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Authors
Chen, Hosea
Park, Rebecca
Wu, Sabrina
et al.

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ENVIRONMENTAL DESIGN: SOLAR ENVELOPES AND WORKPLACE EVALUATION

Interview with Giovanni Betti

BY HOSEA CHEN, REBECCA PARK, SABRINA WU, AND ELETTRA PREOSTI

Giovanni Betti (MA, MSc) is a licensed architect in Italy and the UK with over ten years of professional experience in a wide variety of innovative international projects. His work focuses on the link between environmental performance and architectural design. As an Associate Partner of the Specialist Modelling Group at Foster + Partners, he has contributed to the development of architectural spaces such as the new Apple Campus (Cupertino, USA). In 2015, he moved to Berlin to found and lead the Performance Based Design Team at HENN. Currently, he is an assistant professor in Architectural Design for Building Performance at UC Berkeley. In this interview, we discuss Betti's research on solar envelopes and workplace evaluation.

BSJ: Growing up in Italy, what experiences fueled your passion for urban infrastructure and workplace design, and what led you to continue your research in the U.S.?

GB: I know that everyone has their own fond memories of childhood, but I think that growing up in Italy, and in particular Rome, has allowed me to enjoy a very storied urban environment. The school of architecture is in the heart of the historic city centre. Even if I was living in the periphery, I remember cycling to class so that I could explore the little streets and alleyways of Rome. In fact, my Master of Architecture thesis back in 2005 was about the feasibility of a distributed bicycle network, which is a common enterprise now. For me, the concept of using an emerging technology to piggyback on the historic fabric of a city that was obviously not designed for cars was really intriguing. The work from this thesis really started my fascination with urban fabric and architecture.

After I finished my Master of Architecture in Italy, I moved to the US for a year to get a Master of Science in Built Ecologies at the Rensselaer Polytechnic Institute (RPI). Back then, the field of sustainability and environmental design had just started emerging. What brought me to this field was a sense of duty; I felt I could not be a good architect if what I did was not good for anybody other than my clients. After RPI, I moved to London and afterwards to Germany for both work and familial reasons. My research at the time was essentially a journey of trying to find some sort of clarity for myself on a number of questions. I eventually realized I could not pursue those questions while working for other businesses that had different interests; I wanted to have more agency in directing my own research questions. That was when the opportunity to join Berkeley came up. I applied out of the blue, and here we are.

BSJ: What is a solar envelope? Why is it important for buildings to get sunlight, and why specifically two hours as some regulations suggest?

GB: The solar envelope is a virtual solid figure that architects can use to make building designs that adhere to a certain set of conditions related to the sun. This idea stems from the nexus between building design and health. Access to daily sunlight heavily affects the lifestyle and health of residents, especially because direct sunlight produces an almost germicidal effect that promotes hygiene of the living space. If we can ensure that buildings, especially living quarters, are getting at least a certain amount of direct sunlight every day, this access improves both the residents' overall health and their environment. The regulation for two hours of sunlight referenced in the study is specific to China, where these rules are quite strictly enforced and often drive the urban form. For example, a lot of designs for Chinese residential blocks consist of repetitive units with certain heights and distances between them to ensure that each resident receives at least two hours of daily sunlight.

These regulations also vary by locality. The goal in general, though, is to set certain regulations that will ensure that, even in the depths of winter, most residents will still have some direct sunlight in their living quarters. In this case, the solar envelope would be the area under which all of the adjacent buildings can receive those two hours of daily sunlight.

