LOCIE Polytech'Savoie École d'ingénieurs CTBA Bouche

IMPROVMENT OF SUMMER COMFORT IN TIMBER FRAME BUILDINGS WITH A HEAVY INTERNAL WALL WITH A VENTILATED AIR GAP

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PREBAT Research Project « Bois'Climatique » ADEME

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INTRODUCTION

Climate plan 2004 : **TIMBER CONSTRUCTION**
- renewable material , 1m^3 wood = 1T CO_2
- less erection wastes

Construction and environment wood plan
- timber market : 12.5 % en 2010

RT2005
- consumption reduction (heating, air conditioning ...)
- summer comfort

Timber frame : low inertia → summer discomfort : cooling

→ low energy consumption (factor 4) + low cost + simplicity / reliability

Avoiding air conditioning : peak consumption+ green house effect (consumption and refrigerant leak)

NIGHT-TIME VENTILATION

Classical approach :

- 4-10 ach : cooling : 2 - 5°C
- mechanical or natural ventilation (wind – stack effect)
- performances : flow rate , $(\text{Tint-Text})_{\text{Night}}$, inertia, $(\text{Text})_{\text{day/ night}}$
- drawback : external noise, pollution, intrusion

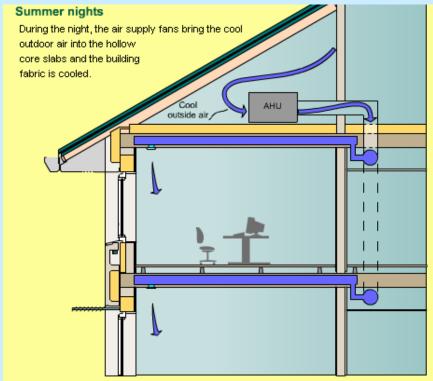
Night structure cooling with ventilated air gaps

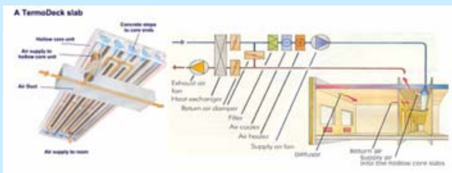
- TermoDeck : hollow core slabs (4*1.2*0.3) – concrete
- CoolDeck : ceiling fan + air gap between PCM / slab
- DMIIV : timber frame ⇒ internal wall with ventilated air gap

1. Increasing inertia – unmodified external envelope
2. Cooling : internal wall
3. Air flow doesn't go inside

TermoDeck

Elizabeth Fry Building





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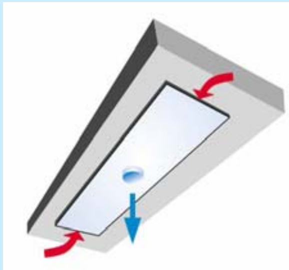
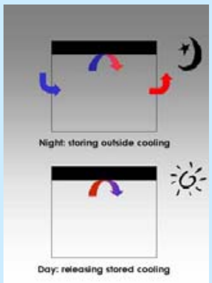
CoolDeck

Stevenage Borough Council





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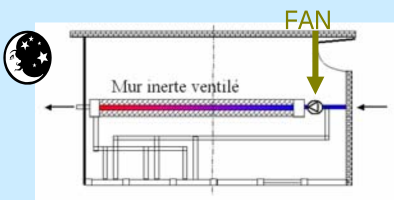
DMIIV



Financed by ADEME-PUCA : "*The use of a heavy internal wall with a ventilated air gap to store solar energy and improve summer comfort in timber frame houses"* (2003-2005)

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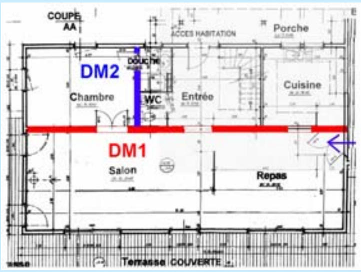
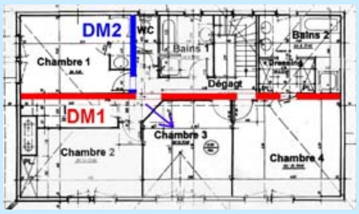
Integration of the DMIIV

house : G. Cuiller
212 m² - 5 bedrooms
13 rooms
Modeling : TRNSYS
Optimization : GenOpt

