Generative and Performative Design: A Challenging New Role for Modern Architects

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Abstract

There is increasing pressure on design architects to both design well and meet a diverse range of often quite stringent performance criteria. This is stimulating a wealth of new approaches to the building design process. Generative and performative design now take a lot of the issues traditionally dealt with by consulting engineers late in the design process and bring them right up front into the earliest, most conceptual stages and very much into the domain of the design architect. To be most effective, this requires of the designer a much greater understanding of building physics and environmental principles, and even the ability to utilise high-level modelling software or write scripts to generate and manipulate complex geometry. These skills are already impacting on the range of subjects offered in some architecture schools. This presentation looks at the drivers of change in this area and the range of skills that new architects will likely need to meet these challenges.

Keywords: generative design, performative design, design process, conceptual design.

1 Introduction

Achieving the high levels of efficiency and performance being demanded of our buildings is requiring new approaches to the design process. Many of these require new skills and a level of proficiency and understanding not previously considered necessary for design architects. By looking at the concepts and methods employed in some of these new approaches, and considering the drivers behind them, it must be possible for architectural education to pre-empt many of the new skills and knowledge resources needed for graduates to not only survive in this changing environment, but to help surge the whole field forward.

2 Generative Design

In the context of this presentation, Generative Design is taken to mean the manipulation of one or more aspects of a building's form or materiality in response to the results of a progressive series of performance calculations. In this way the geometry, material properties and/or operational characteristics of a building can be optimised to meet specific performance criteria.

2.1 The Generative Design Process

A generative design process requires three things:

- *Performance Metric*: One or more calculation results that can be derived directly from a computer model or calculation, providing a quantitative or qualitative indication of building performance. This can be as simple as a single number or as complex as an entire annual load profile. However, it must be possible to construct an unequivocal numerical test by which to determine an ordinal relationship between the results of multiple analysis. This usually means being able to judge the results of one calculation to be better/worse, desirable/undesirable, greater/lesser or above/below another.

- *Configuration Variation*: This is some aspect of the physical configuration of the building model that will be manipulated or changed before each consecutive calculation. This could be as simple as the width of a window or the thickness of insulation in a wall, or as complicated as the entire building form. This aspect is usually the real focus of the problem as the automated manipulation of complex building geometry is still a developing field. It is usually the main difficulty as well. The key is the ability to use script commands or a model generator to make changes that will affect the selected performance metric(s) and allow differences to be judged.

- *Decision-Making Response*: A means of determining which configuration parameter should be varied and by how much in response to each consecutive analysis result. Whilst ideally mathematical optimisation techniques would be used to 'home in' as quickly as possible on the most appropriate model configuration, it is often just as useful at early design stage to incrementally 'approach' a required target or randomly generate values and test for the best results. However, from the numerical test on each performance metric, it must be possible to either judge that the required target has been reached or to compute the magnitude and/or direction of subsequent variations such that results tend more towards desirable than undesirable values.

2.2 Generation and Optimisation

Resistance to generative systems has always been high within the building design industry - for good reason as the issues involved are very complex and there is often no obvious solution to any particular set of design problems. Also, every building is usually a compromise between a vast array of competing requirements. Rarely can a building element be truly optimised for any particular use or application, but instead must be flexible and adaptable to many different uses. Thus, when faced with many competing criteria, the best design solution is often the 'least worst' option.

However, this should not preclude the designer from at least knowing what the optimum for a particular application would be. In fact this is how most designers work - they know exactly what they would like to achieve, but then have to work within the constraints of budget, brief and regulations to achieve the best they can. This is the primary skill of a designer - assimilating a myriad of complex and competing requirements and then making the best set of compromises from a wide range of available options.

Of most significance here is that designers can work equally well with both objective (quantifiable) and subjective (unquantifiable) constraints. In fact, at the earliest stages of design it is only really possible to work with subjective issues as there is insufficient hard information about the building to calculate many of the objective criteria. Computer systems on the other hand tend to be of little use in tasks that involve subjective or unquantifiable parameters, but excel at objective tasks with clearly defined and quantifiable parameters, and with highly repetitive or iterative problems.

Thus the aim of generative design is to achieve the best compromise. Computational analysis and simulation can make a significant contribution at the very earliest stages of design by generating optimal solutions to very focused and tightly defined aspects of the design problem. The results may not be immediately and directly applicable, but provide useful information for the designer to assimilate within the broader design context.

