

Hyperdomes

Non-standard roofing structures, technological evolution and distinctiveness in urban environment

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Abstract. *The development of new shapes in architecture has deeply influenced the current perception of the built environment. The analysis of the processes behind this evolution is, therefore, of great interest. At least two well known factors, influencing this development, may be pointed out: the great improvement of digital tools and the tendency toward building distinctiveness.*

In particular, the innovation of digital tools such as parametric modeling is resulting in an overall diffusion of complex shapes, and the phenomenon is also evident in a clear expressionistic search for architectural singularity, that some might consider as a negative effect of globalization trends.

Though, if we can consider as a positive result the fact that parameterization allows a deeper control over design factors in terms of reference to cultural, historical and physical context, at the same time such control possibilities are sometimes so stark to be even auto-referential, stepping over site-specific parameterization, to create unusual shapes just for the sake of complexity.

The ever-growing diffusion of generative design processes is in fact going to transform niche procedures, frequently limited to temporary decontextualized structures, into an architectural complexification as an end in itself.

The hypothesis of this paper is to demonstrate that site-specific parametrization can be considered as a tool able to translate intentions into shape; it is necessary, for this aim, the widening of the meaning of the word singularity.

Keywords. *Urban environment; distinctiveness; non-standard roofing structures.*

INTRODUCTION

The need for new shapes in architecture has brought a great development in techniques and processes able to control and manage the building construction. It is worth to focus on two factors of this evolution, the improvement of digital tools and the

tendency toward the building distinctiveness. The aim of this work is to define the which digital tools produce distinctive shapes, by analyzing a set of significant case-studies through times.

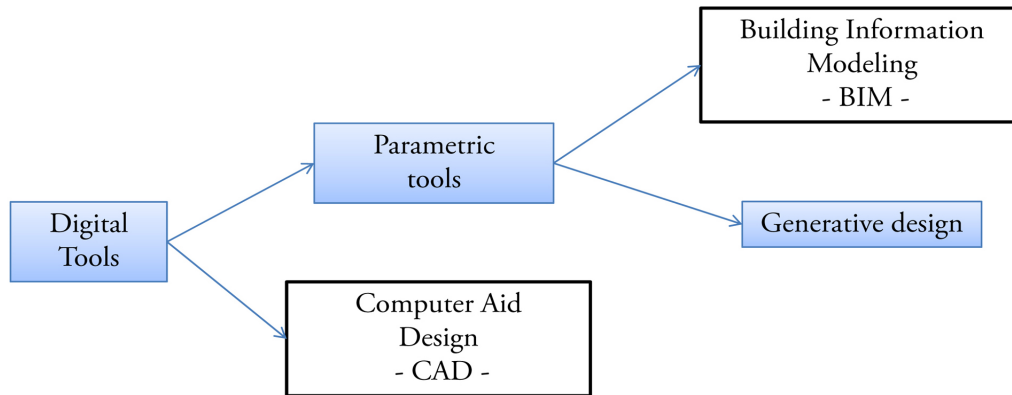


Figure 1
Digital tool scheme. Boxes in blue are the tool families of interest for this work.

DIGITAL TOOLS

We refer to digital tools as a generic expression to define a giant umbrella of different software, which are very different in aims and efficiency. It is therefore useful framing the parametric tools into a narrower family of design instruments. The use of parametric tools for design complex shapes creates new methods, often unexplored, to describe a comprehensive notion of building performance.

The meaning given to parametric tools is worth to be deepened because of relative youngness of this discipline, which lacks of acknowledged notion. There are at least two families of parametric tools that are radically different in methodologies and finalities. The framing applied to this work has been schematize in Figure 1.

The first is the Building information Modeling (BIM), widely used to optimize building performance with a certain degree of constraint. The limit of BIM is the creation of new shapes, which are not pre-build inside the software.

The second family, which is of higher interest for this work, is that corresponding to the so called generative design tools. These digital tools that works in strict connection with coding, which embraces an area of knowledge quite far from traditional architectural design procedures. In this case the architectural form is defined through code, made by declaring variables and constants, by writing

instructions, routines and by running an algorithm until the shape which performs better is reached. The final shapes are so produced only by a sequence of instructions that produces a result. The designer isn't the only actor in the shape creation process, because it is paired with the machine results, which might go beyond the starting idea. In fact the initial shape design, might even be developed into something unpredictable at the start of process. So it is essential to focus the attention on the component that directly modifies the production design, which is the code.

