TECHNICAL SYMPOSIUM 2015
Simple buildings, better buildings?
Delivering performance through engineered solutions
Paper No. 48
Case Study

“Danish buildings 1986–2014. From simple building services to complex building services – and back again?”

Sergio George Fox, CEng, MCIBSE.
Thursday, 16th April 2015
ARCHITECTURE WITHOUT ARCHITECTS


PASSIVE
1970s
E. F. Schumacher

Small Is Beautiful

A Study of Economics as if People Mattered
Arabian Gulf States (Latitude +23 degrees)
1970s Air conditioning design
1980s
Danish Design is ....

a style of functionalistic design and architecture that was developed in mid-20th century. Influenced by the German Bauhaus school, many Danish designers used the new industrial technologies, combined with

ideas of simplicity and functionalism to design buildings,

furniture and household objects, many of which have become iconic and are still in use and production. Prominent examples are the Egg chair, the PH lamps and the Sydney Opera House (Australia).
Arne Jacobsen, Søllerød Town Hall, Denmark. 1939
“1986: Which ventilation system should we choose?”

Bloody Hell Brit! We don’t use that kind of rubbish here! We protect the environment!”
An example of Danish building design from the 1980s.

The Danish Pavilion in Sevilla. Designed in 1989 for EXPO 92
Model of KIVIK's winning design for the pavilion in Seville. 
- Model of the first prize proposed by KIVIK architects.
Gavl mod nord, 1:400. □ Gable toward north, 1:400.

Gavl mod syd, 1:400. □ Gable toward south, 1:400.
Klimabyrøg

På de varmest en dage kan temperaturen i Sevilla snige sig op mod 50 gr. Celsius, og der skal ikke megen fantasie til at forestille sig, hvor ulidelig rumstemperaturen kan blive i en størrelse så, såfremt klimabytningen springer. På den anden side gave budgettet ikke muligheder for et traditionelt klimaanlæg, der desuden skulle have så gevaldige kanaludimensioner, at det ville dominere rummet fuldstændig.

Desuden ønskede man at bruge overensstemmelse mellem de tekniske og de arkitektoniske ambitioner – enkelhed i form skulle følges af enkelhed i funktion, også i de tekniske løsninger. Der var mange andre ideer på bordet – en af de tidligere var at åbne paviljongen, så sejlene stod som store overrissede halevage.

Det var imidlertid ikke muligt, især fordi det store AV-show stillede særlige krav, der kun kunne honoreres ved at lukke rummet. Det simpelste og billigste var at betragte hele rummet som et ventilationsanlæg. Og sådan blev

Air-conditioning

On the hottest days, the temperature in Seville can reach 50 degrees Celsius, and one can easily imagine how unbearable the temperature could be in a space like this if the air-conditioning system broke down. However, the budget did not permit a traditional system, which also would have required enormous duct dimensions, which would have totally dominated the exhibition space.

Instead it was decided to relax comfort requirements in the hall so that the temperature was generally reduced 10 degrees in relation to the outdoor temperature, and not to 20–22 degrees as normally required by anglosaxon tradition.
Results: The Danish Pavillion

Simple cooling system, true to “Danish Design” ideas. 10% cost reduction (and an extra consultant fee.) Space saving and less visual clutter. Less material use and lower operating costs.
Danish buildings in the 1980s were generally simple buildings based on a vernacular, intuitive, empirical, Design approach.
1990s
OUR COMMON FUTURE

THE WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT
Danish buildings in the 1990s were increasingly affected by complexity.

There seemed to be little consensus about sustainability issues, best-practice”, bench-marking, labelling, rating, certification, CO$_2$ quotas etc.
An example of Danish building design from the 1990s.

Den Danske Pavillon i Sevilla
- brug af CFD i idéfasen

Det er vigtigt at åbne og regulere terrænske vindvejsledninger i bygningerne. Artikelens beskrivelse veksler egentlig, hvorfor det i det følgende kaldes CFD-analysen og derudover en af stafordens teksten.