3 Performative Design

Performative design does not, as the name might suggest, mean focussing solely on meeting performance criteria through the manipulation of form. Instead, it means deeply considering the wide array of building performance issues simultaneously with other aspects of the design right from the earliest, most formative conceptual stages. It thus refers to the synthesis of performance and form generation engaged with at a time when the design concept is still sufficiently plastic and pliable that it can be shaped as much by these considerations as any other.
Performative design is only possible because the tools for simulating and analysing buildings are becoming increasingly fast, flexible and easier to use. This means that they can be used by designers and applied to even the simplest block models, allowing their results to be effectively integrated into the early design churn of ideas. It also means that ideas can be pursued, rigorously tested and accepted/rejected very early in the design process.

4 Regulations and Standards

Over recent years government regulations and building rating schemes have become the major drivers of performance-based design within the building industry. Whilst there are a number of design firms who have been developing and applying these techniques over many years, it is only legislation resulting from Kyoto, the European Directive on the Energy Performance of Buildings and high-profile voluntary assessment schemes such as BREEAM and LEED that are making these issues mainstream. Given the incremental nature of government regulation and the growing adoption of LEED internationally, it is clear that the pressure on architects to design well and still meet stringent performance criteria will only increase.

Not all building regulations have a positive effect on performative design. At their core, regulations set the absolute lowest standard that a society will tolerate – a performance threshold that must be met even by the most amateur, incompetent or unqualified practitioner.

These thresholds are typically set well below best practice, however a large number of designers treat them as targets in and of themselves and design solely to meet them. Much of this has to do with how individual regulations are framed. Where compliance is limited to a simple pass or fail, there is little incentive for a designer to go beyond that particular threshold.

4.1.1 A Scaled Approach

On the other hand building rating systems and voluntary assessment schemes tend to provide a scale within which buildings can be compared, allocating stars or setting bands that clearly distinguish high performance from standard practice. Such schemes engender an entirely different mindset. Both the industry in general and designers themselves are rewarded for striving for and achieving increasingly high levels of performance in their buildings, if only in status and recognition.

It is also clear that clients are attracted to scaled rating schemes as they provide a means of distinguishing and marketing their projects. With the client on board, the time, resources and backing are more readily available for designers to pursue innovative approaches to achieving high-performance design.

4.2 Environmental Management Systems

The historic United Nation's Conference on Environment and Development in Rio de Janeiro in 1992 sparked a series of initiatives around the world to develop viable approaches to sustainable development. One of these efforts involved forming a technical team within the International Organization for Standardization (ISO) to develop voluntary environmental management standards, from which evolved the ISO14001 standard for Environmental Management Systems (EMS).

The aim of an EMS is to establish within an organisation the commitment to a systematic approach to reducing the impact of all the environmental aspects over which it has some control. The EMS is the set of processes developed by that organisation to implement, document, and execute all the elements detailed in ISO14001, and to ensure that both management and staff understand and support the organisation’s commitment.

4.2.1 The Impact of Environmental Management Systems

ISO 14001 is all about establishing a continual feedback loop in which environmental impacts are identified, steps taken to reduce them and measures used to ensure a positive effect. The EMS is a formal management program so documents and records must be controlled, training must be conducted and recorded, responsibilities must be clearly defined, measurements must be taken and corrective actions fully documented. Additionally, ongoing audits require the ability to track back through process documentation and clearly identify the basis on which all major design decisions effecting environmental performance were made.

This is the first major impact of an EMS within a design firm. No longer can decisions that impact design performance be left implicit or their effects ignored. The EMS requires explanation, documentation and evidence to support all important decision-making processes. There must also be evidence that a range of different performance measures have been considered in some way. This more explicit nature of decision-making allows more members of the design team to be involved and informed. Decisions are more open to scrutiny, meaning that potential ideas or solutions can come from a wider range of participants with a wider range of experience and skills.

The second major impact is the requirement to demonstrate ongoing improvement. This can be very difficult for a design practice as performance measures will vary with the type and size of projects currently being undertaken. There are only two real changes that firms can implement within the ISO14001 feedback loop:

- Refine and improve the workflows undertaken by staff, and
- Educate and train them to make them more effective.

