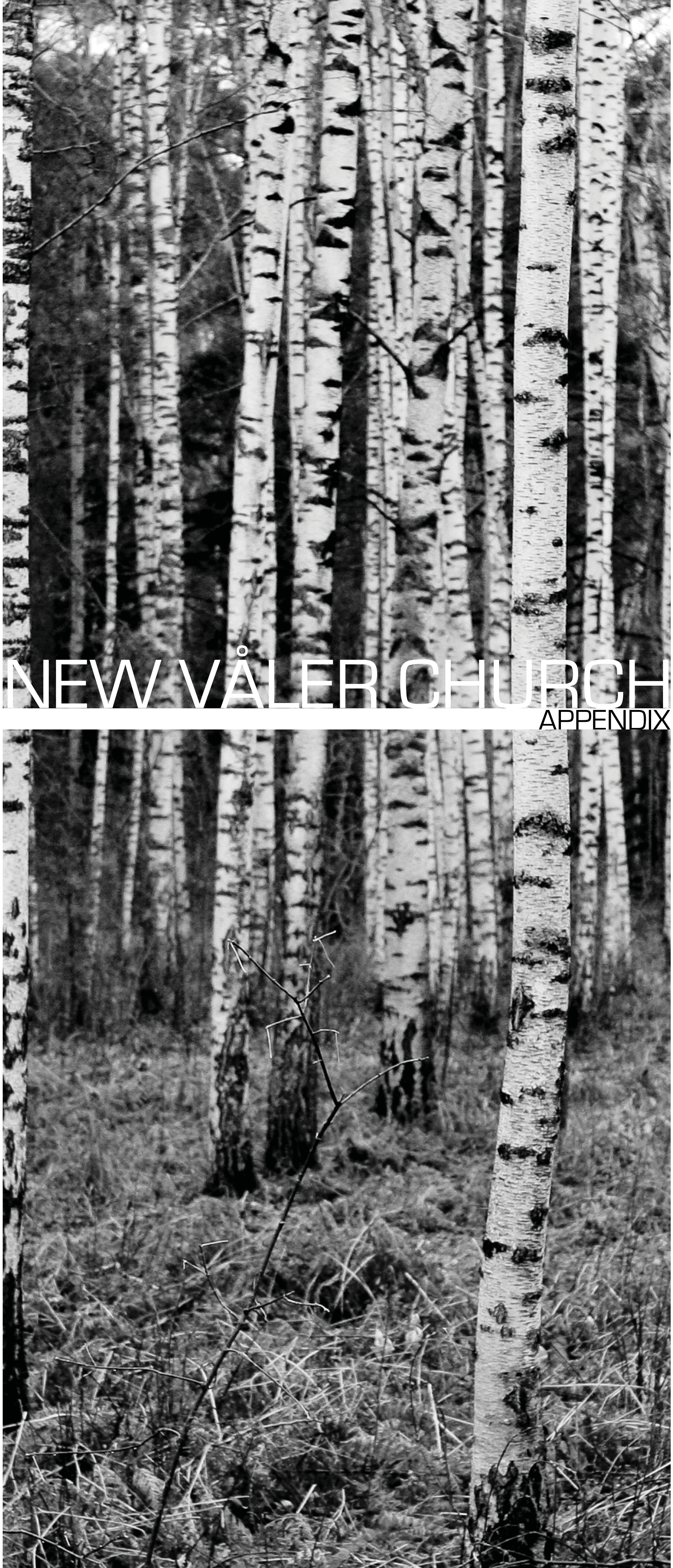

NEW VÅLER CHURCH

APPENDIX

NEW VÅLER CHURCH

APPENDIX

AALBORG UNIVERSITY, DEPARTMENT OF ARCHITECTURE,
DESIGN & MEDIA TECHNOLOGY
MSC4, ARCHITECTURAL DESIGN, SPRING 2012

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SYNOPSIS
APPENDIX

The project is based upon an open competition which took place in the autumn of 2011, formulated by the municipality of Våler. The competition describes the design of a new church for the parish of Våler, as a result of the devastating fire which destroyed the original Church of Våler.
To support the design of the church, theoretical investigations about Sacred Spaces, Nordic architecture and Tectonic design have been made. Furthermore, as the technical focus of the project is sustainability and energy, these themes have also been studied.
The new Våler church is designed as a low-energy building in a Scandinavian context.