The code writing, as an act of creation, corresponding to the designer's intention, gives complete freedom to choose the road to the shape definition. This freedom is partially constrained in controlling the resulting shape, which may go beyond the choice of the preferred shapes. It is so introduced a disruptive innovation in the design process, which changed deeply the ordinary design method.

The ordinary design process is made of a circular correspondence between the mental knowledge of the shape and its final representation. In generative design, instead, the effort is focused in thinking about the code that will produce the shape, until the desired shape is reached. The resulting shape, therefore, is generated with an indirect procedure, not by direct modeling and editing of shape. In this sense,

two classes of design process drivers may be outlined, external and internal: site-specific parameters and building related parameters.

USE OF TOOLS – SITE SPECIFIC AND BUILDING RELATED PARAMETERS

Site-specific parameters are made by the elements of the urban environment that influence the building in its components. The effect of these external constraints is evident in some aspect, as the external skin of buildings, but it may influence the structure and the functions of the generated spaces. The application of these specific parameters is important to provide the building with the correct contextualization within the neighboring spaces. It is therefore important to understand the rules that define the urban environment to better set up parameters that will characterize the building, giving it the character of distinctiveness. The use of these elements points out the importance toward building located in urban environments, which are endowed of their own characters, which cannot be ignored.

In parallel with these elements, collected from external environment, it seems important to underline the importance a second class of factors, the building related parameters. These may be defined as the set of relationships established within the geometric elements of the building skin. This approach works perfectly with art installation, which is needful by itself. The aim of this design method is to give a complex and appealing perception to buildings because for some kind of aesthetical need, a lack of intricacy in shape is perceived as a lack by a large part of designers. This need is largely fulfilled by the use of generative design tools, which easily generates an auto-referential complexity. With these specifics, it is easily understandable how the generative-design tools have been pointed as the next-generation step in the evolution of design process.

SHAPE DISTINCTIVENESS

The innovation of digital tools, is one of the two drivers in new shape generation, the other is the tendency toward distinctiveness.

The singularity is intended as a recognizability of a building in an urban environment. It is considered at the same time as internal and external character of architecture that has to relate to imageability of the shape, considering its connection with urban environment.

Internal singularity is related to the distinctiveness of structural and technological performance of architecture which makes exceptional a building in itself. External singularity, instead, is the recognizability character of the architecture on a larger scale, making it a relevant element of the urban environment. A parallel can be set with the relation between internal and external singularity and the aforementioned connection between building-related and site-specific parameters, as pointed out in Figure 2. The strict relation between the tools for form-finding and the pursued aim creates a disruption in the process of singularity creation. The linear process where tools creates the singularity is transformed into a design loop where tools create complexity, and the singularity generates new parameters to drive the software.

Despite the tools limitless shapes creation, their complex approach and the steep learning curve, keeps away from the use outside academia and top-notch designer.

So that most of the buildings created with the generative process are endowed with internal singularity because they are small-scale architectural manufactures, pavilions and temporary installations that are designed intentionally ignoring the connection with urban environment.

This tendency toward singularity wasn't so definite through the times. It is to be underlined, in this sense, the denial of monumentality, in Le Corbusier's architecture.

Therefore it has seemed uncompleted conducting an analysis of this phenomena, limiting the analysis to contemporary buildings endowed with external and internal singularity, so it was chosen to consider the domes, which have always been distinguishing elements of verticality emerging in horizontally dominated urban environment.