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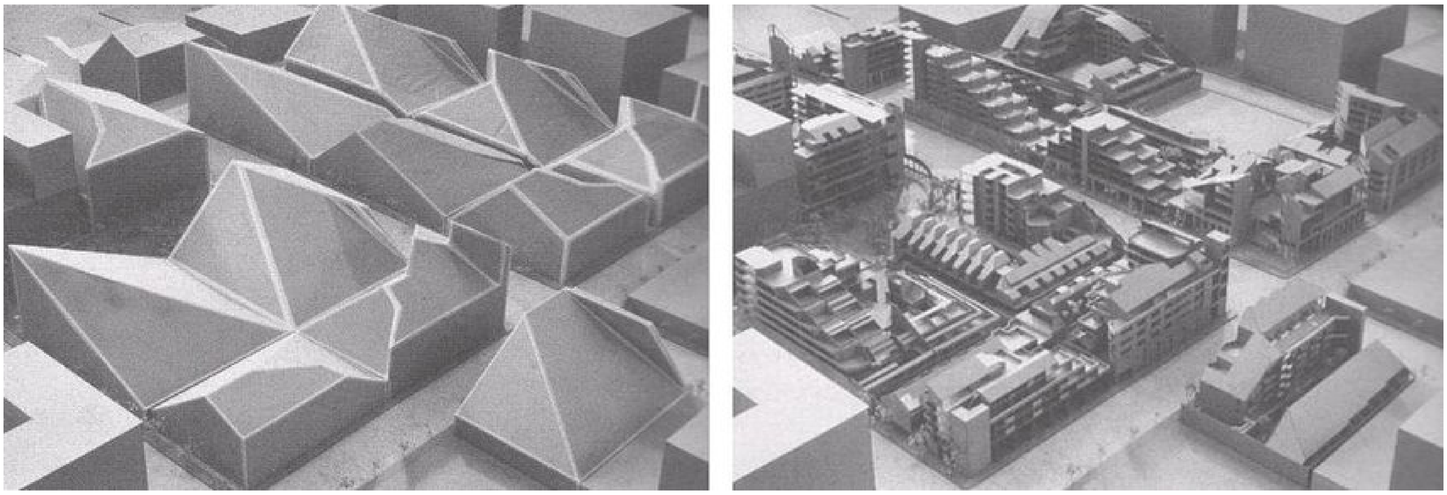


Figure 1: An illustration of solar envelopes on a portion of Los Angeles' Spanish street grid system (right) and buildings within those solar envelopes (left). *Reprinted with permission.*

BSJ: What factors are taken into account when calculating solar envelopes?

GB: There was actually a competition in China which we won that called for the design of a cluster of towers just south of an existing residential development. We wanted to find a way to sculpt the solar envelope more effectively. The methods for developing a solar envelope at the time were primarily focused on geometric spacing, which usually results in quite a conservative solar envelope that does not give you the full possible building height. This is because architects at the time treated each building as a homogenous, binary structure whose surfaces collectively receive the same hours of daily sunlight. We resolved to subdivide the elevations of the surrounding buildings in a number of sensor points where we could calculate sunlight availability. With this information, we then used a recursive approach to grow virtual towers by adding voxels, or units of volume, to our stack while iteratively checking whether we still complied with regulations. By adjusting this model with compliance information, we were able to develop models with a more nuanced approach. In this way, we were able to maximize the height of the towers we wanted to build while preserving the solar access of the residential structures. In the end, we actually managed to have a solar envelope that was larger than the one that we would have gotten with the simpler, binary geometric spacing method.

BSJ: How does your new differential growth paradigm work?

GB: In the model, we have vertical towers that we grow by adding units. After deciding the size of these units, we can check whether the addition of the units would still allow for us to remain compliant with the solar access regulations. Basically, rather than a top-down approach where we would cut down the homogenous model to fit the hypothetical sunlight vectors, this is a more bottom-up approach, where we literally let the solar envelope grow to its maximum size. We can then influence growth ourselves by making the solar envelope grow faster in areas where we want to have more height or more mass build and adjust designs from there.

BSJ: One of the tools you used to design the differential growth model was the Ladybug add-on for the Grasshopper plug-in for Rhinoceros. Can you explain what this tool is?

GB: Nowadays, when we design, we live in this paradigm of "computer-aided design" (CAD). One of the most-used CAD softwares for architecture is Rhinoceros 3D, which is very good for early-stage conceptual studies and all non-standard applications, such as solar envelopes, as it does not make too many assumptions about what a building should look like. Then, inside of Rhinoceros 3D, we have a plugin called "Grasshopper"—which is, interestingly, a visual programming language that uses directed acyclic graphs. These graphs are essentially a series of interconnected nodes which manipulate the way in which data flows. Because data is manipulated by each node, we also have the ability to write proper code in C#, Python, etc. So, it is really great in that sense, because it is a relatively easy way of doing non-standard things. Ladybug and Honeybee are another couple of plugins inside of this ecosystem that relate specifically to solar geometry and environmental analysis.

BSJ: How does architectural design impact an employee's experience in the workplace in terms of interpersonal communication and productivity?

GB: We currently live in a world of digital communication. Even though remote work has proven that we can work without physically being in the same place, we can all acknowledge that there is a lot missing, especially if the work we need to do consists of innovative content. Specifically, when people are isolated, they find it more difficult to produce innovative content. In fact, isolation is probably the cause of most of the struggle accompanying remote work.

Additionally, we lack the unplanned casual encounters with our peers and colleagues that spark innovation. As architects, when we design a workplace, we build a story that tries to understand and enhance who our client is. We ask, "What is the company, and what are its core values?"

