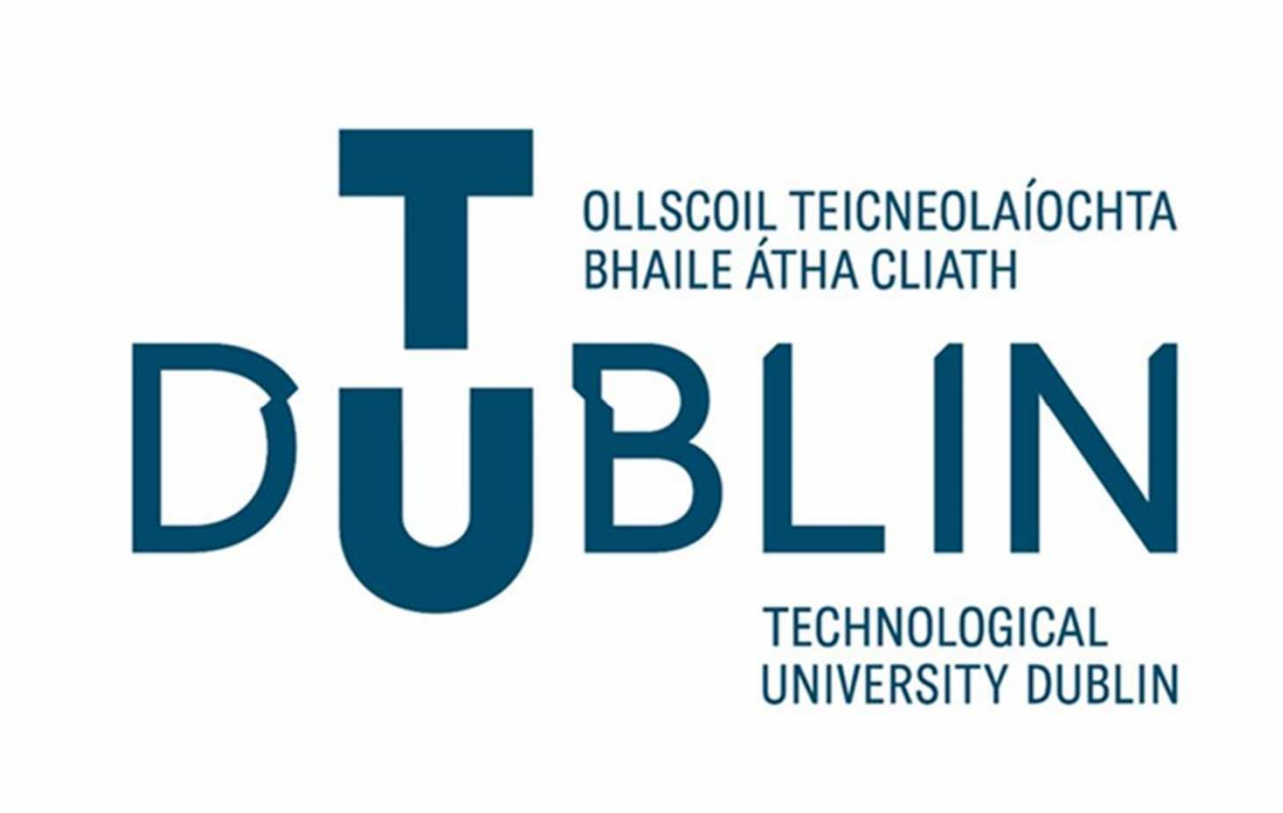


TECH4203- TDS_T6.2

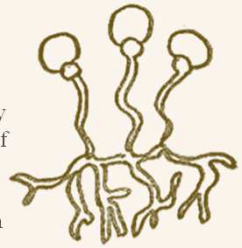
Developed Investigation A1 sheets

C193893996-Shannen Celeste

HOW DOES ENVIRONMENTAL CONDITIONS AFFECT MOULD GROWTH

INTRODUCTION

MOULD is one of the structures certain fungi can form. The dust-like, coloured appearance of moulds is due to the formation of spores containing fungal secondary metabolites. The spores are the dispersal units of the fungi. Not all fungi form moulds.



Fungi are nucleated organisms which lack green colouring matter or chlorophyll, and therefore cannot photosynthesize their food.

INDOOR DAMPNESS IN EUROPE

10- 50%

Indoor Dampness affects 10-50% of indoor environment in Europe, North America, Australia, India and Japan according to WHO.

HOUSE DAMPNESS PROBLEMS

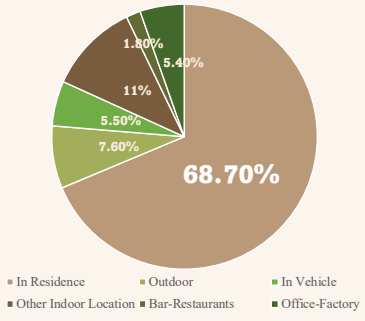
2,092

2022 Issued house improvement request letters by Dublin City Council to landlords

1,491

2019 House Repair Request From Tenants related to dampness

Times Spent Indoor & Outdoor Percentage



3.5X

Worse Indoor Air Pollution than Outdoor Air Pollution

According to Clean Air Day Indoor(UK's largest air pollution campaign)

OBJECTIVES

- Investigate the environmental conditions where mould grows
- Assess the level of risk for building materials and occupants.
- Examining the building materials of where mould grows.
- Determine the environmental strategies that might eliminate or reduce mould growth.
- Evaluate measured indoor humidity and temperature data that can cause mould growth.

AIM

The main aim is to investigate the environmental conditions contributing to mould growth on residential housing that can lead to building deterioration and health risk. Environmental conditions refer to indoor temperature, relative humidity, Carbon Dioxide (C02), internal surface conditions and outdoor temperature

METHODOLOGY

- Building survey and BIM model
- Mould analysis in laboratory
- Mould growth sample in an agar petri dish
- Data logging using data logger for temperature, humidity and CO2
- Infrared Thermal Imaging Camera for Thermal Analysis
- Trisco

MOTIVATION


Death of two-year-old from mould in flat a 'defining moment', says coroner

An Aab Ishak died in 2020, eight days after his second birthday, following 'chronic exposure' in Rochdale

2 Year-old died in 2020

- Direct result of black mould in the flat he lived in UK.
- The mould in the bathroom and kitchen due to "normal daily living activities" and a lack of effective ventilation.


Dublin mum and kids living in mould-infested flat desperately plead for help

Dublin Mould Case

- A flat in Temple Street in Dublin's northside has a severe mould case.
- The whole window in the kid's bedroom and the wall were covered with moulds.
- A girl had to be taken to the hospital because of pneumococcal pneumonia in her left lung. His brother developed rhinitis and is on medication for the rest of his life.

