# THE CURRENT STATUS OF THE CLADDING SECTOR AND ITS OPPORTUNITIES FOR COMPUTER-INTEGRATED MANUFACTURE (CIM)

**J.M. Lee, C.J. Anumba, A.G. Gibb and E. Agbasi**

*Dept. of Civil and Building Engineering, Loughborough University, Loughborough, LE11 3TU, UK*

There is widespread agreement that the construction industry needs to review its business processes in order to be more efficient and to deliver construction projects that are on time, of better quality, cost-effective and that better satisfy the needs of the industry's clients. The primary aim of the project is exploring the potential for CIM in a variety of cladding types and modelling paradigms to improve standardisation of procedure, and achieve greater efficiency in the business processes of the cladding sector. Cladding can be broadly classified as six different types, which are rainscreen, metal & glass curtain wall, formed metal systems, precast concrete, structural sealant glazing, and structural glazing. The distinction between the claddings is clear for some, but vague for others, especially between curtain wall and other cladding types. A cladding project typically involves several participants (clients, designers, system suppliers, specialist sub-contractors (i.e. fabricators), installers, main contractors, etc.). CIM (Computer-Integrated Manufacture) could offer an effective means to enhance the integration of information flow across these participants and stages in a cladding project.

Keywords: CIM, cladding, integration.

## INTRODUCTION

There is wide spread agreement that the construction industry needs to review its business processes in order to be more efficient and to deliver construction projects that are on time, of better quality, cost-effective, and that better satisfy the needs of the industry's clients. This has been emphasised in number of studies of the industry – The Latham Report, the Construct IT Report, The Technology Foresight report on Construction, the Construction Industry Board report, the Construction Industry Council report, and the Egan Task Force report. A key factor in the problems of the construction industry is its fragmentation. The UK cladding sector mirrors this fragmentation, with the result that it is inefficient and lacks the capacity to compete effectively in the growing global market.

In recognition of the above problems, the project has been established with the primary aim of exploring the potential for applicability of Computer-Integrated Manufacture (CIM) to improve standardisation of procedures, and achieve greater efficiency and effectiveness in the business processes of the cladding sector.

This paper covers first part of the project. It focuses on classification of cladding types based on characteristics such as structure, material and building application. It also explores the potential benefit of CIM implementation in the cladding sector.

Lee, J M, Anumba, C J, Gibb, A G and Agbasi, E (2002) The current status of the cladding sector and its opportunities for computer-integrated manufacture (CIM). *In:* Greenwood, D (Ed.), *18th Annual ARCOM Conference*, 2-4 September 2002, University of Northumbria. Association of Researchers in Construction Management, Vol. 2, 493-502.

## TYPES OF CLADDING

### Introduction

Cladding is an all-encompassing term for the external skin of a building that keeps out the weather and provides the building’s aesthetic effect. In low-rise construction it may support its own weight but self-weight and wind loading are normally transferred to the structural building frame. It may form the full thickness of the vertical envelope of the building but can simply be the outer layer with additional layers providing insulation and the internal lining (CWCT, 2000).

Some of the factors, which the cladding has to control, are water, air, sound, light, vision, heat, fire, pollution, security, safety and explosions. Modern facades are required to keep all these factors in balance and clearly some of the various requirements are in conflict.

### Rainscreen

Rainscreen cladding is a multi-layer form of wall construction. In a rainscreen there are two layers of wall. An outer skin (rainscreen) that minimises or prevents water entering the wall and a backing wall (incorporates air and vapour barriers) that prevents excess air leakage. The joints in the rainscreen may allow driven rain to enter the cavity. It is common for rainscreen cladding to incorporate sealed and open joints (sealed vertical and open horizontal). The seals in the air barrier then provide an air seal to control air penetration.

Figure 1 shows the key features of rainscreen cladding.

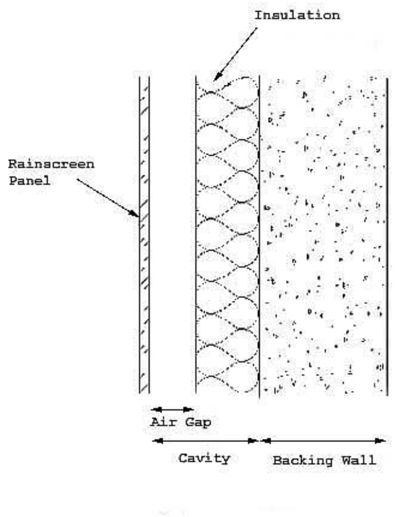


**Figure 1: Simplified Illustration of Rainscreen Cladding (CWCT, 1998)**

### Metal and Glass Curtain Wall

The classification of types of curtain walling varies but the following terms are commonly used:

Stick

Unitised

Panellised

*Stick Systems*
Stick systems rely upon a secondary structural grid, set within or parallel to the wall plane. This grid comprises of generally continuous vertical members (mullions), interspaced by discontinuous horizontal members (transoms) (Figure 2) (Ogden, 1992).

