Using Hygrothermal analysis to examine how the thermal performance, durability and occupant's health are affected, when retrofitting historic solid wall constructions.

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Aim

To establish the most appropriate thermal upgrade intervention for historic walled buildings, that will serve three main functions;

- not reduce the structural integrity of any component of that building
- increase the thermal comfort within and
- not compromise the health of the occupants due to mould formation.

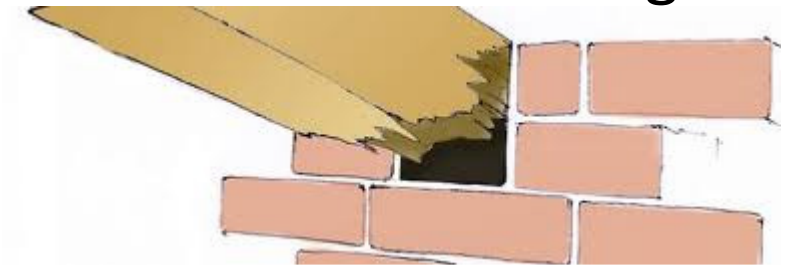
Drivers for change

- EU requirements to meet our 2020 targets
- Epbd recast
- National Government targets for example by the use of the Better Energy Programme in the public sectors 33% target reduction
- Increased awareness by owners of fuel price increases and the need to conserve energy
- Increased tightening of liability on professional ‘sign off’ due to new Building Control Act
- Growing need for ‘post occupancy evaluation’
- Greater appreciation of diversity of building stock

Retrofitting of building fabric has been identified as one of the most effective and cost efficient ways to achieve energy savings in the economy, with the potential for savings in developed countries estimated to be from 60% to 80% (DCENR 2009 Maximising Ireland’s Energy Efficiency; NEEAP 2009-2020,

Existing problem

- Every type of insulation system is currently been specified for external solid walls, often without due diligence as to what effect this can have on the fabric and on the health of the occupants .
- The structural integrity of embedded timbers are most at risk when moisture evaporation is curtailed or impeded.
- Quite often as a result of this entrapment or due to the formation of additional moisture, black mould growth develops leading to reduced living standards and unhealthy conditions which have serious implications for the health of both the building and its occupants.



Motivation

- To use hygrothermal analysis and validated field tests to determine the optimum capability, of solid wall construction thermal upgrades,
- Its proposed that this research will further inform policymakers on how to prevent durability loss and prevent poor living conditions in historic buildings

Objectives

- Identify the number of traditional walled dwellings (non-cavity construction) nationally, that will require retrofitting.
- Identify the structural elements most affected by moisture movement, particularly where the greatest thermal bridging is likely to occur.
- Establish the thermal performance of common construction details identified above.
- Collate and analyse all the data from a sensored datalogging monitoring system for validation
- Identify and justify the most appropriate sustainable retrofit option for different solid wall types.

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Methodology

To achieve objective 1

- Identification of the number of solid wall constructed buildings in Ireland. This will be achieved by reviewing the 2006 and the most recent 2011 CSO statistics in identifying and categorising the structure age and type. The 2011 Tabula report will also be used to assess the age, energy use and type of structure as will the Built Heritage publications from the Department of Environment Heritage and Local Government in cross referencing and determining accurate figures. Other sources include SEAI database on BER assessments

Methodology

To achieve objective 2

- Identification of key structural elements will be carried out, within the fabric of the structures identified above, to establish the 'at risk' areas. These areas will be established by consulting with a number of construction professionals, personal experiences and from a number of written survey condition reports. This will be achieved by determining how for example built in timbers and other components could be adversely affected. by the trapping of moisture by retrofit measures that were unsuitable.

Methodology

To achieve objective 3

- Moisture movement will be simulated to comprehensively address the areas of Durability, Health and Thermal performance.
- The hygrothermal simulation initially will model the 'at risk' structural areas identified above. This will involve the calculation of moisture movement across the wall, establishment of dew point, thermal properties relevant to weather data, thermal mass and thermal bridging analysis by the use of Psi-Therm, in the determination of condensation risk which can cause loss of structural integrity in built in timbers The modelling will also be used to establish U values and these established hygrothermal properties of the fabric of the solid wall will be used to inform the decision making process on retrofitting.

Methodology

To achieve objective 4

- Determination of a framework of energy efficiency measures. As the main aim is to establish the optimum retrofit intervention for a specific solid wall type, it must therefore establish the optimum solution for a particular circumstance. This will be achieved by setting different boundary conditions in the modelling process and observing the hygrothermal changes that occur.

Methodology

To achieve objective 5

- Analysing all of the data set to different boundaries, particularly in relation to moisture movement and possible health issues with the growth of black mould will help inform and identify the most appropriate energy efficiency upgrade for a particular building type. An analysis framework for determining the optimum retrofit interventions for the different wall and element types will be used to determine the effects on the thermal performance, occupant's health and the building fabric.
- Any form of analysis should be underpinned by the energy, cost and emissions savings made for upgrading the buildings guided by conservation principles and philosophies where applicable.

