Testing residential building fabric and reporting on the impacts upon performance and potential risks to occupant safety

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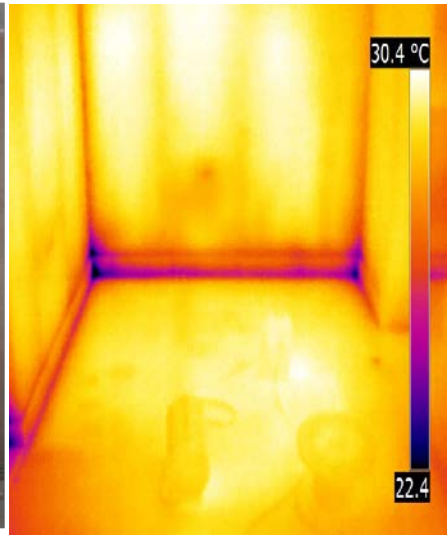
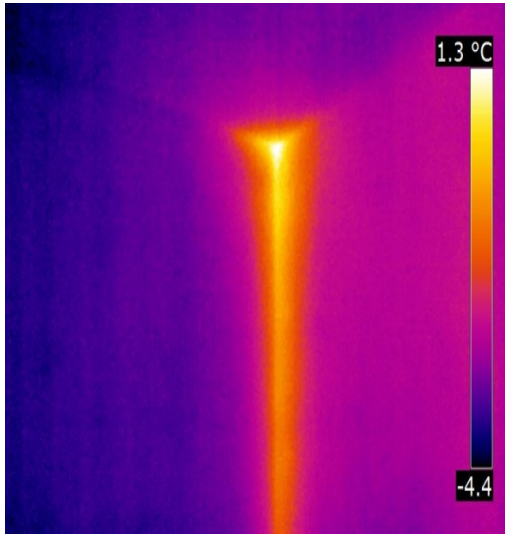
Predicted performance not being realised

- The gap between the ‘as designed’ and the ‘predicted’ performance and ‘actual’ performance of buildings in use and operation in the UK is well documented and is known as the *performance gap*.



- So, dwellings commonly inherit inefficiencies from the construction process, which affect occupancy energy use and impacts upon comfort and fuel costs.

- Less well documented are *anomalies* in mandatory compliance testing, such as air tightness testing, part of the mechanism to ensure thermal performance is achieved.



- Increases in air permeability contribute to increased heat loss and carbon emissions and thereby, decreasing energy and carbon efficiency.

(Nooraei et al. 2013; Littlewood, 2013)

In-Construction Testing

•Traditionally building performance is assessed and monitored once a building is completed and occupied as part of post occupancy evaluation studies.

•Since 2010, Cardiff Metropolitan University have developed a methodology for assessing the performance of buildings during the construction process, entitled: ***in-Construction Testing (iCT).***

•iCT methodologies include observations ***iCT:O*** of compliance tests, ***iCT:Th,*** air permeability ***iCT:Ap*** testing singularly and also combined with whole dwelling smoke tests ***iCT:Aps***:

•The aim of the iCT procedures is to assess whether design (predicted) strategies are translated into construction quality & performance standards in the operation of low carbon buildings.

•For the *iCT:Th* the modus operandi is in three stages:

- pre-test procedures,
- On-test procedures,
- Post test procedures.

(Littlewood, 2013)

Non compliance with test method - example

ATTM L1/2010 COMPIANCES for VALID TEST		DWELLING: Plot-12 4p/3bed End terrace	
Air-test Stage	**Compliant Requirement**	**On-site Observed Actions**	Valid
Envelope Area Calculation	Current Dimensional drawings	211.43m^2 determined pre-test off-site from supplied drawings– not observed to be checked on-site.	NO
Pre-test Dwelling Preparation	Building fabric completed condition	No – test continued	NO
	Internal open access areas <single-leaf doorway area	None - observed	YES
	Adjacent property door & windows opened	Yes-observed	YES
	HVAC sealed	Yes-observed	YES
	Drainage traps filled	No	NO
	External doors & windows closed-unsealed	Yes- observed	YES
	Trickle & passive vents sealed	Closed but unsealed	NO
	Other open-uncontrolled vents-sealed	Not applicable	-
	Other sealing	Electrical sockets & to wall	NO
			-

(Littlewood and Smallwood, 2015)

