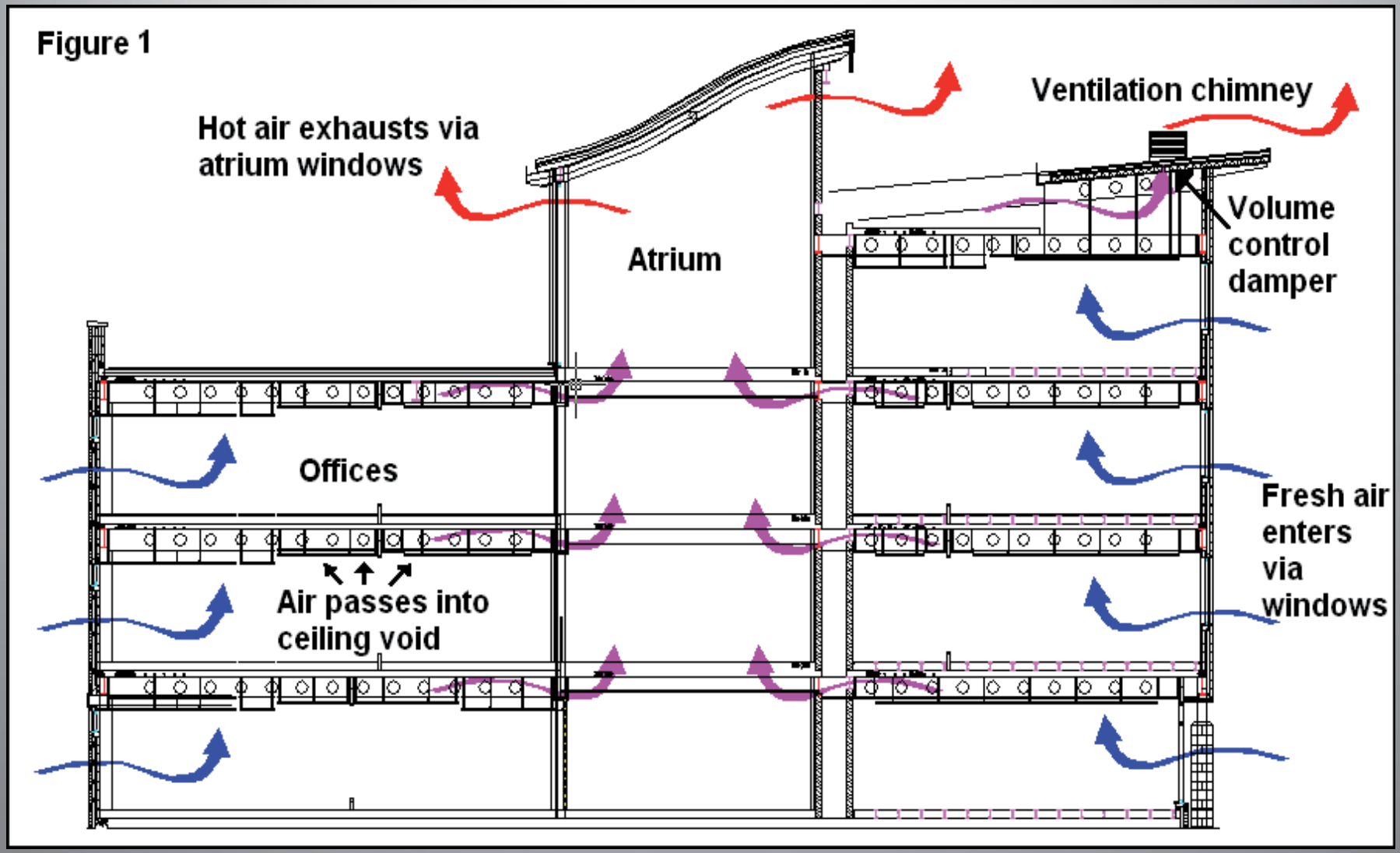
Natural Ventilation - Atrium Street

Cross flow across office wings to central atrium

Deep plan build 30m by use of central atrium exhaust

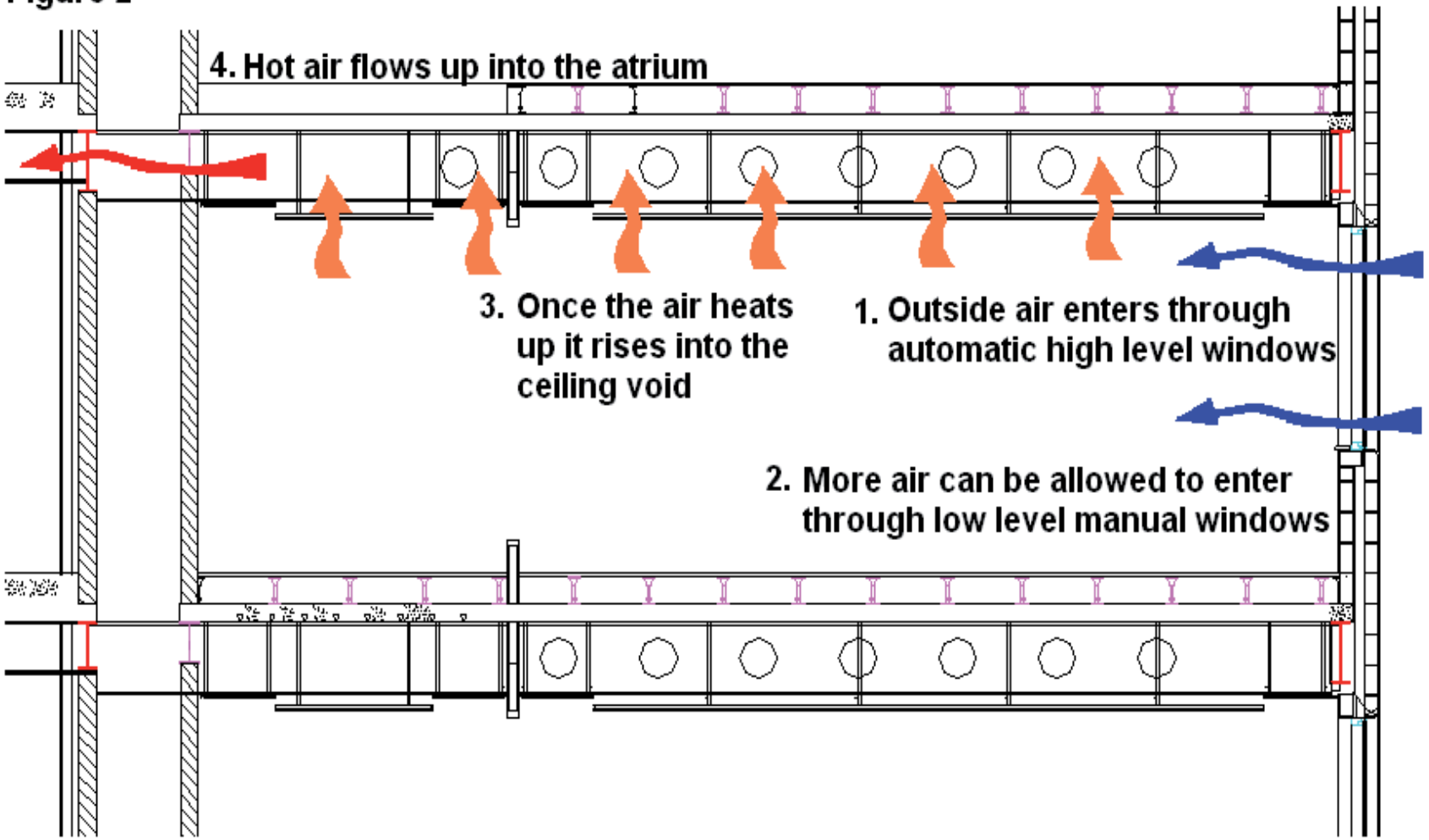
Atrium Street as a ventilation shaft

NATVENT STRATEGY

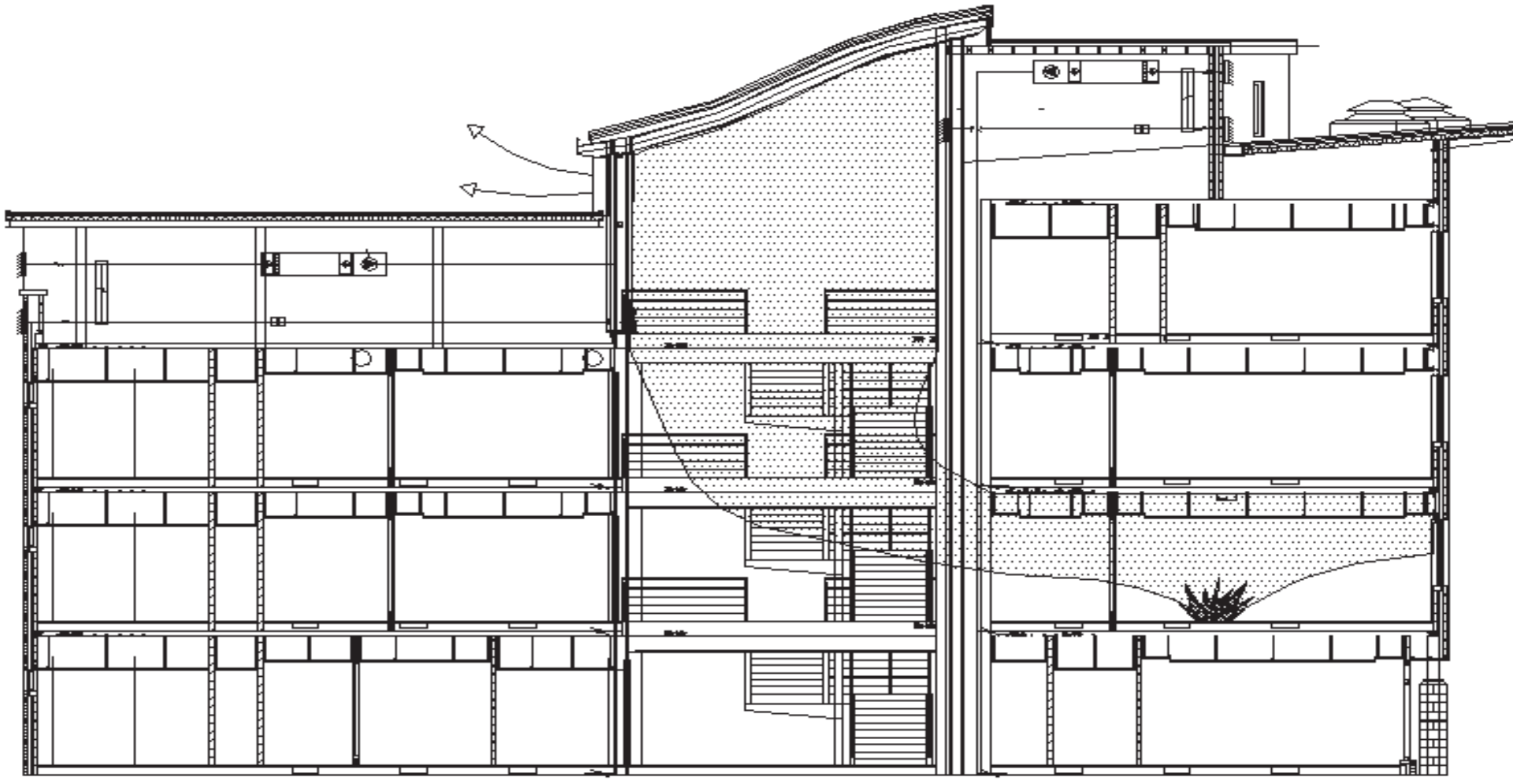


NATVENT AIRFLOWS

Figure 2



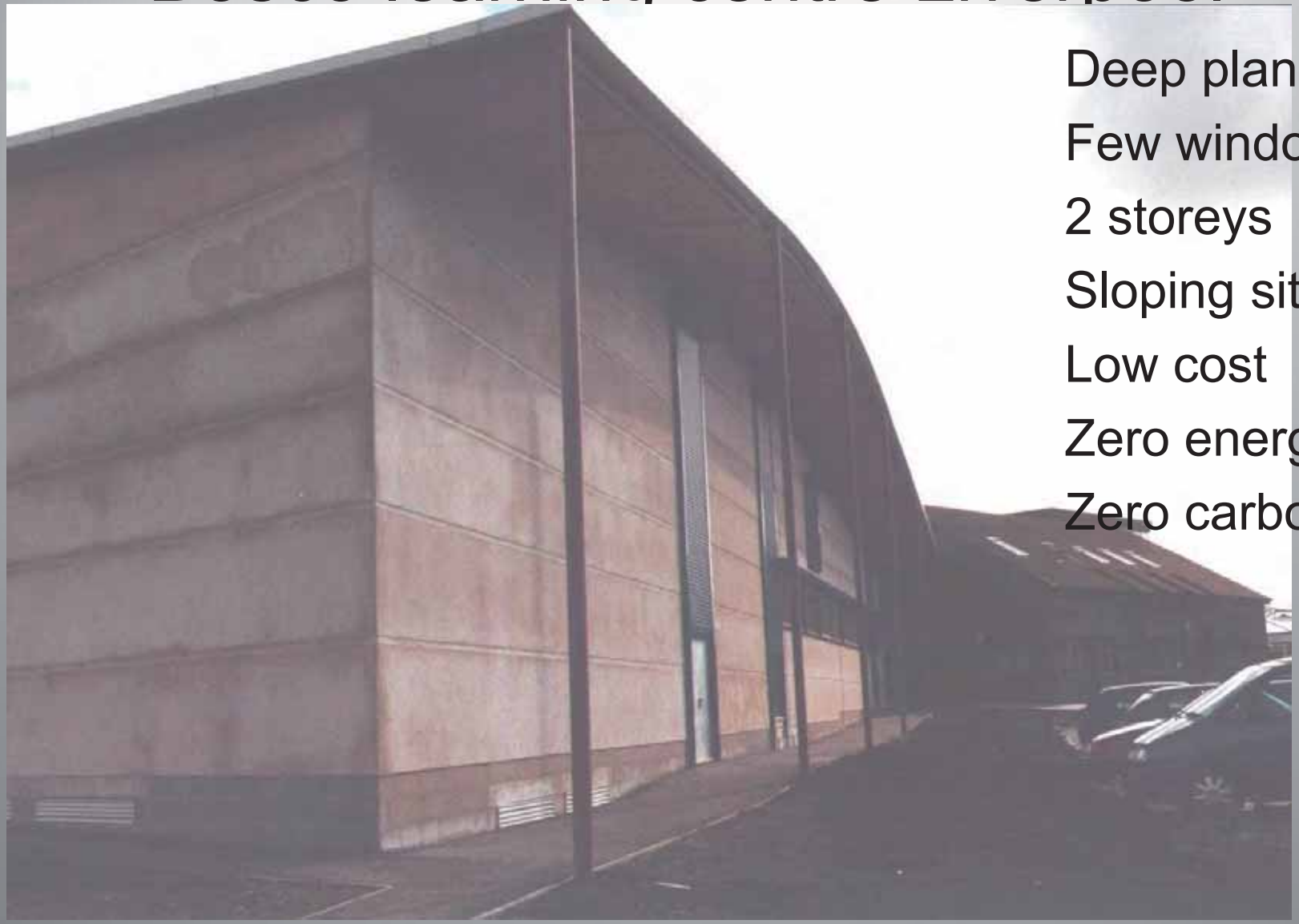
- FIRE SAFETY – NATVENT SMOKE EXHAUST



