Campaign for Accurate Simulation of Shading (CASS)

The ES-SO team have known for a long time that there are problems and inaccuracies with building modelling software. However, the ability to recently compare the actual results from a recent case study to those of the model of a leading international software tool has highlighted the extent of the problem. The analysis has only recently been completed and so this is a draft position paper that will be finalised at our next General Assembly meeting in April.

It is issued as a draft to highlight to our industry that inaccurate building modelling has a major negative impact on the specification of our products (and the lack of) in the building design process and also aims to gain support for further research of all building simulation systems.

We will be devising a strategy to educate and advise both our own industry as well as the architectural and engineering professions. This will be a process of awareness and evolution and will hopefully also develop into behavioural change of how occupiers use blinds and shutters in their homes and offices.

To support this campaign, e-mail your interest to Ann Van Eycken (ann.vaneycken@es-so.com) and we will keep you updated on the progress.

Thank you for your support.

Peter Winters

ES-SO President

1.0 THE CAMPAIGN

It is the mission of this campaign to raise awareness and demonstrate that it is the inaccurate building modelling simulation that is the cause of poor performing new buildings. This has detrimental effects on user comfort, health and creates unnecessary excess energy consumption. Change is essential.

Currently over 20% of new buildings in some countries are overheating[1]. This cannot just be coincidence. If the engineers and architects use building modelling simulations to design them in such a way, then here has to be a fundamental fault with the system.

The ES-SO position is clear. We believe one of the reasons behind this is the assumptions/predictions produced by building modelling software. To prove this, a real-life case study was conducted in London[2] in order to record its results. When the actual results were compared with its model predicted results, the limitations and inaccuracies of some modelling systems were exposed.

The results of the London case study are somewhat different to those created by a leading building modelling software model, to say the least. The case study recorded an operative indoor temperature of overwhelming 47.5°C in late September in an unshaded room whereas the software modelling has predicted that the maximum temperature throughout the whole year would not exceed 27°C. Such prediction is not just a margin of error and this confirms our suspicion that it is the software modelling that is the cause of overheating in new buildings.

As we all know, building modelling software is an essential tool for the design of any new building. As such, it should allow engineers to predict the building’s performance with reasonable accuracy. We accept it will never be an exact science due to the multiple and interconnected variables, but it should produce a good, reliable indication of the likely outcome. After all, this is what is required for compliance with building codes and regulations, for the architect to know their design works, for the client to know they will get what they asked for and expect, and for the occupants to be able to live and work in a building that is comfortable and functions well.

Unfortunately, it is clear that the simple predictive principle used in building modelling does not work in the case of solar shading as the case study clearly demonstrated.

2.0 THE HISTORY BEHIND BUILDING MODELLING PROGRAMMES

Most building modelling programmes were originally created to calculate the needs for air-conditioning. This seemed appropriate at the time when new technologies were evolving, and energy was cheap and plentiful. But time has moved on. The requirements for low energy consumption of new buildings are strict and have led to the drive to super insulate our buildings for winter when the sun is not shining creating overheating problems when it is. And this is not just in the summer as the case study proved. Overheating occurs in September and October too. Building modelling programmes work on many levels but some have not been adequately adjusted to reflect improvements in building design and products or current EN and ISO standards. And the way most of them work, they do not adequately consider and assess the true benefits of shading.

3.0 BUILDING MODELLING AND SHADING BENEFITS

We see several issues with modelling assumptions with regards to shading benefits and these are detailed in the appendices, but our fundamental concern is that with many leading and widely used programmes, there is either no provision to enter the values for shading at all (as in one leading example), OR when there is an input available whatever you input, the results are virtually the same regardless of whether shading was applied or not.

In our case study the modelling assumed/predicted that the maximum temperature difference between an unshaded window and a shaded one is no more than 1.5°C. We all know from experience that this is wrong.

The message that such building modelling sends to modellers is that shading makes such a marginal difference that there will be virtually no benefit in including it in the design.

We have found that there are adjustments within models that actually discount the value shading. For some reason, these are applied to shading but not applied to other building elements. For example, if a window is opened, the energy balance from the glazing is affected but that is not discounted. Neither is there an adjustment for the user failing to use the temperature controls on mechanical heating or cooling or other equipment, yet the fact is they do. Why then should adjustments be made because it is assumed that users cannot understand the correct use of shading?

