ARCHITECTURAL SIMULATION FOR SUSTAINABILITY

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Summary

For more than a decade simulation programs have been readily available for architectural designers. Prediction of the energy or climatic response on built structures has become faster and more reliable. New monitoring procedures integrated with intelligent instrumentation allow for a plethora of new design solutions. Sustainability is finally an electronic and technical factor of any architectural repertoire.

However, the issue is still widely neglected by both professionals and politicians, which in our opinion can result in negative consequences. The co-writers of this paper have even gone so far as to define the current situation as a “spirit of tragedy”. The implications of architectural simulation are far reaching, its costs almost negligible. From the lack of prediction of indoor climate within architectural spaces only errors and waste of energy can be expected in a contemporary building market, where no tradition of environmental concern coming from builders or future inhabitants seems to prevail.

Furthermore, architectural competitions which are mainly based on old schemes that do not require any demonstration of the energy or environmental output of the proposals, increasingly resemble fashion shows or *acte de foi*, since no commitment is expected or demanded between the designers and the final users of the architectural product. Moreover, very often foreign firms get commissions without any experience of local weather or ecological problems, often referring to their projects as “groundbreaking” and “provocative”.

We firmly believe that we should not provoke nature and instead we ought to search for symbiosis with natural environments in an intelligible way, so that every layman could understand and even check this aim, and this is called simulation in science. The adoption of this preventive attitude in the decision-making process is urgent, lest we want to be too late to produce real sustainability in the town-planning and building sector. This is what we would like to stress with our contribution.

1. Precedents of a simulation-oriented architecture

The idea according to which architecture on the whole or at least important components of the buildings could be modelled or simulated to some extent is not a new one. As the natural sciences evolved, architecture which was traditionally connected to such developments also benefited from the new approaches and tried to extend them into the domain of construction.

Structural and environmental issues were typical cases in which the aim to predict the future behaviour of a building was conspicuously sought for.

Already by 1815 Sir John Soane said in his lecture number 8, that: “perhaps in no part of our art is there so little to be learnt from the ancients as in respect of the due warming…of rooms” and touched on the means of controlling a building’s thermal environment.

When rational architecture, later referred to as “sachlichkeit” or “objectivity” in the 20th century, began to be firmly established, several well known pioneers of the modern movement adhered to this attitude. Especially we could mention among them Hannes Meyer and Bruno Taut

Bruno Taut had good occasion to experiment with the former ideas when he was forced to become an exile in Japan where no previous tradition of modern architecture had been established and the climate did not fit in the patterns of European weather conditions. Thus he adduced: “Hence until now Japan cannot have her own architecture if it is not developed according to her own climate. However this is very difficult and even impossible in the short term for the Japanese themselves. Some centuries can pass before they are prepared to act in this way without the help of foreigners.”

Figure 1 . Bruno Taut in his “ tokonoma” in Shôrin-san near Takasaki

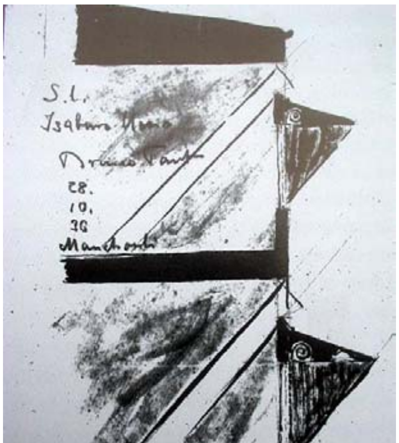


Figure 2. Bruno Taut’s sketch to control light and glare while ventilation runs unimpeded

In a famous sketch of 1936 drawn in the train in Manchuria, he discussed a solution that would increase lighting levels in the upper planes of the rooms and would require a more consistent use of western furniture, designed and sold by him. At the same time the façade is kept in shade and protected from heavy rains but proper ventilation is not impeded.

Figure 3. Detail of the pliable window designed by Taut in the Hyûga House at Atami (Japan)

Several other features for light, movable fenestration were implemented in the Hyûga and Okura Houses showing an amazing concern for environmental demands in a country that was not his own. These elements can be justly considered, despite the scarcity of means, as precedents for a simulation-intended architecture.