HOLLINGWORTH HIGH SCHOOL – NEW SPORTS CENTRE USING DIAPHRAGM WALL AS THE AIR SUPPLY AND EXHAUST SPACES.

DIAPHRAGM WALL USED AS AIR PATHS, INLETS AND OUTLETS - 600mm WIDE CAVITY

Bosco learning centre Liverpool



Deep plan

Few windows

2 storeys

Sloping site

Low cost

Zero energy

Zero carbon

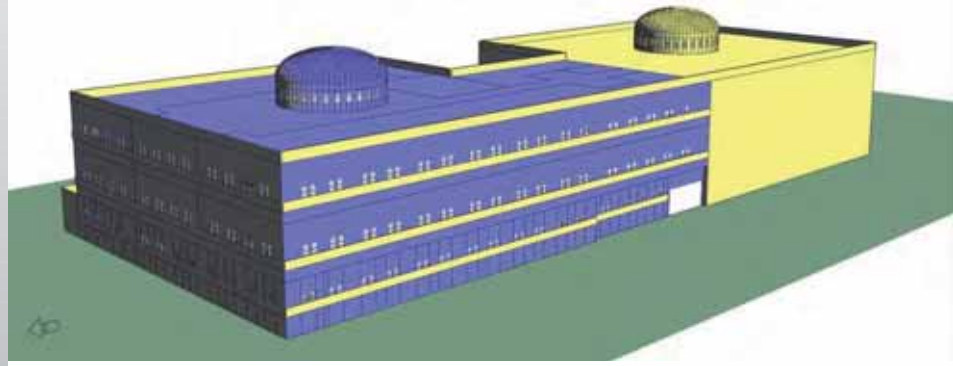
Air enters via low level louvres into the floor void below the building

Theatre - 450 seats. Displacement ventilation from air inlets below stage and seats – exhaust via roof chimneys