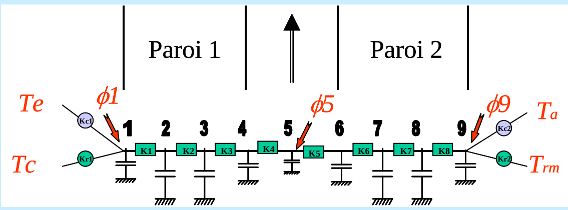




House DM : DM1
House DMbis : DM1 + DM2

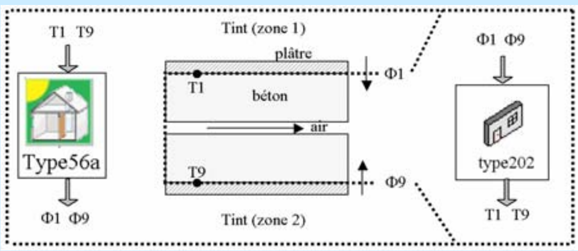
DMIIV : plaster + 10cm concrete + 5 cm air + 10cm concrete + plaster
Ventilation : top to the bottom

Modeling : DMIIV + House



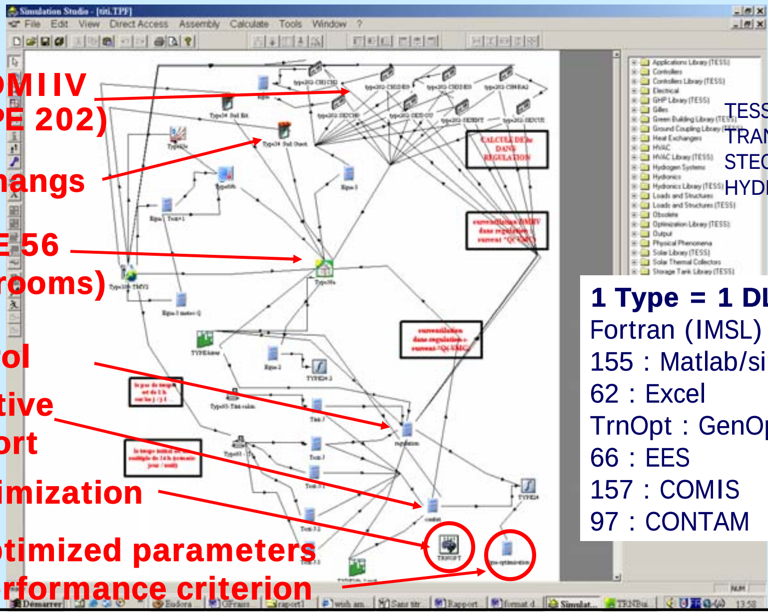
Type 202
(TRNSYS 16)

$$Tout = (\alpha_1 \cdot T_4 + \alpha_2 \cdot T_6) \cdot [1 - \exp(-\alpha_3 \cdot H)] + Tin \cdot \exp(-\alpha_3 \cdot H)$$



Principe of the coupling : Type 202 + TYPE56

TRNSYS : Simulation Studio



1 Type = 1 DLL
Fortran (IMSL) / C++
155 : Matlab/simulink
62 : Excel
TrnOpt : GenOpt
66 : EES
157 : COMIS
97 : CONTAM

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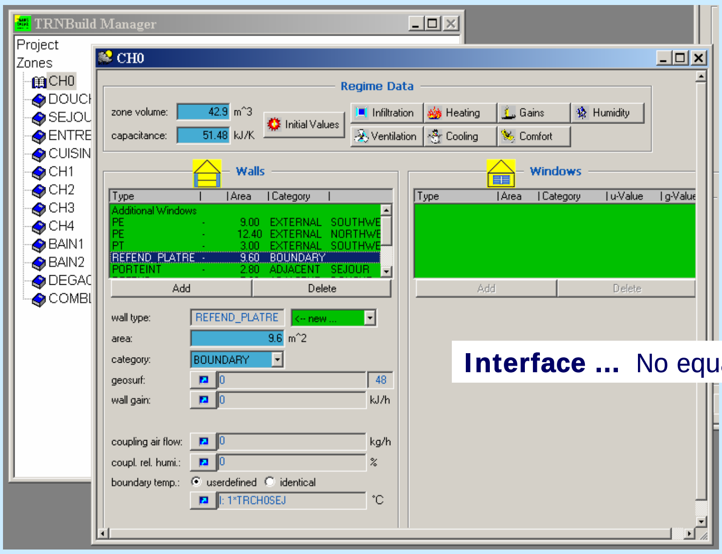
TRNSYS : TYPE 56