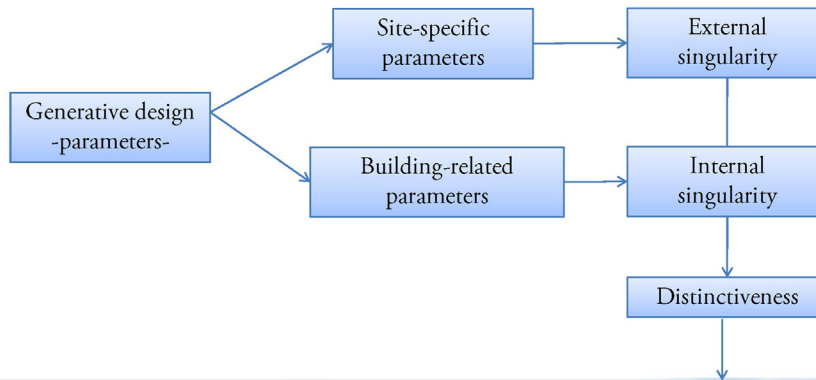


Figure 2
Shape distinctiveness: the case
of the Kunsthaus emerging in
the roofscape of Graz.



FROM DOMES TO HYPERDOMES

The meaning of dome, intended as a “large hemispherical roof or ceiling” (Merriam Webster dictionary) has a deeper significance connected with the its function in the past. In fact the spaces too wide to be covered with normal ceilings, were closed with hemispherical roofing structures. One renowned example of these issues is the cathedral dome of Santa Maria del Fiore in Florence. The base of the dome was built in 1315 and it remained unfinished until 1436. It took more than 100 year to be finished because at that time nobody was able to design a cover for such a span of space, until Brunelleschi, in 1418 conceived a series of structural and strate-

gies to achieve such aim. The dome issue is shown in Figure 3 in which Andrea di Bonaiuto, painted the Church before Brunelleschi’s design. The depicted dome is a fake because in 1350 there was no built dome, just designs. because of the complexity of the aim. Therefore Santa Maria del Fiore dome may be considered as a reference example of non-standard roofing structure clearly emerging in an urban landscape. Further Case studies for these past domes are the XVII century Sindone dome by Guarino Guarini in Turin (Figure 4 left) and the XIX century San Gaudenzio Church dome by Alessandro Antonelli, in Novara (Figure 4 right).

Figure 3
Detail in Santa Maria Novella
from “Spanish chapel” 1350.
Santa Maria del Fiore is
depicted with a fake dome
because it wasn't possible at
that age to build a real one.



HYPERDOMES

The domes as a symbol of this phenomenon have been transformed through times into a more complex form of architecture, rather similar to a singular roofing structure than to a classical structural element. In this work the non-standard roofing structures (as architectural elements to be considered in the broader sense) are acknowledged as key elements to select specific study cases, where the higher level of complexity of non-standard structures can create points of singularity within the context.

When it came the need to define these special non-standard domes, it was necessary to specify a word for structural elements which were a compromise between geometrically defined domes and mesh structures. Therefore the term “hyperdome” will be used in this work to widen the meaning of domes including all the roofing structures which

creates singularities in urban skylines.

As traditional domes produced a break in the skyline of cities in the past, so hyperdomes make a rupture in actual urban context. The singularity that characterized domes of the past is not limited to urban environment, because they represented both technological excellence and structural innovation at their time. We could also refer to more examples, such as the Pantheon in Rome, S. Sofia in Istanbul, the Antonelli Mole in Turin, the works of Boullée or Speer, Nervi and Buckminster Fueller in recent times, but we try to limit our attention to some cases of specific relationship between the digital innovation produced by design tools and its translation into distinct shapes. Similarly, new generations of contemporary “domes”, hyperdomes are landmarks in the skyline, because of their shape and structural singularity, so they get imageability (in the meaning attributed



Figure 4
Churches of XVII century
Sindone dome by Guarino
Guarini in Turin and XIX cen-
tury San Gaudenzio Church
dome by Alessandro Antonelli,
in Novara, relevant prototypes
of hyperdomes clearly mark-
ing the urban and, for the lat-
ter, even regional landscapes.

to this term by Kevin Lynch (1960), as a “quality in a physical object which gives it a high probability of evoking a strong image in any given observer”).