Modelling Experience: Education Projects

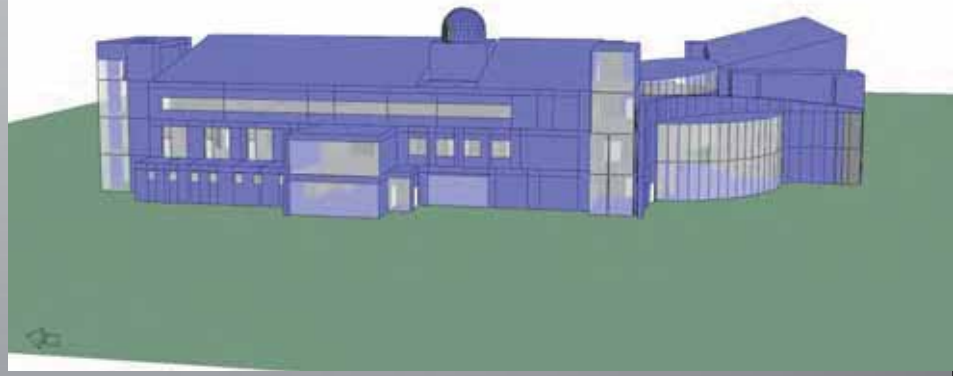
West Cheshire College, UK

University of Sharjah, UAE



Ridgeway CLC, UK

York University, UK



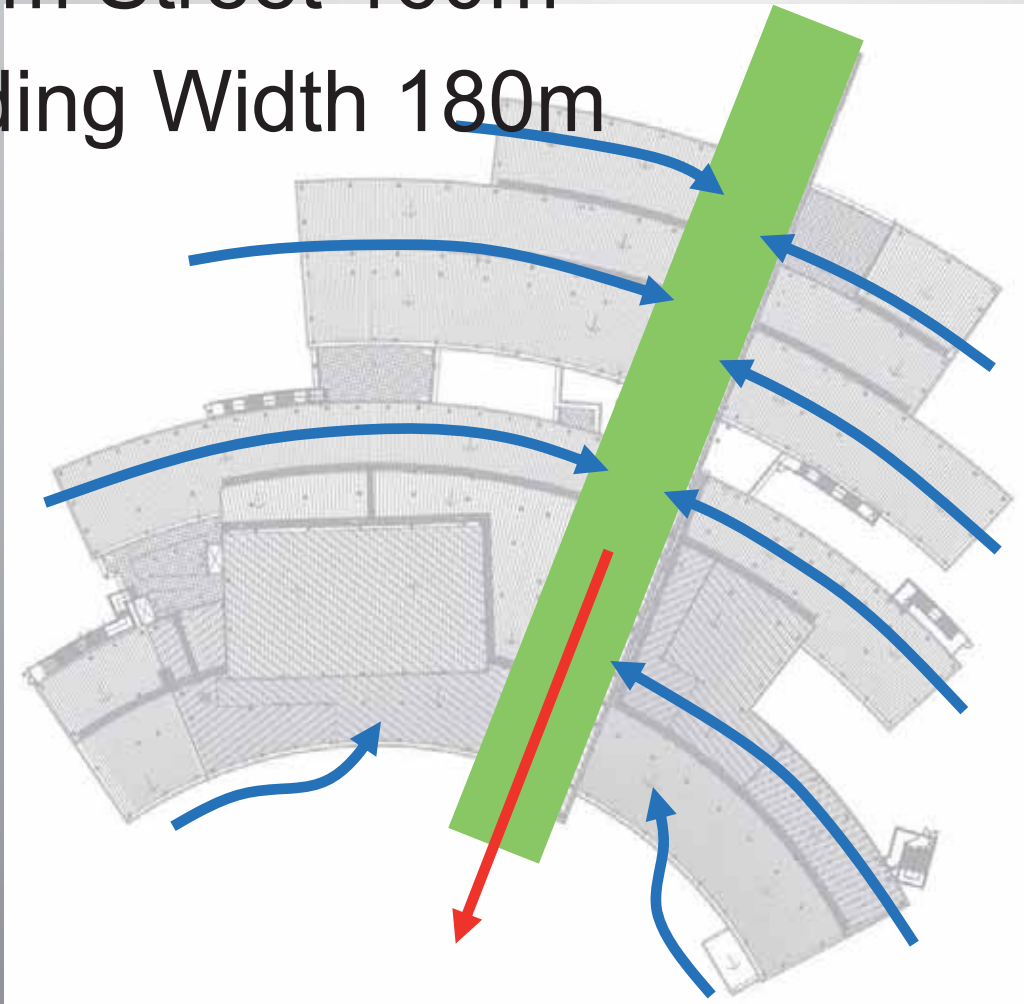
Education: Pendle Vale College

- Project Summary:
  - Size: 13,000m^2
  - Construction Cost: £28M
  - Occupancy: 1200 pupils plus staf
  - Scope: Secondary pupils (11-16);
  - Construction Period: August 2006
  - School opened September 2009
  - Procurement Method: PFI-Based ‘Building Schools for the Future’ (BSF)
  - Low Energy aspirations – beyond Building Regulations Part L (2006) [designed 2005]

Pendle Vale College, Burnley

Pendle Vale College: Natural Ventilation Principle

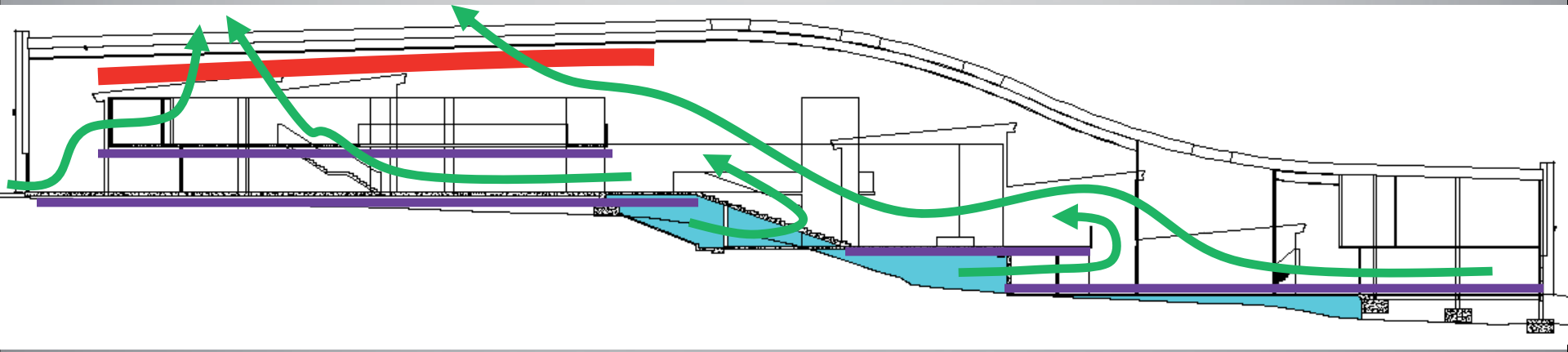
- Atrium Street 160m
- Building Width 180m



Pendle Vale: Ventilation Principle Long Section

Ground coupling

Thermal bouyancy



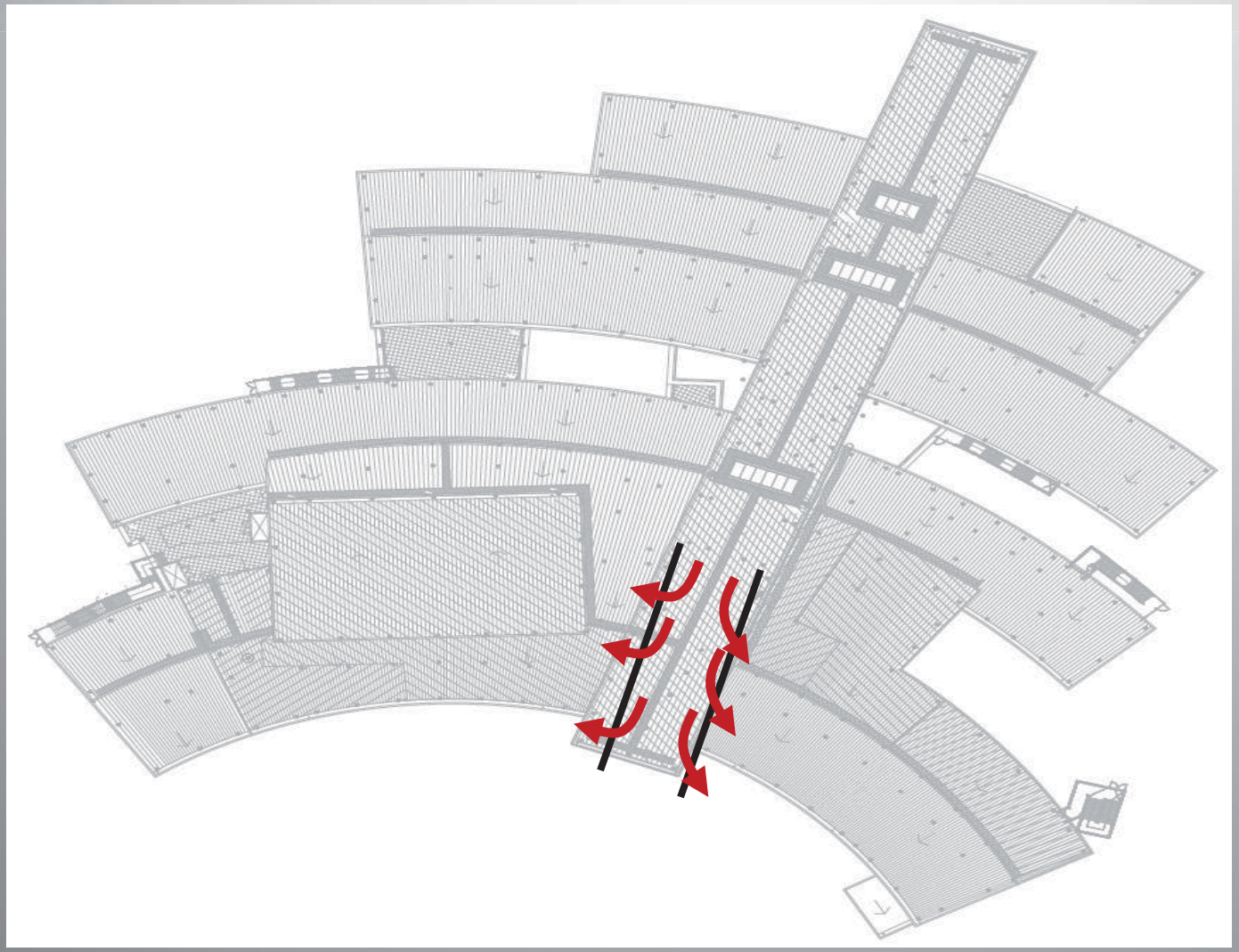
Pendle Vale Floor Plan: Level 01 – sloping site

