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Skills development for retrofitting a historic listed building in Scotland

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Abstract

With the current aim for a low carbon economy in Scotland, it becomes imperative to ensure that there are adequate workforce skills available to support meeting this aspiration. As such, the Scottish Government has developed a low carbon skills agenda that emphasizes rapidly developing and delivering specialist skills that are needed to enable the adoption of new technologies. Developing and delivering specialist skills are arguably not possible without having an understanding of what these skills are. This paper thus reports on the successful trial of an innovative Canadian insulation technology in a historic listed building in Aberdeenshire with a particular emphasis on providing insights into workforce skills needs. The trial was funded by the Scottish Government and the European Regional Development Fund. An 'insulation job' worksheet is developed as a result of the project, which can aid effective project management of insulation jobs in the future. It is evident that the current skills in the industry could be made adaptable to the skills needs for insulating historic listed buildings. Multi-skilling [in particular for small–medium size enterprise (SMEs)] may become inevitable if the size of the project is small as it was the case with the project presented in this paper. Providing learning support for local SMEs, who are still building-up their capability in insulation technologies, is thus essential. Indeed knowledge sharing and dissemination of case studies for successful retrofitting (e.g. insulation) of buildings, in particular historic ones, can inform future development of 'Low Carbon Skills' policy and action.

Keywords: skills; insulation; and historic buildings

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1 INTRODUCTION

Retrofitting buildings, particularly through the adoption of a fabric-first approach, is paramount for enhancing their energy performance and thereby minimizing the likelihood of fuel poverty.[1] The Scottish Government has thus recently launched the National Retrofit Programme (NRP) for enhancing energy efficiency in buildings. The NRP is also aimed at supporting the delivery of low carbon buildings and tackling fuel poverty [1]. Successful retrofitting of buildings requires the development, testing and demonstration of innovative new building technologies and materials [2], which in-turn requires a well-trained and competent workforce. As such, the government provides substantial financial support for education and re-training in the construction industry that is geared towards supporting what is known as the 'Low Carbon Skills'[2] [3, 4]. For example, the Scottish Government has allocated the 'Low Carbon Skills' Fund (£2–3 million), which is administered by Skills Development Scotland,[3] to support skills development for achieving energy efficiency and carbon reduction in buildings.

Building insulation is a key requirement for a low carbon design and refurbishment; nonetheless, there is a perceived skills

[1]Fuel poverty refers to households who spend over 10% of their disposable income on energy bills.

[2]Low Carbon Skills is defined as 'knowledge, skills and competencies that support the design and delivery of low carbon new buildings and low carbon refurbishment projects' [11].

[3]Skills Development Scotland is a non-departmental public body that brought together the careers, skills, training and funding services of Careers Scotland, Scottish University for Industry (learn direct Scotland) and the skills functions of Scottish Enterprise and Highlands & Islands Enterprise.

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Figure 1. *The Bogendollo House.*

gap and lack of training in insulation technologies, and in-particular for 'harder-to-treat properties' [5, 6]. Historic buildings could be regarded as hard-to-treat properties because of the requirement to preserve and restore its original features. The Scottish Government has thus recently invested a £3 million towards a National Conservation Centre based at two locations in Stirling, in a partnership between Historic Scotland, Stirling Council and Forth Valley College.[4] Investment in the centre was in response to the strategy for Traditional Building Skills, published by Historic Scotland in 2011, which reported that 'tradespeople have gaps in the knowledge and skills they need to repair and maintain traditionally constructed buildings with the current qualifications framework in Scotland often does not offer options for traditional skills'.

