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Quality labels for retrofit cavity wall insulation; a comparative analysis

T.J.H. Rovers[a,*], A.G. Entrop[a], J.I.M. Halman[a]

[a]*University of Twente, Faculty of Engineering Technology, Department of Construction Management and Engineering, P.O. Box 217, 7500 AE, Enschede, The Netherlands*

Abstract

Retrofit cavity wall insulation can be exerted to reduce the energy use for space heating and cooling of existing buildings. In multiple countries, quality labels have emerged for this insulation service. In this research project, an evaluation framework for cavity wall insulation is developed by means of literature research, interviews and a multiple case study. The standards of various quality labels prescribing the insulation process are assessed using this framework. Although the analyzed standards can be considered similar to a large extent, some remarkable differences have been identified. The results also indicate that none of the standards address all aspects of the insulation process. This means that the highest quality cannot be guaranteed when following the currently existing standards. Consequently, there is a need for a new quality label that overcomes the shortcomings of the existing standards identified in this research project.

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Keywords: Thermal insulation; retrofit; cavity wall; CWI; standard; certification; high-quality

1. Introduction

Driven by the intention to reduce the energy use of the built environment, and relating to the first step of the Trias Energetica [1], governments increasingly require the thermal shell of new buildings to meet high thermal resistances [2]. It must be recognized, however, that the existing building stock possesses a large energy saving potential as well [3]. Retrofit thermal insulation services are of interest in this context.

* Corresponding author. Tel.: +31(0)53-489-3202; fax: +31(0)53-489-2511.
E-mail address: t.j.h.rovers@utwente.nl

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Typical retrofit thermal insulation measures include cavity wall insulation (CWI), the external (EWI) and internal (IWI) insulation of walls, the insulation of the ground floor (FI) or the ground beneath it (GI), the insulation of roofs (RI) and the application of insulated glazing (double and triple glazing). This research project focuses on CWI, which refers to the process of filling the hollow space (the cavity) between the inside leaf and outside leaf of an exterior brick wall. Contrary to EWI and IWI, CWI hardly affects the aesthetics of the facades, nor does it affect the interior building volume. Furthermore, CWI is both quicker and cheaper than EWI or IWI, although a drawback is that the thickness of the insulation package is limited to the cavity width [4].

Besides an increase of the thermal resistance of exterior cavity walls as a result of retrofit CWI [4,5], an increase in airtightness may be expected [4,5], which is associated with an increase in thermal comfort and a decrease in energy use of the building [6]. In addition, the indoor surface of an insulated cavity wall will approximate the indoor temperature more closely than that of its uninsulated equivalent [5]. This too has a positive effect on the thermal comfort of occupants [7]. Taking into account aforementioned considerations, it is not surprising that retrofit CWI has been a widely applied measure for decades. In 2015, it was estimated that already 1.5 million Dutch dwellings had received retrofit CWI [8], which corresponds to one fifth of the entire Dutch housing stock. Many specialist companies are active in this industry.

In (highly) competitive markets, companies may use a variety of strategies to distinguish themselves from others, such as advertising and providing warranties. However, Dewally & Ederington [9] found that the strongest signal that sellers of high-quality goods or services can send, is to obtain certification by a respected third party. Nicolau & Sellers [10, p. 832] define certification as "the act of formally guaranteeing that a third party analyses and certifies the product or service a firm offers to satisfy the minimum requirements stipulated in some form of guidelines on technical specifications or norms of service." An inventory of such quality labels for retrofit CWI from three European countries is provided in Table 1. Masonry cavity walls are a widespread external wall type in these countries with climates that are characterized by high wind-driven rain loads.

In this research project, an evaluation framework for cavity wall insulation is developed. Subsequently, existing standards for CWI are assessed using this framework.

2. Research method

The inventory of existing quality labels for retrofit CWI in Table 1 shows that quality labels may target 'products', which refer to insulation materials as offered by specific manufacturers, or 'processes', which refer to the manner in which the necessary activities concerning retrofit thermal insulation services are performed. The focus of this study is on the latter. Consequently, an evaluation framework is developed for insulation processes for CWI, using the literature as a reference. In addition, three professionals in the industry are interviewed to identify shortcomings, advantages and disadvantages of the existing Dutch standards in terms of practical applicability. The three interviewees include the director of an insulation company specialized in CWI with expanded polystyrene (EPS) foam pearls, and two workers with experience in applying loose-fill mineral wool (MW) respectively urea formaldehyde (UF) foam in cavity walls. Furthermore, a multiple case study (ten cases) is conducted to acquire further insight in all aspects of the works. The case study consists of project visits targeting each of the three phases of the insulation process, as will be explicated in Section 3. Finally, the developed framework is used to assess the existing standards for insulation processes for CWI, which are shown in the rightmost column of Table 1.

