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Kintsugi: Repairing Gaps Within the Victorian Home, An Integration of Aesthetics and Performance

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Abstract: In a world captivated by novelty and efficiency, repairs in built heritage are reactive, functional acts rather than opportunities for architectural expression. Philosophies such as kintsugi and wabi-sabi reveal the beauty of imperfection and visible mending, offering a counterpoint: repairs as gestures that respect, rather than overwrite, character while improving function. This dissertation explores how such principles might inform retrofitting Victorian timber sash windows, where inconspicuous draughtproofing interventions address both performance and aesthetics. Through experimental airtightness testing (fan pressurisation and tracer gas method) combined with participant-based aesthetic evaluation, six commercially available draughtproofing systems were analysed for their capacity to unite technical and visual considerations. Results show E-profile draughtproofing can significantly reduce air leakage while preserving aesthetic acceptance across diverse sensibilities. The findings suggest that repair can be reframed as visible, thoughtful continuation—an act of architectural storytelling that integrates technical enhancement with the celebratory preservation of time, care, and imperfection.
Keywords: Kintsugi, timber sash window, draughtproofing, aesthetics, repair

1. Introduction

Figure 1.1 Test window and kintsugi

Sir George Gilbert Scott (1857) noted, the window embodies the challenge of reconciling light, air, and view with protection, privacy, and architectural character. Today, this challenge extends to energy and climate performance: buildings account for 30–40% of global energy consumption, with the UK's historic housing stock—21% of homes over 100 years old—posing significant barriers to NetZero targets. Since over 85% of existing dwellings will remain occupied for the next fifty years, retrofitting offers critical potential to reduce emissions while preserving embodied energy and heritage value. Within this, small gaps and cracks, often dismissed as minor, play a crucial role: air leakage accounts for up to 15% of housing energy demand, and targeted draughtproofing can cut heat loss by up to 50%. Yet such interventions are typically conceived as invisible, temporary, and purely functional, undermining their architectural potential.

Traditions such as kintsugi and wabi-sabi suggest an alternative approach: repair not as erasure, but as a visible act of continuity, embedding traces of time and care into material form. Victorian sash windows illustrate this tension acutely: elegant and symbolically rich, yet notoriously leaky, they contribute disproportionately to household energy loss. While replacement is often advised, it conflicts with conservation values, making draughtproofing the more sensitive option. However, current products are visually suppressive and lack permanence, contradicting the expressive qualities and ideals of historic architecture. This dissertation examines how draughtproofing interventions can integrate performance and aesthetics, reframing repair as both functional and beautiful. Using experimental airtightness testing and participant-based aesthetic evaluation, six commercially available systems are analysed for their ability to balance technical enhancement with cultural resonance. The research argues that repair, when conceived as visible and intentional, can deliver both energy efficiency and aesthetic enrichment, offering a model of conservation that is not only functional but celebratory.

2. Literature Review

The retrofit of historic windows has been the subject of extensive technical and conservation debate. English Heritage and the Society for the Protection of Ancient Buildings (SPAB) have consistently emphasised the importance of retaining original fabric, advocating repair over replacement wherever possible (Morris, 1877). English Heritage have quantified the thermal performance of sash windows, showing that gaps between sashes, beads, and meeting rails are significant contributors to infiltration losses, with reductions of up to 80% achievable through targeted draughtproofing (Wood et al., 2009). Another study indicates draughtproofing can reduce air leakage by 33% to 50% (Galbraith and McLean, 1990). There lacked transparency toward the location of sealant applied only stating the intervention was “applied to the frame after care preparation” (Wood et al., 2009), which may prove to be vague for the typical homeowner attempting to draughtproof their home.

Parallel to technical literature, cultural and aesthetic perspectives highlight opportunities for more expressive repair strategies. Townsend and Clarke (1998) explored the repair of timber windows, emphasising authenticity, aligning with Japanese aesthetics such as *wabi-sabi* and *kintsugi* which frame imperfection, repair, and age as qualities that enhance rather than diminish value (Keron, 1994). These philosophies have rarely been applied in Western conservation, where invisibility has long been a guiding principle.