4.0 IS YOUR MODELLING ACCURATE? HOW CAN YOU TELL?

If you want to know whether the modelling that was used is accurate, simply check:

- Is there a minimal difference between unshaded and shaded outputs?
- Does changing the different type or performance of shading change the results?
- Does it require inputs that conform to EN or ISO standards?
- Do the outcomes vary compared to the ES-SO typical building guidance example?

5.0 THE NEXT STEP – WHAT NEEDS TO BE DONE?

Olli Seppanen, former Secretary General of REHVA, highlights in his introduction to the REHVA Guidebook No 12 that shading needs to become the first consideration when specifying air-conditioning systems. Find out more in REHVA Guidebook No 12: "How to integrate solar shading in sustainable buildings."[3]

The need for shading is also supported by Prof. Mick Hutchins, the leading expert in complex glazing systems, who in his report *Dynamic Shading for Comfort and Energy Efficient in High Performance Buildings* clearly states that: "shading will always improve the performance of a glazing system".[4]

The correct integration of shading is also the approach recommended by ES-SO and is further detailed in Appendix D. Shading should be the first line of defence against excessive heat gains and can also efficiently assist in retaining heat when it is required. Calculating the benefits with the ES-SO/ESBO tool is an advisable first step that will help you uncover the true shading benefit potential.

Use the free downloadable tool available at www.es-so.com to compare the results.[5]

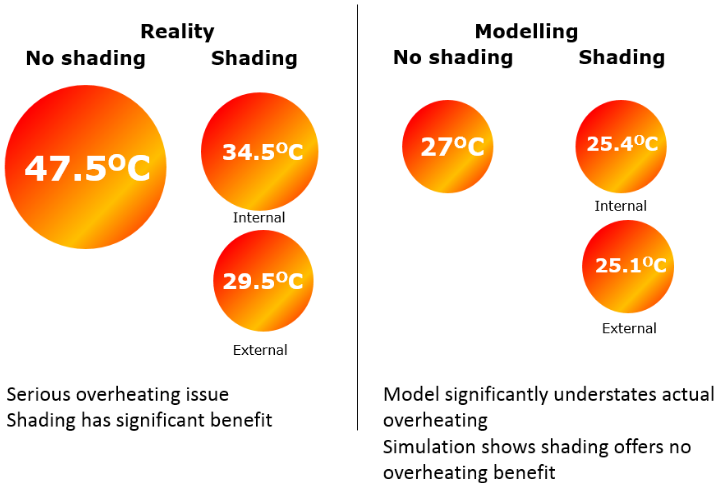
6.0 THE FUTURE – WHAT NEEDS TO CHANGE?

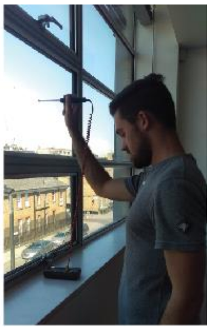
As global temperatures are predicted to rise, we must be designing new buildings not just for now but also for future weather patterns. Standards for building products have been updated to meet that need and understandably modelling should also reflect these changes. For now, the modelling remains the same.

User behaviour also needs to adapt. Those who have traditionally been using air-conditioning may be more inclined to spend money on cooling or heating rather than adjust the shading but as examples in Australia [6] and USA [7] where air-con use is more prevalent show, as energy costs rise, it is the poorest in society that suffer from the lack of suitable and affordable solution that shading undeniably is.

APPENDIX A - Omission Of Shading Benefits

The results shown below were obtained using a globally recognised and widely used dynamic building software package to model our case study. It was tested by a Building Services Engineer and validated by an independent study. [8]





Many modelling systems were originally designed as a method of assessing the load for heating and cooling. The validation is often to the default values for typical buildings in ASHRAE standard 140 [9]. That has only one type of building that allows for any shading and that is fixed. Moveable shading is not calculated on any of the typical buildings. The value is entered as “none” as if some value was added, but it is looked upon more as an obstruction to the ventilation.

In some programmes the shading outputs actually display a negative value compared to unshaded scenarios as there is an implied need for the increased ventilation. The logic for load calculation where air-con is the primary solar control misses the point that the solution should be to minimise the need for ventilation in the first place by using shading to prevent the heat gain rather than allowing the need to be created by not deploying shading and then dealing with avoidable consequences in a more expensive and less environmentally friendly way.