We hope that certain building configurations can lead to

"We currently live in a world of digital communication. Even though remote work has proven that we can work without physically being in the same place, we can all acknowledge that there is a lot missing, especially if the work we need to do consists of innovative content."

a higher volume of innovative content being produced. But, one thing architects struggle with is how to get actual evidence that their structures actually have a certain effect. For example, with company feedback, we know a space that is seemingly "inefficient" due to a lack of work areas might actually be loved by everyone and become a social hub where the identity of the company is formed. Even though employees are not "productive"or do not talk about work in this space, it is still valuable to the enterprise because if there is social cohesion, there is a sense of common purpose and camaraderie. Both of these spur lateral thinking, innovation and a greater sense of purpose and belonging. However, while we know this information anecdotally, there are not enough studies on how we can scientifically determine what will work and why. To solve this problem, I actually borrowed a lot of techniques from urban analysis, which tries to understand how people perceive urban space.

BSJ: What are the indoor connectivity, indoor visibility, and indoor environmental scores used to analyze different workspaces? Why did you choose to analyze these factors?

GB: When we run an analysis or create a model, we simplify reality one slice at a time—often, the smaller the slice, the better. But we need to acknowledge that humans do not perceive reality through such a narrow lens; rather, they are influenced by a number of factors.

In this study, we quantified these factors into three main scores: the indoor visibility score, the indoor connectivity score, and the environmental score.

For the indoor visibility score, I first considered that when we navigate through space, the vast majority of information entering our brain is visual. That is why, as architects, we primarily focus on the visual experiences of people. Thus, I used the visibility score to encompass visible lines of sight, especially in workplaces where people often frequent.

I associated the indoor connectivity score with mental maps. It has been proven that there is a very sharp decay of face-to-face communication in the workplace with increased distance between individuals. So, the probability of me talking with someone who is just four meters away is much higher than the probability of me talking with someone that is forty meters away.

The environmental score is based mainly on daily access to sunlight and is a proxy for the overall environmental quality of a space and its effect on human behavior. For instance, we know that a more pleasant environment is a healthier environment: it is nicer to talk to somebody outdoors where it is sunny rather than indoors where it is darker. In our study, we plan to look more closely as to whether conversations happen more often or if they tend to last longer in environments that have daylight compared to those that only have access to artificial lights.

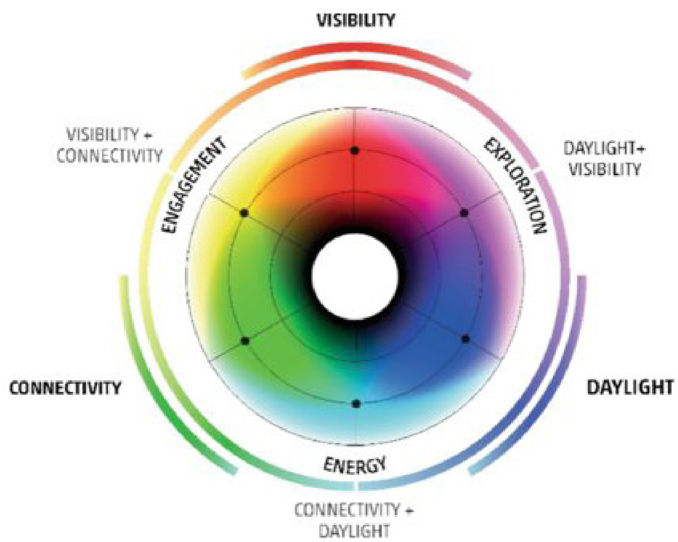
BSJ: What is isovist sampling, and how did you use it to analyze the visibility score?

GB: Isovists are used to trace the area of visible spaces in order to determine various properties. Conducting analyses on the complexity of isovists allows us to use them as tools for examining the quality of spaces. For example, imagine that you are inside of a perfectly square room. If you are standing at the center of the room, the isovist is going to be a square. On the other hand, imagine that you are instead inside of a forest. Now, since there are a lot of trees, the isovist is going to have a star-like appearance, similar to a sunburst. We can then relate these descriptions to, for instance, the presence or absence of visual interest.

BSJ: After generating the multivariable map model, you applied it to three buildings. What parameters did you consider in choosing these three buildings, and what was the purpose of applying the model to these buildings?