The remit of the new centre is to develop and sustain traditional building skills. It is important, however, to ensure that trainees not only learn how to carry-out restoration work successfully but also learn to make buildings energy efficient (thereby reducing its carbon footprint) without altering its original historic features. The existing stock of historic buildings is non-homogenous, and each building type presents its unique challenges as typified by its location, historic features, neighbouring structures, etc. There are a number of case studies available on Historic Scotland's website, which focuses on the 19th and 20th century tenements in Edinburgh and Glasgow. Nonetheless, there is still a lot of work that needs to be done in order to develop solutions for the energy refurbishment of historic buildings as acknowledged by Historic Scotland.[5]

Dissemination of case studies can thus help to inform the retrofitting of historic buildings in the future. This paper reports on the successful trial of insulating a part of a historic listed building in Aberdeenshire with a particular focus on the insulation process management and workforce skills needs assessment. The trial, which was co-funded by the Scottish Government and the European Regional Development Fund, generated a lot of interest in the local press[6] as it was the first time to use this insulation technology in a Scottish listed building without interfering with its historic features.

2 AN OVERVIEW OF THE PROJECT

2.1 Building description

The Bogendollo House, Historic Scotland Building ID: 51386, is located in Fettercairn (Aberdeenshire) and can be described as 'Probably early 19th century, rear wing probably later but before 1863, 20th century additions at W. Traditional 2-storey, 3-bay, L-plan farmhouse with original openings' and it has a narrow cavity wall[7] (Figures 1 and 2) [7].

[4]The Scottish Government, News, available at: www.scotland.gov.uk/News/Releases/2011/10/20101331.

[5]'Of the pre-1919 stock, tenements are the most numerous, especially in central Scotland, with a high proportion of them in use as social housing where pressure for energy efficiency improvement is high. Such structures are vulnerable to interventions as a result of thermal upgrading, specifically in respect of windows, but increasingly with regard to wall insulation and other changes. How this work is done and to what standard is also an emerging area of concern.' Source: www.historic-scotland.gov.uk/energyefficiencyandtraditionalbuildings.pdf

[6]'Insulation trial offers new hope for historic buildings increased energy efficiency' source: www.edinburghsciencetriangle.net

[7]It is estimated that there are 6–9 million homes in Britain requiring cavity wall insulation with an estimated 4–6 million homes being regarded as 'hard-to-fill', which include the following construction types: Narrow Cavity (as with the Bogendollo House), Random Stone, Reinforced Concrete In-Situ Frames, Timber Frames, Rainscreen cladding systems and Non-Traditional System constructions as well as Partial Fill Cavities [9].

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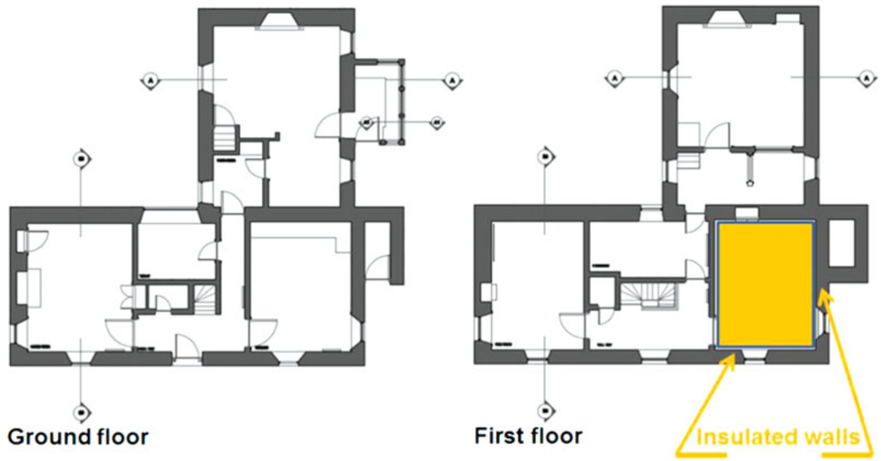

Figure 2. *Floor Plans (from left, ground and first floors). The trial was carried-out as a feasibility study; thus only two external walls in one room were insulated.*

