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Energy Conservation Improvement of the Existing Building Park, Constraints and Challenges

Case of granite traditional constructions in the United Kingdom

BENNAJDI, A., SCOTT, J. , TAYLOR, B.

Scott Sutherland School of Architecture and Built Environment, Faculty of Design and Technology
The Robert Gordon University, Aberdeen, United Kingdom

ABSTRACT: The increase in energy price has sparked a debate in the UK as to what would be the best way to address this problem. The British Prime Minister gave a straightforward and radical answer, suggesting that, existing building stock should be improved to reach a certain standard. The goal is to reduce the energy consumption to ensure a reduction in the running cost of household asset in the UK. The government initiative was to make grants available to dwellings that shows a lack of energy efficiency this includes the increase of insulation of the buildings' envelop as well as renewable energy generator and end use equipments. The CO₂ emissions per capita and the reduction of the national dependency on finite fossil fuel resources are achievable via major refurbishment programmes of both owners occupied and rented properties. Many of the easy measures have been done, leaving only the major areas that need addressing. These areas are complex and expensive therefore home owners and private landlords are deterred from addressing them. Incremental improvements are no longer cost or physically effective, however; therefore a holistic and integrated approach to buildings' refurbishment is required. "Dealing with the existing building stock will become an important topic for architects, town planners and civil engineers" [1]. The aim of this research is to present the different possible scenarios of refurbishment based on the most popular building typologies in the UK.

Keywords: CO₂ emission, energy saving, existing housing stock, thermal insulation

INTRODUCTION

In the United Kingdom, about a third of CO₂ emissions are caused by domestic buildings [2]. It is projected that 70% of the building stock in 2050 will have been constructed before 2005 [3]. This stock constitutes a huge percentage of housing that should be looked after in terms of energy efficiency improvement if the EU's CO₂ emission target is to be met. Architects and building actors have not only the mission of designing new buildings but a new challenge is facing the building industry and "refurbishment becomes the challenge for future architects" [1].

The introduction of the new energy rating scale in housing, for example, is a challenging step toward the reduction of energy use in the UK. New dwelling constructions meet the higher standards for insulation and air tightness laid down in the new Part L of the English & Welsh building regulations, which came into force in April 2006. New part J for the Scottish Technical standards came into force in May 2007. These are the UK government's responses to the EU's Energy Performance of Buildings Directive (Directive 2002/91/EC), which came into force in January 2003.

METHODOLOGY AND INVESTIGATION

Many techniques have been used to assess energy loss, including infrared thermography of individual dwellings. Some local authorities investigated the issue at a wider level using infra red satellite images to assess a locality's thermal loss (Aberdeen city council link). The outcomes can be misleading if the aerial images are taken at face value since the buildings might not be occupied at a time when the images were taken and will show no heat loss as if they are well insulated rather than not heated and vice versa when poorly insulated. These infrared aerial images need to be followed by on site social and environmental investigations, using techniques such as Post Occupancy Evaluation (POE), performance evaluation and developing methodologies, including life cycle analysis, for ascertaining the potential for passive technologies [4]. Energy Performance Certificates (EPCs) are a key requirement for Home Information Packs (HIPs), which became a compulsory requirement for all home sellers in England and Wales. HIPs must contain an index of contents, a sale statement and evidence of title, leasehold documents and an EPC. Of these, only the EPC is a new requirement for property sales. An EPC must be carried out by a trained domestic energy assessor. The government hopes that the packs

will speed up the home buying process and make individuals more aware of the environmental status of their property [5].

In the UK there is clearly, current recession notwithstanding, a large demand for new housing because it offers so many advantages over older property except convenient locations which minimise travel. The introduction of EPC's should make more explicit the disadvantages of buying an older property if, in future, rising energy costs become a significant consideration when purchasing housing. This should lead to an increase in the price differential between new and older properties to reflect the costs of bringing the latter up to current standards. Purchasers of older property are not obliged to implement any of the recommendations in the EPC report.

This paper will show the authors' approach to domestic refurbishment and will detail case studies and preliminary solutions selected from a large typology of buildings identified as the most predominant building types in the UK. The studies are achieved through three major steps: (i) identify the building typologies in the United Kingdom, then (ii) identify the buildings' weakness in term of energy loss using mainly analytical tools such as SAP and evidenced by infrared thermography and utility bills, and finally; (iii) the most complex step of suggesting solutions to improve these buildings' energy rating.

