ArcelorMittal Liège
Research and Development

Memo

To	Mrs. Baddoo
Company	SCI
From	GIORGIA CAROLI - Marie Descamps
	tél :+32 (0) 42.36.89.05 - fax : +32 (0) 42.36.88.98- giorgia.caroli@arcelormittal.com
Date	16/10/2007
Pages	1 of 12
Subject	**ROBUST wp1,2**
	Nos réf. : GCR70028

CONTENTS

Robust WP 1.2 Investigation of steel-intensive systems for this sector and attachment strategies to the existing building and their architectural requirements

Arcelor Research Liege S.C.R.L
Boulevard de Colonster B57
B.4000 Liège - Belgique
T : +32 (0)4 236.88.11
F : +32 (0)4 236.88.98
www.arcelormittal.com

1. GENERAL CONSIDERATIONS

Improving Europe's buildings performances, by post-isolated walls or roof for example, has become a necessity to deal with the energetic challenge, which currently manifests by growing superficial temperatures and decrease of raw materials and petrol. The external insulation of walls is often preferred to internal one to limit the thermal bridges and to preserve inertia. Moreover, external insulation can be placed while the building is still being used. But it is not always possible especially in historical or preserved buildings.

There are different systems to implement external insulation:

1. External insulation and cement plaster: this system is the most common one (it is largely diffuse in Austria, Germany and central Europe). Clearly is not a steel intensive systems and we are not going to analyze it.
2. Insulation panels protected by cladding, with wooden or steel frames connected to existing walls. The insulation layers are placed between the frames. An air cavity for ventilation (between insulation and cladding) is necessary to avoid moisture and condensation; the cladding is fixed on the frame. Particular care should be taken regarding thermal bridges and connections.
3. Cement plaster connected to secondary structure fixed on the primary frame. An air cavity is created.
4. Prefabricated sandwich panels (steel-insulation-steel) mechanically fixed to the existing wall. The external skin works as weather protection and as vapor barrier.
5. Cavity wall system made out of insulation layer, air gap and brick layer. Clearly is not a steel intensive systems and we are not going to analyze it.
6. Over-cladding systems are mainly made out of steel: these techniques can be well applied at renovation works.

2. EXISISTING WALL REQUIREMENTS

The wall:

1. has to be clean
2. Should support the extra weight due to the frame and the cladding
3. Has to be dry.

For masonry walls, particular attention should be given to corners, the north side, the upper floors and the projecting elements (which are usually more deteriorated).

3. SYSTEM REQUIREMENTS

The renovation system should:

1. be weather-tight (in a lot of cases the existing façade is not weather-tight anymore)
2. Support the own weight and the wind loads.
3. Increase thermal capacity.
4. Have a long life span (30 years recommended).
5. Respect fire regulation
6. Compensate the non-verticality of the walls via special profiles.

The installation must be rapid, and prefabricated systems are preferred for their higher quality.

The primary frame can be attached in vertical or horizontal position.

Two kind of spacing wan be use:

- Small spacing between the frames: the frame can be attached to the existing façade
- Large spacing induces important weight: the structure should be stronger or self standing.

Different kinds of cassettes can be used in all the following renovation systems:

1. Cassette with visible fixations, which not allowed thermal movement.
2. Suspended cassette which allows thermal movement
3. Cassette of concealed fix type, which allows all thermal movements.

4. STEEL INTENSIVE SOLUTIONS

4.1 TYPE S – 1

This system is composed by frames fixed to the existing wall and by steel mechanical fixations, keeping a space between the wall and the frame. Insulation is placed between the fixations, and there is an air layer behind the cladding. The advantage of this system is the fixation, which allows an adjustment of the position of the frame (for example if the wall is not straight). Without using thermal bridges breakers, thermal bridges appear at each fixation point.

The cladding can also be replaced by cassettes or sandwich panels. In the case of sandwich-panel, the layer of insulation of the panel does not help the total performance of the system due to the air gap.

The span between the frames depends on the type of cladding chosen.