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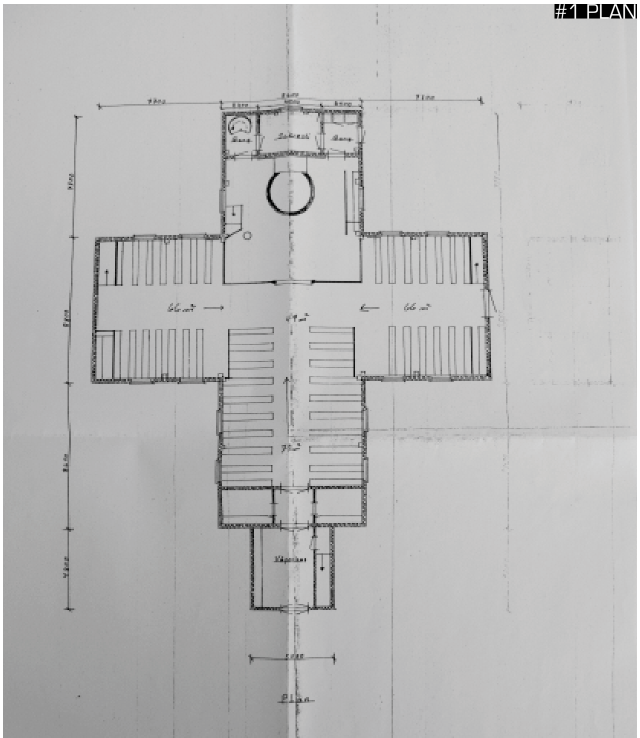
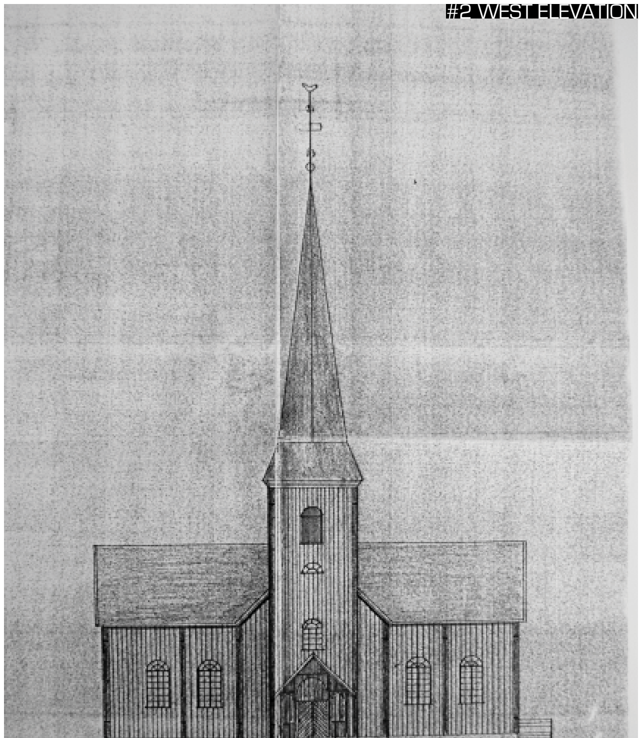
1. DRAWINGS OF THE OLD CHURCH

PLAN & ELEVATIONS

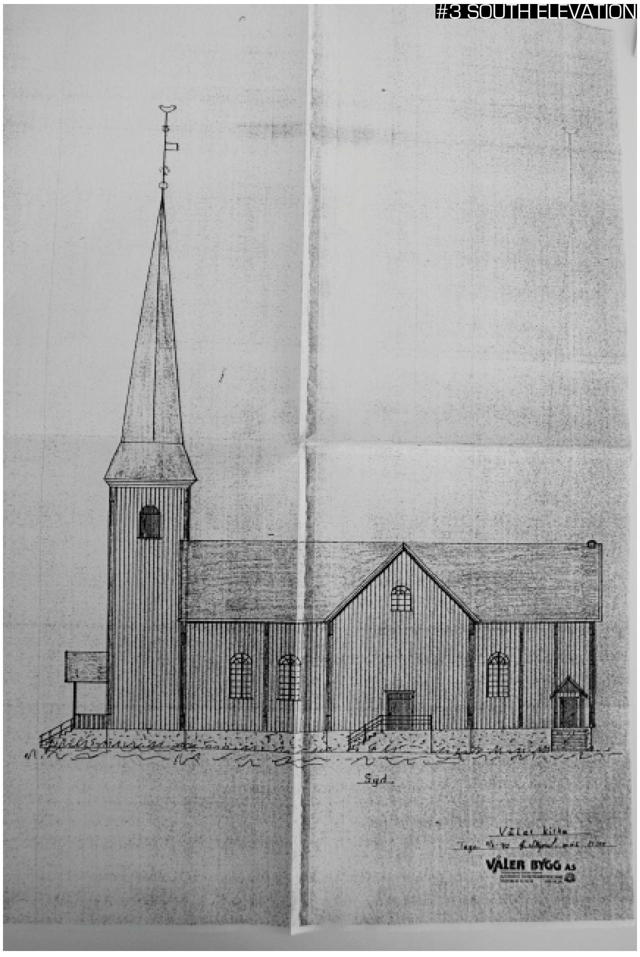
#1 PLAN



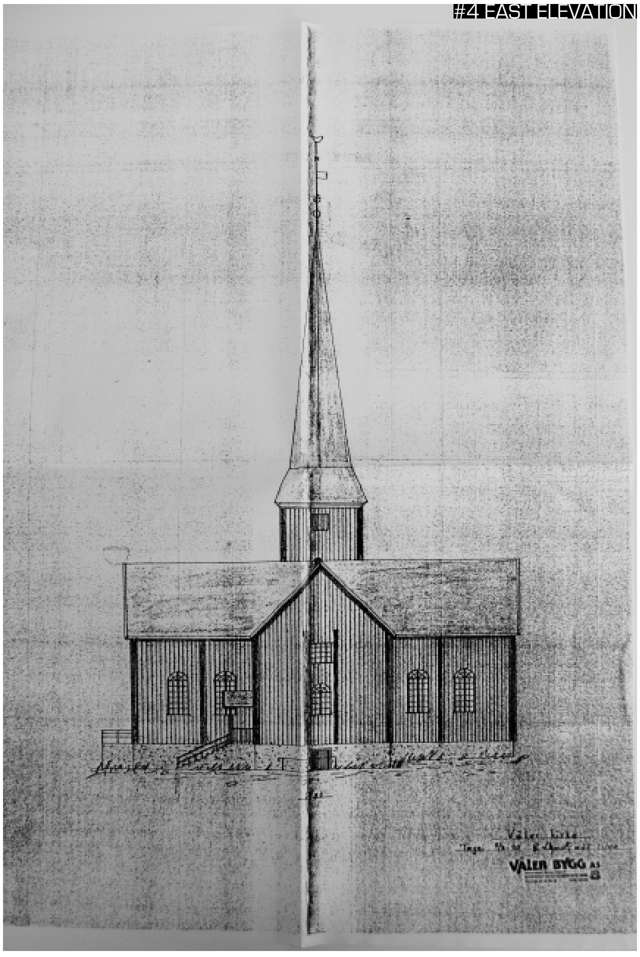
#2 WEST ELEVATION



#3 SOUTH ELEVATION



#4 EAST ELEVATION



2.TECHNICAL CALCULATIONS

2.1. WIND PROFILE

The wind velocity profile have been calculated for suburban or forest areas, through the following equation:

$V_h = V_g \cdot k \cdot h^{\alpha}$

$V_g = V_h / (h/h_g)^{\alpha}$

$\alpha = 0,28$

$V_h = 3$ m/s

$V_g = 3/(10/250)^{0,28} = 7,39$m/s

In a height of 2 meters:

$V_2 = V_g \cdot (h/h_g)^{\alpha}$

$V_2 = 7,39 \cdot (2/250)^{0,28} = 1,91$m/s

This is set as the presumed wind profile to calculate the openings for natural ventilation, with the natural ventilation spreadsheet.