In this sense, that might seem not only challenging but even provocative, some case studies for contemporary structures are the Future Systems’ Selfridges building in Birmingham (Figure 5), the Kunsthaus in Graz by Peter Cook and Colin Fournier (Figure 2), the Opera House in Lyon by Jean Nouvel (Figure 6), the Greater London Authority building (Figure 7), British Museum Great Court in London (Figure 8) and Reichstag in Berlin (Figure 9), all by Norman Foster, the recent roofing structures in Gent and Taiwan (Figure 10) and Meiso no Mori funeral

hall in Kamigahara (Figure 11), by Toyo Ito and the Lingotto dome by Renzo Piano (Figure 12).

CONCLUSIONS

This study has analyzed the aforesaid series of case studies, pointing out how the new relationships between design tools, structural conception, shape innovation, contextual references and symbolic values become key factors to understand the evolution of hyperdomes.

Starting from the given hypothesis this paper has shown a possible interpretation of the current interpretation of domes and how both the internal and external singularity may be considered for giv-

Figure 5

Selfridges building in Birmingham - Future Systems. The hyperdome creates a singularity by integrating itself in the urban environment though being a complex shape.



ing the building a shape distinctiveness in the urban context. A positive or negative assessment of the role of hyperdomes goes beyond the aim of this paper that mainly aims at recognizing and interpretate

the phenomenon of the complex shapes in terms of relationship to the urban context, without involving aesthetic and historical issues that deserve further and specific disciplinary attention. Nevertheless, it

Figure 6

Opera Nationale de Lyon – Jean Nouvel. A contemporary dome, which creates a singularity in urban environment.



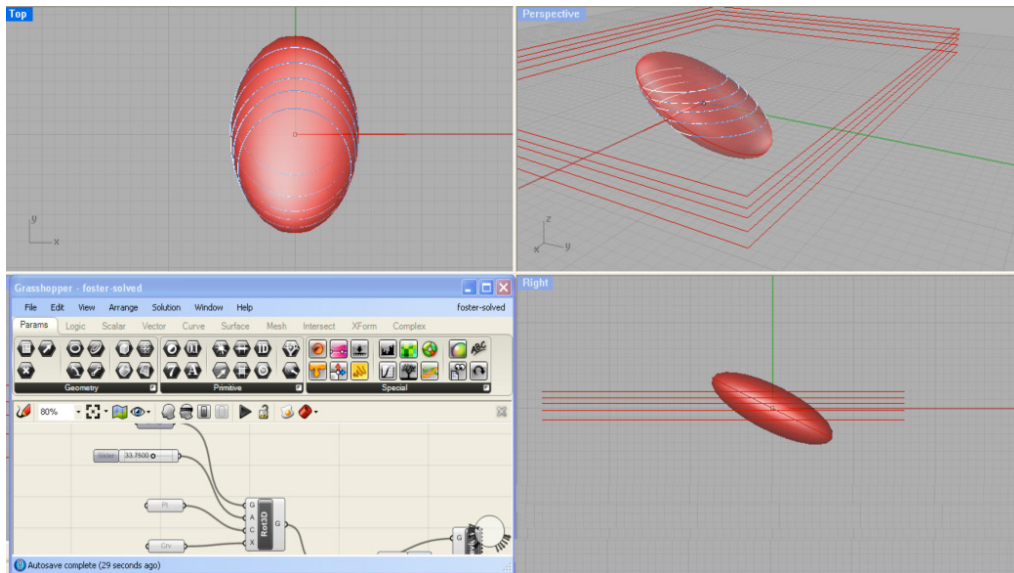


Figure 7
Greater London Authority building - Norman Foster.
Geometric singularity by the discovery of the only rotation angle that creates circular section from an elliptical ellipsoid.

