elevation

The Journal of the Society of Façade Engineering
June 2007

Heat loss in curtain walls
Profile strength with thermal breaks
Feature façades: BMW Munich and New Street Square

SOCIETY OF FAÇADE ENGINEERING

Some designers have suggested that increasing the U value of a curtain wall by 28% is a good way of contributing towards the 28% improvements required by the UK Building Regulations for air conditioned office buildings. In our main article for this issue, we focus on the opening speech from the recent International Conference of Building Envelope Systems and Technology, where the notion of increasing insulation on office buildings as a way of enhancing energy performance was challenged.

To Insulate or to Ventilate?

With the prospect of ever increasing energy costs, business is looking at lowering carbon production, but due to the drivers of market competition, most developers are only driven by legislative forces to save energy. With short-term financial gains fuelled by increasing rents and property values topping the agenda, the notion of future proofing office buildings is left to a few visionaries and long-term investors.

Office buildings can be carbon future proofed by allowing for natural lighting and natural ventilation. The ICBEST speaker made the point that current legislation gives no actual incentive to design naturally ventilated buildings, citing the fact that the performance targets set out in Part L2A of the Building Regulations are defined in terms of reductions in carbon dioxide emissions compared with a notional building. Due to the intrinsically lower energy consumption of a naturally ventilated notional building, it is relatively more difficult to achieve a compliant naturally ventilated building than an air conditioned one.

Designing for natural lighting and natural ventilation both carry huge challenges and problems that have yet to be fully understood and overcome, hence government's legislative reticence. The future solutions to these problems lie with the facade engineers of today: better design and more research will give us a more comfortable future.

A Missing Correlation

between insulation and energy performance

The following is a summary of the keynote speech from ICBEST 2007

The paper, presented by Mikkel Kragh and co-authored by Annalisa Simonella, both from Arup, set out to illustrate that there is no direct correlation between U-value and overall energy performance of a building with high internal gains, such as an office building. This is due to the complex relationship between solar gains and heat losses that is emphasised in highly glazed air-conditioned office buildings.

Curtain Walls and Thermal Performance

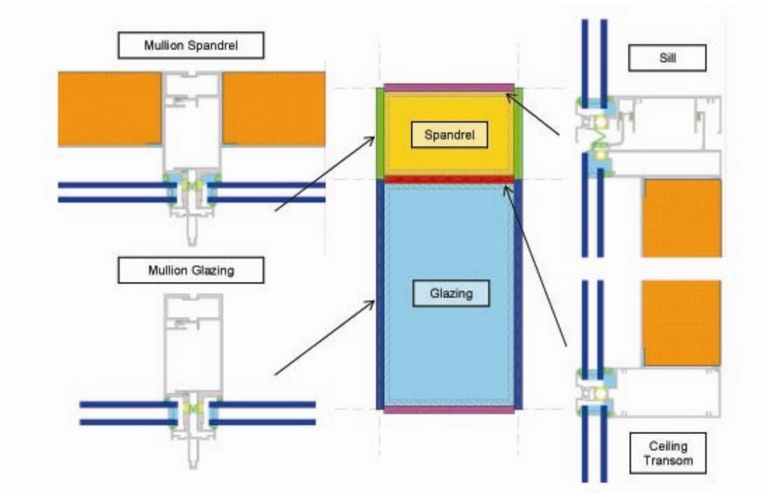
Most office buildings have some form of curtain wall as the principle cladding. This usually consists of component parts with differing functions. The overall thermal performance, expressed as the thermal transmittance (U-value) of the façade, depends on its components: framing, glazing and infill panels. Moreover, the performance of the framing is a function of the way it interfaces with infill panels and glazing.

The authors argued that it is not possible to thermally split curtain wall systems into windows and walls, due to the interdependency of the heat transfer through the connected parts. Therefore, defining the required performance for separate parts of a system is generally not meaningful. Instead, they suggested, it is necessary to consider the curtain walling system as a whole and assess the overall thermal performance, including frames, infill panels, and glazing, specific to any given project.