In the case of Hannes Meyer it is known that he had included considerations on daylighting and thermal or acoustic comfort in several well known projects like the Peterschule in Bassel of 1927, and the Building for the United Nations Society. The syllabus that he proposed as one of the latest directors of the Bauhaus, speaks clearly in favour of his environmental-prediction trends. When he also had to leave Europe and settled in Mexico for many years his ideas on climatic simulation attained unsuspected utility.

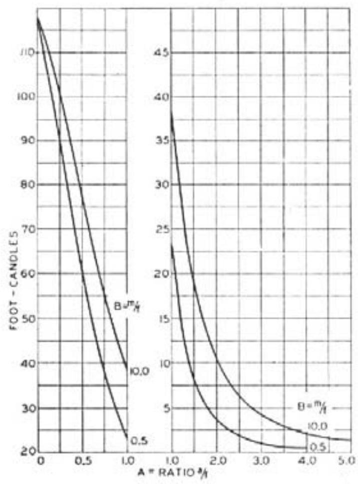


Figure 4: Detail of lighting calculations depicted in the Peterschule Project in Basel (Switzerland); they were based on the recent work of the Engineers Higbie and Levin of Michigan (USA) and it is very surprising that they were known and used in Germany only one year after their publication.

Meyer developed most of his career in Mexico in a climate totally different to that of Central Europe and it is understandable that he had to rely on scientific prediction methods to ensure adequate performance of his buildings, but he also needed the will and disposition to follow this environmental trend.

Such was the example of many others, like Otto Koenisberger who fled from the Nazi regime and established a practice in Bangalore (India), Ladislav Hudec in Shanghai and Antonin Raymond in Japan

2. Caveats and frequent errors

Soon it became customary to introduce tested vernacular elements in all kinds of exotic projects, Le Corbusier, Utzon, Kahn, Aalto, Sert, the Smithsons, Drew and Fry, and Minette de Silva are some of the many architects that convincingly adopted such ideas.

Many of the first attempts were carried out mainly by intuition, and some of the architects who had advocated the introduction of science in the design processes were not especially keen as scientists themselves, which consequently led to considerable errors and in some cases caused them to totally abandon the simulation aids in later projects as is the paradigmatic situation of the prominent architect Oscar Niemeyer

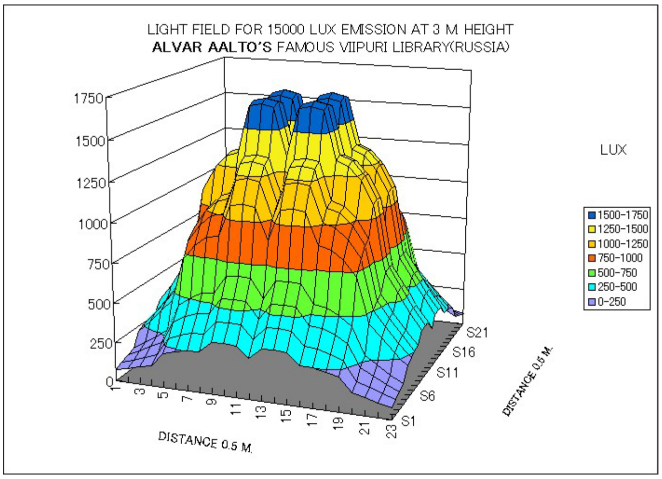


Figure 5. Simulation conducted by the authors, of the famous conical skylights in Viipuri library by Alvar Aalto. This often celebrated solution to achieve even daylight without glare at all times of the year shows some inconsistencies and drawbacks when analysed from a scientific point of view.

3. Necessity of a new approach

To avoid counter-productive repetition of the aforementioned drawbacks, we have suggested that scientific support be a requisite in all environmentally-oriented projects. This support should appear under the form of user-friendly computer tools or architectural engineers and consultants when such tools are not available. The advances in design and simulation should be carried out in parallel and the results have to be checked during and after construction including surveys on the level of user satisfaction.

Following this procedure we have recently completed some design features in several climatic zones for new and retrofitted buildings. We will describe briefly some of our simulations for radiative transfers, both thermal and luminous.