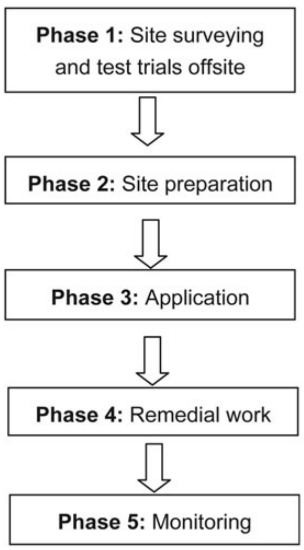

Figure 3. *An outline of the process for Cavity Wall Insulation.*

2.2 The insulation process

Figure 3 depicts the phases of the cavity wall insulation process. Site surveying enabled the formulation of a viable method for the application of the insulation material given the constraints of the building. Access to the cavity was from the loft where fibre tubes (for pouring the insulation material) were threaded at intervals as this was the only way for avoiding drilling holes in the interior wall given the historic status of the building (See Figures 4 and 5). The insulation material applied is water-based foam, which expands slowly with no harmful agents released in the process. The foam allows the wall to breathe thereby controlling moisture movement. According to the insulation contractor, the application of the insulation material from the loft was a method that they did not use before. He explained that 'This is a new process for our company. No one has tried injecting the foam in a pipe longer than 16 inches long and no one knew how it is going to perform (will the material come-out of the pipe or will it set inside it?).

Figure 4. *Wall Cavity—view from the loft before applying insulation.*

Test trials were thus carried-out offsite in order to test the material behaviour. The test was completed successfully. Then, site preparation commenced, which involved the careful removal of skirting boards and a thorough cleaning of the cavity to remove (as much as possible) all debris and dust and to ensure that there were no obstructions. The application process could be illustrated in Figure 5. Further details about the process are beyond the scope of this paper, but it is available as a podcast on the project funders' website [8].

Following the successful application of the insulation material into the cavity, the heat loss through the wall was reduced by ~50%. This unique project opens the door for historic buildings to finally retain warmth, reduce their energy consumption and carbon footprint. The house owner stated that 'I just can't imagine the difference between the other rooms of the house and the one which was insulated'.

3 INSULATION PROCESS MANAGEMENT

In order to support the effective management of the aforementioned process (outlined in Figure 3), in particular the 'Application' phase of the insulation material, the authors proposed formalizing the management process in the future (in

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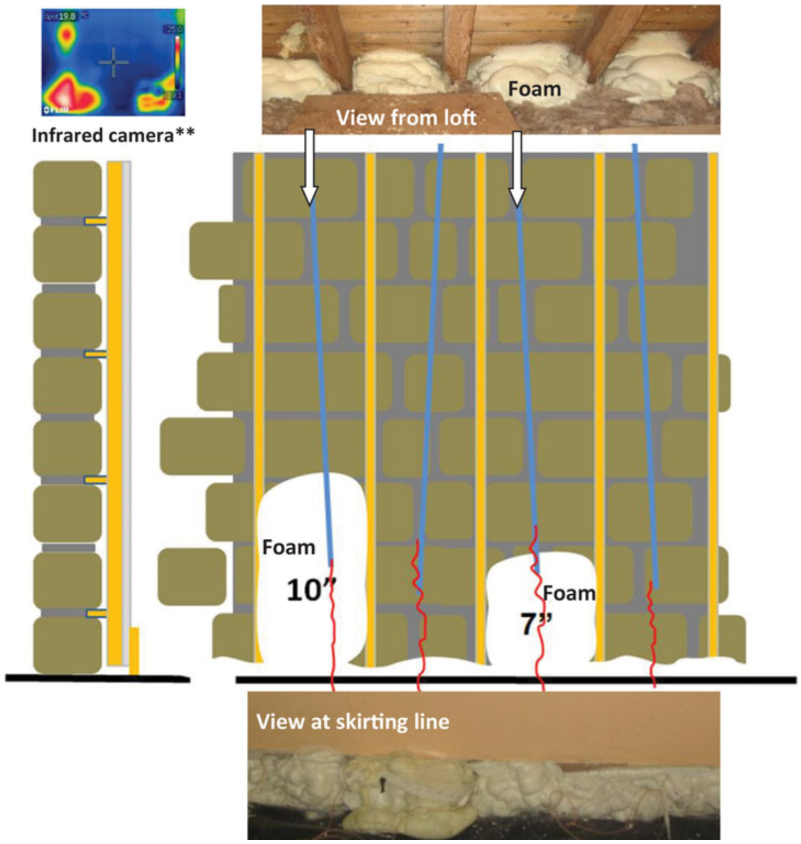