"defining the required performance for separate parts of a system is generally not meaningful"

Under Table 4 of Approved Document L2A, the area-weighted limiting standard for 'curtain walling' is cited as the same as for windows, at 2.2 W/m^2K. This differs from the 2002 UK regulations, there taking 40% of the area as a 'window' with a U-value of 2.2W/m^2K and the remaining 60% of the area as 'wall' with a U-value of 0.35 W/m^2K yields an area-weighted, elemental U-value of 1.1W/m^2K. If detailed calculations were carried out, an additional 10% allowance for cold bridging would be added, taking the maximum allowable U-value to 1.2W/m^2K. If the interpretation of 'curtain wall' includes spandrel zones, then the minimum standard has been relaxed from 1.2W/m^2K of the Part L2 2002 Elemental Method to 2.2W/m^2K under the current Part L2A 2006. Confusingly, another interpretation published by the Building Research Establishment's Building Performance Group separates 'curtain walls' into 'glazed' (controlled fittings) and 'opaque' (thermal elements) components (1). Either way, the intention is that the whole building target CO2 emission rate will capture the façade performance and lead to specification of (significantly) higher performance than that currently stipulated as a minimum standard.

Approved Document L2A refers the specifier to the second tier document produced by CWCT. This gives guidance on areas and trade-offs (2).

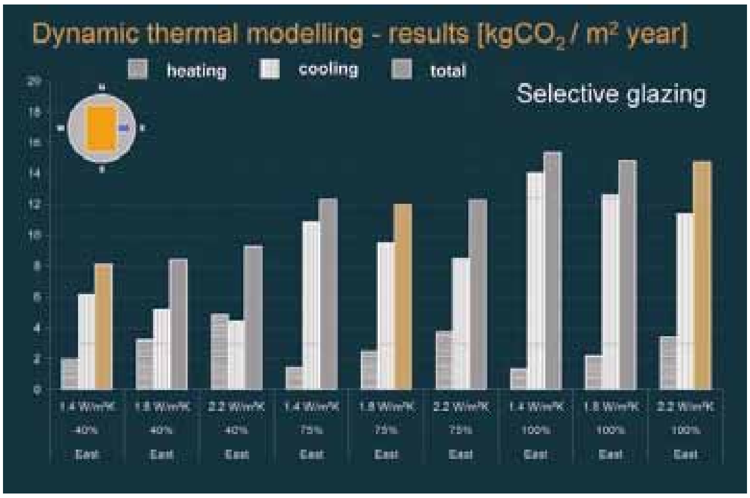


The Component parts of a curtain wall

Modelling

Kragh and Simonella described simulated tests carried out for the research: a single storey zone from an open plan office building 9m wide by 6m deep was modelled using in-house Arup software E+TA ROOM. The external curtain wall component was given different vision percentages from 40% to 100% and modelling was carried out at four cardinal orientations. The objective was to explore the sensitivity to changes in U-value for different glazing percentages and different exposures. Three different values for area-weighted overall curtain wall thermal transmittance (U-value) were modelled: 1.4W/m²K, 1.8W/m²K and 2.2W/m²K. The performance of the double glazing units was set at a common office specifications level: total solar energy transmittance (g-value) of 0.36 and light transmittance at 60%. The model was run using set occupancy, loadings, efficiencies and carbon intensity factors over the CIBSE Test Reference Year weather file.

The results showed that air-conditioning and high solar gains mean high levels of CO_2 emissions. More interestingly, the results also provided information on a possible grouping of the cases. The East and South facing facades with high glazing percentage (75-100%) resulted in the highest emissions. The relatively lower emission rate for the West facing façade is ascribed to the fact that, to some extent, the high solar gains lead to higher indoor temperatures outside of the occupied hours, which does not result in increasing cooling energy consumption.