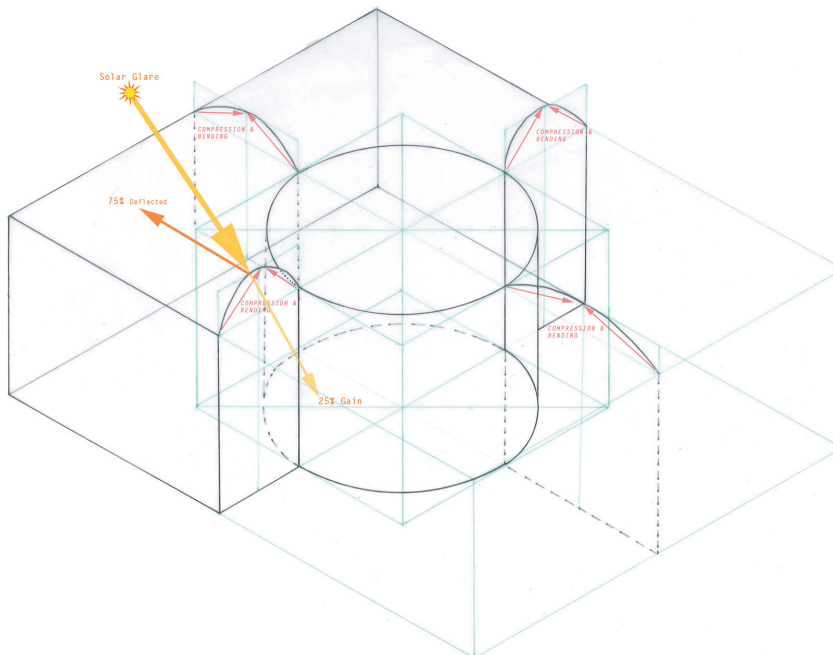
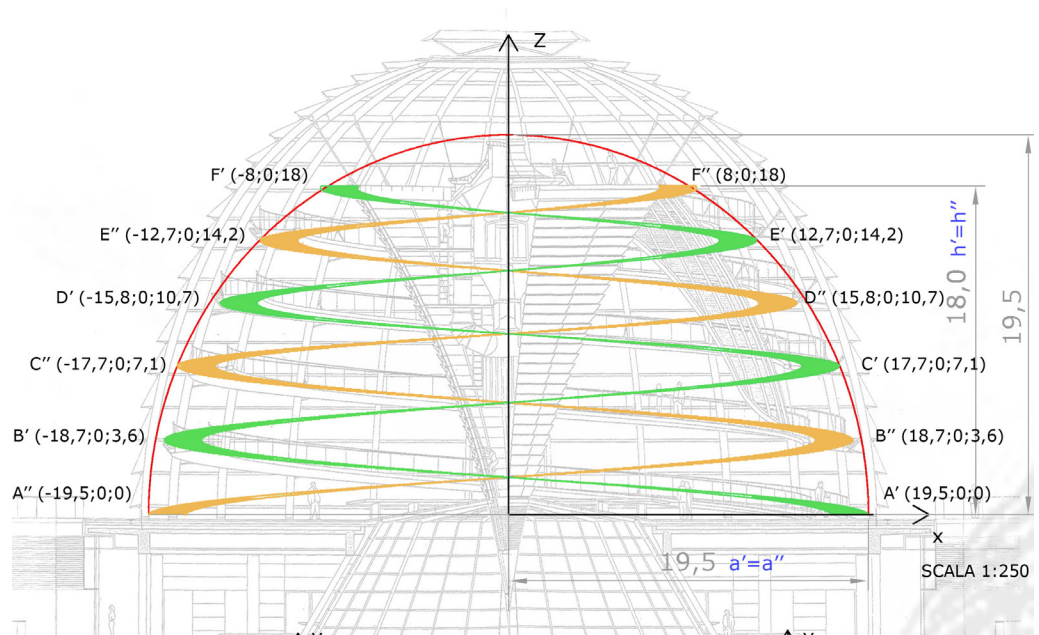


Figure 8
Queen Elizabeth II Great Court at British Museum, Norman Foster. Structural singularity. Effects of compression and bending must pass through the nodes in all directions, decreasing bearing loading of central building. Green performance is achieved through the glass perceived as clear, which is shielding 75% of ultraviolet rays.

Figure 9
 Reichstag dome - Norman
 Foster. Internal geometric
 singularity. Ramp as a spiral
 inscribed in the circumference
 (Loxodrome).