In some tools external moveable shading does not even exist as an input option. Whatever inputs you create for internal shading, the maximum benefit you would achieve is a temperature reduction of just over 1˚C. However, our case study results demonstrated that the temperature in the shaded windows was as much as 18˚C lower than the potential improvement shown in the model. This clearly highlights that the model is fundamentally wrong.

Many simulation systems are “black box” meaning you can only input data and cannot make adjustments to the type of inputs or the algorithms that calculate and alter the performance.

ISO and EN Standards for shading have been updated to conform with the changes in building techniques reflecting improved insulation and glazing performance necessary to achieve low energy building and designs nearing to passive house standards.

We believe it is of the utmost importance that modelling also reflects those changes and incorporates the requirements of those standards. Currently many do not.

APPENDIX B - User Behaviour – The Lack Of Data And Evidence

Many programmes require a predictive value for user behaviour.

The logic often applied is “we do not have information on user behaviour, so we cannot recommend shading as an energy saving measure as the user may not operate it efficiently”. Therefore, an adjustment in our calculations will be made for when shading is not in use OR simply we will not recommend it. On the same basis though, should lighting not be recommended or provided as the user might forget to turn it off when not needed?

The presumption that shading will not be in use, and therefore not provide it, is clearly not right. It assumes that user behaviour (or the implied lack of it when it comes to operating blinds) is the issue. But the fact is if you get hot, you will operate the blinds – that is if we have them. It is a natural reaction and as such mostly done subconsciously. For this reason, surveys of user behaviour may not work and correctly reflect user behaviour. If you ask somebody out of context whether they operated their blinds, what position they adjusted them to, at what time and how long for before they made another adjustment, they may have no recollection of any of this afterwards.

The shading is also presumed to be required for heating and cooling only but this is not the only benefit shading has to offer. Even on NW to NE facing elevations there will be issues of low angle sun creating problems with glare. These could be simply addressed by the correct positioning of the shading allowing the occupant to maximise natural daylight especially on dull days, so important for our well-being. Installation of clear glazing teamed with shading will also be more desirable.

Further assumptions are also based on the belief that where air-con is provided, the user will either turn it up rather than operate the shading, or that users will not use it at all because there is a lack of appreciation.

Overreliance on air conditioning is driving up power prices in Australia

January 3, 2018, University of South Australia

Credit: University of South Australia

A UniSA researcher has called for a change in Australia's building codes in the wake of a study which shows new homes can be less resistant to heat than older, double-brick houses.

In a paper published this week in the international journal *Energy and Buildings*, Dr. Gertrud Hatvani-Kovacs and colleagues also discuss Australians' over reliance on air conditioning, which is placing pressure on the grid, increasing electricity prices and causing more blackouts.

Dr. Hatvani-Kovacs, a Research Associate with UniSA's School of Information Technology and Mathematical Sciences, says Australia needs to change its approach when it comes to cooling homes in summer.

In a study of typical, single-storey brick veneer homes in Adelaide and Sydney during a heatwave, UniSA researchers found that a newer home with a 6-star energy rating used the same amount of energy to cool the

This could be the case when the sun goes down and the user is less likely to respond with adjusting of the shading and could turn the lights on instead. We also accept that those with air-con may choose to operate this rather than the shading.

Predicted use assumptions are not going to be realistic but it is irrational and counter-productive to deny users a benefit plainly based on the assumption they may not fully understand how to use it to save energy. We believe user education is the solution.

Appendix C - User Patterns And The Average Use Theory

Because much of the methodology is based on air-con and heating calculations, it requires an assessment of the 'average amount' of time it is needed in a year. In the assessment of when the expected load is exceeded, the user is simply expected to turn the controls up or down. This does not work for assessment of shading. If the programme determines that shading is not required, then there are no adjustments available and the user overheats.

There is a calculation suitable for estimating air-con loads that is also applied to shading. This application also has the effect of lowering and underestimating the real benefit.

In some programmes where shading is not completely disregarded, there are adjustments available based on the average time the user will put shading in operation. The programming prediction produced can discount the potential shading benefit by as much as 50%.

For example, let's take an external blind fitted in front of a low-e double glazed window with a G_{tot} value of 0.05. That indicates the total solar gain admitted through the blind and glazing of just 5%, meaning 95% heat rejection.

If this is adjusted by 50%, the figure becomes G_{tot} equivalent to 0.525 (52.5% admission) and only 47.5% rejection.

Many calculations offer even further adjustments that even seek to average results for each elevation. As in one example, the geographical position of Paris would require shading 36% of the time on the east elevation, 55% on the south, 30% on the west an 0% on the north. That is an average of 30.25%.

