Institution: Edinburgh Napier University

Unit of Assessment: 14 Civil & Construction Engineering

Title of case study: Development of thin membrane isolators for attached housing enhancing building performance, wellbeing of occupants, resource efficiency and reducing costs.

1. Summary of the impact

Edinburgh Napier University was the first to develop thin membrane vibration isolators (2005) to allow party walls in new attached homes to be built off raft foundations. This led to the first Proof of Concept for the construction industry (2008) for perimeter isolators for blockwork apartments. Several patents have been granted leading to nine products manufactured by Icopal-Monarfloor, based in Manchester (UK), part of the Icopal global group. Over 15,000 homes have been built using these innovative isolators, delivering cost savings to the industry of over £80 million resulting in economic, environmental and quality of life benefits.

2. Underpinning research

A limiting factor for sound insulation performance of cavity party walls in attached housing is when party wall leafs are bridged by rigid junctions such as continuous floor slabs, e.g. raft foundations. This bridging of acoustic and vibration transmission is known as flanking transmission and reduces insulation performance and quality of life for occupants. Future increased use of brownfield sites would require greater use of raft foundations. In 2003 new Part E sound insulation building standards for England and Wales were the first regulations globally to incorporate ISO 717 low frequency spectrum (Ctr) for party walls. This placed significant emphasis on lower sound frequencies, and would not permit cavity walls to be built off continuous slabs due to flanking sound and vibration transmission. If no practical solution was found industry build costs were set to increase by a minimum of 18%.

In 2004 *Smith* and *Wood,* both based at Edinburgh Napier University, started to investigate possible solutions and several house builders offered test sites. ***Smith's*** research on sound and vibration transmission in complex structures [1,2,3] had identified limitations of the existing constructions and influence of the ISO spectrum terms (Ctr) for wall and floor systems. *Wood,* a specialist in architectural technology, had previously developed construction methodologies which led to the Robust Detail Handbook for Part E [2]. In 2005 following a research of material properties *Smith* identified unique vibration and acoustic damping properties of bitumen compound thin layers (3mm thick) which would reduce acoustic bridging and flanking transmission. In 2005 *Smith* and *Wood* researched and designed a novel thin membrane system which could be inserted within existing house designs and not affect the storey heights. In 2005 the research led to a partnership with Icopal-Monarfloor to develop a patent application [4] for acoustic thin membranes for separating walls on raft foundations called Bridgestop©. Theoretical and parametric studies were also carried out for complex cellular blocks as found across European construction types.

During 2007-08 *Smith* and *Wood* also developed new Section 5:Noise design details and performance criteria for the Scottish Government. These findings led to advancing acoustic thin membrane research into multi-storey applications. In 2007-08 the team secured the first ever "proof of concept" funding for construction from Scottish Enterprise (Project TTAIBA) to extend perimeter isolator research into apartments, termed Wallcap. This led to a KTP project (2008-11) with Icopal involving extensive laboratory testing in prototype housing systems and field tests on sites across the UK. Thermal analysis was included [5], as the membranes could reduce cavity convected heat loss and improve airtightness within party walls. Research included applications to timber and steel frame buildings with patent granted in 2012 [6].

Increasing building standards can lead to compatibility clashes between the Structure, Energy, Environment and Sound Insulation regulations. Due to the Napier team knowledge base in addressing such regulatory clashes they were awarded 3 years funding (£465,000) from the

Scottish Funding Council SPIRIT Awards to support demand led research towards technical compatibility solutions for the future low carbon housing construction sector.