Recent interdisciplinary research has called for a reframing of conservation practices to acknowledge both performance and meaning. Climate adaptation demands more integrated approaches to energy retrofit and heritage protection. However, the aesthetic dimension of retrofit remains underexplored. This study responds to this gap by positioning draughtproofing not only as a technical intervention but also as an aesthetic act that can strengthen the cultural resonance of historic homes.

3. Methodology

Figure 3.1 Experimental setup and six draughtproofing interventions

The research employed both quantitative and qualitative methods to assess the effectiveness and reception of six types of draughtproofing interventions. The test subject was a 19th-century single-hung Victorian sash window located within a controlled test cell. Its construction featured traditional details including horns, parting beads, and a meeting-rail rabbet. The selected interventions represented a range of material types and aesthetic qualities: foam strip, brush seal, V-seal, E-profile rubber, secondary glazing film, and spring bronze.

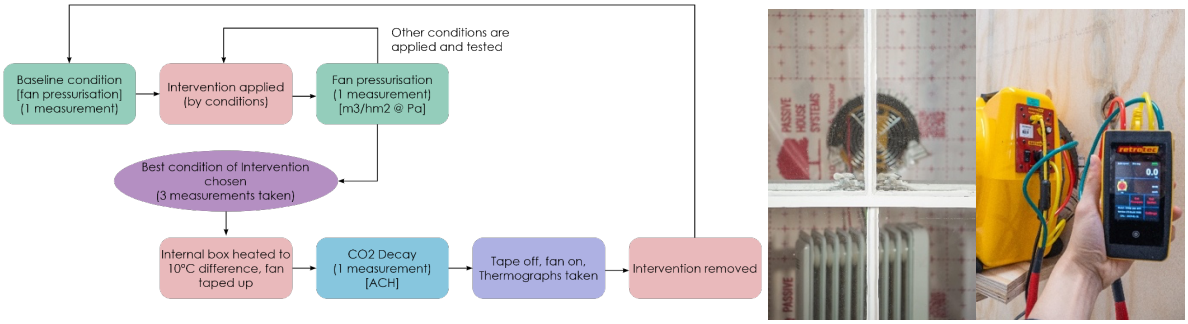

Figure 3.2 Research design flowchart and experimental setup

The sash window was mounted within a purpose-built airtight test box, constructed to isolate the frame from external leakage paths. The box ensured that measured airflow could be attributed solely to the window and its interventions, providing controlled conditions for repeatable performance testing. Air leakage performance was measured using fan pressurisation testing at a standard reference pressure of 50 Pa, providing leakage rates in $m^3/h \cdot m^2$. These tests were complemented by CO_2-decay experiments, which approximated the window's air change rate (ACH) under passive conditions. This dual approach ensured that both systematic and passive leakage behaviours could be observed. Each intervention was tested independently, and the E-profile, as the best-performing solution, was also tested as part of a combined whole-window seal.

Parallel to the technical assessments, a design survey was conducted with 100 participants. The survey (n=100) evaluated each intervention along three axes—aesthetic

receptiveness, historical sensitivity, and pragmatic acceptability—using five-point Likert scales supported by open-ended comments. Principal Component Analysis (PCA) was applied to reduce the dataset and identify latent factors shaping participant responses. K-means clustering of PCA scores segmented participants into three groups: Historians, who prioritised fidelity; Realists, who sought pragmatic balance; and Expressionists, who embraced visible repair. This structure revealed how technical interventions were interpreted through diverse cultural and aesthetic values.