Such predicted outcome suggests adjusting shading on the assumption it is only required for 30.25% of the time thus in reality reducing the benefit by almost 70%. That would lead to the conclusion that a low-e double glazed unit will achieve the same result and further support the theory that there is no need for shading. In reality, even on a mildly sunny day you will need more than 30% heat rejection as otherwise you will overheat.

The consequences of inaccurate average use modelling results are explained in the Scotland Visitor Centre report where the modelled assessment predicted average temperatures of over 24°C for only one fifth of the time whereas in reality they actually resulted in those temperatures being exceeded for half of the working day.[10]

For predicted use where air-con is not provided, the calculations should assume that the shading is in position. It is then a matter of educating the user on how it should be operated.

For anticipated load calculations (where they are provided) there is always a significant tolerance factor added to any modelling calculation for loads in excess of expectations. The benefit of shading will result in an energy bonus discounting the need for it is counter-productive.

So, the question is: “Are user pattern calculations needed at all”? We believe the requirement to calculate the shading load is unnecessary. Unlike heating and cooling, the operating costs are minimal and the benefit of installing comes with a much shorter payback time.

Without any doubt there is a lack of awareness and guidance but the case for shading as an efficient means to controlling heat gain and heat loss is clear. Denying its installation and its use means also denying the opportunity to recognise and promote its benefits and to educate users on how to use these to their advantage. This leads to the exact opposite outcome where energy is wasted rather than saved.

APPENDIX D – Calculating In The Correct Sequence

Most programmes calculate the additional benefit of shading rather than the actual benefit.

The reality is that external shading is the first line of defence in preventing heat gain and internal shading in preventing heat loss. But currently it is the glazing (that the shading needs to stop from allowing the heat to accumulate excessively or from allowing the heat to escape) that is assessed first without shading. This subsequently leads to unnecessary specification of more expensive glazing. This does not need to happen. If the model assessed the benefits of the shading before that of glazing and other building components, the overall outcome of the building loads would be drastically different.

Solar gain, if controlled in the first instance by shading, is a powerful tool. It can reject up to 97%[11] of the heat gain, which means that the glazing performance as such becomes almost irrelevant. Even with single-glazed clear glass the result could be as high as 93% heat rejection.

This suggests that the importance of glazing is related more to heat retention rather than rejection that can be successfully achieved through shading. But equally, if suitable shading such as internal cellular blind with static air gaps is applied, it can create a powerful, first line of defence that will improving the overall insulation of the building. Yet again, the current methodology calculates the glazing first and then deducts that property from the benefit of the shading.

The Early Stage assessment from the ES-SO/ESBO tool[5] will provide a good indication of the benefit but for a detailed assessment, the calculation method of ISO52022/3[12] should be used. This considers each layer of the complex glazing system and clearly identifies the shading benefit. This is described in detail in the ES-SO guide *Solar Shading for Low Energy and Healthy Buildings*[13] and in the report by Prof Mick Hutchins[4]

APPENDIX E – Shading And The Type Of Control

There are adjustments in some programmes that differentiate between manual and automated operation. Typically, this assumes that a manual blind will be in position no more than 50% of the time and an automated system 75% of the time.

It is implied that automated systems could be over-ridden by users and their efficiency could be compromised. But with modern apps and weather monitoring systems that we have now the over-riding very quickly becomes inappropriate and undesirable especially if users are educated and understand how these systems work. They are ultimately responsive to the outdoor environment and therefore more effective than manually operated shading as these are geared for optimal comfort.

Partly driven by the need to find solutions for the child safety issue of blind cords[11], our industry has developed motorised solutions that especially in the home are now much more affordable with many solutions half the cost of what they were 4-5 years ago. Those price reductions are also beginning to affect the cost of web-based controls that are a fraction of the price they once were. The cost objection to motorisation would not be valid when compared to the alternatives[12].

There needs to be a recognition that the trend for automation will accelerate due to decrease in cost and this will be a significant contributor to behavioural change and consequent reductions in energy use.

Manually operated blinds have zero operating costs and their installation costs are minimal compared with operating costs of other heating and cooling devices. User operation is detailed in Appendix C.

APPENDIX F - So What Is The Effect If We Do Not Consider Shading?