Table 1. European quality labels for retrofit CWI

Country	Organization	Quality label	Target	Documents
The Netherlands	SKG-IKOB	KOMO attest	products	BRL 2110
		KOMO process certificate	processes	URL 28-101 (EPS), 28-102 (MW), 28-103 (UF)
	IC	Insula attest	products	BRL 2115 (MW), BRL 2121 (EPS)
		Insula process certificate	processes	BRL 2115 (MW), BRL 2121 (EPS)
Belgium	BCCA	ATG certificate	products and processes	ATG certificates (MW and EPS), WTCB TV 246, STS 71-1
United Kingdom	CIGA	-	processes	Assessor's guide, Technician's guide

3. Theory

An assessment of the existing standards for CWI, as described in Section 2, inevitably entails the question what high-quality CWI actually is. For the purpose of this and future research, the following definition is proposed. High-quality CWI means that the thermal insulation of the cavity wall exclusively leads to: (i) An increase of the thermal resistance of the cavity wall, homogeneously distributed over the wall [4,5], (ii) an increase in airtightness of the building [4,5] and (iii) a closer approximation of the surface temparture of the interior wall relative to the indoor temperature [5]. Besides that, (iv) the filling holes that are drilled in the outside leaf may remain somewhat visible. High-quality CWI also comprises informing the client adequately on technical, financial and scheduling aspects of the works, as well as compliance with (national) legislation.

In order to provide high-quality CWI, the three sequential phases of the insulation process must be completed: (1) investigation, (2) application and (3) post control (pc). The investigation comprises visual inspections and measurements of the outside leaf, the cavity and the inside leaf. The aim is to assess the suitability of the cavity walls for CWI by identifying deficiencies which – when unremedied – could lead to undesired effects of CWI. Cracks in the outside leaf, a highly porous outside leaf or a contaminated cavity could lead to moisture penetration to the inside leaf [11,12,13]. Insulation of a cavity wall with an outside leaf with a high water vapor diffusion resistance makes it more prone to frost damage [14]. Furthermore, an effect of CWI may be that ventilation facilities for the purpose of ventilating crawl spaces or the wooden beams of roofs are shut off, which could lead to moisture problems [15,16].

The aim of the application phase is to obtain a complete and homogenous cavity fill with insulation materials of a good in-situ quality, as well as restoring the aesthetics of the outside leaf to its pre-fill state. The post control phase has the purpose of evaluating whether the applied CWI is indeed of high-quality, and – if it is not – may induce measures to still obtain high-quality CWI.

4. Results

The developed evaluation framework and the results of the assessment are summarized in Table 2. The rows show which aspects are of interest. The columns show the analyzed standards of the four organizations. SKG-IKOB and IC developed three, respectively two standards for CWI with specific insulation materials. BCCA prescribes the application of specific insulation products in technical approvals (ATG certificates). Further prescriptions are included in the STS 71-1 and WTCB TV 246 documents. As the latter are more comprehensive, these two documents are included in Table 2. The standard of CIGA comprises two documents as well.

With regard to the scope, ✓ indicates that the relevant standard applies, whereas ✗ indicates that it does not. With regard to the three phases of the insulation process, a scale of a – d is used: (a) the way in which the aspect is addressed in the standard can be considered correct, in the sense that it is in accordance with our findings from literature, interviews and case study, (b) the aspect is justly addressed, but does not include all relevant elements, (c) the aspect is not addressed and there is no evidence that it should be, (d) the aspect is erroneously not addressed and (?) the aspect is addressed, albeit not known yet whether the interpretation must be considered correct or incorrect.

5. Analysis

Three retrofit CWI measures for existing buildings can be distinguished. Post-insulation (A) refers to the application of insulation material in empty cavities of existing buildings. Re-insulation (B) refers to the application of insulation material in an already post-insulated cavity, where the present insulation material is supplemented. Additional insulation (C) refers to the application of insulation material in a cavity of a wall that was partially insulated during its construction. Besides these three types of retrofit CWI, the measure may also be exerted for newly constructed buildings (D) and temporary buildings (E). An interviewee indicated that for re-insulation and additional insulation, it also must be taken into account what type of insulation material had been used in the past. For instance, it is only possible to additionally insulate with UF foam, if the present insulation material is MW or UF. The WTCB standard states that the material used for additional insulation must be selected with care considering the risk of interstitial condensation, but does not specify materials.