Stick systems are amongst the lightest cladding systems weighing approximately 50 kg/m². Mullion spacing is typically in the range 1.2 to 1.5 m. However, it is usually determined by the internal planning grid of the building. Transom spacing is generally determined by the sheeting material (fabrication and erection considerations) and the architectural order of the façade (Ogden, 1992).

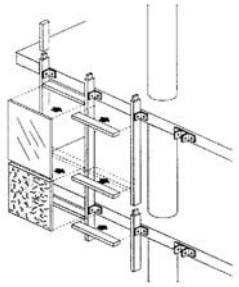

Figure 2: Stick system curtain walling (Colomban, 1994)

*Unitised Systems*
Unitised systems comprise narrow (around one metre), storey-height units of steel or aluminium framework, glazing and panels pre-assembled under controlled, factory conditions (Figure 3) (CWCT, 2000).

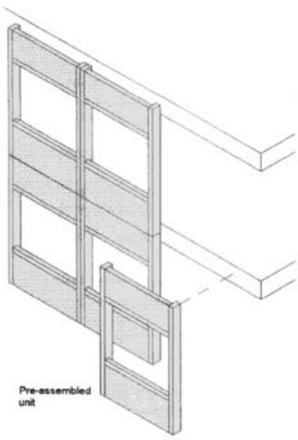


Figure 3: Unitised curtain walling (CWCT, 2000)

*Panellised Systems*
Panellised curtain walling comprises large prefabricated panels of bay width (typically 7-9 metre) and storey height, which connect back to the primary structural columns or to the floor slabs close to the primary structure (Figure 4).

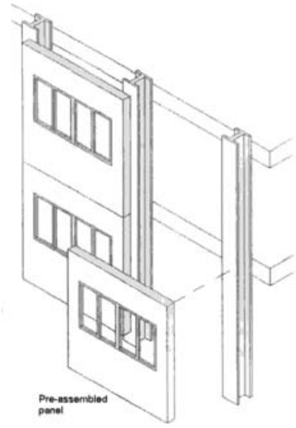


Figure 4: Panellised curtain walling (CWCT, 2000)

**Formed Metal Systems**

*Profiled Metal sheet*

Profiled metal sheet comes in two forms, the trapezoidal or sinusoidal profile.  The panel is an in situ construction incorporating an inner lining and spacer purlins with an outer sheet. The inner lining and spacer purlin may be replaced with a combined element. The lining and purlin are fixed back to either the primary structure or a secondary structure, with the outer sheet fixed through to the purlin. Insulation is commonly located between the purlins (Figure 5) (CladdISS, 2001).

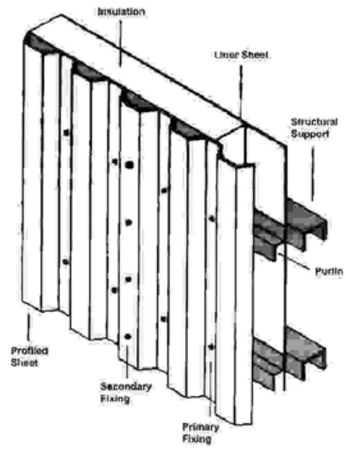


Figure 5: Site-assembled profiled metal system (CWCT, 2000)

*Composite metal panel*

The principal form of composite construction is two thin sheets held apart by a lightweight core to which they are bonded (Figure 6). It is the spacing of the two sheets that is mainly responsible for the rigidity of the final composite: the wider spacing, the greater the spanning capabilities of the finished product (Brookes, 1998).

Typically, a panel with two skins of 0.7mm steel and 55mm of extruded polystyrene insulating can span four metres (Brookes, 1994).

Where insulation is required, composite panels have now almost totally replaced profiled metal sheeting as the product of choice offering a factory-finished surface to both exterior and interior. (Brown, 2000)

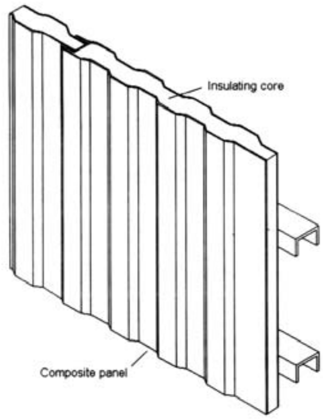


Figure 6: Composite panel (CWCT, 2000)

**Precast Concrete**

The precast concrete panels are non-load-bearing facing panels, self-finished with exposed aggregate or integral factory cast-in finishes, such as natural stone, brick, tiles and mosaics that compose the outer decorative face of the building (Harrison, 2000).