People affected with dampness in Ireland- 2019

600,000

2.9%

Living in Ireland with energy poverty

Highest number ever recorded of Irish households .Occupants won't turn on their household heating due to energy bills. This contributes to build up of dampness especially in older houses

7 out of 10 people

Almost 7 out of 10 people in Ireland are over accommodate(69.6%)

3.2%

Population in Ireland are living in overcrowded accommodation

These overpopulated houses have higher moisture than houses with lower occupants. Especially where ventilation is inadequate

Homes Target for Retrofit

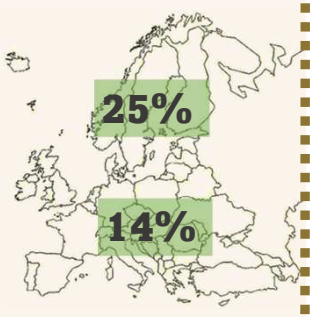
The government are targeting to retrofit 500,000 homes by 2030. However, not all houses can be retrofitted all at once.

500,000

IN A RESIDENTIAL HOUSE?

MOULDS

According to the European Community Respiratory Health Survey (ECRHS) II:



Self-reported visible mould

Visible mould was observed in 14% of European homes

To germinate mould spores, it requires:

Warmth
Source of Nutrition
Oxygen
Moisture

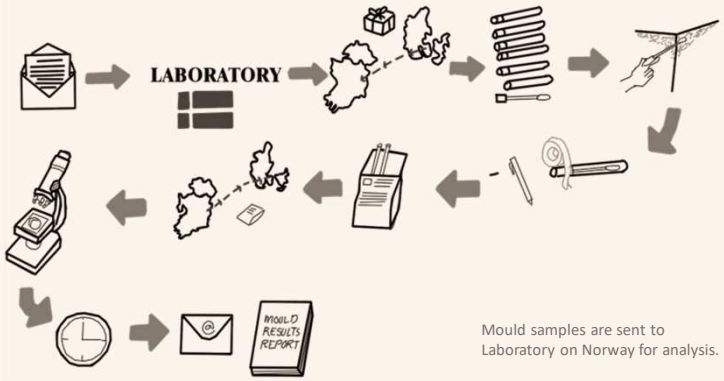
GROWTH

80% — **RELATIVE HUMIDITY**
BS5250

5- 50° C — **TEMPERATURE MOULD GROWTH**
VIITANEN H.A. 1997

400-1,000 ppm — **NORMAL CO2 LEVEL**
WISCONSIN DEPARTMENT OF HEALTH SERVICES

LABORATORY ANALYSIS



Mould samples are sent to Laboratory on Norway for analysis.

LABORATORY RESULTS

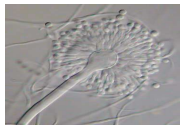
F

Our analysis shows that there are very high levels of mould in the sample. The species composition of the mould is abnormal and there are very high levels of mould species that thrive in damp indoor environments. This means that there is likely to be a damp problem in the building that is adversely affecting the indoor air quality.

4 HIGHEST PRESENT FUNGI

Grows in High Moisture

Mucor/Rhizopus grp
is a large group of a mould containing several thousand species. Generally requires high levels of moisture to grow indoors



Aspergillus versicolor
Most common fungus found in damp buildings. Very high levels can occur in buildings that are damaged by damp.

Grows in Low Moisture

Pen/Asp/Pae grp.
All the fungi belonging to the genus Penicillium, Aspergillus and Paecilomyces. Several species in this group can grow in relatively low moisture levels

Cladosporium sphaerospermum
It requires less moisture than most moulds. Occurs naturally in outdoor air, but it can also grow in homes, plasterboard walls, painted surfaces and wood

VISIBLE MOULDS ON SITE

Mould in Kitchen Window Lintel

Mould in Toilet Wall to Ceiling Junction

Mould in Bedroom Wall to Ceiling Junction

RISK

Asthma triggered by household presences of moulds, dust mites or rats
Center For American Progress, 2016

40%

HEALTH RISK

Mucor/Rhizopus grp
one-sided facial swelling and pain, headache, fever
tissue death.

Pen/Asp/Pae grp.
To weakened immune systems:
infection in the lungs
Sinuses

Aspergillus versicolor
headaches,
lack of concentration,
dizziness.

Cladosporium sphaerospermum
Long-term exposure to a large amount allergies
asthma symptoms.
eye infections

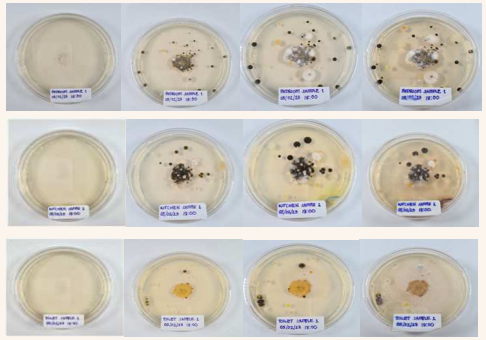
3x

Nearly greater risk of becoming asthmatic for Infants
who are exposed to mould in their living environments than those who did not have extensive mould exposure in their first year of life.
Michael Pinto, 2018

Mould growth can vary strongly depending on the properties of the materials.
Viitanen H. , 2010