If the EMS includes an ongoing training programme and can both measure and demonstrate an increase in the skills and experience of its staff, then ISO14001 registrars have been willing to accept and certify this. Also, by aiming to get all team members to interact on a daily basis with environmental design issues (not just a single green guru), the EMS is able to greatly empower and increase the knowledge assets of an entire firm (and by implication the general profession).

5 Education and Skills

Whilst an EMS manages the overall design process, modelling and analysis tools facilitate the detailed simulation and calculation that underpins the range of different performance measures and design decisions-making tasks required. Education and training at this very detailed and applied level is just as important as any other. Whilst enthusiasm for environmental design is laudable, the knowledge, skill and capacity to actually see it through is critical.

The field of building performance and environmental design encompasses a wide range of different knowledge areas, from lighting to energy, acoustics to air-flow. Even qualified environmental consultants do not profess to be experts is all areas. However when it comes to the application of analysis tools, this is not as readily recognised. Experienced users of ECOTECT or IES are often assumed to have mastered every aspect of the program and therefore capable of any kind of analysis. Unfortunately this is not always true.

As a vendor of building analysis software, Square One sees this problem quite often - with young architects who quote ECOTECT experience on their CV being tasked with diverse lighting and thermal analysis projects even though their actual proficiency was originally limited just to one area such as shading or solar radiation. This requires that practitioners better understand the diversity of knowledge required and that range of actual skills users are likely to have.

5.1 Discrete Knowledge Areas

In an attempt to address this problem, the SQUARE ONE Training Programme has been developed. This delineates the diverse range of concepts and practical skills required for effective environmental design and analysis into an initial series of 14 discrete topic areas.

1. Acoustic Design	*6. Environmental Impacts*	*11. Shading Device Design*
2. Air Flow & Ventilation	*7. Geometric Modelling*	*12. Solar Radiation Analysis*
3. Artificial Lighting	*8. Noise & Noise Control*	*13. Thermal & Energy*
4. Building Energy Codes	*9. Programming & Scripting*	*14. Visual Impact Analysis*
5. Daylight & Sunlight	*10. Shadows & Reflections*	

Figure 1. The initial fourteen discrete topic areas identified for building analysis.

The system also sets out five achievement levels within each topic area that building designers and users can progress through.

LEVEL	ACHIEVEMENT	TITLE	CONTRIBUTION
1	Understanding	Novice	View
2	Capability	Capable	Assist
3	Proficiency	Proficient	Produce
4	Expertise	Expert	Manage
5	Innovation	Eminent	Innovate

Figure 2. The five achievement levels within the SQUARE ONE Training System.

5.1.1 Achievement levels

Achievement levels are designed to give structure to the process of learning each aspect of building performance and analysis, helping designers understand the steps they need to take to progress their development and what each step will enable them to do. Figure 2 shows a summary of the different levels within this particular programme.

This system of achievement levels has three major advantages:

- It allows both new and experienced team members to quickly assess their overall levels of skill and understanding in each area and provides a clear path for improving both their awareness and effectiveness in design projects requiring performance analysis support.

- It breaks up the required knowledge base into a series of discrete and achievable chunks, linked together by a clear logic so as not to be overwhelming.

- It provides an effective means by which design firms can objectively rate, deploy and manage the range of capabilities of different team members within each project.

The last of these points is by far the most important. The structure of the industry is such that the design of large buildings is predominantly a team effort, and often a very large one. No matter how great the enthusiasm or brilliance of individual team members, if the process as a whole does not perform effectively, chances are neither will the building.

For a design project to be effective, it needs team members with a diverse range of skills and contributions to make in many different areas. Not everyone can be a manager. Similarly, not everyone can be a novice. Such a system offers firms an infrastructure by which they can understand the skill levels available within their staff, identify areas needing improvement and actually measure and verify their progress. This represents a major step towards closing the feedback loop required by ISO14001.

6 Conclusion

In addition to an increased level of proficiency and understanding of building performance and environmental principles, it is new skills such as writing scripts and computer programming, not typically taught to architects, that are proving to be a major contributor to the building design process. It is often those designers who have adapted and developed these skills to better integrate performance analysis at the earliest stages that are increasingly designing the buildings best able meet our current environmental challenges.

Architectural education will follow, but it can play a more important role by taking analytical skills more seriously, introducing more architects to computer programming and script writing concepts, and raising the profile of building performance as a major consideration within design studio.