4. Results and Evaluation

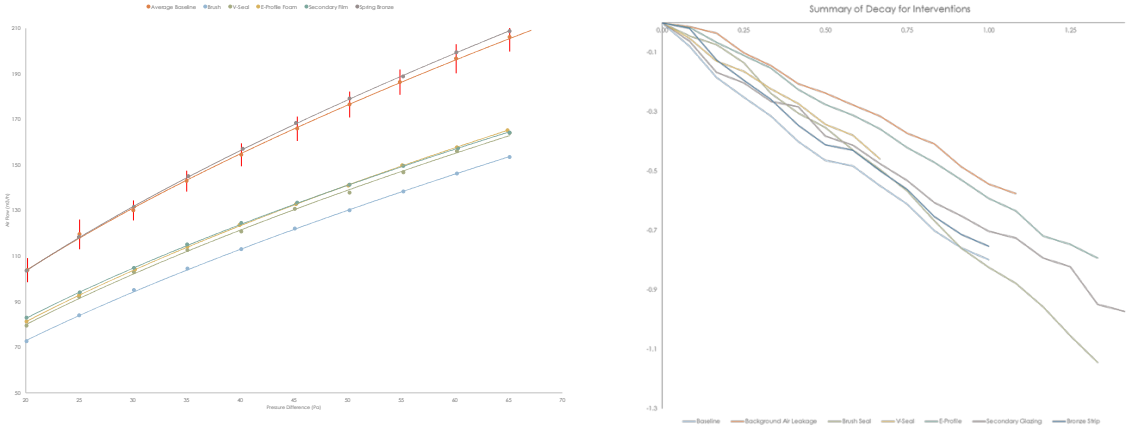

Figure 4.1 Summary of air permeability (left) carbon dioxide decay (right) for all interventions

Table 4.1 Summary of air leakage percentage reduction, inclusive of background air leakage

	q_{50} $[m^3/hm^2 \ @ \ 50 \ Pa]$	*Pressurisation* ↓	ACH $[h^{-1}]$	*CO2 Decay* ↓	*Average* ↓	*Efficacy Ranking*
Foam	10.84 ± 0.12	26%	0.510	12%	19%	4^{th}
Brush	11.94 ± 0.24	26%	0.610	22%	24%	1^{st}
V-Seal	12.74 ± 0.43	16%	0.622	15%	15.5%	5^{th}
E-Profile	12.95 ± 0.10	20%	0.670	21%	20.5%	2^{nd}
Secondary Film	12.94 ± 0.14	20%	0.667	15%	17.5%	3^{rd}
Spring Bronze	16.38 ± 0.14	2%	0.739	6%	4%	6^{th}

Results from the fan pressurisation tests indicated that all interventions provided measurable reductions in air leakage, though performance varied. The brush seal achieved the highest reduction in isolation, lowering leakage by 26%, followed by E-profile rubber at 20.5%, foam at 19%, secondary film at 17.5%, and V-seal at 15%. Spring bronze underperformed in this context, offering only a 4% reduction. CO_2-decay tests confirmed the overall ranking, and in combined application, the E-profile achieved a 43% reduction, underscoring its integrative effectiveness. When compared to figures from English Heritage—where up to 86% reductions are reported—the results underscore the variability of performance based on specific window geometries and sealing quality.

Table 4.2 Summary of aesthetic rankings across different participant characteristics

	Overall	*Historians*	*Realists*	*Expressionists*
Foam	5	5	4	5
Brush	4	4	5	4
E-Profile	2	1	3	2
V-seal	3	2	2	3

Secondary film	6	6	6	6
Spring bronze	1	3	1	1

In terms of visual preference, spring bronze was rated highest overall in aesthetic appeal, followed by the E-profile and then the V-seal. Foam and secondary film ranked lowest, largely due to their temporary appearance and lower-quality finish. Despite bronze's visual strength, its sealing performance was too weak to justify primary use without modification. Importantly, E-profile rubber was the only intervention that ranked in the top two for all three user clusters. For Historians, who prioritised historic fidelity, the E-profile's subtlety and compatibility were acceptable. For Realists, its performance and unobtrusiveness made it the practical choice. Expressionists valued the visibility of repair as a poetic intervention, especially when framed through kintsugi ideals.

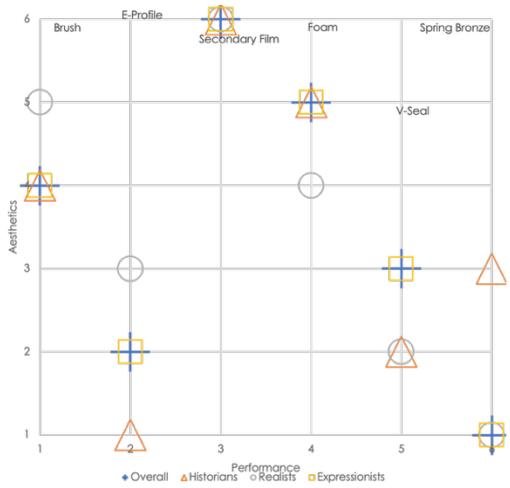

Figure 4.2 Plot of physical performance vs aesthetics of draughtproofing intervention for varied aesthetic principal clusters