MOULD GROWTH IN AGAR PETRI DISH

60 Days Mould Growth



BEDROOM

KITCHEN

TOILET

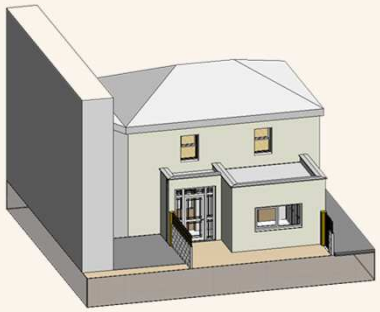
DAY 1 DAY 7 DAY14 DAY60

SHANNEN CELESTE
C19389396
DT175- 4
1st Supervisor: Tim O'Leary

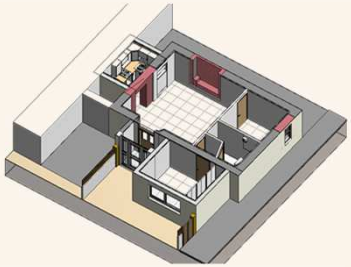
CASE STUDY

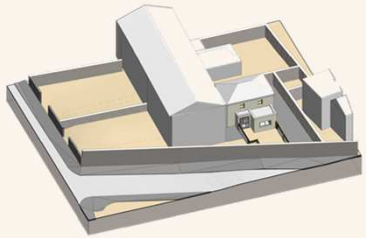
1880's

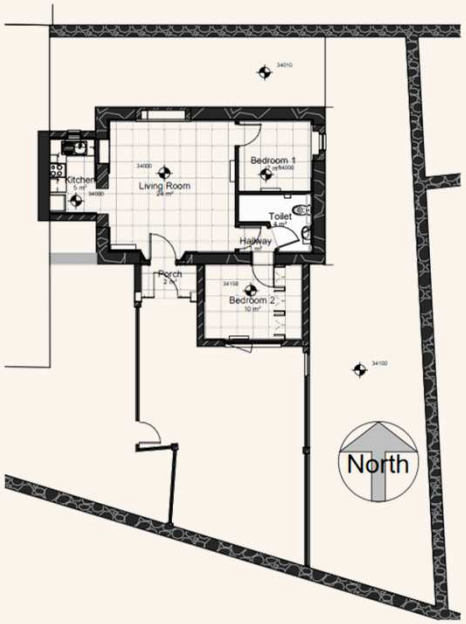
END-OF-TERRACE HOUSE



- Built during the Victorian Era in Dun Laoghaire, Dublin
- Around 960m away from sea
- Protected Structure of County Council
- The house is originally built with bricks. The bricks on some parts and timber rafters and timber decorations can be seen in the internal of the house.



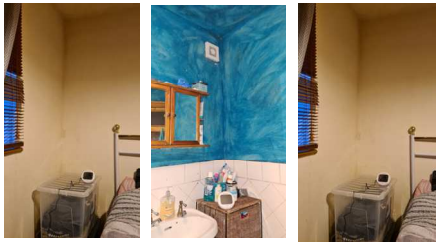




1 0 Ground Floor Plan Copy 1
1 : 100

DATA LOGGING & TEST

Green Eye Data Logger

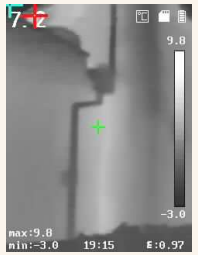


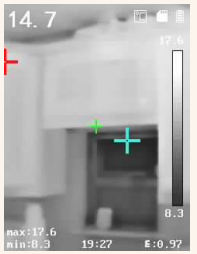
Xetron Data Logger for Surface Temperature

Hukseflux- Wall Heat Flux Logger

Micro Inspection Camera

Thermal Imaging Camera





STANDARD

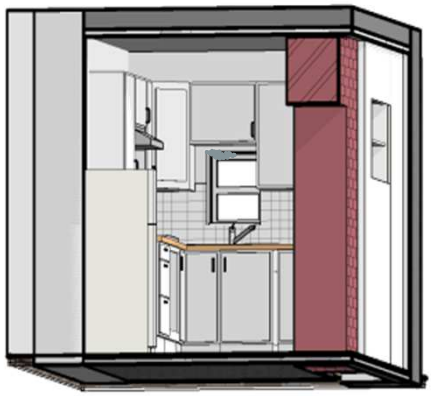
5250:2011+ A1: 2016
Code of Practice for control of condensation in Buildings

ISO 13788:2012
Hygrothermal Performance of Building Components and Building Elements- Internal Surface Temperature to avoid critical surface humidity and interstitial condensation- Calculation Methods

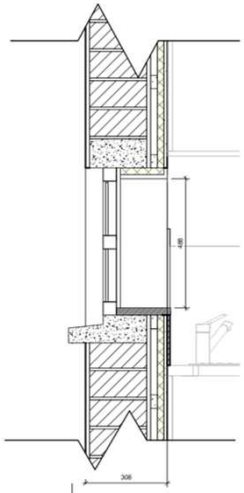
Technical Guidance Document Part L 2021
Conservation of Fuel and Energy – Buildings other than Dwellings

Technical Guidance Document Part F 2009
Ventilation

KITCHEN ANALYSIS

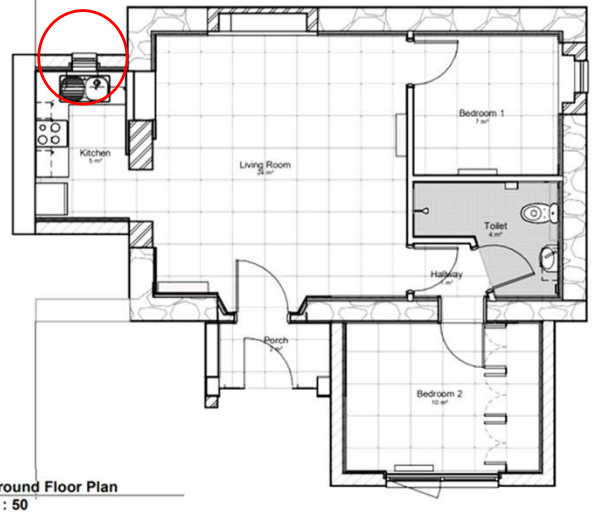


KITCHEN EXTERNAL WALL



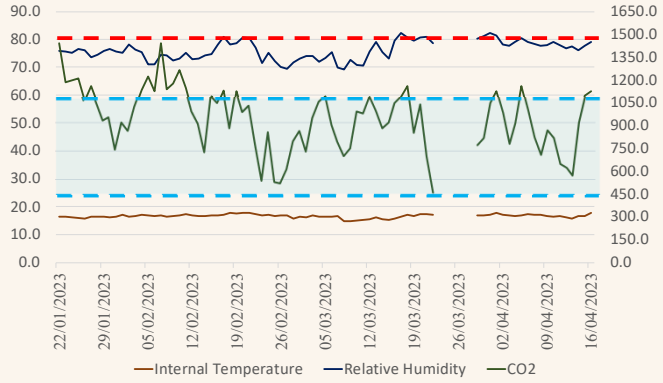
0.782W/m²K

15mm External cement plaster
215mm Concrete block
15mm Cement Plaster
20mm air cavity
25 EPS insulation board
15mm Internal Plasterboard