2.TECHNICAL CALCULATIONS

2.2.1. CHURCH HALL - PERCEIVED AIR QUALITY

THERMAL ENVIRONMENT
activity level of occupants – Mr = 1,2 met - sedentary activity

clothing insulation of occupants
summer:
Icl = 0,5 clo – daily wear clothing
winter:
Icl = 0,95 clo - daily wear clothing

optimum temperatures – category 2
summer:
Icl = 0,5 clo
Mr = 1,2 met   Ts = 24°C ± 2,0°C   regulation 23 - 26°C
winter:
Icl = 0,95 clo
Mr = 1,2 met   Tw = 22°C ± 1,5°C   regulation 20 – 24°C

PPD
Category 2 – PPD = < 10%

Permissible mean air velocity – category 2
turbulence intensity – 40%
summer: va= 0,23 m/s
winter: va= 0,18 m/s

Permissible vertical air temperature difference (between head and ankles)
category 2 - <3°C
Permissible range of floor temperature
category 2 – 19 to 29°C
Permissible radiant temperature assimetry
Category 2   warm ceiling <5°C
Cool wall <10°C

REQUIRED VENTILATION RATE
Comfort
Qc= 10 * ((Gc+(a*A)) / (Cci-Cco) * (1 / εv) [l/s]
Qc – ventilation rate required for comfort (l/s)
Gc – sensory pollution load (olf)
Cc,i - desired perceived indoor air quality (decipol)
Cc,o – perceived outdoor air quality (decipol)
ε - ventilation effectiveness

FOR CHURCH HALL
occupants – 250
area – 309 m2
sensory pollution load
sedentary occupants and no smokers – 0,81 olf / m2
Carbon dioxide - 19 l/h person
Water vapour – 50 g/h occupant

pollution load caused by the building
Non Low polluting buildings (Timber construction) – 0,2 olf / m2

Gc (total) = 0,81+0,2 = 1,01 olf / m2

desired indoor air quality
Category 2 (20% dissatisfaction) – Cc,i = 1,4 decipol

outdoor air quality
suburban, excellent – Cc,o = 0,1 decipol

Ventilation effectiveness - ε
Mixing ventilation = 0,9 (worst case)
Qc = 253,25 l/s = 0,82 l/s.m2 = 0,32 h-1
Room volume of 2814 m3

2.TECHNICAL CALCULATIONS

2.2.2. CHURCH HALL - MONTH AVERAGE

Surface-area to Volume Ratio & Surface-area to Area Ratio

Shape	Height[m]	Area[m2]	Volume[m3]	Exposed Surface Area[m2]	Surface-area to Volume Ratio
Rectangular Structure					
	8	216	1727	755	0,437
	10	216	2159	890	0,412
	12	216	2590	1025	0,396
	14	216	3022	1160	0,384
Ship Structure	8	216	1928	762	0,395
	10	216	2000	889	0,445
	12	216	2400	1016	0,423
	14	216	2799	1143	0,408
Shell structure 0	8	216	1222	527	0,431
	10	216	1398	615	0,440
	12	216	1748	727	0,416
	14	216	1975	827	0,419
Shell structure 1	8	216	1228	534	0,435
	10	216	1525	640	0,420
	12	216	1813	744	0,410
	14	216	2136	860	0,403
Shell structure 2	8	216	1194	522	0,437
	10	216	1517	623	0,411
	12	216	1803	715	0,397
	14	216	2130	823	0,386
Shell structure 3	8	216	1186	499	0,421
	10	216	1495	592	0,396
	12	216	1785	683	0,383
	14	216	2084	777	0,373

Surface-area to Area Ratio	Air change rate (design criteria) [l/s/m2]	Energy Concumption (Month Average) [KWh/m2/year
3,495	0,83	80,9 (0,0)
4,120	0,83	92,3 (0,0)
4,745	0,83	103,5 (0,0)
5,370	0,83	114,9 (0,0)
3,528	0,83	85,7(0,0)
4,116	0,83	97,9 (0,0)
4,704	0,83	110,2 (0,0)
5,292	0,83	122,8(0,0)
2,440	0,83	61,5 (0,0)
2,847	0,83	66,9 (0,0)
3,366	0,83	74,9 (0,0)
3,829	0,83	76,1 (0,0)
2,472	0,83	60,4 (0,0)
2,963	0,83	67,3 (0,0)
3,444	0,83	74,3 (0,0)
3,981	0,83	82,3 (0,0)
2,417	0,83	60,8 (0,0)
2,884	0,83	67,2 (0,0)
3,310	0,83	73,0 (0,0)
3,810	0,83	77,6 (0,0)
2,310	0,83	55,9 (0,0)
2,741	0,83	61,2 (0,0)
3,162	0,83	66,8 (0,0)
3,597	0,83	69,1 (0,0)

Church Hall

The IAQ design criteria's for the buildings is: 0,82 l/s.m^2 = 0,32 h-1
area – 309,0 m2 | volume – 2814 m3