På 15. november 1992 afholdes et stort vugger-styre i Sevilla, hvor den danske pavillon er udfordret. Det er vigtigt at betone, at denne udfordring forventes at have en stor betydning for fremtidens bygningsteknik. Artikelens beskrivelse veksler egentlig, hvorfor det i det følgende kaldes CFD-analysen og derudover en af stafordens teksten.

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Computer simulation programmes and CFD were now being used.

The first calculations of the Pihl offices indicated summer temperatures of 35 degrees Celsius with natural ventilation (a need for ventilation/cooling systems.)
… But the design team took the chance, relying on a vernacular, empirical, intuitive, approach:

Nattemperatur/udlufningsprofil   den 18/19. juni 1995:

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<th>18.00</th>
<th>20.00</th>
<th>22.00</th>
<th>24.00</th>
<th>02.00</th>
<th>04.00</th>
<th>06.00</th>
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<td>21,7</td>
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Overcoming technical barriers to low-energy natural ventilation in office type buildings in moderate and cold climates
**E. Pihl & Son Headquarters, Lyngby**

**Building Description**

The company Headquarters of E. Pihl & Son (one of Denmark's major contractors) is located in relatively quiet surroundings in Lyngby about 10 kilometres north of Copenhagen City. Completed in 1990/94, the building is, in concept, a three-storey office building angled in a diagonal symmetry in which the sides of the angle reflect each other. The corridors are sky-lit galleries and formed as a passageway space. A canopy extends out from one of the wings. Figure 1 illustrates the northwest facade of one of the office wings.

The facade of the building is brickwork and glass while the roof and the internal walls are in situ concrete. Generally the internal concrete walls and ceilings are exposed, and the thermal mass of the building can be characterised as heavy. Internal steel frames support skylights, stairways, fittings and other permanent furnishings. Windows and the glazed facades are made from reflective glass.

Figure 2 shows a typical floor plan. The floor area is about 2,700 m² and the building volume is 8,000 m³. About 2,000 m² (75%) is used for offices and meeting rooms, 400 m² (15%) is circulation area and the remainder is toilets and cloakrooms (100 m²) and the canteen (200 m²).

**Ventilation Philosophy and Aims**

The activity in the building is mainly administrative. On the second floor, above the two-storey foyer, there is a drawing office containing equipment and machinery for producing and folding up blueprints. Conventional, commonly used office machines such as fax, photocopiers and the like are placed in separate rooms on each floor.

![Figure 2: Typical Floor Plan Showing Offices Monitored](image)

This building has given rise to much interest among architects. In 1994 it was nominated for the Mies van der Rohe Prize and the building owner was awarded a Danish architectural award. However, the building is also very interesting from an engineer's point of view. E. Pihl & Son required an office building of high quality with technical installations that were simple and hidden, yet effective and advanced. The building is specifically designed for natural ventilation, except for the toilets, cloakrooms and service areas. As part of the ventilation design stage, the architects and engineers took into account both wind and temperature (stack) generated pressures. Knowledge and ideas from traditional buildings in the tropics were taken into consideration including the principles developed for the Danish pavilion at the Seville fair.

**Ventilation Technology**

Although the ventilation principle is extremely simple, the 'intelligent house' control system (known as I-USB) is highly complex. This system handles not only the ventilation, but also the heating and cooling.

![Figure 1: Outside View of Headquarters Building](image)

**Figure 8: Occupant Reactions: Summer**

**Figure 9: Occupant Reactions: Winter**

**Conclusions**

This is a modern, large office building specifically designed for natural ventilation. As such there is no mechanical refrigeration. The indoor environment was found to be generally satisfactory, even though control problems meant that full advantage could not be taken of the capacity for night cooling during the summer. At all times ventilation was found to be sufficient to meet occupant needs, while careful control of the ventilation rate during the winter (including closing the system down at weekends) meant that unnecessary heat loss was avoided. Despite reduced winter ventilation rates there were no significant odour problems reported and many occupants reported that the general comfort was very satisfactory. Noise propagation was however found to be a problem in some offices.