Pendle Vale Floor Plan : Level 02

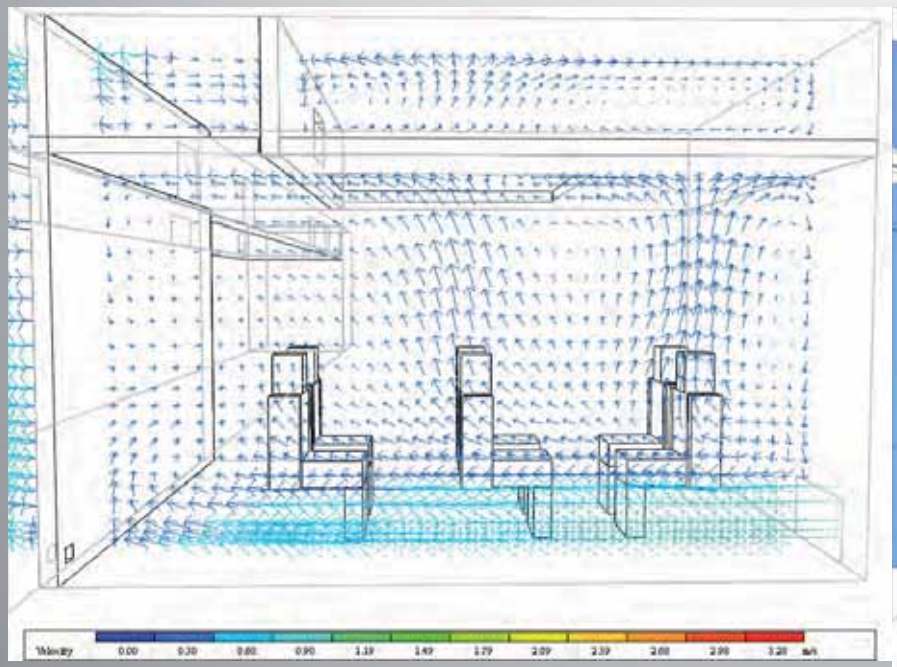
Pendle Vale Floor Plan : Level 03

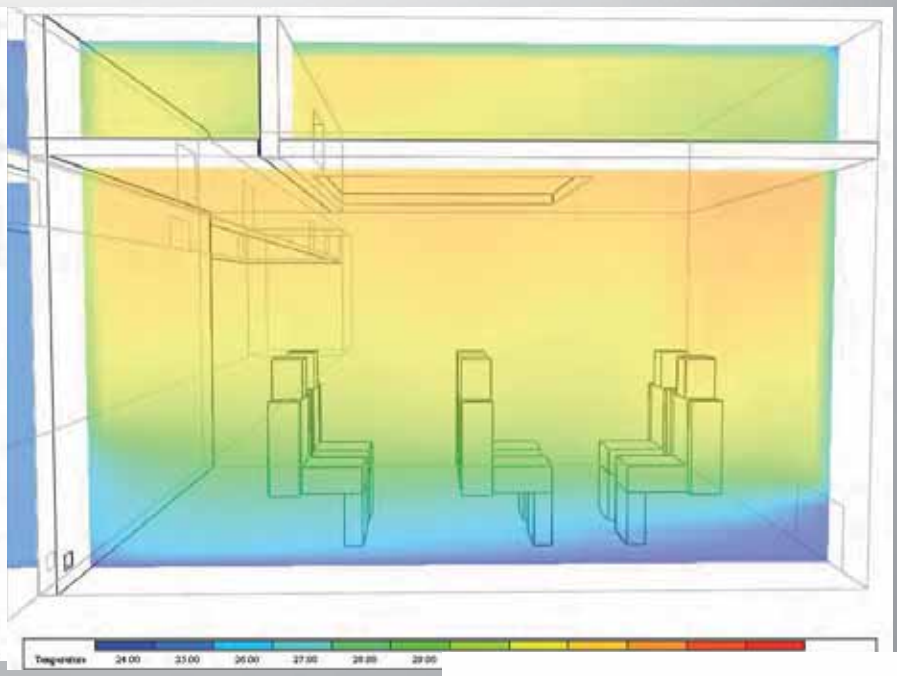
Pendle Vale Floor Plan : Level 04

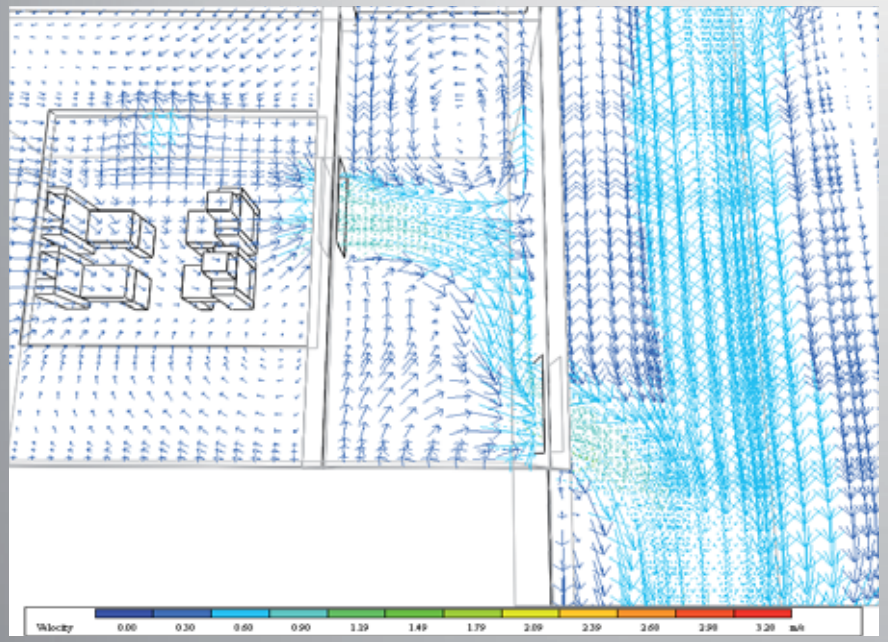
Pendle Vale Floor Plans: Roof – the Vent exhaust