GB: The primary reason we analyzed these three buildings is that they are three milestone workplaces. The first building, built in 1965 for Osram, is a milestone in architectural design because it is the first completely open plan, free-seating arrangement office. The idea is that, in addition to having no individual offices, the furniture is clustered on the large open plan depending solely

Figure 2: This diagram depicts the interconnectedness between connectivity, daylight, and visibility—the factors being measured to calculate the connectivity, environmental, and visibility scores. *Reprinted with permission.*



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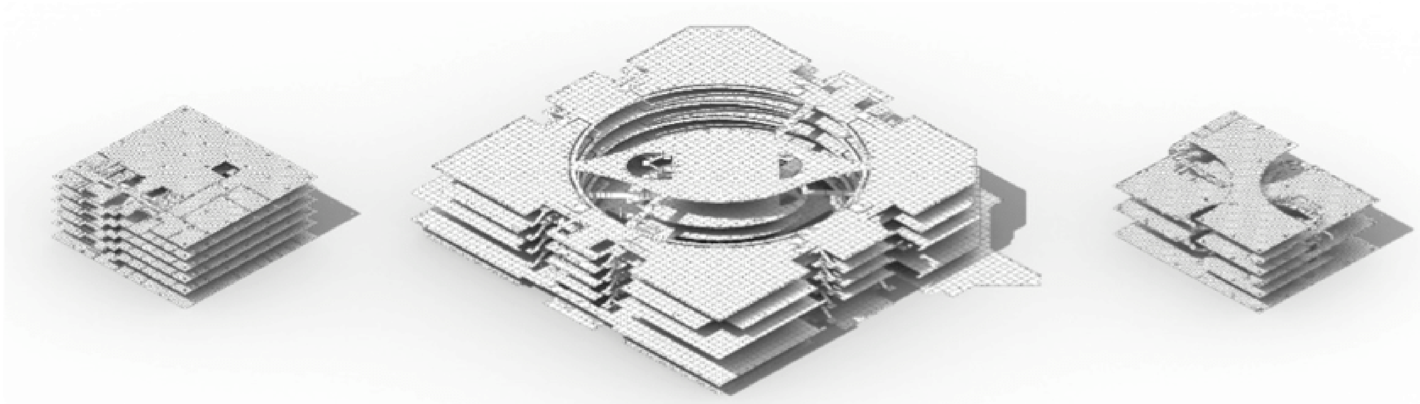

Figure 3: Extracted analysis meshes of the three buildings: the "OSRAM," the BMW Innovation Center, and the Merck Innovation Center. Reprinted with permission.

on the current workplace activities in order to provide flexibility for reconfiguration. This project was seminal and inspired so many open plan offices.

The second building we studied is the BMW Innovation Center, completed in 2004. It is a much larger building than the OSRAM and focuses on the idea of travel distances, which are calculated using different walking speeds and delays from one location of a workspace to another. One key feature of this building is its central hub where everyone can come together and exchange information.

The third building, the Merck Innovation Center in Darmstadt, is about the same size as the OSRAM. Like the OSRAM, the Merck Innovation Center also has an extremely free arrangement of furniture. While in the Osram building you can see a clear separation between circulation (i.e., stairs, lift lobbies, etc.) and office spaces, they are completely enmeshed in the Merck Innovation Centre. The idea is that moving through the building, going to your desk is not a lesser activity than concentrating on your work: in order to be productive, creative and connected with your colleagues, the office environment needs to provide you with a rich social environment that allows for both concentration and interaction.

Overall, it was really interesting to see how these buildings would reflect different ideas of what a workplace should be like and how we could capture these abstract concepts with tangible metrics. I was specifically interested in investigating how we can move towards this understanding of connecting daily productivity with the overall mood, atmosphere, and feeling of a space. One disclaimer: I was not involved in the design of any of these three buildings.

"When we run an analysis or create a model, we simplify reality one slice at a time—often, the smaller the slice, the better. But we need to acknowledge that humans do not perceive reality through such a narrow lens; rather, they are influenced by a number of factors."

BSJ: What changes do you hope to see in future calculations of solar envelopes and in the design of future workplace environments?

GB: I hope that solar envelopes become more frequently used as a tool for urban design, as it will make designing healthy urban landscapes easier. Moreover, with a more fine-tuned understanding of solar envelopes, architects no longer have to plan homogeneously distributed urban volumes. In this way, we can have more healthy and varied buildings, not just cookie cutter architecture. In terms of workplace design, we are living in a moment of big upheaval. I think that we are going to see a lot of changes. Specifically, we will see a persistence of mixed modes of work, where part of a person's work can actually be done more effectively at home. Consequently, the social nature of the workplace is going to grow in importance, and we will have to recalibrate between focused and open-ended work.

This interview, which consists of one conversation, has been edited for brevity and clarity.

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