**The NatVent Project**

NatVent is aimed at reducing energy consumption and carbon dioxide emissions by developing and demonstrating natural ventilation solutions. This project is targeted at climates in which overheating can be avoided by good architectural design and by minimising internal heat gains. By introducing natural ventilation, the complexity of mechanical systems and associated energy demand is eliminated, while the need for air conditioning is minimised. These case study summaries are intended to provide innovative examples of the use of natural ventilation and to demonstrate performance, pitfalls and solutions.

**The NatVent Partners**

Project Partners are:
- Belgium: Belgium Building Research Institute
- Denmark: Danish Building Research Institute
- Netherlands: TNO Building Construction and Research, Delft University of Technology
- Norway: Norwegian Building Research Institute
- Sweden: J & W Consulting Engineers AB

**European Joule Project**

NatVent is a Joule project undertaken with part funding from the European Commission in the framework of the Non Nuclear Energy Programme.

For further information contact:
Nils C. Bangsø, Danish Building Research Institute, SBI, Energy and Indoor Climate Division, PO 119, DK-2070, Hørsholm, Denmark
Tel: +45 45 86 55 33 Fax: +45 45 86 75 33 e-mail: ncb@sb.dk
Results: Pihl & Son’s Building

Simple ventilation system, but now having to overcome “simulation” and administrative barriers. Cost saving (compared to simulation “need”). Space saving and less visual clutter. Less material use and lower operating costs.
Danish buildings in the 1990s were generally becoming complex, with passive systems becoming the exception.

“Danish Design” and simplicity were being translated into cosmetics.
2000s
Fuel used in the EU in 2013

- **Oil**: 34%
- **Gas**: 23%
- **Nuclear**: 14%
- **Renewables**: 12%
- **Coal**: 17%
EU Directive

“Energy Performance of Buildings”

Ratified in December 2001 based on Danish energy performance “data”.
“Calculations based on three and a half years of Energy Labelling of 160,000 Danish houses show that Labelling cost 25 million Euro and described potential energy savings of 125 million Euro.”
National Archive, Islandsgade 10, Odense.

Calculated:
Energy Class: F
Recommendation: Various electrical changes could save 86,000 kr. a year.

Measured:
Energy Class: B
Actual electrical energy consumption is 44,000 kr. a year.
Average, all KU labs, 2010
Actual energy consumption, 2010
Predicted energy consumption

kWh/m²/year
Danish buildings in the 2000s seemed to be getting lost.

Building services design got caught up in a “virtual reality” world of simulations and standards.
An example of Danish building design from the 2000s.

Arabian Gulf States (Latitude +23 degrees) 1970s Air conditioning design
Denmark (Latitude + 56 degrees)  
2000s Air conditioning design
Reversible Heat Pumps were “in fashion”

A heat pump heats your home in the winter...

and cools your home in the summer.
<table>
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<th>A</th>
<th>B</th>
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<tr>
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<td>11</td>
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<td>8</td>
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</table>
Results: Slotsholmsgade 12

Full VAV 6–8 air-change system, with reversible heat-pump system.
Spatial challenges and visual clutter.
High material use and high operating costs.
Anything calculated or simulated in the 2000s got the status of reality.

It really seemed that Hans Christian Andersen’s fairytale of “The Emperor’s New Clothes” was coming true in the building industry.
2010s
Green Build or GreenWASH?
In the 2010s there are signs of reaction to “Greenwash”.

Some Danish clients in the 2010s seem to be regaining a little “common-sense”.
An example of Danish building design from the 2010s.

The Danish Police Headquarters in Copenhagen.