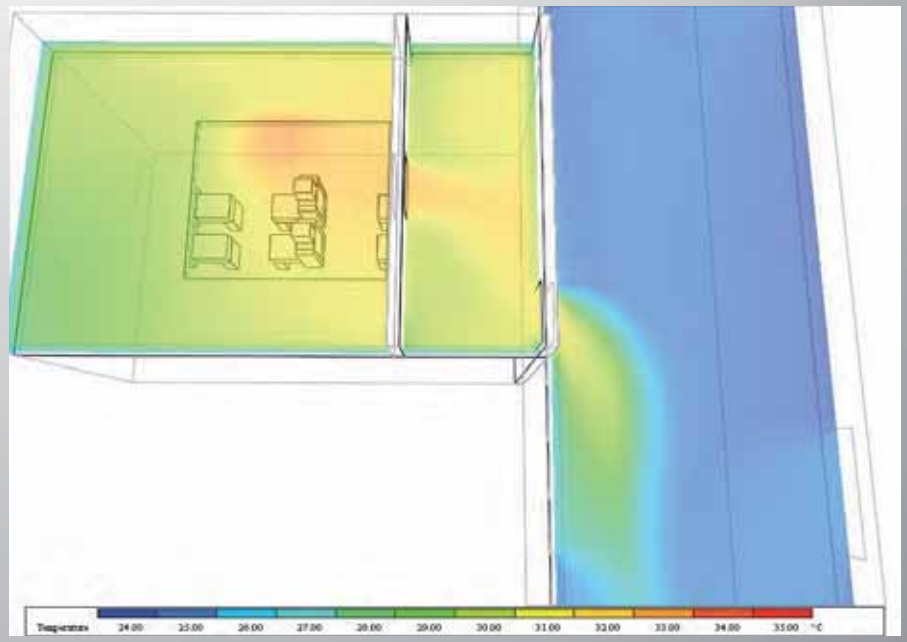


Pendle Vale: Design Validation: CFD Results

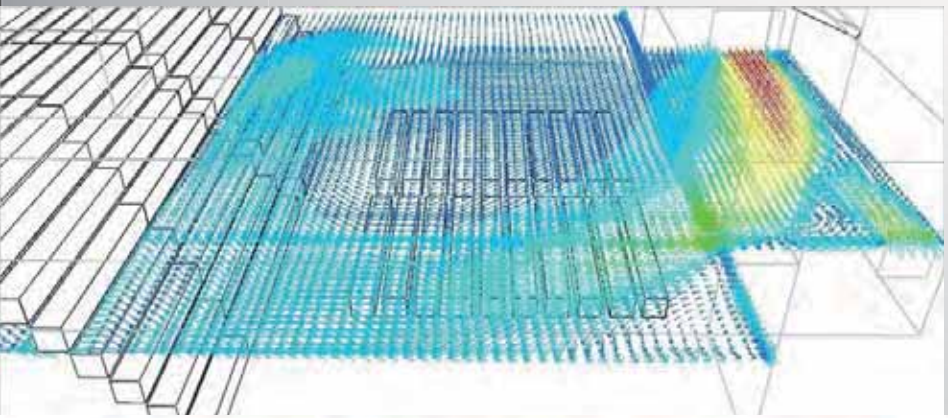


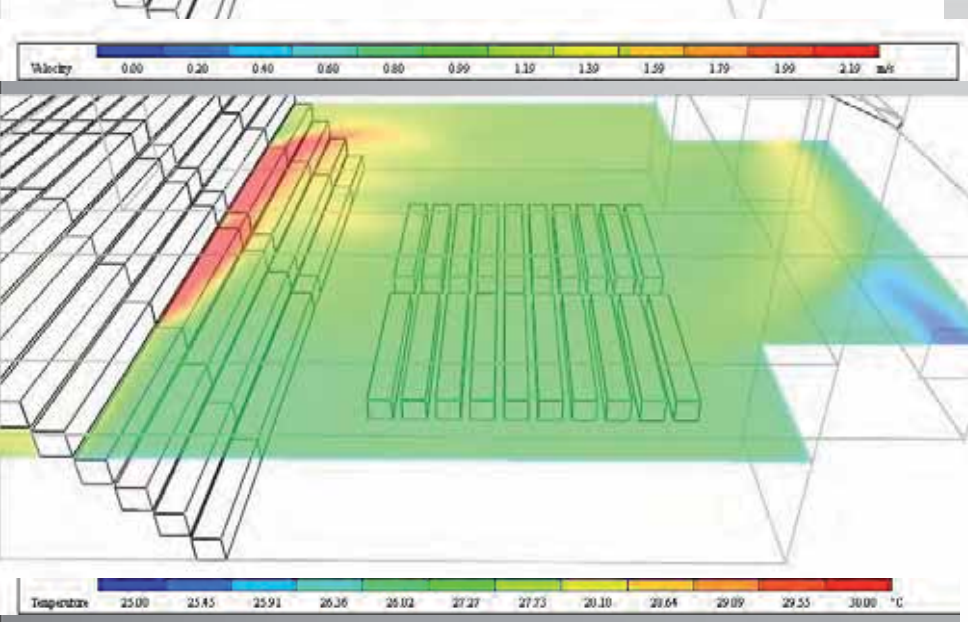


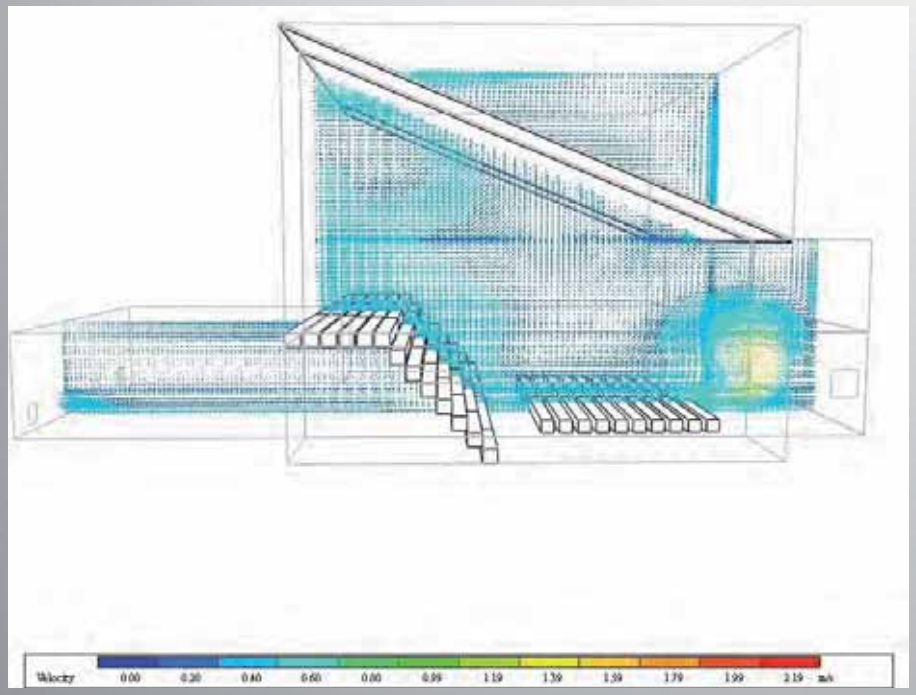

Velocity
0.00
0.30
0.60
0.90
1.19
1.49
1.79
2.09
2.39
2.69
2.98
3.28
m/s

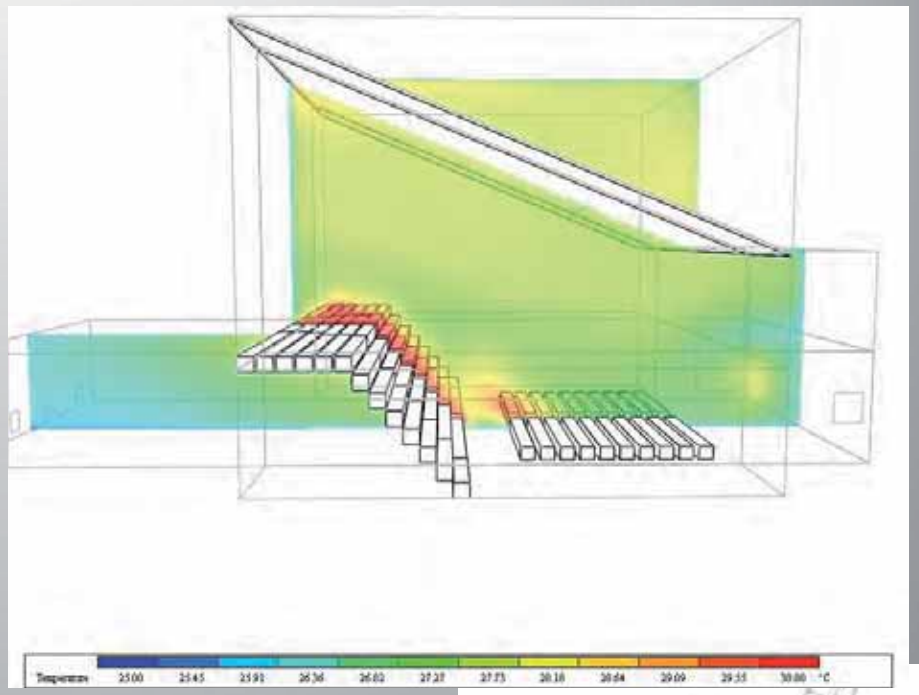

Temperature
24.00
25.00
26.00
27.00
28.00
29.00
30.00
31.00
32.00
33.00
34.00
35.00
°C

Central atrium space – theatre style

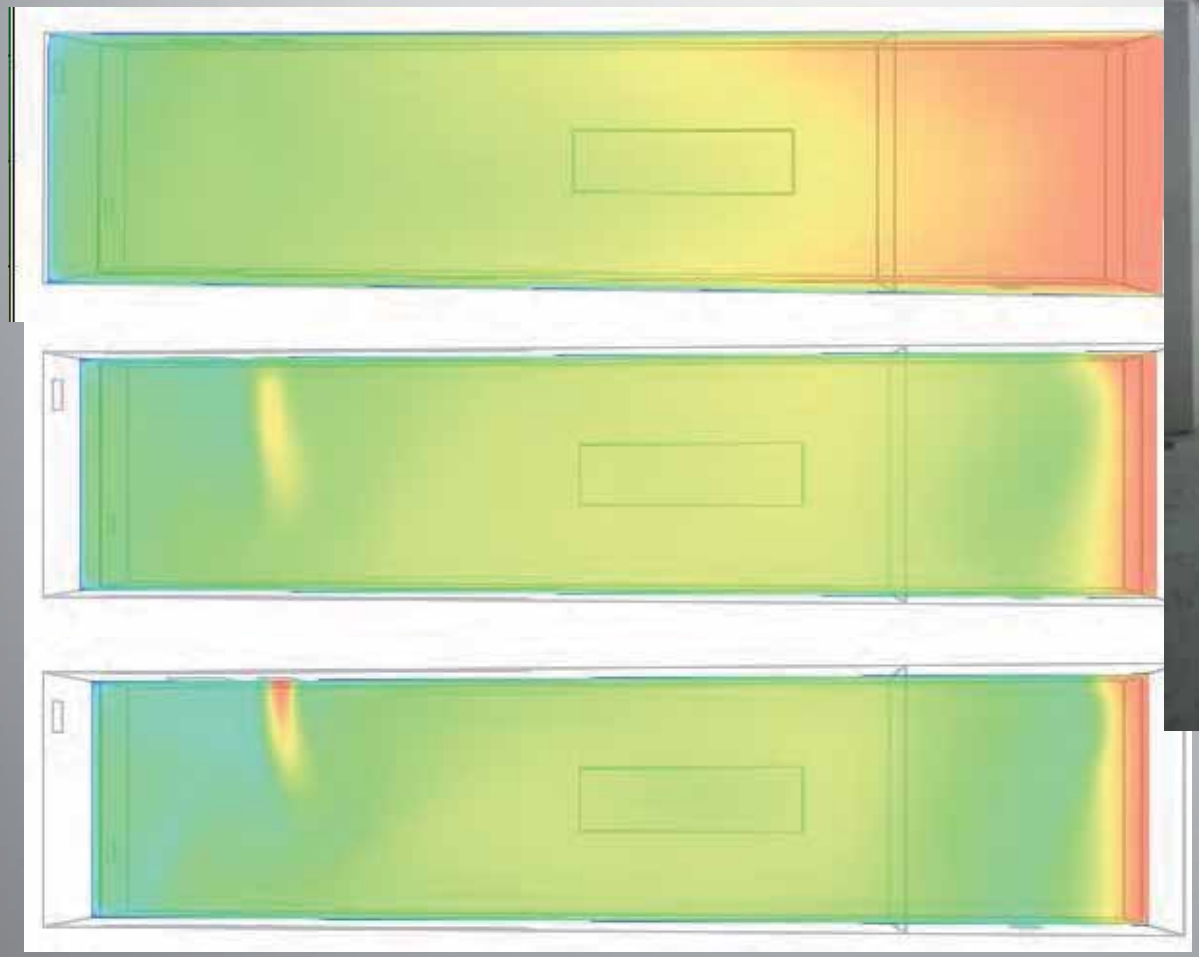


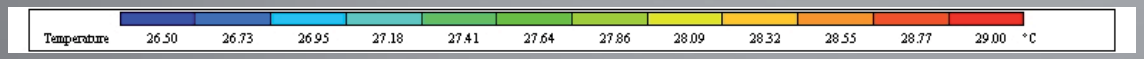



Velocity
0.00
0.20
0.40
0.60
0.80
0.99
1.19
1.39
1.59
1.79
1.99
2.19
m/s


Temperature
25.00
25.45
25.91
26.36
26.82
27.27
27.73
28.18
28.64
29.09
29.55
30.00
°C

Atrium roof – controlled air exhaust





Summary

- Naturally ventilated approach shown to work
- ‘Worst case scenario’ - rooms OK in summer – future years too
- Comfort conditions acceptable
- Low energy/carbon design approach
- High performing Energy Performance Certificate
- Rating ‘B’ – near zero carbon

Southport Eco-Centre -Zero energy , zero carbon
Wind turbine and ground source heat pumps.