The results also show that, for the high solar gains case (over 18kWh/m² floor area annual cooling energy consumption), there is a reversed correlation between the façade U-value and the calculated annual CO_2 emission rate due to heating and cooling. In these cases, a higher U-value leads to lower annual CO_2 emission rates due to heating and cooling. In situations with relatively high solar gains, an increased level of thermal insulation may lead to higher energy consumption as heat is 'trapped' within the perimeter zone.

The authors outlined the intrinsic value of the results by setting them against a real world scenario, where a client may require a highly glazed office. In this case, if the starting point is a 'high glazing percentage', then the value of thermal insulation depends on exposure. For the East and South '75%+' cases, the results displayed no CO_2 reduction for a reduction in U-value from 2.2W/m²K to 1.4W/m²K. For the North and West orientations, there is still a CO_2 reduction to be gained from enhanced thermal performance.

Applying a similar logic to the results, the solar gains will typically need to be controlled in order to both secure occupant comfort and reduce the cooling requirements. As a consequence, the 'high gains' scenario should preferably be avoided, which in turn leads to a situation where the enhanced thermal performance again leads to reductions in heating demand and lower CO_2 emissions. Put simply: when CO_2 emissions are brought down, either by reducing the glazing percentage or by introducing efficient solar control, then the U-values become significant again.

To achieve a realistic energy assessment, more sophisticated methods of verification of solar and thermal performance together should be integral to the design development process. While Kragh and Simonella's paper looks specifically at the fundamental relationship between solar/thermal and building energy performance, their next objective is to extend the assessment to describe the impact of dynamic facades with solar control and daylighting strategies. Further modelling would use the individual variants specific to a project or scenario. Future studies should look at naturally ventilated buildings, cost and payback times, occupant comfort and individual control.

(1) BRE Building Performance Group, 2006 Guide to Part L of the Building Regulations – Part L Conservation of Fuel and Power. Newcastle: NBS

(2) CWCT, 2006. The thermal assessment of window assemblies, curtain walling and non traditional walls. Bath: Centre for Window & Cladding Technology.

Society News

Membership Classes Announced

The annual general meeting of the Society of Façade Engineering was held on 28 March during the ICBEST conference. Delegates attended from Europe, the Middle East and Australasia.

Grateful thanks were expressed at the release of founding chairman, Ant Wilson, who has served the society for its first three years. Ant has been voted back into the steering committee to continue his work. Chris Macey was voted in as new chairman with Mikkel Kragh as deputy chairman.

The aims and objectives of the society were reviewed and approved. The long awaited membership classes were announced, allowing recognition of candidate's qualifications and experience in façade engineering. The classes comprise Affiliate, for students and other people interested in façade engineering; Associate, for those with some experience or qualifications; and Member, for more experienced people and those with higher qualifications and membership of a relevant professional body. Finally, the class of Fellow is for those with considerable experience in this field. Members and Fellows were encouraged to use designatory letters.

Further information is available by emailing **membership@facadeengineeringsociety.org**

Aims and Objectives of the Society

The Society has its aims as those of a learned society and as a qualifying body for the profession. Its aims are to promote the art, science and practice of facade engineering and the achievement of excellence in construction and to further the education and competence of its members helping to ensure the highest professional standards, the society aims to:

1.Act as a qualifying body for those active in the façade industry ensuring the highest professional standards are maintained.
2.Stimulate and coordinate a higher degree of cooperation between the various industry disciplines to drive forward the best value for clients whilst attaining the requisite aesthetic appearance, and ensuring an appreciation of how the façade acts as the primary environmental modifier.
3. Support its members to further their education and competence in the field of façade engineering.
4.Become the leading internationally recognised professional body in the field of façade engineering.

In seeking to achieve its aims, the Society will expect its members to achieve the same standards of excellence.