Foto: www.vaeggen.copenhagen.dk / luftfoto 1922.
Politigården, gang Foto Finn
Lyngesen_www.flfoto.dk
<table>
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<th>Verdi</th>
<th>kW</th>
<th>Procent</th>
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<td>KSN, HS, serverum, pc</td>
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<td>Ventilation</td>
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<td>17,8 %</td>
<td>Ventilationsanlæg 3. sal, loft, udsugning i omklædning</td>
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<td>Hæve/sænkeborde, opladere, TV m.m.</td>
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<td>I alt:</td>
<td>110,0 kW</td>
<td>100,0 %</td>
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Principiel skitse

Oversigt over energiforbrugende enheder og lokaliteter

Version 2; 28/10-09
Endeligt energiforbrug fordelt på anvendelser

Klimakorrigeret

PJ

250

200

150

100

50

0

Ikke energiformål

Transport

Produktions- erhverv

Handels- og service- erhverv

Husholdninger

1980

1990

2000

2011
The Danish Building & Property Agency

“SECOND OPINION”
<table>
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<tr>
<th>Office</th>
<th>SKAB m.v. med åbninger til skakt til loftrommet.</th>
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**Nuærende Indeklima**

Målinger:
Den 9. november 2009 kl. 9.30-10.30 blev rum 16 på 3. sal på Politigården i København undersøgt for indeklimaproblemer og løsninger. Ved ankomst virkede rum 16 varmt og indelukket og ved røgprøver kunne det bekræftes at der var meget lidt luftbevægelse i rummet. Rumtemperaturen var 22,7 grader ved loftet og 22,1 grader ved gulvet, der er en ekstra tegn på meget lidt udeluft til rummet (udetemperaturen var ca. 8 grader). I loftrommet var spjæld til skakt 16 ca. 80% åbent med åbningsareal 25x20 cm. Der blev målt luftaftag skifte på 0,4-0,6 m/s over åbningen mens døreene ved rum 16 var åbne. Da døreene blev lukket faldt luftaftag skifte til ca. 0,1 m/s i gennemsnit. Der bør gennemførés flere målinger for at få en bedre statistisk grundlag for projektet.

Beregninger:
Når døreene er lukkede er luftskifte i rum 16 ca. 0,3 i timen eller ca. 20 m³ i timen. Når døreene er åbne stiger luftaftag skifte til ca. 1,5 i timen eller ca. 90 m³ i timen.

Konklusion:
Vinduerne er for tætte for det naturlige ventilationssystem. Der er ikke nok friskluft til personer der opholder sig i rummet. Skaktsystemet, herunder loftrommet med spjældsystemet, fungerer godt, men luftet tages fra nannaareal.

---

**Klient:** Center for Bygningsbevaring, for SES  
**Emne:** Indeklima  
**Tegnet af:** Sergio Fox Tlf. 27 28 54 00 sergio@sergio.dk  
**Projekt:** Politigården, København  
**Skitsetitel:** Indeklima november 2009  
**Skitse nr.:** VENT 0-A den 17. november 2009
SUMMARY

At-påbud - årssagerne

Printers
Paper
Dust
Computers
Cleaning
Windows
Shading
Chimneys
Mould

Total Effect

0 % 25 % 50 % 75 % 100 %
Results: Central Police Station

Re-establishing the original simple ventilation system, and eliminating “suicide” IAQ issues, worked. Significant cost reductions. Space saving, less material use, and lower operating costs.
Peaks of 85 PJ and 194 PJ

http://www.ens.dk/info/tal-kort/statistik-nogletal/arlig-energistatistik
Based on my experience and the measured results:

Simple buildings ARE better buildings.
Une colonne
1980s: “Attitude” gives real results.

1990s: “Calculations” gives false results.


2010s: “Scepticism” and a “back-to-basics” approach seems to be working.
Architecture Without Engineers

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TECHNICAL SYMPOSIUM 2015
Simple buildings, better buildings?
Delivering performance through engineered solutions