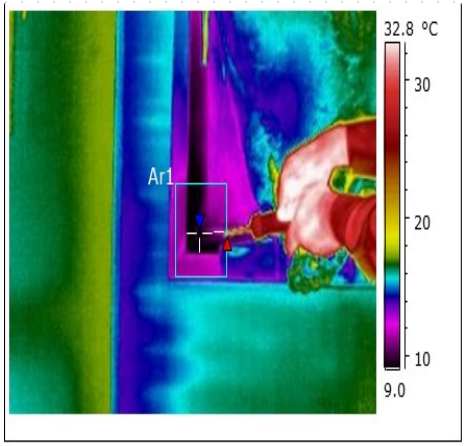
Fabric first approach to Performance / Compliance Checks

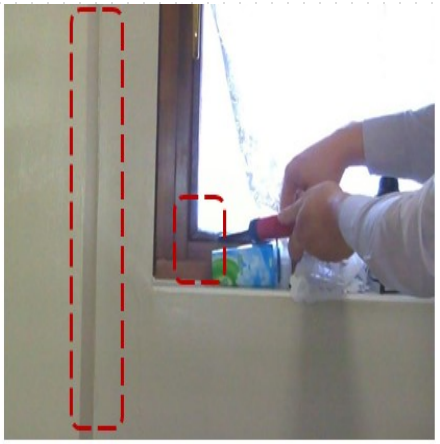
- In the UK, there are approved construction details to meet targets for thermal performance (accredited construction details) & also acoustic performance (robust details).

- There are currently no accredited or robust details that can be used to ensure compliance with fire performance i.e. restricting smoke/fire spread between and in dwellings.

- The recommended standard of fire separation between dwellings of normal risk is generally 30 minutes, but can increase to 60 minutes between buildings or where the upper floor is five metres above ground, generally found in flats (Approved Document B, Table A2).

- In the UK, Building Control Officers have the responsibility of approving building construction and performance targets, including: Accredited & Robust Construction Details are used; the results presented in the two case studies indicate that this may not always be undertaken.





(Littlewood and Smallwood, 2016)

Methodology

Conducting observations of contractor air tests & conducting independent air permeability tests on behalf developer. Test Equipment: Blower door, with depressure test.

Combined air test/whole dwelling tests undertaken when discrepancies in observations/tests.

Case Study One: 2 storey semi-detached house, (3B5P) 20+ dwellings, ADL1a 2010. Timber frame, brick clad, timber frame party wall Tested 06/13.

Smoke Test Equipment
Blower door – pressure test + Colt smoke Generator
Video 1

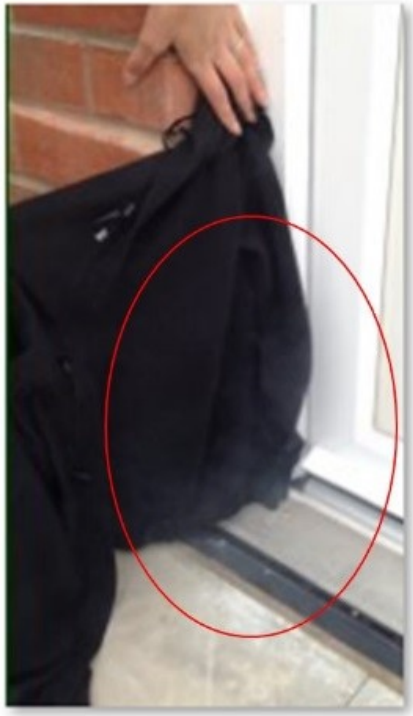
Case Study Two: 1st storey flat, (1b2p) 6 flats per block of two blocks, 3 storeys; with adjoining building. Tested 12/14.

(Littlewood, 2013; Littlewood and Smallwood, 2015, 2016)

Results – Case Study One

Contractor's Air Permeability 04/13	Independent Test 06/13	Target
2.50 m^3/ ($h.m^2$)@50Pa	4.50 m^3/ ($h.m^2$)@50Pa	3.00 m^3/ ($h.m^2$)@50Pa

One fan activated @ 35Pa. Between 30 seconds to 1 minute: smoke spread through party wall (electrical sockets) to adjacent dwelling (occupied); under exterior cills & frames; & from roof space. Defective seals in fenestration & incorrect installation of sockets. Video 2.