Precast concrete came into its own for use in cladding during the 1950s and early 1960s with the development of high-rise housing. There has been something of a renaissance of precast concrete cladding in the last ten years (Brown, 2000).

In contrast to the curtain walling market, the precast concrete cladding market is very simple – there's just the handful of members of the Architectural Cladding Association capable of producing high-quality architectural precast, although they are now being challenged on the very largest projects by a small number of European precasters (Brown, 2000).

**Structural Sealant Glazing**

Structural sealant glazing is a system of bonding glass to a frame using structural (silicone) sealants without an external cover bead (Figure 7) (Button, 1993). The main function of structural silicone sealants is to permanently bond external cladding panels to the façade frame, and to ensure the structural integrity of the building envelope throughout its entire service life. The secondary purpose of silicone and/or other sealants is to provide water tightness for the building (Gutowski, 1994).

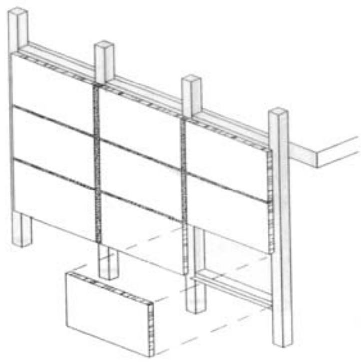

Figure 7: Structural Sealant Glazing (CWCT, 2000)

**Structural Glazing**
Structural glazing systems are usually defined by their means of assembly. There are two main types: bolted and suspended.

*Bolted*
Bolted structural glass facades have evolved over thirty years from the patch-plate, suspended assemblies of the 1960's and 70's through the introduction of Pilkington's Planar system in 1981 and RFR's La Villette ball-joint system (Dodd, 1997).

Sheets of toughened glass are assembled with special bolts and brackets and supported by a secondary structure to create a near transparent façade with a flush external surface (Figure 8) (CWCT, 2000).

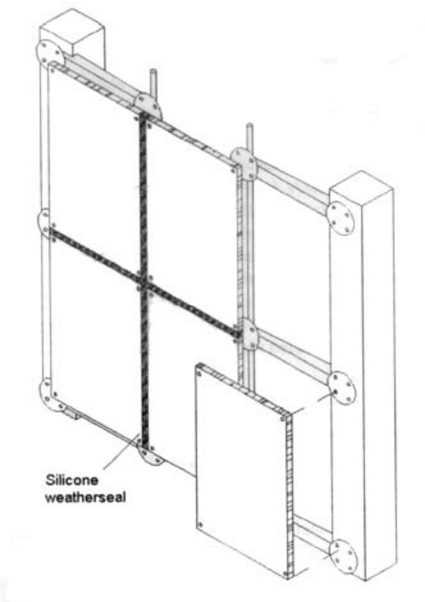


Figure 8: Structural Glazing – bolted (CWCT, 2000)

*Suspended*
The glass is fixed together with corner, rectangular, patch plates and the whole assembly is then either suspended from the top or stacked from the ground and wet-sealed on site (Figure 9) (CWCT, 2000).

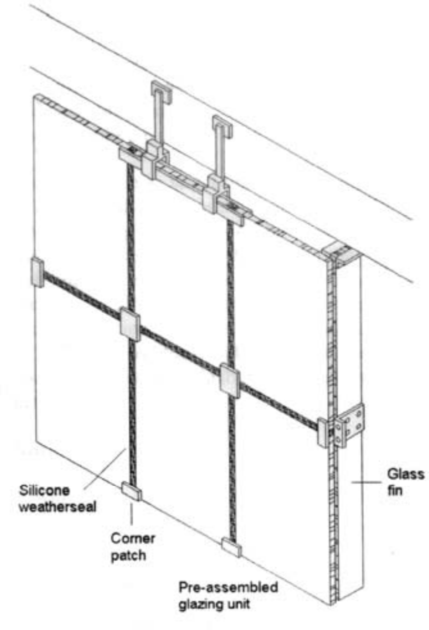


Figure 9: Structural Glazing – Suspended (CWCT, 2000)

## COMPARISON BETWEEN DIFFERENT CLADDING TYPES

The table on next page has been generated from literatures, including technical papers of CWCT (please refer to references section).