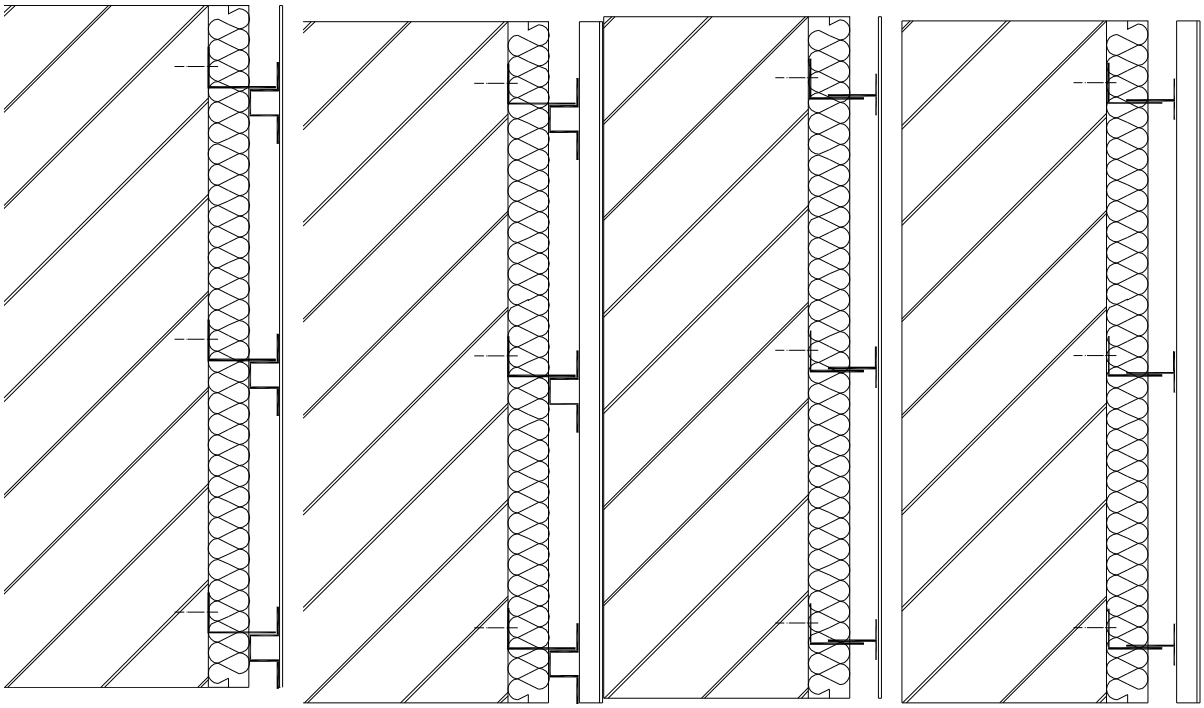


Figure 1: Type S-1, different types of connections

4.2 TYPE S – 2

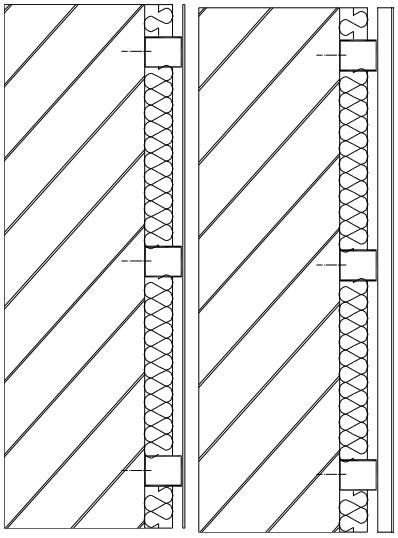


Figure 2: *Type S-2, different types of connections*

The second type is quite similar, but the frame is directly fixed to the wall without leaving space behind the frames. The insulation is also placed between the frames, and there is a cavity behind the cladding.

Cold bridges are higher in this case due to the contact between the frame and the wall. Furthermore, the existing wall has to be quite straight to have a good final planarity.

It's important to create real ventilation behind the cladding.