INTO THE VORTEX

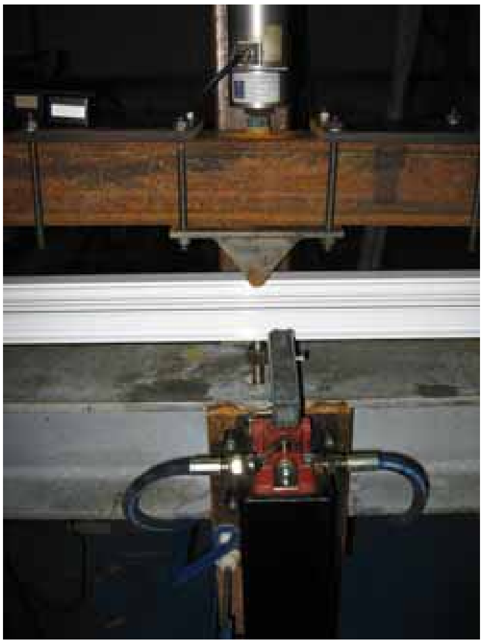
Drive past the Olympic park in Munich these days and you might be tempted to think that aliens have landed on the corner opposite. The seminal tissues of building envelope created by the engineer, Frei Otto in 1972 for the Olympic buildings have now been complemented by some equally challenging facades on the new BMW centre designed by Austrian architects Coop Himmelblau.

The new building is an extension to the headquarters of BWM, and is intended as major visitor attraction, celebrating the technology of the motor car and identity of the brand. The centrepiece is a spiral ramp leading up to the glass double cone, that Wolf Prix, its designer, refers to as, "The eye of the hurricane". This will be used as the dramatic backdrop for events such as the launch of a new model.

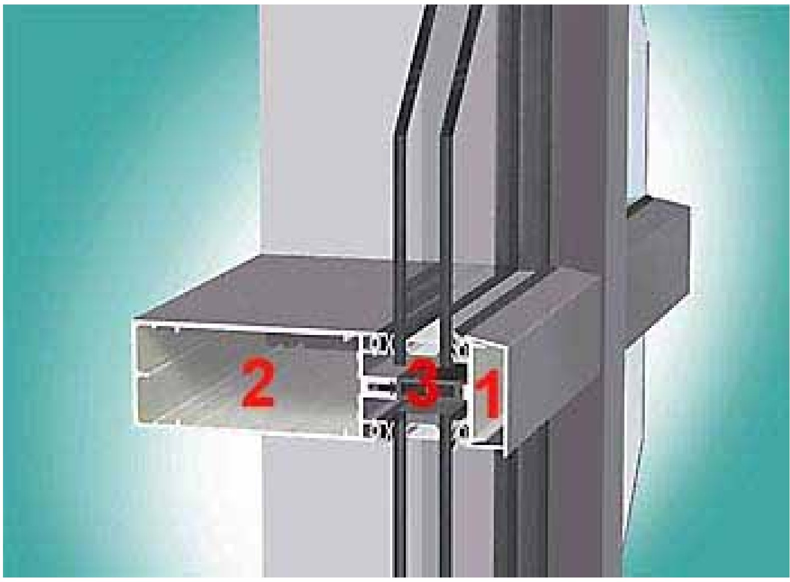
The facades are particularly challenging, being formed in complex 3D curves. The images show the sequence of construction with the building frame just visible behind the façade unit frames. A combination of opaque spandrel and transparent glass units are then fixed on.

The Society of Facade Engineering is running a symposium on Complex Geometry Facades on 7 November. Email membership@facadeengineeringsociety.org

The Effect of Thermal Breaks on Structural Performance



Right: component parts
Left: a profile under test



By Tim Cooke, Group Technical Director at Wintech

The introduction of BS EN 14024 **Mechanical Performance Requirements for Metal Profiles with Thermal Barriers** slipped in unnoticed by many with the industry, effectively entering the market "under the radar".

BS EN 14024 did not replace any previous standards and as such there is little to compare it with. It does however deal with an important issue that has largely gone unnoticed. This is the effect of thermal breaks on the structural performance of windows and curtain walling sections.