In order to define the minimum opening area of the windows, many criteria's had to be decided. The following information had been used:

wind factor= 0,57
V meteo (Wind profile) = 1,91 m/s

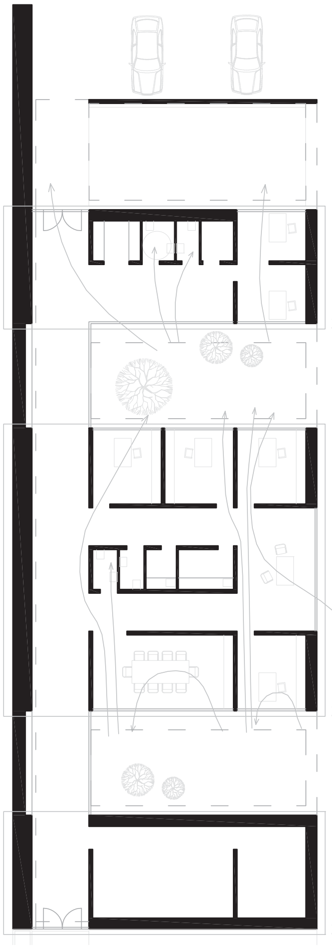
To analyse the natural ventilation principles, the whole building was considered as one zone. The figure represents the ventilation scheme when the predominant wind is from south. However, as the predominant wind in Våler is both from north and south directions, both facades will have inlet openings, so that natural ventilation can be provided in both conditions.

Wind pressure coefficient: inlet: facade 1 = 0,5
outlet: roof (> 30º) = -0,8

Considering that the air extracted from the toilets (10 l/s per toilet) is provided through the inlet of the entrance and the Church Hall, the difference from inlets and outlets is 20 l/s = 0,02 m3/s.

INLETS / OUTLETS		HIGHT (m)	OPENING AREA (m^2)	AFR (m^3/s)	AFR TOTAL (m^3/s)
Inlets	south facade	0,1	0,18	0,284	0,284
outlets	north facade	12	0,18	-0,264	- 0,264

Difference air flow rate: 0,284 m3/s - 0,264 m3/s → 0,02 m3/s
Volume: 2814 m3
Total air flow rate: 0,284m3/s = 0,36 h^{-1} > 0,32 h^{-1}
Location of neutral plan: 6,1 m



The total air flow rate was used in the spread sheet 24h-average to analyse the indoor climate conditions. However, in 24h-average spread sheet is not possible to take in consideration the shadow created by the shell around the glass, which creates consequently overheat during the summer months (see table below). The building is further investigated with the program Be10, which can take the angles of the shadows created by the overhang of the shell in consideration, and thereby will give a more precise result.

TEMPERATURE (ºC)	ti	ti max
June	26,0	29,4
July	26,8	30,2
August	25,6	28,8

2.TECHNICAL CALCULATIONS

2.2.4. CHURCH HALL - BE10 KEY NUMBERS

The figure to the side is taken from the BE10 program. It illustrates the total energy consumption for the church hall.
In addition, the energy contribution to heat, domestic hot water, ventilation and lighting can be seen.

The full documentation of the BE10 calculations for the church hall can be seen on the attached CD.

Key numbers, kWh/m² year

Energy frame in BR 2010

Without supplement	Supplement for special conditions	Total energy frame
57,8	0,0	57,8
Total energy requirement		160,3

Energy frame low energy buildings 2015

Without supplement	Supplement for special conditions	Total energy frame
33,2	0,0	33,2
Total energy requirement		128,4

Energy frame Buildings 2020

Without supplement	Supplement for special conditions	Total energy frame
20,0	0,0	20,0
Total energy requirement		96,3

Contribution to energy requirement

Heat	159,7
El. for operation of bulding	0,3
Excessive in rooms	0,0

Net requirement

Room heating	152,1
Domestic hot water	7,5
Cooling	0,0

Selected electricity requirements

Lighting	0,2
Heating of rooms	0,0
Heating of DHW	0,0
Heat pump	0,0
Ventilators	0,1
Pumps	0,0
Cooling	0,0
Total el. consumption	0,8

Heat loss from installations

Room heating	0,0
Domestic hot water	2,3

Output from special sources

Solar heat	0,0
Heat pump	0,0
Solar cells	0,0
Wind mills	0,0

2.TECHNICAL CALCULATIONS

2.3.1. FRAMING BUILDINGS - PERCEIVED AIR QUALITY

THERMAL ENVIRONMENT
activity level of occupants – Mr = 1,2 met - sedentary activity

clothing insulation of occupants
summer:
Icl = 0,5 clo – daily wear clothing
winter:
Icl = 0,95 clo - daily wear clothing

optimum temperatures – category 2
summer:
Icl = 0,5 clo
Mr = 1,2 met   Ts = 24°C ± 2,0°C   regulation 23 - 26°C
winter:
Icl = 0,95 clo
Mr = 1,2 met   Tw = 22°C ± 1,5°C   regulation 20 – 24°C

PPD
Category 2 – PPD = < 10%

Permissible mean air velocity – category 2
turbulence intensity – 40%
summer: va= 0,23 m/s
winter: va= 0,18 m/s

Permissible vertical air temperature difference (between head and ankles)
category 2 - <3°C
Permissible range of floor temperature
category 2 – 19 to 29°C
Permissible radiant temperature assimetry
Category 2   warm ceiling <5°C
Cool wall <10°C

REQUIRED VENTILATION RATE
Comfort
$Qc = 10 * ((Gc+(a*A)) / (Cci-Cco) * (1 / \varepsilon v)$ [l/s]
Qc – ventilation rate required for comfort (l/s)
Gc – sensory pollution load (olf)
Cc,i - desired perceived indoor air quality (decipol)
Cc,o – perceived outdoor air quality (decipol)
ε - ventilation effectiveness