The solutions presented in this paper vary from a simple insulation increase to a masonry wall to the radical intervention in the building's structure. The aim of this research is to present the different possible scenarios of refurbishment based on the most popular building typologies in the UK. These outcomes will represent a knowledge and source of information for all building industry actors involved in tackling this major problem.

PRACTICAL INTERVENTION

Many of the easy measures such as draught stripping, double glazing and loft insulation have been done, promoted by organisations such as SCARF. This leaves only the major areas needing to be addressed but these are complex and expensive (improving insulation in solid ground floors, replacement of old roofs, etc).

There comes a point in a building's life cycle where incremental improvements are not cost effective but a holistic and integrated approach to building refurbishment and remodelling to bring buildings up to, but preferably above, current standards (e.g. thermal and electrical performance, accessibility and usability by people with disabilities) is required. This is to ensure,

more widely, that older buildings are upgraded to fit with people's aspirations and lifestyles, whilst also ensuring that buildings are more sustainable in years to come.

The energy use will involve potential energy resources where available including the study of the site and surrounding area's potential for renewable energy and internal space layout to make effective use of passive solar and daylight and accessibility. As the interventions are purely related to the building fabrics' specifications; this paper does not consider other aspects of the energy rating efficient mechanical and electrical systems.

CASE STUDIES IN ABERDEENSHIRE

Government led initiatives for environmental change, such as the drive for Low Carbon housing, has focused on new housing – unsurprisingly, this is a significant focus group, and it is easy to adopt environmental features onto these buildings. Importantly, it is recognised that if sustainable design is adopted early in the planning and development of housing projects, in a holistic manner, greater social, economic and environmental benefits can be achieved. This is not the case, obviously, when it comes to existing buildings. Where of planning, design and build already fixed, and there are severe constraints and challenges for an environmental designer to overcome these. The sitting and orientation of houses and developments play a crucial role in environmental designs.

The Aberdeen case studies exhibit this problem quite clearly, and these are described in the following sections. They are late 19th century in date, and late 18th century – existing houses of some age. Over the intervening period they have undergone significant change of use, re-modelling, adaptation and extension in many different phases.

Case Study One: Semi-detached dwelling house, suburban, 1930'S. Originally four family rooms downstairs, two upstairs home, this has undergone significant adaptation during the intervening period due to changing demographic, technology and fashion. Significant alterations have been conducted to include space additions to the roof and most recently to the rear of the building. Technologically, there has been a change to the heating and an increase in the electrical appliances within the building.

With these changes over different periods, it is anticipated that improvements to the building/additions are not consistent throughout the building. For example, the building fabric in different locations will vary and without a thorough building survey, it is unlikely that any one u-value is known or accurate. This will lead, in

practice, to 'cold spots' in many existing buildings. Likely locations for these 'cold spots' are the joints between each additions. For granite wall buildings in Aberdeen the city planning authorities rule out the use of external insulation. "On historical backgrounds, buildings conservation and maintenance, building typologies, condition surveys, structural damages, formerly used materials, life cycle costs, etc [1]."

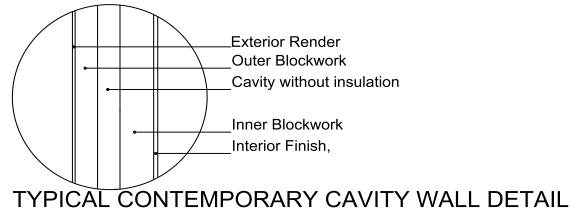


Figure 1: View of the house 1

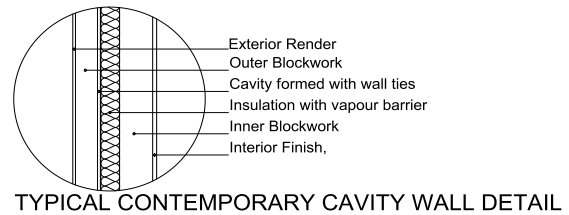


Figure 2: Plan and section of house 1

An unsuccessful attempt for insulation The owners of this dwelling were attracted by many government announcements, such as: "Grants available to many households. As part of the Government's target to tackle climate change, the importance of home energy efficiency is still top of the agenda. As such, insulation continues to play an important part in reducing greenhouse gas emissions, and because of this reason we are able to access various grants from the government and major energy suppliers towards the cost of insulating your home" (eaga insulation). They chose to apply insulation methods used for newly built houses such as masonry cavity walls (Fig. 3), or timber frames (Fig. 4) building.

