BRIDGING THE THEORY: REALITY GAP

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It has been increasingly recognised within the UK that buildings, as-constructed, are not performing in accordance with theory and that one of the reasons for this performance failure can be attributed to unaccounted thermal bypass (ZCH, 2010 and Stafford et al., 2012). The lead author has previously presented papers reporting upon the impact that Convective Thermal Bypass mechanisms can have on building performance (see Siddall, 2009 and 2011). In 2009, the author contended that constructing Passivhaus buildings without dedicating due care and attention to thermal bypass mechanisms could result in building performance failures.

This paper discusses the results obtained from a small number of coheating tests that have recently been undertaken on Passivhaus dwellings. These results suggest that the Passivhaus standard, when complimented by an appreciation of the risks imposed by thermal bypass, is capable of closing this performance gap.

Coheating Tests : Results

A coheating test is a quasi-steady state method that can be used to measure the whole dwelling heat loss (both fabric and background ventilation) attributable to an unoccupied dwelling in W/K. The process involves using electric resistance heating to achieve a mean elevated indoor air temperature of approximately 25°C for an extended period of time; in this case approximately 4 weeks. The daily amount of electrical energy that is used to heat the building is measured and then used to determine the heat input in Watts (W). By plotting the daily energy demand (W) against the daily mean temperature difference between inside and outside (ΔT) the heat loss coefficient (HLC) may then be determined (W/K).

Two dwellings that form part of the recently completed Passivhaus Racecourse development at Hutton Rise, Houghton-le-Spring, Sunderland have just recently undergone a coheating test. The results of the coheating tests (see Figures 1 and 2) have demonstrated a very high level of correlation between the as-designed performance and the as-built performance. Fig. 1 illustrates the results from regression analysis and serves to demonstrate "that the measured and predicted heat loss coefficient for dwelling 1 are in very close agreement with one another (46.7W/K as opposed to the design of 43.4W/K), with the difference in heat loss coefficient being well within the range of the measurement error associated with the test" (Johnston, 2012a). Fig. 2 compares Racecourse dwellings 1 and 2 (far right) with 22 dwellings from the Leeds Metropolitan University coheating database. It can be observed that the performance gap between predicted and measured performance has been closed significantly.

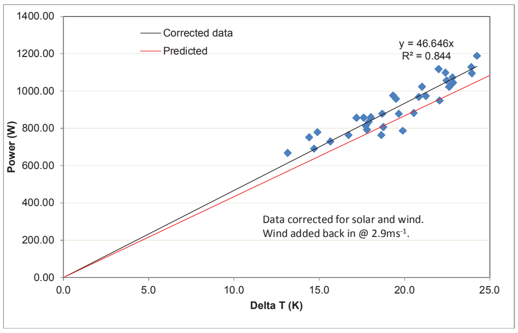

Fig 1: Solar and wind corrected heat loss data for dwelling 1

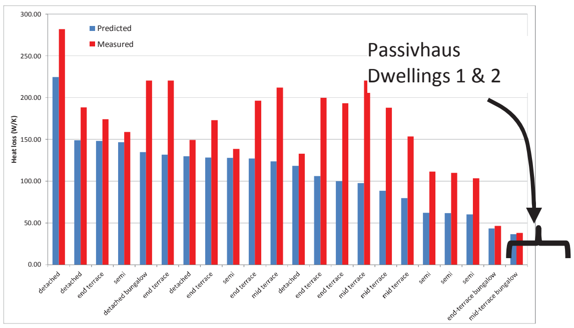

Fig 2: Measured versus predicted heat loss coefficients for 22 dwellings from the Leeds Met database

Coheating Tests : Contextualised

From this very limited study at the Racecourse, it would appear that, with an adequate understanding and appreciation of thermal bypass mechanisms, and diligent accounting of the conductive and radiative heat losses that are addressed by PHPP, it is possible to deliver building envelopes that perform as predicted. The author is conscious that the positive results at Racecourse could be viewed as good fortune, rather a result of careful planning. In essence, this raises the question whether similar results can be achieved in diverse geographic locations with different clients, designers and construction teams.

To begin to address this question, it is necessary to draw upon coheating tests that have been undertaken on other Passivhaus dwellings. It should be noted that these coheating test methodologies were undertaken by other parties and that the coheating methodologies have not yet been normalised, which could lead to uncertainty with regard to both the results and their interpretation. These matters notwithstanding, the author has complied data from coheating tests from other Passivhaus dwellings. Table 1 presents these results. Unfortunately treated floor area and form factor data were not available at the time of writing, and as a consequence it has not been possible to present, or analyse, the data as a heat loss parameter.

	Predicted (W/K)	Measured (W/K)	Error compared to target (W/K)	Dwelling Type
Racecourse Dwelling 1 (Johnston, 2012a)	43.4	46.7	+3.3 (+7.6%)	Terrace
Racecourse Dwelling 2 (Johnston, 2012a)	36.6	38.1	+1.5 (+4.0%)	Terrace
Larch House (Tweed, 2011)	57.6	60 +/- 14	2.4 (+4.1%)	Detached
Lime House (Tweed, 2011)	37.2	41 +/- 8	3.8 (+10.2%)	Detached
Ford Close (Warm, 2012)	45.6	50.4	4.8 (+10.5%)	Terrace
Ranulf Road (Stamp, 2011)	63.6	35 +/- 15	-28.6 (-55%)	Terrace

Table 1: Coheating Test results for Passivhaus dwellings in the UK

The results from the Ranulf Road case study suggest that heat losses are half of those predicted; it is understood that the test results were compromised by high levels of solar gain and insufficient temperature difference (between inside and outside) being maintained for the duration of the test. For this reason, the results of that study are considered to be an outlier and should be excluded from the analysis.

Whilst the availability of coheating data is currently limited, and due to lack of normalisation the comparability of the results questionable, a certain amount of confidence can be found within the studies presented. Should it be a concern that the heat loss is between 3.3% and 10.5% greater than expected? To answer this question a little context is required. The measured mean increase in heat loss from the Passivhaus dwellings is 3.16W/K. In contrast, the highest measured heat loss from any new-build dwelling contained within the Leeds Metropolitan University coheating test dataset was found to be some 282W/K against a predicted total heat loss of 225W/K (see left hand side of fig 2). Putting aside issues of form factor for a moment (which can influence the as-built whole house heat loss coefficient), it can be recognised that 3.16W/K is approximately 1% of the heat loss from the UK Building Regulations Part L 2006 compliant dwelling. In this context, it is contended that such minor errors may be considered trivial.

Conclusions: Does the Passivhaus Standard guarantee performance?

The UK Passivhaus projects that have undergone coheating tests have all considered the risks imposed by thermal bypass and have developed their design and construction processes accordingly. In this respect it cannot simply be stated that the Passivhaus Standard, as it stands, will guarantee performance. It can be concluded however, that Passivhaus Standards of quality assurance appear to work well when complimented by an appreciation of the potential impact of convective thermal bypass. Coheating is a useful means of deriving the measured value of the whole house heat loss (fabric and ventilation losses heat losses), though careful interpretation of the results is required in order to derive useful comparisons between dwellings and test conditions. A normalised method for undertaking coheating tests and analysing the results of such tests would be beneficial as this would aid comparability and reduce methodological differences, thus increasing certainty with regard to both measured results and analysis of data.