Figure 5. *Foam pouring* into the cavity wall. *The foam was injected at different intervals, and the fibre tubes were inserted in each bay to allow the expansion to take place while moving to another bay between the studs. The foam was injected gradually until it reached the top of the wall where it can be visible from the attic. ** The infrared camera was used to monitor the foam expansion behind the lath plaster. At a first spray of the foam for 7 s, the foam expanded for ~400 mm up in the bay, the next step was to pull up the pipe for ~500mm and inject the foam again until the bay was completely full.*

particular for bigger jobs) through gathering the following information from the outset of the project—which could be populated in an 'insulation job' worksheet.

(1) Site location,
(2) Building surveying (*description including any historic features, planning restrictions, construction-type and cavity inspection—where applicable*),
(3) Current energy consumption (*energy bills*) and rating of the building (*Energy Performance Certificate—EPC*),
(4) Project manager name and retrofitting experience,
(5) Access route to the building and traffic control arrangements (*if applicable*),
(6) Method statement for the insulation material application (*including an estimate of material volume to be used and addressing any anticipated problems as well as initial site trials where appropriate, in addition to the required remedial work*),
(7) Risk assessment, health and safety issues,
(8) Cost/benefit analysis (*where appropriate*),
(9) Tentative work programme, in addition to assessment of resources required (e*quipment, workforce skills needs assessment—team roles and responsibilities*),
(10) Insulation job evaluation (*which can include both the performance of the applied insulation as well as the occupants or end-user experience*).

It should be noted that the above-mentioned information was developed in retrospect after the project completion through a post-project review meeting with the industrial collaborator. The information gathered in the worksheet will be dependent on the nature, size and complexity of the project. Nonetheless, the 'insulation job' worksheet is generic and transferrable to other projects. The industrial collaborator, managing director of the insulation company, has thus supported the development and use of an 'insulation job' worksheet on future projects. He commented that 'the guys would know what to expect when they go there and become more productive as well'.

The job worksheet becomes instrumental when considering the need to overcome the 'low quality of preliminary surveys' to assess scope for insulation, the lack of standards relating to quality of remedial works to walls in advance of cavity filling, and lack of recognized technical guidance in filling hard to fill cavities including guidance on the detailed design to mitigate cold-bridges [9]. Research suggests that learning from experience

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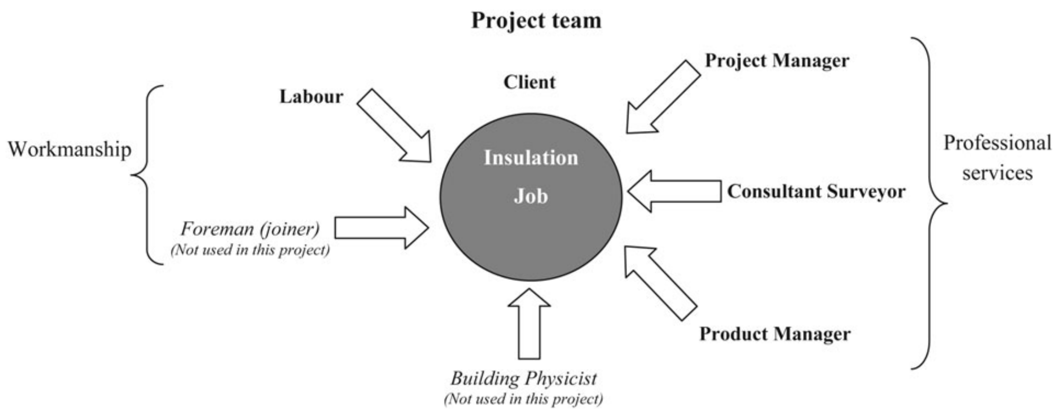