## CIM (COMPUTER INTEGRATED MANUFACTURE) AND ITS PRACTICE AND OPPORTUNITIES IN CONSTRUCTION

As it was previously mentioned, the fragmented construction sector leads to complex technical problems to integrate and computerize its participants and business processes.

A study by ‘Construct IT Centre of Excellence in 1997’ found that the dominant challenges facing UK industry in the view of the academic community are those of integration of industry and its processes. The finding above supported by the Construction Industry Institute study of its membership (1988), which its interviewees considered that the next major advance in the construction industry would take place when project, design and facility computing systems are integrated.

Given that the construction industry typically represents 10% of an economy by measures such as value added and total employment, the importance of solving the integration issue for economic advance generally, is considerable (Brandon, 1995). Recent advances in information technology are seen by many as a rare opportunity for a substantial solution for the integration issues.

The most significant example of CIM application in the construction sector may be CIMsteel project, a pan-European project, which committed to the integration and enhancement of competitiveness of the European Constructional Steelwork Industry from Client brief through the structure's complete life cycle. Its overall objective was to improve the effectiveness and efficiency of the European constructional steelwork industry by the introduction of computer-integrated manufacturing techniques and developing the necessary standards.

Table 1 Comparison of different cladding types (CW stands for metal and glass curtain wall and FM for formed metal system)

| Cladding Type | | Structure | Material | Building Application | Advantages | Disadvantages |
|---|---|---|---|---|---|---|
| **Rainscreen** | | A multi-layer form, consisting an outer skin that minimises water entering the wall and a backing wall that prevents excess air leakage | Aluminium panels, thin natural stone, terracotta units, GRP panels, GRC panels, high pressure laminates, and Composite panels | Over-cladding, Commercial & Utility buildings such as hospitals, theatre, and schools | Relatively tolerable on poor workmanship; Low maintenance requirements; Maintenance cost is also low | Slower installation rate |
| **CW** | **Stick Systems** | Infill units stick to horizontal and vertical framing members | Metal framing, insulated infill units of different materials and facing – glass, metal, stone | Medium to high rise residential, commercial and office buildings | Light; Good at accommodating variability and movement in the building frame; Suitable for irregular shaped buildings | High site costs; Expensive quality control; Slow installation process |
| | **Unitised Systems** | Comprising narrow, storey-height units of steel or aluminium framework and glazing | | | (Compared with stick systems) more complex framing system leading to higher costs | (Compared with stick systems) Complex framing system; Higher direct costs |
| | **Panellised Systems** | Large prefabricated panels of bay width and storey height | | | Rapid installation with the minimum number of site-sealed joints | More expensive than unitised construction |
| **FM** | **Profiled Metal Sheet** | Sheeting rails spanning between structural framing or inner tray liner | Aluminium and galvanised steel as panels or sheets; Mineral wool, honeycomb paper core, bead polystyrene rigid sheet, polyurethane foam as insulation cores | Industrial and agricultural buildings | Tolerable on thermal and differential movement in the outer sheet, flexible to allow of inaccuracies in the structural framing | Less efficient insulation |
| | **Composite Metal Systems** | Two thin sheets held apart by a lightweight core to which they are bonded | | Industrial, commercial, and office buildings | Fast assembly, finished skin on either side | |
| **Precast Concrete** | | Small units to be used to fill gaps between conventional glazing systems, or storey-height panels with cast window openings | Various materials are used to be applied on the surface of a precast cladding, such as tiles, stone (granite, marble, limestone, etc.) | High-rise residential, industrial and office buildings | Good strength-to-weight ratio; Good fire performance; Decorative | Leakage problem, combined with corrosion of steel fixings |
| **Structural Sealant Glazing** | | Glass attached to frames using structural sealant without an external cover bead | Structural sealant; Glass panel | Prestige buildings; Office buildings | Aesthetically creative; Reduction of water and dirt retention; Easy to clean; Speedy site installation | Vulnerable to vandalism; Failure and poor workmanship on sealant could be fatal |
| **Structural Glazing** | | Glass attached to frames using special bolts or suspended using patch plates | Toughened glass; Laminated glass | | No restriction on the height of building to be glazed | Vulnerable to vandalism; Difficult to handle a glass pane during installation |

## POTENTIAL BENEFITS OF CIM IMPLEMENTATION IN CLADDING SECTOR

The UK cladding sector suffers from some key problems in the area of integration and information management, which include:

Lack of integration of information on design, client needs, manufacture and installation, resulting in much rework, loss of data, etc. with data generated at one stage not readily available for reuse downstream or on future projects;

Lack of integration, co-ordination and collaboration between the different participants (clients, designers, system suppliers, specialist sub-contractors (i.e. fabricators), installers, main contractors, etc.) involved in cladding projects;

Lack of communication of design intent and rationale, leading to unwarranted design changes, unnecessary liability claims, increase in design time and cost, and inadequate pre and post-design specifications;

Lack of standardisation in product description resulting in information and data exchange problems;

Information and communication technologies could offer an effective means of overcoming those problems listed above and achieve the meaningful integration through enhanced flow of information across participants and stages in the project process.