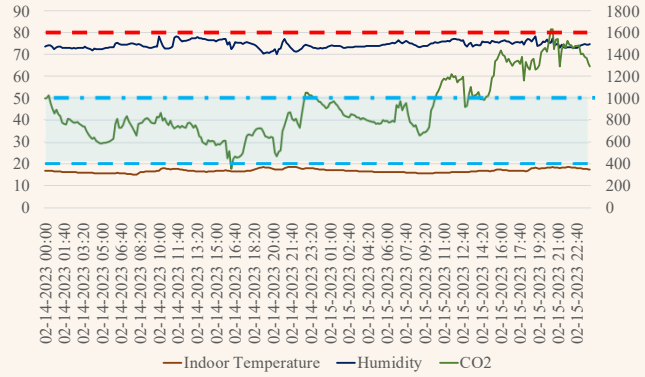


1 Ground Floor Plan
1 : 50

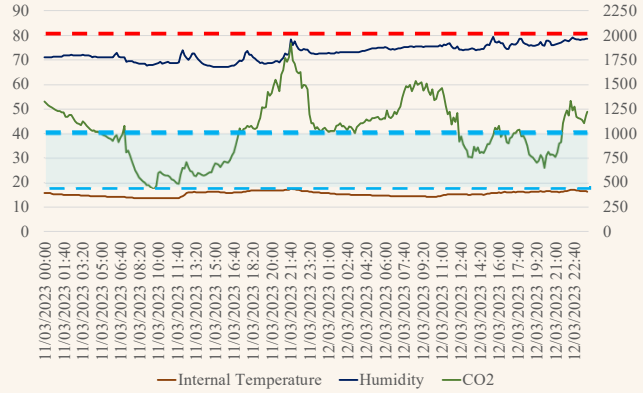
12 WEEKS KITCHEN DATA LOG



Normal Weekdays (2 days)
Feb 14-15,2023



Weekend (2 days)
March 11-12, 2023



CRITICAL RH 80%

Good CO2 Level
in between these 2 lines

Results

Monthly Total Average Results

Month	Temp	C02	RH	Surf. Temp
January	16.2	1078.4	75.5	14
February	16.9	964.9	74.7	13.6
March	16.2	900.9	76.2	13.1
April	16.8	895.5	78.4	13.9

12 Weeks Total Average Results

16.6 ° C INDOOR TEMPERATURE

76.1% RELATIVE HUMIDITY

943.7 INDOOR CO2

13.5 ° C SURFACE TEMPERATURE

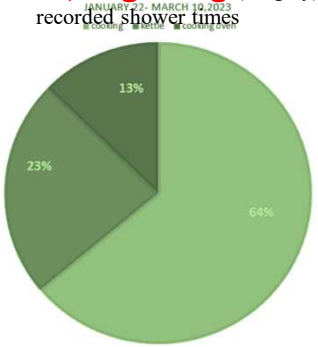
KITCHEN f^*_{Rsi}

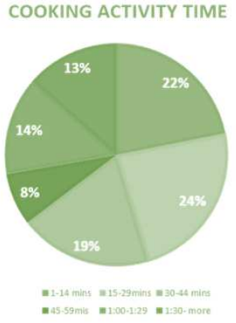
0.63

$f^*_{Rsi} = (\theta_{si} - \theta_e) / (\theta_i - \theta_e)$
$f^*_{Rsi} = (13.5 - 8.2) / (16.6 - 8.2)$
$f^*_{Rsi} = 5.3 / 8.4$
$f^*_{Rsi} = \mathbf{0.63}$

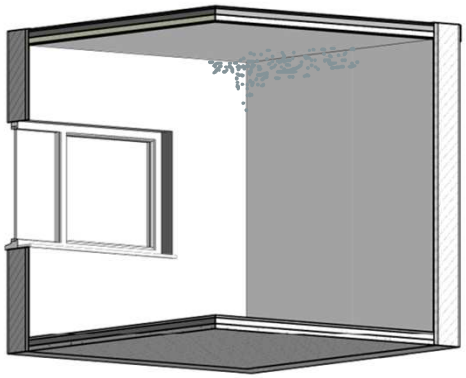
15 mins shower release 600g of moisture

93x Shower Activity from January to March 2023
WEDNESDAY, SATURDAY & SUNDAY is the most common days for showering
SUNDAY NIGHT is the most common time for Showering
27,040g/27kg (roughly) moisture was produced during the recorded shower times

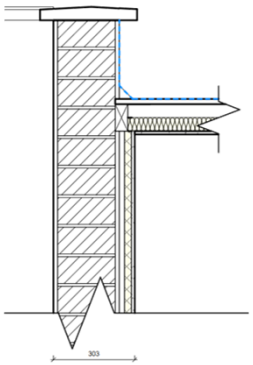




BEDROOM ANALYSIS



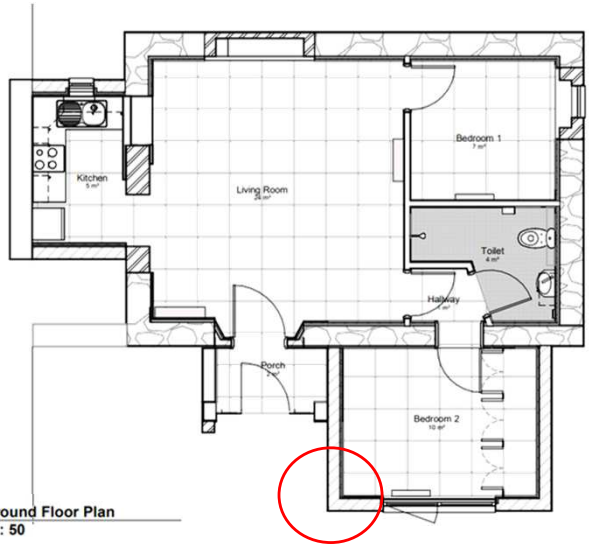
KITCHEN EXTERNAL WALL



0.782W/m²K

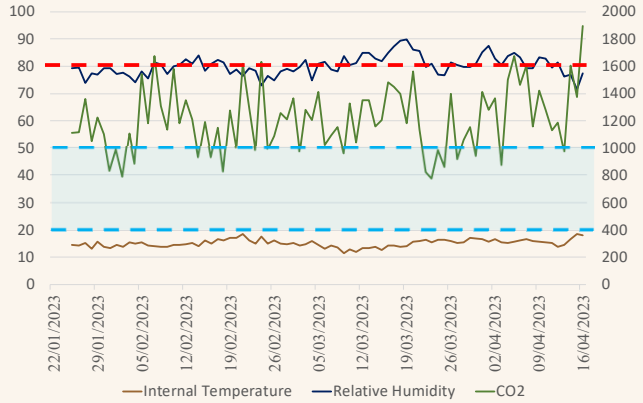
BEDROOM EXTERNAL WALL
15mm Sand Cement External Plaster on
215mm Concrete Block on
20mm Service Cavity on
25mm EPS insulation on
15mm Plasterboard

FLAT ROOF
Waterproofing on
15mm Timber Deck on
50mm Ventilation Cavity on
50mm Wool Insulation on
15mm Plasterboard