The first fourteen out of seventeen identified aspects in the investigation phase include the architectural constraints

Table 2. Assessment of standards for CWI by phase

Phase	Aspects			CIGA		BCCA		IC		SKG-IKOB		
				Technician's guide	Assessor's guide	STS 71-1	WTCB TV 246	BRL 2115 (MW)	BRL 2121 (EPS)	URL 28-103 (UF)	URL 28-102 (MW)	URL 28-101 (EPS)
Scope	Existing buildings	Post-insulation	A	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Re-insulation	B	×	×	×	✓	✓	✓	✓	✓	✓
		Additional insulation	C	×	×	×	✓	✓	✓	✓	✓	✓
	New buildings		D	✓	×	✓	✓	✓	✓	✓	✓	✓
	Temporary buildings		E	×	×	×	×	×	×	✓	✓	✓
Investigation	Facades with moisture or frost damage		1	a	a	a	a	a	a	a	a	a
	Highly porous, painted or glazed facades		2	d	d	b	a	b	b	b	b	b
	Minimum cavity width		3	a	a	a	a	a	a	a	a	a
	Contaminated cavity (debris, mortar snot)		4	d	d	d	a	a	a	a	a	a
	Corroded wall ties		5	d	d	d	a	a	a	d	d	d
	Maximum height of walls		6	?	?	?	?	?	?	?	?	?
	Corrosion by preserved carpentry		7	d	d	d	d	c	a	c	c	a
	Sealing of flues open to the cavity		8	a	a	d	a	a	a	a	a	a
	Ventilation of the crawl space		9	b	b	d	a	a	a	a	a	a
	Ventilation of flat roofs		10	b	d	d	d	a	a	a	a	a
	Moisture load from the inside		11	d	d	a	a	a	a	a	a	a
	Airtightness of inside leaf		12	d	d	d	a	c	c	a	c	c
	Openings in the inside leaf		13	a	d	a	a	a	a	d	d	d
	Walls below ground level		14	d	a	d	d	d	d	d	d	d
	Presence of protected animals (e.g. bats)		15	d	d	d	d	d	d	d	d	d
	Advising the client		16	d	b	b	d	d	d	d	d	d
	Customer care		17	d	b	d	d	d	d	d	d	d
Application	Storage and transport of materials		18	d	d	a	a	a	a	a	a	a
	Injection machinery		19	b	d	d	a	a	a	a	a	a
	Product quality checks		20	b	d	b	d	a	a	a	a	a
	Maintaining drainage openings		21	a	a	d	a	a	a	a	a	a
	Filling holes		22	b	d	d	b	a	a	a	a	a
	Filling operation		23	a	d	d	a	a	a	a	a	a
	Weather conditions		24	d	d	b	b	c	a	b	c	a
	Sealing the drill holes		25	a	d	d	a	a	a	a	a	a
	Cavity barriers		26	a	d	d	a	a	a	d	d	d
	Health and safety workers		27	b	d	b	d	a	a	a	a	a
	Health and safety residents/bystanders		28	d	d	d	d	d	d	d	d	d
	Customer care		29	a	d	d	d	d	d	d	d	d
PC	Handling of complaints		30	d	d	d	d	a	a	b	b	b
	Monitoring		31	d	d	d	d	d	d	d	d	d

that need to be considered when assessing the suitability of cavity walls for thermal insulation. Not considering any of these aspects may lead to undesired effects of CWI, such as moisture penetration to the inside leaf (1-4, 6, 14), frost damage to masonry (2), ineffectiveness of the insulation measure (3), thermal bridging (4), the deterioration of insulation materials (7), clogged flues (8), moisture problems in crawl spaces (9), roof constructions (10) or the wall construction (11) and the entrance of insulation materials (13) or components thereof (12) to the interior of the building. Besides that, the investigation offers an opportunity to identify structural deficiencies (5), which are not necessarily affected by CWI.