9 May, 2016

Solaris building, Blackpool – net zero carbon

PV - EFFECTIVE SHADING AND DAYLIGHT DIFFUSER

Frank Mills
Technical Director
Low Carbon Design Consultants

Developing a successful community

8 Categories for Community sustainability

Climate & Energy

Resources

Transport

Ecology

Business

Community

Placemaking

Buildings

Trafford Waters – zero carbon city

TRAFFORD WATERS

PLANNING APPLICATION

Sustainability and Energy Statement

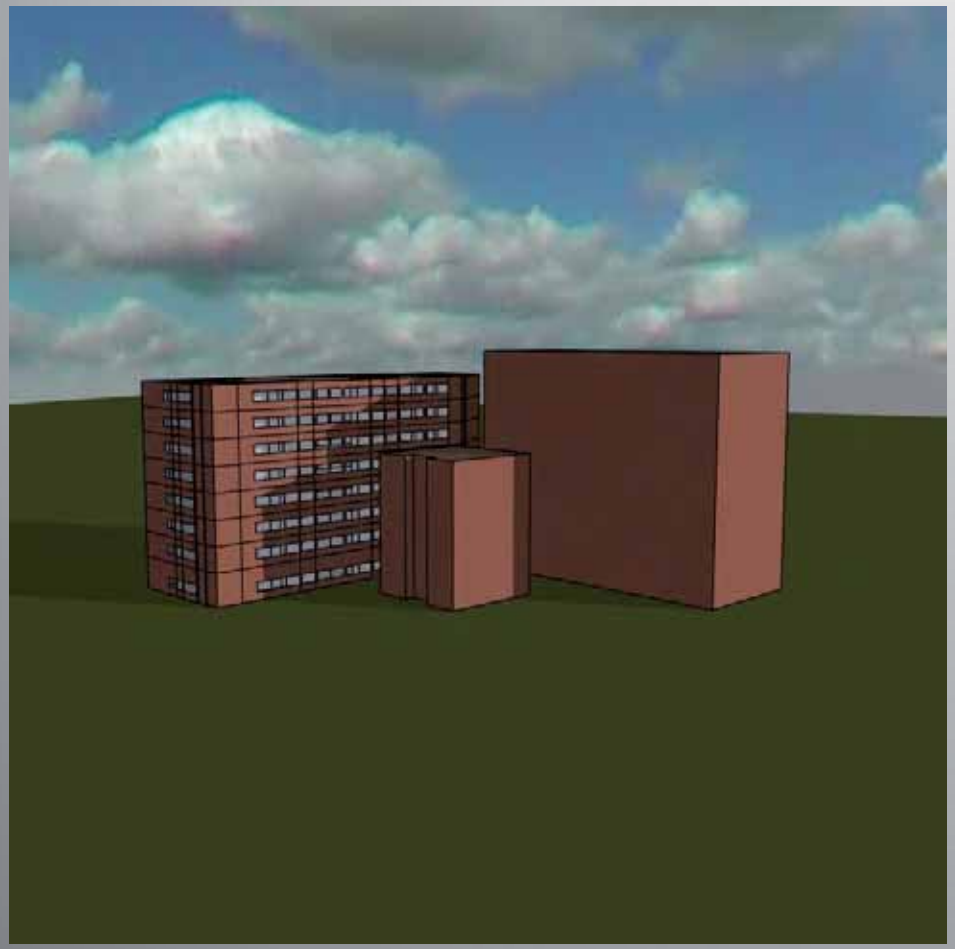
March 2015

PEEL

Office building, Newcastle

Expert advice

Modelling



Issues

- Overheating
- Fresh air needed in winter as well as summer – Indoor air quality all year
- Without cold draughts
- Without rain blowing in (and snow?)
- Without blowing papers around
- Control through variable weather and usage

Dry Resultant Temperature Window opening 120mm

Location	> 25.00	> 26.00	> 27.00	> 28.00	> 29.00	> 30.00	> 31.00	> 32.00	> 33.00	> 34.00	> 35.00	> 36.00	> 37.00	> 38.00	> 39.00	> 40.00	> 41.00
5.109	1117	835	586	396	223	114	49	18	5	2	0	0	0	0	0	0	0
5.108	701	459	271	123	58	14	6	2	0	0	0	0	0	0	0	0	0
54	98	18	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.105	46	7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.104	55	13	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
5.103	173	62	23	4	2	0	0	0	0	0	0	0	0	0	0	0	0
5.102	1481	1199	986	794	556	355	211	96	39	15	2	2	0	0	0	0	0
5.106	114	45	9	2	0	0	0	0	0	0	0	0	0	0	0	0	0
5.101	2341	2046	1761	1469	1207	998	793	558	393	236	122	55	20	7	2	1	0
5.111	943	674	438	279	126	53	14	5	3	0	0	0	0	0	0	0	0
5.11	1007	753	512	329	159	79	19	8	4	0	0	0	0	0	0	0	0
5.112	39	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total hour	8115	6118	4593	3397	2331	1613	1092	687	444	253	124	57	20	7	2	1	0

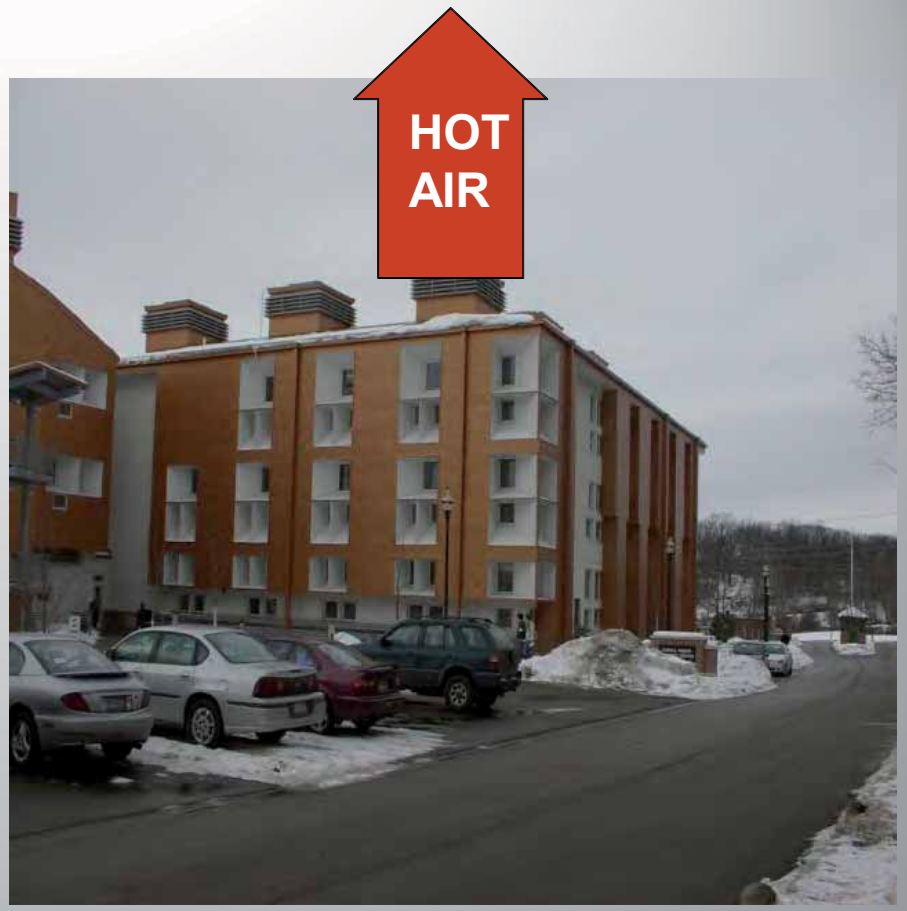
And …Physical site studies

Natural ventilation in a hot and humid summer climate

Naturally ventilated university building in a hot humid ‘extreme’ climate – lowest energy education building in US.