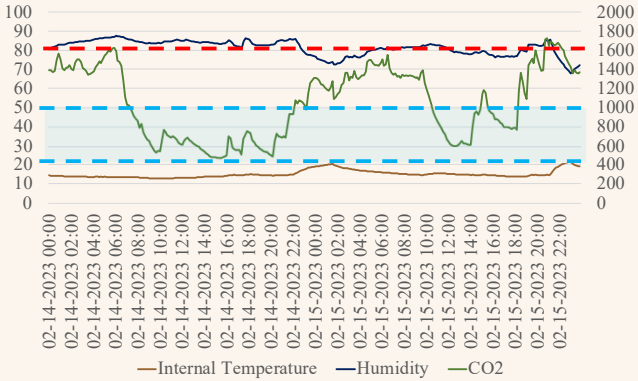


1 Ground Floor Plan
1 : 50

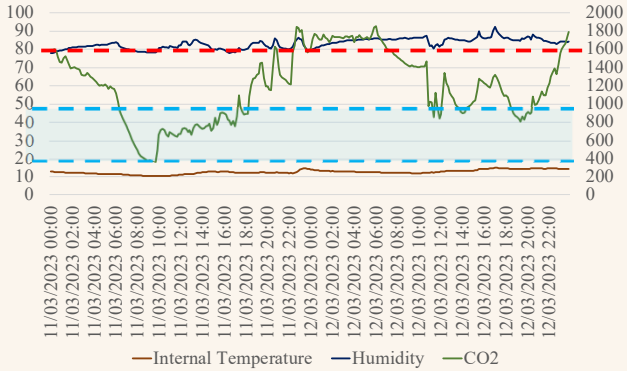
12 WEEKS BEDROOM DATA LOG



WEEKDAYS (2 days)
Feb. 14-15,2023



WEEKEND (2 days)
March 11- 12, 2023



CRITICAL RH 80%

Good CO2 Level
in between these 2 lines

Results

Monthly Total Average Results

Month	Temp	C02	RH	Surf. Temp
January	14.3	1112.7	77.9	
February	15.3	1182.1	78.7	13.4
March	14.7	1166.1	82.0	13
April	16	1362.2	80.7	14.4

12 Weeks Total Average Results

15.1 ° C INDOOR TEMPERATURE

80.2 % RELATIVE HUMIDITY

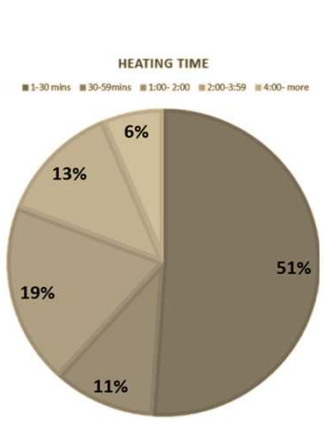
1205.3 INDOOR CO2

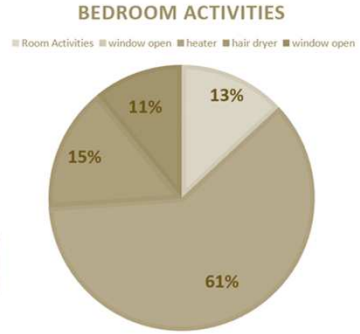
13.5 ° C SURFACE TEMPERATURE

0.76

BEDROOM f^*_{Rsi}

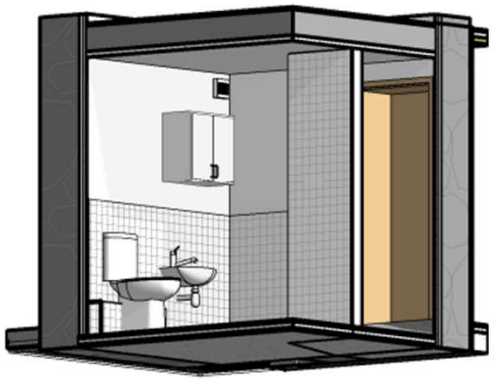
$f^*_{Rsi} = (\theta_{si} - \theta_e) / (\theta_i - \theta_e)$
$f^*_{Rsi} = (13.5 - 8.2) / (15.1 - 8.2)$
$f^*_{Rsi} = 5.3 / 6.9$
$f^*_{Rsi} = \mathbf{0.76}$



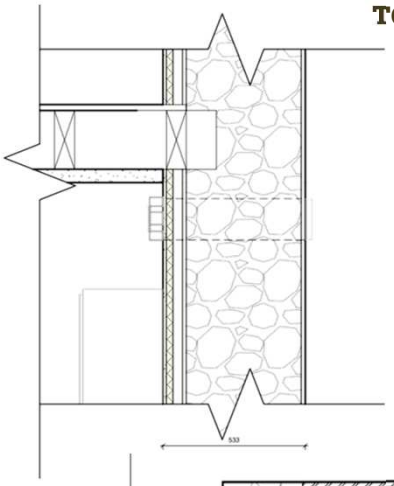


WEEKEND is the most CRITICAL day for Mould Growth

TOILET ANALYSIS

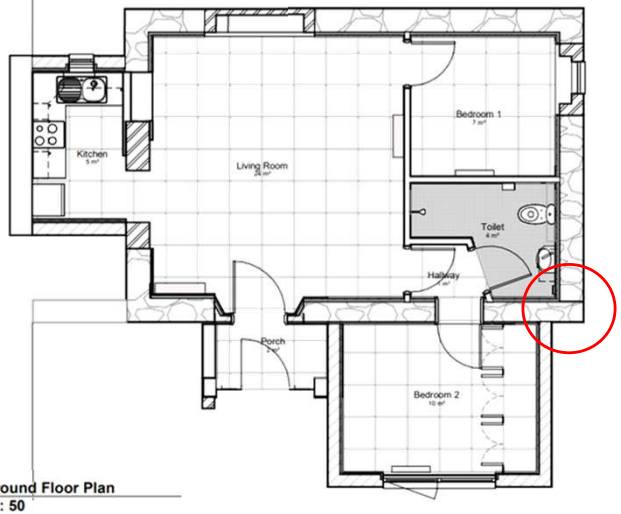


TOILET EXTERNAL WALL



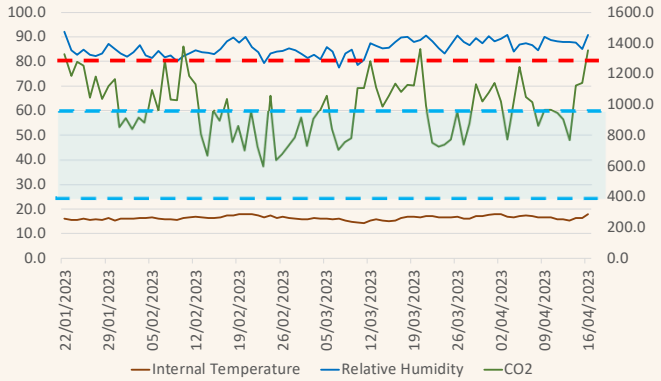
0.784W/m²K

TOILET EXTERNAL WALL
15mm Sand Cement External Plaster on
415mm Stone Wall on
15mm Sand Cement Plaster on
20mm Service Cavity on
25mm EPS insulation on
15mm Plasterboard