FOR FRAMING BUILDING - ADMINISTRATION BUILDING
occupants – 8
area – 393,5 m2
sensory pollution load
sedentary occupants and no smokers – 0,01 olf / m2
Carbon dioxide - 19 l/h person
Water vapour – 50 g/h occupant

pollution load caused by the building
Low polluting buildings – 0,1 olf / m2

Gc (total) = 0,01+0,1 = 0,11 olf / m2

desired indoor air quality
Category 2 (20% dissatisfaction) – Cc,i = 1,4 decipol

outdoor air quality
suburban, excellent – Cc,o = 0,1 decipol

Ventilation effectiveness - ε
Mixing ventilation = 0,9 (worst case)
Qc = 313,3 l/s = 0,8 l/s.m2 = 0,96 h-1
Room height of 3m

2.TECHNICAL CALCULATIONS

2.3.1. FRAMING BUILDINGS - PERCEIVED AIR QUALITY

THERMAL ENVIRONMENT
activity level of occupants – Mr = 1,2 met - sedentary activity

clothing insulation of occupants
summer:
Icl = 0,5 clo – daily wear clothing
winter:
Icl = 0,95 clo - daily wear clothing

optimum temperatures – category 2
summer:
Icl = 0,5 clo
Mr = 1,2 met   Ts = 24°C ± 2,0°C   regulation 23 - 26°C
winter:
Icl = 0,95 clo
Mr = 1,2 met   Tw = 22°C ± 1,5°C   regulation 20 – 24°C

PPD
Category 2 – PPD = < 10%

Permissible mean air velocity – category 2
turbulence intensity – 40%
summer: va= 0,23 m/s
winter: va= 0,18 m/s

Permissible vertical air temperature difference (between head and ankles)
category 2 - <3°C
Permissible range of floor temperature
category 2 – 19 to 29°C
Permissible radiant temperature assimetry
Category 2   warm ceiling <5°C
                  Cool wall <10°C

REQUIRED VENTILATION RATE
Comfort
$Qc = 10 * ((Gc+(a*A)) / (Cci-Cco) * (1 / \varepsilon v)$ [l/s]
Qc – ventilation rate required for comfort (l/s)
Gc – sensory pollution load (olf)
Cc,i - desired perceived indoor air quality (decipol)
Cc,o – perceived outdoor air quality (decipol)
ε - ventilation effectiveness

FOR FRAMING BUILDING - MORTUARY BUILDING
occupants – 2
area – 290,4 m2
sensory pollution load
sedentary occupants and no smokers – 0,01 olf / m2
Carbon dioxide - 19 l/h person
Water vapour – 50 g/h occupant

pollution load caused by the building
Low polluting buildings – 0,1 olf / m2

Gc (total) = 0,01+0,1 = 0,11 olf / m2

desired indoor air quality
Category 2 (20% dissatisfaction) – Cc,i = 1,4 decipol

outdoor air quality
suburban, excellent – Cc,o = 0,1 decipol

Ventilation effectiveness - ε
Mixing ventilation = 0,9 (worst case)
Qc = 231,3 l/s = 0,8 l/s.m2 = 0,96 h-1
Room height of 3m

2.TECHNICAL CALCULATIONS

2.3.3. FRAMING BUILDINGS - 24 HOURS / VENTILATION

Framing building

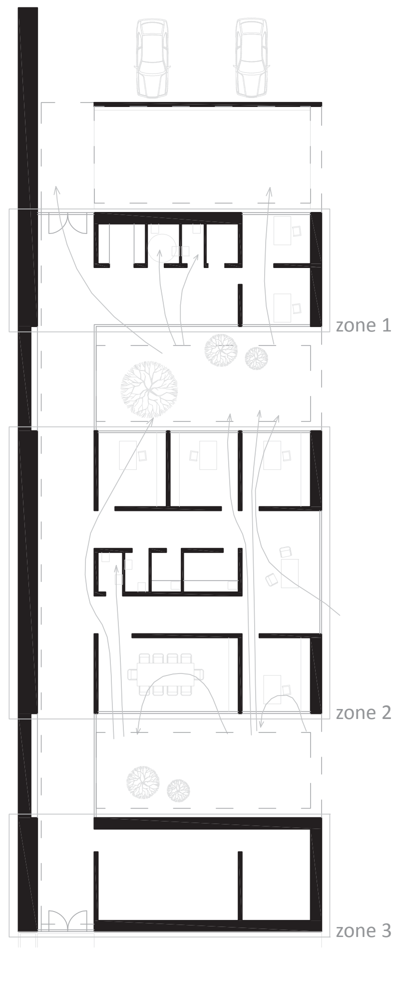
The total airflow rate from the openings should provide sufficient airflow to fulfil the defined air change rate. The IAQ design criteria's for the different buildings is:

Framing Building 1: 0,8 l/s.m^2 = 0,96 h-1
area – 393,5 m2 | volume – 1180,5 m3
Framing Building 2: 0,8 l/s.m^2 = 0,96 h-1
area – 290,4 m2 | volume – 871,2 m3

In order to define the minimum opening area of the windows, many criteria's had to be decided. The following information had been used:
wind factor= 0,57
V meteo (Wind profile) = 1,91 m/s

Framing building - Administration building

To analyse the natural ventilation principles, the building was divided into 3 different zones. The figure represents the ventilation scheme when the predominant wind is from south. However, as the predominant wind in Våler is both from north and south directions, both facades will have inlet and outlet openings, so that natural ventilation can be provided in both conditions.



ZONE 1:
Zone 1 is constituted by the entrance, the two first offices, wardrobe, toilets and small storage. In this zone the used ventilation principle is cross ventilation.