January 2009 T_{out} of -20ºC.
Judson College, Chicago,USA

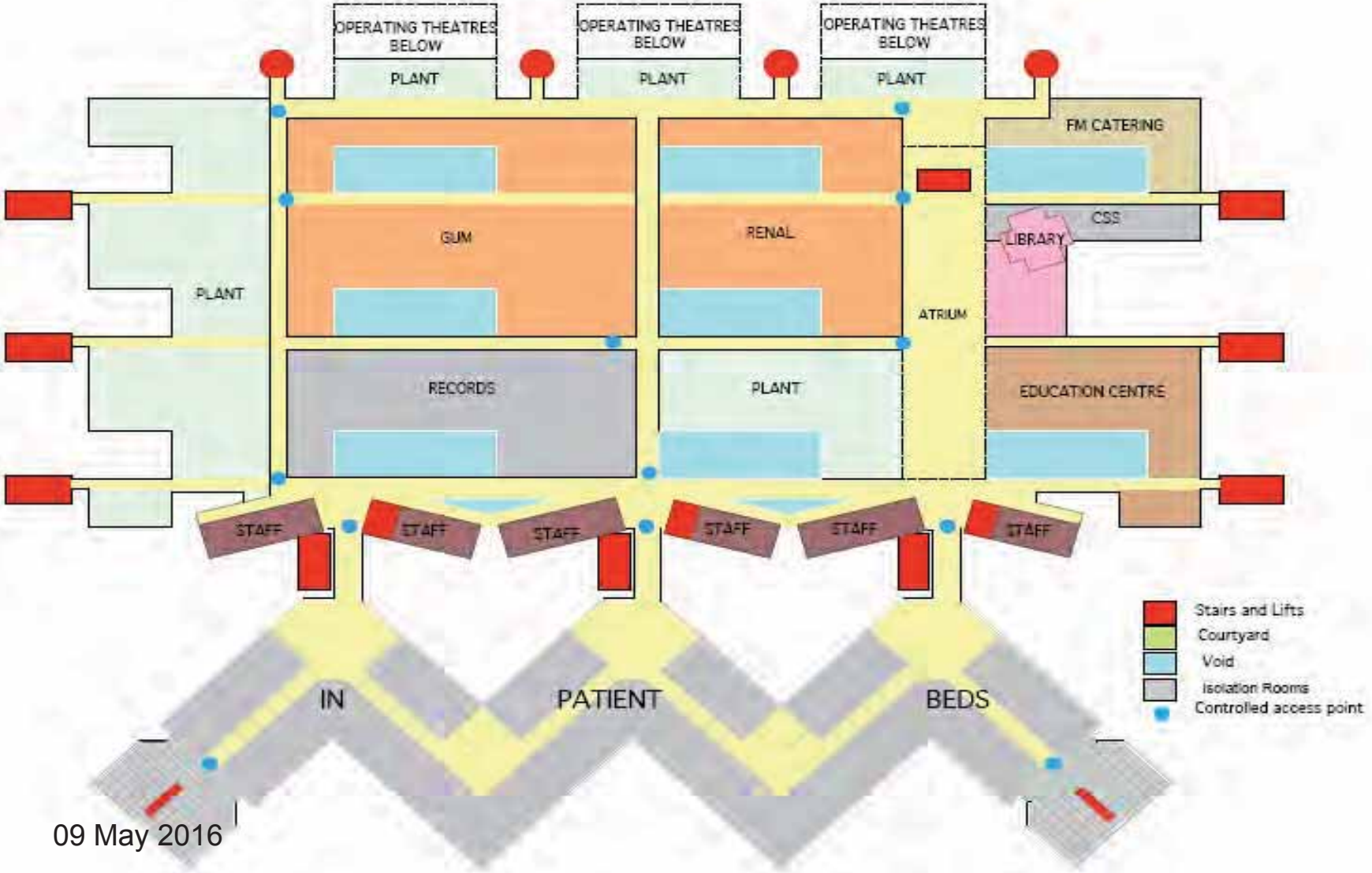
Judson College Chicago



Ground level air intakes and roof air exhausts enable natural ventilation whilst minimising infection control risk

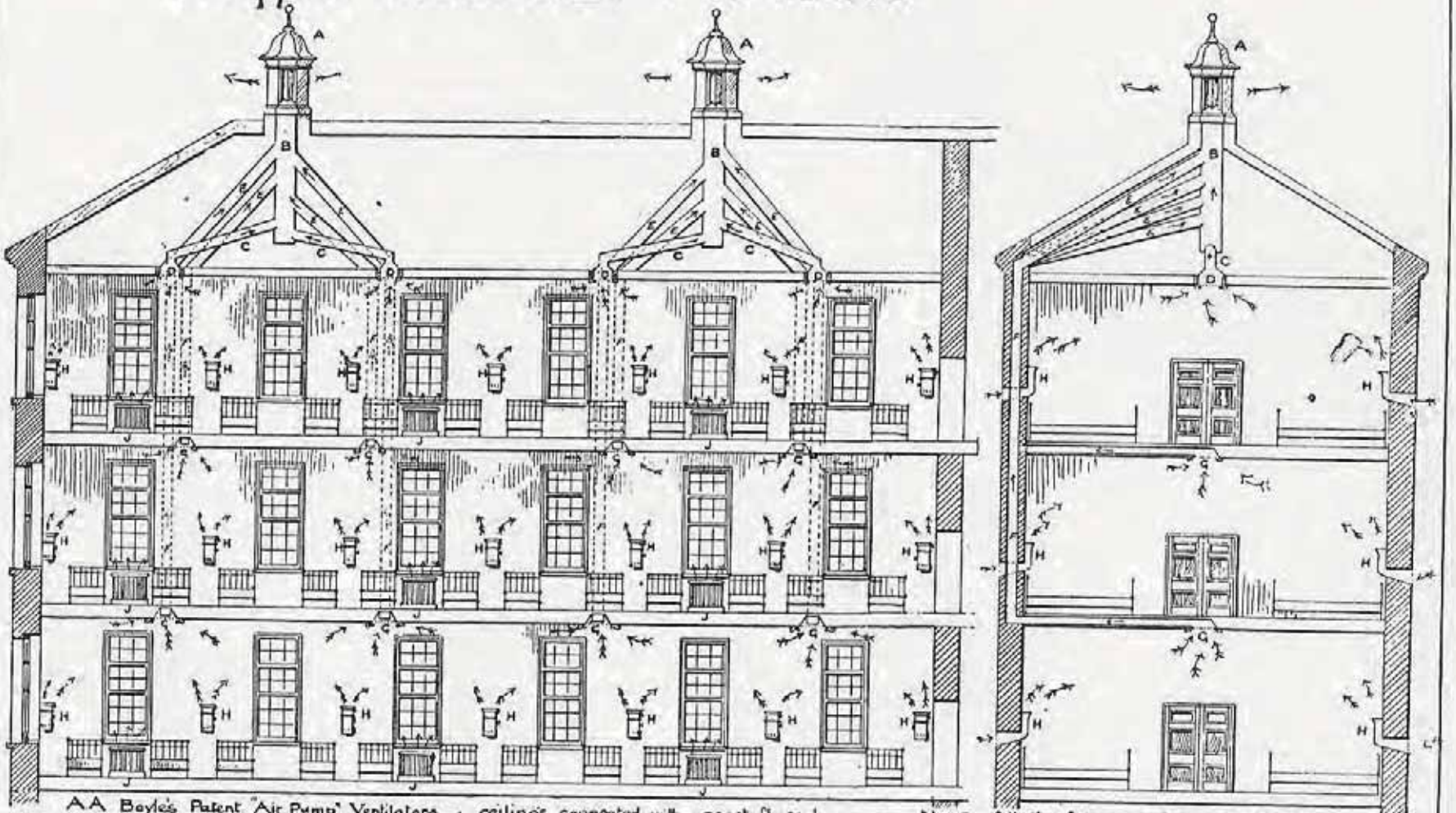
Judson College Chicago

HOSPITAL PLAN FOR NAT VENT – UPPER FLOORS



THE "BOYLE" SYSTEM OF VENTILATION

As applied to HOSPITALS & ASYLUMS



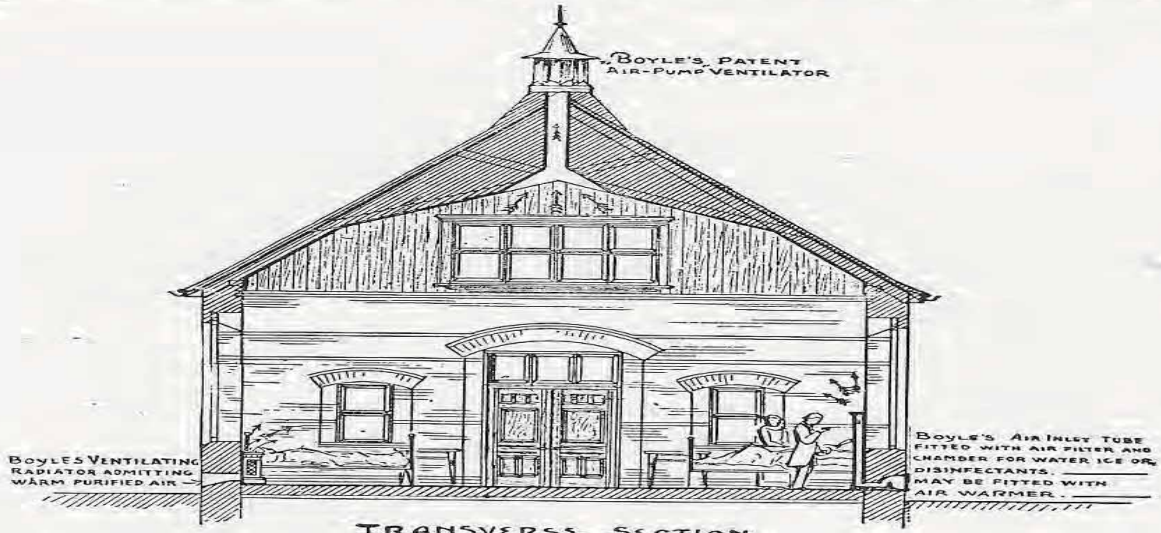
AA Boyle's Patent "Air Pump" Ventilators
B.B. Main Extraction Shafts.
C.C. Branch Extraction Shafts connected direct with Foul Air Exit openings D.D.
E.E. Branch Extraction Shafts connected with Upcast Flues F.F. constructed in walls
G.G Foul Air Exit openings in centre of ceilings connected with upcast flues by shafts between joists in channels formed in concrete floor
H.H. Boyles Air Inlet Brackets for admitting screened purified Air; may be fitted with Air-warmers or Disinfecting Chambers.
J.J. Boyle's Ventilating Radiators, admitting warmed, screened, and purified Air.

NOTE: All the Inlets are fitted with Regulating Valves, for controlling the Air Supply, which passes direct from the outside into the Building.

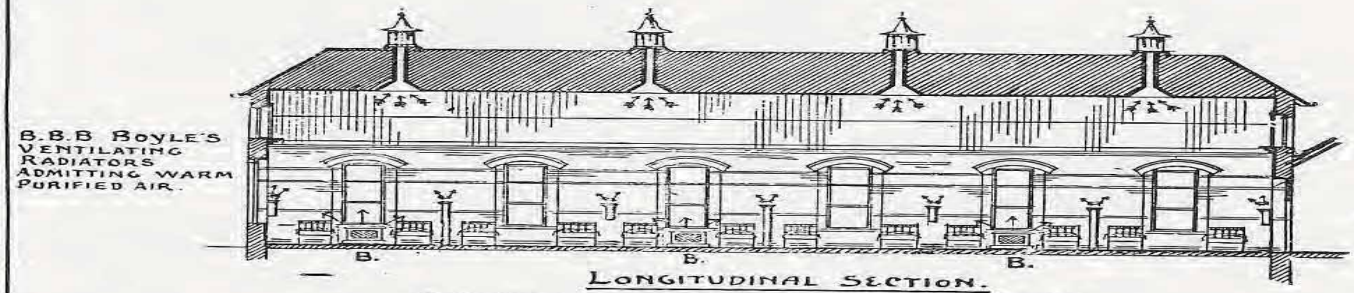
ROBERT BOYLE & SON, LTD
Ventilating Engineers,
LONDON & GLASGOW.