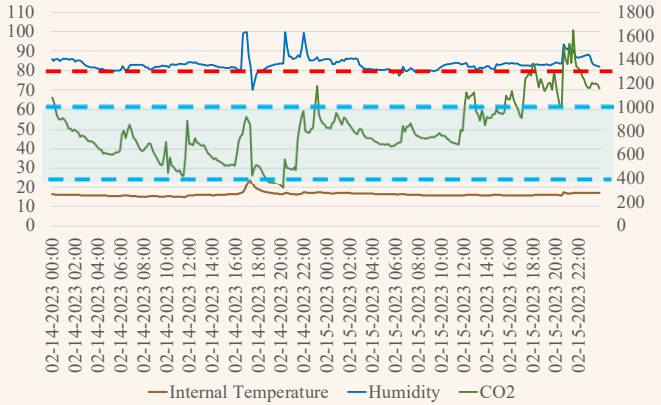


1 Ground Floor Plan
1 : 50

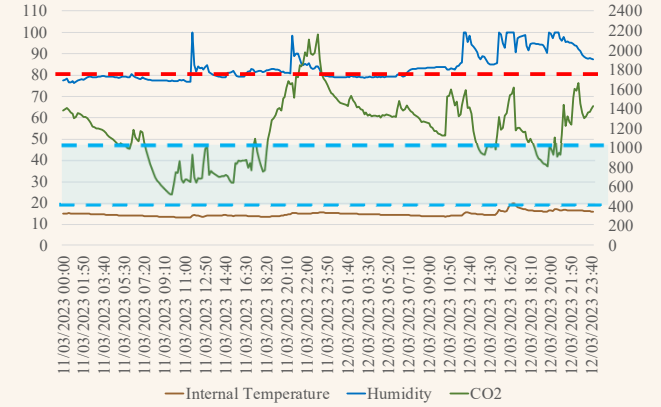
TOILET DATA LOG



WEEKDAYS (2 days)
Feb.14-15,2023



WEEKDAYS (2days)
March 11-12, 2023



CRITICAL RH 80%

Good CO2 Level
in between these 2 lines

Results

Monthly Total Average Results

Month	Temp	C02	RH	Surf. Temp
January	15.7	1133.7	84.3	14.1
February	16.5	911.6	84.2	14.4
March	16.0	964.0	85.7	13.9
April	16.6	1017.4	87.7	14.3

12 Weeks Total Average Results

16.3 ° C INDOOR TEMPERATURE

85.4% RELATIVE HUMIDITY

975.4 INDOOR CO2

14.2 ° C SURFACE TEMPERATURE

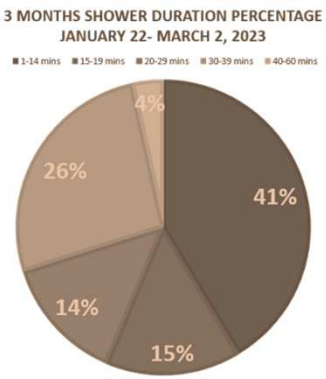
0.74

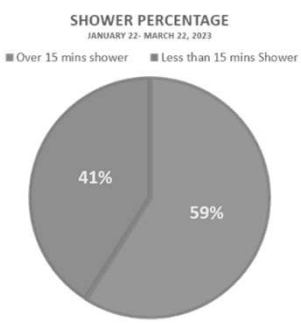
TOILET f^*_{Rsi}

$f^*_{Rsi} = (\theta_{si} - \theta_e) / (\theta_i - \theta_e)$
$f^*_{Rsi} = (14.2 - 8.2) / (16.3 - 8.2)$
$f^*_{Rsi} = 6 / 8.1$
$f^*_{Rsi} = \mathbf{0.74}$