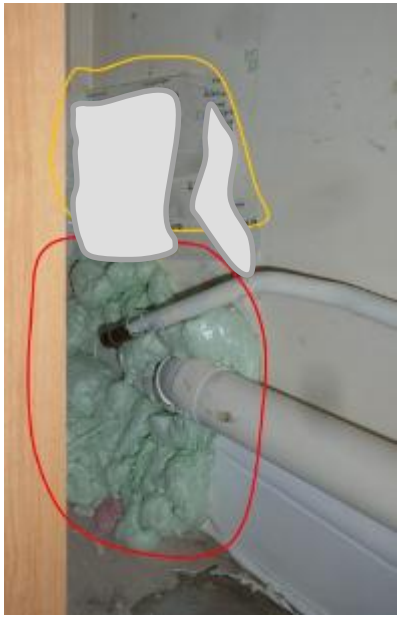


(Littlewood, 2013)

Results – Case Study

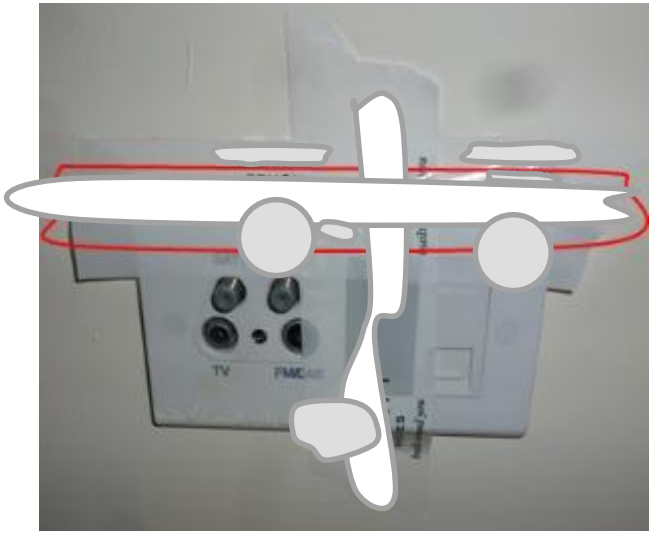
Contractor's Air Permeability 2014	Post-occupancy In-use 2014	Target
4.59 $m^3/(h.m^2)$@50Pa	4.92 $m^3/(h.m^2)$@50Pa	4.70 $m^3/(h.m^2)$@50Pa

Since the air permeability results were higher than the contractor's results & target & also because construction quality was poor from observations and the contractor's test used non-compliance methods: combined air test/whole dwelling smoke test undertaken

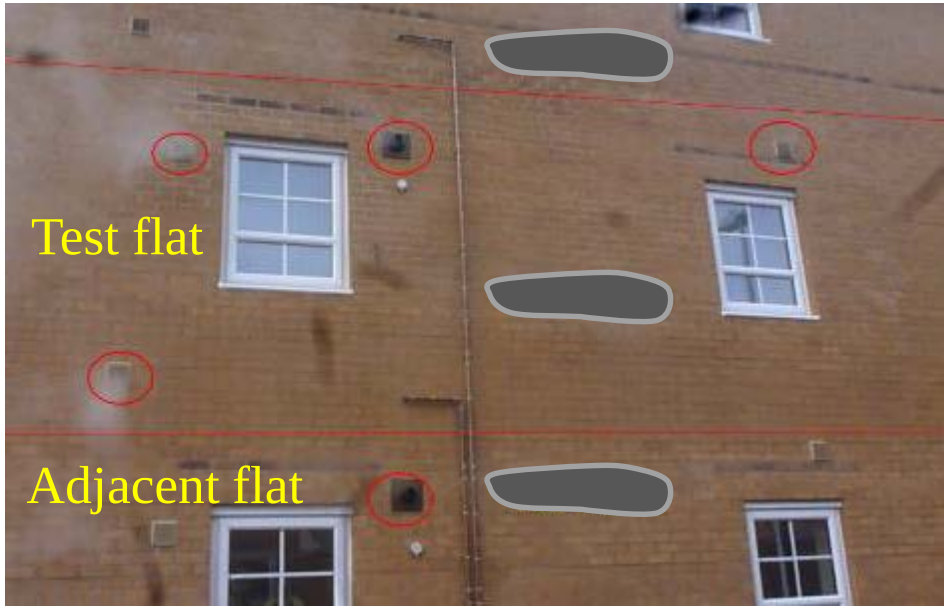


Overuse of expanding foam.

(Littlewood and Smallwood, 2015, 2016)



Results – Case Study Three



One fan activated, between 30 seconds and two minutes smoke spread to eight other flats, the means of escape, electrical/gas meter cupboards & the roof. Tests were repeated by the contractor several times + destructive testing was undertaken. Fire socks not installed/not properly installed.
Video 3, 4, 5, 6.