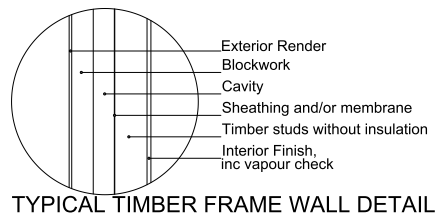


TYPICAL CONTEMPORARY CAVITY WALL DETAIL

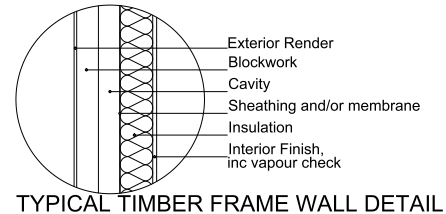


TYPICAL CONTEMPORARY CAVITY WALL DETAIL

Figure 3: Cavity wall before and after insulation



TYPICAL TIMBER FRAME WALL DETAIL



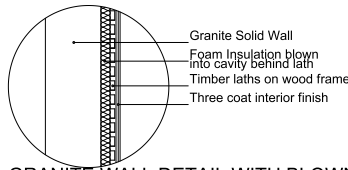
TYPICAL TIMBER FRAME WALL DETAIL

Figure 4: Timber frame wall before and after insulation

The less costly and straight forward method of pouring an insulating material into the cavity was applied. The owners were happy with the results since the house's internal thermal comfort was very satisfactory and the heating system was not 'on' for most

of the time like it was prior to completion of the walls' insulation. The level of humidity was not monitored at that time but the walls' started to show areas of dampness. Investigations revealed a condensation problem throughout the insulated walls. The only solution to remedy this problem was to industrially vacuum the insulation poured in the first instant.

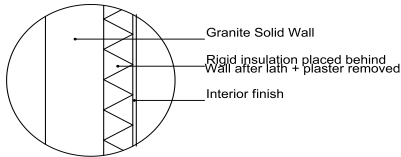
Traditional Granite houses built during this period uses two layers (Fig. 5) where the first one consists of the granite external wall and other inner layer of lath where plaster is applied for the internal finishing. Pouring a none- breathable material in the cavity will not result in a healthy internal environment nor will it maintain the relatively sustainable dwelling's structure.



GRANITE WALL DETAIL WITH BLOWN INSULATION

Figure 5: Traditional granite wall

Complexities such as these, and many others, highlight that a more robust method for improving existing housing to meet Government Low Carbon targets are required. For the above case a relatively costly solution was suggested (Fig. 6): removing the inner Lath/plaster layer and replaces it with a framed plaster board after the installation of a hard insulation panel. Aesthetically, however, this is not always desired.



GRANITE WALL DETAIL WITH RIGID INSULATION

Figure 6: Insulation applied in the granite traditional wall

Case Study Two: Semi-detached rural house, late 18th century. Originally a home with an attached workspace, this rural dwelling has undergone several changes throughout a long lifespan. Large, solid granite walls prevent significant alteration or upgrading of the building fabric on the lower storey, with a conservatory the only physical space added at this level. The roof space, in this instance, is where the house has been developed. There is very little insulation and no large windows in the ground floor, conversely the upper storey has large south facing glazing and an insulated envelope (built in the early 1980's). Initial post occupancy study highlights the significant increase in temperature in the upper storey, while the lower ground floor remains cooler (in the homeowners' opinion). In this instance, the

change in the pattern of use of the building is problematic – daytime activity is in the lower storey, which is cold therefore the heating in the building remains 'on' even on moderately warm summer days. In the evenings, with the upper storey on the same heating loop and benefiting from passive gains, is where significant heat build up occurs. This could be used or perhaps stored, but in this instance it is not, with the preference to release the heat by opening a window. With the ventilation at night, the sequence begins again as no heat is stored overnight and the lower storey remains 'cold' to the home user (especially in the early morning).