The governing equation is the classical:

$$d^2\phi = E_{bi} * \cos\theta_1 * \cos\theta_2 * \frac{dA_1 * dA_2}{\pi * r^2}$$

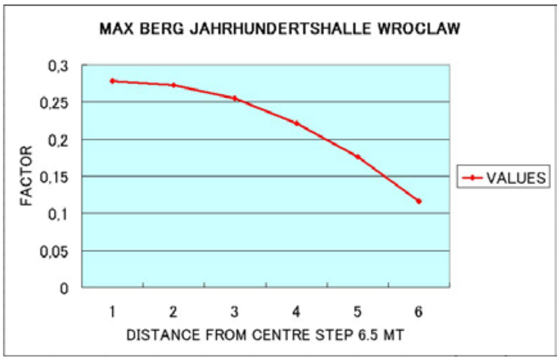
Knowing that *E* (emittance or illuminance) is not constant but can be considered as such for most building surfaces

$$E_{bi} = E(\theta_1, \theta_2) \neq cte.$$

And the typical solution for diffusive materials is,

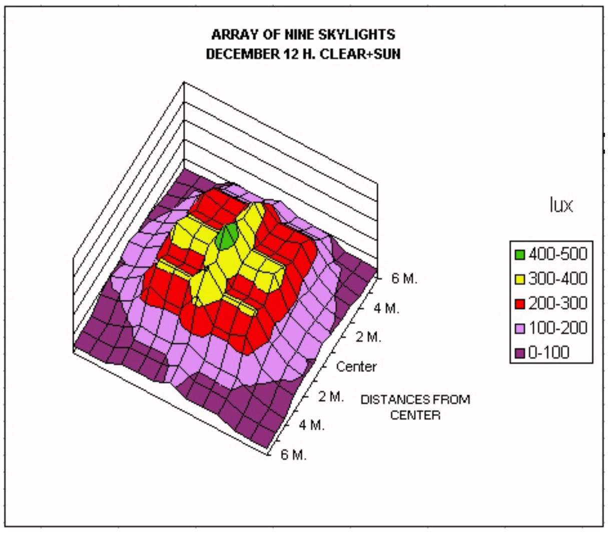
$$E = \frac{L}{2}\Big[\ \arctan\frac{b}{D} + \frac{a\cos\varphi - D}{\sqrt{a^2 + D^2 - 2aD\cos\varphi}} * \arctan\frac{b}{\sqrt{a^2 + D^2 - 2aD\cos\varphi}} + \frac{b\cos\varphi}{\sqrt{b^2 + D^2 sen^2\varphi}} * \Big\{\arctan\frac{a - D\cos\varphi}{\sqrt{b^2 + D^2 sen^2\varphi}} + \arctan\frac{D\cos\varphi}{\sqrt{b^2 + D^2 sen^2\varphi}}\Big\}\Big]$$

3.1 Max Berg's Jahrhundertshalle in Wroclaw (Poland)

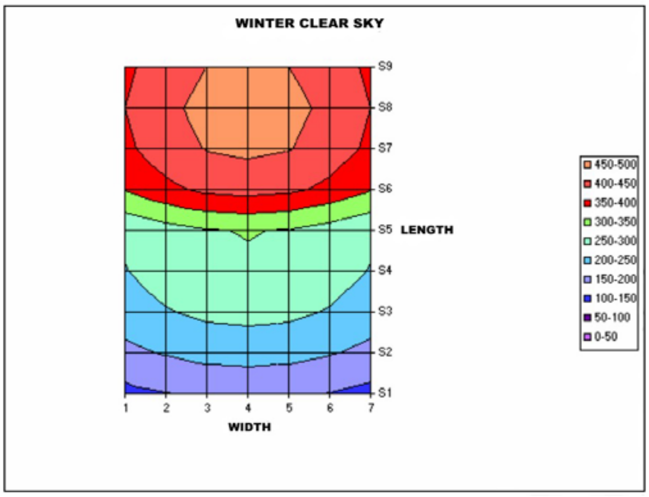


3.2 New Skylights in the Schools of Egebjerg (Denmark)

With Cenergia Energy Consultants



3.3 Retrofit of the Archaeological Museum of Seville (Spain)



3.4 Office Building Development in Gelves (Spain)

4. Conclusions

Provided the increasing depletion of environmental resources it is urgent that we revive the tendency to evaluate the future results of any given architectural product by simulation. This has to be carried out well before the construction of any facilities has started and should be enforced at a global scale by regulations, and mainly in the developing countries.

Sufficient climatic data and information technology do now exist as to make this process affordable and cost effective. Building construction cannot remain isolated in the process to fight against global warming and future hazards, or in other words, we will be forced to resist the increasing pressure of urban speculation with the help of science if mankind is to strive for sustainability,.

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