**SUPPLEMENTARY FILE**

* **S01**

**MATLAB Code for Full Factorial Design (2k)**



* **S02**

**Causal Map**

 A causal diagram is a useful tool for displaying the relationships between variables that affect the risk under study. Figure S02 presents the causal diagram where the consequence node of the proposed diagram is mould growth owing to moisture accumulation (indicated by red colour). The coexistence of substrates, suitable temperature (*T*), and relative humidity (*RH*) levels are the mechanisms that cause this event. Depending on the drying capacity and the amount of moisture intake, *RH* and *T* favourable for mould growth are accumulated; in this case, the RHT index was used. The two primary mechanisms that can contribute to *RH* and *T* are undercooling and water leakage, both of which are linked to the driving forces listed at the parent nodes of diagram.

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| A diagram of a diagram  Description automatically generated |

**Figure S02** Causal diagram for moisture risk

* **S03**

**Table** Parametric variation considered in the present study

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Simulation ID** | **Vapor Barrier + Finished Gypsum** |  | **Rain screen** | **Water leakage** |
| **Six Brick wood frame walls with various vapor barriers, with rain screen, and no water leakage** |
| QCB01-RS-NL | 0.1perm+Coated Gypsum |  | 25mm | No moisture leakage |
| QCB1-RS-NL | 1perm+Coated Gypsum |  | 25mm | No moisture leakage |
| QCB5-RS-NL | 5perm+Coated Gypsum |  | 25mm | No moisture leakage |
| QCB10-RS-NL | 10perm+Coated Gypsum |  | 25mm | No moisture leakage |
| QCB0-RS-NL | No vapor barrier+Coated Gypsum |  | 25mm | No moisture leakage |
| QCB0-C-RS-NL | No vapor barrier+Latex coated Gypsum |  | 25mm | No moisture leakage |
| **Six Brick wood frame walls with various vapor barriers, no rain screen, and no water leakage** |
| QCB01-NRS-NL | 0.1perm+Coated Gypsum |  | No | No moisture leakage |
| QCB1-NRS-NL | 1perm+Coated Gypsum |  | No | No moisture leakage |
| QCB5-NRS-NL | 5perm+Coated Gypsum |  | No | No moisture leakage |
| QCB10-NRS-NL | 10perm+Coated Gypsum |  | No | No moisture leakage |
| QCB0-NRS-NL | No vapor barrier+Coated Gypsum |  | No | No moisture leakage |
| QCB0-C-NRS-NL | No vapor barrier+Latex coated Gypsum |  | No | No moisture leakage |
| **Six Brick wood frame walls with various vapor barriers, with rain screen, with water leakage** |
| QCB01-RS-L | 0.1perm+Coated Gypsum |  | 25mm | Moisture leakage |
| QCB1-RS-L | 1perm+Coated Gypsum |  | 25mm | Moisture leakage |
| QCB5-RS-L | 5perm+Coated Gypsum |  | 25mm | Moisture leakage |
| QCB10-RS-L | 10perm+Coated Gypsum |  | 25mm | Moisture leakage |
| QCB0-RS-L | No vapor barrier+Coated Gypsum |  | 25mm | Moisture leakage |
| QCB0-C-RS-L | No vapor barrier+Latex coated Gypsum |  | 25mm | Moisture leakage |
| **Six Brick wood frame walls with various vapor barriers, no rain screen, with water leakage** |
| QCB01-NRS-L | 0.1perm+Coated Gypsum |  | No | Moisture leakage |
| QCB1-NRS-L | 1perm+Coated Gypsum |  | No | Moisture leakage |
| QCB5-NRS-L | 5perm+Coated Gypsum |  | No | Moisture leakage |
| QCB10-NRS-L | 10perm+Coated Gypsum |  | No | Moisture leakage |
| QCB0-NRS-L | No vapor barrier+Coated Gypsum |  | No | Moisture leakage |
| QCB0-C-NRS-L | No vapor barrier+Latex coated Gypsum |  | No | Moisture leakage |

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| **Six Stucco wood frame walls with various vapor barriers, with rain screen, and no water leakage** |
| QCS01-RS-NL | 0.1perm+Coated Gypsum |   | 10mm | No moisture leakage |
| QCS1-RS-NL | 1perm+Coated Gypsum |  | 10mm | No moisture leakage |
| QCS5-RS-NL | 5perm+Coated Gypsum |  | 10mm | No moisture leakage |
| QCS10-RS-NL | 10perm+Coated Gypsum |  | 10mm | No moisture leakage |
| QCS0-RS-NL | No vapor barrier+Coated Gypsum |  | 10mm | No moisture leakage |
| QCS0-C-RS-NL | No vapor barrier+Latex coated Gypsum |  | 10mm | No moisture leakage |
|