Wind pressure coefficient: inlet: facade 1 = 0,06
outlet: facade 2 = -0,3
roof (< 10) = -0,49

Considering that the air extracted from the toilets (10 l/s per toilet) is provided through the inlet of the entrance and the offices, the difference from inlet and outlet in zone 1 is 20 l/s = 0,02 m3/s

<table>
<tr><th colspan="2">INLETS / OUTLETS</th><th>HEIGHT (m)</th><th>OPENING AREA (m^2)</th><th>AFR (m^3/s)</th><th>AFR TOTAL (m^3/s)</th></tr>
<tr><td rowspan="2">Inlets</td><td>south facade office</td><td>0</td><td>0,12</td><td>0,115</td><td rowspan="2">0,230</td></tr>
<tr><td>south facade entrance</td><td>0</td><td>0,12</td><td>0,115</td></tr>
<tr><td rowspan="2">outlets</td><td>north facade office</td><td>3</td><td>0,2</td><td>-0,105</td><td rowspan="2">- 0,210</td></tr>
<tr><td>north facade entrance</td><td>3</td><td>0,2</td><td>-0,105</td></tr>
</table>

Difference air flow rate: 0,230 m3/s - 0,210 m3/s → 0,02 m3/s
Volume of zone1: 250,8 m3
Total air flow rate: 0,230 m3/s = 3,3 h^{-1} > 0,96 h^{-1}
Location of neutral plan: 2,2 m

The total air flow rate was used in the spread sheet 24h-average to analyse the indoor climate conditions for zone 1. The follow table shows the temperatures for the worst months of the year concerning overheating, considering the use of light internal shading and windows of 2layer-pane with regular glass.

TEMPERATURE (ºC)	ti	ti max
June	23,3	25,2
July	24,1	26,0
August	23,6	25,6

In July the temperature is equal to the max. of 26ºC and thereby further investigations will be made with Bsim. However, the analyse was made with the weather data of Copenhagen which has an avarage temperature lightly higher than Våler, Norway, reason which could justify the need for an high air flow rate to avoid overheating. Furthermore the use of trees for shadow in the patios was not taken in consideration.

ZONE 2:
Zone 2 is constituted by the rest of the offices, a meeting room, toilets, small kitchen and laundry. In zone 2 the ventilation principle used is cross ventilation, which the openings have been dimensioned for. However, single sided ventilation is also possible, depending of the use of the room and the predominant wind.

Wind pressure coefficient: inlet: facade 1 = 0,06
outlet: facade 2 = -0,3
roof (< 10) = -0,49

Considering that the air extracted from the toilets (10 l/s per toilet), the kitchenette (10l/s) and the laundry (20 l/s) is provided through the inlet of the offices and meeting room, the difference from inlet and outlet in zone 1 is 50 l/s = 0,05 m3/s

INLETS / OUTLETS		HEIGHT (m)	OPENING AREA (m^2)	AFR (m^3/s)	AFR TOTAL (m^3/s)
Inlets	south facade office	0	0,11	0,109	0,327
	south facade meeting room	0	0,11	0,109	
	south facade lunch-room	0	0,11	0,109	
outlets	north facade office 1	3	0,2	-0,092	- 0,276
	north facade office 2	3	0,2	-0,092	
	north facade office 3	3	0,2	-0,092	

Total air flow rate:	0,327 m3/s - 0,276 m3/s → 0,051 m3/s
Volume of zone1:	635,4 m3
Total air flow rate:	0,327 m3/s = 1,85 h^{-1} > 0,96 h^{-1}
	< 4,0 h^{-1} (draft)
Location of neutral plan:	2,3 m

The total air flow rate was used in the spread sheet 24h-average to analyse the indoor climate conditions for zone 2. The follow table shows the temperatures for the worst months of the year concerning overheating, considering the use of light internal shading and windows of 2layer-pane with regular glass.

TEMPERATURE (ºC)	ti	ti max
June	23,3	24,7
July	24,1	25,5
August	23,4	24,7

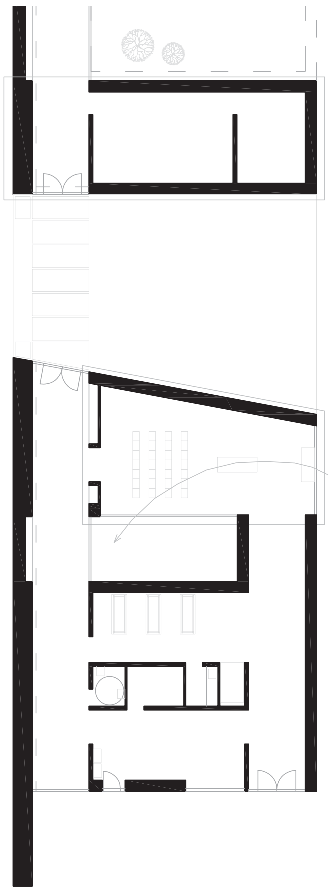
ZONE 3:
Zone 3 is constituted by a storage and technical room, using as ventilation principle cross ventilation.
Wind pressure coefficient: inlet: facade 1 = 0,06
outlet: facade 2 = -0,3
roof (< 10) = -0,49

INLETS / OUTLETS		HEIGHT (m)	OPENING AREA (m^2)	AFR (m^3/s)	AFR TOTAL (m^3/s)
Inlets	south facade storage	0	0,03	0,028	0,056
	south facade technical room	0	0,03	0,028	
outlets	north facade storage	3	0,05	-0,028	- 0,056
	north facade technical room	3	0,05	-0,028	

Volume of zone1: 208,5 m3
Total air flow rate: 0,056 m3/s = 0,96 h^{-1} > 0,96 h^{-1}
Location of neutral plan: 2,2 m

The total air flow rate used for zone 3 is the minimum according to the Norwegian regulations, since the room will not be permanently used. The total air flow rate was used in the spread sheet 24h-average to analyse the indoor climate conditions, which can be seen in the follow table.