Historically the general consensus in relation to the structural effects of thermal breaks has ranged from those who assume the insertion of a thermal break would not affect the structural performance of the window, to those who make some form of allowance for the effect of it without necessarily understanding the reason for it.

In the past when thermal breaks were smaller and made of more rigid materials such as the pour and fill resin type, the effect of the thermal break on the structural strength of the section was minimal. Today, however, as we strive to better U values, thermal breaks are getting larger and their effect on the structural strength of sections is becoming more significant.

In today's industry it is common to use glass reinforced nylon thermal break sections that can be up to 30mm deep and this makes the situation somewhat different. To understand this more fully, we must consider the way the thermally broken section is constructed. Generally there is an external and internal extruded aluminium section with the thermal break section being slid into grooves and crimped into position by means of rolling the section through specifically designed machines.

When bending a combined set of profiles, a degree of shear stress is caused at the joints between aluminium and thermal break. To this end there are a number of important production based techniques that improve the shear strength of these joints. The issue is not that of slippage of the thermal break strip in the jaw of the aluminium profile, as some people might believe, but that of distortion of the thermal break profiles themselves by virtue of their relative lack of rigidity in relation to the base material, aluminium, when combined. If slippage does occur this is a far more serious problem to deal with.

Engineers used to applying a single Ixx value to a bending equation to predict the deflection of a mullion or transom may need to reconsider. The Ixx will vary due to the load induced deformation of the thermal break. The good news is, however, that this variation only occurs with the span of the bar between relative fixings to the building structure and therefore does not significantly complicate the business of calculating mullion and transom deflections. The real challenge is therefore to obtain the relevant "equivalent" Ixx values for the main structural composite sections being used.

The process of calculating the "effective" Ixx for an individual section is now covered in much more detail in the BS EN 14024 document than there is room for here. However the effect Ixx has on a particular section is interesting. For a fairly rigid curtain walling section with a span of 3 to 4 metres, the effect may not be too serious. Typically the values might be:

Span (m)	'Effective' $I_{xx(cm^4)}$	Percentage of monolithic I_{xx} value
2.00	345	91%
2.50	356	93%
3.00	363	95%
3.50	367	96%

The effect becomes more noticeable when lighter window sections are considered.

Span (m)	'Effective' I_{xx} (cm^4)	Percentage of monolithic I_{xx} value
1.50	9.5	78%
2.00	10.5	86%
2.50	11.0	90%
3.00	11.3	93%

From this analysis we note that the smaller sections that are generally only required to span up to 1.5 to 2.0 metres will perform up to <80% of their monolithic capacity, compared with about 95% for the curtain walling sections. This demonstrates that the effect will be more significant on window sections than on curtain walling sections.

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Sustainable Urban Mix

New Street square is a speculative development of approximately 1 million square feet for Land Securities . The site, near Holborn Circus, comprises four individual office buildings, grouped around a new public square and ranging in height from 6 to 18 levels.

The architect , Bennetts Associates, was keen to bring a strong sustainability emphasis to the project. In developing the façade design for each building, their approach not only embraced the role of the façade in moderating the internal office environment and reducing energy use but also considered the embodied energy in the selection of materials. The team were keen to explore alternatives to the increasingly common double skin all glass façade. It was felt that, by understanding, the principles of passive solar design and simple, single skin construction, diversity and layering could be achieved using a limited number of components such as brise soleil and articulated spandrel elements.