Like in the first schema, the cladding can be replaced by cassettes and adapting the frame at the span to the cassettes.

There are different types of fixations and frames, as shown in figure 3.

The E and F type are especially used for transversal loads.

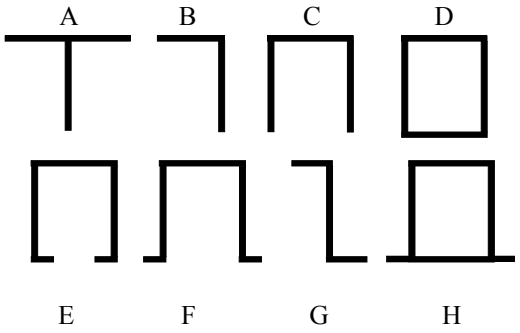


Figure 3: Types of fixation

4.3 TYPE S – 3

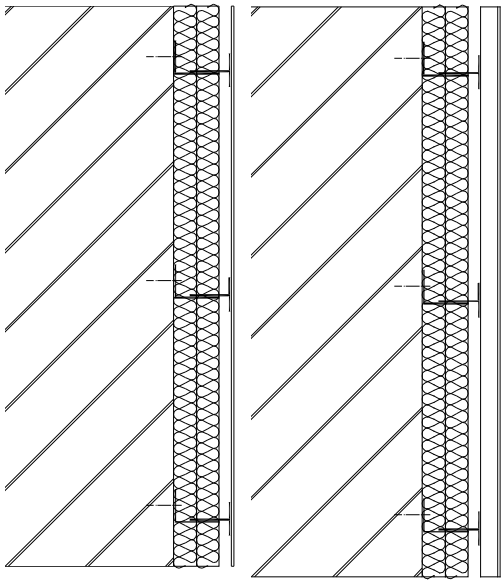


Figure 4: Type S-3

This system is similar at the first one: in this case the two different layers of insulation are put between the mechanical fixations and the frames. Consequently, the cold bridges are somewhat reduced.
In a way the irregularity if the wall helps in reducing the thermal bridge (see fig. 5)

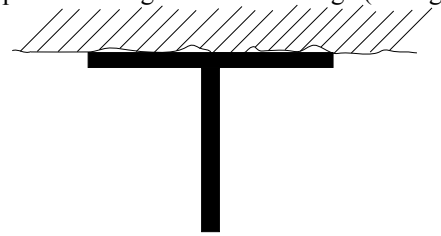


Figure 5: the irregularity of the wall help in reducing the thermal bridges.

The two layers of insulation allow more flexibility in dimension, thickness and so on performance.
As the previous examples, the cladding can as well be replaced by cassettes.
Each system can be completely fixed to the wall, or can be a little loose to enable fixations' thermal dilatation. The second solution means that the top fixation is fixed, and the other ones can move.. The steel structure can be fixed in both the way; we can not say the same in case of aluminum fixation (which has a higher dilatation coefficient $\alpha_{steel} = 12 \cdot 10^{-6}$ m/K and $\alpha_{alu} = 23 \cdot 10^{-6}$ m/K).

5. STEEL AND WOOD

5.1 TYPE W - 1

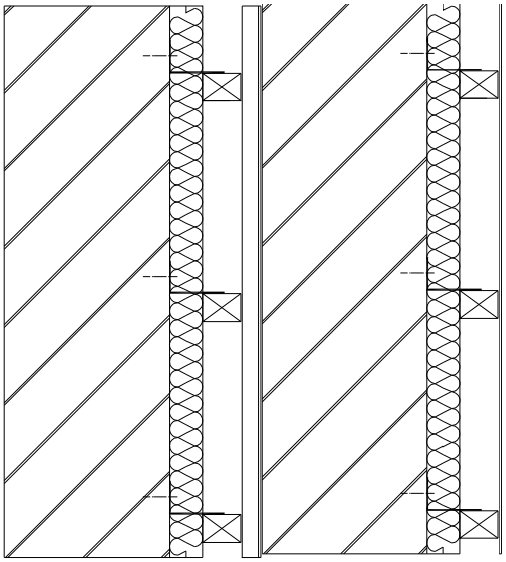


Figure 6: system W-1

This solution is a combination of wood and steel, which is better in terms of thermal bridges. There is no steel to steel contact. Otherwise, the system is working like all the other ones.