3. References to the research

1. R.S. Smith. Implications of Part E Building Regulation proposals for England and Wales. Submitted to the Building Standards Advisory Committee (BSAC), Dept of Environment, Transport and Regions. May**, 2001.**
2. R.S. Smith, J.B. Wood, R.G. Mackenzie and R.K. Mackenzie. "*The Building Regulations 2000 – amendment of the building regulations to allow robust standard details to be used as an alternative to pre-completion testing".* Public Consultation Document. Office of the Deputy Prime Minister. August, **2003**.
3. R.S. Smith, R.K.T. Mackenzie and T. Waters-Fuller. *The implications of ISO 717 Spectrum adaptation terms for residential dwellings.* Proceedings of the Institute of Acoustics, Vol. 29 (1). 34 - 37. ISSN 0308-437X, **2004**.
4. R.S. Smith, J.B. Wood, P. Flynn, D. Parrett and D Bignell. ICOPAL Ltd. (GB) British. *Acoustic Isolator for a Party Wall. (Patent application **2005**, Stage A published **2006**,* Granted **2009**, Patent Published: No. GB 2429719 – product name Bridgestop)
5. R.K.T. Mackenzie, L. Nichols, R.S. Smith, E. Prokofieva. Field-testing sound insulation results and thermographic analysis of dual purpose party wall cavity seal and flanking transmission isolator. Internoise 2010, Lisbon, Portugal. **2010**.
6. R.S. Smith and J.B. Wood Granted Patent Published**:** No. GB 2462037. *Acoustic isolator for building connections*, 22 pages. (licensed to Icopal-Monarfloor, product name WallCap). Publication of notice in the Patents and Designs Journal, Section 25(1): 15 August **2012.**

Key research grants:
2002-04: RSD Project: Investigation into the development of Robust Standard Details. Home Builders Federation (£500,000). [*This project identified the original issue of raft foundations and sound transmission*]. R.K. Mackenzie, R.S. Smith, J.B. Wood and R.G. Mackenzie.
2005: Investigation into thin acoustic membrane for raft foundations: funded by Edinburgh Napier University (£20,000). J.B. Wood and R.S. Smith.
2007-08: Project TTAIBA: Proof of Concept for thin acoustic membrane technologies, Scottish Enterprise, (£141,000), Proof of Concept Award, March 2008. R.S. Smith and J.B. Wood.
2008-11: Knowledge Transfer Partnership (KTP) Icopal-Monarfloor and Edinburgh Napier University (£193,000 of which £73,000 from TSB and £120,000 from Icopal). R.S. Smith, E. Prokofieva and J.B. Wood.
2010-2013: SPIRIT Project: Technical compatibility for future low carbon housing – for structural, energy and acoustic building standards. Scottish Funding Council (£465,000). R.S. Smith, J.B. Wood, J. Currie and R.H. Hairstans.

4. Details of the impact

Introduction: Icopal were chosen as industry partner due to their global lead in geo-membranes and crucially the UK Manchester plant could manufacture the alumite-bitumen compounds required for the thin membrane technology. This impact case study outlines the substantial benefits to the company, industry sector, environment and home occupants quality of life as a result of this original research. The Napier team also developed animations to assist installation training for both Bridestop© and Wallcap series of products which can be viewed via reference [5.1].

Impact period 2008-2013: In 2008 brownfield sites accounted for over 70% of new housing sites and raft foundations were increasingly common. In 2008 the Napier team assisted Icopal-Monarfloor to commence application for Robust Detail status for Bridgestop©. This would allow entry into the Robust Detail Handbook, which is used by over 8,000 specifiers and designers across the new build housing sector. Bridgestop© achieved on site field trials with an average sound insulation performance of 10 dB (decibels) better than building standards, providing the highest levels of sound insulation for new housing. The Bridgestop© isolator system for raft

foundations was awarded Robust Detail status and published in October 2008 (reference E-WM-19) [5.2]. The sustainable construction benefits [5.2] which when applied over the 15,000 homes built during the REF impact period has avoided using 1,080 tonnes of additional gypsum lining (72 kg per attached home) to achieve the equivalent sound insulation performance. Thus also delivering resource efficiencies in materials, transport and carbon. In 2010 Bridgestop© was the first wall structure to receive the maximum four credits under the Code for Sustainable Homes under Health and Wellbeing for sound insulation [5.3]. Many supply chain partners benefited from the system including Wimpey Homes and Roger Bullivant Ltd [5.2, 5.3]. In 2010 Bridgestop© was shortlisted by industry peers for UK Housing Innovation Product of the Year [5.4].

The extension of thin membranes to apartment upper wall-floor junctions (termed Wallcap) was supported by the first ever Scottish Enterprise Proof of Concept Award for construction sector in March 2008 – illustrated by reference code 8-CON-001. Wallcap was licensed to Icopal-Monarfloor in 2009 and was shortlisted for UK Housing Innovation Product of the Year in 2012 [5.5]. Wallcap also complies with the 'effective edge seal' requirements for the Part L thermal regulations to tackle cavity thermal bypass [5.6] which can reduce heat loss by 20% in attached housing. The Napier design of the isolators was such that the Manchester production line produces zero waste. The cavity wall base is also lined with an acoustic isolator involving recycled foam to prevent any mortar drops bridging the cavity party walls. Due to the resilience of the alumite-bitumen compound within the Bridgestop© dpc material it can also act as a methane and radon barrier and also protect such barriers which may be placed below the Bridgestop preventing them being damaged or torn [5.7]. This benefits home occupants and benefits the intended full life cycle of the construction.