15 MINS OF SHOWER

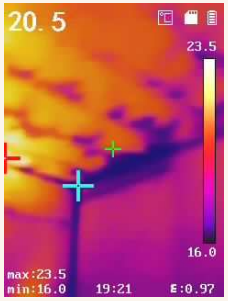
Release 600g of moisture

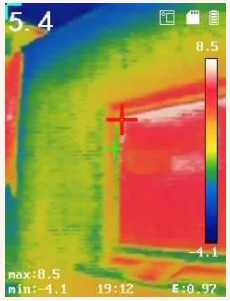




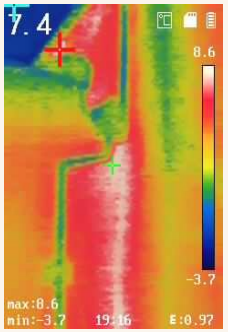
THERMAL IMAGES

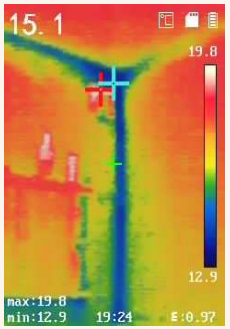
BEDROOM EXTERNAL WALL



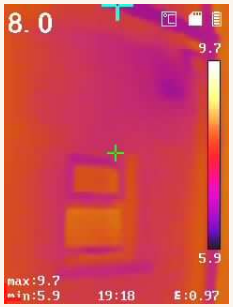


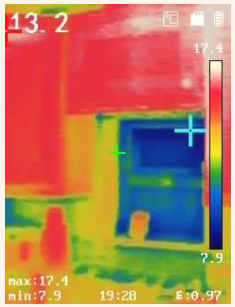
TOILET EXTERNAL WALL



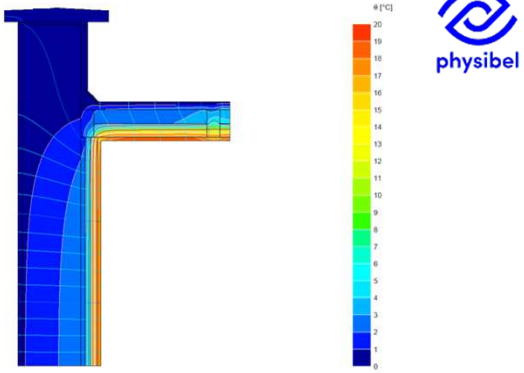


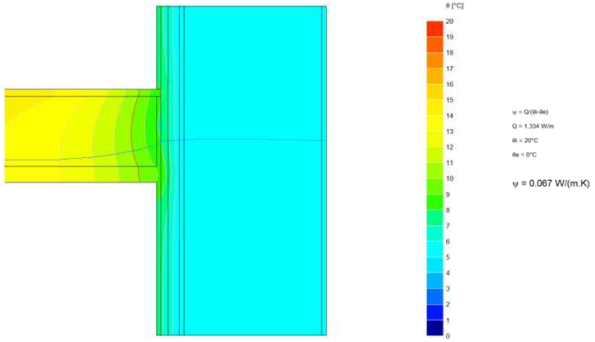
KITCHEN EXTERNAL WALL





TRISCO





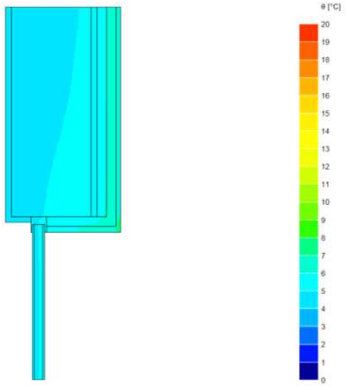


Table C2: Thermal Bridging Details (W/mK)

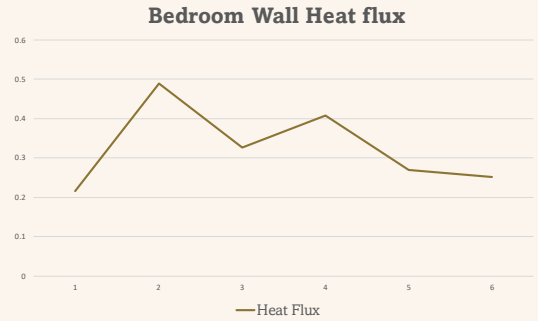
Junction	W/mK	W/mK
Type of Junction	Involving Metal Cladding	Not Involving Metal Cladding
Roof to wall	0.28	0.12
Wall to ground floor	1.0	0.16
Wall to wall (corner)	0.2	0.09
Wall to floor (not ground floor)	0.0	0.07
Lintel above window or door	1.0	0.30
Sill below window	0.95	0.04
Jamb at window or door	0.95	0.05

ISO 13788:2012-5.3

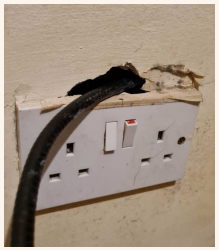
To avoid mould growth the monthly mean relative humidity at the surface should not exceed a critical humidity

0.8	0.75
fRSI= Kitchen	fRSI= Dwelling

HEATFLUX



Inspection Camera inside the service cavity of Bedroom Wall



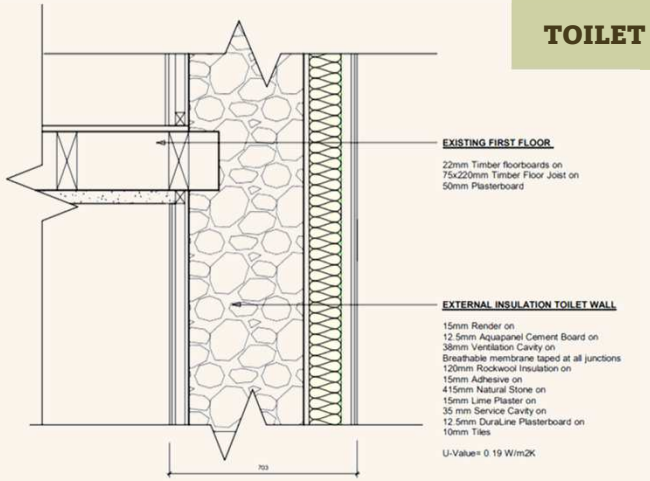
Inspection Camera inserted into a hole in Bedroom Wall

Inspection Camera inside the service cavity of Kitchen Wall

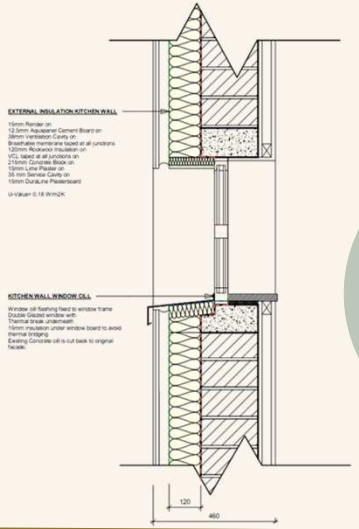
Inspection Camera inserted into the vent hole in Kitchen Wall

STRATEGIES

TOILET

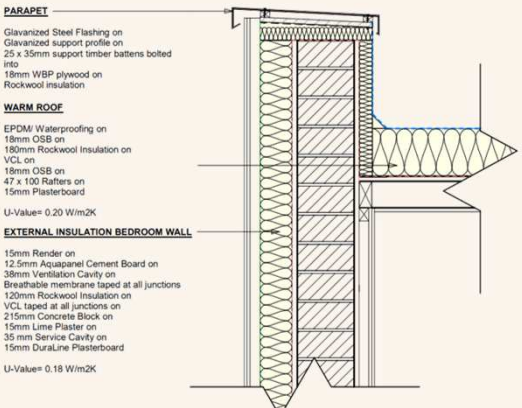


KITCHEN

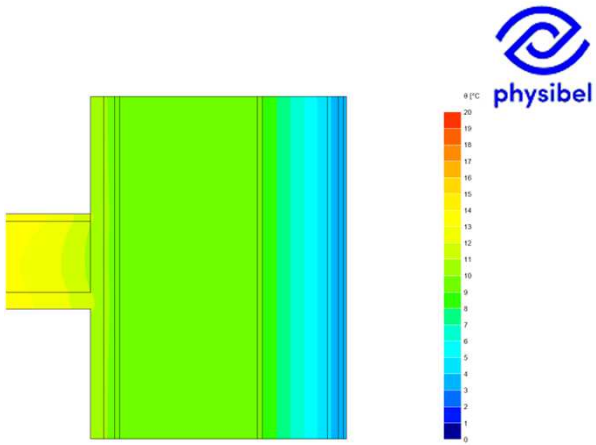


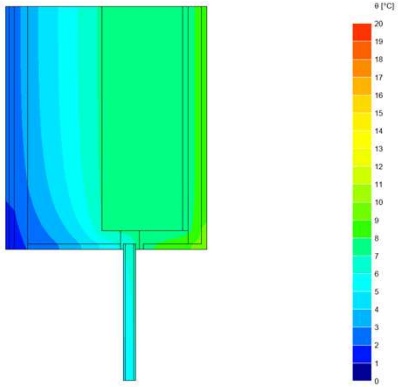
TGD Part L
Material Alteration
0.0.35W/mk