Figure 6. *Occupations for an 'insulation job'.*

through adopting a systematic approach would allow designers to gain effective feedback on their work performance in a project [10]. Companies should thus invest time and resources in order to capture knowledge and experience from previous projects to support their future performance. It has to be noted that a formal evaluation of the insulation job is currently underway as the project is currently still being monitored (phase 5) through data loggers, and but it is an area for further investigation, which is beyond the scope of this paper.

4 WORKFORCE SKILLS NEEDS ASSESSMENT

4.1 Occupations and team roles

The project presented an opportunity for providing insights into the skills needs for the application of an innovative insulation technology in a historic listed building. Workforce skills needs are defined in terms of occupations (See Figure 6 above) and their team role in the project, which is subsequently discussed, in other words 'who is involved?' and 'who is doing what?'

(1) 'Project manager' oversees the entire work in the project and undertakes initial work assessment as per the aforementioned 'insulation job worksheet'. He or she will ensure that the project activities are completed successfully, on-time and on-budget and to the required standards, over the five phases of the project outlined in Figure 3.

(2) 'Consultant surveyor' works with the project manager to undertake the initial building survey and formulate the process for applying the insulation material in collaboration with the project manager. In other words, he or she identifies what needs to be done for successful application of the insulation material, in the light of the constraints of the project, such as accessibility to the wall cavity. Moreover, he or she should carry-out a cavity inspection during the site surveying phase (phase 1).

(3) 'Product manager' would have an expertise in the technical properties of the insulation product[8] being applied. He or she will be able to provide advice on optimum performance of the product, in-line with the manufacturer's specifications, given the constraints of the project.

(4) 'Labour (or two installers who are also known as the "spraying team")'—one worker for setting-up and monitoring the production process of the insulation material (which is created on-site) and the other for spraying and monitoring the foam as it goes into the cavity. Moreover, a semi-skilled joiner carries-out preparatory and remedial work in addition to installing the data loggers for monitoring the performance of the insulation material after application. A foreman joiner, who can supervise the workers on-site, although it was not required on this job as it was a relatively small project, but may be required for bigger jobs in the future.

(5) 'Building physicist'[9] (although not used in this project) is an essential team role in order to provide an in-depth understanding of the energy performance in a building given the present form of its fabric.

The aforementioned occupations and team roles definition are only indicative as they only relate to the context of the project discussed in this paper; however, they can provide a starting point for understanding skills needs and informing future areas of training for insulation jobs. The team has to

[8]The insulation product used in this project was water-based spray foam that expands.

[9]Building engineering physics is a relatively new scientific discipline, which investigates the areas of natural science that relate to the performance of buildings and their indoor and outdoor environments. The field deals principally with the flows of energy, both natural and artificial, within and through buildings. The understanding and application of building engineering physics permits the design and construction of high performance buildings; that is buildings, which are comfortable and functional, yet use natural resources efficiently and minimise the environmental impacts of their construction and operation. Source: www.raeng.org.uk/education/vps/pdf/Engineering_a_low_carbon_built_environment.pdf

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collaborate in order to formulate a viable method for the application of the insulation material given the project constraints. The managing director of the insulation company explained that 'The insulation job is different from a normal project as it requires different mode of working where the team has to be engaged in discussions to come-up with the most appropriate way for applying the insulation'.

Adapting the current skills in the industry is essential to meet the needs for the application of insulation technology. This is consistent with the Household Energy Efficiency Skills Review which contended that the skills requirements for insulation should comprise of: application of existing skills to new materials, installation skills and materials knowledge [6]. The 'know-how' of the insulation process, and specific project experience, could be transferrable to other projects particularly for buildings with the same type of construction. In addition to project-specific team roles, generic skills, such as communication, technology awareness, quality standards and certification, project management and leadership, access to career and training information, health and safety are essential [6]. Indeed these are generic skills required for any construction project.