Remarkable differences between the standards include the interpretation of the aspects concerning the minimum cavity width (3) and the maximum height of walls (6). Both the British and Belgian standards require a minimum cavity width of 50 mm, whereas this is 30 mm for EPS and 40 mm for UF and MW in the Netherlands. Interviewees indicated that such narrow cavities are not encountered often, but that full cavity fills can be accomplished in such cases. The maximum height of walls is set to 12 m, respectively 12.5 m in the British and Dutch standards, although both standards state that higher walls may be insulated if a special assessment shows that the insulation measure does not lead to an increased risk of rain penetration. The Belgian standards relate the maximum wall height to terrain roughness categories, considering the influence of wind-driven rain on the risk of rain penetration. Although the body of literature on the subject of wind-driven rain is vast, the correctness of this aspect could not be validated due to the lack of reported in-situ measurements.

Besides the architectural constraints, the case study and interviews highlighted the importance of correctly advising the client (16) on necessary preparations, the expected results of the procedure in terms of thermal resistance, energy and cost savings, as well as the cost and scheduling of the works. Customer care (17) refers to the fact that a sales(wo)man should explain the procedure and ask for permission to inspect the walls. The fact that the presence of protected native animal species in the cavity (15), such as bats, must be checked, originates from legislation [17].

The first three aspects in the application phase (18-20) are concerned with the quality of the to be applied insulation material. These do not incorporate detailed product requirements (which are addressed separately by the Dutch and Belgian certification organizations), but rather address the in-situ state of the materials. This is related to the weather conditions (24). As EPS foam pearls are applied in combination with a, often water diluted, adhesive, the outside temperature must be at least as high as the minimum film formation temperature (often 0 °C) of the adhesive. For UF foam, an interviewee indicated that besides temperature, also air pressure influences the in-situ foam quality. Filling holes (22) serve the purpose of providing entrance to the cavity so that the insulation material can be applied. The location, pattern and diameter of the filling holes are prescribed. The filling operation (23) refers to the order in which the material is injected through each of the filling holes, and aspect (25) states that those holes must be filled with mortar after the application of the insulation material. Drainage openings (21) must be maintained. Cavity barriers (26) are to be used when insulating semi-detached or terraced houses, to prevent insulation material from entering the walls of a neighbor's home. The health and safety of workers is regulated (27) by national legislation, but the health and safety of bystanders (28) can also be affected by the works. Customer care (29) includes the confirmation of the activities (to be) undertaken with the customer, and the tidying up of the plot after the work is done.

The post control phase includes the handling of complaints (30). The case study showed that monitoring (31) also takes place, in the form of an optional service in which the walls are subjected to visual and thermographic inspections.

6. Discussion and conclusions

In this research project, an evaluation framework for CWI was developed by means of literature research, interviews and a multiple case study. The standards of quality labels from the Netherlands, Belgium and the UK prescribing the CWI process were assessed using this framework. The assessment included the scope of the standards, as well as each of the three phases of the insulation process.

The standards of the Dutch organization SKG-IKOB have the most extensive scope. However, considering that all standards exclusively apply to masonry cavity walls, the usefulness of the applicability to temporary buildings must be questioned. None of the standards specify which materials may be used for re- and additional insulation depending on the material which is already present in the cavity.

With regard to the investigation phase of the insulation process, large differences in the completeness of the various standards are observed. Whereas the standards of CIGA fail to address many aspects (see Table 2), the WTCB standard

and the standards of IC address the architectural constraints of the investigation phase most comprehensively. However, none of them address the inspection of walls below ground level (14), nor are aspects concerning the presence of protected animals (15), advising the client (16) and customer care (17) addressed. Furthermore, as has been noted in Section 5, the minimum cavity width (3) and the maximum height of walls (6) differ in the standards.

The application phase is prescribed in greater detail in the Dutch and Belgian standards than in the British ones. The standards of IC address most aspects of the application phase, but do not include matters related to the health and safety of residents/bystanders (28) and customer care (29). The post control phase is only addressed by the Dutch standards, but none of the standards address the possibility of monitoring (31).

In conclusion, the various standards prescribing the CWI process largely address similar aspects, although some remarkable differences have been identified. Most striking, however, is that none of the standards address all aspects of the insulation process. Therefore, it must be concluded that the highest quality CWI cannot yet be guaranteed when following any of the currently existing standards. Consequently, there is a need for a new quality label that overcomes the shortcomings of the existing standards identified in this research project. A new standard will be developed, incorporating aforementioned considerations, which will eliminate the deficiencies of the existing standards.

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