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Simulation ID** | **Vapor Barrier + Finished Gypsum** |  | **Rain screen** | **Water leakage** |

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| **Six Stucco wood frame walls with various vapor barriers, no rain screen, and no water leakage** |
| QCS01-NRS-NL | 0.1perm+Coated Gypsum |  | No | No moisture leakage |
| QCS1-NRS-NL | 1perm+Coated Gypsum |  | No | No moisture leakage |
| QCS5-NRS-NL | 5perm+Coated Gypsum |  | No | No moisture leakage |
| QCS10-NRS-NL | 10perm+Coated Gypsum |  | No | No moisture leakage |
| QCS0-NRS-NL | No vapor barrier+Coated Gypsum |  | No | No moisture leakage |
| QCS0-C-NRS-NL | No vapor barrier+Latex coated Gypsum |  | No | No moisture leakage |
| **Six Stucco wood frame walls with various vapor barriers, with rain screen, with water leakage** |
| QCS01-RS-L | 0.1perm+Coated Gypsum |  | 10mm | Moisture leakage |
| QCS1-RS-L | 1perm+Coated Gypsum |  | 10mm | Moisture leakage |
| QCS5-RS-L | 5perm+Coated Gypsum |  | 10mm | Moisture leakage |
| QCS10-RS-L | 10perm+Coated Gypsum |  | 10mm | Moisture leakage |
| QCS0-RS-L | No vapor barrier+Coated Gypsum |  | 10mm | Moisture leakage |
| QCS0-C-RS-L | No vapor barrier+Latex coated Gypsum |  | 10mm | Moisture leakage |
| **Six Stucco wood frame walls with various vapor barriers, no rain screen, with water leakage** |
| QCS01-NRS-L | 0.1perm+Coated Gypsum |  | No | Moisture leakage |
| QCS1-NRS-L | 1perm+Coated Gypsum |  | No | Moisture leakage |
| QCS5-NRS-L | 5perm+Coated Gypsum |  | No | Moisture leakage |
| QCS10-NRS-L | 10perm+Coated Gypsum |  | No | Moisture leakage |
| QCS0-NRS-L | No vapor barrier+Coated Gypsum |  | No | Moisture leakage |
| QCS0-C-NRS-L | No vapor barrier+Latex coated Gypsum |  | No | Moisture leakage |

* **S04**

**Typical Simulation Outputs**

|  |  |
| --- | --- |
| Chart  Description automatically generated | Diagram  Description automatically generated with medium confidence |
| (a) | (b) |

**Figure S04** Typical simulation outputs― graph of *T*, *RH*, and water content across wall cross-section on 26th Feb 2023 (heating season) for: (a) stucco wall, and (b) brick wall

* **S05**

**Manual Design Tool Dew Point Method**

The numerical calculation by transient hygrothermal simulation were evaluated using manual design tool, i.e., Dew Point Method. Calculation was performed using excel spreadsheet for condition when outdoor climate is the most severe (lowest temperature) on day 148th. The material properties of wall components, temperature, and relative humidity are taken from WUFI database. Procedure for dew point calculations:

1. Calculate temperature drop (proportional to thermal resistance).

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where *T* is temperature at each layer (°C) and *R* is thermal resistance of each layer (m2.K/W)

1. Calculate saturation vapor pressure.

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where *ps* is saturation vapor pressure (Pa) and *t* is temperature (°C)

1. Calculate vapor pressure drops (proportional to vapor resistance).

  (

where *p* is actual vapor pressure at each layer (Pa) and *Z* is water vapor diffusion resistance (1/perm)

1. Compare saturation vapor pressure and actual vapor pressure.

Result is shown in Figure S05. The graph indicates that at that time step, condensation occurs on OSB sheathing layer facing stud cavity, where the actual vapor pressure at OSB layer is higher than the saturated vapor pressure. This result corresponds with the simulation results in Section 3. However, the manual design method has major limitations, such as it only predicts condensation without knowing how long the moisture stored and moisture damage it may cause. In addition, the method only considers vapor diffusion transport mechanism, steady-state, and one-dimensional.



**Figure S05** Actual vapor pressure and saturated vapor pressure across wall components using dew point method. Blue dotted line is saturated vapor pressure; orange line is calculated vapor pressure