4.2 Multi-skilling

The insulation contractor undertaking the work was a small–medium size enterprise (SME). SMEs tend to have an emphasis on multi-skilling where an employee tends to play more than one team role. Whilst there was not a formal foreman joiner, the surveyor and project manager had to play that role. It is also worth noting that the size of the project and complexity of the building will determine whether one individual would be required for each distinctive team role. However, multi-skilling in a range of insulation technologies is not applicable to the project discussed in this paper since the insulation material applied was product-specific and hence the skills required were related to a specific product.

Moreover, it may not be practical for a contractor to specialize in more than one insulation technology especially if they are competing in the market. Product-specific training for the technology used in this project is discussed in the next section. However, given the current UK Green Deal scheme that promotes investment in energy efficiency measures in homes (such as insulation), Energy Assessors should provide an impartial advice to their clients on the most appropriate and cost-effective technology based on their knowledge of the range of insulation technologies currently available in the market.

4.3 Training

The insulation contractor had to undertake product-specific training, which was delivered in-house at the parent company headquarter in Canada. The training involved providing an awareness of the product, its properties and examples of its application. The training developed by the company involved both classroom and on-site training. After the successful completion of the training, the local contractor in Scotland became accredited by the parent company and joined the company's global network of approved installers. The insulation company director commented that 'the training they undertake prepares them well for what they are going to expect. But they are learning all the time. We sit down and talk down through jobs that have been done and if they have issues they will raise it with us and if we don't know how to tackle it then we can bring someone from the parent company'. Notwithstanding the product-specific training, it is the responsibility of the approved installers to address the issues pertaining to the use of a foreign product in Scotland (in terms of complying with building regulations and materials standards and specifications). For example, the insulation contractor had to seek approvals from the British Board of Agrément before starting to use the product on any project in Scotland.

In addition to the product-specific training, the workforce involved in an 'insulation job' can further or advance their learning through conducting a formal training needs analysis as stipulated by the 'Low Carbon Skills knowledge or competency Area' [11]. The training needs analysis involves individuals reviewing their current role and identify whether there are gaps in their existing knowledge and work towards addressing those gaps, i.e. being a self-learner and a 'reflective practitioner' by identifying opportunities for skills development.

Training needs can include acquiring knowledge of building regulations, carrying-out energy assessments using Standard Assessment Procedure.[10]

5 CONCLUSION

This paper has provided insights into skills development needs in the light of the insulation of a part of historic listed building in Aberdeenshire using an innovative Canadian insulation product. With almost three-quarters of Scottish houses are of cavity wall construction, this project can contribute to the understanding of insulating buildings (in-particular historic ones), which have cavity wall construction. It is argued that the current skills in the construction industry could be made adaptable to the requirements for the application of insulation technologies in historic buildings.

Finally, if there will be a wide spread application of retrofitting historic buildings in Scotland, then there is a need to understand what insulation technologies could be most likely used and then what investments in skills will be required to make this achievable? An answer to this question is crucial for providing guidance to government skills policy in support of retrofitting historic buildings in Scotland. The recent introduction of the NRP by the Scottish government is a positive step but the extent

[10]'The Standard Assessment Procedure (SAP) is DECC's methodology for assessing and comparing the energy and environmental performance of dwellings. Its purpose is to provide accurate and reliable assessments of dwelling energy performances that are needed to underpin energy and environmental policy initiatives' (Source: Department of Energy and Climate Change—www.decc.gov.uk/en/content/cms/emissions/sap/sap.aspx).

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of its focus on the energy refurbishment of historic buildings is yet to be seen. Skills development and training can perhaps be a requirement on the NRP projects, and this could present an opportunity for collaboration with the newly formed National Conservation Centre to specifically build-up the construction industry capability in 'low carbon skills' for heritage buildings.

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