A "rainscreen system" (Anderson and Gill[1]) allows water or moisture to enter the cavity but an internal system drains the water outside.

The cladding can also be replaced by cassettes or panels.

[1] Anderson J.M. and Gill J.R. Rainscreen cladding : guide to design principles and practice CIRIA Building and Sructural Design Report – Walls ; Construction Industry Research & Information Association, 1988

4.2 TYPE W - 2

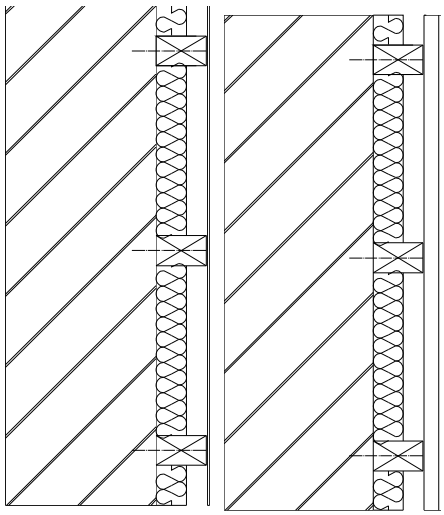


Figure 7: System W-2

In this case, there's no space between the wooden frame and the wall, which means that the wall should be quite plane. We can also insert struts between the wall and the beam to correct the planarity of the wall.

There is no steel to steel contact so the thermal bridges are reduced, but their surface is bigger than in the previous type.

The cladding can also be replaced by cassettes or panels.

4.3 TYPE W - 3

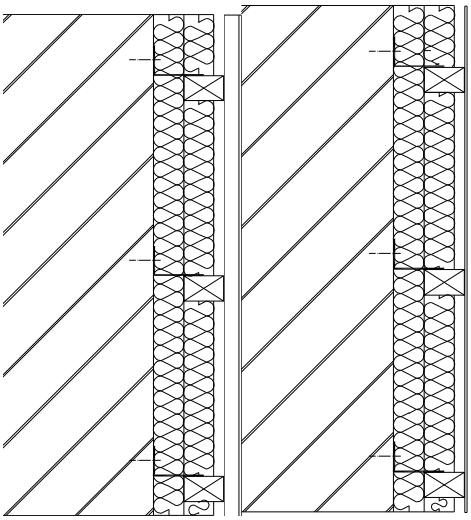


Figure 8: System W-3

The same concept as the type S-3 can be applied with the insulation divided in two different layers.

The advantage of putting two layers is to reduce air infiltration by different ways of lying, without superimposing junctions.

The cold bridge is minimal.

The cladding can also be replaced by cassettes or panels.

6. PANELS

Figure 9: Panel system and application in High-quality passive house renovation in Weiz (Austria)

Sandwich and composite panels can be used in renovation. Fire protection impose that the both the skin of the panel are not perforated.

The figure 9 shows an example of panels, and the junctions between them. In this case, it's really important not to leave air space between the wall and the panel, to avoid convection. The planarity of the support could make could make this requirement really difficult to achieve.

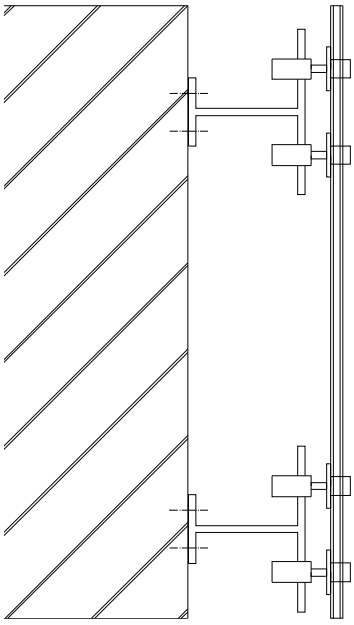
It is important to place a vapor barrier between the panel and the wall, to avoid condensation and moisture.