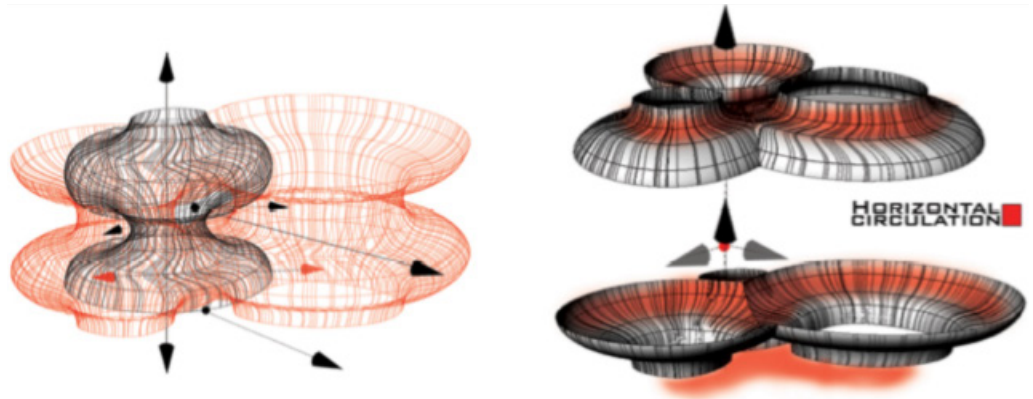
seems possible to anticipate that the sake for searching the shape singularity as an end in itself, that many recognize as a common issue in contemporary architectonic structures, it seems to be necessary, but not sufficient, to mark the urban environment with significant permanent signs that need to go

through a further long term process of historical, cultural and even social interpretation and acceptance.

REFERENCES

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Figure 10
 Taichung Metropolitan Opera
 House - Toyo Ito. Singularity
 in flux allowed by the walls
 which bends to merge with
 floors and ceilings.



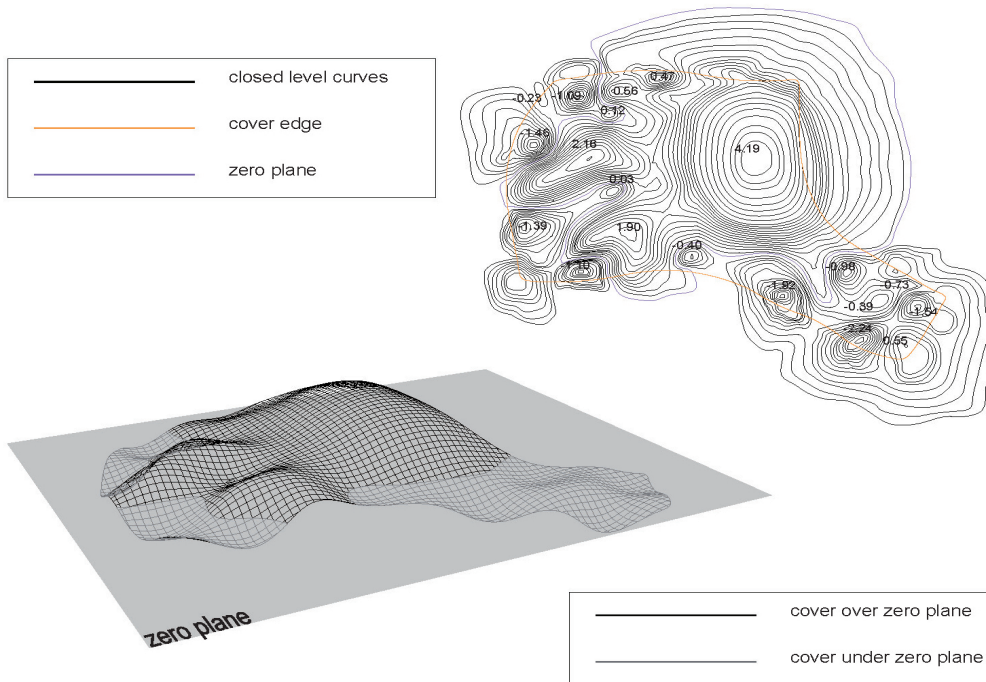


Figure 11
Meiso no Mori Crematorium
- Toyo ito. A generative design
applies the mechanical theory
that minimizes strain energy
in a structure to create a ra-
tional free-curved surface.



Figure 12
The organic shape of the
"Bolla" (Bubble) designed by
Renzo Piano on the roof of the
Fiat Lingotto Factory in Turin.