Interface ... No equation

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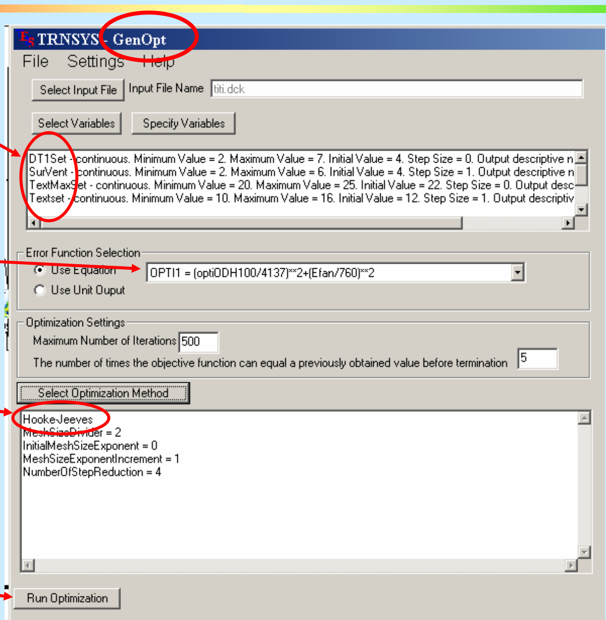
Optimization : TrnOpt

Optimized parameters

Performance criterion

Optimisation Method



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Inertia

RT2005 : Simplified method

Maison	PB	PH	PV	inertie quotidienne	inertie séquentielle
REF (CH0)	L	-	-	moyenne	très légère
REF (séjour)	L	-	-	moyenne	très légère
REF (CH1)	-	-	-	très légère	très légère
REF (CH3)	-	-	-	très légère	très légère
DM (CH0)	L	-	-	moyenne	très légère
DM (séjour)	L	-	-	moyenne	très légère
DM (CH1)	-	-	-	très légère	très légère
DM (CH3)	-	-	-	très légère	très légère
DMbis (CH0)	L	-	L	**lourde**	**légère**
DMbis (séj)	L	-	-	moyenne	très légère
DMbis (CH1)	-	-	L	**moyenne**	très légère
DMbis (CH3)	-	-	-	très légère	très légère

$S_{DMIIV} / S_{floor} > 0.9$

→ REF = DM

Simulation TRNSYS : $\tau_{63\%}$

			REF	DM	différence
RDC	CH0	medium	50 h	57 h	+ 14 %
	Douche	medium	56 h	71 h	+ 27 %
	Séjour	medium	49 h	51 h	+ 4 %
	Entrée	medium	56 h	65 h	+ 16 %
	Cuisine	medium	56 h	63 h	+12 %
Etage	CH1	low	33 h	48 h	+ 45 %
	CH2	low	33 h	46 h	+ 39 %
	CH3	low	33h	43 h	+ 30 %
	CH4	low	33 h	42 h	+ 27 %
	Bain1		40 h	52 h	+ 30 %
	Bain2		40 h	59 h	+ 47 %
	Dégagement		38 h	57 h	+ 50 %

→ REF ≠ DM increase

House DM : DM1
House DMbis : DM1 + DM2

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STUDIED CASES

Weather : Carpentras

REF : reference house
DM : house with DMIIV (DM1) : ventilated air gap
DMbis : house with DMIIV (DM1 and DM2) : ventilated air gap
M16 : DM1 = 16 cm (concrete) and classical night ventilation

Other cases :
REF-SC : REF without fixed shading (overhang)
DM-NV : idem DM but without night ventilation
M16-NV : idem M16 but without night ventilation
DM-Reg : idem DM but with a simplified control algorithm

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Control and Optimization

Night ventilation control : (22h-7h during summer)
{ $Tint_{max}(j) > Tint_{max\text{-}set}$ **or** $Text_{max}(j) > Text_{max\text{-}set}$ } **and**
{ $Tint > Text + \Delta T_{set}$ } **and**
{ $Text > Text_{set}$ } **and**
{ $Tint > Tint_{set}$ }

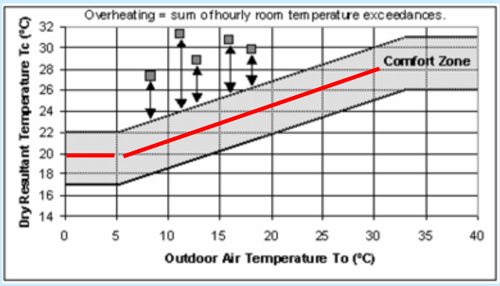
Simplified control : { $Tint > Text + \Delta T_{set}$ }

Optimization :

$$Perf = \left(\frac{ODH100}{ODH100_{ref}}\right)^2 + \left(\frac{Efan}{Efan_{ref}}\right)^2$$