As the UK cladding sector of the construction industry accounts for over £2 billion worth of output each year, the scope for improving the efficiency and competitiveness of the cladding sector, through greater standardisation and integration in the project delivery process, is considerable. Parallels can be drawn with the constructional steelwork sector, an industry that is more organised and further down the road to standardisation, integration and automation. Compared with the structural steelwork sector there are two important practical differences. Firstly the cladding sector is not (yet) supported by specialist engineering software, and secondly the fabricated components are smaller and very much lighter. Cladding is thus considerably more amenable to the early introduction of cost-effective computer integrated manufacturing, yet has only limited investment in CAD.

## CONCLUSIONS

Cladding can be broadly classified as six different types, which are rainscreen, metal & glass curtain wall, formed metal systems, precast concrete, structural sealant glazing, and structural glazing. The distinction between the claddings is clear for some, but vague for others, especially between curtain wall and other cladding types.

The task, the classification of cladding types, was a demanding task. As it was mentioned, distinction between them is sometimes vague and as more new kinds of products are developed it makes the analysis even harder.

The concept of CIM, which originally was developed in the manufacturing industry, has been adopted into the construction industry to improve its productivity, reduce costs, and increase value to all parties. It has potential benefit to improve the flow of information and data exchange between project participants and different organizations.

However, in practice, compared with the manufacturing industry, the full concept of CIM is not yet realized in the construction industry.

One of the reasons for relatively poorer performance in construction sector is its highly fragmented nature, and the number and diversity of different firms and organizations who must communicate during the different stages of a project. The hindrance is mirrored to the cladding sector, as well. CIM could play useful role to integrate and improve the information flow through the process of a cladding project and between different organizations.

## REFERENCES

Agbasi, E., *et al.*, *Potential for process improvement.* Computer integrated manufacture of cladding systems (CIMclad) report 1, 2001

Brandon, P. & Betts, M., *The field of integrated construction information: an editorial overview*, Integrated Construction Information, E & FN SPON, London, 1995

Brookes, A.J., *Cladding of Buildings 3rd ed.*, E & FN SPON, London, 1998

Brookes, A.J., *Performance Requirements for Composite Panels*, International Conference on Building Envelope Systems and Technology (ICBEST-94), Singapore, 1994, pp24-31

Button, D. & Pye, B., *Structural Glass Systems*, Glass in Building, Butterworth Architecture, 1993, pp325-341

Colomban, M., *History and technical development of curtain wall*, International conference on building envelope systems and technology (ICBEST-94), Singapore, 1994, pp2-20

Construct IT Centre of Excellence, *Research Futures: Academic Responses to Industry Challenges*, Construct IT Centre of Excellence, Salford UK, 1997

CWCT, *Cladding types. Technical Note No.15*, Centre for window and cladding technology, Bath UK, 2000

CWCT, *Curtain Wall Type. CWCT technical note No.14*, Centre for window and cladding technology, Bath UK, 2000

Dodd, G., *Essential Elements of Bolted Structural Glass Systems*, International Conference on Building Envelope Systems and Technology, UK, 1997, pp79-84

Gibb, A. et. al., *CladdISS (CD-rom)*, CWCT, Bath, 2001

Gutowski, W.S. & Lalas, P. & Cerra, A, *The sealant aspects of building envelope systems and technology*, International Conference on Building Envelope Systems and Technology (ICBEST-94), Singapore, 1994, pp32-37

Harrison, P., et. al., *Cladding fixings – good practice guidance*, Construction Industry Research and Information Association (CIRIA), 2000

Jung, Youngsoo, *Planning for computer integrated construction*, Journal of computing in civil engineering, 1999, pp217-225

Ogden R.G., *Curtain Wall Connections to Steel Frames*, SCI (Steel Construction Institute) publication 101, 1992

Sanvido, V.E. & Medeiros, D.J., *Applying Computer-Integrated Manufacturing Concepts to Construction*, Journal of Construction Engineering and Management, Vol. 116, No. 2, 1990

Thorpe, A., *The role of data transfer*, Integrated Construction Information, E & FN SPON, London. 1995, pp37