The office floor plates throughout the development have been designed in such a way that they could be fitted out with a choice of environmental control systems

Top: partially complete upper levels
Right: louvers on the west wall

including active or passive Chilled Beams, Chilled Ceilings or Fan Coil Units. This degree of flexibility meant that a limit of 110W/m2 of external heat gain was imposed on the façade design. The ratio of glazed to solid facade had to be carefully balanced with the needs of good daylight and effective shading. Apart from one building, facades are typically about 60% glazed. A large proportion of direct sunlight is kept off the façade by external shading to avoid direct and radiant heat gains. The design team felt, however, that a portion of direct sunlight should be admitted to animate the interior spaces. This generally happens at the top of the window where shading stops short of the top of the glass. A high level opening window was located here, which acts both as a smoke clearance vent and has the potential for night cooling of the space when combined with an exposed structural slab.

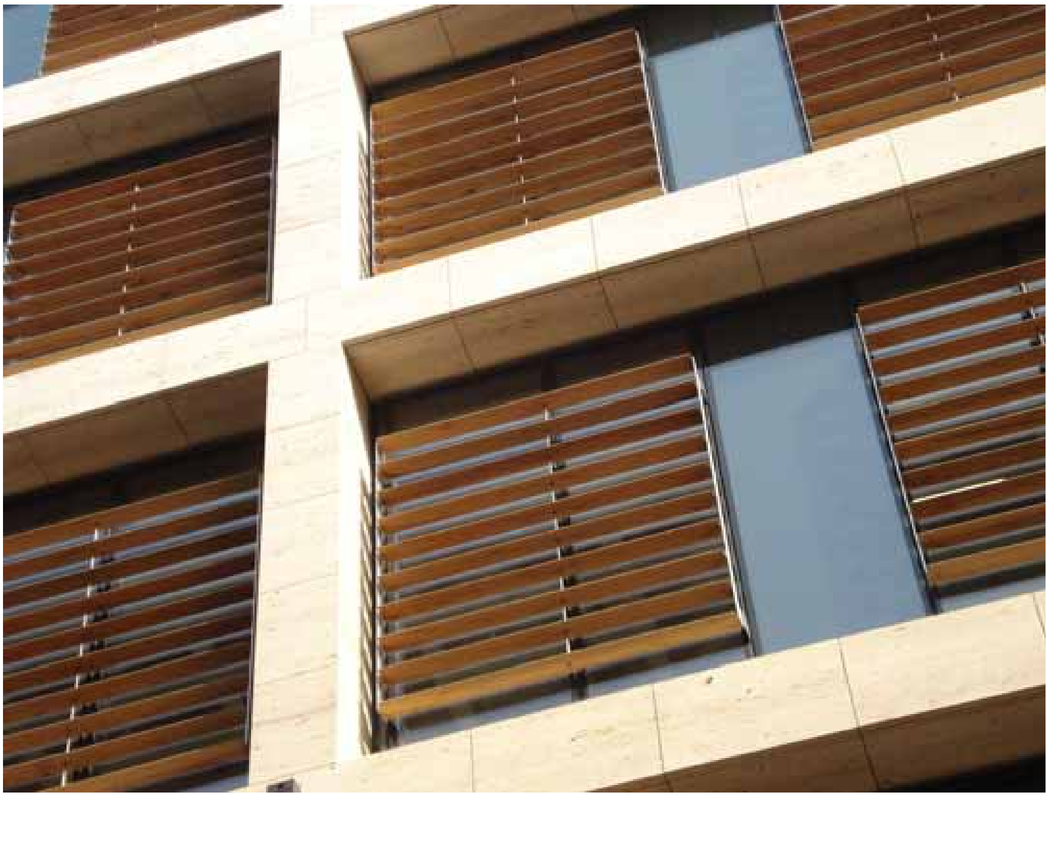
Three of the four main buildings have fairly regular, orthogonal plan forms while the fourth takes up the triangular shape of the remaining site area. Where external shading is provided on the orthogonal buildings, it is generally surrounded by a frame of precast concrete or stone elements which are directly expressive of the underlying flat slab structural frame. The tall, triangular building does not directly express its frame but, instead, is wrapped in a layered skin of glass and shading elements.