Figure 7: View of the house 2

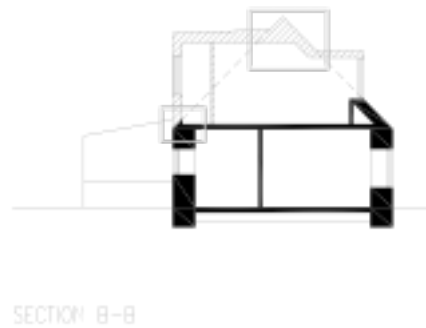
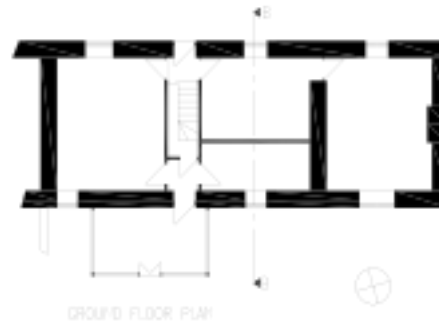


Figure 8: Plan and section of house 2

This dichotomy has developed from the addition of a thermally lightweight dormer extension in the roof space (the dormer continues the full length of the building). This has been added without upgrading or any real improvement of the building fabric in the lower storey – there has been no real, effective environmental strategy. This is common throughout the North East of Scotland, if not wider a field. There are two solutions to the problems addressed in case study 2. The solution most likely to fit the current issues is retrofitting of insulation on the interior and floor (assuming space permitting) this creating a thermally lightweight lower storey. This floor will always behave differently to the upper floor (due to the influence of passive solar gain through the large south facing windows), however, and should be treated as a separate space, if not cut off from above, then thermally sealed. The environmental strategy for the two spaces should be separate with two thermostatically controlled zones within the building.

The second solution, far more imposing on the household, should have been considered and initiated when the upper storey was first retrofitted. The solution should have looked at the retrofitting holistically, in terms of social change (pattern of use) as well as environmental change. This might have led to locating the living spaces in the upper storey, while the bedrooms, etc, were relocated to the ground floor. This *does* have disadvantages; however, as the ground floor is directly placed onto the street (privacy and security) and the economic outlay at the time of the refurbishment was limited. In reality, the former solution is the most pertinent *now* but looking for novel solutions should never be discounted.

DISCUSSION

The two cases addressed in this paper are very limited comparing the wide range of housing typologies in the UK. Nevertheless, they represent a specific, existing and older construction type which is prevalent throughout the UK. Despite the close similarity between the two construction types presented in this paper, one of them required a reconfiguration of its internal space distribution and the other still requires a deep reflection on how its insulation can be achieved with respect to the integrity of the interior design. The failure of the cavity fill insulation in the first case was fortunately discovered at an early stage otherwise the lath structure could be rotted and an entire costly refurbishment operation would have been required.

On the other hand the rejected alternative solution, despite its acceptable technical standard, the soul of the internal spaces was not appreciated by the owner; therefore the solution should be technical and maintain the originalities of the existing housing stock. The

limited availability of qualified and experienced labour will constitute another challenge, and guidance on how to deal with the large numbers of housing typologies that the UK contains should be issued to various agencies involved in informing the future labour force. This process will take more than two decades to be solved and a scientific study with a focus on a better control of energy consumption and CO₂ emission should be conducted. The proposed research will also garner understanding of the social and psychological impacts of the potential radical restructuring of British housing estates. Other type of buildings, such as large office buildings, benefit from integrated information systems that assist architects and designers to achieve better energy conservation [5], the housing area does not benefit from such IT tools and a parallel development still needs to be achieved, the skills and technology based on academic research.

CONCLUSION

The first case study shows building constructions for which there is not yet a robust way of upgrading insulation and therefore further research is required to widen the range of dwellings that can be successfully and safely upgraded. The need for whole systems approach for refurbishment or extension of a dwelling is illustrated by the second case study. All the issues with existing houses in Aberdeen and current methods or practices are not adequate. Hence, there is a need for further research to explore or evaluate the best methods for building insulations.

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