$ODH100 = \Sigma\, (Tint - Tconf)^2$

$Tconf = a.Te_{ref} + b$



Adaptive Comfort

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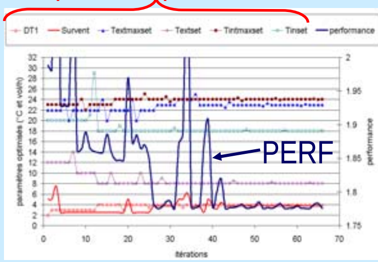
Optimization results

	initial	DM	M16
Perf	2 [-]	1.775 (-11%)	1.805 (-10%)
$Tint_{max\text{-}set}$	23 °C	24	26
$Text_{max\text{-}set}$	22 °C	23	20.5
Δt_{set}	2 °C	4	3
$Text_{set}$	12 °C	8	8
$Tint_{set}$	20 °C	18	20.5
vol/h	5	3.75	3.75
ODH100 (°C.h)	4151 (DM) 3232 (M16)	4625 (+11%)	3639 (+13%)
Efan (kWh)	755 (DM) 686 (M16)	553 (-27%)	516 (-25%)

Functioning : less often

Lower flow rate

Optimized parameters



- lower Fan consumption
- ODH100 : increase

Perf : – 10 %

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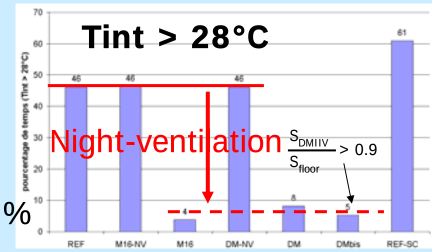
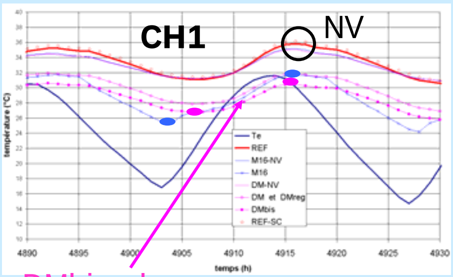
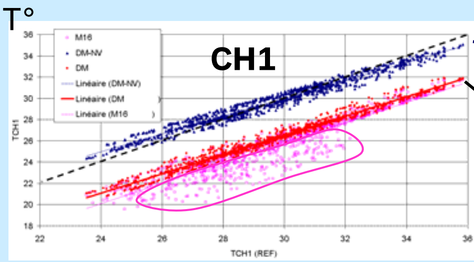
Cooling performance



(living-room and bedroom)



DMbis : low range
(depth cooling)



DM-NV : -1°C for $TCH1_{ref}$=36°C

DM and M16 : -4°C

RdC : + 4°C (without overhang)

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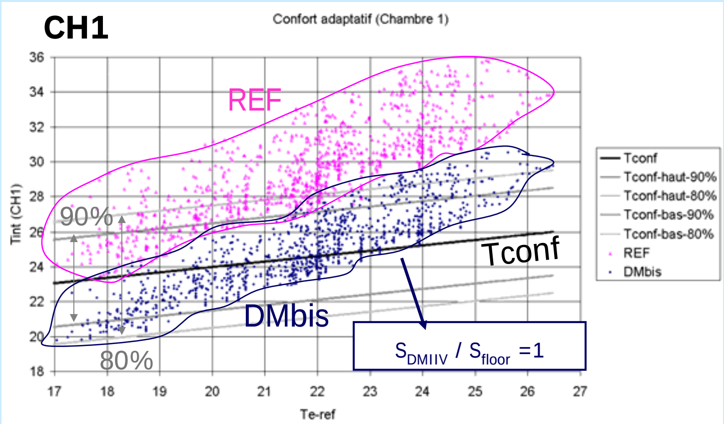
Adaptive comfort



$Te_{ref} = (Te_{24h,1} + 0.8 * Te_{24h,2} + 0.4 * Te_{24h,3} + 0.2 * Te_{24h,4}) / 2.4$

DM : COP = 5 – cooling 15 kWh/m² and 14 W/m²

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CONCLUSION

DMIIV without Night cooling : $\tau_{63\%}$ +10h and T_{int} –1°C max
DMIIV + Night cooling :

- timber frame unmodified
- low consumption (COP = 5 and T_{int} – 4°C)
- advanced control : lower fan consumption (-27%)

advantages : noise, pollution, safety, heat transfer air/mass
disadvantage : air ducts and connections

Future :

- 2007 : end of the PREBAT feasibility study « Bois'Climatique »
- Bois'Climatique 2 : real house
  - experimental validation (performances et models)
  - house : « RT2005 » or « passive » (INES)

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