TEMPERATURE (ºC)	ti	ti max
June	24,1	24,9
July	24,9	25,7
August	24,7	25,6



Framing building 2
This building is divided in two zones. The first zone is constituted by the chapel which make use of natural ventilation, while the mortuary functions, due to its different temperature and ventilation requirements, will constitute together with the storage a different zone, supplied by mechanical ventilation.

ZONE 1:
Wind pressure coeficiente: inlet: facade 4 = -0,3
outlet: facade 1 = -0,3
roof (< 10) = -0,49

It is consider that facade 1 will have negative pressure as it is facing a small patio and, thereby will not receive direct wind.

INLETS / OUTLETS		HEIGHT (m)	OPENING AREA (m^2)	AFR (m^3/s)	AFR TOTAL (m^3/s)
Inlets	east facade chapel	0	0,18	0,14	0,14
outlets	south facade chapel	3	0,3	-0,14	- 0,14

Volume of zone1: 234,9 m3
Total air flow rate: 0,14 m3/s = 2,14h^{-1} > 0,96 h^{-1}
Location of neutral plan: 2,3 m

TEMPERATURE (ºC)	ti	max
June	23,2	25,1
July	24,0	25,9
August	23,4	25,1

2.TECHNICAL CALCULATIONS

2.3.4. FRAMING BUILDINGS - BE10 KEY NUMBERS

The figure is taken from the BE10 program. It illustrates the total energy consumption for the Administration building.
In addition, the energy contribution to heat, domestic hot water, ventilation and lighting can be seen.

The full documentation of the BE10 calculation for the administration building can be seen on the attached CD.

Key numbers, kWh/m² year

Energy frame in BR 2010

Without supplement	Supplement for special conditions	Total energy frame
56,0	0,0	56,0
Total energy requirement		39,7

Energy frame low energy buildings 2015

Without supplement	Supplement for special conditions	Total energy frame
32,1	0,0	32,1
Total energy requirement		31,9

Energy frame Buildings 2020

Without supplement	Supplement for special conditions	Total energy frame
20,0	0,0	20,0
Total energy requirement		23,9

Contribution to energy requirement

Heat	39,4
El. for operation of bulding	0,1
Excessive in rooms	0,0

Net requirement

Room heating	32,7
Domestic hot water	6,7
Cooling	0,0

Selected electricity requirements

Lighting	5,1
Heating of rooms	0,0
Heating of DHW	0,0
Heat pump	0,0
Ventilators	0,0
Pumps	0,0
Cooling	0,0
Total el. consumption	11,7

Heat loss from installations

Room heating	0,0
Domestic hot water	1,5

Output from special sources

Solar heat	0,0
Heat pump	0,0
Solar cells	0,0
Wind mills	0,0

The figure is taken from the BE10 program. It illustrates the total energy consumption for the Mortuary building.
In addition, the energy contribution to heat, domestic hot water, ventilation and lighting can be seen.

The full documentation of the BE10 calculation for the mortuary functions building can be seen on the attached CD.

Key numbers, kWh/m² year

Energy frame in BR 2010

Without supplement	Supplement for special conditions	Total energy frame
57,7	0,0	57,7
Total energy requirement		58,9

Energy frame low energy buildings 2015

Without supplement	Supplement for special conditions	Total energy frame
33,2	0,0	33,2
Total energy requirement		47,4

Energy frame Buildings 2020

Without supplement	Supplement for special conditions	Total energy frame
20,0	0,0	20,0
Total energy requirement		35,5

Contribution to energy requirement

Heat	57,1
El. for operation of bulding	0,7
Excessive in rooms	0,0

Net requirement

Room heating	49,6
Domestic hot water	7,5
Cooling	0,0

Selected electricity requirements

Lighting	2,7
Heating of rooms	0,0
Heating of DHW	0,0
Heat pump	0,0
Ventilators	0,5
Pumps	0,0
Cooling	0,0
Total el. consumption	3,4

Heat loss from installations

Room heating	0,0
Domestic hot water	2,2

Output from special sources

Solar heat	0,0
Heat pump	0,0
Solar cells	0,0
Wind mills	0,0

The indoor climatic conditions of the framing building have been examined in the 24 hours spreadsheet, showing that zone 1 is the most problematic area of the building concerning overheat. Therefore, it has been chosen to further examine the conditions of the indoor climactic conditions of this zone, through the documentation and simulation program BSIM.

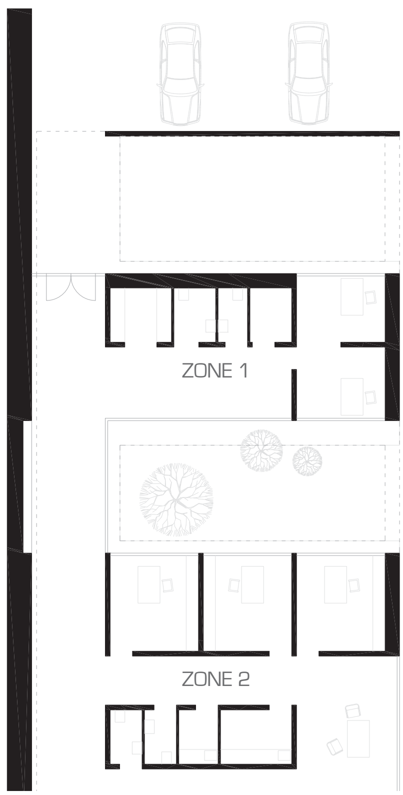
Zone 1
Zone 1 is very exposed to solar radiation through the highly glazed south facade. Therefore will receive a great amount of passive solar gains, giving the possibility to accumulate a great amount of heat in the heavy constructions. Thus it is considered crucial to further evaluate this zone to make sure that is within the requirements of the Norwegians legislations.