Literature review

The findings

Numer of studies: Climate 2000, EDRA, HYGROBA, EnOB

- WuFi software has had a number of validated field tests (slightly more than Delphin)
- Delphin deals with salt migration whereas WuFi doesn't
- However full simulation of Heat, Air and Moisture (HAM) and comprehensive validation particularly to historic buildings is rare
- Most field testing have omitted the effects of either solar radiation, horizontal rain and or air movement
- A number of tests have and are still been carried out based on the Glaser method which does not take account of liquid moisture
- EN 15026: (2007) should be used as it is more comprehensive

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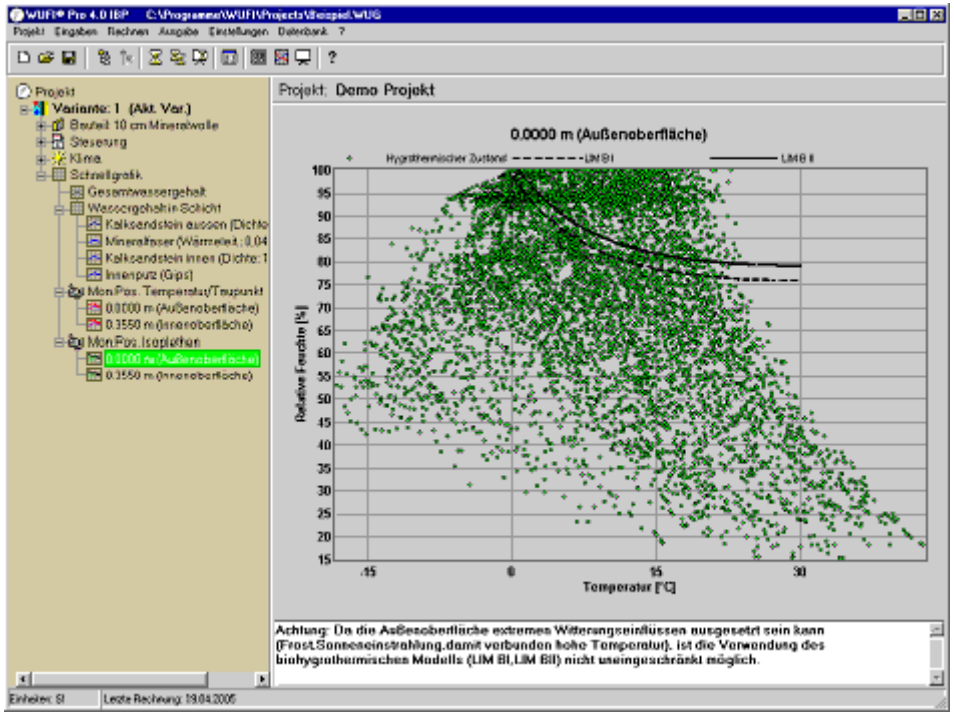
Why model

- The ability to extract the hygrothermal condition at the surface of a component at a given time (Isopleth) is useful in predicting the performance



Data gathering

Desktop study

- Condition survey reports
- Interviews
- Surveys

Field Testing

- Monitoring of solid wall building over a 12 month period on north and south facing walls

Equipment required

Equipment	Function
• Datalogger	• Collate results
• Temperature probes	• To determine internal, external and ‘in line ‘ temperatures
• Humidity stats	• To determine internal, external and ‘in line’ humidity levels
• Barometric pressure stat	• Determine air pressure
• Precipitation	• Amount of rainfall
• Wind direction	• To analyse effects of driving ‘horizontal’ rain
• Wind speed	
• Solar radiation	• Measure effects of radiation on inward movement of moisture

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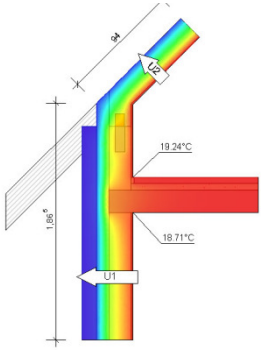
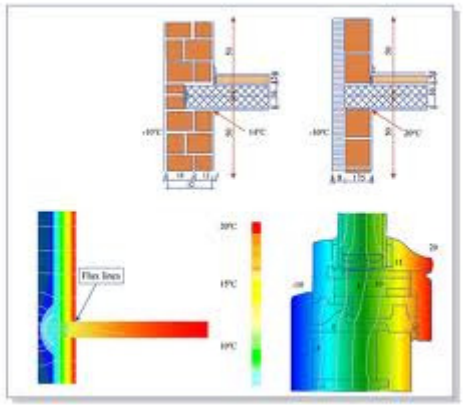
Simulation requirements

Software

- Psi-Therm



- Delphin or WuFi



- IES

Function

- Condensation risk analysis in 2D and 3D for steady state conditions
- Hygrothermal modelling to determine non steady state conditions
- To determine the effects of internal air movement

Material properties

Component

Bricks

Mortar

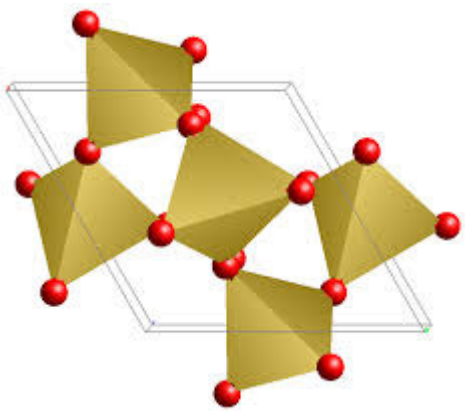
Render

Lime plaster

Wood

Properties

- Density, Porosity, Weight, Absorbptivity



Progress to date

- Screening of the software requirements down to WuFi and Delphin
- Establishment of scale of problem
- Building identified
- 25% of equipment purchased
- Psi-Therm course finished by June 2014

Perceived difficulties

- Finding a Delphin training course
- IES training
- Quality and accuracy of affordable weather stations
- Establishment of accurate U values
- Time constraint on validating a retrofit intervention

Thank you