(Littlewood and Smallwood, 2015, 2016)

Independent Fire Engineer View of Case Study Results

"*Regarding your query, it does not surprise me that often buildings are signed off and then subsequently issues are identified. It is an issue regarding fire safety, the local authority fire service have powers under the Regulatory Reform (Fire Safety) Order 2005 to serve an 'Enforcement Notice' if there are serious concerns to life. The term used in the order is something like, " where a failure places one or more relevant persons at risk of death or serious injury in case of fire*"

Reply from Fire Engineer (ex Fire Officer) as expected…**tell the fire service!"**

(Littlewood and Smallwood, 2015, 2016)

Implications for occupant comfort, health and safety

The government building control officer responsible for issuing the fire certificate refused to visit the dwellings to observe the results of the smoke tests.

With no compliance test to verify smoke/fire spread is resisted for 30/60 minutes, the potential risk to 1.1 Million & 500,000 households (built since 2004 and to be built with accredited and robust details) could be significant.

October 2015: care home fire 2013, built in 2001, High Court Case: housing association with the Sussex Fire Service claim that because the compartmentation failed to contain the smoke and fire spread for one hour, the fire service were prevented from tackling the blaze before rapid fire engulfed the building across the six storeys (Wilson, 2015); 30 people were evacuated with serious injuries.

June, 2015, Chief Fire Officers Association collating incidents of fires involving timber frame construction, more housing associations using this construction method more frequently (Williams, 2015).

The biggest cause of death in a fire is due to smoke inhalation, before the fire.

Next Steps – 2015:2017

July 2015, two year Research and Enterprise Investment Fund (REIF) grant awarded by Cardiff Metropolitan University, collection of further data:

interaction with the UK Fire Service/their safety teams, information needed on:

- causes of fires and occupant deaths in dwellings/between dwellings in the UK,
- the types of dwellings and their construction method that cause fires/smoke spread between dwellings,
- Whether a construction site test is required to demonstrate compliance with compartmentation to prevent smoke/fire spread for 30/60 minutes,
- adequacy of Approved Document B certification for compartmentation;
- Adequacy of construction details to for compartmention. (Littlewood and Smallwood, 2016)

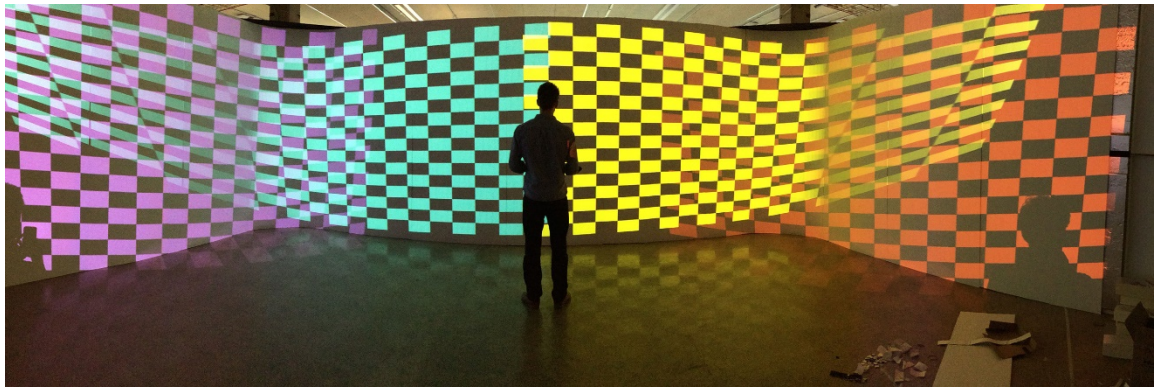
Next Steps – 2015:2017

observation of compliance tests;

undertaking combined air permeability tests with whole dwellings smoke tests and also in conjunction with thermography;

refinement of the iCT methodology/the implementation of the smoke testing process using heated smoke;

Results presented through the Perceptual Experience Laboratory - experience of what it is like to be in a fire - understanding how occupants react in a fire.



(Littlewood and Smallwood, 2016)

Work Plan 2015:2017

3.1 Literature review (09/15-08/16)
Report causes of fires and occupant deaths in dwellings/between dwellings in the UK, (milestone 1).

3.2 Presentation to/Data Collection with Fire Officers (12/15-05/16)
views on causes of fires and occupant death in dwellings/between dwellings, (milestone 2).

3.3 Observations + iCT Tests on selected case studies and analyse results (12/15 – 08/17)
Observation report (milestone 3), accredited details/robust details issue (milestone 4), fire spread modelling (milestone 5), iCT operational guides (milestone 6-7).

3.4 Disseminate results & PEL 11/15 – 08/17
PEL experiments (milestone 8), workshops and publishing results (milestone 9)

3.5 Develop and submit funding bid 11/15 – 08/16
Extend study across Wales, UK (milestone 10)

THANK YOU FOR LISTENING

ANY QUESTIONS

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