It's a face-sealed system[2], so it has to be air-tight and water-tight. Different types of panels exist on the market.

The skins of the panels can be made of steel, but also of glass or ceramic tiling, as shown in the figure 9.

7. SPECIFIC SYSTEMS

7.1 DOUBLE SKIN GLASS WALL



This is not a real steel-intensive solution, but it's quite interesting. The principle is to create a new glass façade, with a dynamic air space between the wall and the glass. This air space is opened during summer, and there is a natural air flux. In winter, this space is totally closed, so an extra insulation layer is obtained.

This system was executed in France, (Haubourdin's town hall) to improve the energy balance of the building. The space between the wall and the glass is about 1m, and there is a mechanical ventilation system (double flux) inside.

Figure 10: Double skin glass facades

[2] Anderson J.M. and Gill J.R. Rainscreen cladding : guide to design principles and practice CIRIA Building and Sructural Design Report – Walls ; Construction Industry Research & Information Association, 1988

7.2 NOT VENTILATED AIR GAP

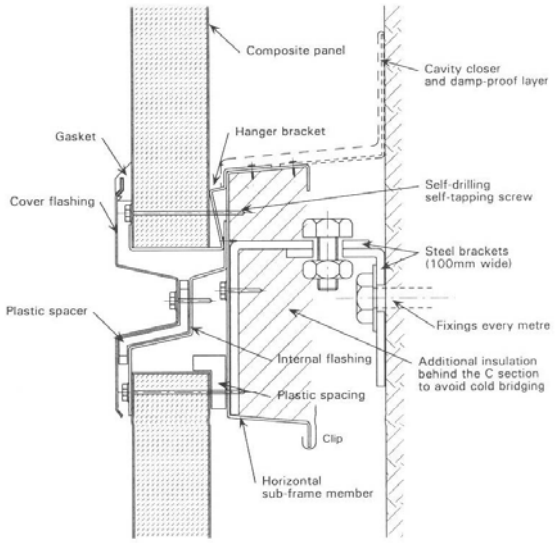


Figure 11: Joint detail in prototype steel over-cladding system

Another specific system was developed by the University of Edinburgh as part of British Steel and European-funded demonstration project. This is a prototype with panels, and air layer behind those. The originality is that the air gap is not ventilated. So we get an extra insulation layer. The problems of this prototype are that it is very difficult to create a non ventilated air layer and thermal bridges are present at each junction between panels[3].

[3] Source: "Over-cladding of existing buildings using Light Steel - Building envelope"
The Steel Construction Institute – 1998 p.42

REFERENCES

[1] CSTB, (2001), *Ossature bois et isolation thermique des bardages rapportés faisant l'objet d'un Avis Technique ou d'un constat de traditionalité*, Cahiers du CSTB n°3316

[2] CSTB, (2000), *Ossature métallique et isolation thermique des bardages rapportés faisant l'objet d'un Avis Technique ou d'un constat de traditionalité*, Cahiers du CSTB n°3194

[3] Esko Miettinen, Hari Ripatti, Risto Saarni, (1998), *Use of steel in housing renovation*, Teräsrakenneyhdistys

[4] Hauglustaine Jean-Marie, Simon Francy, Baltus Catherine, Liesse Sophie, (2006), *L'isolation thermique des façades verticales – Guide pratique pour les architectes*, ULg-UCL-Minitère de la Région wallonne

[5] ICTAB, (2004), *Tôle d'acier préfini pour rénovations d'immeubles*, Collection guides pratiques

[6] Pattou et Associés, (2007), *Façade double peau et VEA pour un bow-window*, Les cahiers techniques du bâtiment, Annuel 2007, p.44-45

[7] The Steel Construction Institute, (1998), *Over Cladding of Existing Building using Light Steel – Building envelope*, Oakdale Printing Company Limited, Poole, Dorset

[8] www.corusgroup.com
[9] www.rockwool.be
[10] www.vmzinc.be