The purposes of this simulation is to define the expected thermal indoor conditions of Zone 1.
Zone 1 consists of an entrance Hall, two offices and a core, which contains a wardrobe and toilets, as shown on Plan I. The geometrical model created in BSIM, has been slightly simplified to make sure that BSIM performs the most precise calculations. The Zone 1 is build as one thermal zone, and within the same thermal zone the hallway is created as another room. As a part of the simplifications, it has been chosen not to model the interior walls in the zone.
The Zone 2 is modelled as different building, as it does not influence directly the thermal indoor climate in Zone 1, but will provide shadows for it.

Pre-conditions
The building is oriented with a rotation of 12,85 degrees to west in relation to true north.

Each of the construction parts of the building, walls, terrain deck and roof have been modelled from the BSIM database, with the U-values that can be found in the attached CD.

The windows of the building are modelled as Vitrocsa windows, with three-layer glazing units, and can be found in Appendix 3.1. The windows towards south and north (in the offices) are provided with perforated solar screens. The openness of the screens have been tested with the BSIM simulation, for a percentage of 50%, 67% and 75%. Through the test it was shown that the screens with a openness of 50% provide optimum shading, bringing the number of hours of overheating down on 36 hours, and thereby



I - PLAN OF ZONE 1 & ZONE 2

less than the 50 hours required from the Norwegian regulations. The copper solar screens are placed on the exterior of the windows, and will be installed in tracks where they can be controlled automatically or individually if desired.
In the BSIM simulation, the shadows from the shading devices were simulated through the creation of two equal sized windows, constituting together the total are of windows. One of them was set without shutter, while the second was set with shutter, thereby simulating the openness of 50% of the copper screens. The shutter is set active when the indoor operative comfort temperature rises more than 23 degrees.

The ventilation is defined as calculated with the natural ventilation spreadsheet, with the opening towards south placed in the floor and the openings towards north located in the top of the windows.

Systems

People load: The people load of zone 1 is defined by the presence of two persons that work in the two offices placed at the entrance of the building. The schedule for people load is defined within the normal working hours.
Equipment: The equipment is defined as computer equipment, with a heat load equal to 100W per Person.

Artificial light: The artificial lighting is defined by 8W/m^2 for the ceiling lighting and 1 asymmetric architect lamp with low energy bulb per Person.

Infiltration: The infiltration is set with a basic air change of 0.3h^{-1}.

Heating: The heating system is defined as radiators / convectors which are set as active all year, except in the summer. It has been chosen to use radiators / convectors as it is easier to adjust for the indoor climate, as floor heat has a slower reaction time. The heating is put to active at a set point of 22 degrees.

Mechanic ventilation: The mechanic ventilation is active during the entire year, except from the week 20 to the week 38, where the natural ventilation will provide the sufficient air change. The basic air change is equal to the IAQ design criteria defined by the step-by-step method in CR1752, and is given as 0,01 m^3/s.
The ventilation is designed with a heat recover system with a maximum heat recover coefficient of 0,8, making it possible to take use of the recover of the inlet air, which can reduce the requirements of heating.

The mechanic ventilation system is designed as a VAV-system, which is possible to adjust in case of change of loads. The set point for the air temperature is set to 22 degrees and the minimum inlet temperature to 16 degrees.

Venting: The natural ventilation is set to be active in the summer period, which in this case has been defined from week 21 to week 38. The basic air change is defined as 3h^{-1}, with a maximum air change rate at 5h^{-1}. The calculation method is defined by BSIM, and is given as Combined Two Levels. The set point for the natural ventilation control is put to 22 degrees.

3. U-VALUES

3.1. VITROCSA FRAME

The calculation of the total u-value of the Vitrocsa Window Frame and the 3-layer Energy Glazing, Window Type 4-18-4-18-4, Energy/Clear/Energy can be seen below.

The values of the Glazing are given as:
Ug Value = 1
Gg = 0,53
LTg = 0,78

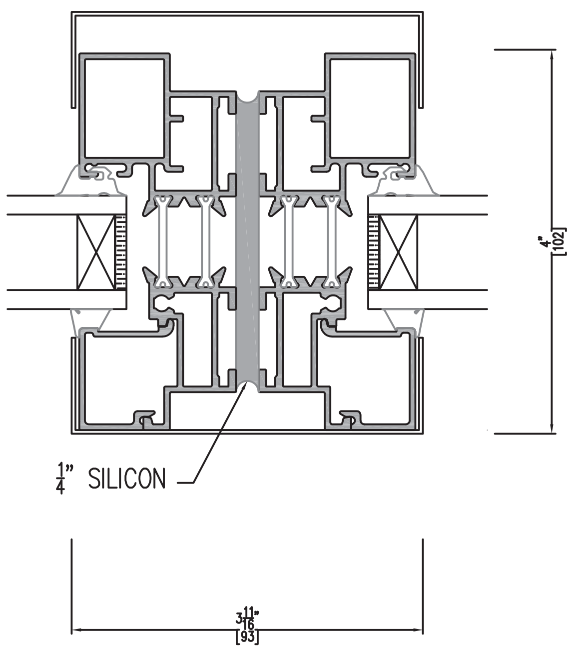
The total u-value of the frame and the glazing can be calculated from following formula:

$U = A_g U_g + l_g \Psi_g + A_f U_f + l_k \Psi_k$

Where,
A_g is glazing part in m2
A_f is area of the frame
l_g is the circumference of the glazing part
Ψ_g is the linear transmittance coefficient

U = (0,962x0,53) + (3,856*0,05) + (0,038*0,28) = 0,71 W/m²K

This u-value have been used in the BE10 and BSIM calculations.



I - DETAIL OF A TH+ VITROCSA PROFILE, USED IN THE VERTICAL ELEMENTS OF THE CHURCH HALL