"The ventilation seems to be perfect."—LORD CLIFFORD (*Member of the House of Lords Committee on Hospitals*) on the "Boyle" System of

THE "BOYLE" SYSTEM OF VENTILATION
As applied to an INFECTIOUS DISEASES HOSPITAL.



TRANSVERSE SECTION.



LONGITUDINAL SECTION.

SHEWING INLETS FOR FRESH AIR and EXTRACTION TUBES

NOTE:—Fresh, purified air warmed or cooled, admitted underneath beds where desired

ROBERT BOYLE & SON, Ltd.
Ventilating Engineers.
LONDON & GLASGOW.

"In reply to your request that I should tell you how the 'Air-Pump' Ventilators recently fixed in the new building here are answering, I am able to inform you that they appear to fulfil their object in a completely satisfactory manner."
—F. FOORD CAIGER, M.D., *Medical Superintendent*, South Western Fever Hospital, London.

N.B.—For table of sizes and number of ventilators required for the ventilation of Fever Hospitals, see pages 156, 157.

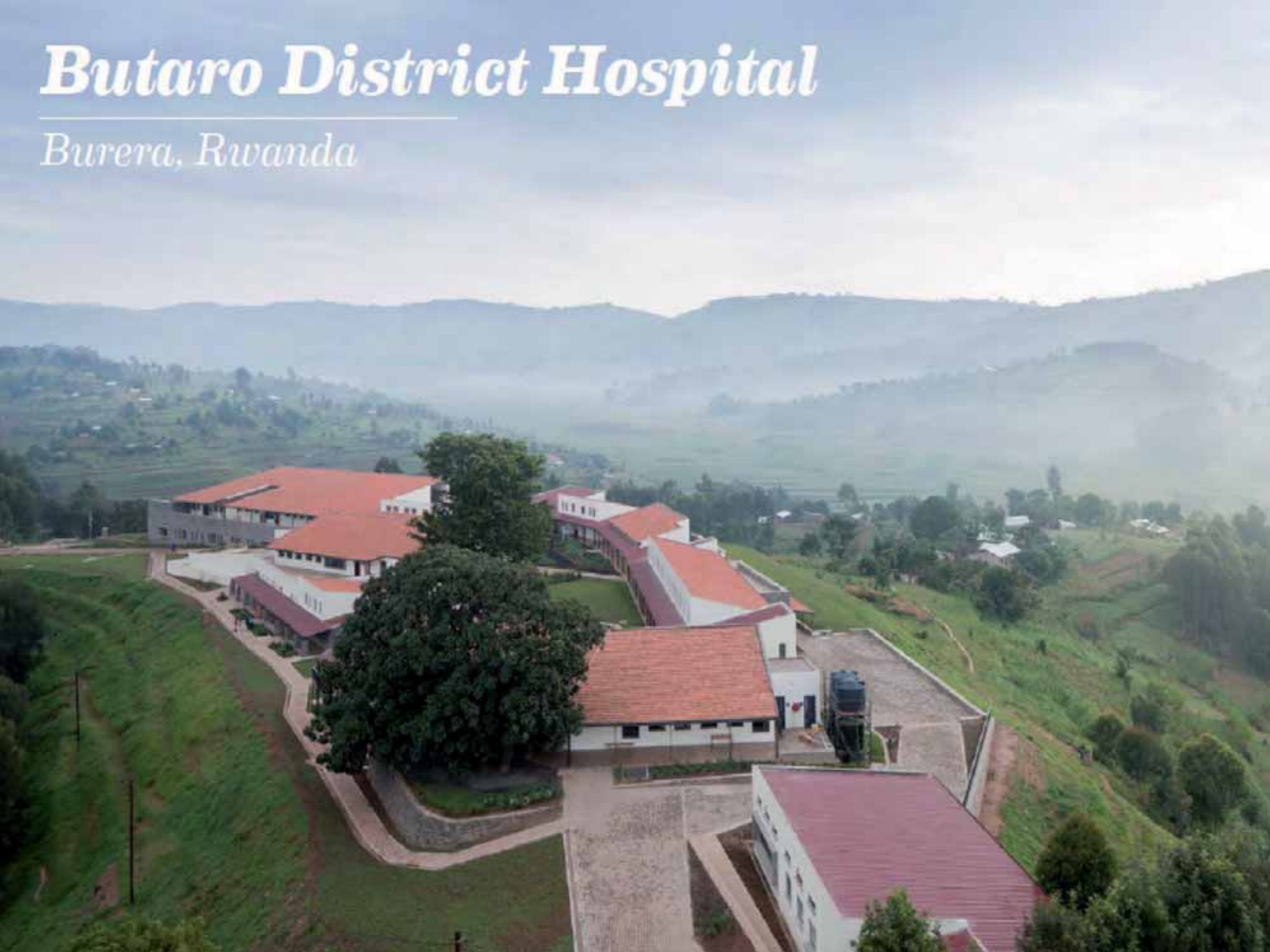
How would you design a healthcare facility if you couldn't use mechanical systems?

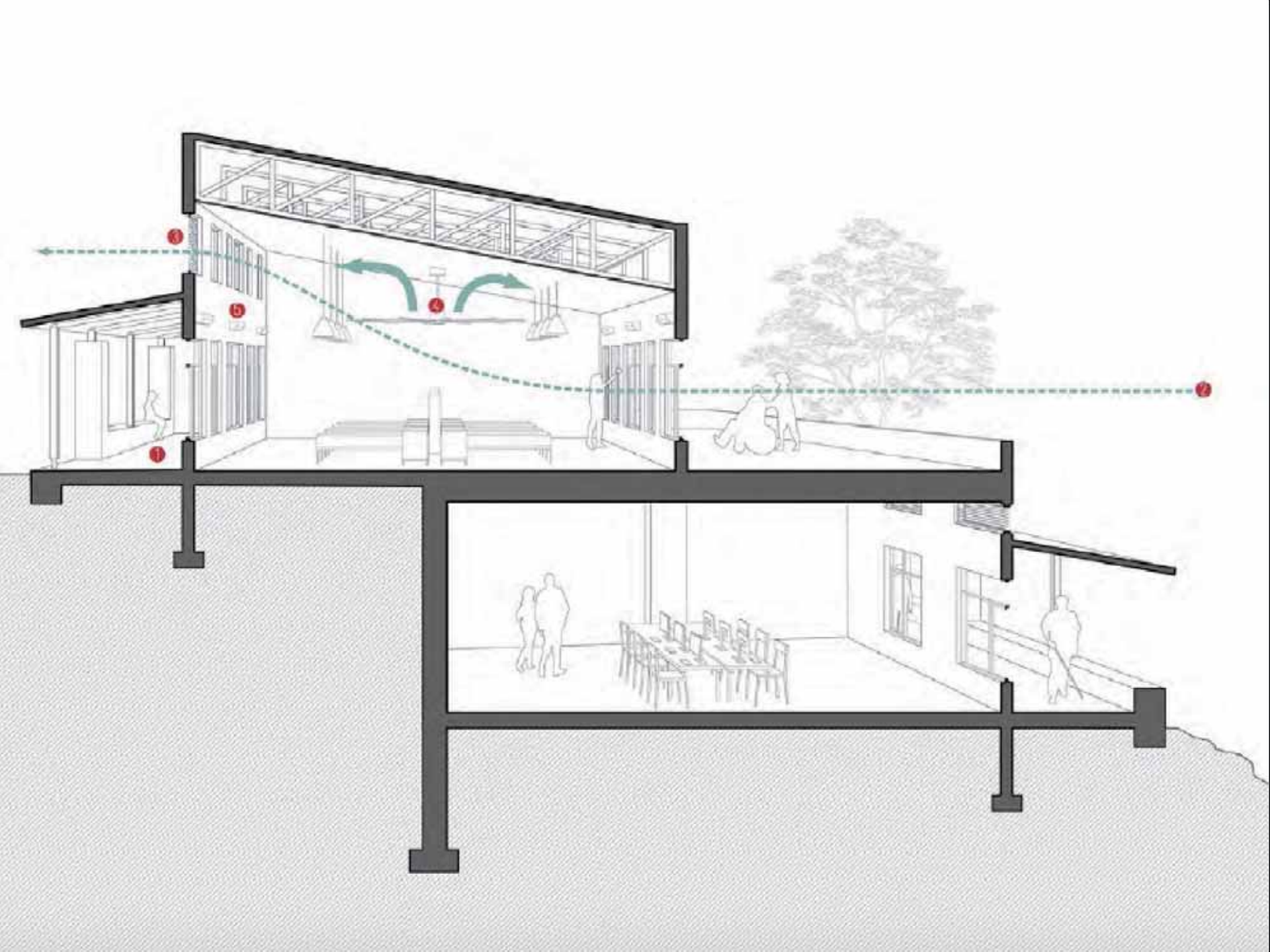
Arish Guity MASHRAE

Rwanda, Africa

Butaro District Hospital

Burera, Rwanda





Nyanza Maternity Ward

Nyanza, Rwanda

CONCLUSIONS

- NATURAL VENTILATION IS A LOW ENERGY VENTILATION AND COOLING STRATEGY
- REQUIRES BUILDING TO ‘BREATHE’
- HYBRID APPROACH IN HOT AND HUMID SUMMER CLIMATES
- AIR INLETS AND OUTLETS REQUIRE CALCULATION AND STRATEGIC DESIGN
- COMPUTER MODELLING
- FIRE ENGINEERING
- ACOUSTICS – EXTERNAL AND INTERNAL
- CONTROLS ESSENTIAL
- REQUIRES ARCHITECTURAL AND ENGINEERING INTEGRATION

Questions

Frank Mills BSc(Hons) FCIBSE MIMechE MASHRAE MIE

Chartered Consulting Engineer

7, Fylde Avenue

Leyland

Lancashire

PR26 6RP

- **t: 01772 424124**
- **m: 07850 024523**
- **e: famills@low-carbondesign.com**