When plotted on a matrix comparing aesthetic preference to performance, E-profile emerged as the best-balanced option. Participants consistently remarked on its clean finish and seamless fit, describing it as "purposeful," "caring," and "honest." Interestingly, some users reported that visible seals, when crafted with care, enhanced the perception of authenticity rather than diminishing it. This finding challenges the conservation orthodoxy that concealment equates to sensitivity and suggests a new paradigm in which visibility and narrative become conservation assets.

5. Discussion – Intersection between Physical and Aesthetic Performance

The study reveals that retrofit performance cannot be judged solely by numerical airtightness gains or by aesthetic preference in isolation. Instead, value emerges at the intersection of technical efficacy and cultural resonance. The E-profile exemplifies this balance: while not the highest-performing intervention, it consistently ranked among the most visually acceptable across user clusters, delivering sufficient leakage reduction without disrupting the historic fabric. Its success demonstrates that modest but well-integrated improvements can have greater long-term impact than technically superior yet visually intrusive solutions.

Crucially, the survey results challenge the conservation orthodoxy that invisibility equates to sensitivity. Respondents frequently described visible, crafted seals as signs of care, authenticity, and continuity. Here, aesthetics is not a concession but a catalyst: visibility

becomes a communicative act, reframing retrofit as narrative rather than erasure. This reframing, rooted in the metaphor of kintsugi, positions repair as both technical intervention and cultural enrichment—closing physical gaps while opening interpretive ones.

6. Conclusion

Figure 6.1 Final readings of kintsugi in the built environment

This research reframed the everyday act of draughtproofing a Victorian sash window as an architectural expression of care and continuity. Among the six tested interventions, the E-profile emerged as the most balanced, reducing systematic air leakage by 20.5% (43% in isolation) while achieving strong aesthetic acceptance across participant groups. By contrast, brush seals delivered the highest airtightness (24%) but lacked visual appeal, while spring bronze embodied the ethos of visible repair yet failed to reduce draught effectively. Comparisons with English Heritage findings highlighted how performance varies not by product alone but by the singular conditions of each window—its material, age, and context—underscoring the necessity of intimate, detail-driven retrofit practices.

Beyond numbers, the study shows that repair in heritage is never purely technical. Survey responses affirmed that visible, well-crafted interventions can enhance authenticity, transforming repairs into acts of storytelling rather than compromise. This research argues for a conservation ethos that welcomes traces of time and repair as inscriptions of resilience and care. In a culture often enamoured with novelty, such an approach revalidates fragility and endurance as architectural virtues. Victorian homes, marked by centuries of use, need not conceal their scars; when repaired with thoughtfulness, their gaps become not flaws to erase but legible expressions of love and reverence for the imperfect beauty of the built world.

7. References

GALBRAITH, G. H. & MCLEAN, R. C. 1990. Interstitial Condensation and the Vapour Permeability of Building Materials. *Energy and Buildings,* 14**,** 193-196.

KERON, L. 1994. *Wabi-Sabi for Artists, Designers, Poets & Philosophers,* Berkeley, California, Stone Bridge Press.

MORRIS, W. 1877. *The SPAB Manifesto* [Online]. SPAB. Available: https://www.spab.org.uk/about-us/spab-manifesto [Accessed 9 January 2025].

PALMER, J., BOARDMAN, B., BOTTRILL, C., DARBY, S., HINNELLS, M., KILLIP, G., LAYBERRY, R. & LOVELL, H. 2006. Reducing the environmental impact of housing: Final report. Environmental Change Institute, University of Oxford.

SCOTT, G. G. 1857. *Remarks on secular & domestic architecture, present & future,* London, J. Murray.

TOWNSEND, A. & CLARKE, M. 1998. Repair of Wood Windows. *In:* SPAB (ed.) *Technical Pamphlet 13.* London.

WOOD, C., BORDASS, B. & BAKER, P. 2009. Research into the Thermal Performance of Traditional Windows: Timber Sash Windows. English Heritage.