In selection of materials, it was felt that an opportunity could be explored to reduce aluminium usage through consideration of timber for shading elements which would have a lower embodied energy profile. Western Red Cedar was selected for its durability which, does not need to have applied finishes. For aluminium components, Polyester Powder Coating was selected as the finish as studies showed that transport emissions would be lower in comparison to the particular supply chain alternatives for anodising. To reduce packaging waste, the cladding panels were delivered to site on reusable steel pallets without plastic wrapping.

Bennetts Associates developed a close working relationship with D&B contractor, Sir Robert McAlpine, and cladding subcontractor Permasteelisa, who manufactured and installed the cladding for all four main buildings. Cladding panels were all preglazed unitised elements which were installed from the office floor plates. Precast and stone cladding elements were also procured and co-ordinated by Permasteelisa with their suppliers Loveld (precast), and Grant Ameristone with Hoffman (Jura Limestone).

The Final building is due for completion in April 2008.

Top: cantilevered west brise soleil wall and glazed north facade
Left: contrasting pavilion walls
Below: typical detail



boom time...?

Consider this image taken recently from the Thames towards the City of London. How many cranes grace the skyline? The answer is actually 24. OK, nothing, you say, compared to Dubai where boom means more than just part of a crane. The sight of Broadgate Tower hoving into view reminds us of the number of planning applications that are either passed or soon to be submitted for high-rise buildings in this area alone. Things are really looking healthy in the commercial property sector, with the announcement of the sale of the first building over a billion pounds, when HSBC sold its 45 storey Canary Wharf headquarters to Spanish property group Metrovacesa.

But this is just a small part of an industry on the boil: add to this the large scale urban regeneration master-plans that are going through planning (including the Olympic park); the continuing strength of the health sector; the retail renaissance; not to mention the demand for high and medium rise residential up and down the land, and you have what could be described as significant pressure on supply.

Boom town: Dubai is crane capitol of the world

What does all this mean for the cladding industry? Many UK fabricators are wary of rapid expansion and European contractors are being enticed back to their own markets and further east. Up to five European float lines going out of production this year for maintenance means that glass may rise in price by as much as 10%. Although aluminium has been steady for the last 6 months, speculation may drive prices upwards. The industry's greatest asset, its skilled labour force, is in short supply. The net result of these pressures can only be rising prices and longer lead times.

And what does the picture hold for the future in these uncertain times? Well at least we know that the skyline of our cities will be changed forever.

[continued from page 5]

It is essential therefore when evaluating the performance of thermally broken sections, that there is a full understanding of the basis on which the Ixx value has been calculated.

In conclusion, it is important that engineers involved in assessing the capability of window sections fully understand the implications of the thermal break, otherwise the deflections of these frames are likely to be more excessive than otherwise expected.

NOTE: Manufacturers of curtain wall sections with screw fixed pressure plates generally publish Ixx values for the structural mullion/transom box section only and are therefore not affected by the above.

Events

March saw the return of ICBEST, the International Conference of Building Envelope Systems and Technology to the UK, with 3 days of presentations, meetings and an exhibition at Bath University attended by over 150 delegates. Topics such as environmental physics, structures, materials, procurement and defects were covered in depth. Many interesting case studies such as the glazed facades of Suvarnabhumi Bangkok International Airport and the High Museum of Art in Atlanta provided some practical background to the theory.

All 44 papers are published in the conference proceedings, which is available from the Centre for Windows and Cladding Technology in book form, priced at £70 for members and £120 for non-members.

Call for Articles

As the Society of Façade Engineering grows, so does its magazine. But without paid staff, the magazine relies totally upon the input of members to supply articles, photographs and news to keep it going. If you wish to submit an article on your project, a technical feature, a date for the diary, or any other newsworthy item, please email the editor, Mark Taylor at editor@facadeengineeringsociety.org

Diary

28 October-1 November 2007 Interbuild at NEC Birmingham. www.interbuild.com

7 November 2007 SFE daytime event: Complex Geometry Facades. Further information will be sent to society members in due course.