Just suppose we were wrong in that shading is not required. But why does virtually every window have a blind fitted? In commercial buildings that cannot be just for decoration, it has to be because there is a need. If they were not deemed necessary in the design stage, then it has to be because the user has consequently identified a problem that needed addressing and justified the additional expenditure.

The consequence of any subsequent fitting is almost always a more expensive and less than ideal solution. By transferring the specification from the designer/engineer to the facilities team, the tools to achieve the best performance are not available, and certainly not in the same price range. In a domestic situation the consumer is even less aware.

The provision of appropriate and most suitable shading devices at design stage is therefore crucial. Providing education on shading use is important and this has been identified as a weakness in some countries. It is the responsibility of the shading industry to work to improve the understanding and back this up with accurate data, training and education[13].

APPENDIX G - How Else Can Shading Be Beneficial?

Focusing building modelling on building load calculations completely overlooks other essential shading benefits, in particular light and glare control.

Attempting to tackle daylight and glare problems without shading does not provide the best solutions. Glazing and air-con do have an important part to play, but dynamic blinds and shutters offer a much-needed holistic approach if acknowledged at design stage when they should be considered alongside ventilation and artificial lighting. Only then the maximum natural daylight can be realised.[14]

Shading needs to be treated as part of the building services, not just the decoration at the window. As detailed in the BVST study[15], it should be considered as air-conditioning for the glazed parts of a building.

We all naturally understand the advantages of shading. Our bodies are attuned to seek it in hot conditions. Even though humans have changed from living 90% outside to 90% of our time inside over the last 100 years, this does not mean that our bodies have adapted to excessive heat. If our eyes, see the sun our brain tells our body it is hot.

That was confirmed by a study by Loughborough University[16] on the effect of photochromatic glazing that had been fitted in a test room. They found that the occupiers operated the pre-existing blinds rather than relying on the glazing that did not adjust sufficiently to effectively provide a solution.

There are many further reasons for needing shading and detailed explanations can be found at ES-SO's *Solar Shading for Low Energy and Healthy Buildings* available from www.es-so.com and at http://www.es-so-database.com/index.php/knowledge-base

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References

1 https://www.shadeit.org.uk/resource/zch-overheating-homes-big-picture/

2 De Grussa Z., A Case Study assessing the impact of Shading Systems combined with Night-Time Ventilation strategies on Overheating within a Residential Property Proceedings of the joint 38th AIVC, 6th TightVent and 4th venticool Conference: "Ventilating healthy low-energy buildings", Nottingham 13- 14 September 2017

3 http://www.rehva.eu/publications-and-resources/eshop/eshop-detail.html?tt_products%5BbackPID%5D=1560&tt_products%5Bproduct%5D=40&tt_products%5Bcat%5D=3&cHash=9ee0aab2677ef586b60244bce3c1e5c5

4 https://bbsa.org.uk/uploads/pages_653_5a93c70399b55.pdf

5 http://www.es-so.com/tools/esbo

6 https://phys.org/news/2018-01-overreliance-air-conditioning-power-prices.html

7 https://bbsa.org.uk/uploads/pages_653_5a93caf834a59.pdf

8 https://bbsa.org.uk/uploads/pages_653_5a93cb90e0200.pdf

9 https://www.ashrae.org/File%20Library/Technical%20Resources/Standards%20and%20Guidelines/Standards%20Addenda/140_2007_b.pdf Table 7-51

10 www.es-so.com/images/downloads/Downloads%20publications/BRE_Scotland_Visitor_Centre_-_Simulation_Based_Window_Blind_Assessment_Best_case_Renson.pdf

11 www.makeitsafe.org.uk

12 http://www.rehva.eu/publications-and-resources/eshop/eshop-detail.html?tt_products%5BbackPID%5D=1560&tt_products%5Bproduct%5D=40&tt_products%5Bcat%5D=3&cHash=9ee0aab2677ef586b60244bce3c1e5c5

13 https://www.shadeit.org.uk/resource/national-energy-foundation-solar-shading-impact-report/

14 www.es-so.com/images/downloads/papers/Brochure_SolarShading_screen_LR.pdf

15 https://www.shadeit.org.uk/resource/co2-reduction-external-venetian-blinds/

16 Preliminary findings of a case study into the application of electrochromatic glazing in a UK office Ruth Kelly, B. Painter, K.N. Irvine & J. Mardaljevic De Montfort University, Leicester, UK and The James Hutton Institute, Craigiebuckler,Aberdeen, UK Loughborough University, Loughborough, UK