Enhancement of Icopal's existing thin membrane patented technology was strengthened as a result of the work with Edinburgh Napier [5.8]. These products are now used by aggregate block, aircrete, timber frame and steel frame industry sectors. The KTP project with Icopal-Monarfloor delivered more than three times the estimated turnover and led to over 50% of company profits stemming from these Napier designed products. In May 2013 the KTP was classified by the Technology Strategy Board as "outstanding" and nominated for national KTP awards 2013. [5.9]

Icopal-Monarfloor (UK) is working with the Icopal global group to develop similar isolator solutions for wider international markets. 9 new products have emerged from the Napier research with a further 4 planned for launch in 2014. New industry supply chain partnerships and joint ventures between Icopal-Monarfloor and other companies have since been formed including UK and other multinational companies (e.g. Knauf).

The research team have presented their findings to over 200 companies at industry seminars and exhibited at Ecobuild, Futurebuild and the Edinburgh Science Festival. Finally one of the most powerful statements of the benefits from the original research is provided from the company: *"The average cost saving on substructure costs, by using Bridgestop and not having to undertake expensive alternative build systems is 18%. This has since been used in over 15,000 homes across the UK saving £80 million in build costs by not having to build alternative constructions involving deeper foundations, secondary suspended floors or additional gypsum linings which has also resulted in substantial sustainability benefits*." Lee Nichols, Product Development Manager, Icopal Monarfloor.

5. Sources to corroborate the impact

[5.1] Icopal website showing Bridgestop and Wallcap products and product animations designed and developed by Napier team.
http://www.monarfloor.co.uk/products/second-generation/bridgestop.aspx
[5.2] The Bridgestop © isolator system for raft foundations was awarded Robust Detail status and in October 2008 (Robust Detail reference E-WM-19)
http://www.monarfloor.co.uk/Press-Centre/News-Archives/News-Archive-2008/ICOPALS%20MONARFLOOR%20BRIDGESTOP%20WINS%20A%20ROBUST%20DETAIL.

aspx
[5.3] Bridestop is ranked for the highest level of sound insulation under Code for Sustainable Homes and is awarded maximum 4 credits and benefits to Roger Bullivant foundation systems.
http://www.architectsjournal.co.uk/specification/product-anatomy/icopals-bridgestop-is-first-to-four-credits/5216355.article
[5.4] Bridgestop shortlisted by industry peers for UK Housing Innovation Product of the Year in 2010
http://www.house-builder.co.uk/awards/?awards_id=21
[5.5] Wallcap shortlisted by industry peers for UK Housing Innovation Product of the Year in 2012
http://www.house-builder.co.uk/awards/?awards_id=23
[5.6] Thermal benefits of Wallcap and Part L regulations
http://www.monarfloor.co.uk/Press-Centre/News-Archives/News-Archive-2009/Napier%20Innovation%20Improves%20Sound%20and%20Thermal%20Insulation%20in%20Homes.aspx
[5.7] Benefits of application of system to protect radon barriers and gas protection barriers by use of the bridgestop system preventing tearing
http://www.monarfloor.co.uk/Press-Centre/News-Archives/News-Archive-2009/ICOPAL%20SYSTEM%20MORE%20THAN%20PAYS%20FOR%20ITSELF%20IN%20CUTTING%20ACOUSTIC%20COSTS.aspx
[5.8] Strengthening of Icopal group's existing product patent portfolio (Last Paragraph)
http://www.monarfloor.co.uk/Press-Centre/News-Archives/News-Archive-2009/Napier%20Innovation%20Improves%20Sound%20and%20Thermal%20Insulation%20in%20Homes.aspx
[5.9] Rating by Technology Strategy Board on the KTP partnership between Icopal and Napier developing perimeter isolators
http://www.monarfloor.co.uk/Press-Centre/News-Monarfloor/knowledge-transfer-partnership.aspx