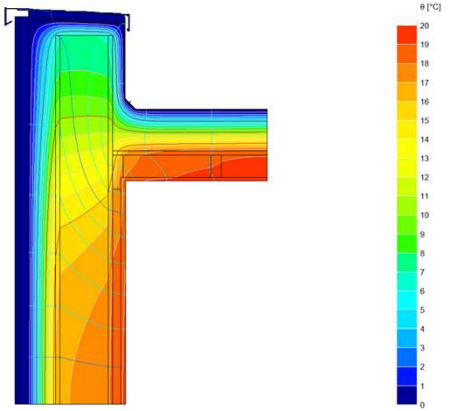
BEDROOM



THERMAL UPGRADE







Traditional Solid Wall Buildings are permeable structures. They Exchange moisture readily with indoor and outdoor environment. This type of dwelling needs permeable insulation like:

- CALCIUM SILICATE
- DIATHONITE
- WOODFIBRE
- HEMP INSULATION
- SHEEP WOOL
- ROCKWOOL

VENTILATION

EXITING VENTILATION in DWELLING

Poor ventilation in dwelling caused high average CO2 level during 12 week test duration. The Lowest Average is 943.7ppm

- KITCHEN VENTILATION HOOD
- WINDOW TRICKLE VENTS TROUGH WINDOW FRAME
- AXIAL BATHROOM EXTRACTOR FAN CONNECTED TO LIGHT SWITCH(TURNED OFF AFTER 1m8sec)
- LOUVRE WALL VENT

HOW TO IMPROVE VENTILATION?

Opening Windows and Doors for at least 10 mins

Upgrade Ventilation with Mechanical Heat Recovery Ventilation

Avoid Drying Laundry Indoor and with a heater

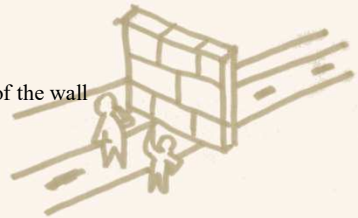
SUMMARY

LIMITATIONS

- As a result of the short time frame for this research project, measured environmental conditions were limited to 12- weeks.
- Testing the moisture content of each construction material was not applied but a further study along with an expert can sought out.
- The research focuses on junctions in ceiling, roof and window head where moulds are most visible.

KEY BARRIERS

Lack of Knowledge
Accessibility to the inner side of the wall
Cost/ Budget for investigation



KEY FINDINGS

Great Thermal Looping behind Internal EPS insulation board

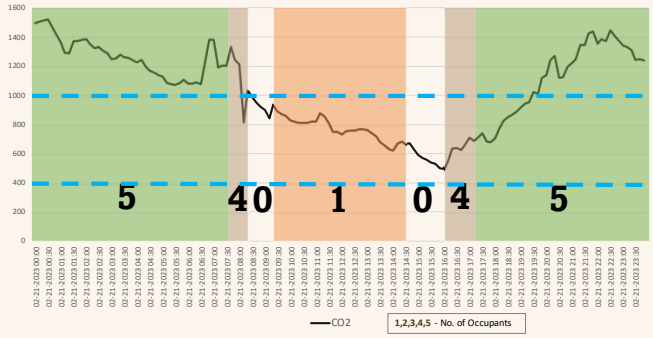
0.301 W/Mk -ΔT
KITCHEN

0.237 W/Mk -ΔT
TOILET

0.327 W/Mk -ΔT
BEDROOM

Using Scientific Method of heat flux data logging, I was able to find out that there's a Thermal looping happening in the service cavity of the wall. Heat flux was installed to the wall according to the standards, however the results are giving 0 heat transfer. Upon investigating, it was found that ventilation ducts in walls are not sealed. There are also few existing holes in the wall causing air movement.

1 Day-CO2 & Occupants Graph



KEY FINDINGS

TEMP. RISE
0.4° in
10 mins

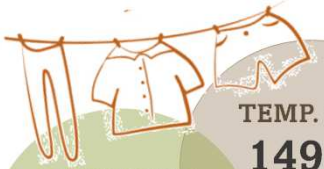
HUMIDITY RISE
8.2% after
10 mins

Hair Drying in the Bedroom

SHOWER

HUMIDITY RISE
19.2%
after 10 mins

TEMP. RISE
0.7° in
10 mins



HUMIDITY RISE
5% after 10 mins

TEMP. RISE
149 ppm
after
10 mins

When drying laundry indoor beside heater

TEMP. RISE
0.4° in
10 mins

Cooking when door & window not opened

HUMIDITY RISE
8.2% after
10 mins

To be noted:
The key findings are based on a certain dwelling,activities and number of people limited to the case study. Results will be different based on differerny…

CONCLUSION

To conclude, as a result of the data obtained through survey, data logging and analysis, the risk of mould growth in the dwelling is high. According to the samples sent to a laboratory, moulds that can grow in high humidity and low humidity is present.

Human activities together with the building design, contributes highly to the development of moulds. High CO2 activities like laundry indoor drying, showering and cooking can cause CO2 levels to rise up to 2800ppm. More than twice the recommended healthy air of 400-1000 ppm by the Wisconsin Department of Health Services.
Without opening windows or doors during these activities shows that the ventilation alone in the dwelling is not enough to eliminate the poor air quality.

Therefore, on the findings and analysis from this investigation, there are ways to prevent mould growth in buildings based on the standards of BS5250, TGD Part L, TGD Part F &ISO 13788:2012. However, in older buildings, there are barriers to completely investigating moulds. It is not always possible to dismantle an existing building to find the extent of defects that mould caused. Visual surveys, Data logging and Analysis of wall surfaces are not enough. There are moulds that are likely growing inside walls. Laboratory analysis may still be necessary to clarify each building material and eradicate the problem with a proper solution. Sometimes, this will cost owners to pay more. Incorrect diagnosis of the source of mould growth can lead to a huge amount of money for repairs. This addresses the need of knowledge not only for the designer but as well as the owner or occupants of the dwelling.

FURTHER STUDIES

- The recommendation for further study is to consider a longer data-logging timeline.
- Setting up a standard ACD for Old Stone Buildings
- Case Studies of Stone Buildings/ Older Buildings
- Mould Growth in Different Insulations
- Effects of Moulds in different masonry materials
- How will we ensure that retrofitting old dwellings will eliminate dampness problems and is up to standard?